



Figure 1. Named for the site of its origin, Mt. Vision, the Vision Wildfire was the largest in Point Reyes National Seashore in the last 60 years.

The use of GIS (geographic information systems), however, aided both the fire suppression and natural resource rehabilitation efforts.

INTERACTIVE APPLICATION OF GIS DURING THE VISION WILDFIRE AT POINT REYES NATIONAL SEASHORE

BY SARAH G. ALLEN, DAVID KEHRLEIN, DAVID SHREVE, AND RICHARD KRAUSE

THE MOST DEVASTATING wildfire to burn in Point Reyes National Seashore, California, in over 60 years spread rapidly through the park in the fall of 1995 (figure 1). Over 12 days, the fire burned more than 12,000 acres and destroyed 45 homes on state, federal, and private lands. At the height of the fire suppression campaign, 2,164 personnel, including 74 hand crews, 27 bulldozers, 7 air tankers, 7 helicopters, and 196 fire engines, were involved. Named the Vision Fire after the site where the fire was ignited in an illegal campground (Mt. Vision), the lessons learned from this incident also provided tremendous insights into fire management.

One lesson learned was the usefulness of geographic information systems (GIS) and global positioning systems (GPS) in the fire suppression and rehabilitation efforts. This is the story of how a team of GIS specialists and resource managers applied GIS during a wildfire in a wildland-urban interface, and what we recommend to better prepare for the use of GIS in such an emergency.

BAER TEAM ASSESSES IMPACTS

Shortly after the fire began, the Point Reyes Superintendent called in the Burn Area Rehabilitation Team (BAER team), a multiagency group with expertise in

plants, animals, soils, water resources, cultural resources, structures, and roads and trails. (See the Highlights story on the BAER team in *Park Science* 16(1):6). Their primary task was to document both the fire effects and fire suppression impacts on park resources. Within 2 weeks, with the aid of GIS, this team was able to make a comprehensive assessment and recommend actions to the National Park Service for short- and long-term restoration and rehabilitation.

Plant communities within the fire area are diverse and include marshland, coastal prairie, coastal grasslands, riparian, coastal dune, northern coastal scrub, bishop pine forest, and Douglas-fir forest. Each community has associated species that are unique to California and the world. Within the burn perimeter, many species of plants (23), mammals (8), birds (24), insects (8), amphibians (4), reptiles (2) and fish (4) are sensitive or endemic to the park. Several species have special recognition under the U.S. Endangered Species Act and the California Endangered Species Act.

The assessment noted extraordinary changes in the physical, chemical, and biological status of park resources. A number of plant communities and associations burned at very high to severe intensities

(figure 2), influencing recovery of the ecosystems. These included Bishop pine forests, coastal scrub, northern coastal prairie, and some Douglas-fir forests. Many of these communities occur on steep slopes exceeding 54 degrees.

Soil associations within the burn are highly prone to erosion and repel water following moderate to intense fire. Ero-

sion potential is also very high due to locally high rainfall (14 inches per month).

Fire suppression actions associated with containing and controlling the Vision Fire relied heavily upon direct and indirect



Figure 2. The BAER team noted the variability of blaze intensities. Where it was hottest, the fire will retard vegetation recovery and promote erosion, two processes that the park will monitor.

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mechanized bulldozer fire line construction. Bulldozer line construction totaling 23 miles occurred primarily within the wilderness; much of it occurred in the upper reaches of watersheds with impacts to existing trails with direct line construction on extremely steep and unstable slopes. In some areas, the fire lines traversed locations of known noxious weeds and increased the potential for spread of these species. Down slope are numerous watersheds, riparian areas, wetlands and estuaries.

Both the fire and suppression activities exposed many cultural resources; both Native American midden sites and historical ranch dump sites dating back to the turn of the century were uncovered. In addition to the 45 structures destroyed by the fire, tens of telephone poles were damaged and an estimated 2,000 hazardous trees posed a risk to park visitors along roads and trails.

As part of the fire recovery effort, the park initiated several studies to evaluate fire and fire suppression effects on the ecological integrity of communities within and adjacent to the burn area. GIS-GPS will help to monitor treatments and affected resources to determine the efficacy of measures taken to mitigate suppression and rehabilitation actions.

GIS SUPPORT ARRIVES

During and immediately following the fire, the park used GIS and GPS to map and monitor the daily and hourly spread of the fire (figures 3 and 4), measure fire suppression actions, assess damage to natural resources, and evaluate damage to adjacent homes in the wildland-urban interface. Technicians created numerous GIS-GPS data layers, including those for fire intensity, bulldozer line locations, and fire perimeter over time. These data layers were integrated in a form that enabled the park to measure, monitor, and map several data themes simultaneously, providing a more comprehensive understanding of the effects of the fire.

