United States General Accounting Office

GAO

Testimony

Before a Public Forum Hosted by Representative Joel Hefley and Representative Mark Udall

For Release on Delivery
Expected at 1 p.m. MDT
Thursday, August 28, 2003

GEOSPATIAL INFORMATION

Technologies Hold Promise for Wildland Fire Management, but Challenges Remain

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G A O

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GAO-03-1114T

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August 2003

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Highlights

Highlights of GAO-03-1114T, a testimony before Representative Joel Hefley and Representative Mark Udall

Why GAO Did This Study

Over the past decade, a series of devastating and deadly wildland fires has burned millions of acres of federal forests, grasslands, and deserts each year, requiring federal land management agencies to spend hundreds of millions of dollars to fight them. GAO was asked to provide an interim update on key segments of an ongoing review of the use of geospatial information technologies in wildland fire management. Specifically, GAO was asked to provide an overview of key geospatial information technologies and their uses in different aspects of wildland fire management and to summarize key challenges to the effective use of these technologies. The final report is expected to be issued in September 2003.

GAO's review focused on the five federal agencies that are primarily responsible for wildland fire management: the Department of Agriculture's Forest Service and the Department of the Interior's National Park Service, Bureau of Land Management, Fish and Wildlife Service, and Bureau of Indian Affairs.

Note: The graphics in this report are in color and are best viewed electronically.

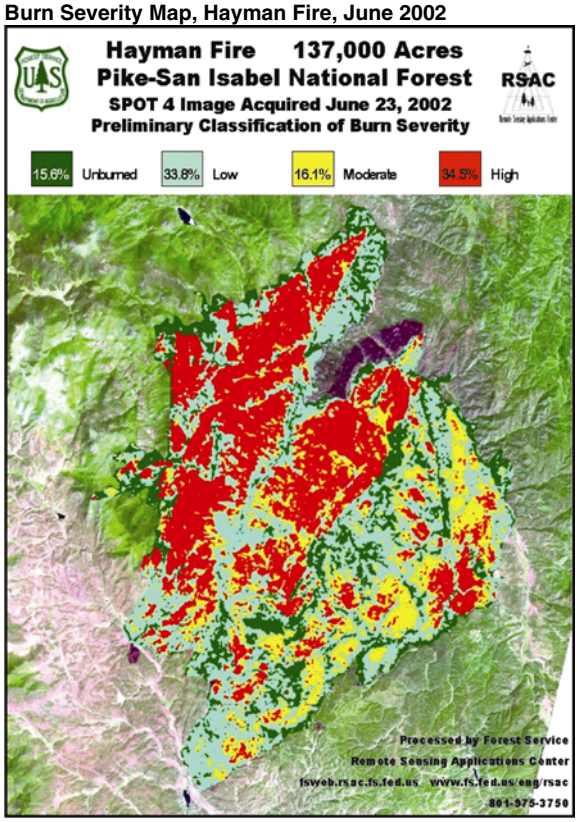
www.gao.gov/cgi-bin/getrpt?GAO-03-1114T

To view the full product, including the scope and methodology, click on the link above. For more information, contact David Powner at (202) 512-9286 or pownerd@gao.gov.

What GAO Found

Geospatial information technologies—sensors, systems, and software that collect, manage, manipulate, analyze, model, and display information about locations on the earth's surface—can aid in managing wildland fires by providing accurate, detailed, and timely information to federal, state, and local decision makers, fire-fighting personnel, and the public. This information can be used to help reduce the risk that a fire will become uncontrollable, to respond to critical events while a fire is burning, and to aid in recovering from fire disasters. However, there are multiple challenges to effectively using these technologies to manage wildland fires, including challenges with data, systems, infrastructure, staffing, and the effective use of new products. Clearly, effective management of information technology and resources could help address these challenges. In our final report, due to be issued next month, we will further discuss geospatial information technologies, challenges to effectively using these technologies, and opportunities to improve the effective use of geospatial information technologies. We will also make recommendations to address these challenges and to improve the use of geospatial technologies in wildland fire management.

Burn Severity Map, Hayman Fire, June 2002



Source: Forest Service, Remote Sensing Applications Center.

Congressman Hefley and Congressman Udall:

We appreciate the opportunity to join in today's forum to discuss our ongoing work on geospatial information technologies that can be used to aid in wildland fire management. At your request, we will provide an overview of key geospatial information technologies and their uses in different phases of wildland fire management. We will also discuss key challenges to effectively using these technologies. This statement provides an interim update on key segments of our ongoing review of the use of geospatial information technologies in wildland fire management. We expect to issue our final report next month.

In brief, geospatial information technologies—sensors, systems, and software that collect, manage, manipulate, analyze, model, and display information about locations on the earth's surface—can aid in managing wildland fires by providing accurate, detailed, and timely information to federal, state, and local decision makers, fire-fighting personnel, and the public. This information can be used to help reduce the risk that a fire will become uncontrollable, to respond to critical events while a fire is burning, and to aid in recovering from fire disasters.

However, there are multiple challenges to effectively using geospatial technologies—all complicated by the fact that wildland fire management extends beyond a single agency's responsibility and requires a collaborative interagency approach. Key challenges include issues with geospatial data, systems, infrastructure, staffing, and the use of new products.

Clearly, effective interagency management of information resources and technology could help address the challenges faced by the wildland fire community in using geospatial information technologies. The National Wildfire Coordinating Group—comprising representatives from the five land management agencies[1] and from other federal, state, and tribal organizations—has several initiatives planned or under way to address challenges to effectively using geospatial technologies and to improve the interagency management of information resources. However, progress on these initiatives has been slow. In our report, due to be issued in September 2003, we further discuss the use of geospatial

[1] Five federal agencies are primarily responsible for wildland fire management: the Department of Agriculture's Forest Service and the Department of the Interior's National Park Service, Bureau of Land Management, Fish and Wildlife Service, and Bureau of Indian Affairs.

technologies in support of wildland fire management, challenges to effectively using these technologies, and opportunities to address key challenges and to improve the effective use of geospatial technologies. We will also make recommendations to improve the use of geospatial technologies in support of wildland fire management. An overview of the approach we used to perform our work—our objectives, scope, and methodology—is provided in appendix I.

Background

Over the past decade, there has been a series of devastating and deadly wildland fires on federal lands. These fires burn millions of acres of forests, grasslands, and deserts each year, and federal land management agencies spend hundreds of millions of dollars to fight them. Wildland fires also threaten communities that are near federal lands. During the 2002 fire season, approximately 88,458 wildland fires burned about 6.9 million acres and cost the federal government over $1.6 billion to suppress. These fires destroyed timber, natural vegetation, wildlife habitats, homes, and businesses, and they severely damaged forest soils and watershed areas for decades to come. The 2002 fires also caused the deaths of 23 firefighters and drove thousands of people from their homes. Only 2 years earlier, during the 2000 fire season, approximately 123,000 fires had burned more than 8.4 million acres and cost the federal government over $2 billion.

Wildland Fire Management Life Cycle: An Overview

Effectively managing wildland fires can be viewed in terms of a life cycle—there are key activities that can be performed before a fire starts to reduce the risk of its becoming uncontrollable; other activities that can take place during a fire to detect the fire before it gets too large and to respond to it; and still others that can be performed after a fire has stopped in order to stabilize, rehabilitate, and restore damaged forests and rangelands.

- Pre-fire activities can include identifying areas that are at risk for wildland fire by assessing changes in vegetation and the accumulation of fuels (including small trees, underbrush, and dead vegetation) as well as these fuels' proximity to communities; taking action to reduce fuels through a variety of mechanisms (including timber harvesting, management-ignited or prescribed fires, mechanical thinning, and use of natural fires); and monitoring fire

weather conditions. Other activities during this phase can include providing fire preparedness training and strategically deploying equipment and personnel resources to at-risk areas.

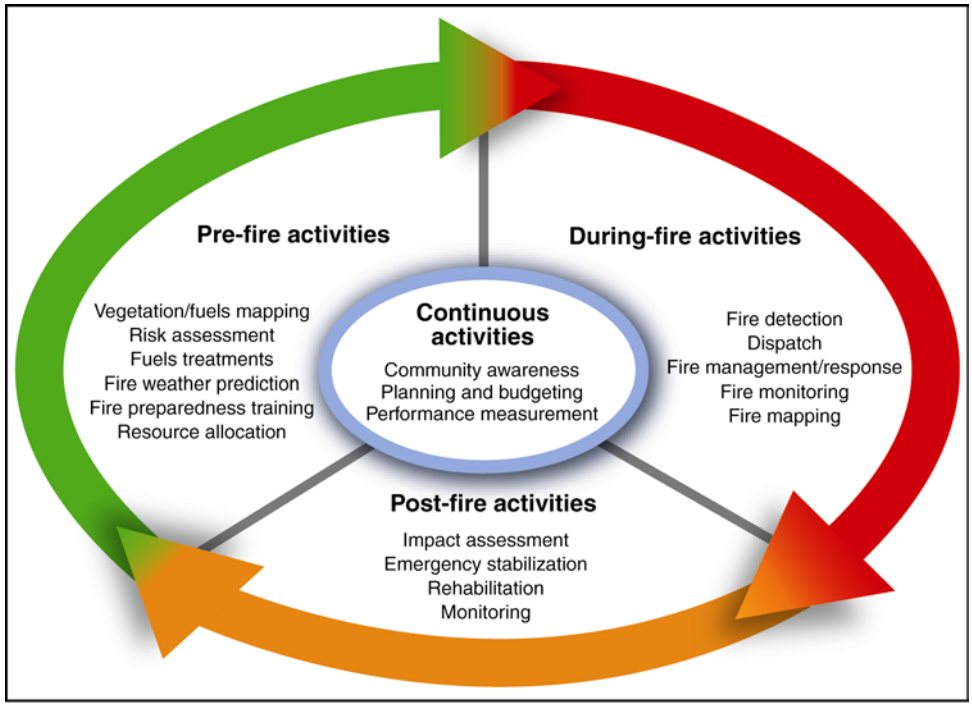
- Activities that take place during a fire include detecting fires, dispatching resources, planning the initial attack on the fire, monitoring and mapping the fire's spread and behavior, and planning and managing subsequent attacks on the fire—if they are warranted.

