Fire Management *today*

Volume 66 • No. 3 • Summer 2006

Smoke Issues and Air Quality

Also: Our Response to Hurricane Katrina

United States Department of Agriculture
Forest Service

Coming Next...

The next issue of *Fire Management Today* (Fall 2006) will feature a series of articles that describe and probe the challenges and opportunities associated with both elements of "fire use"—prescribed fire and wildland fire use. The issue's special coordinator is Tim Sexton, fire use program manager for the USDA Forest Service, Fire and Aviation Management, Washington Office, National Interagency Fire Center, Boise, ID.

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On the Cover:

Left: Smoky haze shrouding the sun over the Bitterroot River following the 2003 fire bust in the mountains around Missoula, MT. Photo: Kristen Honig, Los Alamos, NM, 2003. Bottom Right: Sun in smoke from the 2006 Ward Lake Fire, Quachita National Forest. Photo: Nate Bell, Potter Rural Fire Department, Mena, AR. Top Right: Smoke column rises up from the 2004 Nuttall-Gibson Complex, Coronado National Forest. Photo: Jayson Coil, Flagstaff, AZ.

For more on the air quality issues raised by smoke from wildfires and fire use, see the articles beginning on page 4.

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

WHERE THERE IS FIRE THERE IS SMOKE

Pete Lahm

This issue of Fire Management Today highlights the expanding science of smoke issues and air quality. From the discussion of Web-based tools that predict how much smoke might come from that fire and where it might go, to the growing array of monitoring equipment to measure the concentration of smoke on the ground in real time, the technology available to fire managers today to support better smoke management decisions is vastly different than just a few years ago.

The integration of smoke management into fire management decisions has never been greater. A land manager can now support a decision to ignite a prescribed fire with better knowledge of potential smoke impacts based on the USDA Forest Service Research's BlueSky-RAINS model—explained in detail beginning on page 12.

A public information officer from an air regulatory or land management agency—through the use of increasingly portable air quality monitoring devices—can more frequently be found providing information about the measured levels of pollutants to a community inundated by smoke. In addition, the interagency linkages between land managers and the air quality regulatory community are also impressively growing. Many entities are now working together to improve the quality and utilization of these tools.

Pete Lahm, coordinator for this special "smoke and air quality" issue of Fire Management Today*, is the smoke management specialist for the USDA Forest Service, Fire Ecology Division of Fire and Aviation Management, Washington, DC.*

Better Tools and Approaches

Better tools and approaches to address fuels management and understand the state of fuels on the landscape are now being developed for fire managers. They are being fashioned with an eye toward how smoke emissions will be calculated and how fire management's potential smoke impacts can be demonstrated.

The clear recognition of the state of wildland fuels and the undertaking of addressing this reality through increased vegetation management efforts is fully underway. On a national scale, prescribed fire and wildland fire use are two approaches that are dramatically increasing to address the fuels crisis.

The amount of smoke is increasing in the environment—whether from the large wildfire with catastrophic effects in the wildland/urban interface, the managed wildland fire use incident, or the ignited prescribed fire. An example of this integration of smoke with fuels management is the rapidly developing LANDFIRE ecosystem and fuels mapping project, with its set of vegetative data layers that will allow for multiple methods for calculating fire emissions.

> The integration of smoke management into fire management decisions has never been greater.

Through the expanding array of modeling tools, these emissions estimates can then be used to support better smoke management decisions, both on the ground and for planning purposes. The integration of smoke management and how air quality can be incorporated into the planning of vegetation treatments can also be found in the rapidly developing Strategic Placement of Treatments (SPOTS) projects, also discussed in the following pages.

Combined Science: Fire and Smoke

There is an increasing awareness of both the unprecedented air quality effects of wildfire on air quality health standards and the efforts to mitigate—where possible—these smoke impacts. The need to increase the use of prescribed fire in many areas across the country—as well as to further utilize wildland fire—reinforces the need for future growth in the smoke management arena.

As we reintroduce fire into natural ecosystems, our technical tools will need to be further improved and new approaches developed to balance the protection of air quality and its human health benefits, as well as to address the current fuels crisis within the wildlands around us. As we proceed, this issue will highlight a number of leading efforts and technologies in this growing integration of the combined science of fire and smoke. ■

Applying BlueSky Smoke Modeling Framework on Wildland Fires

Louisa Evers, Sue Ferguson, Susan O'Neill, and Jeanne Hoadley

Smoke is a common concern on long-duration wildland fires, both those managed for resource benefits and suppression incidents. Since the mid-1980s, the Western United States has seen an increasing number of smoke events and prolonged smoke production from these large and long-lasting wildland fires.

Fine particulates in smoke from wildland fires—at concentrations well below the National Ambient Air Quality Standards (NAAQSs) for "PM2.5" set by the Environmental Protection Agency (EPA)—can cause significant health problems for people with respiratory illnesses, young children, and the elderly (Core and Peterson 2001).

Prolonged smoke events can also have significant adverse effects on small, tourism-dependent economies as visitors either shorten their visits or cancel trips due to smoke in the area. Moreover, many of these small towns and businesses have only a few months in the summer and fall in which to make the needed revenue to carry them through the winter and spring. In many resort areas, reduced visibility can obscure or conceal the main scenic attractions.

Communities with existing air quality problems and class 1 areas—those places designated by the Clean Air Act for air quality protection or improvement—are also sensitive to particulates produced by long-duration fires and large-spread events. The increased use of prescribed fire to meet National Fire Plan and Healthy Forests Restoration Act goals and objectives escalates the potential for smoke impacts to extend into the spring or fall. All of these concerns highlight the need for real-time emission production and smoke dispersion modeling.

BlueSky accurately predicted a smoke event into central Washington's Wenatchee–Leavenworth area that was confirmed by verbal reports and data from particulate monitors.

Enter: BlueSky to the rescue.

The Creation of BlueSky

Project BlueSky (Ferguson and others, 2001, O'Neill and others, 2005) evolved from the smoke management plans for Oregon and Washington in the Pacific Northwest.

Air quality managers in these two States were pushing Federal land managers to get more involved in anticipating potential impacts from prescribed burning. A 1999 national smoke-modeling meeting on Washington's Mt. Baker–Snoqualmie National Forest resulted in the formation of the BlueSky modeling consortium.

Participants at this meeting included:

- Federal land managers from several agencies,
- Air quality regulators from several States,
- EPA representatives, and
- Members of the air quality modeling group (now known as the AirFIRE team) from the Pacific Northwest Research Station's Pacific Wildland Fire Sciences Laboratory in Seattle, WA.

Project Goal

The BlueSky project goal was to build a centralized, automated tool for estimating potential smoke impacts at the surface by simulating smoke's movement across the landscape. To accomplish this, the project's coordinators first assembled all of the existing and developing knowledge on fuels, weather, and smoke.

At the same time, the Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS) was conceived as a method of

Continued on page 7

Louisa Evers is the fire ecologist for the USDI Bureau of Land Management, State Office, Portland, OR; the late Sue Ferguson was the former leader of the AirFIRE Team, USDA Forest Service, Pacific Northwest Research Station, Pacific Wildland Fire Sciences Laboratory, Seattle, WA; Susan O'Neill is an air quality engineer for the USDA Natural Resources Conservation Service, Portland, OR; and Jeanne Hoadley is the meteorologist technology transfer specialist for the USDA Forest Service, Pacific Northwest Research Station, Pacific Wildland Fire Sciences Laboratory, Seattle, WA.

Sue Ann Ferguson
February 11, 1953 – December 18, 2005

Lifelong sailor—Sue Ferguson sailing on Lake Washington in September 2005. Photo: Greg Ferguson, Sue's brother.

Dr. Sue Ferguson passed away December 18, 2005, on a gloriously beautiful, crisp, blue-sky Seattle day. Sue had been battling cancer for the past year and one-half. She leaves behind a legacy of accomplishments in her research and in her relationships with friends, family, and coworkers. With her enthusiasm, tenacity, and boundless energy, Sue was an inspiration to all who knew her.

Sue Ferguson enjoyed a 13-year career in avalanche forecasting before coming to wildland fire research at the USDA Forest Service's Pacific Northwest Research Station (PNW) in 1992. At PNW, she worked as a research meteorologist with the Fire and Environmental Research Applications Team. Sue founded the Atmosphere and Fire Interactions Research and Engineering (AirFIRE) Team.

Everywhere she went, Sue thought big. She organized scientists and users to create large enterprises that have had lasting effects.

As an avalanche forecaster, Sue created the *Avalanche Review*, now a premiere publication in the field. She worked at a variety of avalanche centers throughout the United States. Sue developed several programs that enhanced the operations—and have been instrumental in saving many lives—at all of this country's avalanche centers. For her many contributions to snow and avalanche research and forecasting, Sue was awarded an honorary membership in the American Avalanche Association.

Wildland Fire Research

In wildland fire research, Sue provided the vision and helped establish the Northwest Regional Modeling Consortium, a multiagency effort to develop improved weather forecasts. Using these predictions, she was able to offer land and fire managers tailored real-time forecast products that enhance and display existing fire weather indices such as the Haines Index, Fosberg Fire Weather Index, and a new dry lightning index.

Through the National Fire Plan, she created the BlueSky smoke-modeling framework, the innovative tool that—for the first time—allows users to see real-time predictions of cumulative smoke impacts from prescribed, wildland, and agricultural fire. This tool has been hailed as one of the best research products to emerge from the National Fire Plan. It recently won the National Fire Plan's Excellence in Research Award. The success of Sue's Northwest Regional Modeling Consortium and BlueSky smoke-modeling framework has prompted similar efforts around the country. Now—due to Sue's work and vision—real-time tailored forecasts of fire indices and smoke predictions are available throughout the lower 48 States.

Sue was also instrumental in the revival of the American Meteorological Society's biennial Fire and Forest Meteorology Conferences. Through her dedicated work, the utility of meteorology in fire research has been elevated to an unprecedented level. Her efforts continue to benefit and assist managers and researchers in the fire management field.

Sue Ferguson will be sorely missed. Her talent and wisdom and her infectious laugh, smile, and good humor made us all better for being with her.

Editor's Note: *People with comments, memories, stories, or photos of Sue Ferguson—to share with her family and friends—are asked to contact Sim Larkin, AirFIRE Team, USDA Forest Service, Pacific Wildland Fire Sciences Laboratory, 400 N. 34th St., Suite #201, Seattle, WA 98103, 206-732-7849 (office), 206-321-2013 (cell), slarkin@fs.fed.us (e-mail).*

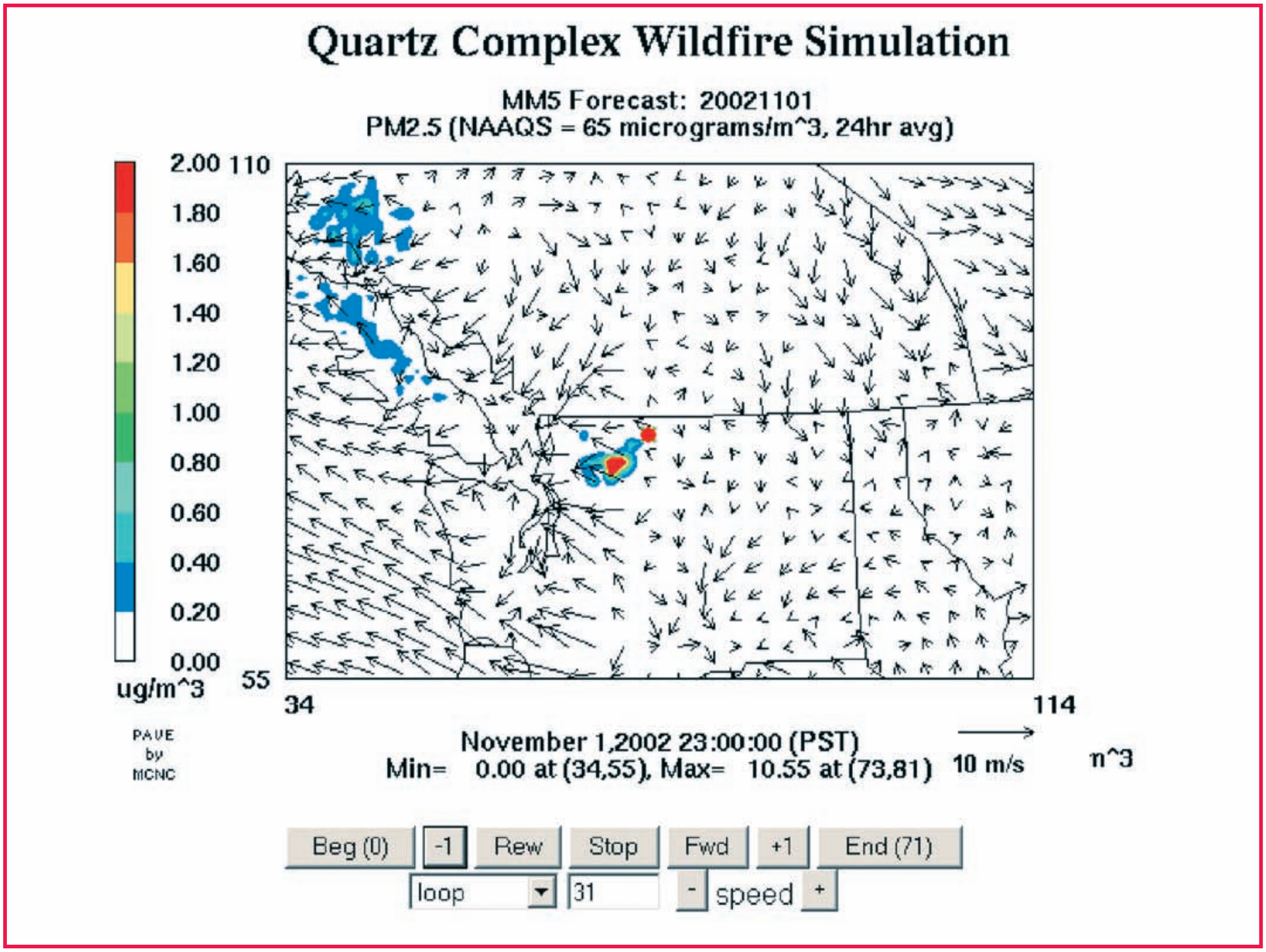

Figure 1*—An example of BlueSky output for the Quartz Mountain Complex, November 1, 2002.*

Continued from page 5

organizing the country into weather and smoke-modeling areas (Riebau and Fox 2003). (See article on page 12 that provides details on the FCAMMS and their implementation of BlueSky across the country.)

Fine particulates in smoke from wildland fires can cause significant health problems for people with respiratory illnesses, young children, and the elderly.

First Use of BlueSky

The first use of BlueSky predictions on a wildland fire occurred in 2002 in Washington's Pasayten Wilderness on the Okanogan National Forest. Called the Quartz Mountain Complex, it comprised two early-September fires. Shortly after discovery, the complex, spreading rapidly, threatened to move into the "Red Zone"—the area closest to the Canadian border. This fire activity triggered a suppression decision.

Firefighter safety on this remote complex was the primary driver behind the subsequent management decision to employ a confinement strategy. The complex had the potential to spread for up to 2 months before snowfall would extinguish it. The Okanogan National Forest managers decided to order Gary Cones' Fire Use Management Team to manage this incident due:

The first use of BlueSky predictions occurred in the Pasayten Wilderness on Okanogan National Forest.

- To the late-season nature of the fires,
- The complex's insulated location in the middle of the vast Pasayten Wilderness, and
- The fact that the fires posed few threats to other resources.

Potential Smoke Impacts

The Okanogan National Forest was most concerned about potential adverse impacts from smoke on the economies and public health in Washington's nearby Methow Valley and in the area of Penticton, BC. Using past fires, the forest identified potential daily fire growth rates—depending on wind direction and speed—of 500 or more acres (200+ hectares) as sufficient to cause adverse effects.

Tom Leuschen of the Okanogan National Forest, who was assisting the fire use management team, asked for assistance in smoke modeling from Sue Ferguson, project leader for smoke-modeling research for the USDA Forest Service's Pacific Northwest Research Station.

BlueSky was far enough along in its development to test operationally on a wildland fire. Together, Leuschen and Ferguson decided to try BlueSky as the modeling framework for smoke management projections on the Quartz Mountain Complex.

Running daily for almost 3 months, BlueSky accurately predicted a smoke event into central Washington's Wenatchee–Leavenworth area that was confirmed by verbal reports and data from particulate monitors. Figure 1 shows an example of BlueSky output for the Quartz Mountain Complex. Representatives from the Okanogan National Forest and Washington Department of Ecology were pleased with the results of this test of BlueSky.

Estimating Wildland Fire Smoke Impacts

Besides BlueSky's proven value in estimating potential impacts from prescribed burning, beginning in 2002, the value of this tool for estimating air quality impacts from wildland fire has also been demonstrated.

> All of these concerns highlight the need for real-time emission production and smoke dispersion modeling.

Wildland fire can pose considerations—such as prolonged ignition periods and adequately accounting for extended smoldering—that are not associated with prescribed fire. Based on past fire seasons using BlueSky on wildfires, such considerations are being addressed.

In addition, BlueSky continues to be a valuable communication tool for the public and air quality regulators.

References

Core, J.E.; Peterson, J. 2001. Public health and exposure to smoke. In: Hardy, C.C.; Ottmar, R.D.; Peterson, J.L.; Core, J.E.; Seamon, P., eds. and comps. Smoke management guide for prescribed and wildland fire: 2001 edition. NFES 1279. Boise, ID: National Wildfire Coordinating Group: 27–33.

Ferguson, S.A. 2001. Smoke Dispersion Prediction Systems. In: C.C. Hardy; R.D. Ottmar; J.L. Peterson; J.E. Core; P. Seamon; eds. and comps. Smoke management guide for prescribed and wildland fire: 2001 edition. NFES 1279. 27–33. Boise, ID. National Wildfire Coordinating Group.

Ferguson, S.A.; Peterson, J.; Acheson, A. 2001. Automated, real-time predictions of cumulative smoke impacts from prescribed forest and agricultural fires. Presentation at conference: Fourth Symposium on Fire and Forest Meteorology; 13–15 November; Reno, NV.

O'Neill, S.; Hoadley, J.; Ferguson, S.; Solomon, R.; Peterson, J.; and Larkin, N. 2005. Applications of the BlueSkyRAINS Smoke Prediction System, EM: The Magazine for Environmental Managers, Air and Waste Management Association, September 2005; 42–45.

Riebau, A.; Fox, D. 2003. Fire Consortia for Advanced Modeling of Meteorology and Smoke. Presentation at conference: Fifth Symposium on Fire and Forest Meteorology; 16–20 November; Orlando, FL. ■

For More Information

FCAMMS
For more information on the Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS), visit the gateway Website at http://www.fs.fed.us/fcamms/ and click on the FCAMMS for your area.

BlueSky
For more information on BlueSky, visit the Website at http://www.blueskyrains.org or contact Jeanne Hoadley at 206-732-7867, jhoadley@fs.fed.us.

BlueSky Proves Its Value in Predicting Smoke

Louisa Evers

In the fall of 2002, I was the long-term analyst on the fire use management team assigned to the Quartz Mountain Complex on the Okanogan National Forest. This was my first exposure to the BlueSky smoke-modeling process and my first introduction to the concept of the Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS).

> We ensured that the New Mexico State air quality coordinator and the Southwest Coordination Center knew that the smoke predictions were posted on a publicly available Website.

Due to BlueSky's merits and success in 2002, I used BlueSky smoke predictions on three incidents in different areas of the country the following year.

While the 2003 fire season was slightly below average for the number of wildland fires and acres burned, it was still a significant season in terms of smoke production. For the first time, the number of acres burned in suppression incidents was only slightly larger than the number of acres burned in wildland fire use and prescribed fire projects.

The year also saw record-high energy release component values in much of the Western United States. Wildland fires that are not suppressed immediately under such conditions are more likely to spread and continue burning throughout the summer and into fall.

2003 Smoke Impacts

Competition for "air space" therefore became quite keen in certain locations during 2003. The biggest events were the series of wildland fires that started in northern Idaho and western Montana in August, and in southern California in October.

In late June of 2003, Gary Cones' Fire Use Management Team was dispatched to New Mexico's Gila National Forest to manage the Dry Lake Complex. The complex started in late May and wasn't declared out until October—becoming the largest fire in recent New Mexico history. Due to the complex's prolonged nature, smoke impacts became a concern for the local communities surrounding the Gila Wilderness.

For assistance in setting up BlueSky on this incident, I called Ned Nikolov at the Rocky Mountain FCAMMS. We then contacted Sue Ferguson at the USDA Forest

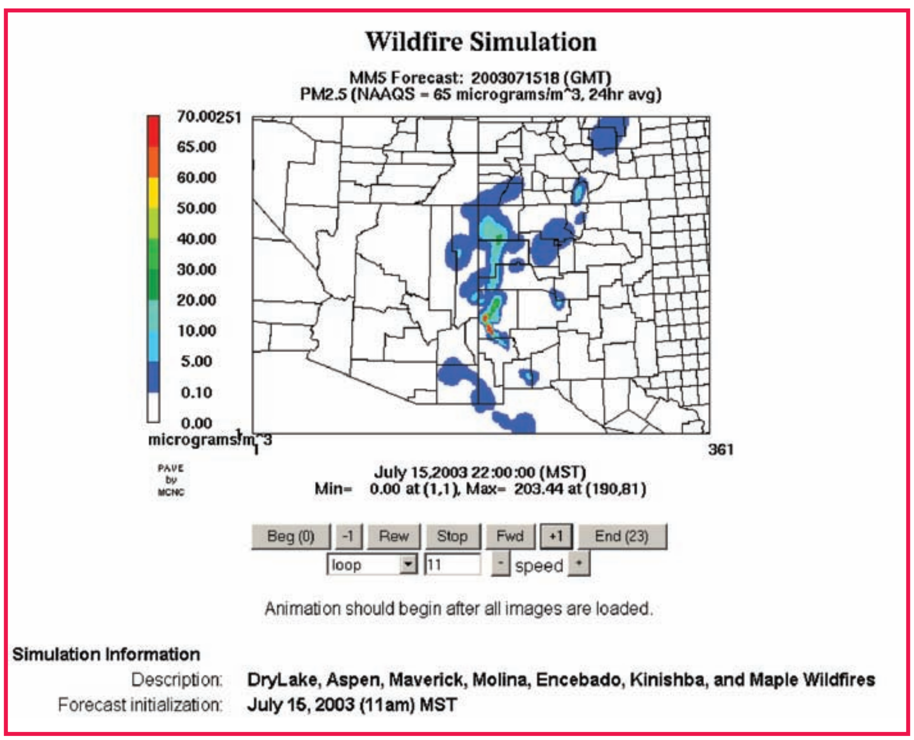

***Figure 1**—BlueSky predictions for Arizona and New Mexico, including the Dry Lake Complex on the Gila National Forest on July 15, 2003.*

Louisa Evers is a fire ecologist for the USDI Bureau of Land Management, State Office, Portland, OR.

Service's Pacific Northwest Research Station's Pacific Wildland Fire Sciences Laboratory in Seattle, WA.

Two Predictive Runs Per Day

I provided estimated number of acres burned per day; the Rocky Mountain FCAMMS provided the MM5 (mesoscale model—a real-time meteorological measurement) weather fields for New Mexico and Arizona; and Susan O'Neill, then at the USDA Forest Service, Pacific Northwest Research Station's Pacific Wildland Fire Sciences Laboratory in Seattle, WA, initialized the BlueSky model and instituted two predictive runs per day.

