Mynard, C.R., G.N. Keating, and P.M. Rich. 2007. GIS community mutualism pays off in a New Mexico fire emergency. Chapter 2. Fostering Collaboration and Communication, pp. 39-49 In: Christopher Thomas (ed). *Standards for Success: GIS for Federal Progress and Accountability*. ESRI Press, Redlands, CA.

GIS Community Mutualism Pays Off in a New Mexico Fire Emergency

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Many of us watched and listened with trepidation to news reports of the May 2000 Cerro Grande wildfire as it swept through Los Alamos, New Mexico, burning approximately 43,000 acres. Captivating as the reports were, the media did not fully portray the conditions under which many individuals valiantly worked behind the scenes to provide support to emergency responders.

GIS technology was an integral part of emergency response during the fire, and it continues to support postfire restoration and environmental monitoring. Under often-dangerous circumstances and for long hours, GIS staff from Los Alamos National Laboratory (LANL) and volunteers from other organizations worked to produce maps and provide support for emergency managers. After the fire, LANL GIS groups supported the multi-agency Burned Area Emergency Rehabilitation (BAER) team with GIS data and maps for planning mitigation efforts. The BAER Team included experts from the U.S. Postal Service, U.S. Forest Service (USFS), Bureau of Indian Affairs, U.S. Department of Energy (DOE), LANL, County of Los Alamos, Pueblo of Santa Clara, and Pueblo of San Ildefonso. These GIS efforts during and after the fire offered important lessons about institutional matters, working relationships, and emergency preparedness.

The Setting

Los Alamos is a small city of 11,000 people in north-central New Mexico, located about 25 miles southwest of Santa Fe at the foot of the Jemez Mountains. Home of the DOE's world-famous Los Alamos National Laboratory, the town nestles amid a dense forest of pine, spruce, fir, and aspen that drapes the steep mountain slopes. The irregular surrounding terrain impedes highway access, and the heavily forested canyons facilitate the rapid spread of fire. Both are important factors in combating forest fires that sometimes threaten the area.

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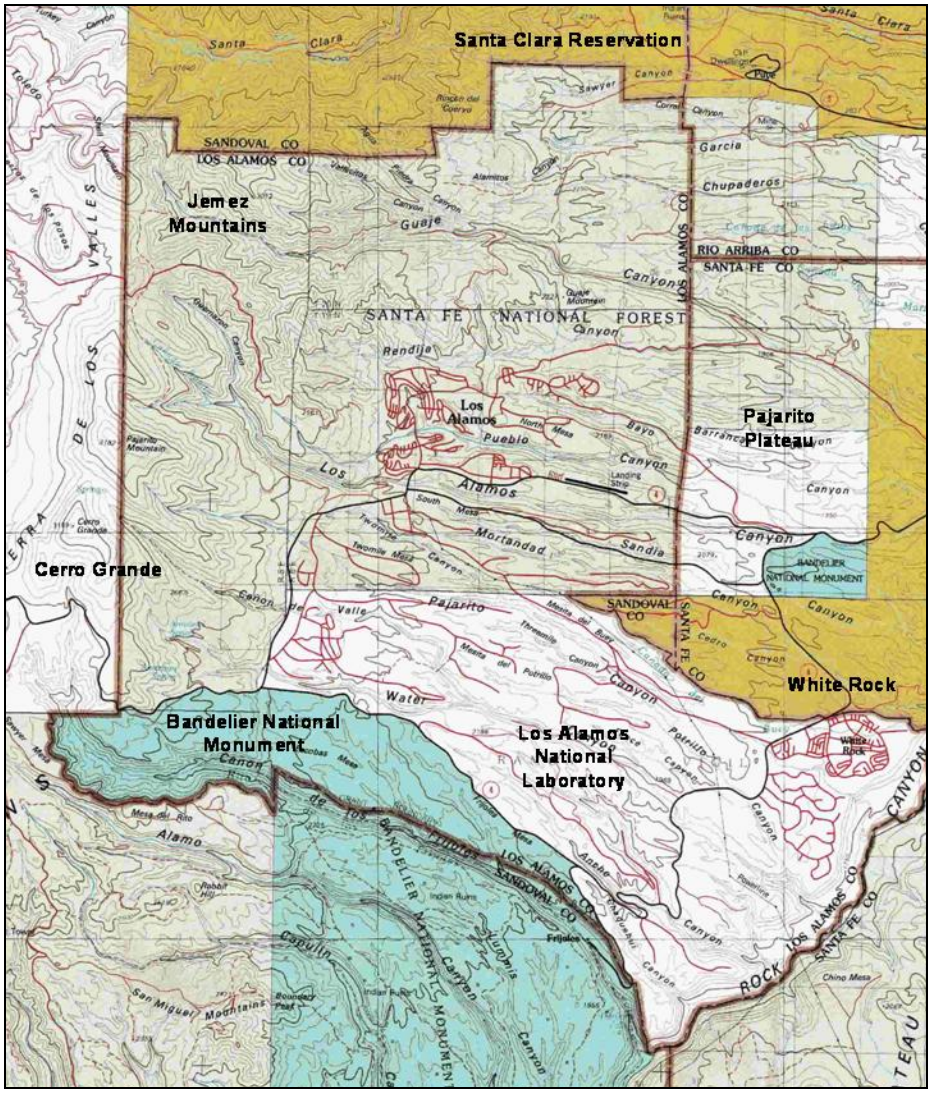

