Geospatial Technology in Wildland Fire: FIRES Final Needs Assessment Report

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October, 2003

SUGGESTED CITATION

Warnecke, Lisa, Emily Constantine Mercurio, Susan E. McLellan, Nan Johnson and Rebecca Wallace, 2003. *Geospatial Technology in Wildland Fire: FIRES Final Needs Assessment Report*. Auburn, New York: Institute for the Application of Geospatial Technology.

KEYWORDS

Wildland fire, wildfire, fire policy, forestry, natural resources policy, public lands policy, intergovernmental relations, geographic information technology, geographic information systems, GIS, remote sensing, satellite imagery, global positioning system, GPS, geospatial data.

CREDITS AND DISCLAIMER

This material is based upon work supported by the National Aeronautics and Space Administration under award No. NAG5-10051. Any opinions, findings, conclusions or other statements expressed in this material are solely those of the authors and do not necessarily reflect the views of the National Aeronautics and Space Administration.

Due to the quickly-changing nature of various websites referenced in this report, some HTTP locations may not be accurate over time.

PREFACE

The United States faces unprecedented challenges concerning wildland fire. Trends clearly indicate increasing costs and growing risks to life and property as development increases in wildland areas. Wildfire management is increasingly complex to direct, manage and fund, not only for suppression and response, but also for wildfire mitigation, preparedness and recovery. Traditionally directed by the federal government with state government participation, new approaches also must effectively engage local governments, other stakeholder organizations and the public. Growing challenges also demand the combined wisdom of past approaches with deployment of modern methods and resources.

Geographic or geospatial information and related technology (GI/GIT) is increasingly used and recognized as an unprecedented perspective and resource to modernize and improve government effectiveness. Its unprecedented value is most marked when multiple organizations, competing interests and other complex challenges are involved, and particularly when time is of the essence. As indicated in this report, wildland fire management is a leading example of how GI/GIT makes a difference.

Technological advances promise to further help the fire community enhance firefighter and public safety; strategic, management and tactical decision making; deployment of resources, understanding and prediction of fire behavior and effects, and development and implementation of approaches to best mitigate, plan and prepare for, and recover from wildfires. Yet, as also discussed in this report, the fire community has increasing challenges to institutionalize GI/GIT. Moreover, the fire community continues to have data reporting, management and accountability issues that could be aided with more effective use of GI/GIT.

This report was prepared by GeoManagement Associates, Inc. (GMA) under contract to and with the Institute for the Application for Geospatial Technology at Cayuga Community College (IAGT) for the Rochester Institute of Technology (RIT) Chester F. Carlson Center for Imaging Science. It was prepared for the Forest Fire Imaging Experimental System (FIRES) project, which was funded by the National Aeronautics and Space Administration under award No. NAG5-10051.

The report represents the Final Needs Assessment for FIRES, but it also was designed to inform the overall wildland fire community and to help address these matters. In particular, it should help respond to increasing needs for policy and strategic direction and action regarding GI/GIT in wildland fire, such as indicated by the U.S. General Accounting Office in its September, 2003 report on this topic (GAO-03-1047). The report does not intend to, nor does it provide recommendations. Instead, experiences, issues, ideas and suggestions are provided as input to future efforts.

Because of their work and experience with federal, state, local, regional and tribal governments, RIT asked IAGT and GMA to prepare this document. IAGT is a not-for-profit organization whose mission is to develop, plan, enhance, distribute, coordinate and promote NASA and other geospatial data and technology for educational, environmental and economic benefits. The application of GIT is the foundation for all work done at the IAGT. These technologies include remote sensing, geographic information systems, global positioning systems, digital elevation models, and 3-dimensional, interactive visualization of these technologies. IAGT provides GIT products and services to the government, educational, and commercial sectors. GMA provides research, consulting and policy advice regarding GI/GIT about and for all levels of government in the United States.

Beginning with the FIRES project in 2001, RIT's Chester F. Carlson Center for Imaging Science has requested input from and supported investigation about the wildland fire community for its related work. The FIRES objective was to investigate the fundamental science behind wildland fires, and to establish the feasibility of observing fires from remote platforms using near infrared and thermal remote sensing. While the FIRES project ends in 2003, RIT continues to be involved in the development wildfire remote sensing technologies, and is currently developing tools for a next-generation, tactical airborne wildfire detection system.

Emily Constantine Mercurio served as project manager for this project at IAGT. Dr. Lisa Warnecke, GMA President, served as lead report author with assistance from IAGT and selected others with subject matter expertise to help prepare and contribute to this report.

LEAD AUTHOR'S NOTE AND ACKNOWLEDGEMENTS

This report culminates investigation about and interaction with the wildland fire community in the United States for almost four years. The information presented and contained within this document was obtained through collection and review of documents, attendance at meetings and other events, formal and informal discussions with members of the wildland fire community and others, and subsequent evaluation of these findings. Many efforts have been made to ensure the accuracy, currency and completeness of the information provided, but sincere apologies are offered for any errors, omissions or misinterpretations. The report is solely the responsibility of the authors.

Though relatively new to wildland fire management, this work has been very rewarding. I quickly gained a unique and deep respect for the exemplary tradition of wildland fire fighting in the country, and particularly the individuals dedicating themselves to this work. Firefighters are often appropriately recognized for the adversity and risks they often face. Also deserving strong commendation are the professionals who regularly conquer formidable challenges to effectively apply GIS, remote sensing, GPS and related data for wildland fire management, whether in response, or mitigation, preparedness or recovery.

Successful use of these technologies is testimony of the perseverance, tenacity and dedication of public servants working with GI/GIT in fire, regardless of their employer. Many thanks are offered to the countless individuals who helped me understand many complex and difficult challenges and issues. This report would not have been possible without the help of these individuals, located throughout headquarters, regional and field offices of several federal agencies, and also several State Foresters and others in the nation's State Forestry Organizations with wildland fire responsibilities. I also thank Joe Frost, Fire GIS Coordinator at the U.S. Forest Service for the two diagrams uniquely shown in this report.

This work has been aided by exemplary co-authors. Much sincere thanks is offered to Emily Constantine Mercurio, Susan McLellan, Nan Johnson, and Rebecca Wallace, who each provided unique knowledge and experience to improve the report. Many thanks also are offered to Robert Brower and Dana Piwinski at IAGT, and Tony Vodacek and Mike Richardson at RIT, for asking us to conduct this work.

Additional thanks are offered to Colleen Phillips of the U.S. General Accounting Office and Bruce McDowell of the National Academy of Public Administration. Service as a consultant to these organizations added unique opportunities and insight to help. Several other organizations are cited individually in the text and for many of the figures, and are also acknowledged and thanked.

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1.0 INTRODUCTION

The purpose of this report is to aid both the Center Chester F. Carlson Center for Imaging Science at Rochester Institute of Technology (RIT) in its work related to wildland fire, and the wildland fire community in general. It describes:

- key directives; local, state, federal and other stakeholders; and interorganizational mechanisms regarding and impacting all phases of wildland fire in the United States, and
- experiences, approaches, issues, needs, opportunities and suggestions concerning geographic or geospatial information and related technology (GI/GIT) in wildland fire.

While the report meets its intended use for the FIRES project at RIT, it also uniquely combines the policy, management and programmatic contexts in which GI/GIT operates for wildland fire to inform (1) wildland fire and other government policy makers and managers, (2) GIT and other IT professionals, and (3) practictioners working in wildland fire and related areas. It was designed in particular to help the fire community respond to increasing needs for policy and strategic direction regarding GI/GIT in wildland fire, and to strengthen collaboration among the fire community and with others, such as the broader emergency management and homeland security community, and the growing number of individuals and organizations that develop and utilize GI/GIT.

