The Zaca Fire: Bridging Fire Science and Management

By Josh McDaniel
FALL 2007

The Figueroa RAWS (Remote Automated Weather Station) sits at 3200 ft on a grassy knob in the mountains above Santa Barbara. The small unit is bristling with antennas, sensors, solar panels, and various weather measuring devices, making it appear like a stationary and earthly version of a Mars rover. Quietly collecting and transmitting critical weather data, such as wind speed and direction, relative humidity, fuel moisture, and air temperature, the Figueroa unit and other nearby RAWS stations became invaluable on the recent Zaca Fire, feeding data to new, powerful fire spread projection models as the fire spread across the Los Padres National Forest, and the San Rafael and Dick Smith Wilderness Areas. The Zaca Fire eventually burned nearly a quarter of a million acres, becoming the second largest fire in modern California history. For such a large fire, it was remarkable that no serious injuries were sustained, and there was only minimal damage to structures. Successful management of the Zaca should be directly attributed to the tremendous hardwork and determination of the fire crews, but it is also owed in large part to the willingness of fire managers to recognize the constraints of the terrain and the fuels and to use patience, planning, and the best science available in laying out an opportunistic and effective strategy.

On the Zaca, fire behavior modelers worked closely with the Incident Management Teams (IMTs) to provide information critical for accurate long-term planning on a large, complex fire. In turn, fire managers provided feedback on how results and model outputs could be adjusted to better fit with their concerns and needs. The result was a real-time integration of science and practice.

Sparks on the 4th of July

The Santa Ynez Valley above Santa Barbara is home to world-class wineries, multi-million dollar celebrity homes, and sprawling ranches. All were threatened on the 4th of July when a fire was ignited by ranch hands repairing a water pipe in a steep and rugged canyon. Sparks from a metal grinder ignited a fire in the parched vegetation, and the fire quickly began running up the ridge above the canyon.

Santa Barbara County fire crews arrived on the incident within minutes and were able to build containment lines on the bottom edge of the fire, but the fire was already moving into difficult terrain on the steep hillsides of Zaca Ridge. By the next day, the fire had moved onto the Los Padres National Forest and the Forest Service went into “unified command” with California state fire officials (CAL FIRE) and Santa Barbara County Fire. The Incident Commanders (ICs) quickly began a planning process for containing and suppressing the fire.

Firefighters faced extremely dry fuel conditions on the fire line during the Zaca Fire.Photo: John Newman

Within days, the fire moved into the San Rafael Wilderness, a rugged area with steep canyons and ridges, dense and highly flammable fuels, and little access. However, that did not take the pressure off fire crews. In southern California, development is never far away, and the San Rafael is ringed by a number of small communities and ranches, many only separated by a single ridge from the potential advance of the fire. In addition, given the fuels and the lack of natural barriers, the fire also had the potential to eventually threaten Santa Barbara and the urban coastal area (and ultimately did). From the beginning the firefighters and managers knew they were dealing with both a wildland urban interface fire and a wilderness fire in an extremely dense and dry fuel environment. Complexity was the name of the game.

“The Forest is 68% roadless and Mother Nature is in control. We understand wind and topo-driven fires, but fuel-driven is a different beast,” says James Smith, a division chief on the Los Padres National Forest. “This is one of those fires you aren’t just going to go in and put out. There is no reason to put firefighters in harm’s way.

Given the complexity, the Boise National Incident Management Organization (NIMO) team was brought in to manage the fire. NIMO teams are new, and they were created to fight fires using some different approaches than are traditionally employed. Focusing on Appropriated Management Response (AMR), cost-effectiveness, and risk-based decision making, the teams are expected to develop a new model for fighting and managing large, long-duration fires.

Initially, the NIMO team provided decision support, but within a few weeks they assumed command of the fire. First, the team, along with personnel from the Los Padres National Forest began the Wildland Fire Situation Analysis (WFSA) process, outlining suppression objectives to the incoming IMTs. As they began gathering information on predicted weather, available resources, values at risk, and the actual fire perimeter, they were contacted by Bernie Bahro, the U.S. Forest Service Pacific Southwest Region (R5) liaison for a new Rapid Response Decision Support Team, regarding use of the new Wildland Fire Decision Support System (WFDSS) FSPro and RAVAR models in support of the WFSA (See box below for explanation of WFDSS-FSPro and WFDSS-RAVAR).

WFDSS Features

Stratified Cost Index (SCI) - Using historical data, SCI calculated expected suppression costs of large fires (>= 300 acres) with similar fire characteristics such as fuel types, fire intensity, topography, region, and values at risk. Actual expenditures on FY 2006 and future large fires will be compared to their "expected" cost as calculated by the SCI.

FSPro - FSPro calculates the probability of fire spread from a known perimeter or point; a combination of RERAP and FARSITE. It provides long-term and strategic decision support. The model works by simulating thousands of fires with different weather scenarios using a minimum travel time (MTT) fire spread method.

RAVAR - RAVAR integrates directly with the FSPro model to identify values threatened by a fire. The structure layer of RAVAR is generated through local county surveys and records. It can also include assessments of non-monetary values such as critical habitat, cultural heritage sites, etc.