- Post-fire activities can include assessing the impact of the fire, providing emergency stabilization of burned areas to protect life, property, and natural resources from post-fire degradation, such as flooding, contamination of a watershed area, and surface erosion; rehabilitating lands to remove fire debris, repair soils, and plant new vegetation; and monitoring the rehabilitation efforts over time to ensure that they are on track.

- Other activities—such as enhancing community awareness—can and should take place throughout the fire management life cycle.

Figure 1 depicts a fire management life cycle, with key activities in each phase.

Figure 1: Wildland Fire Management Activities

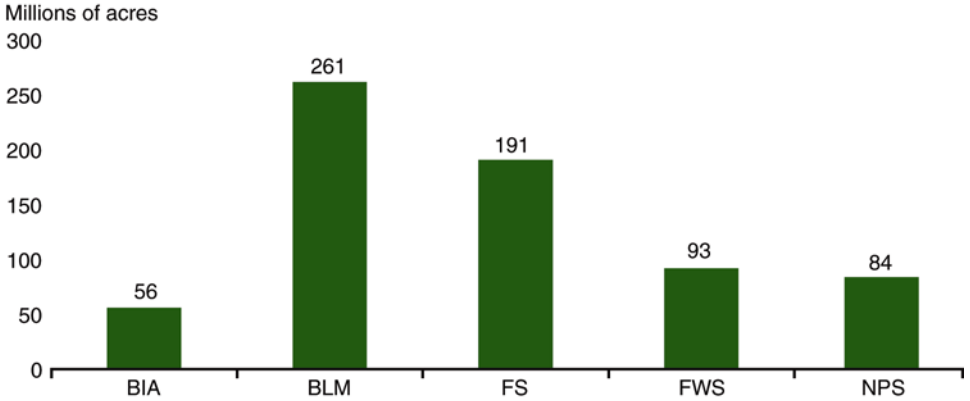


Source: GAO.

Federal Land Management Responsibilities

Five federal agencies share responsibility for managing the majority of our nation's federal lands—the Department of Agriculture's Forest Service (FS) and the Department of the Interior's National Park Service (NPS), Bureau of Land Management (BLM), Fish and Wildlife Service (FWS), and Bureau of Indian Affairs (BIA). While each agency has a different mission and responsibility for different areas and types of land, they work together to address catastrophic wildland fires, which often cross agency boundaries. In addition, state, local, and tribal governments and private individuals own thousands of acres that are adjacent to federal lands and are similarly susceptible to wildland fires. Figure 2 shows the number of acres of land managed by each of the five federal agencies.

Figure 2: Acres of Land Managed by Federal Land Management Agencies



Source: Bureau of Land Management and Forest Service data, as of 2003.

The National Fire Plan

After years of catastrophic fires, in September 2000, the Departments of Agriculture and the Interior jointly issued a report on managing the impact of wildland fires. This report forms the basis of what is now known as the National Fire Plan—a long-term multibillion-dollar effort to address the nation's risk of wildland fires. The plan directs funding and attention to five key initiatives:

- **Hazardous fuels reduction**—investing in projects to reduce the buildup of fuels that leads to severe fires.
- **Firefighting**—ensuring adequate preparedness for future fires by acquiring and maintaining personnel and equipment and by placing

firefighting resources in locations where they can most effectively be used to respond to fires.

- **Rehabilitation and restoration**—restoring landscapes and rebuilding ecosystems that have been damaged by wildland fires.
- **Community assistance**—working directly with communities to ensure that they are adequately protected from fires.
- **Accountability**—establishing mechanisms to oversee and track progress in implementing the National Fire Plan, which includes developing performance measures, processes for reporting progress, and budgeting information.

A key tenet of the National Fire Plan is coordination between government agencies at the federal, state, and local levels to develop strategies and carry out programs. Building on this goal of cooperation, the five land management agencies have worked with state governors and other stakeholders to develop a comprehensive strategy and an implementation plan for managing wildland fires, hazardous fuels, and ecosystem restoration and rehabilitation on federal and adjacent state, tribal, and private forest and rangelands in the United States. In developing these integrated plans and initiatives, the land management agencies identified other federal agencies that have roles in wildland fire management: agencies that manage other federal lands, including the Department of Defense and Department of Energy; agencies that research, manage, or use technologies that can aid in wildland fire management, including the Department of the Interior's U.S. Geological Survey, the National Aeronautical and Space Administration, the Department of Commerce's National Oceanic and Atmospheric Administration, and the Department of Defense's National Imagery and Mapping Agency; and agencies with other fire-related responsibilities, including the Department of Homeland Security's Federal Emergency Management Agency and the Environmental Protection Agency. The integrated plans also identify key state and local organizations that may collaborate on wildland fire management.

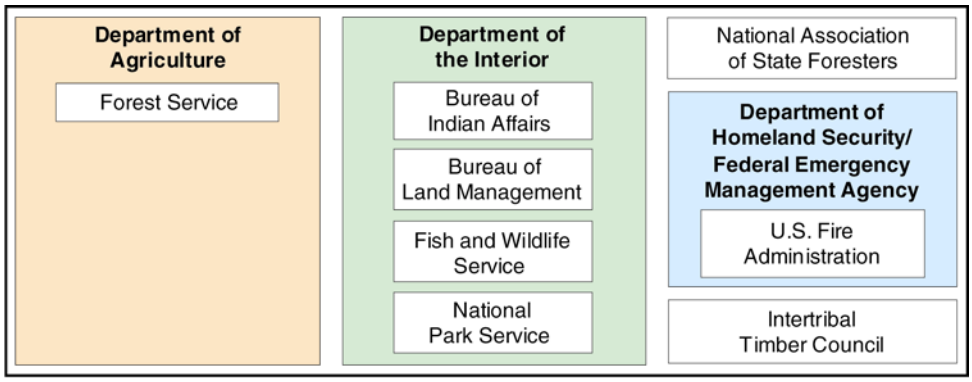
An Interagency Framework Supports the National Fire Plan

Over the past four decades, the Departments of Agriculture and the Interior have established an interagency framework to handle wildland fire management—a framework that currently supports the National Fire Plan. In 1965, the Forest Service and the Bureau of Land Management established the National Interagency Fire Center,

in Boise, Idaho. The fire center is the nation's principal management and logistical support center for wildland firefighting and now includes the five land management agencies, the National Weather Service, and the Department of the Interior's Office of Aircraft Services. The Department of Homeland Security's Federal Emergency Management Agency and the National Association of State Foresters also have a presence at the center. Working together, representatives from this mix of organizations exchange fire protection information and training services and coordinate and support operations for managing wildland fire incidents while they are occurring, throughout the United States.

In 1976, the departments established the National Wildfire Coordinating Group to coordinate government standards for wildland fire management and related programs, in order to avoid duplicating the various agencies' efforts and to encourage active collaboration among entities. This group comprises representatives from the five land management agencies and from other federal, state, and tribal organizations. Figure 3 identifies these member organizations. The coordinating group seeks to foster more effective execution of each agency's fire management program through agreements on common training, equipment, and other standards; however, each agency determines whether and how it will adopt the group's proposals. The group is organized into 15 working teams, which focus on issues including information resource management (IRM), fire equipment, training, fire weather, and wildland fire education. Most recently, the coordinating group established the IRM program management office to further support the IRM working team by developing guidance and products. In addition, the IRM working team has established two subgroups to focus on specific issues involving geospatial information and data administration.