Figure 2.3. *Topographic map of Los Alamos. Cerro Grande, where the fire began, is on the left. (courtesy of U.S. Geological Survey)*

LANL stretches between Los Alamos and White Rock, a suburb to the southeast, and consists of nearly 45 square miles of forested canyons and mesas. Isolated clusters of experimental facilities, testing areas, and research laboratories are scattered across this landscape. The laboratory, operated by the University of California (Los Alamos National Security, LLC, as of 2006) for the DOE, is best known for its weapons research but is also considered one of the nation's outstanding science and technology laboratories in many other fields including physics, climate change, computer science, biology, ecology, and geology.

LANL's research has long involved high explosives and radioactive and hazardous materials. Certain locations at the laboratory, called potential release sites (PRSs), are suspected of having contamination from past activities, and they are regularly studied to determine if environmental remediation is necessary. PRSs could be a concern if fire or soil erosion threatens to disperse contaminants found to be present.

Facing an Emergency

On May 4, 2000, National Park Service (NPS) personnel ignited a prescribed fire on Cerro Grande, a mountain four miles southwest of Los Alamos. Prefire conditions seemed appropriate for a controlled burn, but by the next day, the fire had escaped its containment and began advancing eastward, pushed by strong winds. The blaze, then considered a wildfire, began spreading toward LANL, entering LANL property and the town of Los Alamos by May 10 and causing significant damage..

Figure 2.4. *Ground fire. (courtesy of U.S. Geological Survey)*

By May 18, the fire was only 80 percent contained. Los Alamos and White Rock had been completely evacuated, and the laboratory remained closed until May 22, a shutdown unprecedented in its 57-year history. While the fire took no human lives, 429 families lost their homes, and many structures were burned, including 112 small structures at LANL.

The public and local government were concerned about chemical or radiological contaminants that might be present in smoke or later be washed from denuded soils. LANL emergency managers also needed as much information as possible about the fire, including where the fire was actively burning and where it had burned, what facilities were at risk, what structures had been burned, what infrastructure and utility damage had been sustained, where new fire roads were located, and which PRSs were burned or might be in the fire's path. Analytical data about possible contaminants in the affected PRSs were also needed.

Communicating a Need

Despite the evacuation the need for GIS support was evident, and the challenge was how to provide it from an off-site location and how to access the necessary data, which was diverse, formatted in various ways, and located on numerous servers at LANL and elsewhere.