The Boise NIMO Incident Commander, Aaron Gelobter, decided to take a hard look at the new decision support tools and attempt to use them for long-term strategic planning. First, working with personnel from the Los Padres National Forest, he used the FSPro runs to establish WFSA lines and RAVAR to estimate values threatened – more than $66 million.

However, fires often have a habit of disregarding well laid plans. The Zaca exceeded the WFSA two days after the first WFSA box was established, and it surpassed a second WFSA soon after. Gelobter went back to Bahro and asked him to adjust the model, calibrating it to match the actual rate of spread, and using more accurate estimates of fuel moisture. The new outputs were used to draw a much larger WFSA boundary that used the fire spread probabilities from the model to better understand the potential size of the fire, guiding their AMR approach to management of the fire.

"The WFDSS tools were useful initially, but not in the way they were intended. The FSPro, RAVAR and Stratified Cost Index (SCI) analysis were supportive of projected suppression expenditures. Accordingly, a $70 - $80 million fire would be cost effective [This quote came from an interview early on during the fire. The fire eventually reached $120 million], and the FSPro runs sustained drawing a large WFSA box, creating more flexibility to do more objective-driven AMR. So, the tools were useful in that sense, but they just weren't reflecting what was happening on the ground. So, we asked Dr. Mark Finney to calibrate the models in order to more realistically represent current burning conditions and provide more value to the manner in which line officers using these tools would make their decisions," says Gelobter.

As it became clear that Gelobter and the NIMO team were serious about using the tools to do long-term planning on the fire, Mark Finney, the developer of FSPro, reported to the fire to interact more closely with the team, and see if the model could be adjusted to better fit their needs.

Working with Probability

At first glance the maps, produced by FSPro look like other rate of spread maps produced by programs such as FARSITE (also developed by Finney) – colored, concentric circles radiating across a topographic map. However, a closer inspection reveals an important difference that is essential for interpretation. The contour lines do not represent rate of spread projections or fire perimeters – they correspond to ***probabilities*** of fire spread. Where programs such as FARSITE use existing weather forecasts to model fire spread, FSPro runs hundreds of different weather scenarios, reconstructed from historical data collected over the last 10-20 years by RAWS (such as the Figueroa RAWS described in the introduction) and then uses those runs to develop a map showing the probability that the fire will reach a certain spot over a certain time period - usually 7 to 14 days.

Finney describes the difference this way:

“A FARSITE map is essentially a fire spread projection using one weather scenario. And, an FSPro map is the result of hundreds of FARSITE runs based on historical weather scenarios. You can take any spot on the map and see how many times the fire reaches that spot within the given time period under all of the different scenarios. Once the model finishes running all of the different scenarios, it produces an output map with probability contours linking all of those spots, showing the likelihood that a fire will reach a certain area within a given time period. So, if the model runs 1000 different weather scenarios and the fire reaches a point in 800 of those runs, the point will be located on the 80% contour line.”

Aaron Gelobter, found those outputs useful to a point, but found the probability contours insufficient for constructing a long-term plan. He needed to have a relatively good idea of when the fire would reach certain locations on the landscape – trigger or decision points for management actions. As designed, the models only presented the probability that the fire would reach that point within a 14 day period. It did not provide any information on whether it was more likely to arrive at that point on day 1 or day 14.

Dr. Mark Finney, the developer of FSPro, worked with the Incident Management Team to produce model outputs tailored to their needs and concerns.

Finney took Gelobter’s insight, and fine tuned the model outputs. Most of the information the IC requested was generated in the process of producing an FSPro map, but it was ‘thrown away’ in the overall task of producing the probabilities. Each run of a weather scenario produced projections of intensity and fire perimeter, but those were combined for the final output. Finney wrote programming code “functions” to capture those intermediate outputs and then created a map showing projected arrival times for the fire at certain trigger points. He was able to come back to the IC with new FSPro Time and Space modeling 24 hours after the request.

After consulting over the new maps, the NIMO team decided to use the information to formulate the long-term plan for the fire – setting up contingency actions and decision points ahead of the fire advance.

“The WFDSS tools gave us confidence that we were not behind the power curve,” says Gelobter. “It showed us that there was a 25 percent probability the fire would reach our primary line at Buckhorn Road in four days. That told me that the line at Buckhorn was not a primary, and needed to be changed to an alternate line. Many of our operations folks were saying the same thing, so when the modeling tools started matching local knowledge, it gave us more confidence in our decisions.”

Using updated long-term projections from the FSPro runs, the NIMO team was able to develop a strategic plan, establishing primary and contingency control lines out ahead of the fire, and creating an adaptable plan for resource needs beyond immediate tactical operations. The planning allowed the team to preposition resources ahead of the fire as well.