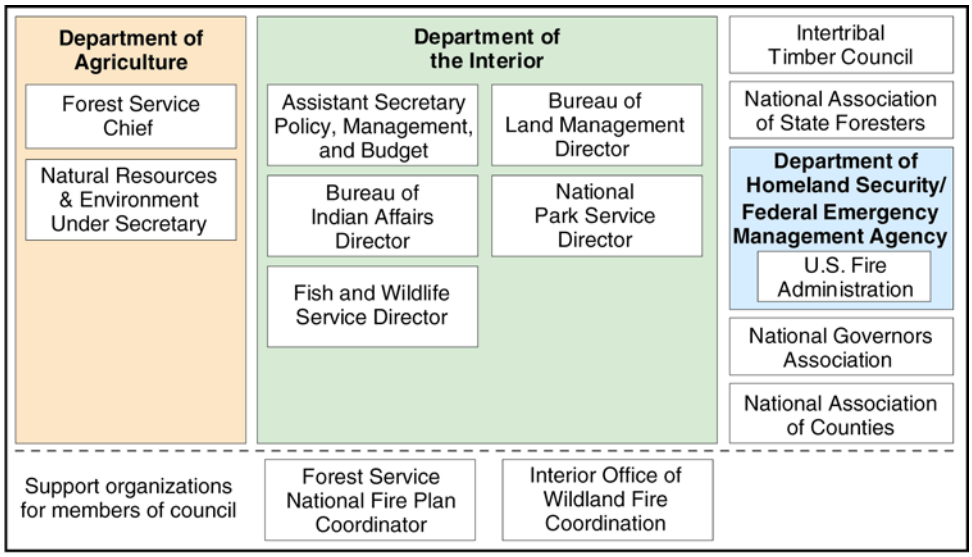
Figure 3: National Wildfire Coordinating Group: Member Organizations



Source: National Wildfire Coordinating Group.

In recent years, we have reported that despite these interagency efforts, the Forest Service and the Department of the Interior had not established clearly defined and effective leadership for ensuring collaboration and coordination among the organizations that respond to wildland fires.[2] Further, the National Academy of Public Administration recommended that the Secretaries of Agriculture and the Interior establish a national interagency council to achieve more consistent and coordinated efforts in implementing national fire policies and plans.[3] In response to these concerns, in April 2002, the Secretaries of the two departments established the Wildland Fire Leadership Council. This council comprises senior members of both departments and of key external organizations, and is supported by the Forest Service's National Fire Plan Coordinator and the Department of the Interior's Office of Wildland Fire Coordination. The Council is charged with providing interagency leadership and oversight to ensure policy coordination, accountability, and effective implementation of the National Fire Plan and Federal Wildland Fire Management Policy. Figure 4 identifies members of the Leadership Council.

Figure 4: Members of the Wildland Fire Leadership Council



Source: Office of Wildland Fire Coordination.

[2] U.S. General Accounting Office, *The National Fire Plan: Federal Agencies Are Not Organized to Effectively and Efficiently Implement the Plan*, GAO-01-1022T (Washington, D.C.: July 31, 2001); *Severe Wildland Fires: Leadership and Accountability Needed to Reduce Risks to Communities and Resources*, GAO-02-259 (Washington, D.C.: Jan. 31, 2002); *Wildland Fire Management: Improved Planning Will Help Agencies Better Identify Fire-Fighting Preparedness Needs*, GAO-02-158 (Washington, D.C.: Mar. 29, 2002).

[3] Frank Fairbanks, Henry Gardner, Elizabeth Hill, Keith Mulrooney, Charles Philpot, Karl Weick, and Charles Wise, M*anaging Wildland Fire: Enhancing Capacity to Implement the Federal Interagency Policy* (Washington, D.C.: National Academy of Public Administration, December 2001).

Numerous Geospatial Technologies Can Be Used to Address Different Aspects of Wildland Fire Management

Geospatial information technologies—sensors, systems, and software that collect, manage, manipulate, analyze, model, and display information about positions on the earth's surface—can aid in managing wildland fires by providing accurate, detailed, and timely information to federal, state, and local decision makers, fire-fighting personnel, and the public. This information can be used to help reduce the risk that a fire will become uncontrollable, to respond to critical events while a fire is burning, and to aid in recovering from fire disasters.

Specific examples of geospatial technologies include remote sensing systems, the Global Positioning System, and geographic information systems. In addition, specialized software can be used in conjunction with remote sensing data and geographic information systems to manipulate geographic data and allow users to analyze, model, and visualize locations and events. Table 1 describes key geospatial technologies.

Table 1: Key Geospatial Technologies

Technology	Description
Remote sensing systems	Remote sensing systems observe data that are either emitted or reflected by the earth and the atmosphere, collecting these data from a distance—such as from a satellite or an aerial platform. Remote sensing systems involve different observing technologies, including cameras, scanners, radar and sonar systems, radiometers, lasers, and thermal devices—to name a few—and are capable of collecting data from one or more bands of the electromagnetic spectrum.[a] Data from different bands provide different kinds of information. For example, data observed in the infrared band can identify heat sources that are not observable in the visible band of the electromagnetic spectrum. When data are collected from multiple bands, a more sophisticated analysis can be performed. Key factors that differentiate one sensor from another include the type(s) of data collected, the resolution[b] of the images, the width (or swath) of area covered on the ground, and the rate at which the sensor's platform revisits an area on the ground. After being observed, remotely sensed data need to be processed—a function which can include referencing the data to a position on earth, calibrating them, and then transforming them into a usable format. The resulting product can be an image or a quantitative data product, which can in turn be used as an input to other geospatial technologies, including geographic information systems and specialized software.
Global Positioning System	The Global Positioning System is a constellation of orbiting satellites that provides navigation data to military and civilian users around the world. These satellites orbit the earth every 12 hours, emitting continuous navigation signals. With the proper equipment, users can receive these signals and use them to calculate time, location, and velocity. Receivers have been developed for use on aircraft, ships, and land-based vehicles, as well as via mobile hand-held units. Data from the Global Positioning System can be used to reference remotely sensed aerial images or ground-based human observations to specific geographic coordinates, a process called geo-referencing.
Geographic information systems	A geographic information system (GIS) is a system of computer software, hardware, and data used to manipulate, analyze, and graphically display a potentially wide array of information associated with geographic locations. These systems can receive input from remotely sensed images from satellites and aerial platforms, as well as from other sources including human observation, tabular data, and maps. These systems are capable of relating multiple layers of data (such as roads, vegetation, structures, and utilities) concerning the same geographical location and representing these multiple layers of information as one composite result.
Specialized software	Specialized software for modeling, decision support, and visualization complements the sensing, positioning, and GIS technologies described above by allowing analysts and managers to analyze data and explore different scenarios—and thereby make better informed decisions. For example, fire behavior specialists use such software to model fire behavior. Inputs to these models come from satellite images as well as weather data, tabular data, and on-the-ground observations.

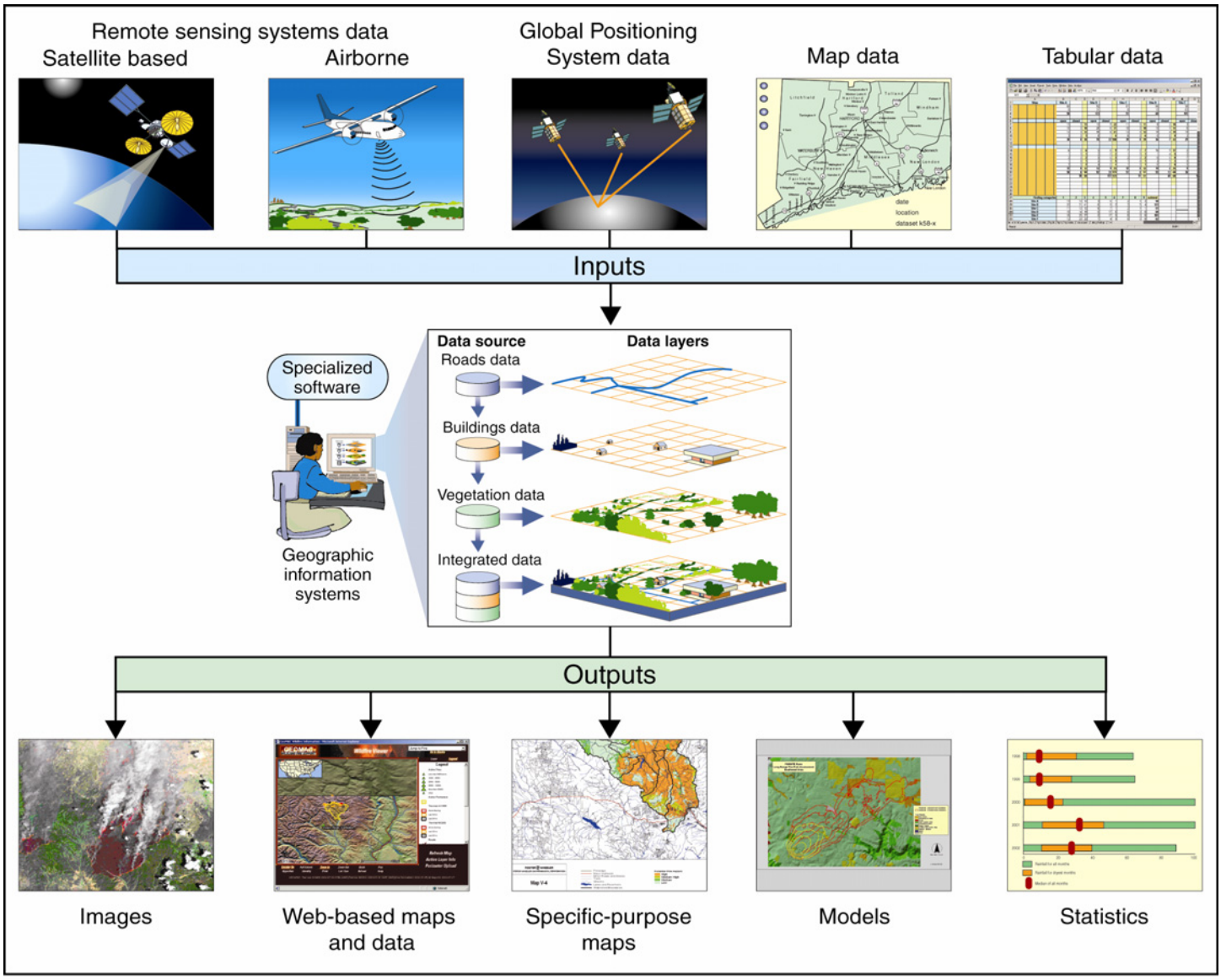
Source: GAO research and analysis.