1.1 OVERVIEW OF REPORT

This report begins with general and recent information about the many wildland fire conditions and issues that face fire and other government leaders in the United States today. Chapter 2 provides an overview of key policy direction; federal, state, local and other stakeholders; interorganizational arrangements and other relationships, and associated governing issues to date in the wildland fire community.

The following four chapters are organized by the phases of emergency management as they apply to wildland fire management. Chapter 3 addresses wildland fire mitigation, planning, and preparedness, a topic of increasing attention and concern. Chapter 4 provides an overview of detection activities and needs in the fire community. Chapter 5 addresses response resources, systems and activities that are undertaken for response and management of wildland fire incidents and effects. Chapter 6 includes recovery activities that are undertaken to assess, restore and rehabilitate a burned or impacted area or community after a wildland fire has occurred. This includes damage assessment and monitoring of these fire effects, and mitigating future fire effects in these areas.

Chapter 7 provides several policy, management, resource and other issues, needs and suggestions based on the findings in the report that face wildland fire management. This report is complemented by the report of a Fire Science Workshop, which was sponsored by the Rochester Institute of Technology (RIT) in November, 2001 (Vodacek, 2002).

1.2 KEY WILDLAND FIRE ISSUES TODAY

As shown in Figure 1-1, wildland fires in the United States have been increasing in their occurrence, size and severity. Records and research also show that the risk and cost of large wildland fires is growing sharply, particularly over the last decade. Moreover, it is commonly recognized that more fires occur than are reflected in these figures. Many small fires are quickly extinguished, and are never reported to state or federal officials.

Attention and concern has been growing across the nation, beginning in the western states. Wildland fire is one of the most critical, complex and controversial public policy issues facing our society. Many fire issues today focus on the tradeoffs between the goal of maintaining fire adapted ecosystems, the need to protect the public and human settlements that are growing near wildlands, and how and when government should act or not act in these regards.

Total Fires and Acres Burned

Year	Fires	Acres
2002	88,458	6,937,584
2001	84,079	3,555,138
2000	122,827	8,422,237
1999	93,702	5,661,976
1998	81,043	2,329,709
1997	89,517	3,672,616
1996	115,025	6,701,390
1995	130,019	2,315,730
1994	114,049	4,724,014
1993	97,031	2,310,420

Figure 1-1. Total Fires and Acres Burned, 1993 to 2002

Many wildlands, and particularly forests, are commonly considered to have unnaturally high fuel loads, such as dead trees and dense undergrowth, due in part to past land management and fire suppression policies and approaches. These conditions, along with an unnatural mix of plant species due to the spread of exotics and disease, are sometimes collectively referred to as "unhealthy", a term used to characterize forests and other wildlands. Regardless of how or why wildland fires start or grow, they threaten human lives and safety, wildlife and other natural resources, valued properties, and utility lines and other infrastructure. It is increasingly recognized that several and extensive efforts are needed before, during and after fires so that proper and effective management and emergency response can be provided.

Populations that once resided outside of wildland areas are moving into forested and other wildland areas. These locations have become known as the wildland-urban interface (WUI), which is defined as the transition zone between typically wooded, rural areas and homes that lie on the outskirts of developed areas. However, this term, is somewhat misleading in that many of these areas are very rural, rather than urban. Areas classified as WUI can be as small as just a hand full of structures. Whether impacting such rural or urban areas, wildland fires are expected to grow and become increasingly hazardous and costly in WUI due to current population and development trends. Increasing growth in these interface areas and the growing incidence of large fires demand increased public and governmental attention and action, including determination and implementation of effective approaches to mitigate, prevent and prepare for wildfires, as well as to respond to them with minimal loss of life and property. Increasing risk of WUI fires also demands better governmental capabilities to understand such fires in order to establish effective approaches.

Wildfire costs grow correspondingly with the incidence and severity of wildfire, particularly in these WUI areas and in terms of direct costs for suppression as well as indirect costs. As discussed in Chapter 2, the most costly fire suppression year to date was 2002, with costs exceeding $1.6 billion. This compares to an average of far less than $1 billion in past years, and particularly prior to the noteworthy 2000 season. Most of these costs are due to large escaped fires, though only 1 or 2% escape control and cause the majority of damage and costs. Of the fires reported in 2000, only 1% was larger than 100 acres, but they accounted for approximately 93% of the total acres burned. In 2002, 615 escaped control, and over $1 billion was spent on them alone. It is very clear that large escaped fires represent the most concern, and by far, the greatest costs. Policy leaders and the public are increasingly asking for more understanding and accountability about these costs. As a result, Congress has asked both the U.S. General Accounting Office (GAO) and the National Academy of Public Administration (NAPA) to investigate related matters, with NAPA recently conducting a dedicated study in this regard (NAPA, 2002).

Costs of fires can go beyond suppression and response to also include significant rehabilitation and recovery work. In addition, indirect fire costs, such as fiscal impacts on businesses, and economic, social and health impacts on residents also are increasingly recognized and add to the complexity of wildland fire issues and decision-making. The 2000 fire season stands out in this regard because of its multiple impacts on nearby rural areas. In Idaho alone, businesses lost over $50 million as a result of wildfires, and Montana businesses lost approximately $3 million per day during the tourist season. Additional costs also were experienced in terms of agricultural loss and watershed restoration costs. Moreover, ecosystems are often detrimentally altered in significant ways. For example, cheat grass and similar non-native species that create an increased fire risk and disrupt natural systems often establish themselves in burned areas, increasing the danger of future wildfires.

Significant questions and issues continue today about the ability to adequately understand the impact of weather, topography and other variables on the behavior, outcome and impact of fires, and how to make critical decisions on how and where to suppress or manage fires. As revealed in part by remote sensing (see Chapter 6), some of the acres included in fire statistics as being burned (as determined by fire perimeters) may not burn severely or at all. For example, as shown in Figure 1-2, five of the most well known and threatening large fires in 2002 had relatively small areas of high burn severity. The largest, the Biscuit fire in Oregon, had 61% of its area (over 300,000 acres) covered by low burn severity or was unburned. Improved understanding of burn severity conditions on all fires can have important implications in future fire management matters and issues, both during and after the fire. Drought conditions, which are particularly severe in recently years compared to past decades, can have increasing and unprecedented influence on fire.

	Rodeo-Chediski	**Hayman**	**Missionary Ridge**	**McNally**	**Biscuit**
State	Arizona	Colorado	Colorado	California	Oregon
Location	Fort Apache Indian Reservation	Pike-San Isabel National Forest	SW, 5 miles north of Durango	12 miles north of Kernville	SW Oregon, Northern CA
Federal Lands	Apache and Sitgreaves	Pike-San Isabel National Forest	San Juan NF, BLM, BOR	Sequoia, Inyo, Giant Sequoia National Monument	Siskiyou and Six Rivers National Forests
Cause	Human (possibly arson)	Human, Arson	Human, accidental	Human	Lightning
Area	462,614 acres	137,860 acres	73,391acres	150,670 acres	500,000 acres
Structures Lost	426 Structures	133 Homes, 1 Commercial Building, 466 Outbuildings	83 Structures	14 Structures	4 Homes, 9 Outbuildings, 1 Lookout and several Recreation Sites
Ownership	38% within NF, 60% Reservation	72% National Forest	94% National Forest	Not Given	99% National Forest
Landscape	Chaparral, Ponderosa Pine, Juniper	Rugged terrain of Ponderosa Pine, Mixed Conifer, Oak	Ponderosa Pine, Mixed Conifer	Mixed Conifer, Heavy Brush, Grass, Fir Stands	Forested and Wetland Areas
Suppression Cost (in millions)	~153	~39.9	~39.9	~45.7	~153
Fire Severity Based on BAER Analyses	51% med or low	32% high	Not Given	9% high	16% high

Figure 1-2. Comparison of Five Large Fires in 2002
Courtesy of Greg Aplet, The Wilderness Society

Federal, state and local wildland fire policies, particularly those detailing protocols for when to suppress or let fires burn, are increasingly debated and controversial, and are now a growing part of broader debates about environmental policies. Debate on fire management issues and approaches is complicated by additional issues regarding the use of government-issued "prescribed fires" (i.e., the deliberate application of fire to wildlands for management purposes). Inherent risks in using this approach have raised questions and have caused debate about when to perform prescribed burns or when to let fires burn. Growing societal concerns about fire effects on air and water quality, erosion, watershed health, and other conditions are even more critical when caused by government direction and action.