A Long Duration Fire

For most of July, the fire had moved to the south, but in early August a flank of the fire crossed the Sisquoc River, a wild and scenic river that is the major drainage in the San Rafael Wilderness. This was a major turning point in the management of the fire as it entered new terrain and a new dense fuels environment. The fire then moved to the north and northeast as well, threatening to run all the way up to the Sierra Madre ridge. This meant two main fronts developed on the fire – one moving to the south into what became known as the Live Oak Zone and the other to the north and northeast into what was termed the Richardson Zone.

The FSPro projections showed this potential development in July, and the management team knew it would be difficult to keep the fire on the southern side of the Sisquoc. The long-term plan designated the crossing of the Sisquoc as a trigger point for a major shift in strategy once this occurred. Since the fire was growing in size and moving away from the initial base camp, it was logistically becoming difficult to manage the north side of the fire. The plan called for a transfer of command to an Area Command Team and two Type 1 National IMT teams – one in the Live Oak Zone and one in the Richardson Zone.

When the fire crossed the Sisquoc, the IMT teams were already in place, and both had been thoroughly prepped on the long-term strategy and the control points laid out ahead of the fire.

Tim Sexton, who worked as a deputy IC on the Richardson Zone, felt that the FSPro runs were valuable in managing the fire. “For the purposes we used it, FSPro performed well. It gave an accurate assessment of what the fire might do. When that was updated with reality and operations analysis, it was useful.”

Rocky Opliger was the IC for the second IMT team to transition through the southern Live Oak Zone – an area of the fire that threatened the Santa Barbara front country. He felt that FSPro helped the team’s strategy in a number of ways.

“When we took over, the plan was to continue firing down to Pendola, but I thought that there were some problems with that approach. First, that would involve burning up a large portion of the watershed for Santa Barbara, and second I thought it had a decreased probability for success. FSPro was showing us that if we didn’t hold it, it was going into the front country and could last until we got into the wind event season. We decided to go direct and secure the corner a lot sooner.”

Opliger also says that FSPro also showed a weakness in the northwest corner of the fire that had to be dealt with before the fire crept up the Sisquoc and entered new terrain and fuels. The teams repositioned some hotshot crews for mop up and reinforced secondary lines, eliminating the threat. He says that the real strength of FSPro is pointing out the critical points in the fire, allowing managers to position resources more efficiently and effectively.

Lessons Learned

Like any new application, WFDSS has been a rapidly evolving tool, and its use on the Zaca Fire will likely be marked as a major point in its development. Problems with interpretation have hindered its use over the past two fire seasons, however, the collaborative work between fire scientists and managers on the Zaca and other fires during the 2007 fire season has gone a long way in solving those problems.

Managers have had a hard time interpreting the probability contours; and even if they have gotten past the interpretation barrier, they have struggled with how to use the information. However, the experience on the Zaca spurred the move to tailor some outputs to better suit managers’ information needs and to facilitate interpretation.

The 2007 fire season provided many opportunities to explore and refine the models. As of the end of August 2007, WFDSS has been used to support 140 fire incidents, with a total of 910 FSPro analyses, 92 RAVAR analyses. The long duration of many fires this season required updated analyses for each fire as the perimeter expanded, fire suppression restricted the active fire perimeter, and seasonal weather patterns shifted.

According to Mark Finney the adjustments made on the Zaca Fire have already been incorporated into the outputs the WFDSS team in producing for other national fires.

“We are working on it. Now, advanced users are able to download the raw data and do the calculations themselves. We want to make it much more user friendly.”

“We have learned a lot about how to *not* make a system friendly for users. We want to set up a map-based system rather than a strict web-interface. We are talking to Google Earth about creating a system where users can click on weather stations on a map to get data and they can draw in a fire perimeter or proposed barriers and actions.”

He says that these developments in the WFDSS system, along with the online availability of LANDFIRE data will mark “a major revolution in how fire behavior analysis is conducted.”

The experience of the Zaca Fire demonstrates a window of opportunity to improve the link between science and management. A major concern often expressed in both fire research and fire management circles is that there is a lot of science being produced, but very little that can or is being incorporated (depending on your perspective) into fire management. There may be a current opening to change that state of affairs.

This fire season has shown that fire management is changing at a more rapid pace than ever before. Point protection, AMR, and other non-traditional suppression techniques and strategies have become the norm. Much of this change is driven by necessity, as fire managers have struggled to fight larger and more intense fires over longer fire seasons with fewer resources. But, it is change nonetheless. And in this dynamic environment there is potential to build new more substantial links between science and the field.

Advances in Fire Practice is a sub-site of wildfirelessons.net and is focused on bringing efforts and ideas to the forefront that leaders in the fire management, practice, and research communities have identified as innovative and widely applicable. It provides access to critical and proven fire information and resources. Advances in Fire Practice section can be reached directly by going to http://www.wildfirelessons.net/AFP.aspx or through the main Wildland Fire Lessons Learned Center website at www.wildfirelessons.net.

The Wildland Fire Lessons Learned Center actively promotes a learning culture for the purpose of enhancing safe and effective work practices in the entire U.S. wildland Fire community. It is located at the National Advanced Fire & Resource Institute in Tucson, Arizona.

Wildland Fire Lessons Learned Center
Established 2002