[a] A spectral band is a set of adjacent wavelengths in the electromagnetic spectrum. Examples include the ultraviolet, visible, near infrared, mid-infrared, and thermal infrared bands.

[b] Spatial resolution is a measure of the size of the smallest feature that can be distinguished in an image. That is, in a 30-meter resolution image, one could discern objects 30 meters and larger. Images with smaller discernable objects are considered to have higher resolutions.

While individual technologies can be used to obtain information and products, the integration of these technologies holds promise for providing even more valuable information to decision makers. For example, remote sensing systems provide images that are useful in their own right. However, when images are geo-referenced and combined with other layers of data in a geographic information system—and then used with specialized software—a more sophisticated analysis can be performed and more timely and sound decisions can be made. Figure 5 provides an overview of the relationships among the different technologies and some resulting products.

Figure 5: Overview of the Flow of Data Among Key Geospatial Information Technologies and Resulting Products of These Technologies



Source: GAO, Art Explosion, U.S. Geological Survey, Forest Service.

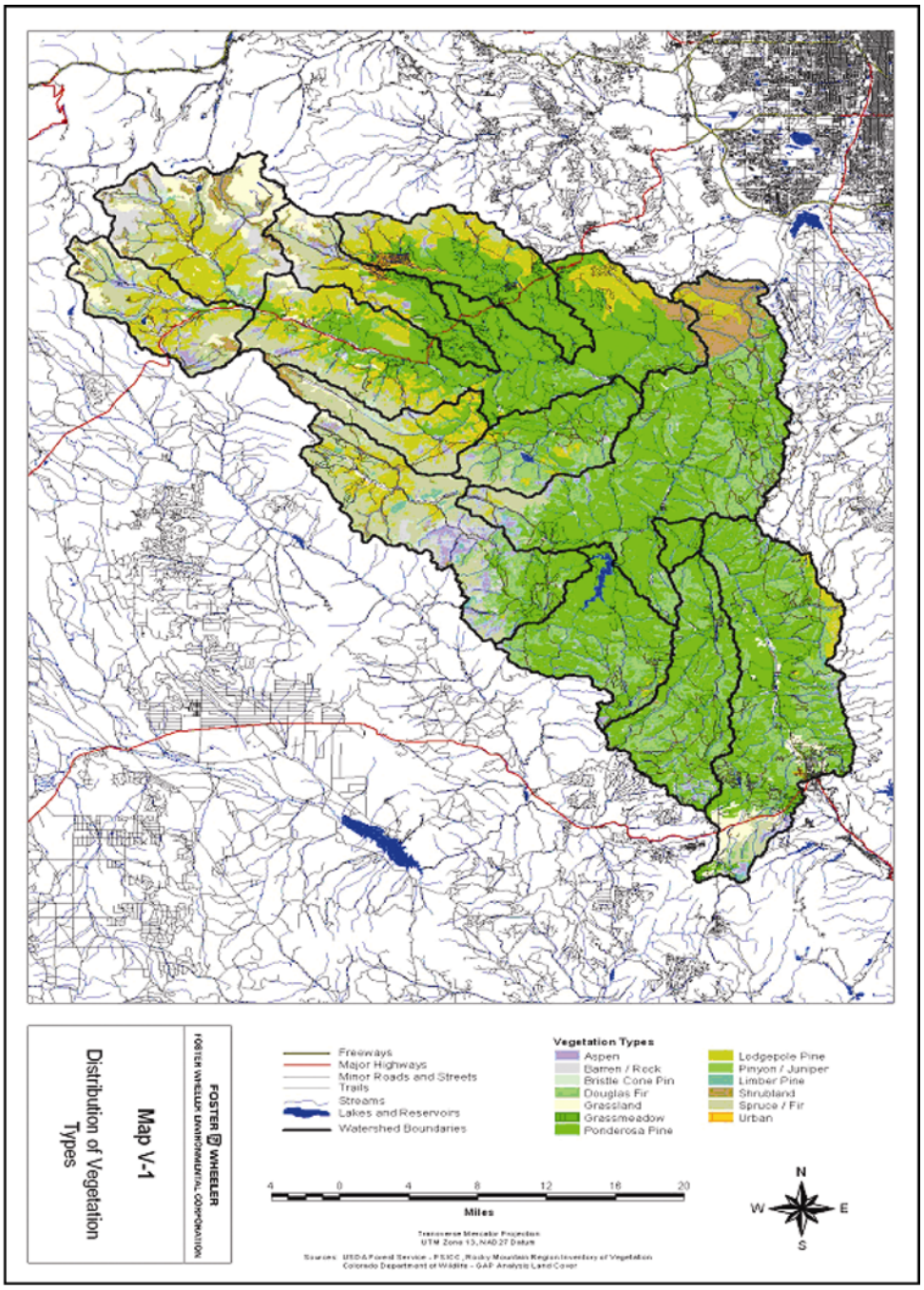
Federal Land Management Agencies Are Using Geospatial Technologies to Support Wildland Fire Management

The geospatial information technologies mentioned above—remote sensing systems, the Global Positioning System, geographic information systems, and specialized software—are being used to some extent in managing wildland fires. These technologies are used throughout the wildland fire management life cycle. Key examples follow.

Examples of Geospatial Technology Use: Pre-fire

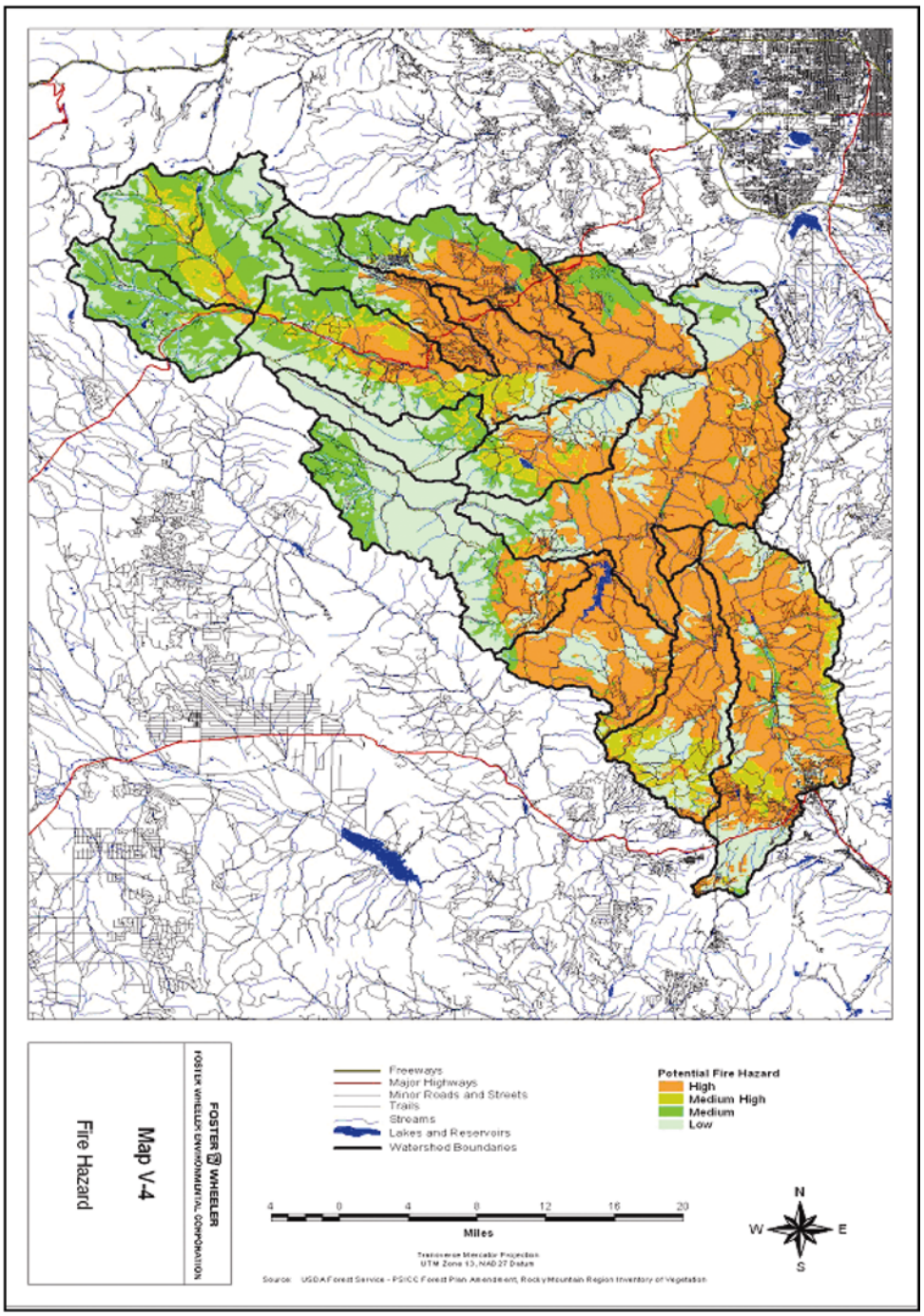
Before a fire starts, local and regional land managers often use vegetation and fuels maps derived from remote sensing data in conjunction with a geographic information system to understand conditions and to identify areas for fuels treatments. Some land management offices have also developed software to help them assess risk areas and prioritize fuels treatment projects. For example, figure 6 depicts a vegetation map, and figure 7 depicts a map showing areas with increased risk of fires. Interestingly, an area that the map identified as being at high risk of fire later burned during the Hayman fire of 2002.