These model results were then posted on the Rocky Mountain FCAMMS Website. In addition, I provided information to the Gila National Forest's public affairs office on how to access the model for distribution to the public.

> The year 2003 saw record-high energy release component values in much of the Western United States.

We also ensured that the New Mexico State air quality coordinator and the Southwest Coordination Center knew that the smoke predictions were posted on a publicly available Website. (Figure 1 shows BlueSky predictions for fires in New Mexico and Arizona, including the Dry Lake Complex.)

BlueSky to the Rescue Again

In August 2003, Cones' Fire Use Management Team was sent to Idaho to manage 10 wildland fire use incidents on the Clearwater and Nez Perce National Forests. During our briefing, dry thunderstorms were moving over our part of Idaho and western Montana, igniting several hundred wildland fires. Our team continued to manage the wildland fire use incidents as well as several suppression fires managed under a confinement strategy. Because of the air quality problems related to the numerous fires burning near Missoula, MT, the Montana–Idaho Airshed Group and the air quality program manager for the USDA Forest Service's Northern Region wondered what impact our wildland fire use incidents might be having on Missoula and the Bitterroot Valley's air quality.

Once again, I contacted Sue Ferguson and Susan O'Neill at the Seattle lab to set up BlueSky for us. They were already modeling the potential smoke impacts from several of the larger Missoula area fires. We realized we had a logistical modeling problem. We were dealing with nearly 80 wildland fire use and suppression incidents scattered over four ranger districts and two national forests.

I eventually decided to ask BlueSky to model potential smoke impacts using two points of origin that represented the more active concentrations of fire activity. These model results (fig. 2) indicated that while we were contributing to air quality problems in Missoula, the impact was relatively insignificant due to much lower levels (less acres) of fire growth than the fires in closer proximity to Missoula and the Bitterroot Valley.

Stagnant Air Problems

Finally, in September 2003 I used BlueSky once again on California's Stanislaus National Forest. Cones' Fire Use Management Team was assigned to two fires—one on each side of Spicer Reservoir. Each fire was located in a different air quality district. Each district had different regulations and levels of concern.

Smoke was affecting both of these air quality districts, as well as several others. In addition, several other wildland fire use incidents were occurring between the Stanislaus National Forest and Yosemite National Park. There were resultant stagnant-air problems in the San Joaquin Valley.

> BlueSky was asked to model potential smoke impacts using two points of origins that represented the more active concentrations of fire activity.

Proved Its Value

Nighttime smoke was the most significant problem. Several of the area's small communities were occasionally experiencing very dense smoke. There were also con-

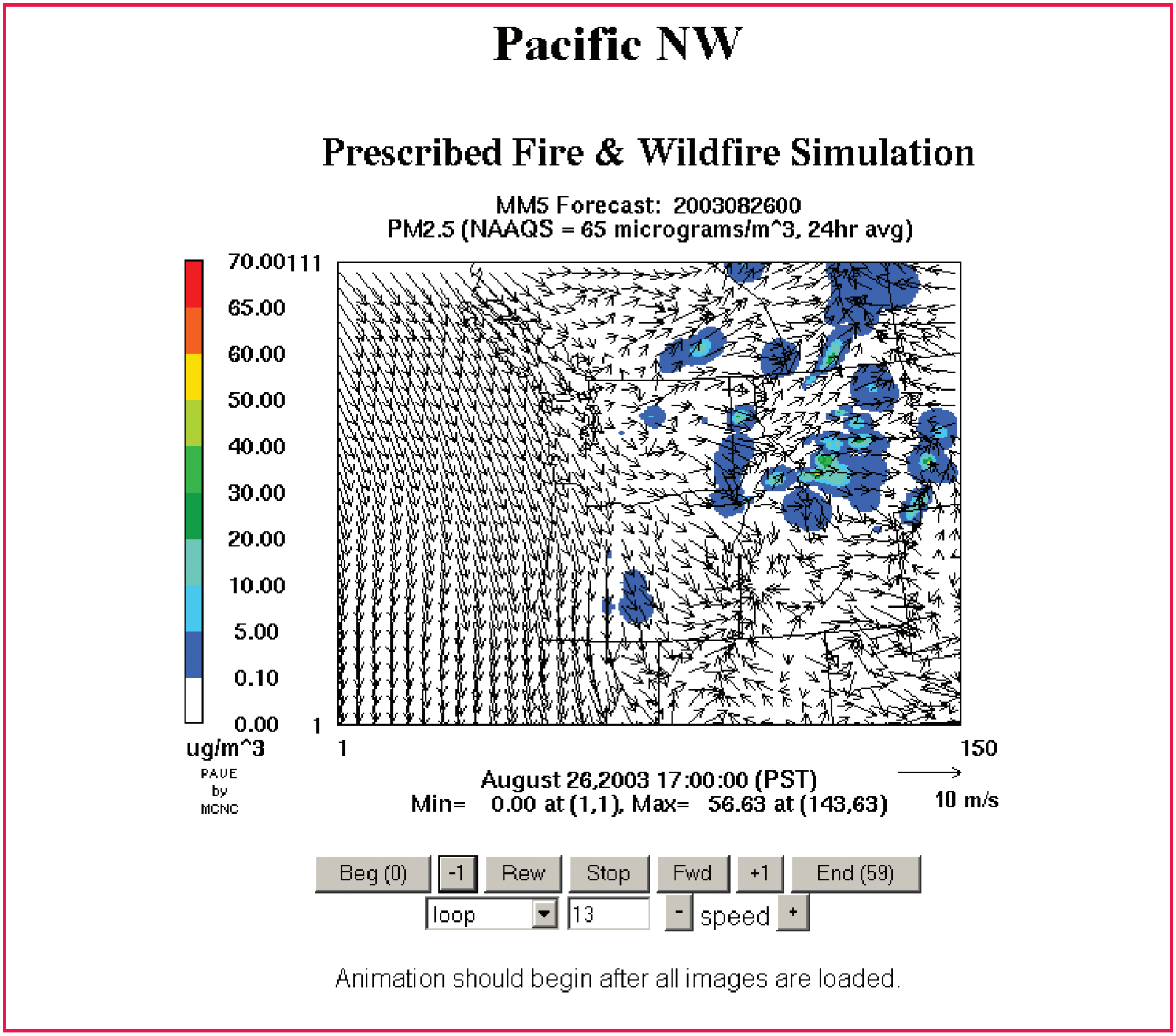

Figure 2—BlueSky predictions of smoke in northern Idaho and western Montana on August 26, 2003.

cerns that daytime smoke could affect Carson City, NV, and the Lake Tahoe area.

Once again I contacted Susan O'Neill and the California-Nevada FCAMMS and asked them to start BlueSky. Working with the Stanislaus National Forest and our team's information officer, we successfully distributed information on model results to the air quality boards, local communities, and several news outlets.

For the third time that fire season, BlueSky proved its value as a communication tool.

For the third time that fire season, BlueSky proved its value as a communication tool. ■

Smoke, Fire, and Weather: What Forest Service Research Is Doing To Help

Brian E. Potter, Narasimhan K. Larkin, Ned Nikolov

Many Federal and local land management agencies are expanding their fuel management efforts by using combinations of mechanical removal, prescribed fire, and mixed treatments. When prescribed fire is used to any extent, execution of the fuel management plan requires great care to avoid unexpected fire behavior that could endanger personnel or property.

While prescribed fire managers focus their attention primarily on people and events in the immediate vicinity of the fire, they must also be aware of potential impacts from smoke. For a burn on any given day, air quality regulations related to public health and visibility can be the limiting factors in the final go/no-go decision.

Failure to meet air quality obligations can lead to more stringent legal limits on future prescribed fires and a poor public image for the burning agency. Even when smoke from a fire does not violate any laws, it can still be a nuisance or annoyance to the public.

Both fire behavior and smoke transport depend largely on weather conditions at and near the ground. Resources may be carefully allocated and distributed days or months in advance of the burn. Terrain and fuels may be studied and measured in great detail—noting species composition, fuel loads, and topographic features with great specificity.

> To mitigate and reduce downstream smoke complaints, clients in the Pacific Northwest and elsewhere have used BlueSky and BlueSky-RAINS on prescribed burns for go/no-go decisions and timing.

But when it's time to light the drip torches—even with the most careful preparation and preburn study—the weather is the deciding factor. For instance, the burn must wait for another day if current conditions are too dry or too windy, the wind is blowing toward a city or a 1977 Clean Air Act class I area, or the forecast calls for other unfavorable conditions. More than just inconvenient, weather delays can also lead to added resource expenses.

Regional Fire Consortia

When it comes to weather forecasts, fire managers have very specific information needs. Will the weather be dry enough, or too dry, to burn? Where will the smoke travel? How much smoke is likely to linger in the vicinity of the fire? Are the weather conditions likely to change rapidly—possibly resulting in a loss of control?

The regional Fire Consortia for the Advanced Modeling of Meteorology and Smoke (FCAMMS) are research groups that study the interaction of fires, smoke, and the atmosphere to develop science-based products that help meet these needs. Each group has a USDA Forest Service research component and works with the Geographic Area Coordination Centers and National Weather Service meteorologists to develop the tools needed by land and fire managers on the ground.

These experimental forecast products enhance and expand the standard National Weather Service products such as fire weather forecasts, red flag watches and warnings, and spot forecasts. The experimental products are available daily on the Internet, allowing feedback from the users to the research teams. The ultimate goal is to develop better operational weather products.

Understanding Land Manager Needs

While each individual FCAMMS performs globally relevant research, they also work together to apply this research regionally. Based on the success of the Northwest Regional Modeling Consortium (NWRMC), an association of organizations with a common interest in weather issues that formed in 1992, the FCAMMS were created to work with regional land managers to better understand their needs

Brian Potter is a research meteorologist for the USDA Forest Service, North Central Research Station, East Lansing, MI. In December 2004—when this article was written—he was acting team leader of the AirFIRE Team, USDA Forest Service, Pacific Northwest Research Station, Portland, OR. Narasimhan Larkin is a physical climatologist for the Pacific Northwest Research Station's AirFIRE Team; and Ned Nikolov is a research meteorologist for the USDA Forest Service, Rocky Mountain Research Station, Rocky Mountain Center, Fort Collins, CO.

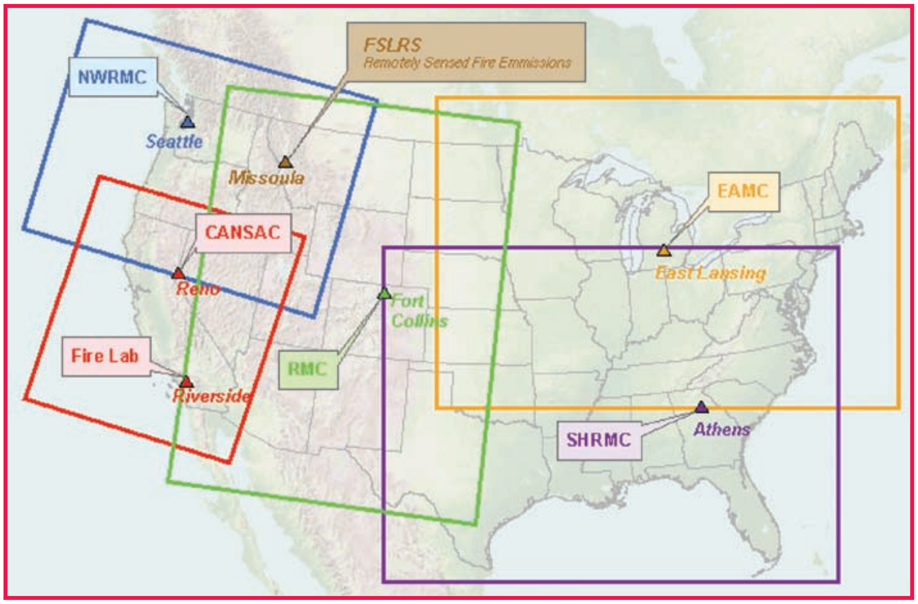

Figure 1*—Locations and areas covered by the numerical weather models of the regional Fire Consortia for the Advanced Modeling of Meteorology and Smoke (FCAMMS).*

and interests. Thus, the FCAMMS develop research programs and new science-based applications to meet these needs and interests. In 2002, under the National Fire Plan, four additional FCAMMS were formed to span the contiguous 48 States (fig. 1).

The meteorologists at the FCAMMS each have their own area of specialization, and the FCAMMS strive to match the science to the scientists. As new scientific knowledge and tools develop, the FCAMMS share them to benefit the entire country, as well as to evaluate their performance and applicability in each region.

The FCAMMS each maintain their own Websites that provide information on new or experimental products and research programs for their region. These regional Websites provide fire weather, fire danger, and smoke products in presentation formats tailored to the needs of fire and smoke managers working on individual fires.

Efforts are currently underway to create a single Web interface for the uniform display of products of interest to national users. Maintenance of separate national and regional Web pages allows the FCAMMS to present information that meets two potentially different sets of user needs.

BlueSky Smoke Modeling Framework

With funding from the National Fire Plan, the USDA Forest Service AirFIRE team, a member of the NWRMC, created a science-based smoke modeling framework named BlueSky (http://www.fs.fed.us/bluesky). To simulate movement of smoke across the landscape, this system links together previously developed models of fuel emissions and combustion, smoke plume rise, and smoke dispersion.

BlueSky provides fire managers with simulations of where smoke from fire in their region—as well as from other regions—is likely to travel. BlueSky users can view output such as expected smoke trajectories and surface concentrations of PM2.5—one of the measures dictated and regulated by the Clean Air Act—using a variety of visualization systems. The BlueSky Consortium, which includes Federal, State, tribal, and local agencies, governs BlueSky's development.

Before BlueSky's development, most fire managers had to rely on the ventilation index (VI), which is the depth of the atmospheric mixed layer multiplied by the average windspeed in that layer. The VI assumes that smoke mixes uniformly from the ground through the

FCAMMS and Related Websites

http://www.fcamms.org	Gateway Website with links to all FCAMMS.
http://gacc.nifc.gov	National Geographic Area Coordination Center Website.
http://www.airfire.org/bluesky	BlueSky Website.
http://www.blueskyrains.org	BlueSky-RAINS Website.
http://fire.boi.noaa.gov	National Weather Service Fire Weather Forecast Website.

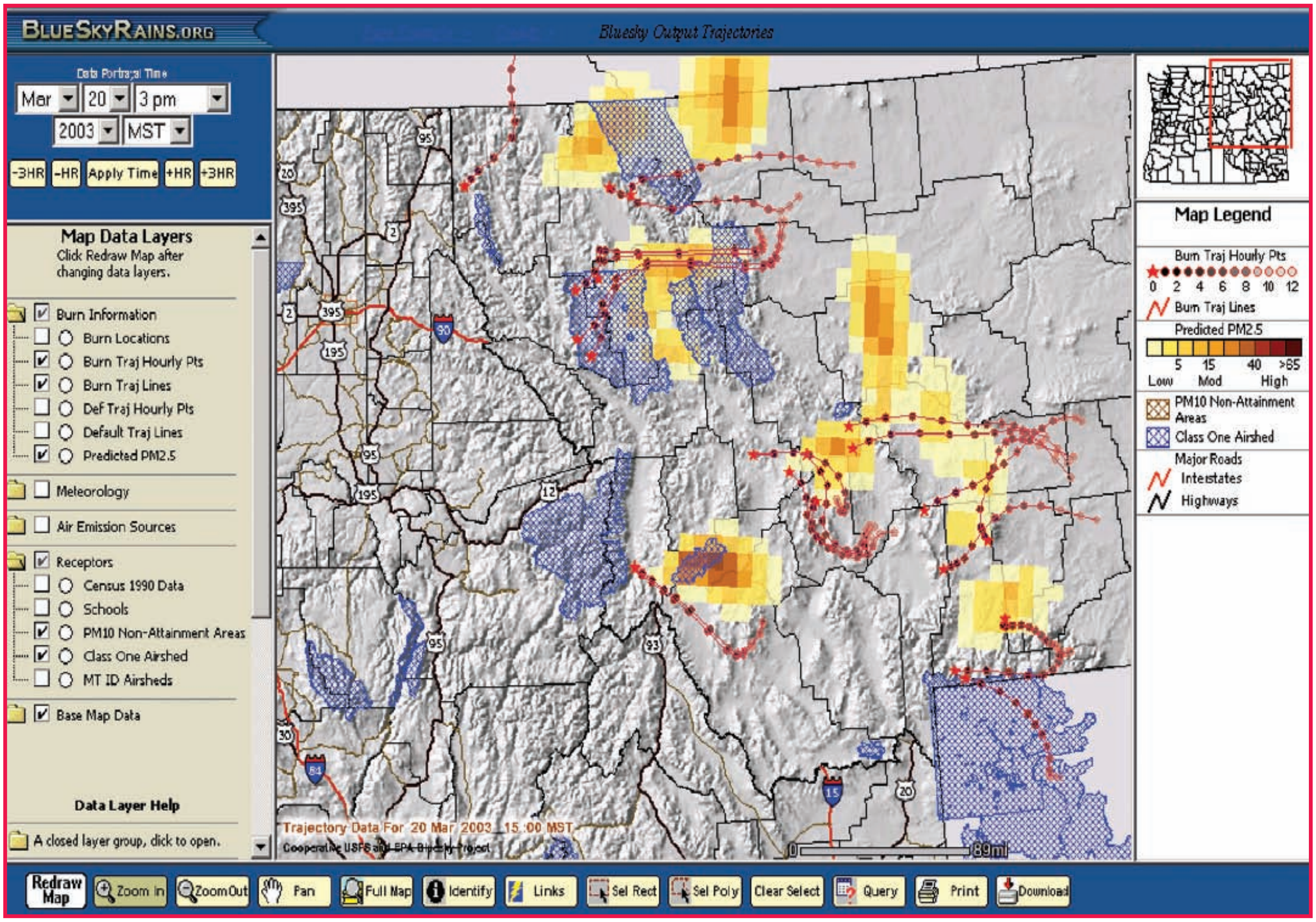

Figure 2—*Example of BlueSky-RAINS interface showing smoke trajectories, PM2.5, and class 1 airsheds in northern Idaho and western Montana.*

mixed layer, that there is no change in wind direction with height, and that the wind and mixed-layer depth will not change substantially while the fire is burning.

And yet, anyone who has seen a fire knows that smoke does not mix uniformly from the ground to the top of the plume. It is less obvious—but just as true—that wind direction usually changes with height, and that both mixed-layer depth and winds in the mixed layer change significantly throughout the day, or when pressure troughs or cold fronts pass.

Tremendous Leap Forward

BlueSky represents a tremendous leap forward in smoke management tools for prescribed fire. The system distributes smoke upward from the ground based on the heat of the fire and the structure of the atmosphere. BlueSky determines the direction and speed of smoke movement across the landscape, all based on physical laws. This allows the smoke to travel in different directions at different heights, depending on winds at those heights. It also allows BlueSky to determine how much smoke might remain near the ground—where it impacts visibility and human health.

Because BlueSky uses the same type of weather model that the National Weather Service uses for regular forecasts, it is sensitive to the diurnal changes in the atmosphere and to the passage of fronts or troughs. In essence, BlueSky allows users to go from a two-dimensional (height and one horizontal direction) view of smoke transport to a four-dimensional (all three spatial dimensions as well as time) view.

BlueSky has been available across the lower 48 States since the summer of 2005. The Forest Service's AirFIRE Research Team (http://www.airfire.org), part of the NWRMC, distributed the modeling framework to the other FCAMMS. Each, in turn, has implemented BlueSky and created a regional system for users to enter information regarding location, time, and size on planned fires.

Regional Implementations

While AirFIRE continues to provide technical support for BlueSky, each FCAMMS is also responsible for evaluating BlueSky's performance in its own region. To ensure that predictions are optimized for its area, geographic differences between the Pacific Northwest and other areas—such as lake effects and sea breezes in the Lake States and Atlantic Coast, arid conditions in the Southwest, and the importance of smoldering emissions in the Southeast—require regional implementation of BlueSky. This ability to regionally "tune" models and products is one of the strengths of the FCAMMS.

BlueSky also works with the Rapid Access Information System (RAINS), a GIS-based Web tool originally developed by the Environmental Protection Agency (EPA) and later modified to function with BlueSky by the EPA and the AirFIRE team. RAINS provides an array of visualization tools that allow users to overlay—from their Internet browser—a variety of GIS layers such as roads and urban centers; to zoom in and out; and access the underlying data (fig. 2). This coupling of BlueSky and RAINS is commonly referred to as BlueSky-RAINS.

BlueSky-RAINS

BlueSky-RAINS is the most popular way to access the BlueSky smoke predictions in the Pacific Northwest. To support their fire and smoke management efforts, a variety of users access the Website:

- The Washington Department of Natural Resources,
- The Oregon Department of Forestry,
- The USDA Forest Service's Pacific Northwest Region,
- The Environmental Protection Agency's Region 10,
- The Montana/Idaho Airshed Group,
- Northwest tribes, and
- Other Federal, State, and local officials.

Members of the public also access the site to obtain information about smoke and fires around the Pacific Northwest.

In addition to standard GIS layers—towns, highways, rivers, and other humanmade and natural terrain features—user-specific layers such as the borders of the Montana/Idaho Airshed Group reporting areas are also available. These can be displayed underneath meteorological forecast information such as winds and VI, as well as projected smoke concentrations.

To mitigate and reduce downstream smoke complaints, clients in the Pacific Northwest and elsewhere have used BlueSky and BlueSky-RAINS on prescribed burns for go/no-go decisions and timing. The Montana/Idaho Airshed Group uses BlueSky-RAINS daily in issuing permits for prescribed burns.

> Failure to meet air quality obligations can lead to more stringent legal limits on future prescribed fires and a poor public image for the burning agency.

On wildfires, BlueSky-RAINS has been used to support a variety of decisions, including whether to let wildland fire use complexes burn and the timing and visibility for aircraft operations. Many organizations also use BlueSky and BlueSky-RAINS as part of their public communication.

BlueSky Consortium

The development of BlueSky-RAINS has been directed through the BlueSky Consortium, which includes both developers and users of the system. These users have been integral in determining the system's look and feel, as well as its capabilities. Through yearly workshops and other training opportunities, the system has evolved into one that is user friendly and directly applicable to decision support. Efforts are now underway to migrate RAINS to the other FCAMMS areas.

In 2004, after viewing BlueSky-RAINS, EPA Director Mike Leavitt urged the creation of a major western implementation of BlueSky-RAINS for viewing smoke effects from wildfires. The goal of this BlueSky-RAINS–West project was to forecast wildfire smoke for public health purposes—including air quality warnings—across a large portion of the Western United States.

At the time of this writing, this project—a joint effort of the Forest Service, Environmental Protection Agency, and U.S. Department of the Interior—is in a demonstration phase. A final assessment report is expected in the near future.

BlueSky-RAINS–West Project

The BlueSky-RAINS–West project has involved both the NWRMC and the Forest Service's Rocky Mountain Center (RMC), another of the FCAMMS. AirFIRE helped coordinate development of the BlueSky-

RAINS–West project among the Federal agencies and RMC took lead responsibility for delivering daily BlueSky forecasts.

In 2004, RMC had enhanced its Web-based user interface by introducing a "user submission form" for prescribed burns, allowing users to enter their planned burns and receive forecasts of likely smoke dispersion. Because RMC had the ability to provide high-resolution forecasts with weather information for every 2.3-square-mile (6-km2) area across the West, it provided the smoke forecast fields for the BlueSky-RAINS–West project. (For logistical and technical reasons, RMC switched to a 4.6-square-mile (12-km2) resolution in fall of 2004.)

The FCAMMS were created to work with regional land managers to better understand their meteorological and smoke management forecast needs and interests.