Wildfire management is increasingly complex to direct, organize, fund and implement. Not only is this true for suppression and overall response, but also for wildfire mitigation, preparedness and recovery. As discussed in Chapter 2, the number of participants and stakeholders is large and diverse, including several federal agencies, all state governments, many local governments and others. As a result, roles, policies, approaches and intergovernmental arrangements differ widely across the country. This is particularly important because most fires are not on federal land, with over 70% of the reported fires typically on state, tribal or private lands. The states are responsible for fire protection on private lands as well as on the lands they manage, and local governments also have important fire response and management roles in many areas. GAO has investigated and has made recommendations about these and several of the other issues described above in reports issued in recent years.

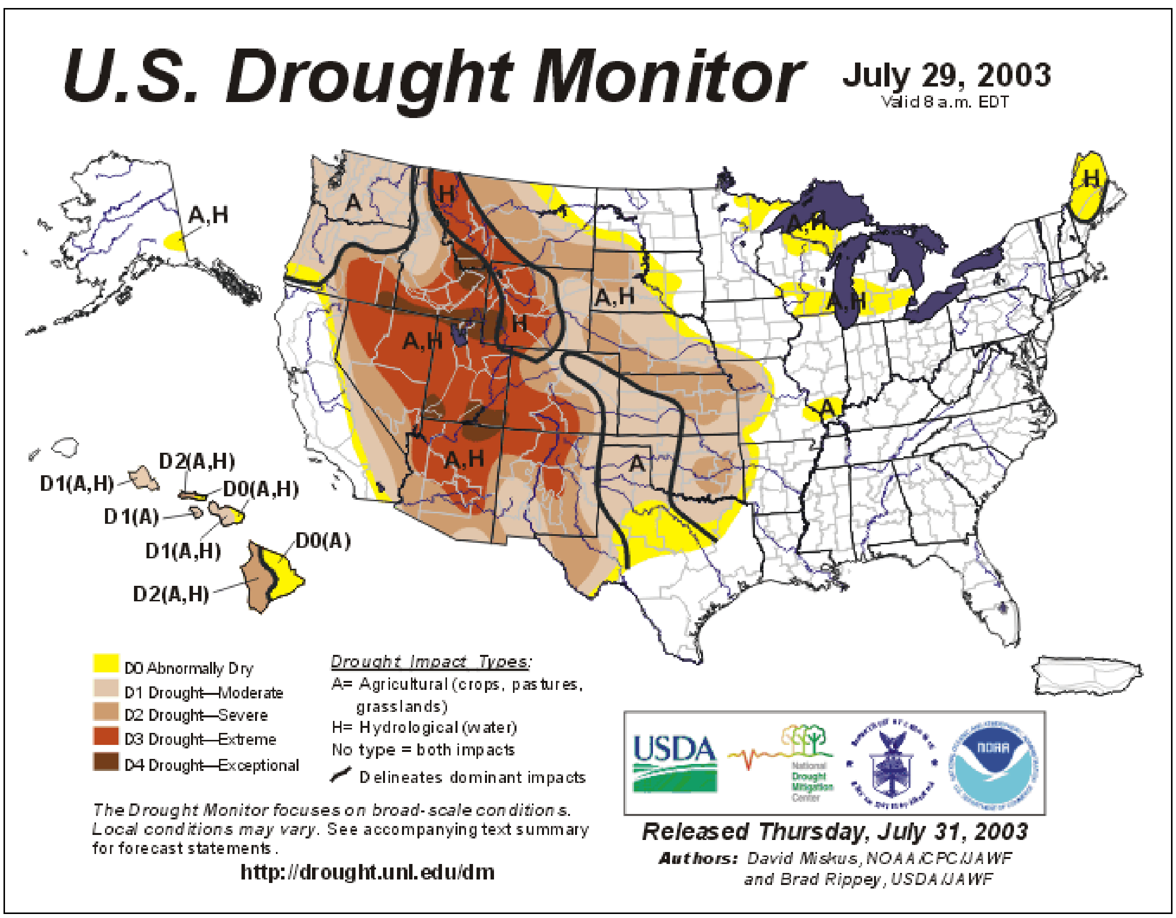

Figure 1-3. U.S. Drought Monitor Example

The overall size and severity of fires in the 2003 and future fire seasons is unpredictable. Much of the nation faces record-breaking drought conditions, as shown in Figure 1-3, which can have many unprecedented impacts on fire conditions. This is true particularly in areas in and near the Rocky Mountains, where some conditions are worse that they have been in decades. Very high to extreme fire indices have been reported this year in 15 states. Many parts of the West also experienced record-breaking heat this summer. As of August 1, all of the large fires and losses were located in the West, as shown in Figure 1-4. Some firefighters have lost their lives, including two helicopter crashes in late July. Despite these conditions, many of the season's fires are being managed for fire use, to allow fire to burn naturally in wildland areas.