As the fire raged, USFS had a GIS capability for preparing daily operations maps for fire crews and for briefing the news media, but specialized maps of LANL facilities were also needed. Sandia National Laboratories, a DOE research and development laboratory in Albuquerque, began supporting the emergency activities with fire maps that were used to make essential decisions about LANL assets that might be at risk. The Environmental GIS office at Sandia served primarily as a data gathering/distribution node and provided fire perimeter data needed by DOE teams who were monitoring for radiation and chemical releases in and around LANL.

On May 13, Denise Bleakly of the GIS office at Sandia began gathering data by first requesting assistance from members of the New Mexico Geographic Information Council. At no cost, she quickly received regional GIS datasets from the Bureau of Land Management (BLM), USFS, and the University of New Mexico Earth Data Analysis Center. These data enabled Sandia to prepare initial fire maps.

Meanwhile, LANL's GIS staff had begun to assemble a team in Santa Fe to assess the impact of the fire on the PRSs. One of the main GIS facilities at the laboratory, the Facility for Information Management, Analysis, and Display (FIMAD), was the primary data repository and GIS resource for the lab's large Environmental Restoration (ER)

project that produced more than a thousand new maps each year. During the fire, FIMAD was closed due to the lab's shutdown, but its computer servers continued to function unattended. The servers were connected to the lab's Intranet, which also remained online. That this link to the FIMAD servers remained was critical to off-site GIS efforts.

Two LANL staff members, who lived outside the evacuation zone and were working at home on assignments, combined the data they had on hand, which was sufficient for creating base maps of the laboratory. For a GIS facility, the ER project made use of an existing subcontract with the Loft4 Digital Media Studio in Santa Fe. To support FIMAD efforts during the emergency, a safe place was needed to store sensitive project data, and Sandia offered this service.

Within 48 hours, the linkage between mission concept, basic equipment, GIS expertise, data for maps, networking experience, and office space was achieved, and the group was able to establish an improvised GIS facility at Loft4 using the additional staff and equipment there.

GIS for Emergency Response

Managing the emergency response to the Cerro Grande fire was made difficult and complex by the fire's rapid progression, its changing location, and the fact that the fire divided into two fronts. Constantly updated maps were critical for LANL managers and firefighters to decide which response to make and how to deploy the hundreds of personnel on the fire lines.

BLM conducted nightly overflights to collect location data of the rapidly moving fire. BLM staff would digitize the infrared imagery, create polygon or line files, and relay this data each morning to the GIS facility at Sandia, where they were converted to spatially referenced overlays of fire perimeters and hot spots overlaid onto base maps. Sandia electronically transferred these files to the FIMAD server at Los Alamos or directly to Loft4. LANL staff at Loft4 used them to create hundreds of maps that showed the expanding burned areas in relation to contaminated areas (PRSs). The GIS efforts continued 24 hours a day for 10 days. LANL and Loft4 personnel, divided into shifts, quickly developed team roles and responsibilities, which proved effective during the demanding hours of around-the-clock operations.