Figure 6: Vegetation Map, Rocky Mountain Region, Colorado, August 1999



Source: Forest Service, Colorado State Forest Service.

Figure 7: Fire Hazard Map, Rocky Mountain Region, Colorado, August 1999



Source: Forest Service, Colorado State Forest Service.

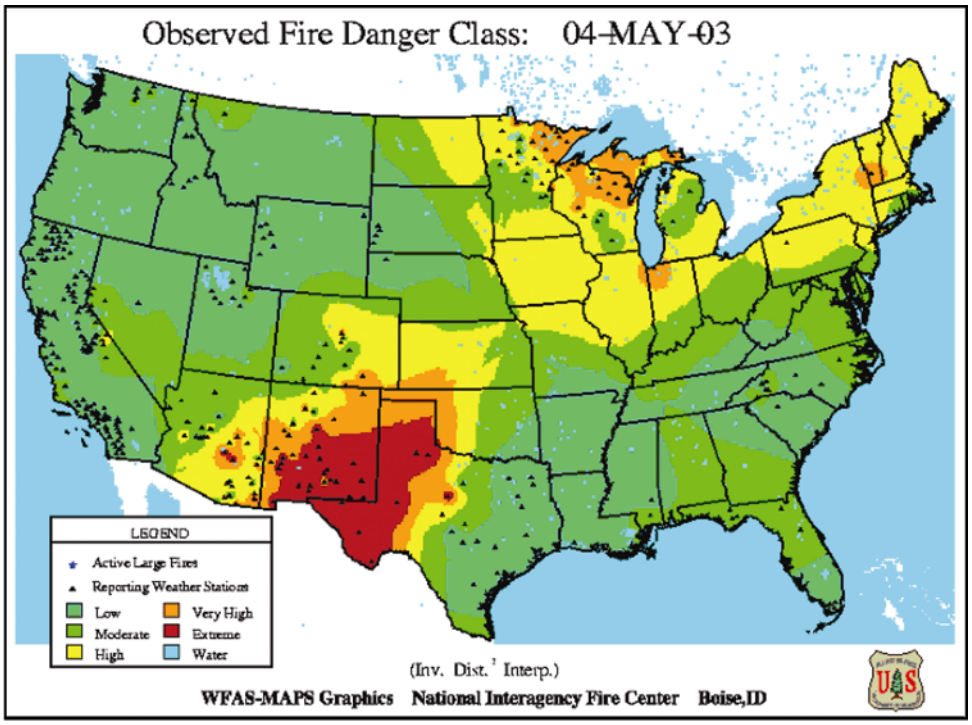
Land management agencies also use geospatial products related to the weather to aid in fire planning, detecting, and monitoring activities. Weather-based products are derived from ground-based lightning detection and weather observing systems as well as from fire-related weather predictions from the National Weather Service.

Figure 8 depicts a seasonal fire outlook, and figure 9 depicts a fire danger map that is based on daily weather predictions.

Figure 8: National Wildland Fire Outlook

Source: National Interagency Coordination Center, Boise, Idaho.

Figure 9: Fire Danger Map

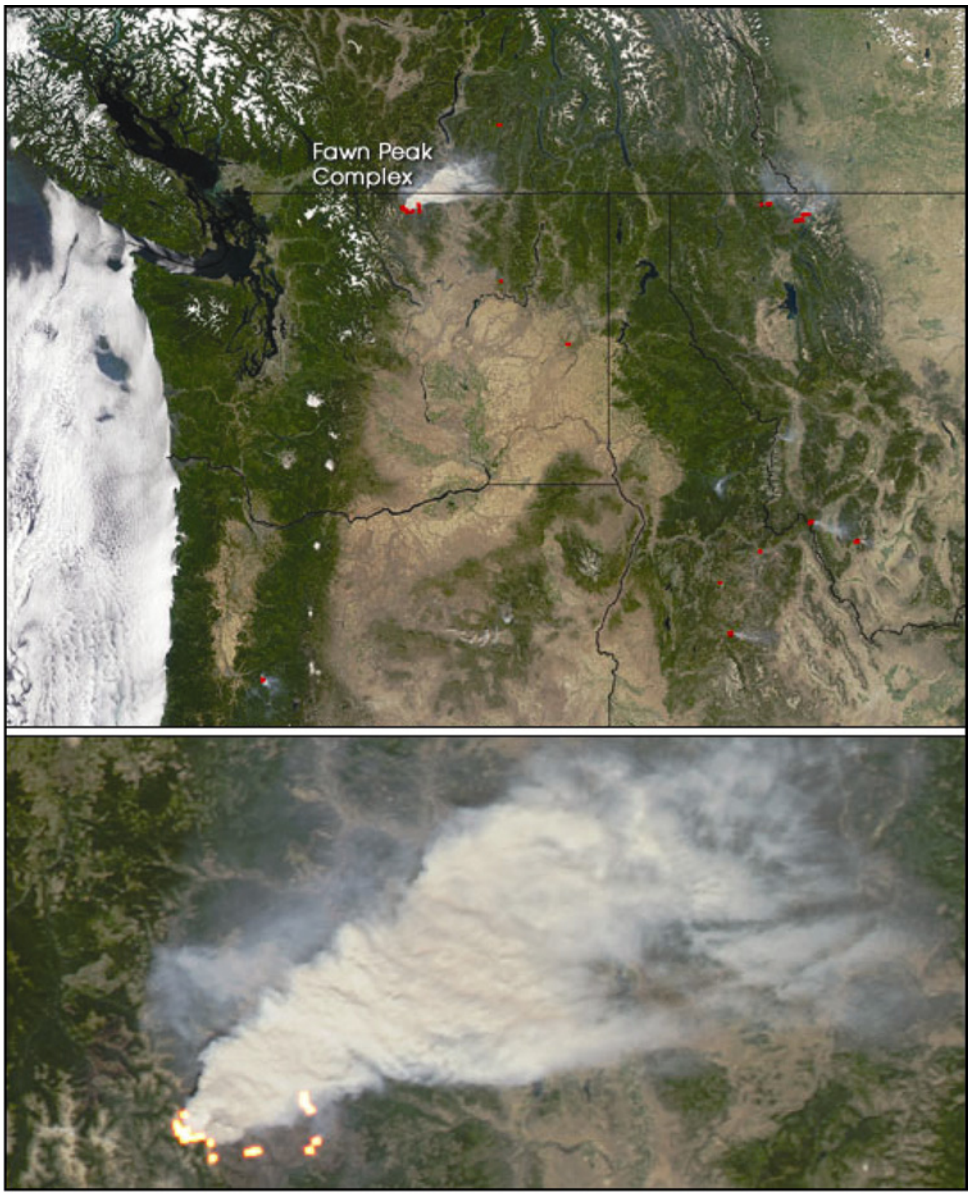


Source: National Interagency Fire Center.

Examples of Geospatial Technology Use: During-fire

During a fire, some fire responders use satellite and aerial imagery, in combination with Global Positioning System data, geographic information systems, and specialized fire behavior modeling software, to obtain information about the fire and to help plan how they will respond to it. For example, the Forest Service uses satellite data to produce images of active fires. Also, the National Interagency Fire Center manages an aerial infrared program that flies aircraft equipped with infrared sensors over large fires to detect heat and fire areas. These images contribute to the development of daily fire perimeter maps. Figure 10 depicts a satellite image of active fires. Figure 11 depicts a satellite image of a fire perimeter, and figure 12 depicts an aerial infrared image and a fire perimeter map based on that image. Some incident teams also use fire growth modeling software to predict the growth of wildland fires in terms of size, intensity, and spread, considering variable terrain, fuels, and weather. Using this information, incident managers are able to estimate short- and long-term fire behaviors, plan for potential fires, communicate concerns and needs to state and local governments and the public, and request and position resources. Figure 13 shows the output of a fire behavior model.