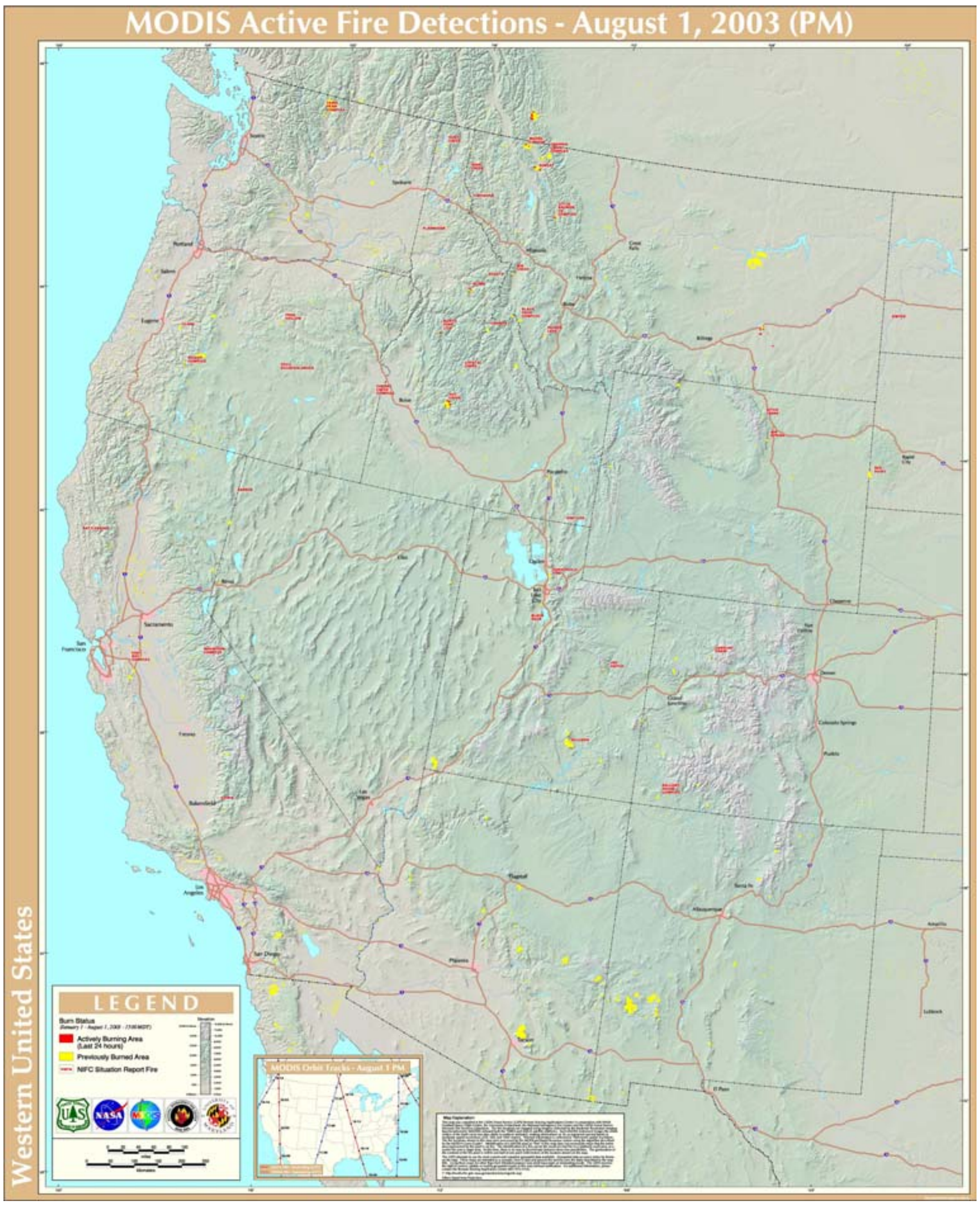

Figure 1-4. MODIS Active Fire Detections Example

1.3 GENERAL GI/GIT RESOURCES AND USES FOR WILDLAND FIRE

Advances in geographic or geospatial information and related technology (GI/GIT) are increasingly recognized as valuable assets and resources for many aspects of fire management. These technologies are beginning to be understood as useful for increasing the knowledge and effectiveness of fire leaders. In fact, developments in geospatial modeling and communications technology "have changed how we perceive the process of wildfire and how we manage it" (Goldberg, Neuenschwander and Ryan, 2001).

In this report, the acronym "GIT" is used to include remote sensing, geographic information systems (GIS), and use of the global positioning system (GPS). "GI" is used to include the data and information that can be referenced to some point or location on the earth, and is derived, managed or otherwise used with these technologies.

GI/GIT has proven useful in all phases of wildland fire management, as described in the following chapters. It is increasingly used - and is increasingly expected to be used, particularly during large fires. However, despite advances, GI/GIT usage in wildland fire has generally been inconsistent and lacking in standardized approaches and processes across agencies and governmental units. Moreover, as revealed in this report, many more opportunities exist for wildland fire management and various stakeholders to better incorporate these resources into planning, management and operational processes, as well as into overall decision-making. Lessons learned from GI/GIT adoption in many other settings and application areas show that policy direction, institutionalization and standardization are leading factors in influencing the effective use and outcomes of GI/GIT usage within one or a combination of organizations.

1.3.1 Geographic Information Systems

Geographic Information Systems (GISs) are widely used in almost every government-funded fire management effort by some fire organization in some capacity. A GIS can be defined as a computer system that is designed to assemble, store, retrieve, manage, manipulate, analyze and display data that can be referenced to a location on the Earth. GIS also can be considered to encompass the broader resources required for achieve this functionality, including hardware, software, data and personnel.

GIS has the unique capability to combine and enable users to understand otherwise disparate data referenced by location in disparate databases; whether they be in map, chart or table form. Vast quantities of data with a geographic component can be incorporated into "one view" to allow the operator to perform analyses on these data and the relationships between different data sets. Increasingly recognized as a unprecedented tool to "model reality", some government leaders are beginning to use GIS to study, understand, make decisions and communicate past, current, and anticipated conditions to the public, elected and policy officials, and staff, often in real time. As stated by Maryland State Forester Steve Koehn, "a picture is worth a 1000 words, but a map is worth a 1000 pictures" (Koehn, 2003).

One example of how fire management uses GIS at a strategic and policy level is when land cover maps, fuel load maps, moisture indexes, weather conditions, human settlements and other data are analyzed together to help determine or predict the location of high-risk, fire-prone areas. Providing that these data are frequently updated and in a compatible digital format, such analyses can be done nearly automatically and in real time. This information can then be distributed widely and used to improve effectiveness and safety, and to evaluate and make key management decisions and critical trade-offs based on evaluations of potential scenarios and impacts.

Data used with GIS comes in many forms and from a variety of government, research, private sector, non-governmental, and other sources. The federal government is commonly recognized as one of the largest users of GIS and associated data worldwide, and is a large developer and provider of data. Data resources of the land and fire management agencies are complemented by data from the U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA) and others.

However, as demand grows for better GIS data precision and currentness, state and particularly local government data resources are increasingly recognized as critically important, especially near developed areas, frequently termed the “Wildland Urban Interface” (WUI). Data from researchers, private vendors and non-profit organizations, are usually provided in response to specific project needs. New GIS data can also be created through the individual and combined use of remote sensing, photogrammetric techniques, traditional surveying and GPS, which shall be discussed in the following sections.

1.3.2 Remote Sensing

Remote sensing is more difficult to define than GIS, as it is both a science and a tool. Remote sensing is the process of determining properties of objects without contact, usually by measuring and recording images based on electromagnetic energy that has interacted with the objects. Remote sensing has included aerial photography for decades, but also includes space-based and airborne platforms that fly with one or more electronic sensors on board. The sensors involved in remote sensing can collect imagery and other data in nearly any wavelength of the electromagnetic spectrum and at many different levels of spatial resolution.

Typically, fire management needs visual and thermal infrared data that can be represented as images. Fire managers also need to have data that is spatially accurate and fine enough to see small fires and the exact location of them. The spatial resolution of satellites is generally less than that of aerial instruments, but their advantage is that the data is of lower cost. In addition, some satellite systems provide near-continuous data collection over the same geographic area. The advantage of aerial-borne remote sensing instruments is that they generally have greater spatial resolution and are calibrated in the thermal wavelengths especially sensitive to fires. These sensors are typically flown at night to detect “hot spots” on the ground less than 12 inches in size.

Remote sensing also involves the manipulation of images to derive useful information, including data sets that can be used with GIS. Features of interest, like roads, urban areas, forests, and other land cover types can be identified in and extracted from remotely sensed imagery. Once extracted from the image, these areas of interest are used to create lines, points, or polygons that represent that particular land cover. These lines, points, or polygons and the geographic coordinates or other information attributed to them can then be imported into a GIS and used in various analyses. Satellite remote sensing and aerial photography have often been synthesized and used to create topographic maps, road maps, USGS maps, and many other familiar map products used in the fire management community.

Remote sensing can also be used to determine moisture content of vegetation based on the collection of near-infrared data. A clear distinction can be made between high and low moisture levels. This capability has many applications for the fire management community, as it is able to identify different vegetation types and vegetation moisture levels based on unique infrared signals that have been identified for those plant species.

Weather data is also a product of satellite-based remote sensing. Many weather satellites are in a fixed position above Earth, and are known as geostationary satellites. These types of satellites have often been used to not only check forecasts for storms and potential lightning strikes, but to also detect and monitor fires in near real-time. However, the current constellation of geostationary satellites being used generally have spatial resolutions from 250 to 1000 meters per pixel, which may be too coarse for detecting smaller fires.

Remote sensing can also be used in the development of elevation models. Traditionally, elevation data was created through aerial photograph stereo pairs, which are used to calculate the amount of offset and parallax to derive elevation measurements at any point on the ground, with an accuracy of a few centimeters. New technologies, such as RADAR (Radio Detection and Ranging) and more recently, LIDAR (Light Detection and Ranging), use an active airborne sensor to measure the return rate of a signal produced by the sensor. The rate of return is then synthesized to obtain the elevation of points on the ground off of which the active signal was “bounced”. The accuracy of these systems is not quite that of traditional stereo-pair derived measurements, but often suits the needs of fire management where accuracy of less than ten meters are often acceptable. Elevation models derived from RADAR and LIDAR sources are generally lower in price than traditional photogrammetric methods, and can provide a product delivery of a few days. This is significantly faster than time-intensive photogrammetric methods, which can take weeks or months depending on the size of the area.