Specifically, RMC's role in the project includes:

1. Producing meteorological forecasts for the entire West using the MM5 mesoscale model (a real-time meteorological measurement);
2. Running BlueSky for the entire West using MM5 forecast fields as drivers; and
3. Delivering BlueSky output to RAINS.

In addition, RMC maintains a non-GIS user interface to the BlueSky output on its official Website (http://www.FireWeather.info) to serve as a backup display to the BlueSky-RAINS product.

Future Research Areas

The implementation of BlueSky by all of the FCAMMS and the lessons learned from the BlueSky-RAINS–West project are providing insights into how well BlueSky performs under different circumstances. Future smoke management research areas for the FCAMMS include:

- Ongoing field observations for evaluation and improvement of surface PM2.5 estimations,
- Improving the accuracy of smoke dispersion predictions by improving forecasted wind fields through a more realistic simulation of vegetation-controlled surface heat and moisture processes,
- Better representation of smoke from smoldering fires,
- More realistic treatment of smoke transport at night and near large bodies of water, and
- Adding the ability to use multiple fuel or emissions models to provide a sense of the uncertainty in BlueSky output.

Beyond smoke management, the FCAMMS are also working on:

- Increasing the spatial resolution of forecasted fields from 4.6 square miles (12 km2) to 3.1 square miles (8 km2),
- Integrating high-resolution weather information and predictions into the National Fire Danger Rating System, and
- Daily evaluation of how well the weather models used by the FCAMMS are predicting fire-related indices.

FCAMMS Future Work

As they have since they formed, the FCAMMS will continue to work to answer questions raised by their users—the fire management, smoke management, and fire weather communities. The various projects and programs involving BlueSky and BlueSky-RAINS demonstrate the general philosophy behind the FCAMMS.

Based on regional needs and scientific expertise, research programs develop tools to address these needs. These tools can then be shared across the United States and beyond. They can also be tested in other geographic regions. Adjustments for these areas can improve the tools for everyone. Moreover, because each FCAMMS works primarily with local users, no single region's users have to depend on scientists from another region for support.

The FCAMMS continue to work on new products and tools to share. If BlueSky-related products are any indication, there is more than enough work to keep the FCAMMS busy. ■

Smoke-Monitoring Equipment and Applications

Andy Trent and Ricardo Cisneros

Before lighting a prescribed fire on the Okanogan and Wenatchee National Forests, fire managers rely on Tom Robison to check air quality in several of the nearby small towns. Using data from a network of real-time smoke monitors, Robison helps fire managers prevent prescribed fire smoke from violating air quality standards.

If a monitor downwind from the proposed burn shows elevated particulate concentrations, the fire manager works with Robison to determine if the burn should be postponed. This process is part of a smoke management plan developed by the forest to address the 2003 notice of violation issued by the State of Washington's Department of Ecology.

In the past, smoke monitoring may have been conducted by a visual assessment of the local area—or even by simply breathing in a whiff of air to determine whether smoke was present.

The Montana Department of Environmental Quality has established visual parameters to assess current air quality conditions (see table 1). However, new portable monitoring equipment—another tool for fire managers—can do a better job of estimating smoke concentrations.

Health Effects

These commercial monitors use different technologies to estimate the particulate concentrations in real time, with an emphasis on measuring the levels of particles smaller than 2.5 microns in diameter. Such fine particles can penetrate deep into human lungs—where the body's defense mechanisms can't remove them.

While most healthy people will not be affected by the particles produced by prescribed fires, people with respiratory or cardiopulmonary disease, as well as other physical ailments, can be at risk. Fire managers should therefore be aware of the

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***Table 1**—Visibility ranges used in the State of Montana to determine health effect categories from smoke. The table was developed by the Montana State Department of Environmental Quality.*

Categories	Visibility		$PM_{2.5}$ Particulate Levels (averaged 1 hour, µg/m^3)
	miles	km	
Good	10 and up	≥ 16	0–40
Moderate	6–9	10–14	41–80
Unhealthy for sensitive groups (children, elderly, persons with cardiopulmonary and respiratory disease)	3–5	5–8	81–175
Unhealthy	1.5–2.5	2.4–4	176–300
Very unhealthy	0.9–1.4	1.4–2.2	301–500
Hazardous	0.8 or less	≤ 1.3	> 500

health effects of smoke and minimize the public's exposure.

The selection of a smoke monitor depends on its intended use. If the highest degree of accuracy is needed, "gravimetric samplers," which capture particles on a filter, should be used. Fire managers or air resource specialists can use gravimetric samplers to help determine if air quality standards have been violated.

Gravimetric samplers and other Environmental Protection Agency-approved techniques are used to monitor compliance with National Ambient Air Quality Standards (NAAQSs). Gravimetric samplers cannot provide real time results. Because their filters need to be analyzed at special facilities, their results will not be available for days, or even weeks.

Real-Time Monitoring

While real-time smoke monitors provide nearly instantaneous estimations of particulate concentrations, they are not as accurate as gravimetric samplers. Real-time monitors give "ballpark" estimations and provide trend information of the current situation. These real-time monitors can be used for a variety of purposes:

- **On Wildland Fires.** Real-time smoke monitors can provide (1) information to the public and incident information officers regarding local smoke concentrations and potential impacts from smoke; (2) current smoke concentration and trend data to local air quality regulators and health departments; (3) fire safety information during emergency operations; and (4) smoke concentrations at fire camps and incident command posts.
- **On Wildland Fire Use Incidents.** Similar to wildland fire monitoring, real-time smoke-monitoring instruments can provide data to the public, incident information officers, local air quality regulators, and health departments. Additionally, the data from these monitors can be used to ascertain impacts on class I wilderness areas (congressionally designated to protect pristine air quality) and assess impacts from the incident to help determine whether or not the incident's air quality objectives are being met.
- **On Prescribed Fires.** Real-time monitoring instruments can (1) provide additional information to fire mangers for go/no-go decisions; (2) determine nuisance smoke levels; (3) provide data to develop comparisons between prescribed and wildfire smoke concentrations for public education and compliance with prescribed fire monitoring requirements; (4) evaluate impacts from smoke; (5) and monitor air quality before, during, and after the burn, as well as for National Environmental Policy Act documentation.

Evaluating the Technology

The USDA Forest Service's Missoula Technology and Development Center (MTDC) has been evaluating real-time particulate monitors for several years. MTDC worked with the Rocky Mountain Research Station's Missoula Fire Laboratory to compare the results from real-time monitors with a filter-based, Environmental Protection Agency "Federal Reference Method" gravimetric sampler* to determine the accuracy of each of the real-time monitors.

Real-time monitors also have been deployed during large wildfires. Several publications have been produced describing the results of the evaluations (available at http://www.fs.fed.us/eng/t-d.php).

Most of MTDC's work has focused on real-time smoke monitors that use light-scattering principles to estimate smoke concentrations. Advantages of these instruments, known as nephelometers, include being lightweight, portable, and relatively easy to use. Most can be operated for short periods using a battery. For longer deployments, line power or solar panel arrays might be needed.

The accuracy of nephelometers is affected by several factors, including the composition, size, and shape of the particles being sampled. For most of the nephelometers used for smoke monitoring, MTDC has developed conversions from the light scattering measured by nephelometers to smoke concentration. If nephelometers were used to monitor particles of dust or other sources, a different conversion factor would be utilized.

The Forest Service uses several different commercial monitors, including the MIE DataRAM (fig. 1), Radiance Research Nephelometer, Met One Instrument's E-Sampler, and TSI's DustTrack*.

Beta Attenuation Technology

Another monitor being evaluated uses a principle called beta attenuation to estimate the particulate

* The EPA has developed design standards and requirements that samplers have to meet in order to be compliant. These standards are called Federal Reference Methods standards. Samplers that meet the standards are therefore known as Federal Reference Method samplers. They are always filter-based (gravimetric) samplers.

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Figure 1—The MIE DataRAM is a small, portable, real-time smoke monitor—shown here with a satellite telemetry system. The USDA Forest Service, USDI Bureau of Land Management, and some State agencies have used the DataRAM for monitoring smoke from wildland and prescribed fires.

concentration. Beta attenuation monitors (BAMs) work by depositing particulate from the sampled air onto a filter tape that is exposed to beta particles. Calculations convert the amount of beta particles being attenuated or absorbed by the particles on the tape to a smoke concentration.

This beta attenuation technology has been used by the Environmental Protection Agency and States to monitor air quality for NAAQS purposes. Met One Instruments has repackaged their rack-mounted BAM-1020 monitor into a smaller, more portable, environmentally protected system to be used for smoke monitoring. This instrument is called an E-BAM (fig. 2).

Meteorological sensors, such as those measuring ambient air temperature, relative humidity, and windspeed or direction, can be added to these instruments to greatly enhance the utility of the monitoring effort. The Forest Service has purchased several E-BAMs. Additionally, the Environmental Protection Agency is undergoing a large-scale test to determine the usefulness of the E-BAM for monitoring wildland fire smoke by State air quality specialists during emergencies.

Downloading the Data

A data telemetry system can be used to obtain information from smoke monitors in real time. Some monitors, like the ones used on the Okanogan and Wenatchee National Forests, are established at fixed sites from which phone lines and modems can be used to download data. Other instruments can transmit the data using cell phone modems or radios, although the range might be limited.

MTDC worked with a satellite communications company (Airsis, Inc.) to develop a satellite telemetry system that can be used with most of the real-time smoke monitors. This system uses the

Figure 2—The Met One Instrument's E-BAM is a new portable beta attenuation instrument used by some agencies for monitoring smoke. It can be configured with meteorological sensors (shown) such as windspeed and direction, temperature, and relative humidity. Photo: Air Resource Specialists, Inc.

low-earth orbiting satellite system (ORBCOMM) to transmit data hourly to a Web server.

The data are displayed on the Interagency Real-Time Smoke Monitoring Website at http://www.satguard.com/usfs. A global positioning system receiver was incorporated into the satellite system, allowing the monitor's location to be correlated to the data for GIS and archiving purposes.

Sierra Nevada Pilot Study

In March 2004, the Forest Service Pacific Southwest Region's Fire Management and Air Programs established the Sierra Nevada Smoke Monitoring Pilot (SNSMP). This 2-year study in California's southern Sierra Nevada region is testing the utility, accuracy, reliability, and monitoring requirements of the Met One Instruments BAM 1020 and E-BAM continuous particle monitors. The monitors' effectiveness as practical smoke management tools is also being evaluated.

Information collected from this study will help land managers understand spatial and temporal air quality trends that affect the southern Sierra Nevada region. This will improve the fire managers' ability to communicate potential air pollution health impacts from prescribed fire and wildfire to the public.

Ten portable E-BAM instruments can be deployed quickly to monitor short-term smoke events and community impacts at the height of the fire season. Five line-powered, tripod-mounted E-BAMs and three solar-powered, trailer-mounted E-BAMs were deployed on the Sequoia, Sierra, and Stanislaus National Forests.

Two of the E-BAMs operated year round; three operated only during the 2004 burn season. The remaining systems were used to support smoke-monitoring events (including the 2004 Yosemite Meadow Complex Fire) and as backup units.

All of the E-BAMs were equipped with basic meteorological instrumentation. Satellite telemetry systems were configured with each of the units. The raw data were displayed on the Interagency Real-Time Smoke Monitoring Website.

> This information can help forest and range managers meet fuel reduction goals while minimizing the impacts of smoke on air quality.

Immediate Web Access

Immediate Web access to the data transmitted during this pilot study provides fire managers with information to help implement strategies to reduce smoke production—or alter its transport. Air Resource Specialists, Inc., of Fort Collins, CO, also collects all ORBCOMM-transmitted SNSMP data for daily operational instrument integrity checks, data archive, quality assurance, validation, and reporting.

Validated SNSMP data summaries and reports are e-mailed regularly to local fire and air managers and are posted on the Forest Service Air Monitoring Program Project Website at http://www.air-resource.com/fsairpgm/fscor/fscor.html.

Land managers also have a growing interest in sharing information with the public in a way that displays their agency's interest in balancing public health and air quality concerns with forest health, as well as the need to address hazardous fuels for community safety.

Helping Forest Managers

Monthly and annual data summaries from the pilot study will be used to develop local information for communities with histories of smoke impacts. Particle concentration and meteorological data will be correlated with public nuisance complaints to create a complaint "threshold" air quality index—different from the existing health thresholds. Satellite imagery and ground-based digital photography will document visibility conditions during periods of poor air quality.

Smoke emissions from prescribed and wildland fires continue to be a concern in many areas. At the same time, the need to manage the increasing forest and range fuels is critical. The SNSMP and the Okanogan and Wenatchee National Forests' smoke-monitoring programs illustrate how networks of real-time smoke monitors and portable smoke monitors can be deployed quickly and provide high-quality information.

These monitors are configured with a telemetry system that allows easy, real-time access to the data. This information can help forest and range managers meet fuel reduction goals while minimizing the impacts of smoke on air quality. ■

Real-Time Smoke Monitor Specification/Cost and Operations Comparison*

By Air Resource Specialists, Inc., and Andy Trent

Parameter	E-BAM	E-Sampler	DataRAM 4	DustTrack 8520	Radiance Research Nephelometer
Sampling Method	Beta Ray Attenuation	Nephelometry – forward scattering	Nephelometry – forward scattering (600 & 880 nm)	Nephelometry – forward scattering (780 nm)	Nephelometry – back scattering (550 nm)
Range of Concentration	0–100 m g/m3	0–100 mg/m3	0–400 mg/m3	0.010–100 mg/m3	0–1mg/m3 (approx)
Power Requirements	AC, DC, Battery, Solar	AC, DC, Battery, Solar	AC, DC, Battery (6V), Solar	AC, DC, Battery (7.2 V= 6 C cells), Solar	AC, DC, Battery, Solar
Environmentally Enclosed	Yes	Yes	No	Yes – as accessory	No
Met Sensor Interface	Yes (max of 4 sensors) – WS/WD, AT/RH, Bar Pressure	Yes – WS/WD, RH (Ambient temp and pressure standard)	No	No	No
Calibration Technique	Factory, manual calibration check	Factory, automatic span/zero mode	Clean-air zero adjust	Factory, manual calibration	Factory, manual span and zero calibration
Approx System Weight	< 50 lb (22.8 kg)	13 lb (5.9 kg)	12 lb (5.44 kg)	4 lb (1.81 kg)	5 lb (2.27 kg)
Mfg Base Price	$7,500	$4,500	$10,750	$5,000 with enclosure	$5,500
Pros	Good accuracy and reliability, meteorological sensors can be added, tripod setup, environmentally protected, satellite telemetry.	Small and light weight, tripod mounted, meteorological sensors can be added, easy to use and calibrate, environmentally protected, satellite telemetry.	Easy to use, small and light, very portable, dual wavelength, satellite telemetry.	Easy to use, small and portable, environmentally protected (accessory).	Reliable, small and portable, low power consumption.
Cons	Bulky compared to other instruments, pump failures, residue buildup on nozzle can cause poor data.	Pump failures, data tends to drift to zero at low concentrations.	Prone to failures if shipped excessively, difficult to troubleshoot, not environmentally protected, no tripod mount.	Satellite telemetry has not been developed to date.	Difficult to calibrate, no environmental enclosure, no satellite telemetry to date.

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SPOTS: Maximizing Fuel and Vegetation Management Effectiveness

Sue Stewart

The hazardous fuels treatment and ecological restoration task confronting our Federal land management agencies, tribes, States, counties, and local communities is enormous. Across these lands, acres burned by wildland fire continues to increase (fig. 1). Many of these acres are uncharacteristically severe.

While not all wildland fires grow to catastrophic proportions, many do become "problem fires"—large, destructive, dangerous, and costly to manage. Often, these fires are symptoms of a larger forest health issue in which ecological realities conflict with both social expectations and economic limitations.

To protect communities, assets, resources, and investments, we must continue to treat the symptoms of problem fire through fire suppression efforts. At the same time, however, the cause of these fires must also be addressed through hazardous fuels reduction and vegetation management activities that result in landscapes that provide a mixture of:

- Species,
- Stand and fuel characteristics,
- Tree sizes, and
- Density and distribution of fuel.

Enormous Task

Furthermore, all of these landscape features must be both consistent with management objectives and sustainable given the expected disturbance processes—including fire, insects, and disease. Only through dedication and alignment of the full force and capabilities of integrated, interagency efforts can meaningful progress be made toward the restoration and maintenance of more resilient ecosystems.

Landscape-scale restoration of desired, ecologically consistent conditions is a long-term goal that should guide all land management activities. Given the enormous size of this task, annual priorities should address the most urgent work first. This includes activities to reduce the likelihood of extreme fire behavior in and around communities, as well as efforts to protect a range of valuable social and ecological assets and attributes.

This prioritization can be aided dramatically with the use of existing analysis tools, including modeling software and data sets that can support the development and assessment of alternative treatment patterns at a variety of scales.

Reducing Undesired Effects

Only 2 to 3 percent of all ignitions escape initial attack. Some of these become the problem fires that damage resources, threaten communi-

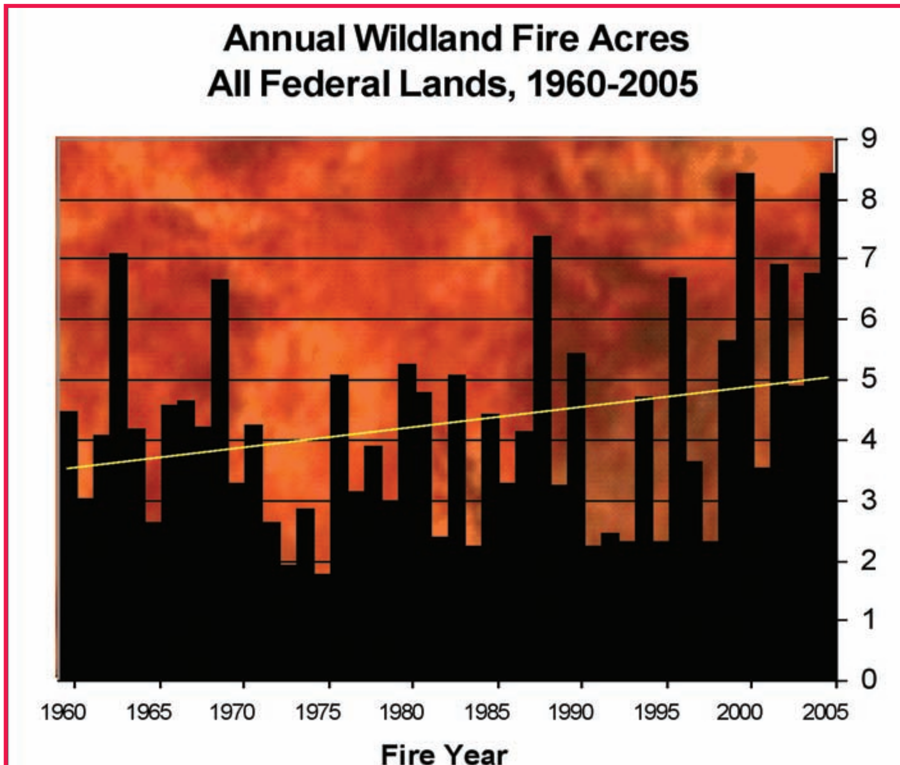

***Figure 1**. Wildland fire acres trend over 45 years. Source: National Interagency Fire Center, wildland fire statistics.*

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ties, and cost millions of dollars in suppression efforts.

Fuel reduction treatments have proven effective in changing fire behavior and effects at the individual stand level. These treatments can also address the more complex issue of changing landscape-scale fire behavior, effects, and suppression costs.

Gaming—simulating—expected fire behavior scenarios at the landscape scale with information tools like FARSITE or FlamMap suggests that the deliberate and strategic placement of management units might very well reduce the potential for problem fires to move across the landscape. Such management actions include hazardous fuel reduction as well as other vegetation management for a variety of objectives—from habitat improvement to forest health and silvicultural treatments.

These "problem fires" are the symptoms of a larger forest health issue in which ecological realities conflict with both social expectations and economic limitations.

A strategic approach to the placement of treatments—including their arrangement relative to the prevailing wind, size, shape, and treatment intensity within the unit—could reduce the undesired effects of problem fires and the acres burned with undesired severity.

Strategic Fuels Placement Theory

Figure 2 (Finney 2001) demonstrates the strategic fuels placement theory. On the far left side of the image, a fire simulation was run in a single fuel type in a theoretical landscape with constant slope and winds. The elliptical shape shows the ultimate fire perimeter following the designated simulation time, with the concentric lines showing fire perimeter at intermediate time intervals.

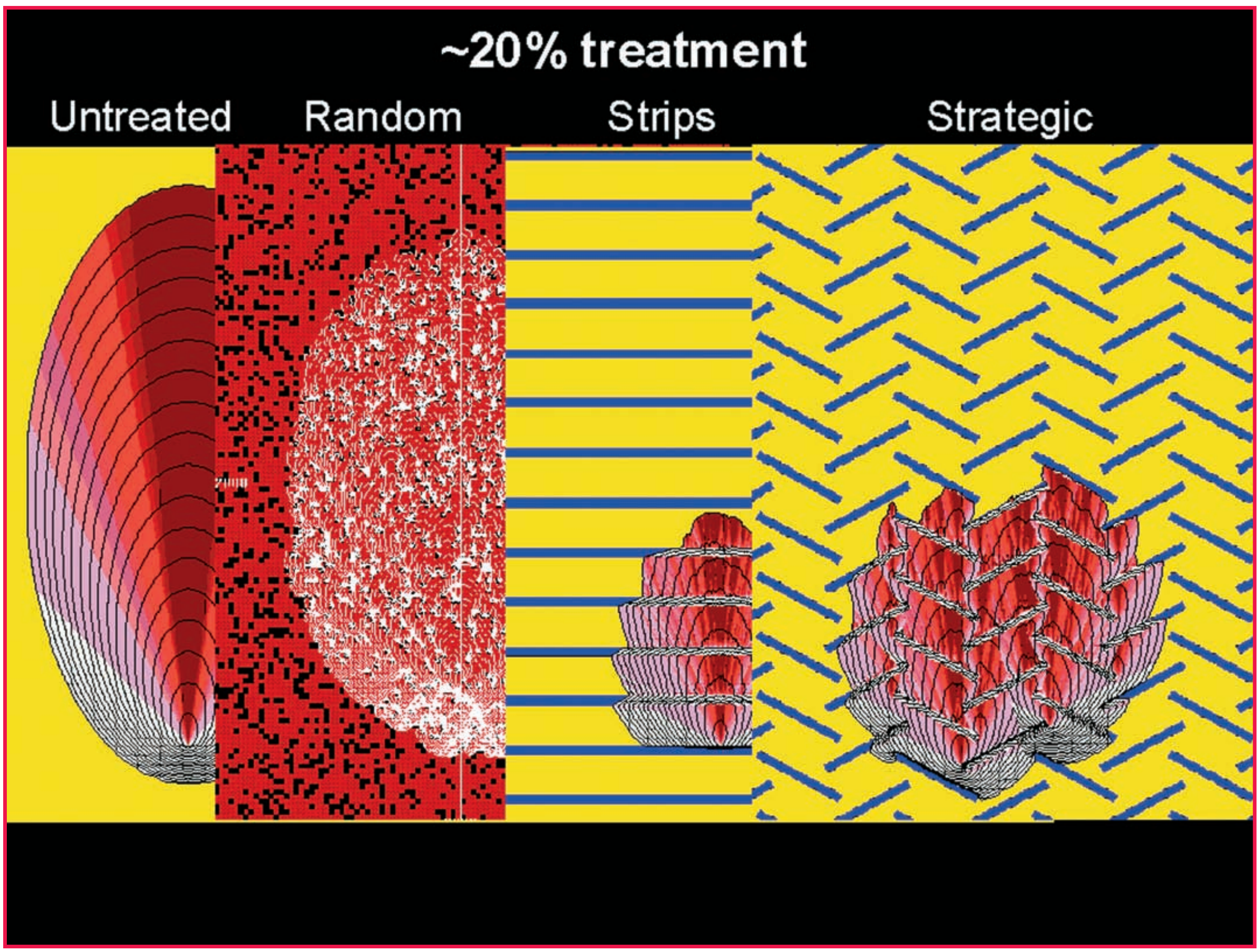

***Figure 2**. Mark Finney's FARSITE scenarios for strategic treatment patterns.*

The next window to the right has 20 percent of the theoretical landscape treated in a random pattern, resulting—with all other conditions held equal—in slower fire spread rates in the treated areas. While the overall fire size is somewhat smaller, considering the effort expended in placing those fuel treatments, the change is minimal.