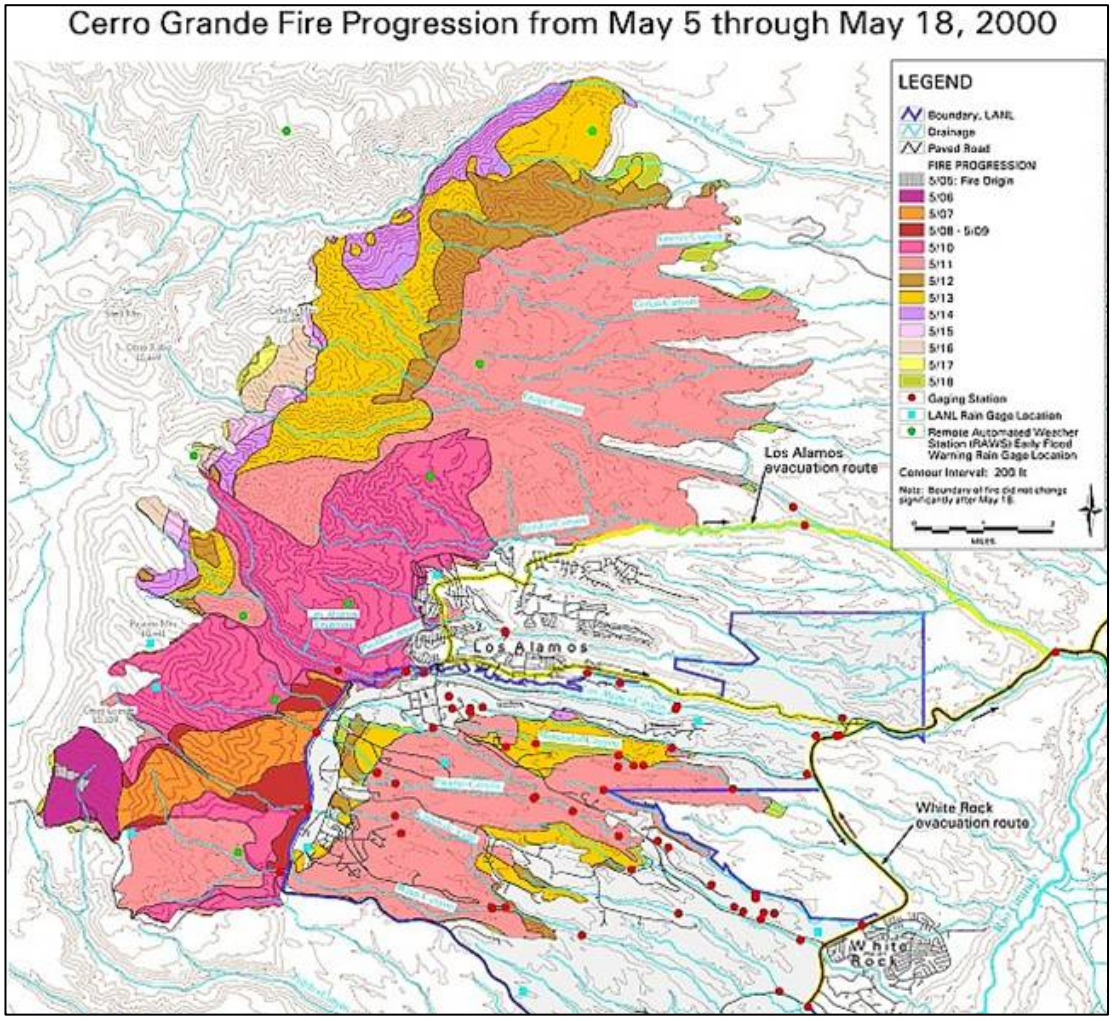

Figure 2.5. *Cerro Grande Fire Progression Map showing areas burned on successive days. (courtesy of GISLab, Los Alamos National Laboratory)*

A coordinated effort from the GIS community is necessary for cross-institutional integration of GIS technology. The fire illustrated how important it is for staff to work together and how effective GIS can be when cooperation is optimal.

The LANL Emergency Operations Center staff used the maps produced by FIMAD staff in Santa Fe to plan the laboratory's response to the changing fire threat, mark locations of new fire roads, and identify at-risk, damaged, or destroyed structures. Using a range of runoff and erosion computer models, LANL staff was able to perform several modeling runs while the fire was still burning strongly. The models were used to identify areas that posed threats to humans, infrastructure, and the environment should a large rain event occur.