1.3.3 Global Positioning System

The Global Positioning System (GPS) is a system operated and maintained by the U.S. Department of Defense and is based on a constellation of satellites maintained in precisely known Earth orbits. Ground-based electronic receivers determine locations (coordinates) on the Earth's surface using information radioed form multiple satellites that are in view of the receiver. Widespread use of GPS receivers is becoming more common, as they are typically small, inexpensive instruments capable of locating their exact position on the ground, based on the triangulation of locations obtained from GPS satellites in Earth's orbit.

GPS can be used in several ways. When placed on board airplanes used for hot spot reconnaissance, it can be used to help fire management obtain precise locations of these hot spots and deploy resources to a specific location. It can also be used on the ground to help guide fire fighters to safe locations when fighting fires. This is particularly beneficial for smokejumpers that often lack adequate positional information and maps that might otherwise help them contain or suppress a fire, and also help guide them to safety.

GPS also can be used to assist in the creation and update of GIS data. For example, fire perimeters and road lines are features that often change over time. When updated maps of these features are needed, it is sometimes cost-prohibitive and too time-intensive to deploy traditional surveys or to fly aerial photographs used to create a base map. Instead, a GPS receiver can be put in a vehicle or on a person that will drive or hike along these roads and perimeters. GPS data can then be downloaded directly off of the device onto a personal computer, immediately imported into a GIS, and superimposed on top of existing digital topographic maps or other geospatial data of the same area of interest.

2.0 OVERVIEW OF WILDLAND FIRE DIRECTION, STAKEHOLDERS, AND COORDINATION MECHANISMS IN THE U.S.

A broad range of public and private entities in the United States participate in wildland fire management. Several Federal agencies have important wildland fire roles, and state and local governments share important responsibilities for all aspects of wildfire management. These conditions result in varying and changing approaches, roles, policies, and intergovernmental arrangements across the country, with several nuances unique to some areas and not others. This is particularly important because most fires are not on federal land, and states have leading roles on all other lands except those managed by tribal governments. For example, as shown in Figure 2-1, approximately 75% of the reported fires in 2002, and approximately one-third of the total acres burned in the season, were not on federal lands.

While the federal government provides significant assistance and support, state governments are responsible for fire protection on private lands as well as on the lands they manage, which are approximately 4% of the nation's landmass. Local governments also have important fire response and management roles in many areas. To mitigate and address wildland fire needs and problems, a coordinated approach and arrangements among key governmental organizations and stakeholders are required. This chapter describes wildland fire policy and direction within the United States over time, and the major wildland fire management participants, stakeholders, and interorganizational mechanisms concerning wildland fire.

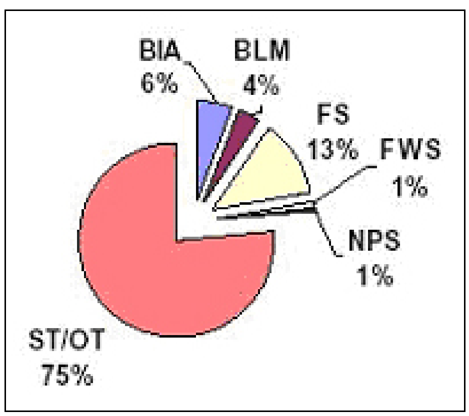

Figure 2-1. Percent of Reported Fires in 2002 by Agency and Level of Government

2.1 HISTORICAL CONTEXT AND FEDERAL DIRECTION

Wildland fire has shaped ecosystems and impacted society throughout time. The country's experiences with fire have directly influenced federal policy direction for over a century, with varying direction and emphasis on both fire use and suppression to meet societal and ecological needs.

Major fires occurred in New England and the Great Lakes areas in the late 1800s. The nation's worst wildfire in terms of lives lost occurred in 1871, when an entire town in Wisconsin was destroyed and 1,500 people died. The "great fires of 1910" resulted in about 50 million acres being burned, far more than in recent years. These types of calamitous events helped form the federal policy of aggressive wildfire suppression, which dominated fire management decisions into the late 1900s, and influenced federal land management in general. For example, the 1910 fires encouraged support for the Weeks Act, adopted in 1911, and included specific provisions about fire protection. It also authorized 75 million acres of federal land acquisition to protect watersheds from development and fire. As shown in Figure 2-2, far more acres were reported burned during the fires seasons in the early decades of the century than in recent years.

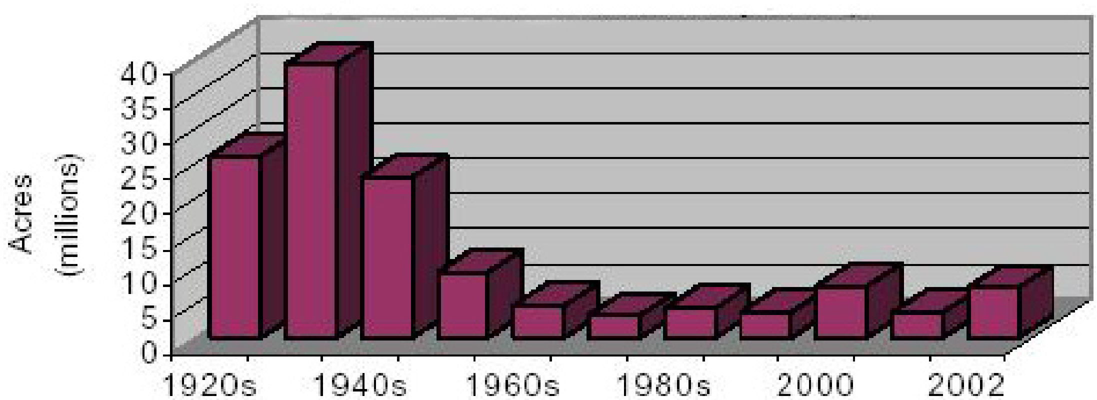

Figure 2-2. Average Acres Burned by Decade and Recent Years
Courtesy of Greg Aplet, The Wilderness Society

Due in part to these conditions, wildland fire policy direction for most of the 20th century was to actively suppress all fires on public lands. These policies were adopted with good intentions: to protect public and private investments, and to prevent the destruction of forests, savannas, shrub lands, and grasslands. However, as documentation and research grew in the 1970s, land and resource managers began to question such fire management approaches. Research showed that fire often brought ecological benefits to burned areas, and aided in regeneration of native flora, improved habitats, and also reduced infestation of pests and exotic and invasive species. With the use of more and more resources, it was recognized that the success of firefighters in suppressing wildfires had in large part had a negative impact on the health of forests, rangelands, and overall ecosystems. Decades of fire suppression and past land-use practices disrupted natural fire regimes. Primary among the changes were shifts in species composition, growing instability of wildlife and plant species, and increased fire hazard caused by the accumulation of large quantities of burnable vegetation, known as “fuels.” These changing conditions caused federal land managers to reassess their wildland fire policies and approach, and to recognize the ecological role and needs for fire.

At about the same time, the U.S. Office of Management and Budget (OMB) began to question the growing costs associated with the then current "out by 10 a.m." suppression policy that was typically followed. As a result, the Forest Service and other federal land management agencies initiated policies to monitor rather than suppress fires when they posed no immediate threats. Fire managers were encouraged to use fire as a tool to improve the condition of wildlands, including letting fires burn in unpopulated areas, or using prescribed fires a tool for fuels treatment. It was recognized that this approach could achieve land and resource management objectives and minimize built up vegetation, thus reducing the potential for catastrophic fires in the future. These policies remained in effect until 1988 when some of the prescribed fires in Yellowstone National Park became larger than expected, placed significant resources at risk, and caused fear and concern among the public.