The third image from the left shows the perfect solution with 20 percent of the landscape treated. The linear treated strips are perpendicular to the wind direction and fire spread. While the fire is dramatically smaller, the solution—in the real world—is impractical due to the variety of other resource and social objectives that often influence land management decisions.

In the fourth image (farthest to the right), this strategic pattern, with slightly overlapping linear treatments aligned against the wind, also yields smaller fires while treating the same landscape proportion as the "perfect linear solution" (represented in the third image from left, discussed above). This strategic approach appears most effective when the treatments can be accomplished on at least 20 percent, but less than 60 percent, of the landscape.

Different Treatment Outcomes

When less than 20 percent of the acres are changed to a slower-burning fuel type, the pattern and distribution of treated areas has minimal influence in reducing ultimate fire size, intensity, and effects. Where it is possible to treat more than 60 percent of the area—regardless of the specific placement of fuel treatments—most fires will be smaller and less intense, and the actual treatment pattern will mean little.

To be most effective in robbing the momentum needed for significant runs into tree crowns in a moving fire, the treated areas should be:

- Smaller in size than the expected problem fire event,
- Oriented perpendicular to the expected fire spread direction, and
- Slightly overlapping spatially—to force a moving fire to flank or spot around the treated area, rather than burning through at high speed (fig. 3).

In many cases, treating 20 to 60 percent of the landscape will be a significant step toward the long-term goal of restoring ecosystems at meaningful scales. Treating at this rate, however, may not fully accomplish the goal with the first entry.

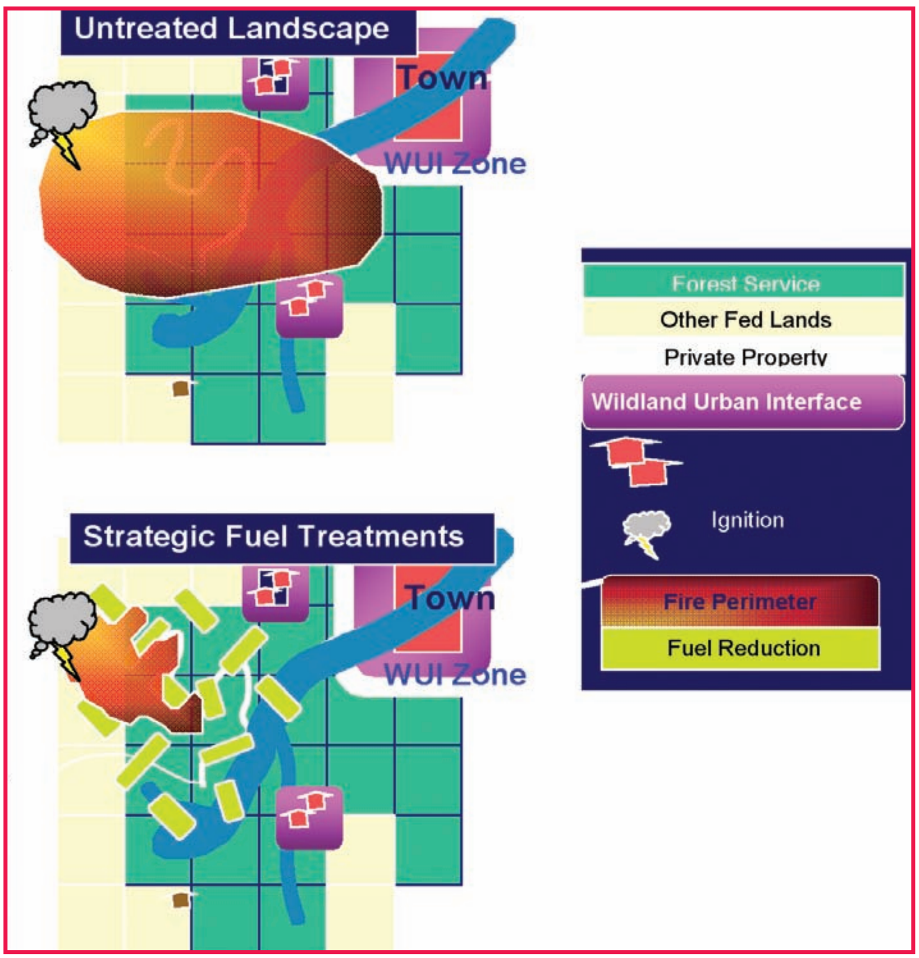

***Figure 3**. This cartoon depiction of a SPOTS approach shows fire in an untreated landscape, compared to the same event following strategic placement of treatments.*

Increasing Manager's Comfort Level

On the other hand, if the initial strategic entry is successful in reducing the probability of large, uncharacteristically severe fire, it can benefit managers by providing more time to continue working toward the long-term restoration goal. In addition, success in this initial strategic entry also increases the comfort level of both managers and communities for allowing more unplanned fires to be managed for resource objectives as wildland fire use events.

An additional benefit of this strategic approach is the ability to locate areas where biomass could

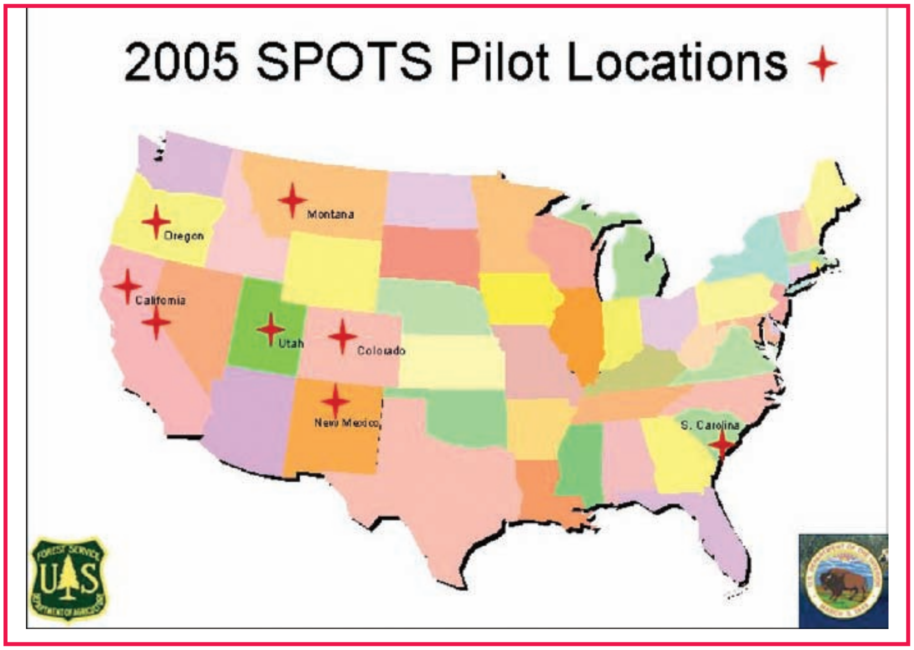

Figure 4*. Location of 2005 SPOTS teams.*

be made available to help offset treatment costs. Such an analysis could provide a vision of levelized biomass supply strategies to encourage business growth and capital investments.

A Framework for SPOTS

In 2005, eight interdisciplinary planning teams across the country tested "Strategic Placement of Treatments" (SPOTS) approaches to design landscape level treatment strategies. SPOTS are project specific, while the "Strategically Placed Landscape Area Treatments" (SPLATS) have been applied at a strategic scale rather than a practical one.

These eight teams also were key in developing a consistent framework to describe the common analysis features of all strategic landscape scale projects designed to minimize the adverse impacts of unwanted wildland fire.

These pilot areas (Fig. 4) are located throughout the country in a range of fuel and vegetation types and social settings. One of these projects is an interagency effort between the USDA Forest Service and the USDI Bureau of Land Management.

While strategic approaches to account for different fuels, topography, weather, and social factors will vary throughout the country, all spatial approaches targeting undesired fire behavior will feature collaboration throughout and will include the following seven steps.

The seven steps, or elements, of the standard approach to SPOTS:

1. Define the analysis area explicitly on a map with acre values. This should be large enough to contain the expected problem fire. It might be necessary to game—simulate with information tools—some ignitions in areas of contiguous fuels under extreme summer weather conditions to see where fire might go.

2. Identify the protection targets and assets within that landscape. These will include wildland/urban interface areas, private inholdings and infrastructure, administrative sites, Threatened and Endangered Species Act species' habitats that are not compatible with the current expected fire behavior and effects, and ecosystem components that are rare or unique locally or regionally (such as stands of large, old trees where they are uncommon).

3. Define the problem fire behavior or effects to be mitigated in the treatment. Most fires are successfully suppressed before reaching problem fire proportions. The strategic approach is not intended to fireproof a landscape against all possible fires. In fact, the desired scenario might include more frequent, broadly spread, low-intensity fires to create and maintain desired fuel conditions. The problem fires might include crown fire or fast-moving surface fire. They might also involve long-range spotting, affect house-filled canyons with only one way out, or threaten a downwind community with weeks of adverse smoke impacts. The specific concerns might be fire suppression cost, value lost in resource damage, or threats to public and firefighter safety—or any combination of these. Determination of the problem fire should be based on fire history and observed burn size and patterns, or the presence of contiguous hazardous fuels that could feed a rapid fire run into and

Only through dedication and alignment of the full force and capabilities of integrated, interagency efforts can meaningful progress be made toward the restoration and maintenance of more resilient ecosystems.

over a protection target. The assessment must also include extreme fire weather parameters observed nearby to support modeling. The description should delineate the weather factors used in modeling that contribute to the problem fire behavior and effects.

4. Design of treatment units. Treatment units should be designed to be specifically located to insulate the protection target areas from undesired fire behavior and effects, as well as to allow suppression forces to be as safe and successful as possible in controlling unplanned ignitions. The treatments should be targeted at the specific problem fire attributes while still addressing other resource objectives and concerns such as wildlife habitat, watershed values, and recreation opportunities. If the problem fire concern constitutes large and costly events, the treatments should increase the chances of slowing or stopping high-intensity, high-severity, or high-cost fires.

> This transparent display of tradeoffs is one of the great strengths of a SPOTS approach to analysis and implementation.

5. Test the proposed treatment pattern against modeled expected wildfire behavior and effects. This modeling will include the use of FARSITE or FlamMap to evaluate spatial fire behavior and effects. A variety of other spatially explicit models and simulations can be run concurrently to display the effects of the planned treatment pattern on (1) wildlife habitat, (2) vegetation management, (3) forest health and watershed values, (4) recreation opportunity, (5) economic impacts, and (6) smoke production or visual quality effects. This integrated modeling of a given treatment pattern's success allows for tradeoff displays to the team and decisionmaker. This success of the treatment pattern should also demonstrate how the proposed treatment has an expected impact on the outcome of an unplanned fire event, as well as indicate how the treatment also meets a variety of other objectives. In this way, the integrated team can test a variety of treatment patterns and intensities to determine the "best fit" for the area's objectives. Specifics on the appropriate level of risk reduction will be locally defined and take into account all of the project's other objectives as well as forest plan guidance for the area.

6. Display tradeoffs graphically or in tabular format. The choices between treatment patterns should be suitable for display, using charts, graphs, or tables to show differences between potential patterns and treatment intensities. This transparent display of tradeoffs is one of the great strengths of a SPOTS approach to analysis and implementation.

7. A final, vital characteristic of a spatial fuel management approach will be a strong monitoring and adaptive management strategy. The only way to ensure that the plan and implementation was successful is to document wildland fire events following treatments. Questions to ask include: So what? Were the fuel reduction treatments successful? Can the approach be improved?

SPOTS approaches should fit very well with products from the national LANDFIRE data set. Two of the nine pilot efforts tested SPOTS using LANDFIRE data to build FARSITE landscape files and run interactive analysis of treatment effectiveness.

Using SPOTS, we are standardizing—for the first time—the approach to defining the risk of unwanted wildland fire and prescribing treatments to address these risks at appropriate scales. The resulting patterns should also lead to smaller, less intense wildland fire and ultimately reduce suppression costs and provide managers with more time for restoration activities.

Reference

Finney, M.A. 2001. Design of regular landscape fuel treatment patterns for modifying fire growth and behavior. Forest Science. 47: 219–228.

A Review of Smoke Management and Emission Estimation Tools

Pete Lahm

With the growing use of prescribed fire and the rise in utilizing the wildland fire use option, the toolbox for fire managers to better assess smoke impacts and improve decisions pertaining to fire management and air quality is growing rapidly.

This article reviews the array of tools that are currently available to use for:

- Estimating fuel consumption,
- Calculating smoke emissions,
- Projecting smoke impacts, and
- Incorporating smoke impacts and air quality concerns into planning for fuel treatments.

Ongoing investment into fire science is resulting in fire and air quality professionals and researchers making important strides on all these elements of smoke management.

The National Ambient Air Quality Standards (NAAQSs) are based on periodic scientific study and review as established in the Clean Air Act. The current science is indicating that the NAAQSs need to be more stringent for some of the pollutants that wildland fires emit.

These impending changes to the NAAQSs reinforce the need to continue—and perhaps increase—the investment into smoke management tools that support better air quality and fire decisionmaking. The tools described below are the products of a broad effort that will help land and air quality managers address the smoke effects of wildland fire.

Pete Lahm is the smoke management specialist for the USDA Forest Service, Fire Ecology Division, Fire and Aviation Management, Washington, DC.

Emissions Estimation

There is an increasing need for wildland fire emission inventories to facilitate air quality planning throughout the United States. Better knowledge about smoke emissions from an area that will burn, or is currently burning, will support better fire management decisions.

> One of the challenges for all smoke dispersion and impact models is to characterize the accuracy of their prediction of smoke trajectories, concentration of pollutants, and duration of impacts.

Better fire activity and emissions inventories are critical for use in models that project downwind smoke impacts such as BlueSky-RAINS or VSMOKE. These inventories will also be important for showing the effects and tradeoffs of different land and vegetation management options.

Fire emissions estimates are essential to support inventories of pollutants for complying with the regional haze rule, and to ensure that fire is represented accurately in efforts to address areas that do not meet air quality standards. The more accurate these fire emissions estimates are at national, regional, and local levels, the more they can be relied on by fire and air quality managers to make appropriate decisions.

Critical Calculation Factors

The first step in creating a high-quality emissions inventory is an accurate assessment of how much area was burned or will be burned. Mapping the area and critically assessing the actual blackened area are vital.

For retrospective inventories, recordkeeping of daily fire activity should, at a minimum, include:

- The blackened acres,
- The location of the area burned (latitude and longitude of some known location of the fire such as centroid or start location), and
- When the fire occurred.

Armed with these critical data, the next steps in emissions calculation can utilize the latest fire science tools. Estimating the same information is also important for planning purposes.

Fuels Characterization

After assessment of blackened acres, the next step is to determine the fuels that burned—or could burn. Advances in characterizing the vegetative landscape are best epitomized by the LANDFIRE effort, which is incorporating the latest independent scientific methods to

characterize fuels. This undertaking is developing information that can be used by managers to describe how much fuel might be available for consumption and also allow calculation of smoke emissions.

The LANDFIRE effort is a USDA Forest Service and U.S. Department of the Interior multipartner wildland fire, ecosystem, and fuel mapping project. Its products include nationally consistent landscape-scale maps and data that will describe vegetation, fire, and fuels characteristics across the United States. It will integrate many currently available map products and develop new fire science products. These map products will allow managers to prioritize and plan hazardous fuel reduction and ecosystem restoration projects—as well as provide input for a variety of fire behavior and effects software packages such as FARSITE, CONSUME, and FOFEM.

The first products are now available for some locations via the national rapid assessment models, available at http://www.landfire.gov.

Mapping Efforts

There are several fuel characteristic systems that are useful for estimating emissions that have been developed by Forest Service Research. These will also be available in the map products of the LANDFIRE effort. Surface fuel maps describing the spatial distribution of the standard 13 fire behavior fuel models (Anderson 1982) will also be mapped. Recently, the 13 fire behavior models have been expanded, resulting in an additional map layer using a set of 43 fire behavior fuel models (Scott and Burgan 2005).

While these two maps are useful for fire behavior prediction, there are also drawbacks to using them for calculating fire emissions. They do not include the critical duff fuel layer loading—a key contributor to fire emissions. Other regional-scale wildland fire emission inventory efforts have included assumptions that address this data shortcoming (Air Sciences Inc., Western Regional Air Partnership fire emission projects, 2002-ongoing).

A more robust and complete fuel characteristic system created specifically to derive fire emissions estimates will provide the basis for another map layer that will soon be available. This layer will utilize the Fuel Characteristic Classification System (FCCS) (Ottmar and others [in press], Sandberg and Ottmar 2001). This is an interactive catalog of measured physical properties of wildland fuelbeds across the United States.

> Understanding the needs and requirements of the model users is key to understanding the levels of confidence needed in a smoke dispersion model.

Currently, the stand-alone system is available at the Fire and Environmental Research Applications Team (FERA) website at http://www.fs.fed.us/pnw/fera/products. FCCS is designed to provide realistic estimates of fuelbed characteristics. It also provides an estimate of fire behavior and effects, including an estimate of fuel mass available for combustion (under benchmark environmental conditions) during the flaming, smoldering, and residual combustion stages.

The fuelbeds and the available fuel estimates can then be mapped at any scale from the project level to the continental level. In 2005, a 1-kilometer map of FCCS fuelbeds and FCCS Fire Potentials (including available fuel) was developed for the contiguous United States. A further refined mapping of FCCS will be included in LANDFIRE.

Future Emission Inventories

FCCS calculates, by default, available fuel in each combustion stage when the fuelbed is extremely dry. The FCCS user can then apply any set of consumption algorithms and emission factors, such as those in CONSUME or FOFEM models—or the approximations contained in the Fire Emissions Production Simulator (FEPS) to represent known fuel moisture conditions. To allow expected emissions to be mapped and used in future emission inventories, FERA will incorporate emission factors and consumption algorithms within FCCS.

Another LANDFIRE layer that will soon be available is the Fuel Loading Model (FLM) layer, which can also be used for calculating smoke emissions. This FLM classification contains 10 unique fuel categories that are described by the loading of 7 fuel components—shrub, herb, four woody fuel classes, duff, and litter (Lutes and others 2007 [in prep]). These loading values can be put into various fire effects models such as CONSUME or FOFEM to compute fuel consumption and then emissions.

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The Integration of Smoke Impacts with Fuel Management

The tools discussed in the accompanying article have a variety of uses. This utilization is determined by the need to address the air quality impacts from wildland fire—both in a retrospective analysis as well as for onsite decisionmaking.

Although the tools have utility for planning, the actual integration of air quality concerns with projecting the air quality impacts of a chosen fire and fuels management strategy is still developing.

The burgeoning Strategic Placement of Treatments (SPOTS) approach (see article on page 22) for maximizing the effectiveness of fuel and vegetation management perhaps highlights how the consideration and potential quantification of wildland fire's air quality impacts can be integrated into a planning effort.

In the SPOTS approach, the large problem wildfire is determined and modeled for fire growth and behavior. Many of the fuel characteristics, fuel conditions, and weather conditions that are needed for fire behavior runs support smoke management tools and can provide an estimate of emissions.

The potential duration of these problem fire emissions is also important for later comparisons with alternative treatment options. If the integrated landscape assessment area is in a location that does not meet air quality standards, scenarios of the projected wildfire impacts on air quality can be prepared for air quality impact demonstration purposes.

Displaying Management Tradeoffs

As alternative fuel and vegetation treatment patterns are developed using the SPOTS approach and assessed for effectiveness in reducing the risk of the problem fire, emissions can be calculated concurrently. These emissions can then be displayed as part of the tradeoff of different landscape management approaches.

Displaying the total projected annual particulate emissions for each alternative is a good start for comparison purposes. If biomass utilization is part of the fuels management strategy, the removal of potentially consumed fuel and subsequently averted emissions could also be displayed. The emissions benefits of projected use of emission reduction techniques—such as piling and burning or burning under high fuel moisture conditions in larger fuels or duff—could also be shown in the tradeoff display.

The final chosen option for fuel and vegetation management of the area could potentially be included in a local emission inventory maintained by the air regulatory agency for modeling and incorporation into their airshed management strategies.

This last step can help meet current "conformity determination" requirements for areas located in nonattainment status for air quality standards—or allow for incorporation into upcoming PM2.5 (one of the particulate matter standards dictated and regulated by the Clean Air Act) ozone and visibility State implementation plans.

As the SPOTS analysis of fuels management alternatives frequently uses GIS tools, many of the LANDFIRE layers can be effective for determining potential emissions of the fire scenarios. In addition, GIS analysis can aid in understanding the interaction between treatment areas and plans, as well as the boundaries of nonattainment areas for air quality standards, class 1 areas, and other smoke sensitive locations.

Choosing Treatment Strategy

Air quality spatial information might also influence the likelihood of success for a chosen treatment strategy. If only prescribed burning is chosen as the treatment of choice in a smoke-sensitive area or an area where burning is limited due to smoke management program rules, this consideration can be accounted for in the overall assessment.

Smoke concerns can influence the likelihood of success in meeting the acreage targets or the timing of fuel treatment efforts. Using the projected fire activity and emission inventory can also allow for more serious levels of air quality impact modeling that might be useful for meeting conformity determination requirements, as well as for displaying the tradeoffs.

Understanding the air quality challenges and incorporating them into a SPOTS-based strategy analysis—or any vegetation management planning effort—could result in different outcomes. This could change the mix of treatments—such as biomass utilization versus prescribed fire—which could lead to reduction of smoke impacts from the needed fuels treatments.

Monitoring the progress and implementation of the chosen vegetation management strategy is also part of the SPOTS approach. Over time, both air quality and fuel conditions change. Monitoring the effects of the SPOTS approach and how it affects air quality could therefore provide for further adaptive management and midcourse adjustments. ■

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There are several LANDFIRE canopy fuel layers that are also useful for smoke modeling. The canopy bulk density layer maps the density of available canopy fuel for crown fire combustion (kg m^{-3}). This layer, along with the stand height (m) and canopy base height (m) layer can be used to compute the amount of fuel consumed in a crown fire. The last canopy layer, canopy cover (percent), might also be useful in modeling smoke emissions.

All eight LANDFIRE fuel data layers should provide sufficient information to model fuel consumption and emissions at multiple scales. The options for calculating smoke emissions from LANDFIRE products are a clear indication of the integration of fuel and smoke management needs. They also provide an opportunity to build more refined emission inventories based on the expanding knowledge of fuel characteristics.

Calculating Fuel Consumption

Total fuel loading (available fuel) derived with the fuel characterization tools is an important step in calculating smoke emissions from fire. However, fuels burn under different fuel moisture and meteorological conditions that can vastly affect (increase or decrease) the emissions.