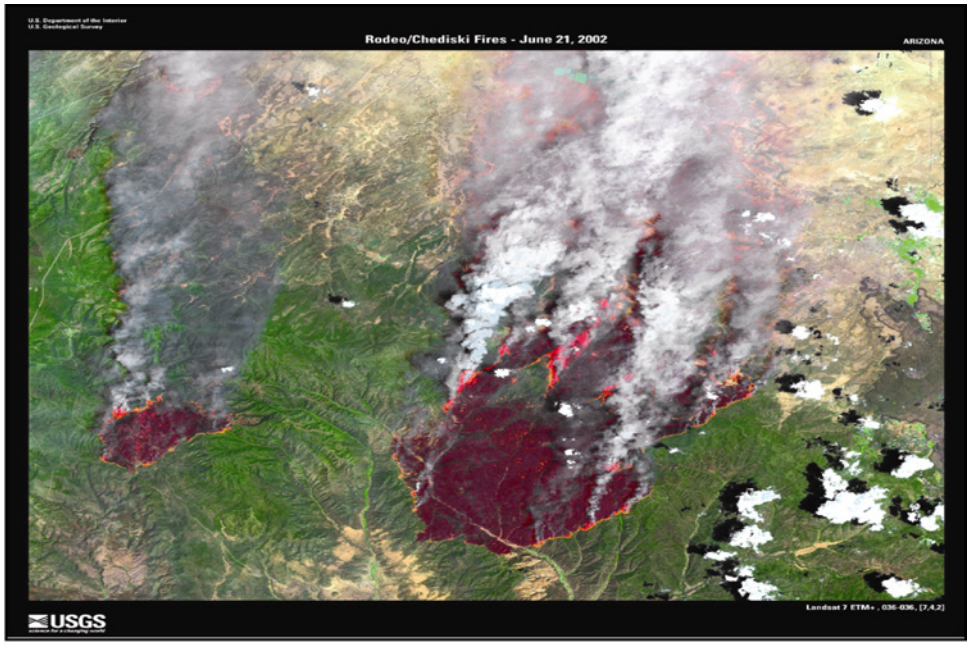
Figure 10: Satellite Images of Fires in Northwest United States, July 21, 2003



Source: National Aeronautics and Space Administration.

Note: Image from NASA's Aqua satellite, Moderate Resolution Imaging Spectroradiometer (MODIS).

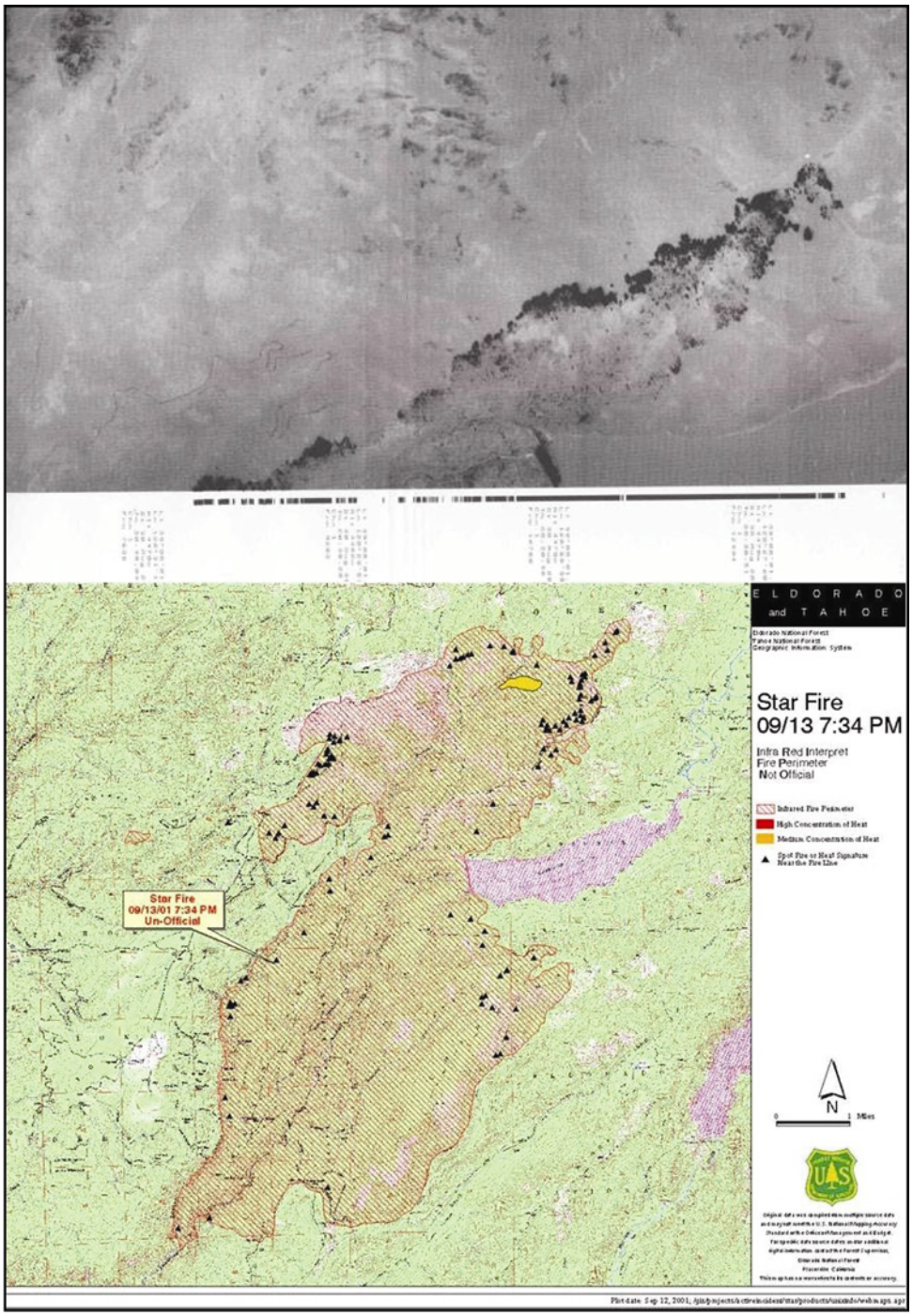
Figure 11: Satellite Image Showing Early Fire Perimeters for the Rodeo and Chediski Fires, Arizona, June 2002



Source: U.S. Geological Survey.

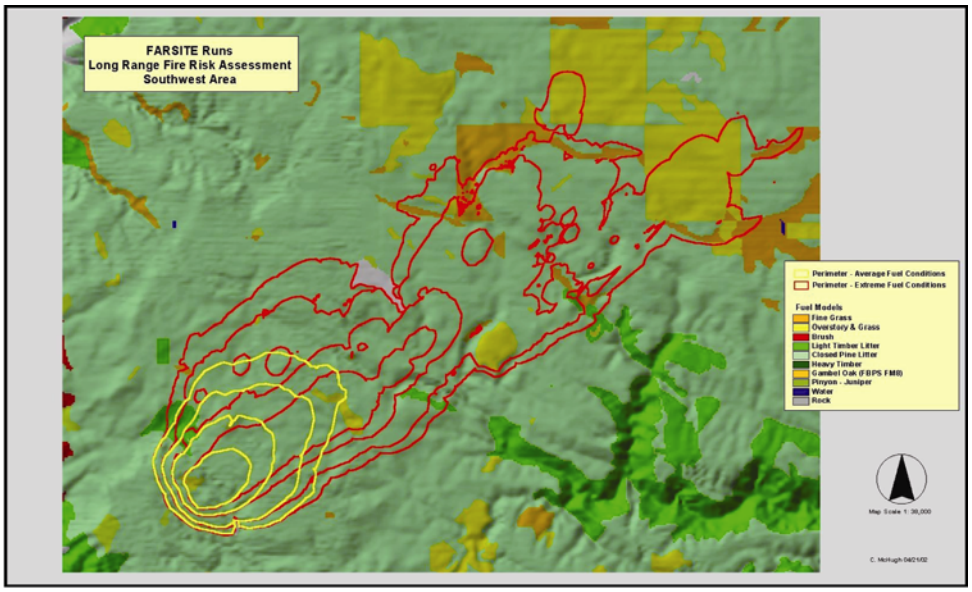
Note: Image from the U.S. Geological Survey's Landsat satellite.

Figure 12: An Aerial Infrared Image and Resulting Fire Perimeter Map



Source: Forest Service, Remote Sensing Applications Center.

Figure 13: Output of a Fire Behavior Model



Source: Forest Service, Fire Sciences Laboratory, Missoula, Montana.

Geospatial technologies are also used to provide information on active fires to the general public. The wildland fire community and the U.S. Geological Survey established an Internet Web site, at www.geomac.gov, to provide access to geospatial information about active fires. This site allows visitors to identify the location of wildland fires on a broad scale and then focus in to identify information on the location and status of specific fires. Figure 14 shows images from the Web site.

Figure 14: Internet-Based Maps of Active Fires

Source: U.S. Geological Survey.