Since then, emphasis has been placed on balancing tradeoffs and needs between aggressive suppression and fire use. Emphasis has also been placed on making appropriate decisions based on fire management plans for individual land management units, and for unique conditions for each fire. The federal government has taken several steps to investigate and address wildland fire during the last decade. However, since 1990, such attempts have been complicated by large and influential fire seasons. For example, the Oakland, California fire of 1991 destroyed 454 structures and 25 lives were lost, though only 1600 acres burned. Also well remembered is 1993 when 14 firefighters tragically died in a single July day on Storm King Mountain in Colorado. The number, acres and costs of fires spiked nationwide in 1994 and 1996. The Florida fires of 1998, 1999 and 2000 served as a reminder that wildland fire is a nationwide rather than just a western issue. In 1998 alone, 500,000 acres were burned, and 337 structures were lost in Florida, with an estimated impact of $800 million including suppression, local government and other costs, including loss of tourism and timber revenue (Cleaves, 2001).

Following this noteworthy decade, the 2000 fire season also became one of the worst seasons in recent years due to the volume and cost of fires. Conditions were influenced by the predominant weather feature, La Nina, which created a wet winter in the Pacific Northwest and dry conditions in the South from California to Florida. Active lightning storms and persistent hot weather through the summer helped cause an unusually high incidence of severe fires. August 2000 is remembered for the severe and record fire activity occurred in the Northern Rockies and in the Eastern Great Basin. The fire management community was stretched as never before, since sufficient resources were not available to meet demand, even with foreign and military assistance. However, the 2000 season was likely most well known because it included a prescribed fire, which became known as the Cerro Grande fire, that escaped control and burned 235 homes in Los Alamos, New Mexico and caused $1 billion in damages. The impact of this prescribed fire escaping control was much more serious than the Yellowstone fires of

1988. The season served as a loud call for action, which ultimately influenced governmental attention and action still in effect today.

Attention to the severity, costs and impact of fires in 2000 has been reinforced with recent developments. While fewer fires and burned acres were reported in 2001 than some recent years, the 2002 season was worse in several respects. Nationwide, just over 88,000 fires were reported by federal land management agencies and state governments, which were less than 2000, but some fire records were broken. Arizona, Colorado and Oregon had the largest fires ever recorded in their states in the last century. Colorado State Forester Jim Hubbard reported that it was necessary to temporarily shut down 26 water treatment facilities in Colorado due to fires in 2002. At no time in the state's history had this ever been necessary due to fire (Hubbard, 2003). The season was also uniquely marked by several air tanker and helicopter crashes, as well as large civilian deployment (at one point in early July as many as 28,000 firefighters were on assignment), thousands of homeowner evacuations, and hundreds of lost structures.

2.2 FEDERAL POLICY DIRECTION CONCERNING WILDLAND FIRE

The federal government's long held leadership and supportive role in our country's wildland fire policies and management approaches has continued and expanded through time, based on fire experiences and societal concerns. Changing conditions on public and other lands, severe fire seasons, and growing understanding of fire's relationship to the ecosystem have prompted the federal land management agencies to reassess the bases for their fire management operations.

Societal and federal government concerns about wildfire grew at policy levels after the Yellowstone fires and increased during the 1990s. Several significant studies, conferences and activities were initiated to address this growing problem. For example, Congress established a National Commission on Wildfire Disasters, whose 1994 report discussed the large accumulation of fuels on public lands and the growing risk of wildfire danger due to these conditions. The severe fire season of 1994 saw greater fire suppression costs than any year to date (close to $1 billion and 34 lives lost), and raised concerns that the potential for catastrophic wildfires was increasing beyond the nation's capability to respond to them. This resulted in more calls for action, including a review of federal wildfire policy.

2.2.1 1995 Federal Fire Policy

Responding to this 1994 report and severe fire season, the secretaries of the Departments of the Interior and Agriculture tasked the federal wildland fire agencies to closely re-examine their programs and ensure that uniform Federal policies and cohesive interagency and intergovernmental fire management programs existed. The final report, the *Federal Wildland Fire Management Policy and Program Review* (published in December 1995) became the first interagency policy for the federal wildland fire management programs, now known as the "1995 Fire Policy". Fourteen department and agency representatives signed the policy, plus a representative from the National Association of State Foresters. While not a law, the policy had important impacts, including greater focus on protecting human life and saving property. It was the first comprehensive statement of wildland fire coordination between the two departments. Moreover, the policy affirmed the valuable role that fire plays in managing ecosystem health and reducing the risk of catastrophic fires. Concerns about fuel loads and threats to communities were also elevated in this report and subsequently since fire costs for these areas are increasing relative to other areas.

2.2.2 Forest Service "Cohesive Strategy"

As the incidence of fires and perceived risks grew in the late 1990s, Congress held several hearings and tasked the U.S. General Accounting Office (GAO) to conduct related investigations. Among the related topics addressed, GAO examined: (1) the extent and seriousness of problems related to the health of national forests in the interior West; (2) the status of efforts by the Department of Agriculture's Forest Service to address the most serious of these problems; and (3) barriers to successfully addressing these problems and options for overcoming them.

In its 1999 report, *Western National Forests – A Cohesive Strategy is Needed to Address Catastrophic Wildfire Threats* (GAO/RCED-99-65), GAO affirmed that the most extensive and serious problem related to the health of national forests in the interior West is the over-accumulation of vegetation. It was concluded that these conditions caused an increasing number of large, intense, uncontrollable, and catastrophically destructive wildfires.

GAO noted that the Forest Service began to address the issue of forest health during the 1990s, including the development of plans to increase the number of acres on which fuels are reduced to three million acres annually. However, GAO specifically found that the Forest Service lacks adequate data to develop a cohesive strategy for reducing and maintaining accumulated fuels on national forests of the interior West at acceptable levels. They recommended that the Forest Service take the necessary steps to acquire the data to develop such a strategy.

On October 13, 2000, the Forest Service published its response to the GAO report: *Protecting People and Sustaining Resources in Fire-Adapted Ecosystems – A Cohesive Strategy* (http://www.fs.fed.us/r4/fires/strategy.pdf). The document established a framework to restore and maintain ecosystem health on Forest Service lands in fire-adapted ecosystems in the interior West. The strategy introduced institutional objectives corresponding to the Government Performance and Results Act goals, established program management priorities and cost estimates, confirms the need for constituency involvement and laid out research and development efforts to help. Four priority areas were established, including:

- The wildland-urban interface;
- Readily accessible municipal watersheds;

- Threatened and endangered species habitat; and,
- Maintenance of existing low risk Condition Class 1 areas (The Forest Service categorizes fire risk on its lands by three broad condition classes. Condition Class 1 is low risk, Condition Class 2 is medium risk, and Condition Class 3 is high risk.)

This strategy became a key basis for the fuels aspect of the National Fire Plan (see below) and has been complemented with comparable work by the Department of Interior, with finalization of an Interagency Cohesive Fuels Strategy in 2003.

2.2.3 2001 Federal Fire Policy

The severe fire season of 2000 and, in particular, the Cerro Grande fire in New Mexico, prompted the secretaries of Agriculture and the Interior to once again request that the federal wildland fire community review its policy and its implementation. An interagency group with representatives from the Department of the Interior (DOI), the Forest Service, U.S. Fish and Wildlife Service (FWS), Bureau of Land Management (BLM), National Park Service (NPS), Bureau of Indian Affairs (BIA), U.S Geological Survey (USGS), Bureau of Reclamation, Environmental Protection Agency (EPA), Department of Defense (DoD), Department of Energy (DOE), National Weather Service (NWS), U.S. Fire Administration, Federal Emergency Management Agency (FEMA), and the National Association of State Foresters (NASF) was formed to review the 1995 Fire Policy.