Tools to calculate consumption of fuels for different fuel moistures have also been improving. Examples include FOFEM and CONSUME. The CONSUME model has recently undergone significant improvements to allow for better emissions estimations. CONSUME (Ottmar and others 1993) is a software application designed for land managers to provide fuel consumption and emissions for several key air pollutants. After a user inputs fuel characteristics, lighting patterns, fuel conditions, and meteorological attributes, CONSUME provides fuel consumption and emissions by the flaming, smoldering, and residual combustion phases for the tree, shrub, grass, litter, and duff fuelbed strata. Including duff loading and determining its consumption are critical for accurate emissions estimation.

The latest version of CONSUME—version 3.0—is designed to import fuel data directly from the FCCS. The model provides output that can be formatted as input for a variety of smoke impact models.

The emissions estimated from CONSUME can also provide usable outputs for burn plan preparation and smoke management reporting requirements. CONSUME 3.0 can be used for most forest-, shrub-, and grasslands in North America. It is anticipated to be released in February 2006. It can be downloaded at http://www.fs.fed.us/pnw/fera/products/consume.html.

> The tools discussed in this article represent a broad effort that will help land and air quality managers address the smoke effects of wildland fire.

FOFEM version 4.0 (Reinhardt and others 1997) is another model that can provide information on fuel consumption and estimate emissions. It was developed for predicting tree mortality, fuel consumption, smoke production, and soil heating caused by prescribed fire or wildfire. Revised in 2000 (Reinhardt and Keane 2000), FOFEM 5.0 added an improved consumption model for woody fuels, replacing previous empirical fuel consumption algorithms. This model also has the capability to be run in batch mode, which is useful for smoke impact model input. It is periodically updated and available at http://fire.org/.

Smoke Production: A Critical Step

If the emissions estimates described above are to be used for determining potential air quality impacts, several key steps are necessary.

Air quality health standards are typically a concentration of a pollutant measured over a set time period. As fire consumes fuels and emits smoke over time with varying levels of strength, a simulation of air quality effects can be used to capture the relationship between emissions and air quality impacts.

FEPS calculates fuel consumption, emissions, and heat release characteristics of prescribed burns and wildfires. Critical hourly plume rise estimates are also calculated. Total burn consumption values are distributed over the life of the burn to generate hourly emission and release information. Data includes the amount and fuel moisture of various fuel strata, hourly weather, and a number of other factors.

An evolution of the Emissions Production Model (EPM) (Sandberg and Peterson 1984), FEPS can be used for most forest, shrub, and grassland types in North America—and the world. The tool was developed to support application at a broad scale—needed for regional air quality planning as well as for the manager at the local project level.

The program allows users to produce reasonable results with very little information by providing default values and calculations. If more detailed information is available, customization of the data is possible to produce more refined results.

Incorporating FEPS directly into smoke dispersion models is a future task that needs to be addressed. The output from FEPS can drive a variety of smoke dispersion models that allow for assessment of potential air quality impacts. FEPS can be downloaded at http://www.fs.fed.us/pnw/fera/products.

Smoke Dispersion and Impact Models

FEPS and other tools can provide the information needed to simulate how fire emissions can be lofted into the atmosphere. The meteorological conditions under which the fire occurs—or will occur—are critical to the ground-level smoke effects and subsequent pollutant concentrations against which the NAAQSs are measured. Simulating the dispersal of emissions from a fire in the atmosphere can be accomplished with varying levels of complexity.

A simple and self-contained smoke dispersion model is the Simple Approach Smoke Estimation Model (SASEM). This was developed to meet regulatory requirements for the conservative—it predicts higher than actual concentrations—go/no-go type screening of prescribed fires in Wyoming (Sestak and Riebau 1988). Updated in 2000, SASEM 4.0 still has utility for simple smoke impact assessments in flat terrain. It is available at http://www.azdeq.gov/environ/air/smoke/download/sasem4.exe.

The Smoke Impact Spreadsheet (SIS) utilizes CALPUFF (Scire and others 2000). This is a more complex air quality dispersion model. SIS is a simple-to-use planning model for calculating particulate matter emissions and concentrations downwind of wildland fires. A series of burns were modeled using CALPUFF that provided a spreadsheet of smoke impact results. SIS conservatively predicts downwind particulate matter concentrations for comparison with air quality standards. SIS is available at http://www.airsci.com/SIS.htm.

Increasing in complexity, VSMOKE (Lavdas 1996) is a model that estimates downwind concentrations of particulate matter at 31 fixed distances. This model can also estimate visibility impacts for assessment of smoke impacts on roads at these same receptor points.

> These new standards will create a need to develop new, more accurate models.

VSMOKE can provide estimates on the dimensions of the plume above the ground at each of the 31 distances. Inputs from a model like EPM or FEPS are useful for a smoke impact analysis using VSMOKE. When there is a need for a site-specific, detailed assessment of impacts, VSMOKE or VSMOKE–GIS are valuable tools. They are available at http://216.48.37.155/vsmoke.

As air quality standards become more stringent, more sophistication and confidence in the prediction of smoke impact assessment models are needed. New, more stringent Environmental Protection Agency standards for coarse particulate matter (the particulate matter between 2.5 and 10 microns in size) are being proposed.

If promulgated, these new standards will create a need to develop new, more accurate models—as well as emission factors—in order for fire and air quality managers to estimate emissions and air quality impacts with increasing confidence.

The BlueSky smoke impact model (Ferguson and others 2003; O'Neill and others 2005) predicts ground level pollutant concentration based on user input of planned prescribed fires. Information on BlueSky is available at http://www.fs.fed.us/bluesky.

This model approach demonstrates the need for smoke impact tools that support good prescribed fire and wildland fire use decisions. Although inputs from the user can be quite basic, the underlying system is extremely complex and allows for modeling of many burns of different types while providing a valuable approach to address the difficult-to-model interaction of wildland fire smoke and the atmosphere. BlueSKY is continually evolving and is currently available for application in the lower 48 States.

Situation in the Southeast

Some smoke impact model development work focuses on the complex prediction of ground level smoke concentration. A series of fairly region-specific smoke management models is under development by the Forest Service Smoke Management Team in Athens, GA.

The Southeast is a hotbed of prescribed fire activity. It is also a region with a number of areas that do not meet air quality standards for fine

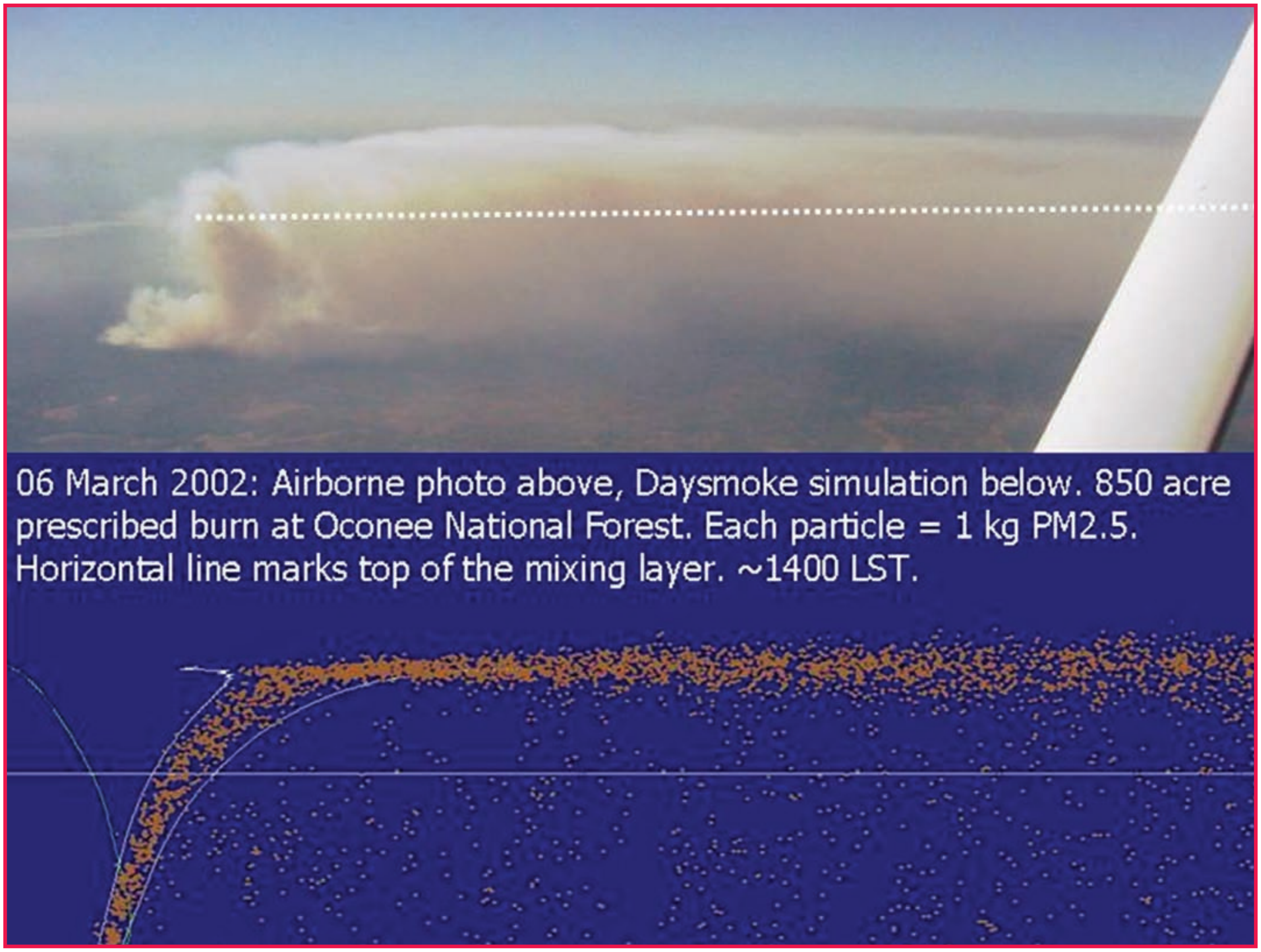

***Figure 1**. Upper panel shows airborne photo of smoke plume of an 850-acre (344 ha) prescribed burn on the Oconee National Forest in March 2002. Lower panel shows DaySmoke simulation. Each particle = 1 kg PM2.5. Horizontal line marks the mixing height. The observation and the model both show approximately 30 percent of the smoke plume in the free atmosphere above the mixed layer.*

particulate matter (particulate matter less than 2.5 microns in size).

These high-end models predict smoke or fog near ground at night (NightSmoke) and during the day (DaySmoke). Both models require fairly complex meteorological data to run. One of the NightSmoke models, Planned Burn (PB)–Piedmont (Achtemeier 2001, 2005) was placed in operation by the State of South Carolina in 2004. Further implementation is planned at individual forests and refuges in the Southeast.

DaySmoke (Achtemeier and others 2005) is a smoke injector for the regional-scale Community Multiscale Air Quality Modeling System (Byun and Ching 1999) that can be used to estimate fine particulate concentrations downwind from individual burns or multiple incidents, as well as other pollutant sources.

One of the challenges for all of the smoke dispersion and impact models is to characterize the accuracy of their prediction of smoke trajectories, the concentration of pollutants, and duration of impacts. Building confidence in their predictions by fire managers, land management planners, and air quality regulators is a significant challenge that will require substantial future effort. Some of the previously discussed models are currently undergoing limited efforts toward this end. Understanding the needs and requirements of the model users is key to understanding the levels of confidence needed in a smoke dispersion model.

Building on this need is the validation test—through field observations and measurements of smoke from prescribed burns—of DaySmoke. Figure 1 shows the observed smoke behavior compared to the DaySmoke simulated smoke dispersion. With the escalating national prescribed fire and wildland fire use activity and the

increasingly stringent air quality standards, a great need exists to further assess accuracy and develop confidence for the existing—and developing—smoke management dispersion models.

Long-Term Investment

The various tools and models outlined in this article represent a quick review of readily available opportunities to integrate smoke management and air quality concerns with fire and fuels management science.

Our vegetation management programs that use fire as the key management strategy for addressing public safety and resource management are increasing. At the same time, more stringent air quality standards for the protection of public health and welfare are being implemented.

The need for further refinements to these tools for better assessing smoke impacts and improving fire and air quality decisions will continue to increase. Their refinement and development needs to be a continuing, long-term investment.

References

Achtemeier, G. L. 2001: Simulating nocturnal smoke movement. Fire Management Today. 61(1): 28–33.

Achtemeier, G. L. 2005. Planned burn—Piedmont: A local operational numerical model for tracking smoke on the ground at night: Model development and sensitivity tests. International Journal of Wildland Fire. 14, 85–98.

Achtemeier, G. L.; Goodrick, S.A.; and. Liu, Y-Q. 2005: A coupled modeling system for connecting prescribed fire activity data through CMAQ for simulating regional scale air quality. Proceedings of EastFire Conference, Fairfax, VA. May 2005.

Anderson, H. E. 1982. Aids to determining fuel models for estimating fire behavior. General Technical Report INT–122, USDA Forest Service Intermountain Research Station, Ogden, Utah, USA.

Byun, D.W. and Ching, J.K.S., editors. 1999. Science Algorithms of the EPA Models-3 Community Multiscale Air Quality (CMAQ) Modeling System. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/R–99/030.

Ferguson, S.A.; Peterson, J.; and Acheson, A. 2001. Automated, real-time predictions of cumulative smoke impacts from prescribed forest and agricultural fires. Fourth Symposium on Fire and Forest Meteorology, 13–15 November; Reno, NV.

Lavdas, L.G. 1996. VSMOKE User's Manual. U.S. Department of Agriculture, Forest Service, Southern Research Station. GTR–SRS–6. 147 pp.

Lutes, D. C.; Keane, R.E.; and Caratti, J. F. 2007 [in prep]. Fuel loading models: A national classification of wildland fuelbeds for fire effects modeling. Canadian Journal of Forest Research.

O'Neill, S., Hoadley, J.; Ferguson, S.; Solomon, R.; Peterson, J.; and Larkin, N. 2005. Applications of the BlueSkyRAINS Smoke Prediction System, EM: The Magazine for Environmental Managers, Air and Waste Management Association, September 2005, pp. 42–45.

Ottmar, R.D.; Burns, M.F.; Hall J.N.; and Hanson, A.D. 1993. CONSUME User's Guide. Gen. Tech. Rep. PNW–GTR–304. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, OR. 117 pp.

Reinhardt, Elizabeth D.; Keane, Robert E.; Brown, James K. 1997. First Order Fire Effects Model: FOFEM 4.0, users guide. Gen. Tech. Rep. INTGTR–344. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 65 p.

Reinhardt, Elizabeth D; Keane, Robert E. 2000. A national fire effects prediction model—revision of FOFEM. Abstract. Joint Fire Science Program Principle Investigators Meeting; 2000 October 3-5, 2000; Reno, NV. <http:// www.nifc.gov/joint_fire_sci/jointfiresci.html>.

Sandberg, D.V.; Peterson, J. 1984. A source strength model for prescribed fires in coniferous logging slash. Presented at the 1984 Annual Meeting, Air Pollution Control Association, Pacific Northwest Section, 1984 November 12-14, Portland, Oregon. 10 pp.

Sandberg, D. V.; Ottmar, R.D.; and Cushon, G.H. 2001. Characterizing fuels in the 21st century. International Journal of Wildland Fire 10: 381–387.

Scire, J.; Strimaitis, D.G.; Yamartino R.J.; Xiaomong, Zhang. 2000a. A User's Guide for CALPUFF Dispersion Model (Version 5). Earth Tech, Inc., Concord, MA.

Scott, J., and Burgan, R.E. 2005. A new set of standard fire behavior fuel models for use with Rothermel's surface fire spread model. General Technical Report RMRS–GTR–153, USDA Forest Service Rocky Mountain Research Station, Fort Collins, CO.

Sestak, M.L., and Riebau, A.R. 1988. SASEM, Simple Approach Smoke Estimation Model, U.S. Bureau of Land Management, Technical Note 382.

Responding in Force to Hurricane Katrina

This country's interagency incident management teams and their crews respond to far more than wildland fire incidents.

Every year, incident management teams are dispatched throughout the United States to a wide range of these "all-hazard" nonwildland fire emergencies. Past assignments have included everything from the aftermath of the September 11 terrorist attacks (in New York City and Washington, DC, area) and the massive Space Shuttle Columbia search and recovery mission, to the quarantine and eradication of Newcastle Disease—the fatal virus that affects all bird species and threatens the commercial poultry industry.

When the category 4 Hurricane Katrina—possibly the largest hurricane with the greatest destructive strength ever recorded—devastated the Gulf Coast region in August 2005, our country's wildland fire incident management teams and their firefighter crews once again got the call to help. They responded in force.

Hurricane Katrina killed—directly and indirectly—more than 1,700 people. More than 1.2 million people were evacuated. An estimated 1 million people had their homes destroyed and were displaced—representing a humanitarian crisis on a scale unseen in the United States since the Great Depression.

Hurricane Katrina was the costliest natural disaster in the history of the United States. Federal disaster declarations blanketed 90,000 square miles (233,000 km2)—an area almost as large as the entire United Kingdom.

Mission Asssignments

At peak deployment, 5,500 wildland fire personnel—including 3 area command teams and 31 incident management teams—were committed to this incident. (During the entire 2005 hurricane season, a total of 13,000 wildland fire personnel were dispatched to 30 different locations in 7 States.)

While the Hurricane Katrina assignments—throughout the Southeast—varied, for the most part, incident management teams were assigned to three basic missions:

1. Operations or Logistics Staging Areas. Where teams were tasked with building "cities" to support workers from dozens of agencies assigned to relief and recovery efforts.

2. Points of Distribution (PODs). Where teams assisted with the shipment—often over huge geographical expanses—of ice, water, and meals ready to eat. They also worked in conjunction with local organizations at these PODs to clear trees from roads and powerline right-of-ways. (At a site in Texas, local utility companies were reportedly amazed at how quickly—and safely—incident management team crews opened up miles of right-of-ways. These wildland firefighters—no strangers to clearing trees and brush—exceeded, by several weeks, the local utility crews' ability to accomplish this gargantuan task.)

3. Evacuee Support and Shelter Operations. Where incident management teams helped implement and sustain these efforts, in some cases facilitating ongoing evacuation actions and field hospital operations.

The incident management teams that responded to Hurricanes Katrina and Rita comprised specialists from the USDA Forest Service; the U.S. Department of the Interior agencies, including the Bureau of Indian Affairs, the Bureau of Land Management, the National Park Service, and the U.S. Fish and Wildlife Service; along with State and local fire program specialists.

Hurricane Katrina Insights and Lessons Learned

For more coverage and discussion about the interagency wildland fire community's response to Hurricane Katrina relief efforts, see the articles beginning on page 35.

They include an incident commander's insights—he and his team were sent into "mass chaos"—and his lessons-learned recommendations, and one crew person's reflection on all that she experienced and learned on two hurricane tours.

More information on the wildland fire community's Hurricane Katrina mobilization and response is available through the Wildland Fire Lessons Learned Center Website at:

http://www.wildfirelessons.net/Scratchline.aspx

and

http://www.wildfirelessons.net/AAR.aspx.

Learning From the IMT Assigned to the New Orleans Airport

George Custer

Editor's Note: This article and its related sidebar are excerpted and edited from Incident Commander George Custer's After Action Review report on his Southern Area "Red" Incident Management Team's Hurricane Katrina assignment. Custer's entire original After Action Review report—along with other incident management team's hurricane response reports—are available through the Wildland Fire Lessons Learned Center Website at http://www.wildfirelessons.net/AAR.aspx.

Our Hurricane Katrina response assignment was one of the most challenging incidents that the Southern Area "Red" Incident Management Team (IMT) has ever encountered. (The team's past "all-hazard" nonwildfire assignments include 30 hurricane incidents, the Columbia Space Shuttle recovery effort, the Oklahoma City bombing, and several U.S. Department of Agriculture disease outbreaks.)

Once again, this response to Hurricane Katrina shows the versatility of all of our wildland fire IMTs.

The following is a summary of what went well—what worked and lessons learned—during the Southern Area Red Team's assignment at the Louis Armstrong New Orleans International Airport.

What Went Well

Our IMT established meeting schedules and integrated all agencies and other entities with a presence at the airport. This was crucial for information exchange and development of the incident action plan (IAP).

We issued an IAP the second day after our arrival with:

- Phone numbers,
- Contact names,
- Agency missions,
- Feeding and showering schedules, and
- Other pertinent information.

Meetings were conducted to record issues of concern and find solutions to these and other problems. These meetings were also a source of input for counting onsite personnel to know how many we needed to feed and to shower each shift.

Onsite personnel, especially the Disaster Medical Assistance Team (DMAT) units, thought that our development of the IAP and meeting schedule had a calming effect in the mass chaos that ensued during the first 5 to 6 days of the incident.

Saving Lives

Personnel assigned to the DMAT units worked tirelessly in response to the thousands of injured, infirm, and elderly who arrived at the airport. Although there were many problems with support, procedures, and logistics, the DMAT personnel should be praised as heroes for their work and professionalism. They were surely responsible for saving numerous lives and giving comfort to hundreds more.

Onsite coordination and cooperation with military units (especially the 82nd Airborne) was welcomed and helped with overall organization and command and control. The 82nd Airborne arrived onsite and grew to more than 2,200 personnel. Because they were self-supporting, they did not impact our onsite feeding and showering of civilian and other military resources.

Under the command of Colonel Victor Petrenko, the military unit coordinated the establishment of a joint interagency operations center (JIOC). After the initial response of September 1 to 6, the 82nd Airborne brought all agencies together at the JIOC to meet once per day to discuss issues and concerns—and find resolutions.

IMT Takes the Lead

Communication throughout the airport complex was disjointed at best. Some agencies had their own radios—but few could talk outside of their networks. It became obvious that one agency needed to take the lead in providing a standardized radio communication capability for all agencies. For this operation, our IMT—the Southern Area Red Team—provided that leadership role.

The communication role of our IMT was also important in establishing the JIOC. Our team's communications unit leader supplied both voice

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George Custer is the incident commander for the Southern Area "Red" Incident Management Team and is the fire management officer for the USDA Forest Service, Ocala National Forest, Umatilla, FL.

Southern Area Red Team's Katrina Chronology

Sunday, August 28, 2005 (1 day before Hurricane Katrina hits Gulf Coast)

Most of our incident management team (IMT) members receive an "alert call" to prepare for deployment—allowing them time for reconfiguring their clothing, kits, and personal supplies for a hurricane assignment.

The actual team callout comes around 1600 hours. The information on the mission assignment is sketchy and very limited. Instructions are for team members to report to Port Allen, LA, by 1800 hours the next day—when Hurricane Katrina is scheduled to make landfall. Due to the storm's intensity, most of the team members cannot reach this destination until the day after that.

Monday, August 29, to Wednesday, August 31

We stay at the U.S. Army Corps of Engineer's lock and dam facility in Port Allen, LA, through Tuesday night. On Wednesday, we move to the West Baton Rouge Parish 4-H facility where we are staged awaiting assignment.

The team organizes six scouting teams—with Federal Emergency Management Agency approval—to look for likely base camp locations closer to the New Orleans area. A report is received later in the morning that indicates the need for logistical and operational support at the Louis Armstrong New Orleans International Airport—where a field hospital has been operational for several days with little support.

Thursday, September 1

Early this morning, our team travels in two separate convoys to the airport with caterer and shower units in tow. By 1900, food is served and showers are operational. For the first time in several days, medical, airport, and other support personnel eat their first cooked meals and take showers.