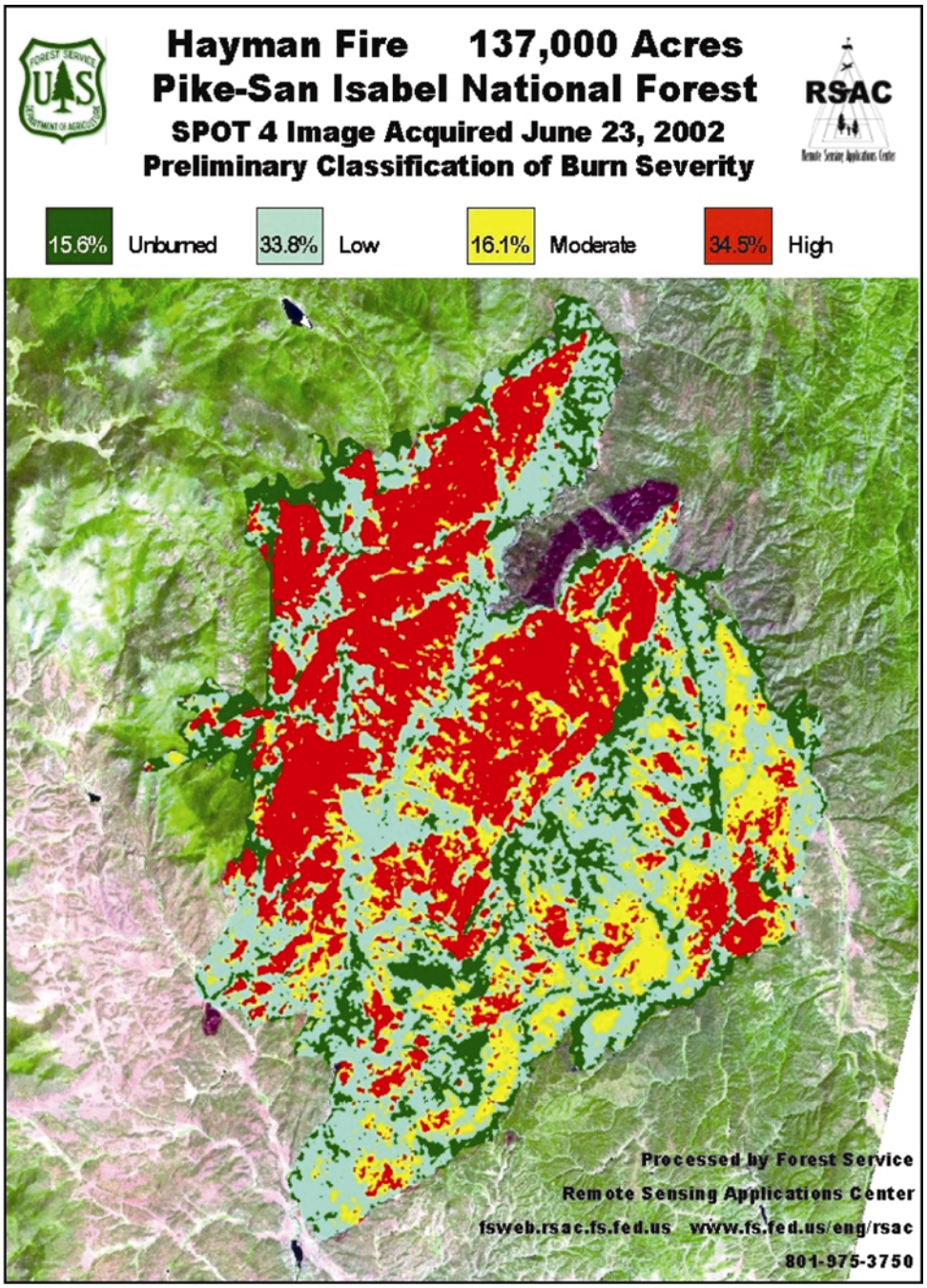
It is important to note that there are many commercial products and services available for use during a fire—ranging from high-resolution aerial and satellite imagery, to handheld Global Positioning System devices, to enhanced visualization models, to

on-site geographic information systems, equipment, and personnel. Incident commanders responsible for responding to fires often choose to purchase commercial products and services to supplement interagency resources.

Examples of Geospatial Technology Use: Post-fire

After a fire occurs, burned-area teams have recently begun to use remote sensing data in conjunction with geographic information systems to determine the extent of fire damage and to help plan and implement emergency stabilization and rehabilitation efforts. Typical products include burn severity and burn intensity maps. Figure 15 depicts a satellite image and a burn severity map showing areas that have a high priority for emergency stabilization measures. Geospatial technologies also aid in monitoring rehabilitation efforts for years after a fire to ensure that restoration plans are on track.

Figure 15: Burn Severity Map, Hayman Fire, June 2002



Source: Forest Service, Remote Sensing Applications Center.

New Uses of Geospatial Information Technologies to Aid in Wildland Fire Management Are under Development

The Forest Service and Interior are researching and developing new applications of geospatial information technologies to support business needs in wildland fire management. In addition, the Joint

Fire Science Program, a partnership of the five land management agencies and the U.S. Geological Survey, funds numerous research projects each year on fire and fuels management. Once again, these initiatives vary greatly—ranging from research on remote sensing systems to the development of interagency information systems with geospatial components, to improvements in existing software models. Examples of these efforts include the following:

- **Sensor research.** Several new research projects are under way on LIDAR and hyperspectral sensors.[4] For example, a BLM state office is researching the use of high-resolution hyperspectral and LIDAR imaging technologies for improving the identification of vegetation; planning hazardous fuels projects; and monitoring wildland urban interface projects, the effects of wildland fires, and fire rehabilitation efforts. Additionally, the Forest Service is exploring the use of mobile LIDAR systems for assessing smoke plumes, and it is conducting research on using LIDAR data, satellite data, and modeling techniques to forecast air quality after a fire.

- **Vegetation data and tools.** The five land management agencies and the U.S. Geological Survey are working together to develop a national geospatial dataset and a set of modeling tools for wildland fire planning. This effort, called LANDFIRE, is to provide a comprehensive package of spatial data layers, models, and tools needed by land and fire managers. The system is expected to help prioritize, plan, complete, and monitor fuel treatment and restoration projects on national, regional, and local scales. A prototype of the system covers central Utah and Northwestern Montana and is expected to be completed by April 2005.

- **Interagency information systems.** The five land management agencies are developing information systems for use by Interior and Forest Service offices to track efforts under the National Fire Plan. The National Fire Plan Operations and Reporting System is an interagency system designed to assist field personnel in managing and reporting accomplishments for work conducted under the National Fire Plan. It is a Web-based data collection tool with geographic information system (GIS) support that locates projects and treatments. It consists of three modules—hazardous fuels reduction, restoration and rehabilitation, and community assistance. While the agencies are currently using the system, it will not be fully operational until 2004. Another information system, the Fire Program Analysis system, is an interagency planning tool

[4] LIDAR sensors measure the reflection of emitted light; hyperspectral sensors observe data in multiple contiguous channels of the electromagnetic spectrum.

for analysis and budgeting to be used by the five federal wildland fire management agencies. The first module—preparedness—is scheduled for implementation in September 2004 and will evaluate the cost effectiveness of alternative initial attack operations in meeting multiple fire management objectives. Additional system modules are expected to provide geospatial capabilities and to address extended attack, large fires and national fire resources, hazardous fuels reduction, wildland fire use, and fire prevention.

- **Improvements in existing systems.** There are multiple efforts planned or under way to improve existing systems or to add geospatial components to systems that are currently under development. For example, researchers at a federal fire sciences laboratory are exploring possible improvements to the Wildland Fire Assessment System, an Internet-based system that provides information on a broad area of national fire potential and weather maps for fire managers and the general public. Specifically, researchers are working to develop products that depict moisture levels in live fuels, which will aid in assessing the potential for wildland fires.

The Wildland Fire Community Faces Numerous Challenges in Using Geospatial Information Technologies Effectively

There are numerous challenges in using geospatial information technologies effectively in the wildland fire community. Key challenges involve data, systems, infrastructure, staffing, and the effective use of new products and technologies—all complicated by the fact that wildland fire management extends beyond a single agency's responsibility.

- **Data issues**. Users of geospatial information have noted problems in acquiring compatible and comprehensive geospatial data. For example, GIS specialists involved in fighting fires reported that they did not have ready access to the geospatial data they needed. They noted that some local jurisdictions have geospatial data, but others do not. Further, they reported that the data from neighboring jurisdictions are often incompatible. Geospatial information specialists reported that the first days at a wildland fire are spent trying to gather the geospatial information needed to accurately map the fire. While concerns with data availability and compatibility are often noted during fire incidents, these issues are also evident before and after fire incidents. For example, we recently reported that the five land management agencies did not

know how effective their post-fire emergency stabilization and rehabilitation treatments were because, among other reasons, local land units do not routinely collect comparable information.[5] As a result of unavailable or incompatible data, decision makers often lack the timely, integrated information they need to make sound decisions in managing different aspects of wildland fire.

On a related note, the development of data standards is a well-recognized solution for addressing some of the problems mentioned above, but there are currently no nationally recognized geospatial data standards for use on fires. GIS specialists frequently cited a need for common, interagency geospatial data standards for use with fires. They noted that the land management agencies and states do not record information about fires—such as fire location, fire perimeter, or the date of different fire perimeters—in the same way.

System issues. In 1996, NWCG reported that there was a duplication of information systems and computer applications supporting wildland fire management, noting that agencies were using 15 different weather-related software applications, 9 logistics applications, and 7 dispatch applications.[6] Since that time, the number of applications has grown—as has the potential for duplication of effort. Duplicative systems not only waste limited funds, but they also make interoperability between systems more difficult.