The group's report, *Review and Update of the 1995 Federal Wildland Fire Management Policy* (heretofore known as the 2001 Federal Fire Policy) (http://www.nifc.gov/fire_policy/index.htm), was fully endorsed by the secretaries of Agriculture and Interior in letters sent just before their departure from government at the end of the Clinton Administration. In total, 12 federal agencies and the National Association of State Foresters (NASF) signed the 2001 Federal Fire Policy. It is focused on strategic direction for a broad range of wildland fire management related activities, and includes the following principal conclusions:

- The 1995 Federal Fire Policy is still generally sound and appropriate.
- As a result of fire exclusion, the condition of fire-adapted ecosystems continues to deteriorate; the fire hazard situation in these areas is worse than previously understood.
- The fire hazard situation in the WUI is more complex and extensive than understood in 1995.
- Changes and additions to the 1995 Federal Fire Policy are needed to address important issues of ecosystem sustainability, science, education, communication, and to provide for adequate program evaluation.
- Implementation of the 1995 Federal fire Policy has been incomplete, particularly in the quality of planning and in interagency and interdisciplinary matters.
- Emphasis on program management, implementation, oversight, leadership, and evaluation at senior levels of all federal agencies is critical for successful

implantation of the 2001 Federal Fire Policy. (Review and Update of the 1995 Federal Wildland Fire Management Policy, 2001, ii-iii)

Key themes of the policy review report include ecosystem sustainability, fire planning, fire operations, interagency coordination and cooperation, and program management and oversight. The policy does not directly address information technology conditions, issues or needs, including geographic information technology or remote sensing. However, it does indicate "there are gaps in scientific understanding" within the federal fire management program and that "no system exists for collecting and compiling consistent data among agencies" (Review and Update of the 1995 Federal Wildland Fire Management Policy 2001, p. 13.)

Concerning provision of appropriate data, the policy notes "disagreement remains between the National Weather Service (NWS) and federal land management agencies involved in wildland fire management on the products, standards and level of weather services required and how they are provided." More specifically, fire management agencies believe they require more weather services to support the full range of fire management activities, such as those beyond response work. (Review and Update of the 1995 Federal Wildland Fire Management Policy, 2001, p. 17.) One problem is that the NWS interprets statutory and related congressional committee report language in such a way that prohibits them from providing data to non-federal organizations for wildland fires being managed for beneficial uses, such as hazardous fuel reduction. This reduces the quality of fire plans and wildland fire treatments, and increases the risk to public and firefighter safety. This situation was subsequently changed with the land management agencies developing their own internal institutional capacity for provision of weather data, as described later in this report.

2.2.4 National Fire Plan

The severe 2000 fire season prompted additional action to address wildland fire needs. President Clinton asked the secretaries of Agriculture and the Interior to develop recommendations on how to best respond to the fire season, reduce the impact of wildland fires on rural communities, and ensure sufficient firefighting resources in the future. On September 8, 2000, the secretaries issued their response, *Managing the Impact of Wildfires on Communities and the Environment*, which can be found at the website http://www.nwfireplan.gov/GeneralInformation/Managing_Impact.htm.

Known as the "National Fire Plan" (NFP), this document is comprised of (1) the above mentioned document, (2) Congressional direction and expanded appropriations for wildland fire for fiscal year 2001, (3) various strategies, some in final and others in draft form, to implement all or part of the plan, and (4) the federal wildland fire management policy that was adopted in 2001, as described above, which provides the foundation for interagency efforts under the plan (GAO, 2001). The key recommendations in the report were that the departments needed to:

- Ensure adequate firefighting preparedness for coming fire seasons

- Restore landscapes and rebuild communities damaged by wildfire
- Invest in projects to reduce fire risk
- Work directly with local communities to ensure adequate protection
- Be accountable and establish adequate oversight and monitoring for results

Almost $2.9 billion was appropriated to implement the NFP through the 2001 Interior and Related Agencies Appropriations Act (PL 106-291), as shown in Figure 2-3. Significantly, this amount was $1.8 billion above the President's request. Of that figure, over $700 million went to replenish and enhance the departments' fire suppression accounts that were depleted by the 2000 fire season and to repay FY 2000 emergency transfers from other appropriations accounts. Subsequent appropriations for FY 2002 and 2003 reflect continuing Congressional support for NFP. However, the agencies are authorized to use a smaller amount of funds for suppression, and must then "borrow" any additionally needed funds from other programs. These funds are later replenished, but such transfers and delays have detrimentally impacted many programs and funding recipients, such as the states.

Department/ Agency	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003 Enacted**	**President's FY 2004 Request**
USDA/Forest Service	$1,035 (64%)	$1,910 (66%)	$1,590 (55%)	$1,401 (68%)	$1,572 (69%)
Department of Interior	$591 (36%)	$977 (34%)	$678 (45%)	$650 (32%)	$699 (31%)
Total	$1,626	$2,887	$2,269	$2,051	$2,271

Figure 2-3. Federal Fire Budgets by Department and Year
Totals are in rounded millions of dollars

The secretaries of Agriculture and Interior were required in the Congressional report language in 2001 to provide Congress with an action plan explaining how they would meet NFP goals, including a financial plan detailing how funds would be spent. Each department prepared its own action and financial plans to translate the five NFP recommendation areas into a number of proposed accomplishments for each fiscal year, with the one for FY 2002 available at (http://www.fireplan.gov/content/overview/?LanguageID=1). The report language also tasked the departments with 10 additional actions that included publishing a list of communities that are at "high risk" from wildfire as discussed in Chapter 3, and to develop an integrated 10-year comprehensive strategy for addressing the nation's wildland fire problems as described below. In sum, the plan stood out from past direction in that it included Congressional Committee recognition and action to increase funding for wildland fire for this and subsequent years, and direction to reduce fire risk in wildland urban interface areas (GAO, 2001).

Since these documents have been completed, the secretaries of Agriculture and Interior subsequently directed their agencies to modify their internal directives and other documents to reflect the 2001 Federal Fire Policy, and to undertake actions amongst themselves, state, tribal, and non-federal organizations to implement the recommendations in the policy. Implementation of the National Fire Plan continues and it is now in its third year. Moreover, the Department of Interior has conducted similar work to establish an Interagency Cohesive Fuels Strategy in 2003.

The National Fire Plan, 2001 Federal Fire Policy and Cohesive Strategy continue to serve as the leading federal policy directives for wildland fire in the United States. More recently, additional documents have been prepared with state, local and other stakeholders. These documents serve as national, rather than just federal policy direction, as described in the last part of this chapter. Before leaving office, Interior Secretary Bruce Babbitt asked the National Academy of Public Administration (NAPA) to study the methods and procedures being used by federal land management agencies for planning and managing wildland fires, and to develop recommendations for improving the land management agencies' capacity to implement the 2001 Federal Fire Policy (NAPA, 2001). In addition, Congress has and continues to ask the U.S. General Accounting Office (GAO) to study various aspects of federal wildland fire policy, management and implementation of these provisions, with the findings of these studies discussed in the following chapters.

In addition to dedicated wildland fire directives, federal agencies also must follow statutory, administrative, and other direction and requirements for their agencies for other purposes, but often can impact fire efforts. In addition, federal fire activities are effected by several environmental laws that impact land planning, fuels treatment, endangered species, air and water quality, and archeological resources.

2.3 FEDERAL AGENCIES WITH DIRECT WILDLAND FIRE ROLES

The federal government has an increasing number of organizations involved in wildfire management. Their activities have been growing in recent years, particularly during the severe 2000 fire season and the subsequent increase in federal appropriations for fire under the National Fire Plan, in addition to funds for mitigation, preparedness, and response. The federal organizations with direct wildland fire roles include those responsible for land management and emergency management.