Upon arrival at the airport, the scene we encounter can best be described as surreal. Disaster Medical Assistance Teams have hundreds of patients scattered about the main terminal and ticketing area.

More than 300 of these people are confined to stretchers. Most are the elderly and infirm. Others have injuries from hurricane-related accidents. Medical personnel are stretched to the breaking point. Security is minimal. And yet, the evacuation of displaced Americans has begun.

Evacuees are arriving by bus and helicopter. Many appear to come from nursing home environments. The well and able are processed with the sick and—despite efforts to separate—all comingle with each other.

Friday, September 2

The situation grows even worse as the evacuation progresses to a speed that does not seem sustainable. Planes arrive to start the airlift of evacuees to places unknown. Sick are transported on military medical C-130 and C-17 aircraft.

While this certainly helps, it does not gain any ground on the incoming numbers of people.

Saturday, September 3, and Sunday, September 4

Peak activity occurs. More than 10,000 evacuees are transported onto planes leaving the airport on more than 60 flights. (These numbers are reported at meetings. While we have no actual confirmation, observations would indicate that these estimates are close.)

Helping Hand—Firefighters working under the Southern Area "Red" Incident Management Team help load the sick and injured onto medical transport planes. Photo: USDA Forest Service, Southern Area "Red" Incident Management Team.

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and data, including radio systems—distributing more than 300 radios to more than 10 agencies. On this incident, it was important to have handheld radios used in a tactical (radio-to-radio) environment.

Throughout the incident, the ordering of a dedicated type 2 helicopter to carry internal loads and ferry personnel played a vital role in carrying out critical orders. Due to poor communications, questionable road conditions, and heavy traffic, over-the-road deliveries often took 2 to 3 times the normal driving time.

While this resource would not be needed for mobilization center and receiving and distribution missions, it should be considered anytime base camps or support camps are located in the affected zone.

Simplified the Process

The buying team and our IMT's ordering manager were left at the 4-H facility in Port Allen, LA (which we continued to lease). This was the closest location for getting immediate access to supplies. Orders were placed from the airport to the ordering manager and buying team, who were then in position to fill orders quickly from their location.

Ordering a helicopter to deliver supplies was a great success. This facilitated and significantly simplified the process for obtaining needed supplies.

The health and safety record of our IMT was outstanding. The conditions that were first encountered certainly could have led to illness and injury. Constant vigilance of hygiene, including waterless hand cleaners, wipes, and hand washing, allowed no "camp crud" to occur. We had no reports of gastrointestinal problems, colds, or any other such maladies. Our only injury reported was one stubbed toe.

ICP Tips

Damage should be expected at incident command post (ICP) sites that are chosen near hurricane disasters. Our team and crews lived and set up our ICP at the airport in concourse B, gates B7 through B15. Our IMT's safety officers had to be proactive and reasonable in their approach to mitigation. Simply saying "we can't do that" would not have worked. The areas we used were inspected for hazards and mitigated through creative means, including:

- Posting glow sticks at fire extinguisher locations,
- Unlocking doors, and
- Closing certain areas to pedestrian traffic.

We also posted 24-hour security, had a fire evacuation plan—as well as riot plan—and identified meeting locations.

Hazardous Evacuation Effort

Our IMT's operations section also took control of a hazardous and unsupervised helicopter evacuation effort. It was apparent that as dozens of helicopters jockeyed for position at the offloading ramp, the potential was high for an aircraft accident to occur on the ground.

Oftentimes, the offloading of evacuees was no more than a helicopter crewman pointing in which direction to leave the ship. Evacuees wandered about amid dozens of helicopters—all with rotors turning.

Our team's operations section chief quickly took control of the landing area and the offloading of evacuees. Helicopters were organized into two rows, waited their turn to offload, and the division group supervisor guided evacuees to exits or to baggage carts for transport to medical. ■

Mass Chaos—That's how George Custer, incident commander for the Southern Area "Red" Incident Management Team, described the scene at the Louis Armstrong New Orleans International Airport when they first arrived. Photo: USDA Forest Service, Southern Area "Red" Incident Management Team.

Hurricane Katrina Incident: Areas of Concern and Recommendations

George Custer

Editor's Note: This article is excerpted and edited from Incident Commander George Custer's After Action Review report on his Southern Area "Red" Incident Management Team's Hurricane Katrina assignment. Custer's entire original After Action Review report—along with other incident management teams' hurricane response reports—are available through the Wildland Fire Lessons Learned Center Website at http://www.wildfirelessons.net/AAR.aspx.

1. Who's in Charge?

One major point of disconnect during our incident management team's (IMT's) Hurricane Katrina assignment was the impact of running the evacuation of displaced Americans through the Louis Armstrong New Orleans International Airport without regard for the ongoing Disaster Medical Assistance Team's (DMAT's) field hospital operations.

At all levels, within all agencies, no one was able to determine who was in charge of the evacuation effort—or how many evacuees would arrive at the airport site. Medical staff, therefore, could not plan or schedule for the number of evacuees—or the seriousness of the illnesses and injuries.

Evacuees spent long hours—often overnight—with little or no food, and no accommodations other than the specific spot of ground that they occupied. The ill and injured overloaded the DMAT's ability to treat them. In addition, because of the overcrowding within the airport facility, the well and able people were exposed to the ill people.

The smell of body waste permeated the air as the vast numbers of people taxed the restroom facilities and persons often relieved themselves in place.

George Custer is the incident commander for the Southern Area "Red" Incident Management Team and is the fire management officer for the USDA Forest Service, Ocala National Forest, Umatilla, FL.

Recommendation. Although the situation was dire in New Orleans and evacuations were needed, communications is still the key to any successful operation. Proper planning—starting with a briefing at the airport—would have enabled those of us involved to assist with the evacuation, feeding, and comfort of evacuees. IMTs are ready at a moment's notice to make adjustments and recommendations and to supply the necessary personnel to assist. These abilities have been developed through responses to the ever-changing wildland fire environment in which we are used to operating.

> At all levels, within all agencies, no one was able to determine who was in charge of the evacuation effort—or how many evacuees would arrive at the airport site.

2. Rumor of a Riot

One evening, the IMT received numerous disturbing phone calls and phone messages from an individual who said he was a Washington, DC, employee and spoke as if he had the highest authority. The individual informed me (the incident commander) by message—and our logistics section chief by phone—that there was a riot in progress at the airport and that the IMT needed to escape the situation.

No riot occurred and the IMT was always well protected by our security personnel as well as by the many other security agencies within the facility.

Recommendation. Unconfirmed rumors can cause panic. Situational awareness is best left to those on the ground. IMTs need to come prepared to handle security concerns during any emergency—especially a nonfire emergency that involves evacuations.

3. Health Concerns

Possible exposure to body fluids, bacteria, and contagious disease was an ongoing concern on this incident. Despite some health-care-related exposures, our IMT members stayed healthy and accident free during this assignment.

Crews and personnel were vigilant in their personal hygiene. They

wore gloves and avoided as much exposure as possible. All who were involved with patient transport received training by professional health care workers and doctors.

Recommendation. IMT members—especially those involved with operations and logistics—should be immunized for contagious diseases such as hepatitis and tetanus.

4. Military Interaction

All future disasters of this magnitude will surely require the continued support and use of regular military units as well as U.S. Army National Guard assets. Integration and definition of roles is not always clear. Often, both civilian assets and the military are tasked with identical missions. This situation—occurring at the same shared location—can become a logistical concern.

Recommendation. Military support and interaction during declared national emergencies need to be examined. While military assets should be self-supporting, sometimes they are not. When others have better arrangements, asking the military personnel to not eat, shower, or use their facilities seems unfair. Using IMTs to support the military might be practical—but

Agencies Need To Heed National Response Plan

What if they made a National Response Plan (NRP), but nobody really heeded it?

The NRP represents the core arrangement for managing domestic incidents. It establishes a comprehensive all-hazards approach to enhance this country's ability to manage domestic incidents.

The plan details the Federal coordinating structures and processes to be used during these national incidents. When responding to these incidents, it specifies how the Federal Government's resources will work in concert with State, local, and tribal governments, as well as with the private sector.

The NRP is predicated on the National Incident Management System (NIMS). Together, the NRP and the NIMS provide a national-level template for working together to prevent or respond to threats and incidents—regardless of cause, size, or complexity.

In March 2004, Tom Ridge, then-Secretary of the Department of Homeland Security, directed all Federal and State agencies that support declared Federal disasters to adopt the NIMS for disaster response and preparedness.

Unfortunately, the wildland fire incident management teams (IMTs) assigned to these national all-hazard incidents often see scant evidence that this is occurring in nonwildland fire agencies.

Case in Point

According to George Custer, incident commander of the Southern Area "Red" IMT that was assigned to the Hurricane Katrina relief effort, the various emergency responders at the Louis Armstrong New Orleans International Airport evacuation and field hospital incident were acting as separate entities.

They were not responding to this emergency under a unified command structure.

Custer said that while his IMT managed to overcome the lack of Incident Command System (ICS) involvement of the other agencies, they nonetheless encountered some problems that could have been avoided if all agencies practiced ICS. Examples of these problems included:

- No inbriefing,
- Inconsistent shift schedules,
- Confusion over authority and roles,
- Lack of organization, and
- Duplication of processes.

Most Important Recommendation

Custer believes that the most important recommendation to come from the overall Hurricane Katrina incident is the need to organize under the NIMS and to use ICS for overall command and control on these all-hazard nonfire incidents.

"Once again," Custer reports in his team's After Action Review report, "it is clear that State and Federal agencies need to urgently work to accomplish the 2003 Homeland Security Presidential Directive 5." (It outlines the need for adopting the NRP and NIMS.) "Key agencies such as FEMA and other State and Federal agencies need to complete this presidential directive and train together with NIMS—or develop courses that facilitate this need."

More information on the National Response Plan is available at http://www.dhs.gov/dhspublic/interapp/editorial/editorial_0566.xml. ■

is this the role that IMTs should play? Thought should be given to this at the higher levels of disaster response.

5. Resource Orders Denied

During the Hurricane Katrina response surge through the Southern Area Coordination Center, our IMT was erroneously denied our resource orders.

Once the team had assembled at the assigned location and began to assess the situation, we began the process of ordering needed personnel. However, the IMT's ordering manager was denied all orders and told that we could not place orders because the team was already filled.

I then made personal contact with an individual who was able to resolve this problem.

Recommendation. Coordination center personnel should be aware that their job is to support IMTs. If they are unclear on the ordering process, they should consult with their supervisors.

6. Procurement Work Continues

The ongoing work of procurement and contracting personnel continues after the actual incident assignment.

Recommendation. It should be noted that procurement and contracting personnel will continue to work on items related to the Federal Emergency Management Agency (FEMA) well into the next fiscal year. To close out these items, personnel should work in an overtime capacity and not impact their normal duties. A means of reimbursement for time should be established and used by these personnel.

7. Need Appropriate Funding

We should have the appropriate funding to enable the two Southern Area IMTs to have the tools, supplies, and vehicles to respond to hurricanes and other all-hazard nonfire disasters.

Recommendation. While this recommendation is not meant to exclude any other IMTs from funding for Federal responses, it needs to be recognized that the two Southern Area IMTs have been tasked almost every year since 1990 to respond to hurricanes and other FEMA-declared disasters. These two IMTs—the Red and Blue Teams—have responded to more than 30 hurricane assignments, the Columbia Space Shuttle recovery effort, the Oklahoma City bombing, and several disease outbreaks. With the great amount of funds appropriated to other agencies, it only seems fair that the IMTs be able to procure such items as command trailers, generators, and communication equipment. We continue to see agency after agency arrive at these assignments with motor homes, trailers, and other equipment—yet their part of the response is generally much more narrowly focused than ours. If we are to share in the burden, we should also share in the financing.

8. Cache Nonfire Supplies

We need to have nonfire incident supplies stored at the Southern Area Cache and other caches.

Recommendation. Certain supplies that are nonfire in nature should be allowed to be stored at local or regional caches. It seems apparent that IMTs will continue to support and respond to FEMA assignments. Stocking of such things as generators, light kits, safety reflective vests, traffic cones, glow sticks, and hand sanitizers could greatly aid IMTs during the initial stages of these disasters.

9. Stress Debriefing Teams

Critical incident stress debriefing teams were available and used on this incident. The original concept, however, was to have crews and teams travel outside of their normal return route and "require" that they attend a critical incident stress debriefing.

Recommendation. While critical incident stress debriefing can help individuals with those needs, requiring individuals or crews to attend debriefings will surely not achieve the desired outcome. The idea of having these stress debriefing teams available is to be commended. But these teams need to be mobile and able to travel to the crew's location or site of need. The IMT's own human resource specialist might be the best contact and representative for communications with critical incident stress debriefing teams.

10. Air Operations Suggestions

Our IMT's operations section noticed a need for the Incident Command System (ICS) in the air operations arena at the Louis Armstrong New Orleans International Airport. Military

aircraft were flying into the airport and landing and offloading evacuees with no coordination as to how to safely move evacuees from the flight line. The evacuees were walking behind aircraft with rotors turning. There were few—and sometimes no—trained helicopter personnel on the deck to:

- Offload and direct aircraft,
- Plan missions for reconnaissance or law enforcement into the affected area, or
- Marshal aircraft for an entire 24-hour period.

Recommendation. Under ICS, the air operations branch director needs to be in place to facilitate safe air operations along with an individual for air support. A central point of contact for military helicopter operations is also needed to provide for a safe and effective operation. In these situations, there is also a need for:

- Trained and carded helicopter crewmembers to manage the deck operations of unloading–transport–marshaling of aircraft by all agencies involved;
- A daily shift change briefing with air resources to capture any changes in the frequencies, priorities, and safety concerns; and
- A detailed, daily unified air operations plan to cover the safety issues, identify key contacts from all cooperating agencies, and develop a clear operations plan based on missions planned.

The staffing of the tower (military and Federal Aviation Administration) for flight operations for incoming and outgoing aircraft is essential. We need the ability to monitor and communicate with them. The coordination on the location of law enforcement, military, and medical staff to specific areas will result in less congestion on the flight deck. IMTs should include the following safety items in their equipment lists for what to bring to these incidents:

- Highly visible vests,
- Nightglow sticks, and
- Landing batons for both night and day operations.

11. Lack of Security Resources

There were no dedicated security resources located at the helicopter landing area. While numerous agencies were seen at the landing, triage, and staging areas, no agency ever dedicated resources to this function—despite requests from our IMT. Moreover, this initial contact for the evacuees into the airport property was a point where numerous weapons and ammunition were voluntarily surrendered.

Recommendation. The agency that had law enforcement responsibility for the evacuation should have provided security for response personnel. Numerous law enforcement agencies were present but none would step forward to brave the outside heat and take on this role. In the future, when any evacuation is in progress, IMTs should be aware of this problem—even if the IMT is not in charge of the evacuation effort.

12. Lack of Unified Leadership

At the initial IMT meeting—in response to DMAT concerns—we established a meeting schedule and an issue-solving process. Our planning section chief was requested to facilitate a DMAT meeting the following day after the morning leadership huddle.

Recommendation. Encourage additional training to embrace

Line Up—Truck trailers loaded with supplies—water, ice, and meals ready to eat—for hurricane victims await delivery assignments. Photo: USDA Forest Service, Jeanne Pincha-Tulley's California Incident Management Team.

ICS and a unified command structure for disasters. The IMT tried to enact a unified organization concept. This worked to a degree, but the unified command concept proved to be unsuccessful.

13. Bogus Resource Orders

Resources arrived at our ICP that were never ordered by our IMT. This might have occurred because other entities with access to the ordering system appeared to be ordering resources without consulting the incident commander. Also, the numbers of personnel assigned to the IMT never exceed 225, but a human resources specialist arrived unannounced and unexpectedly.

Early in our assignment, several forklift operators were ordered under our IMT's "O" numbers. However, they were not ordered by the team and were not needed for a base camp operation. In addition, several team personnel had orders to mistakenly report to Denton, TX.

Recommendation. The Southern Area Coordination Center should review its ordering process and determine how these mistakes occurred. It appears that in several cases, it was as simple as not changing the reporting location with the resource order and status system order before sending the order.

14. Phone Charges

A letter dated September 20, 2005, indicated that charges for personal cell phones used during FEMA incidents would not be reimbursed. The letter further defined the need to use FEMA cell phones or to order FEMA phones through FEMA's system.

The smell of body waste permeated the air as the vast numbers of people taxed the restroom facilities and persons often relieved themselves in place.

Recommendation. The lack of cell phone coverage and hard line phones in the first couple of days did delay the ordering process and impeded the ability of the IMT to communicate important information up the line. Often, the only working cell phone was a personal phone. A system to identify whose cell phones should be reimbursed needs to be determined (such as an IC letter, no personal calls). Key IMT personnel—such as the ordering manager, facilities unit leader, finance, and others—incurred charges in excess of $400 on their personal cell phones. These individuals used their phones for incident business and should be reimbursed. The IMT does have a team cell phone kit. But early in the incident, mailing or delivery of this kit into a disaster area was not possible. We should pursue integrating FEMA into "I-Suite" (a multiple-function software automation tool for processing incident data management functions on an interagency basis) as soon as possible. This will enable FEMA to extract daily cost summary information without requiring the IMTs to print hard copies of reports. Reports are requested in numerous formats, already available in the I-Suite application Incident Cost Accounting and Reporting System. ■

All-Hazard—George Custer (right), incident commander for the Southern Area "Red" Incident Management Team with NASA astronaut Dom Gorie (left) during the all-hazard Space Shuttle Columbia Search and Recovery incident in 2003. Photo: Tom Iraci, USDA Forest Service, Pacific Northwest Region, Portland, OR, 2003.

True Story: A Firsthand Experience With Hurricane Katrina's Aftermath

Betsy Haynes

Editor's Note: In October 2004, Betsy Haynes submitted an article to Fire Management Today about Virginia's Bedford County Interagency Wildland Fire Academy that joined 200 firefighters from 9 States and successfully occurred despite ongoing torrential downpours from Hurricane Frances.

In October 2005, FMT asked Betsy if she could revise her original article with information on that fall's academy, the focus of which was to be how the Incident Command System is used on hurricanes. Unfortunately, the wildland fire academy that was to concentrate on hurricane incidents had to be cancelled—due to a hurricane incident. Most of the academy's scheduled participants were already assisting with the massive interagency Hurricane Katrina recovery operation. Betsy Haynes was also dispatched to help.

Thousands of interagency wildland firefighters participated in the initial Hurricane Katrina and Hurricane Rita recovery efforts. That's thousands of individual stories. FMT asked Betsy Haynes to share one of these stories with us—her story.

Just prior to Labor Day weekend—after 15 years of occasionally assisting as a wildland firefighter—I am called out as a type 2 firefighter to respond to the Hurricane Katrina Recovery efforts.

I had never done hurricane duty before.

At the Shenandoah Eastern Interagency Coordination Center in Luray, VA, I meet several people from various national parks and national forests scattered across the Eastern United States. All of us are heading to the destruction of Hurricane Katrina on the same interagency type 2 crew. We include employees from the USDA Forest Service, USDI Fish and Wildlife Service, USDI National Park Service, and one "casual" West Virginia structure firefighter.

Our National Park Service employees are from:
- Petersburg National Battlefield,
- Shenandoah National Park,
- New River Gorge National Park,
- Richmond Battlefield National Park, and
- Booker T. Washington National Monument.

We also have people from the George Washington and Jefferson National Forests, and the U.S. Fish and Wildlife's Blackwater National Wildlife Refuge and Great Dismal Swamp National Wildlife Refuge.

At 8 a.m., all of us climb aboard several vehicles and embark for Port Allen, LA. Due to the devastation from Katrina—and driving time restrictions (10-hour-per-day limit)—the drive takes almost 3 days.

As we negotiate this tedious route to the incident, we are hearing more and more of the terrible post-hurricane news. Several of us—due to the reports of rioting and shooting in New Orleans—are admittedly afraid. We begin to question why we had signed on to assist with this incident—to embark on this journey—in the first place.

Hurry Up and Wait

We finally arrive at the incident command post (ICP) at Port Allen. We are fed and told to prepare for the night. After taking a shower, one of my crewmates informs that this ICP is being converted to a displaced persons' camp. We're moving again. This is the experience that every wildland firefighter is accustomed to: the plan has changed; hurry up and wait.

We reload into our vehicles and drive another 45 minutes to an American Legion building somewhere in the vicinity of Baton Rouge. When we get there around 11 p.m., the darkened building is full of other—sleeping—crew members from all over the country.

I tiptoe with two other women through what seems like oceans of snoring men and squeaky cots. We try not to giggle. It's like we're suddenly inside one enormous bad pajama party!

Betsy Haynes is a USDI National Park Service Park Ranger at Booker T. Washington National Monument in Hardy, VA.

The next morning—with little or no sleep—we embark on an hour's drive to Covington, LA, to help distribute food, water, and ice to the myriad residents who no longer have any of these basic necessities.

Everyday from 7 a.m. to 6 p.m. we staff the Points of Distribution where people drive up to receive these supplies. The constant line of vehicles—filled with families, pets, and memories—is nonstop. The people peer out at us through their windows—and their tears. They tell us their amazing and emotional stories. We begin to understand why we have come here.

Learned Spanish and Selflessness

We are working with The Diablos, a Mexican crew with a working agreement with Big Bend National Park in Texas. We begin to speak some Spanish, learning the words for "food," "water," "ice," and also some numbers. These Diablo crew members—many of whom do not have much themselves in their own lives—are nonetheless here to unselfishly assist these natural disaster victims.

Our accommodations keep changing. We stay a few nights camped in an old high school yard in Plaquemine, LA. Then, after a 2-hour drive, we relocate to a vacant JC Penney store in Hammond, LA. We sleep here each night and drive to a Covington shopping center to work every day. In the post-Katrina traffic, it is a 45-minute one-way drive.

The Covington shopping center where we are distributing the necessities to hurricane victims has a Belk department store. Many of its employees become our friends. They share their stories with us. They bring us food to eat—besides our meals ready to eat.

We are serving 5,000 vehicles per day, every day. To help distract us from the monotony of our work, these local residents also provide us with everything from birthday cakes to Mardi Gras parades. They tell us that by doing these things for us, they don't focus on the reality of their own disaster-impacted situations.

After 10 days, we focus on training the new military reserve crews who are replacing us. Then we begin our long journey home. We all know we did make some difference here—but we also know that so much more still needs to be done.

Called to Help Again

In late September, just 10 short days after arriving home, I am called out again to help with the ongoing hurricane recovery effort. This time, I am a deputy information officer with Gordon Wissinger's Eastern Incident Management Team. (Wissinger is Chief Ranger in Virginia's Shenandoah National Park.)

This is my first detail as an information officer on a hurricane incident. I am dispatched to Lafayette, LA, where I am to provide information on the activities of this overhead team's efforts with this area's many national parks that have all been affected by hurricanes Katrina and Rita.

My fellow information officer Randy Sutton—a district ranger from North Carolina and Virginia's Blue Ridge Parkway—and I drive to Lafayette. It is a long, 10-hour drive in which we stop only for lunch and gas—no supper! We are suppose to spend the night in a "church flophouse"—the organization's youth building. But when we finally get there, I am directed to sleep on the floor of an adjacent recreation vehicle.

Mistaken Sleeping Arrangements

In the evening twilight, weary from our long road trip, I gather my belongings, sleeping bag, and pillow, and head for the RV. When

Going Up—Betsy Haynes prepares for a helicopter reconnaissance flight above the New Orleans area. Pilot Andy Boecker (beside her) warns Haynes and John Quirk (far left), Superintendent of the New Orleans Jazz National Historic Site, that due to the terrible smells they will encounter, they should smear vaporub beneath their nostrils. Photo: Randy Sutton, USDI National Park Service, Blue Ridge Parkway.