This issue is complicated by the fact that there is no single, comprehensive inventory of information systems and applications that could be of use to others in the interagency wildland fire community. A single comprehensive inventory would allow the wildland fire community to identify and learn about available applications and tools, and to avoid duplicating efforts to develop new applications. We identified five different inventories of software applications—including information systems, models, and tools—that are currently being used in support of wildland fire management. While these listings are not limited to geospatial applications, many of the applications have geospatial components. The most comprehensive listing is an inventory managed by NWCG.

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[5] General Accounting Office, *Wildland Fires: Better Information Needed on Effectiveness of Emergency Stabilization and Rehabilitation Treatments*, GAO-03-430 (Washington, D.C.: Apr. 4, 2003).
[6] National Wildfire Coordinating Group, *Information Resource Management Strategy Project: Wildland Fire Business Model* (National Interagency Fire Center: August 1996).

This inventory identifies 199 applications used in support of wildland fire, but even this inventory is not complete. That is, it did not include 45 applications that were included in the other inventories. Additionally, it did not include 23 applications that we had identified.

Infrastructure issues. Many geospatial specialists noted that there are problems in getting equipment, networking capabilities, and Internet access to the areas that need them during a fire. For example, at a recent fire in a remote location, geospatial specialists reported that they were unable to produce needed information and maps because they had problems with networking capabilities. Again, this issue is critical during a fire, when incident teams try to set up a command center in a remote location. However, it is also an issue when federal regional managers try to obtain consistent information from the different land management agencies' field offices before or after fires. The majority of local field offices have equipment to support geospatial information and analysis, but some do not.

Staffing issues. Geospatial specialists noted that the training and qualifications of the GIS specialists who support fire incidents is not consistent. Specifically, officials noted that skills and qualifications vary widely among those who work with geographic information systems. For example, some GIS specialists are capable of interpreting infrared images as well as developing maps, but others are not. Some have experience working with GIS applications but are not specifically trained to develop GIS maps for fires.

Use of new products. While many commercial vendors are developing geospatial products and services that could be of use to the wildland fire community—including advanced satellite and aerial imaging; GIS applications and equipment; and advanced mapping products including analyses, visualization, and modeling—many have expressed concern that the wildland fire community is not aware of these advancements or has little funding for these products. Land managers acknowledged the value of many of these products, but noted that they need to be driven by business needs. Agency officials also expressed concern that the cost of these products and services can be prohibitive and that licensing restrictions would keep them from sharing the commercial data and products with others in the wildland fire community.

Clearly, effective interagency management of information resources and technology could help address the challenges faced

by the wildland fire community in using geospatial information technologies. Such an approach could address the implementation and enforcement of national geospatial data standards for managing wildland fires; an interagency strategic approach to systems and infrastructure development; a plan for ensuring consistent equipment and training throughout the wildland fire community; and a thorough evaluation of user needs and opportunities for meeting those needs through new products and technologies.

The National Wildfire Coordinating Group—comprising representatives from the five land management agencies and from other federal, state, and tribal organizations—has several initiatives planned or under way to address challenges to effectively using geospatial technologies and to improve the interagency management of information resources. However, progress on these initiatives has been slow. In our report, due to be issued in September 2003, we further discuss the use of geospatial technologies in support of wildland fire management, challenges to effectively using these technologies, and opportunities to address key challenges and to improve the effective use of geospatial technologies. We will also make recommendations to improve the use of geospatial technologies in support of wildland fire management.

In summary, the federal wildland fire management community is using a variety of different geospatial technologies for activities throughout the fire management life cycle—including identifying dangerous fuels, assessing fire risks, detecting and fighting fires, and restoring fire-damaged lands. These technologies run the gamut from satellite and aerial imaging, to the Global Positioning System, to geographic information systems, to specialized fire models.

Local land managers and incident teams often acquire, collect, and develop geospatial information and technologies to meet their specific needs, resulting in a hodgepodge of incompatible and duplicative data and tools. This problem is echoed throughout the fire community, as those who work with different aspects of fire management commonly cite concerns with unavailable or incompatible geospatial data, duplicative systems, lack of equipment and infrastructure to access geospatial information, inconsistency in the training of geospatial specialists, and ineffective use of new products and technologies. These challenges illustrate the need for effective interagency management of

information technology and resources in the wildland fire community. We will report on opportunities to improve the use of these technologies in our final report.

This concludes my statement. I would be pleased to respond to any questions that you may have at this time.

Contact and Acknowledgements

If you have any questions on matters discussed in this statement, please contact David Powner at (202) 512-9286 or by E-mail at pownerd@gao.gov, or Colleen Phillips at (202) 512-6326 or by E-mail at phillipsc@gao.gov. Individuals making key contributions to this statement include Barbara Collier, Neil Doherty, Joanne Fiorino, Chester Joy, Richard Hung, Anjalique Lawrence, Tammi Nguyen, Megan Secrest, Karl Seifert, Lisa Warnecke, and Glenda Wright.

Appendix I: Objectives, Scope, and Methodology

Our objectives were to provide an overview of key geospatial information technologies for addressing different aspects of wildland fire management and to summarize key challenges to the effective use of geospatial technologies in wildland fire management. To accomplish these objectives, we focused our review on five key federal agencies that are responsible for wildland fire management on public lands: the Department of Agriculture's Forest Service and the Department of the Interior's National Park Service, Bureau of Land Management, Fish and Wildlife Service, and Bureau of Indian Affairs.

To identify key geospatial information technologies for addressing different aspects of wildland fire management, we assessed policies, plans, and reports on wildland fire management and technical documents on geospatial technologies. We assessed information on Forest Service and Interior efforts to develop and use geospatial technologies. We also interviewed officials with the Forest Service and the Interior, interagency organizations, commercial vendors, and selected states to determine the characteristics and uses of different geospatial technologies in supporting different phases of wildland fire management. In addition, we met with officials of other federal agencies, including the Department of the Interior's U.S. Geological Survey, the Department of Defense's National Imagery and Mapping Agency, the National Aeronautics and Space Administration, the Department of Commerce's National Oceanic and Atmospheric Administration, and the Department of Homeland Security's Federal Emergency Management Agency, to identify their efforts to develop geospatial information products in support of wildland fire management.

To summarize key challenges to the effective use and sharing of geospatial technologies, we reviewed key reports and studies on these challenges. These include the following:

Burchfield, James A., Theron A. Miller, Lloyd Queen, Joe Frost, Dorothy Albright, and David DelSordo. *Investigation of Geospatial Support of Incident Management.* National Center for Landscape Fire Analysis at the University of Montana. November 25, 2002.

Committee on Earth Observation Satellites, Disaster Management Support Group. *The Use of Earth Observing Satellites for Hazard Support: Assessments & Scenarios.* National Oceanic and Atmospheric Administration, n.d.

Department of Agriculture (Forest Service) and Department of Interior. *Developing an Interagency, Landscape-scale Fire Planning Analysis and Budget Tool.* n.d. [December 2001].

Fairbanks, Frank, Elizabeth Hill, Patrick Kelly, Lyle Laverty, Keith F. Mulrooney, Charlie Philpot, and Charles Wise. *Wildfire Suppression: Strategies for Containing Costs.* Washington, D.C.: National Academy of Public Administration, September 2002.

Fairbanks, Frank, Henry Gardner, Elizabeth Hill, Keith Mulrooney, Charles Philpot, Karl Weick, and Charles Wise. *Managing Wildland Fire: Enhancing Capacity to Implement the Federal Interagency Policy*. Washington, D.C.: National Academy of Public Administration, December 2001.

National Oceanic and Atmospheric Administration. *Wildland Fire Management: Some Information Needs and Opportunities.* Working paper, National Hazards Information Strategy, July 2002.

National Wildfire Coordinating Group. *Information Resource Management Strategy Project: Wildland Fire Business Model.* National Interagency Fire Center. August 1996.

National Wildfire Coordinating Group, Information Resource Management Working Team, Geospatial Task Group. *Geospatial Technology for Incident Support: A White Paper*. April 12, 2002.

We also interviewed federal officials from interagency wildland fire groups including the national fire directors, the National Wildfire Coordinating Group's (NWCG) Information Resource Management (IRM) working team, NWCG's IRM program management office, the IRM working team's geospatial task group, and the Wildland Fire Leadership Council to discuss challenges and ongoing efforts to address these challenges. In addition, we reviewed post-fire reports on the Hayman, Biscuit, and Cerro Grande fires to identify how geospatial technologies were used on these fires and to evaluate any challenges the incident teams may have encountered in using these technologies. We attended federal and commercial conferences on geospatial information technologies, interviewed representatives from selected states and commercial vendors, and

observed group discussions on challenges in effectively using these technologies and plans for addressing them.

We conducted our review at the federal agencies' headquarters in Washington D.C., the Forest Service's Remote Sensing Applications Center and Geospatial Service and Technology Center in Salt Lake City, Utah; the U.S. Geological Survey's Rocky Mountain Mapping Center in Denver, Colorado; the U.S. Geological Survey's Earth Resources Observation Systems Data Center in Sioux Falls, South Dakota; the National Interagency Fire Center in Boise, Idaho; and the Forest Service's Rocky Mountain Research Station, Fire Sciences Laboratory in Missoula, Montana.

Forest Service and Interior officials generally agreed with the facts as presented in this statement and provided technical corrections, which we have incorporated. We conducted our work supporting this statement and our overall report between October 2002 and August 2003, in accordance with generally accepted government auditing standards.

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