These tasks were possible only through the efforts of many personnel and the generous support of state and federal agencies, private organizations, and vendors. Point Reyes National Seashore, like many parks, had a fledgling GIS program

with some equipment and was in the process of upgrading and moving its GIS resources to new quarters when the fire occurred. Fortunately, within 12 hours of ignition, the California Office of Emergency Services dispatched a strike team of GIS specialists to aid in the fire analysis. This self-contained team included four GIS specialists and computer hardware and software capable of assessing the spread of the fire. Upon this foundation, a fully operational GIS lab was in place within 2 days of fire ignition.

The GIS lab extended to three offices, and cables snaked through hallways networking computer hardware between GIS platforms. At the height of the operation, hardware consisted of two Sun Microsystems UNIX-based workstations (with Arc/Info and ArcView software), two DOS-based personal computers (one with PC ARC/INFO and the other with MapInfo), two laptop computers, two Hewlett-Packard HP650C DesignJet printers, a digitizer, and various smaller printers. During the fire, the GIS team consumed five rolls of plotter paper, four color cartridges, several reams of paper and tens of diskettes.

Numerous people with computer systems administration skills, including GIS and GPS experience, rotated through the GIS lab, which helped keep the operation running smoothly, 24 hours a day. Individuals came from the National Park Service (field area office and Golden Gate National Recreation Area); the University of California, Berkeley; the California State Lands Commission; and the Burn Area Emergency Rehabilitation (BAER) team. Additionally, one person acted as liaison between the GIS lab and the outside world, helping to interpret the needs of the "customers" and what the lab could produce. The language of users and producers often necessitated translation because many disciplines (e.g., geology, hydrology, ecology, computer science) were combined into the GIS.

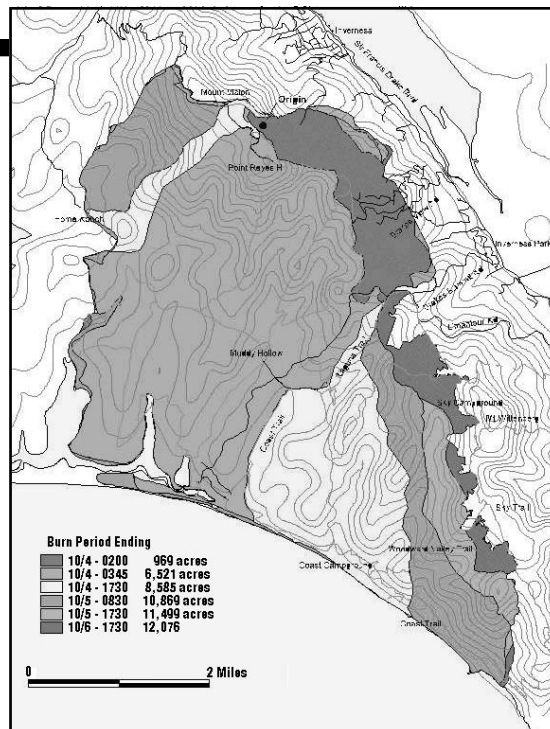


Figure 3. Through the use of GIS, staff were able to produce detailed fire perimeter maps that not only aided fire suppression efforts, but also documented resource damage for follow-up rehabilitation.

GIS PRODUCTS

Map "users" ultimately defined the products we generated; however, the demand for and the sophistication of products evolved over time as users perceived the value and capability of the GIS output. Users included decision makers from all disciplines, fire fighters, public information officers, the BAER team, researchers from universities, and the general public.

Initially, the most critical information required from the GIS lab was the fire perimeter. Twice per day, a helicopter equipped with a GPS unit flew the fire perimeter, and a map was promptly produced for the fire fighters. Another critical data layer was the location and condition of structures destroyed by the fire. The California Department of Forestry, Marin County Fire Department, and NPS personnel surveyed homes in the burn area with various GPS unit models (Trimble Navigation, Light ProXL, and Basic Plus) and collected data on the condition and location of structures. Within 4 days of fire ignition, and while the fire was still burning, these data were converted to a GIS data layer and overlaid with a county parcel map to identify the owners of the structures.

**Fire Perimeter
October 6--5:30 P.M.
12,354 acres**

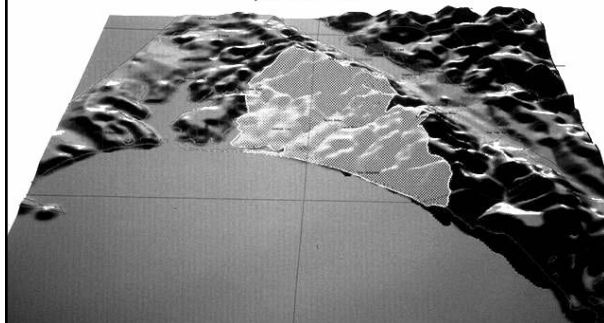


Figure 4. The GIS team produced a multivariable, simulated, 3-dimensional map, which indicated that topography is important in defining high intensity burn areas. The hottest zones occurred along ridges where winds were highest.