I open the door, three surprised young men—approximately 15 years old—peer out at me.

"I am supposed to be sleeping here tonight," I inform them.

"Oh no you're not!" they laughingly reply.

Fortunately, they are more than pleased to tell me of another camper nearby. I open the door to this temporary abode to find all beds already taken by other women. Not to worry. I make my bed on the floor.

We get up early the next morning and drive 2 more hours down to Thibodaux, LA, where the ICP is located on a portion of the Jean Lafitte National Historical Park and Preserve. Our team is taking over for J.D. Swed's National Incident Management Team.

Team's Main Goals

Our team's main goals are to assist:

- The area's various national parks in cleaning up and preparing to reopen,
- Displaced USDI National Park Service employees in receiving Federal Emergency Management Agency (FEMA) trailers, and
- Preparation efforts for USDI National Park Service Director Fran Mainella's upcoming visit to these recovery areas.

The national parks we are working with include:

- Jean Lafitte National Historical Park and Preserve,
- New Orleans Jazz National Historic Site,
- Cane River Creole National Historical Park,
- Big Thicket National Preserve, and
- Gulf Islands National Seashore.

Chalmette National Battlefield, within Jean Lafitte National Park, is the site of the 1815 Battle of New Orleans. This historic battlefield is located in St. Bernard's Parrish, one of the most badly damaged areas from Hurricane Katrina. The monument was established in 1864. Its cemetery holds soldiers from the time of the Civil War to the Vietnam War.

Our team has been called here to help begin the laborious task of recovering this national treasure—and others. The work crews arriving at Chalmette are embarking on their own battle with the aftermath of Mother Nature.

Bugs, Vaporub, and Gag Reflex

On one of our first days here, Randy Sutton and I are scheduled to take an aerial reconnaissance helicopter flight above New Orleans and the various surrounding national parks damaged by Katrina—including the New Orleans Jazz National Historic Site and the Bataria Preserve section of Jean Lafitte National Historical Park and Preserve.

It is going to be a long, 1½-hour flight. We are warned that the air above New Orleans will be incredibly odiferous. Smells so bad, they can cause the gag reflex. We are handed vaporub and vomit bags. I fear I might get nauseous—but during the flight, the smell never seems to overwhelm me.

We are staying in a nice hotel in Houma, LA. However, we've heard reports from others who are not so lucky. Many have been assigned to "scary hotels" with lots of roaches. We even heard that one woman who received bites was told by her hotel staff to prove that the bugs were from her room. So she brought in a bottle with a bunch of bugs!

Assisting Displaced Employees

From the minute we arrive, we are all working as busy as bees in these summerlike conditions. Our daytime temperatures continue to hit the mid-80s every day.

Our work includes cooperating with various partners, including Bayou Segnette State Park, FEMA, and the General Services Administration. We are helping to find housing for national park employees displaced by the hurricane. Our law enforcement crews are assisting residents and employees in protecting their property and recovering personal items. Other team members are helping in ground support, supply, first aid, and finance and payroll.

Our team is also responsible for ordering:

- Saw crews,
- Carpenters,
- Electricians, and
- Historic preservation specialists.

We spend approximately 20 days in Louisiana. By the time our team starts our demobilization process, we have successfully reached many of our goals. USDI National Park Service Director Mainella visited and saw, firsthand, the temporary housing available for her employees. In addition, some park units were finally able to reopen to the public.

I am back home now, working at my regular job as a ranger at the Booker T. Washington National Monument in Hardy, VA. I find myself feeling privileged for having this home and this job to return to. My unusual Hurricane Katrina assignments have provided me a unique opportunity to discover how fortunate I truly am. ■

Pitfalls in the Silvicultural Treatment of Canopy Fuels

Christopher R. Keyes and J. Morgan Varner

No one denies that forest stand structure is related to fire behavior, or that canopy fuel structure can be altered using silvicultural methods to successfully modify forest fire behavior—reducing the susceptibility to crown fire initiation and spread (Graham and others 2004).

Silvicultural treatments can be applied to remediate hazardous stand structures that have resulted from the exclusion of low-intensity surface fires. Abundant case studies offer evidence of crown fires subsiding when encountering recently thinned stands (Agee and Skinner 2005). Many modeling studies corroborate this phenomenon (Keyes 1996; Scott 1998; Stephens 1998; Van Wagtendonk 1996).

And yet, despite their great potential, valid concerns still exist regarding the effects of silvicultural canopy fuel treatments on forest fuel complexes and fire behavior.

Crown Fire Potential

Thinning to reduce the mass of canopy fuels and to disrupt these fuels' vertical and horizontal continuity is the most widely utilized silvicultural tool in canopy fuel management.

Decision-support tools for these canopy fuel management practices are based on a quantitative model (first proposed by Van Wagner in 1977) of the relationships between crown fire behavior, surface fire behavior, and canopy fuel structure.

This model has since been refined and adapted for use in prescribing fuel treatments (Agee 1996; Alexander 1988; Keyes and O'Hara 2002; Scott and Reinhardt 2001), and is utilized by virtually all crown fire behavior prediction and decision-support software currently used in North America, including:

- *FARSITE* (Finney 1998),
- *NEXUS* (Scott 1999),
- The *CrownMass* program of the *Fuels Management Analyst* tool suite (Fire Program Solutions 2003), and
- The *Forest Vegetation Simulator*'s Fire and Fuels Extension (Reinhardt and Crookston 2003).

The wisest fuel management strategies are those that yield enduring effects with limited requirement for follow-up treatment.

Crown fire behavior under the Van Wagner model is segregated into two constituent processes:

1. Crown fire initiation—or the ignition of crown fuels as surface fire converts to crown fire; and
2. Crown fire spread—or the perpetuation of crown fire, after crown ignition, through a continuous canopy.

Silvicultural canopy fuel treatments attempt to depreciate crown fire potential by targeting structural parameters associated with crown fire initiation or crown fire spread—or both of these elements. All other factors held constant, practices that either raise the canopy base height or reduce the anticipated surface fire intensity decrease susceptibility to crown fire initiation. Practices that reduce the canopy bulk density decrease susceptibility to crown fire spread.

Other factors, however, are almost never held constant. Canopy fuel treatments used to abate one component of crown fire potential simultaneously affect other components.

Understanding Fuel Structures

To prescribe effective and enduring silvicultural treatments to canopy fuels, a detailed understanding is required of two important areas. The first is an understanding of the many ways in which stand structure directly and indirectly relates to fire behavior and crown fire hazard. This will help in anticipating the deleterious side effects of fuel treatments on other aspects of fire behavior. The second is an understanding of forest fuel dynamics, or changes in forest fuel structures over time. This will help in forecasting the influence of those treatments on fire behavior

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Nine Ways Fuel Treatments Can Exacerbate Wildfire Hazard

A review of stand processes associated with thinning suggests the following nine situations in which well-intended thinning treatments can inadvertently exacerbate crown fire hazard or fire severity.

1. Translocation of fuel loads. Unless slash is adequately burned or removed, thinning translocates live canopy fuels to the forest floor as part of the surface fuel complex (fig. 1). Thinning converts live canopy fuel with high moisture content to dead fuel with substantially lower moisture content—and greater flammability. For example, live foliage moisture content largely unaffected by ambient conditions—even under wildfire weather conditions—will typically be around 100 percent, and rarely lower than 80 percent. Dead foliage reacts more rapidly to changes in humidity than any other fuel type, and often hovers in the range of 5 percent during wildfire conditions.

2. Inflated fuelbed depth. Residue generated from thinning results in the temporary inflation of fuelbed depth. This is one of the parameters to which surface fire behavior is most sensitive (fig. 1). Given surface fuel complexes of equal load, inflated fuelbeds result in greater fire behavior than compressed fuelbeds. Fuelbed inflation can be prevented by whole tree harvesting in merchantable stands. It can also be ameliorated by lopping, compaction, mastication, chipping and redistribution, and pile or broadcast burning.

3. Increased fuel availability. The canopy directly influences the microclimate of the forest floor. Reducing canopy cover by thinning facilitates the drying of dead surface fuels. This is due to increased light on the forest floor, increased forest floor temperatures, and greater air movement and exchange. In short, reducing the canopy can create a forest floor microclimate that more closely tracks ambient conditions. Lower forest floor fuel moisture content results in greater quantities of fuel available to burn in the event of a fire.

Figure 1—Unmanaged surface fuel loads and fuelbed depths associated with thinning specifically for fire resistance (Northern California). Top: Monterey pine plantation. Bottom: tanoak/Douglas-fir stand.

Figure 2—Smoldering duff in longleaf pine stand undergoing restoration prescribed burn (Florida).

4. Greater subcanopy wind penetration. Under continuous closed canopies, subcanopy windspeeds are dampened considerably below ambient conditions. This relationship of stand structure to subcanopy winds has been recognized operationally in the application of midflame windspeed adjustment factors based on slope position and structural factors. Thinning exposes the subcanopy environment to greater wind penetration and turbulence—resulting in higher midflame windspeeds, enhanced rates of spread, and potentially more erratic fire behavior.

5. Reduced duff moisture content. Duff moisture content is regulated in part by canopy shade. Thinning increases sunlight and winds on the forest floor. Underlying duff horizons retain less moisture, which controls both the ignition and duration of smoldering combustion in duff fuels. Duff consumption has been linked to elevated mortality of remnant trees in many thinned and restored forests (fig. 2).

6. Proliferation of stump sprouts. Live surface fuel loads can increase dramatically when hardwood tree and shrub species resprout after the main stem has been damaged or cut. Sprouts are highly competitive and can reclaim full canopy cover in the understory or midstory within several years after thinning (fig. 3). Unless herbicides or subsequent prescribed fires are applied, the thinning of sprouting species serves to relocate elevated live fuels from the midstory or overstory down to the forest floor level. Thus, this complex of fine live fuels is intermingled with dead fuels, resulting in greater surface fire intensities (fig. 4).

7. Proliferation of seedling regeneration. In undisturbed stands, litter and duff perform a mulching role, forestalling new stem initiation by seedfall or soil-banked seeds. Thinning and other mechanical fuel treatments, however, are inevitably accompanied by some amount of soil disturbance that functions as a form of site scarification. For other objectives, this is a common silvicultural practice that is deliberately used to expose mineral soil for seedling germination and establishment. Soil disturbance also facilitates the recruitment of shrub and

Figure 3*—Rapid sprouting of redwood to 5-feet (1.5 m) heights, less than 1 year after thinning in a dense, young plantation. Crowns of sprouts will interlace with overstory crowns within 10 years (northern California).*

Figure 4*—Sprouts of Ceanothus thrysiflorus emerge from within piles of untreated slash from midstory fuel treatment less than 1 year prior (northern California).*

Figure 5a*—Naturally regenerated cohort of ponderosa pine ladder fuels beneath overstories thinned to 60 ft^2 (5.6 m^2) per acre (Oregon).*

herbaceous species. The heavier the thinning, the greater the extent of soil disturbance and subsequent promotion of live understory fuels (figs. 5a, 5b).

8. Release of advance regeneration. Seedlings or saplings of shade-tolerant tree species are commonly present as advance regeneration in shaded understories. Thinning favors the survival and growth of these species over shade-intolerants, which retain foliage at lower light levels during the course of stand development. Hence, crown recession of such a cohort occurs more slowly, resulting in deeper crowns and a greater vertical continuity between surface and aerial fuel complexes.

9. Cessation of overstory crown recession. In closed stands of continuous canopies, canopy base height ascension occurs by crown recession of individual trees—the natural process of branch abscission on shaded lowermost branches. Thinning increases the light quality and quantity available to lower branches in overstory tree crowns and, thus, extends their persistence. Unless artificial pruning is conducted to lift the canopy base height, it remains constant until crown closure reoccurs and the crown recession process commences again. Because it promotes conditions that simultaneously halt crown recession and speed the growth of understory ladder fuels, heavy thinning perilously expedites the vertical integration of the canopy fuel and surface fuel complexes (fig. 6). ■

Figure 5b*—Naturally regenerated cohort of ponderosa pine ladder fuels beneath overstories thinned to 30 ft^2 (2.7 m^2) per acre basal area (Oregon).*

Figure 6*—Ponderosa pine with understory of natural regeneration and Ceanothus velutinus after partial cutting (Oregon). Overstory crown recession has stopped, but seedlings are growing in height at an increasing rate.*

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over realistic management time scales (see sidebar on next page). Thinning does much more than simply reduce the density and contiguity of aerial fuels. Directly or indirectly, every canopy fuel treatment affects—to some degree—each of the following determinants of fire behavior:

- Canopy bulk density and base height,
- Both live and dead surface fuel load and composition,
- Dead surface fuelbed depth and density,
- Dead surface fuel moisture contents,
- Duff cover and horizontal continuity,
- Duff moisture content, and
- Midflame windspeed.

Creation, Transformation, and Decay

The forest fuel complex is never constant. It is embroiled in continuous processes of creation, transformation, and decay. The following "fuel dynamics" occur even in the absence of significant allogenic disturbance:

- Crowns of shade-tolerant species elongate vertically;
- Crowns of shade-intolerant tree species ascend while shedding self-pruned lower branches;
- Canopy differentiation occurs with attendant competition-induced mortality;
- Species mixtures stratify and partition the canopy space volume;
- New seedlings initiate in understory cohorts;
- Shrubs extend their crowns vertically and horizontally; and

- Coarse woody debris and litter degrade structurally and compositionally, decompose eventually, and are replaced by a gradual cascade of litter fall, senesced and abscised branches, and snags.

Fuels management activities directly affect these processes through their effects on stand development and dynamics.

Fuel Management vs. Maintenance

Historically, low- and moderate-intensity fires in many forest types regulated spatial and structural patterns of forests and their fuels over long temporal scales. Maintenance fires governed potential fire behavior and sustained resistance to crown fires.

Rather than restoring historical fire regimes, today's fuels management interventions establish new fuel structures and transition stands into new trajectories of structural development. This management action has direct implications for future fuel structures and fire behavior.

It is therefore vital that seemingly benign prescriptions implemented today be regarded for:

- Their effect on fuel dynamics,
- The need for future stand manipulations,
- The costs of these manipulations, and
- Their likelihood of consistent implementation.

Wise Fuel Management Strategies

Because funding for today's programs cannot be expected to exist indefinitely, the wisest fuel management strategies are those that yield enduring effects with limited requirement for follow-up treatment. Under some circumstances, this might mean managing for structures that do not necessarily replicate historical fire-maintained structures, but that might nonetheless possess sustained resistance to one or more aspects of crown fire potential.

For example, maintaining continuous closed overstories by light thinning that removes ladder fuels—or perhaps simply pruning such stands to raise canopy base heights—are practices that serve to reduce crown fire initiation potential without promoting the subsequent development of ladder fuels that eventually negates these benefits.

While silvicultural manipulations to degraded, fire-adapted forest ecosystems offer great promise for restoration, our current prescriptions need to be examined carefully for their dynamic effects on fuel structures over time.

References

Agee, J.K. 1996. The influence of forest structure on fire behavior. In: Agee, J.K., ed. Proceedings of the 17th Forest Vegetation Management Conference: Working With Fire; 16–18 January 1996; Redding, CA: 52–68.

Agee, J.K.; Skinner, C.N. 2005. Basic principles of forest fuel reduction treatments. Forest Ecology and Management. 211: 83–96.

Alexander, M.E. 1988. Help with making crown fire hazard assessments. In: Fischer, W.C.; Arno, S.F., comps. Proceedings of the Symposium and Workshop: Protecting People and Homes From Wildfire in the Interior West; 6–8 October 1987; Missoula, MT. Gen. Tech. Rep. INT–GTR–251. Ogden, UT: USDA Forest Service, Intermountain Research Station: 147–156.

Finney, M.A. 1998. FARSITE: Fire Area Simulator—Model development and evaluation. Res. Pap. RMRS–RP–4. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station.

Fire Program Solutions. 2003. Users' guide to crown mass. Estacada, OR: Fire Program Solutions, LLC.

Graham, R.T.; McCaffrey, S.; Jain, T.B., tech. eds. 2004. Science basis for changing forest structure to modify wildfire behavior and severity. Gen. Tech. Rep. RMRS–GTR–120. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station.

Keyes, C.R. 1996. Stand structures and silvicultural strategies to prevent crown fires in northern Rocky Mountain forests. Masters thesis. Missoula, MT: University of Montana.

Keyes, C.R.; O'Hara, K.L. 2002. Quantifying stand targets for silvicultural prevention of crown fires. Western Journal of Applied Forestry. 17(2): 101–109.

Reinhardt, E.D.; Crookston, N.L., tech. eds. 2003. The fire and fuels extension to the forest vegetation simulator. Gen. Tech. Rep. RMRS–GTR–116. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station.

Scott, J.H. 1998. Fuel reduction in residential and scenic forests: A comparison of three treatments in a western Montana ponderosa pine stand. Res. Pap. RMRS–RP–5. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station.

Scott, J.H. 1999. NEXUS: A system for assessing crown fire hazard. Fire Management Notes. 59(2): 20–24.

Scott, J.H.; Reinhardt, E.D. 2001. Assessing crown fire potential by linking models of surface and crown fire behavior. Res. Pap. RMRS–RP–29. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station.

Stephens, S.L. 1998. Evaluation of the effects of silvicultural and fuels treatments on potential fire behavior in Sierra Nevada mixed-conifer forests. Forest Ecology and Management. 105: 21–35.

Van Wagner, C.E. 1977. Conditions for the start and spread of crown fire. Canadian Journal of Forest Research. 7: 23–34.

Van Wagtendonk, J.W. 1996. Use of a deterministic fire growth model to test fuel treatments. Sierra Nevada Ecosystem Project, final report to Congress. Vol. II: Assessments and scientific basis for management options. Water Res. Rep. 37. Davis, CA: University of California–Davis, Center for Water and Wildland Resources. ■

Changing Beliefs and Building Trust at the Wildland/Urban Interface

Jeremy S. Fried, Demetrios Gatziolis, J. Keith Gilless, Christine A. Vogt, and Greg Winter

What makes prescribed burning an acceptable fuel management approach to most people in one community, but unacceptable to most people in another community?

Is it the people—their knowledge, understanding, attitudes, and beliefs? Or is it the context—proximity of homes to fuels, an area's fire history?

Can demographic and geographic information be used to predict where different fuel management approaches will be accepted or resisted?

Our recently concluded Joint Fire Science Program-funded project Demographic and Geographic Approaches to Predicting Acceptance at the Wildland/Urban Interface sought answers to these and related questions through:

- Focus groups,
- Survey research, and
- Geographic and geostatistical analysis.

We sought to assess and understand wildland/urban interface homeowners' attitudes toward different fuel management approaches by focusing on:

- How they are influenced by beliefs about likely outcomes,
- Their trust in the implementing agency, and
- The importance they place on fuel management issues.

We hoped that acceptance of fuel management approaches could be modeled from homeowners' beliefs and attitudes as predicted at the neighborhood scale using demographic variables, such as those collected by the U.S. Census; and contextual variables, such as proximity to high hazard fuels or catastrophic fire incidents.

> The survey responses showed striking regional differences in fire-related beliefs, attitudes, experiences and acceptance of fuel management approaches.

Discussions and Focus Group Interviews

In discussions with fire and fuel managers and focus group interviews with homeowners living in wildland/urban interface areas of California, Michigan, and Florida, we discovered a collection of issues and concerns that were remarkably consistent in these disparate sections of the country.

Building on these discussions, we developed and tested a nationally applicable survey instrument for evaluating public acceptance of fuel management approaches. We focused on three specific approaches that seemed to experience widely varying levels of acceptance within and between wildland/urban interface communities:

- Prescribed burning,
- Mechanical treatment, and
- Defensible space ordinances.

We then tested this survey instrument at some particularly fire-prone wildland/urban interface sites in these same three States, mailing out 4,850 surveys and receiving 2,260 responses back. The survey responses showed striking regional differences in fire-related beliefs, attitudes, and experiences, as well as different levels of acceptance of fuel management approaches. The responses also revealed some common factors related to fuel management approach acceptance at all of the study sites.

Survey Results

On average, California wildland/urban interface residents held strong positive attitudes toward mechanical fuel reduction on public lands (5.8 on a 7-point scale), and defensible space ordinances requiring firesafe zones around their homes (also 5.8). While the aver-

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age Floridian surveyed held strong positive attitudes toward prescribed burning (5.7), less than half held positive attitudes toward defensible space ordinances. Michigan wildland/urban interface residents were slightly positive toward mechanical treatments (5.0). They were relatively neutral toward all three of the proposed fuel management approaches.

At sites in various States, differences in homeowners' experiences were sometimes striking. For example, 32 percent of the California respondents reported that they were required to remove flammable vegetation on their property. Only 2 percent of respondents in Florida and Michigan reported that they were required to do this.

This disparity was mirrored in the proportions of respondents reporting that they had actually removed vegetation from their property. A total of 91 percent of California respondents reported doing so, versus only 44 percent of Florida respondents, and 42 percent of Michigan respondents.

Such differences in experience were also reflected in the respondents' attitudes. California and Michigan respondents who had removed vegetation were more likely to have positive attitudes toward defensible space ordinances.

Attitudes and Beliefs

Homeowners' attitudes toward all three fuel management approaches were contingent on the personal importance—a measure of relevance—that homeowners attached to these approaches, and to the perceptions of these fuel management approaches' cost-effectiveness.

Beliefs also influenced attitudes. For example, a belief that prescribed burning results in uncontrolled fires translated into reduced acceptance. The acceptance of mechanical treatment and defensible space ordinances was diminished by the belief that these approaches adversely impact landscape aesthetics.

When faced with three hypothetical "up or down" votes for each of the three fuel management approaches, the vast majority of respondents—99 percent in California, 96 percent in Florida, and 86 percent in Michigan—indicated that they would approve one or more. Most respondents, however, also found one or more approaches objectionable. The percent of respondents who "voted" yes for all three of the fuel management approaches was 49 percent in California, 32 percent in Michigan, and 18 percent in Florida.

> Acceptance of each fuel treatment approach could be predicted from attitude and the degree to which people trust the agencies responsible for carrying out these approaches.

The approach with the greatest support varied by site. Respondents were asked "If you were given the opportunity to vote for or against allowing fuel management approach 'X' in County 'Y', how would you vote?" At the California and Michigan sites, mechanical treatment was most accepted, with 88-percent and 73-percent approval, respectively. When the Florida respondents were asked this same question, prescribed burning was rated most acceptable, with 87-percent approval.

Trusting the Agencies

An attitude score—on a 7-point scale with endpoints labeled "extremely negative" and "extremely positive" and a midpoint labeled "neutral"—was elicited for each fuel management approach with this three-part question: "How would you rate your general attitude toward each of the three fuel management approaches? (Please circle one number for each fuel management approach.)"

Although attitude and approval were closely related, the percentage of respondents from all three states approving a fuel management approach was consistently lower than the percentage reporting a positive attitude. While the disparity between approval and attitude varied by approach and site, as many as 40 percent of the "no" votes were cast by those with a positive attitude.

Clearly, something else was tempering the positive attitudes toward the fuel management approach being considered. Statistical analysis revealed that "trust in the agency" accounted for at least part of this moderation in positive attitudes.