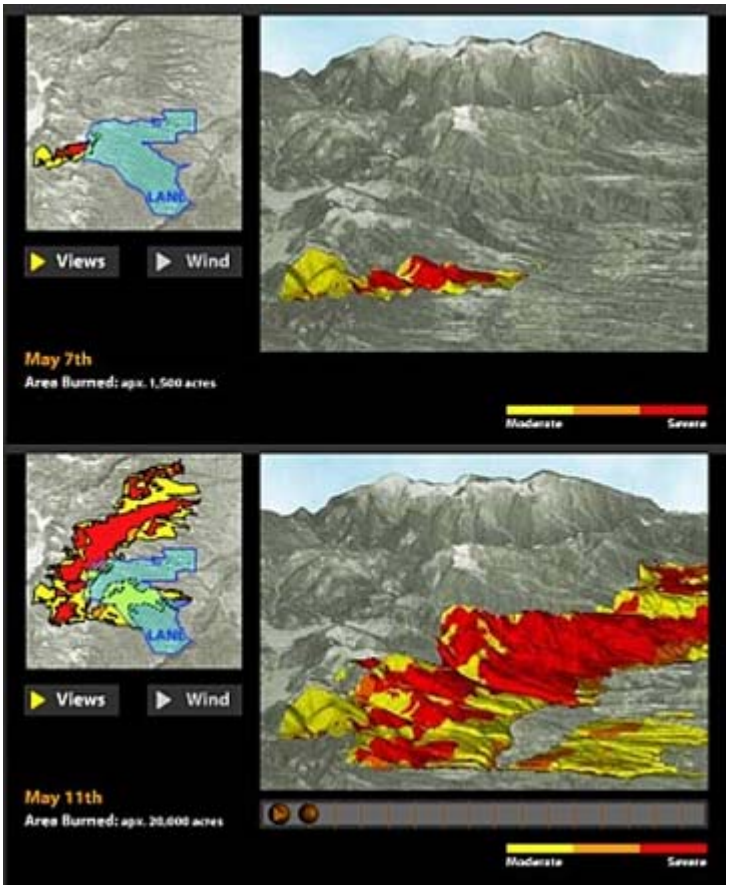

Figure 2.6. *Cerro Grande Rehabilitation Project GIS web pages with animated 3D views of fire progression and wind data. (courtesy of GISLab, Los Alamos National Laboratory)*

Postfire Collaborations and Decision Support

The BAER team arrived on Monday, May 15, and began a preliminary assessment of the fire area. BAER teams are formed after major fires to assess damage caused by the fire and to implement a rehabilitation plan that will prevent loss of life and property and reduce further natural resource damage. BAER teams are composed of highly skilled wildlife biologists, archaeologists, soil scientists, landscape architects, geologists, ecologists, engineers, foresters, botanists, GIS and GPS specialists, and other professionals from around the nation. Team members included personnel from the USFS, BLM, NPS, USGS, and LANL.

In addition, a multi-agency team was formed to begin emergency rehabilitation for the Cerro Grande fire. The Multi-agency Coordination (MAC) Team, formed on May 15, included representatives from all the landowner agencies and acted as the umbrella organization during the assessment and rehabilitation. The goal of the MAC is to provide interagency communications and minimize red tape.

As the BAER team and LANL began to assess damage and plan recovery efforts, the need for infrastructure information and maps of fire severity increased dramatically. Fortunately, none of the LANL GIS facilities was damaged or destroyed in the fire, and FIMAD and other LANL GIS offices quickly responded with coordination, computers, and logistical support and provided data and supplemented maps that the BAER team produced.

The BAER team arrived while the fire was still burning, and LANL GIS staff worked closely with the team to determine burn severity patterns in the laboratory's forests and grasslands and to provide information about ecological, biological, and archeological resources at LANL. Additionally, they provided USFS's Incident Management team with data on area fuel loading and forest structure for use in the service's fire behavior model, which helped to determine where to position firefighting assets.

On June 2, the Emergency Rehabilitation Team (ERT) formed to conduct initial assessments of potential environmental impacts from the fire. The team consisted of representatives from LANL groups and other organizations from outside the laboratory.