Data were also gathered using GPS on location of hand and bulldozer fire lines, roads, trails, fire suppression effects, noxious weeds, vegetation plots, photo points, and survey points. GIS was then used for mapping, measuring, and monitoring post-fire analysis of burn effects and rehabilitation prescriptions. Examples of preliminary products generated include generalized location and identification of high to moderate burn intensity zones, of fire suppression measures, of cultural resources in relation to bulldozer lines, and of threatened and endangered species in relation to fire suppression actions. As users perceived the ability of GIS to measure and calculate information, they requested reports on acreages, linear distances, and other parameters.

Several data layers already existed in the park GIS, including soils, digital line graphs (DLGs), digital elevation models (DEMs), and a few U.S. Geological Survey digital orthophoto quads (maps produced from aerial photographs that are corrected for parallax and referenced to control points on the ground); however, a crucial missing data layer was a digital vegetation map. A recent Landsat Thematic Mapper (TM) image was available but it was not ground-truthed and could only be used for general reference. Instead, we created a vegetation map using the USDA Natural Resources Conservation Service digital soils map and correlating the information with the associated vegetation

types. This proved surprisingly useful for some of the analyses with some adjustment based on spot checking with aerial photos.

As time allowed, we also added more precise and inclusive information to the existing GIS databases. Examples include measuring more precisely the extent and location of potential soil erosion sites, monitoring the spread of noxious weeds and the recovery of vegetation communities, and locating roads and trails with greater accuracy (the USGS DLGs were inaccurate). These data were crucial in assessing fire effects and guiding rehabilitation and mitigation prescriptions.

To speed up production of maps and to assure conformity in style, we brought in specially tailored, preexisting programs (AML—the programming language for Arc/Info) and developed new ones. At one point, we plotted a California Department of Fish and Game Heritage Program species list of concern from the State Lands Commission in Sacramento via the Internet on a plotter at Point Reyes.

MAKING IMPROVEMENTS

The fire teams faced several challenges when using GIS that cost precious time. With just a little preplanning, many of these issues could be eliminated. For example, GIS support was not formally

conventions and data categories needed to be standardized. Unfortunately, we lost the opportunity to track the fire history because maps drawn by firefighters were lost as the GIS lab was gearing up. Improvements would include adopting a map projection standard and maintaining the software to convert nonstandard projections. A metadata form might also be developed and maintained during the fire to aid in standardized data input. The simple act of providing a bin for early map storage might prevent future map losses. One set of hard copy maps should also be kept in a secure place. We could have devoted more time to the GIS products themselves if we had prepackaged GPS data dictionaries for field data collection. Likewise, prepackaging software that would facilitate GIS products to be made from maps of several sizes would have helped. Furthermore, this software needs to transfer easily across computer platforms.

Not only was translation between platforms poor, but hard disc space was also inadequate. Permission to access files on the UNIX workstations also caused trouble. An experienced system administrator was always needed but not always present. Despite lacking the space for bulky computer systems, digitizers, and plotters, we still could have used more computers. We had no method to track computer system performance problems for follow up. A virus, brought in a laptop

The park used GIS and GPS to map and monitor the spread of the fire, measure fire suppression actions, assess damage to natural resources, and evaluate damage to homes.

linked to the incident command structure; consequently, the GIS team responded to many nonprioritized requests. A simple solution would be to place the GIS function in the incident command structure. Products should be prioritized with those that support fire operations being highest priority.

Many problems specific to GIS occurred. Differences in map projections and data scales created incompatibilities. Data were often incomplete and sometimes out of date or of poor quality, and file naming

computer, plagued systems for a couple of days before being identified and removed. Scanning for viruses as new equipment is brought in would be a good idea as is providing a log book to document computer problems. Establishing solid vendor contacts would also help so that problem solving can occur swiftly when a computer disaster occurs. Maintaining a list of computer trained contacts could help address problems that occur in the

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evening or on weekends. Connections with GIS specialists from other agencies, organizations, and universities through conferences, and professional societies, were the key to getting the GIS lab jump-started during the Vision Fire.

Finally, GIS is a technical specialty, and its capabilities were not well understood by fire staff, which resulted in redundant efforts. For GIS to function smoothly in this environment, more than one person per agency is needed who has GIS experience (training) and an understanding of the capabilities and limitations of this management tool. A debriefing meeting, held shortly after the event, is also useful in documenting problems such as these and leading to improvements.

The Vision Fire at Point Reyes is a wake-up call for many private and public entities. Although impossible to contemplate and identify every problem in providing GIS related services during fires or other emergency operations, we are convinced that GIS is, and will continue to be, a vital tool to emergency responders in the future. We hope that by documenting our experiences, identifying the problems we encountered, and identifying preplanning considerations, more public and federal agencies will be better prepared to handle emergency incidents more effectively.

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