Wildland/urban interface homeowners reserved their greatest trust for firefighting, as indicated by their agreeing with the statement: "The government does a good job of protecting private property from wildland fires." In response, California respondents were at 5.2 on the 7-point agreement scale, Florida respondents were at 4.9, and Michigan respondents were at 3.9. Floridians were slightly more trusting (4.5) of the use of prescribed

burning ("I trust the government to make the proper decisions about the use of prescribed burning") than Californians (4.1) or Michigan respondents (3.3).

Acceptance of each fuel treatment approach could be predicted from attitude and the degree to which people trust the agencies responsible for carrying out these approaches.

Accepting Fuel Management Approaches

Because trust tends to evolve from experience, it is interesting to note that in California—where defensible space requirements have been in place for more than 20 years, and creating and maintaining defensible space is fairly widespread—the study's respondents held more positive attitudes toward defensible space and greater trust in the agencies responsible for enforcing these ordinances. In addition, rates of engagement—actually implementing defensible space work on the ground—at the California site far exceeded the other States' study sites.

We sought to assess and understand wildland/urban interface homeowners' attitudes toward different fuel management approaches.

Most remarkable to us was how many attributes that seemed logically connected to the acceptance of fuel management approaches proved to have no significant relationship.

For example, experience with a particular fuel management approach was largely unrelated to acceptance. In fact, every other demographic and geographic variable we collected in the survey—or computed in a geographic database—was unrelated to acceptance. These variables included:

- Length of residence,
- Age,
- Educational attainment,
- Income,
- Property value,
- Proportion of the vicinity in high-hazard fuels,
- Number of large historical fires in the vicinity,

Three Significant Lessons

From listening to wildland/urban interface homeowners in this study, significant lessons emerged that can be used in planning fuels management communications and outreach programs.

Lesson #1. There are no easy shortcuts to predicting acceptance of fuel management. Beyond the broad, regional differences that the survey testing demonstrated, the only way to find out what residents will support is to ask them. This means that message development and outreach activities should be targeted widely, rather than to specific subpopulations that are presumed to have particular attitudes.

Lesson #2. Attitudes toward some fuel treatment approaches are far less positive than they need to be for these approaches to achieve widespread acceptance. For example, 58 percent of respondents in Florida and Michigan held neutral or negative attitudes toward defensible space. In Michigan, 58 percent were also neutral or negative toward prescribed burning. The conceptual model employed in this study, however, is that beliefs drive attitudes. For instance, let's say education and demonstrations induce more homeowners to believe that prescribed burning:

- Won't lead to more uncontrollable fires,
- Doesn't have terrible consequences for scenic beauty, and
- Will reduce firefighting costs.

We would then expect attitudes to become more positive and acceptance of prescribed burning to increase.

Lesson #3. Even with positive attitudes, a lack of trust in the agency doing the treatments can significantly reduce the acceptance of a fuels management approach. On average, homeowners with negative attitudes toward fuel treatment approaches disagreed with the notion that the government can effectively manage wildland, including:

- Wildfire,
- Prescribed burning,
- Mechanical fuel reduction, and
- Defensible space ordinances.

While social science researchers are not in complete agreement about what constitutes trust, evidence suggests that with different fuel management approaches homeowners will place more trust in land managers who are competent, credible, and share their values that relate to natural resource management. ■

- Distance to the perimeter of the closest large fire, and
- Distance to the nearest area of high-hazard fuels.

Because support for a fuel management approach turned out to be unrelated to any geographic variable—or combination of variables—that we considered, it was not surprising that this support similarly exhibited no spatial continuity. This flies in the face of the notion "birds of a feather flock together"—a premise relied upon by marketers when ZIP codes or census tracts are believed to be useful as a basis for business decisions. This approach, however, does not appear to be useful for predicting opinions on fuel treatments.

Spatial Discontinuities

We observed many cases in an earlier study in Michigan's jack pine forest in which one family would take all possible precautions to create and maintain a defensible space, yet the family right next door would purposely not disturb their natural setting—responding that they "live in the woods to *live* in the woods."

These residents believed that any vegetative screening on their property would remain undisturbed unless destroyed by fire or altered by future landowners.

The existence of such spatial discontinuities, and the nonsignificance of geographic variables, meant that it was not possible to generate meaningful maps of predicted acceptance that could be used for targeting promotional messages based on easily obtained demographic and geographic data. ■

For More Information

For more information on this study Demographic and Geographic Approaches to Predicting Acceptance at the Wildland/Urban Interface and its results—including links to publications completed to date—please see the Social Acceptance of Fuel Treatments Website at http://www.fire-saft.net/index.htm. Published results from this study and the one that preceded it can also be found within the following publications.

Fried, J.S.; Winter, G.J.; Gilless, J.K. 1999. Assessing the benefits of reducing fire risk in the wildland urban interface: A contingent valuation approach. International Journal of Wildland Fire. 9(1): 9–20.

Vogt, C.; Winter, G.; Fried, J. 2003. Antecedents to attitudes toward prescribed burning, mechanical thinning and defensible space fuel reduction techniques. In: Jakes, P., ed. People and Wildfire—Proceedings from the 9th International Symposium on Society and Resource Management. Gen. Tech. Rep. NC–231. St. Paul, MN: USDA Forest Service, North Central Research Station: 74–83.

Vogt, C.A.; Winter, G.; Fried, J. 2005. Predicting homeowners' approval of fuel management at the wildland/urban interface using the Theory of Reasoned Action. Society and Natural Resources. 18(4): 337–354.

Winter, G.J.; Fried, J.S. 2000. Homeowner perspectives on strategies for reducing fire damage at the wildland/urban interface. Society and Natural Resources. 13: 33–49.

Winter, G.J.; Fried, J.S. 2001. Estimating contingent values for protection from wildland fire using a two-stage decision framework. Forest Science. 47(3): 349–360.

Winter, G.J.; Vogt, C.; Fried, J.S. 2002. Fuel treatments at the wildland/urban interface: Common concerns in diverse regions. Journal of Forestry. 100: 15–21.

Winter, G.; Vogt, C.A.; McCaffrey, S. 2004. Examining social trust in fuels management strategies. Journal of Forestry. 102(9): 8–15.

Franklin Awards Salute Achievements in Cooperative Fire Protection

Melissa Frey

Every year the USDA Forest Service's Fire and Aviation Management staff presents the prestigious Franklin Award to the agency's State fire protection partners who have illustrated exceptional achievement in reaching underserved communities.

"Ensuring that all citizens benefit is a critical part of our Cooperative Fire Protection programs," explains Tom Harbour, Forest Service Director of Fire and Aviation Management. "Increased interaction with underserved communities by our State forestry fire service cooperators is vital."

Four Award Categories

The Franklin Award, initiated in 1999, is named for Benjamin Franklin, the founder of America's volunteer firefighting force. Each year, four categories are considered for this award:

- **Volunteer Fire Assistance**
  Volunteer fire assistance is designed to help smaller communities improve—or begin—fire protection. The Volunteer Fire Assistance Award is for the State that demonstrates the best outreach to help underserved communities improve the fire protection they offer to their people.

- **State Fire Assistance**
  State fire assistance provides financial assistance, technical training, and equipment to ensure that Federal, State, and local fire agencies can deliver a coordinated response to wildfire. The State Fire Assistance Award is given to the State that has demonstrated the greatest and best utilization of this assistance.

- **Management of Federal Excess Personal Property (FEPP)**
  FEPP is made available to help State and local fire services obtain equipment that might otherwise be unaffordable. The FEPP Award acknowledges the State that demonstrates the best outreach to help underserved communities equip themselves to improve fire protection.

- **Overall Excellence in Reaching Underserved Communities**
  The Director's Award represents overall excellence in reaching underserved communities. It is presented to entries with the best overall effort in at least two of the four Franklin Award categories.

Melissa Frey is the Federal Excess Personal Property Program Officer and the General Manager of Fire Management Today *for the USDA Forest Service, Fire and Aviation Management, Washington, DC.*

Leah MacSwords, Kentucky State Forester, receives a 2005 Franklin Award from Jack Troyer, USDA Forest Service Acting Deputy Chief. The award acknowledges the Kentucky Division of Forestry's outstanding outreach in placing Federal Excess Personal Property within the State's low-income rural areas. Photo: USDA Forest Service.

Franklin Awards are not necessarily given for each category every year. For instance, in 2003, the award was presented in only one of the four categories.

Two of the 2005 awards were presented at the October 2005 National Association of State Foresters annual awards luncheon in Madison, WI. Jack Troyer, the Forest Service's Acting Deputy Chief for the National Forest System, presented the FEPP Award and State Fire Assistance Award.

2005 FEPP Award

Leah MacSwords, State Forester, Kentucky Division of Forestry, accepted the FEPP Award for her agency's efforts. Under the guidance of FEPP Manager Bernie Anderson, equipment has been placed in Kentucky's low-income rural areas and in the historic Appalachian Mountain region. Both local governments and volunteer fire departments in Kentucky have indicated how valuable the FEPP program is to the communities within this State.

The Kentucky Division of Forestry has placed FEPP on loan with 645 fire departments—including 288 new departments. A special emphasis is given to fire departments and communities located in Kentucky's rural areas. This has been accomplished in numerous ways:

- The Kentucky Division of Forestry has developed a computerized "needs list" that gives priority to new fire departments, ensuring that underserved fire departments receive FEPP.
- In the placement of FEPP equipment, special consideration is given to remote communities that do not have local fire support.

We gratefully acknowledge the outstanding efforts to ensure fire protection for all Americans by our State partners.

- In 2004, the Kentucky Division of Forestry acquired more than $759 million worth of FEPP by placing 16 vehicles in rural fire departments.
- Presently, the agency has current FEPP loan agreements with 530 Kentucky fire departments—representing 65 percent of the State's total fire departments.
- The agency provides FEPP technical assistance—37 fire department visits were made in 2004.

2005 State Fire Assistance Award

The Wisconsin Firewise Community Program received the State Fire Assistance Award in recognition of its outstanding use of State fire assistance grant funds. This occurred through the efforts and dedication of Jolene Ackerman, the Wisconsin Department of Natural Resources' wildland/urban interface coordinator, and the assistance and support of Wisconsin State Forester Paul Delong, who was presented with the award.

The Wisconsin Firewise Community Program had its start in Crystal Lake last year with a community chipping day. A multiple-front approach by wildland/urban interface coordinator Ackerman increased awareness and mitigation of wildland/urban interface issues. Specific initiatives include:

- Door-to-door assessments of fire-prone property;
- Structural mapping development and printing to aid firefighter units by providing comprehensive location of all structures;
- Hand crew training;
- Video materials developed to train landowners;

Wisconsin State Forester Paul Delong (left) receives a 2005 Franklin Award from Jack Troyer, USDA Forest Service Acting Deputy Chief. The award acknowledges the State's outstanding use of State fire assistance grant funds. Photo: USDA Forest Service.

• Newspaper advertisements, Smokey Bear billboards, and Firewise workshops where the fire danger is particularly acute;
• Color brochures highlighting the accomplishments of hazard mitigation projects;
• "Point of Origin," the biannual publication for State fire program partners; and
• "Living With Fire," the publication—shared as an insert inside newspapers throughout the State—that addresses wildland/urban interface issues.

2005 Volunteer Fire Assistance Award

The Volunteer Fire Assistance Award was presented to Randy Pogue and Jerry Heaslet of the Arkansas Forestry from Rich Kvale, National Cooperative Fire Protection Program Manager, at the 2005 National FEPP workshop in Chicago, IL.

Pogue and Heaslet received the award for their outstanding use of Volunteer Fire Assistance funding—with the support of John Shannon, State Forester, Arkansas Forestry Commission. They have shown exemplary efforts in getting equipment and supplies out to underserved communities throughout the State of Arkansas. These efforts include:

• The Arkansas Forestry Commission has more than tripled the number of certified fire departments since the inception of the Rural Fire Protection Program in 1979. To date, there are 964 certified fire departments in Arkansas.
• The Arkansas Forestry Commission makes equipment available to rural fire departments through State contract purchases and the FEPP program. It offers an interest-free revolving loan for purchases of vehicles and equipment worth up to $15,000.
• An Annual Fire Show is sponsored by the Arkansas Forestry Commission every fall to showcase improved firefighting equipment and the various fire protection programs.

The Minnesota Division of Forestry continues to improve fire protection for its rural residents.

• In 2004, 2,035 firefighters from 626 fire departments were trained in wildland fire suppression. That training is currently being updated to improve its quality.
• 196 departments were awarded $1,000 matching grants—totaling more than $204,000.
• The 2000 population census revealed that nine Arkansas counties were identified as having inadequate fire protection. Special efforts and trips were made to the communities in these counties to increase awareness of the available Federal and State fire protection programs.

2005 Director's Award

The 2005 Director's Award went to the Minnesota Division of Forestry. Under the direction of State Forester Bob Tomlinson, the Minnesota Division of Forestry has extended its already excellent program to better serve Minnesota communities.

Through its outreach and constant communication between rural fire program staff and State firefighters, the Minnesota Division of Forestry continues to improve fire protection for its rural residents. Specific programs and actions include:

• In cooperation with a group of fire chiefs, the "Minnesota Wildland Urban Interface Guidelines" were created. This action provided a great deal of information and also established a basis for cooperation between fire departments and their local Federal and State wildland management agencies.
• A fax/e-mail network has been created to share wildland fire information between the Minnesota Division of Forestry and the local fire departments. Available information includes fire weather reports, red flag warnings, staffing levels, aircraft availability, and experienced fire behavior.
• Information booths are set up at Minnesota State Fire and Rescue schools throughout the State. Photo displays show available FEPP and guidelines on the FEPP program, as well as contact information.
• The FEPP and Volunteer Fire Assistance Programs, as well as related programs operated by the State, are advertised on the rural fire department assistance Websites. Pictures are posted for all FEPP property available. ■

Southwestern Ponderosa Pine: Ceanothus, Wasps, and Fire

Hutch Brown

There's a shrub that grows under southwestern ponderosa pines called buckbrush or red root or Fendler's ceanothus (*Ceanothus fendleri*). Once, it bloomed in profuse white clusters in the dappled shade of big old pumpkin-barked pines or in the patches of meadow between them. Its smooth, thorny branches, no more than 3 feet high, spread out thicketlike among the lush green grasses, adding diversity to the understory.

A Fendler's ceanothus in bloom. Note the low, spreading habit and the ponderosa pine seedling on the left. Photo: Dave Powell, USDA Forest Service, Umatilla National Forest, Pendleton, OR; courtesy of Forestry Images http://www.forestryimages.org, no. 1215037).

Then the sheep came in the 1800s, and the grasses soon went and the fires starved. Hand crews came with shovels and starved the fires that remained. Wet cycles came in pulses after 1910 and again after 1970, flushing the forest floor with pine seedlings that were never choked by grasses or thinned by fire. They grew into saplings and poles and thickets, besieging the big trees and everything else on the parched forest floor—including the ceanothus.

> While examining a ceanothus fruit, he saw a tiny wasp emerge, one never identified in Arizona.

In many places, ceanothus withered away into not much of a shrub at all. No longer stimulated by fire, it often failed to regenerate from seeds or resprout from roots. All that sometimes remains today are little twigs sticking out of the thick pine duff, with little spoon-shaped leaves on them. You might easily step on them and never notice.

But one researcher from the Ecological Restoration Institute in Flagstaff, AZ, did notice (Huffman 2002). Working on the nearby Fort Valley Experimental Forest, he explored what was happening on the altered forest floor. He wondered whether overstory manipulation alone would be enough to restore plants like ceanothus.

In the process, he found something that nobody ever had before. While examining a round, reddish fruit from Fendler's ceanothus, he saw a tiny wasp emerge, one never identified in Arizona before. The larval wasp had lived inside the fruit, destroying the seed, something no one had ever suspected.

The tiny wasp is called a seed chalcid (*Eurytoma squamosa* Bugbee). Seed chalcids spend most of their life cycles inside the fruits they parasitize; adults soon die, but not before breeding and laying eggs inside more fruits. In the study area, larval wasps were killing more than a third of the seeds that ceanothus was producing.

With that rate of mortality, can ceanothus ever fully recover? Did presettlement fires kill wasp larvae inside fallen fruits while stimulating the seeds to grow? It's another piece of the puzzle that is fire and fuels, grasses and ceanothus, wasps and their hosts in the ponderosa pine ecosystem. It's an intricate chain of life and death, and the ecosystem will only be whole again when the chain is restored.

Hutch Brown, the former managing editor of Fire Management Today, *is a writer/editor for the Chief's Office, USDA Forest Service, Washington, DC.*

Acknowledgment

The article is based on a story told by H.B. "Doc" Smith of the Ecological Restoration Institute in Flagstaff, AZ, on May 25, 2005, during a USDA Forest Service practitioner's workshop on ecological restoration in southwestern ponderosa pine, Cibola National Forest, Mount Taylor Ranger District, NM.

Reference

Huffman, D.W. 2002. A seed chalcid (Eurytoma squamosa Bugbee) parasitizes buckbrush (Ceanothus fendleri Gray) seeds in a ponderosa pine forest of Arizona. Western North American Naturalist. 62 (October): 474–478.

All Our Past Issues Now Available on the Web

Thanks to a concerted effort by several people, all past issues of *Fire Management Today* (FMT) as well as the journal's predecessors—*Fire Control Notes, Fire Management Notes*, and *Fire Management*—are now available on the FMT's Website.

"You can now view or download all past issues, from Volume 1, Issue 1 of Fire Control Notes on up to the most recent issue of *Fire Management Today*," explains Delvin Bunton, systems analyst, USDA Forest Service, Ecosystem Management Coordination Staff, Natural Resource Information System, Sandy, OR.

The idea to scan past issues of FMT evolved from discussions between Bunton and April Baily, former general manager, *Fire Management Today*, USDA Forest Service, Fire and Aviation Management, when the two were working on the journal's 30-year index (Bunton 2000b). Hutch Brown, then-managing editor of *Fire Management Today*, also helped.

During this indexing process, despite extensive searches in several university libraries and Forest Service offices, Bunton couldn't unearth some of the journal's early issues. As he perused these archived editions, Bunton realized that many problems that confront the wildland fire community today are not at all new (Bunton 2000a). He realized that finding a way for current fire managers and students to read these past issues of FMT seemed a worthwhile challenge.

Bunton therefore wrote a project proposal. Baily kept asking for the funding. More than 1 year after their first request, funds finally became available for the project.

Briefing the Night Shift

Bunton and Baily managed to gather all but about 40 issues from the USDA Forest Service Washington Office collection. Bunton provided a dozen copies from his personal library. Ann Bruce at the Tall Timbers Research Station in Tallahassee, FL, graciously loaned approximately 25 issues. Sara Garetz at the Pacific Southwest Research Station library in Vallejo, CA, loaned the last 5 missing issues in bound volumes.

Bunton then delivered all the issues to Lance Gilmore of NetOne-ScanOne in Portland, OR, for the actual scanning process. Gilmore's team made this difficult scanning job possible.

Bunton received three CDs with individual page images, PDF files for most volumes, and a database that related the images to issues. He then checked each issue for completeness and fixed minor problems such as incorrect page order. Bunton, the persistent project ramrod, then scanned the few dozen missing pages out of more than 7,000 pages scanned—and sleuthed down four or five still-missing issues for scanning.

After Baily retired in July 2004, Melissa Frey, *Fire Management Today's* new general manager, continued to push the project forward. Under her direction, she took the PDF files and built the Website.

"We thank all those people who helped make the scanning possible," Bunton said. "And we hope that current and future fire managers, students, and others will find our effort worthwhile. As a former boss used to say: '*Remember to brief the night shift*.' We hope that making all of this journal's past issues available for research helps to meet that charge."

References

Bunton, D. R. 2000a. Creating an index that mirrors our past. Fire Management Today. 60(1): 27–31.

Bunton, D. R. 2000b. Subject index–volumes 31–59. Fire Management Today. 60(1): 32–94.

How To Download an Issue of FMT

1. Open your browser and go to http://www.fs.fed.us/fire/fmt/index.html.

2. Click on the link "By Volume beginning 1936." Scroll down to the issue of interest. You now have two options to save the file:

- Double click on the desired issue and open the PDF with Adobe Reader. Click on the File menu, select Save As, choose the directory to save the file on your PC.
- Or, right click on the issue. Choose Save Target as. A window opens to choose where to save the issue. The top window will show the folder name (labeled Save in:). If you choose, the bottom window (labeled Fire name) allows you to change the file name.

3. After you make any changes you desire, click on the Save button and the PDF file will copy to your computer.

4. Navigate to the folder in which you saved the PDF. Double click on the file from which you want to print an article. Adobe Reader will open. You can now print the entire issue, or just the pages you desire.

Guidelines for Contributors

Editorial Policy
Fire Management Today (FMT) is an international quarterly magazine for the wildland fire community. FMT welcomes unsolicited manuscripts from readers on any subject related to fire management. Because space is a consideration, long manuscripts might be abridged by the editor, subject to approval by the author; FMT does print short pieces of interest to readers.

Submission Guidelines
Your manuscript may be hand-written, typed, or word-processed, and you may submit it either by e-mail or by mail to one of the following addresses:

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Style. Authors are responsible for using wildland fire terminology that conforms to the latest standards set by the National Wildfire Coordinating Group under the National Interagency Incident Management System. FMT uses the spelling, capitalization, hyphenation, and other styles recommended in the United States Government Printing Office Style Manual, as required by the U.S. Department of Agriculture. Authors should use the U.S. system of weight and measure, with equivalent values in the metric system.

Try to keep titles concise and descriptive; subheadings and bulleted material are useful and help readability. As a general rule of clear writing, use the active voice (e.g., write, "Fire managers know…" and not, "It is known…"). Provide spellouts for all abbreviations. Consult recent issues (at http://www.fs.fed.us/fire/fmt/index.html) for placement of the author's name, title, agency affiliation, and location, as well as for style of paragraph headings and references.

Tables. Tables should be logical and understandable without reading the text. Include tables at the end of the manuscript.

Photos and Illustrations. Clearly label all photos and illustrations (figure 1, 2, 3, etc.; photograph A, B, C, etc.). At the end of the manuscript, include clear, thorough figure and photo captions labeled in the same way as the corresponding material (figure 1, 2, 3; photograph A, B, C; etc.). Captions should make photos and illustrations understandable without reading the text. For photos, indicate the name and affiliation of the photographer and the year the photo was taken.

Websites on Fire*

Bushfire Cooperative Research Centers Program

Australia's Bushfire (wildfire) Cooperative Research Centers (CRC) program is developing a range of research products that collectively aim to enhance the management of wildfire risk to communities in economically and ecologically sustainable ways.

The Bushfire CRC, established under Australia's Commonwealth Government, aims to:

- Develop an internationally renowned center of excellence to lead and coordinate bushfire research in Australia,
- Provide a research framework that will improve the effectiveness of bushfire management agencies, and
- Increase the self-sufficiency of communities in managing the risks from bushfires.

Perusing this organization's informative, user-friendly Website provides knowledgeable insights into state of wildland fire research occurring today "Down Under."

The organization's research program focuses on five interrelated wildland fire research activity areas:

- Safe Prevention, Preparation, and Suppression;
- Management of Fire in the Landscape;
- Community Self-Sufficiency for Fire Safety;
- Protection of People and Property; and
- Education, Training, and Communication.

Found at **www.bushfirecrc.com**.

* Occasionally, Fire Management Today briefly describes Websites brought to our attention by the wildland fire community. Readers should not construe the description of these sites as in any way exhaustive or as an official endorsement by the USDA Forest Service. To have a Website described, contact the managing editor, Paul Keller, at 503-622-4861, pkeller@fs.fed.us (e-mail).

New Photo Contest Procedures

New timelines and guidelines are being developed for the next *Fire Management Today* photo contest. These will be announced in a future issue of FMT.

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