GIS analyses and modeling were important tools for the assessment team in determining the immediate and long-term threat of flash flooding and soil erosion. The results of these studies contributed to management decisions to close a facility found to be at high risk from flash floods, construct flood retention structures, and make improvements to bridges, culverts, and stream channels on LANL grounds and within Los Alamos County.

Because in some places the soil had become hydrophobic—water-repellent—flash flooding was a big concern. GIS analyses revealed the potential for stormwater discharge rates of two and a half to nearly six times normal and warned of the possibility of huge flash floods that could reach White Rock. This prompted the construction of a major retention structure. Additionally, FIMAD and the ER project staff provided data and maps about PRSs, particularly those located in burned areas, those affected by the fire, or those in drainage areas subject to erosion. Several hundred maps were produced in a few weeks and were used for geomorphological, geological, and sediment transport and migration studies. There were also several remote-sensing techniques used to determine the impact of fire on vegetation, erosion, forest fuel loading, and soils, and the GIS team used data from them for modeling future fire potential, forest regrowth, and runoff.

GIS Support for Rehabilitation

Soon after the fire, the Cerro Grande Rehabilitation Project (CGRP) was initiated to coordinate efforts to restore damaged infrastructure and property at the laboratory and to mitigate hazards resulting from the fire such as flooding, erosion, and dead and dying trees. These ongoing remediation and mitigation efforts increased the need for GIS at LANL.

In August 2000, CGRP funded a new GIS for its subprojects and as an institutional GIS resource for research and operations. GISLab, the successor to FIMAD, manages these programs and several other tasks including planning for forest thinning, delineation of floodplain changes, input for upgrading GIS capabilities at the new emergency operations center, mapping infrastructure, and predictive fire modeling. These activities have improved LANL's disaster response capabilities and have enabled a significant reduction in risk from future fires, floods, and other emergencies.

GISLab's spatial data warehouse is a major component of an enterprise GIS design that features large data storage capacity, geospatial search functions, and Web-based access to both spatial data and metadata.

At its annual User Conference in July 2002, ESRI presented GISLab of LANL and the BAER team with its Special Achievement in GIS award, recognizing their GIS efforts during the fire and afterwards in support of CGRP. Dr. Paul Rich, team leader for GISLab said, "The events of May 2000 were extraordinary. The response of the GIS community was equally extraordinary…the most important preparation was in place—a dedicated community of GIS professionals skilled at solving problems…"

Lessons Learned and Future Plans

The Cerro Grande Fire taught decision makers at LANL many lessons about the use of GIS in emergencies, some that were immediately apparent and others that became evident later on:

- GIS provides an integrating framework for assessing natural and human hazards in a landscape context.
- A strong GIS capability is needed for emergency response.
- Coordinated emergency plans are needed for GIS operations.
- A method for locating employees should be in place.
- GIS data should be complete, backed up, and available during an emergency.
- GIS procedures should be flexible so they can be adapted to the circumstances.
- GIS resources should be fully integrated within the organization.

A coordinated effort from the GIS community is necessary for cross-institutional integration of GIS technology. The fire illustrated how important it is for staff to work together and how effective GIS can be when cooperation is good. The efficiency and effectiveness of GIS efforts were dependent on interactions within the organization and with external agencies.

Former LANL GISLab Team Leader Dr. Paul Rich has been representing LANL on the DOE Geospatial Science Steering Committee, and helped lead an effort that led to recent formation of a new DOE Geospatial Science Program. This new program was established in 2005 to coordinate and maximize DOE's investment in geospatial activities as they support DOE's core mission.

The Cerro Grande Fire was a serious regional emergency that provided neighboring governments and LANL with important lessons about how to deal with large-scale disasters. These lessons are being incorporated into local, state, federal, and LANL disaster planning so that future emergencies will be handled with improved procedures, communication, and coordination. Recently, efforts from the DOE GIS user group and other stakeholders have highlighted the benefits of coordinating GIS efforts across the DOE complex.

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