Five federal land management agencies have direct fire responsibilities, including four in the Department of Interior (DOI) and the Forest Service (FS) located in the Department of Agriculture (USDA). DOI agencies include the Bureau of Indian Affairs (BIA), the Bureau of Land Management (BLM), the Fish and Wildlife Service (FWS), and the National Park Service (NPS). Together, these agencies manage approximately 687.5 million acres of public land, which constitute almost 29% of the nation's land mass. However, as shown in Figure 2-4, the agencies vary significantly in terms of the number of acres managed, and in the purposes for which then manage these lands, which in turn influences wildland fire approaches.

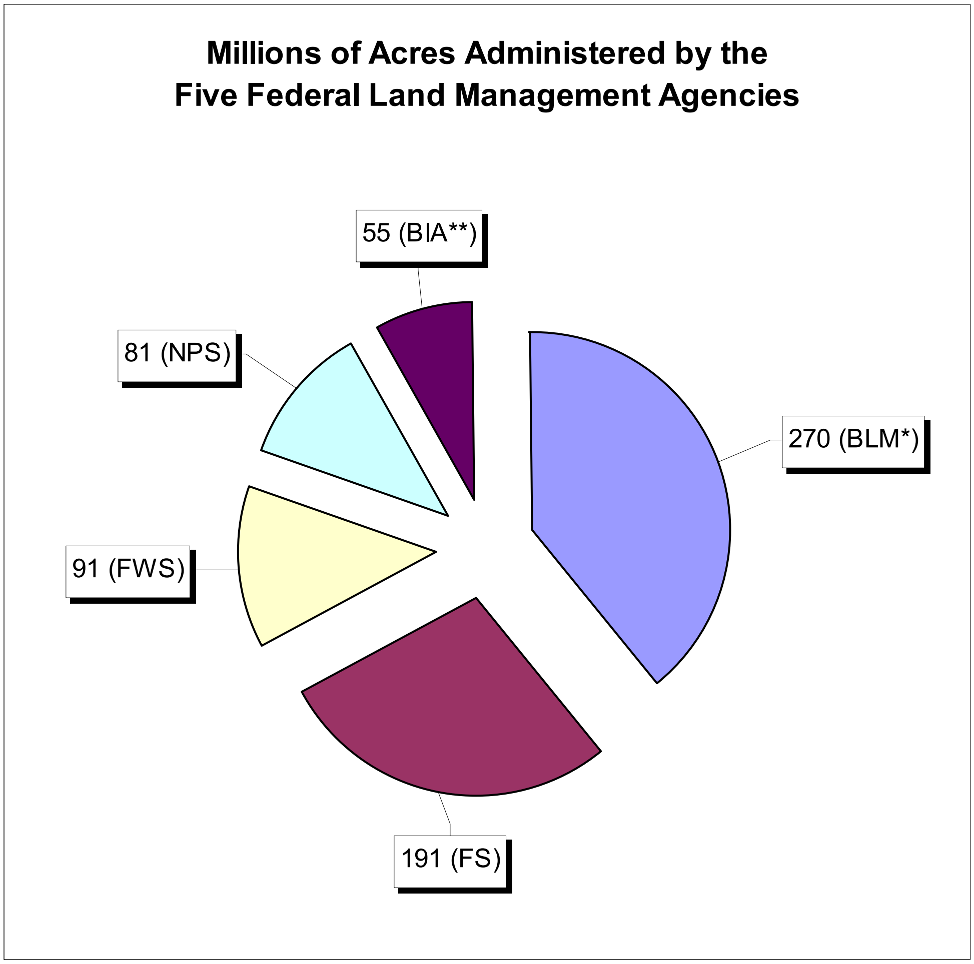

Figure 2-4. Millions of Acres Administered by the Five Federal Land Management Agencies

** BLM also has wildland fire management responsibility for an additional 124 million acres of non-federal land. ** This includes 43 million acres of Tribe-owned land, over 11 million acres of Individual-owned land, and 443,000 acres of Federal-owned land.*

While BLM manages the most federal acres in the nation, the agency with the most fire responsibilities and expenditures today and over time is the Forest Service. The relative amount of fire expenditures varies by year, based on the fire season, as shown in Figure 2-5. Each of the land management agencies is responsible for wildfire mitigation, preparedness, response, and recovery for the lands under their care, but also has other roles as described below.

Year	Bureau of Land Management	Bureau of Indian Affairs	Fish and Wildlife Service	National Park Service	USDA Forest Service	Totals
1994	$98,417,000	$49,202,000	$3,281,000	$16,362,000	$678,000,000	**$845,262,000**
1995	$56,600,000	$36,219,000	$1,675,000	$21,256,000	$224,300,000	**$340,050,000**
1996	$96,854,000	$40,779,000	$2,600	$19,832,000	$521,700,000	**$679,167,600**
1997	$62,470,000	$30,916,000	$2,000	$6,844,000	$155,768,000	**$256,000,000**
1998	$63,177,000	$27,366,000	$3,800,000	$19,183,000	$215,000,000	**$328,526,000**
1999	$85,724,000	$42,183,000	$4,500,000	$30,061,000	$361,000,000	**$523,468,000**
2000	$180,567,000	$93,042,000	$9,417,000	$53,341,000	$1,026,000,000	**$1,362,367,000**
2001	$ 192,115,00	$63,200,000	$7,160,000	$48,092,000	$607,233,000	**$917,800,000**

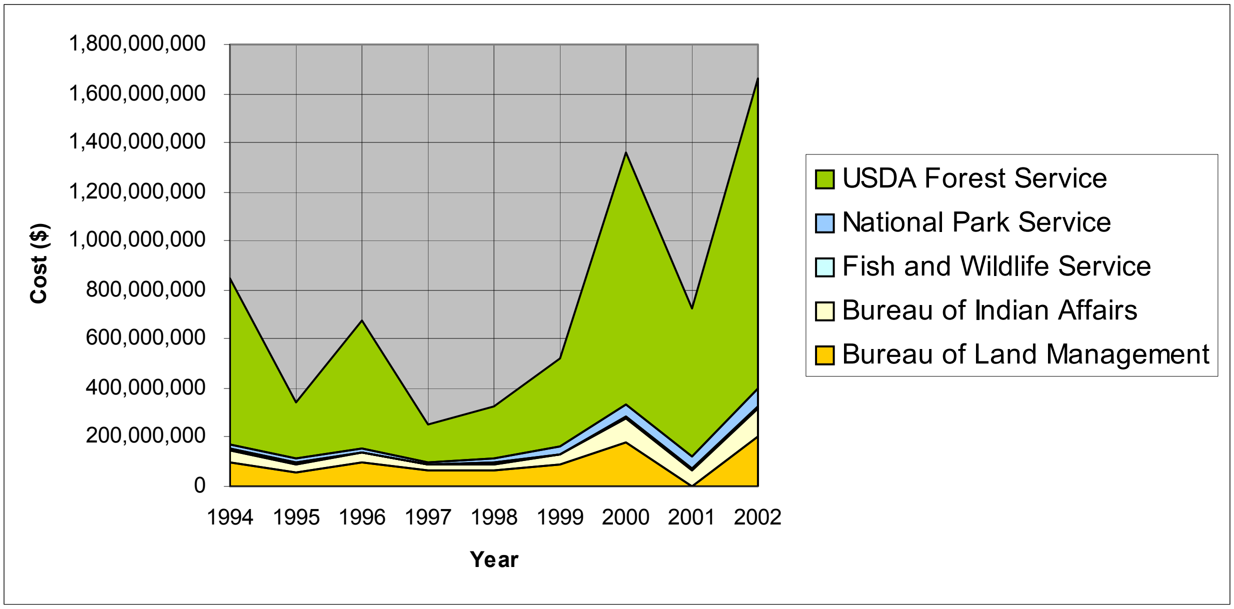

Figure 2-5. Relative Amounts of Fire Expenditures Per Year by the Five Federal Land Management Agencies

2.3.1 U.S. Department of Agriculture - Forest Service

The Forest Service's origin can be traced back to 1891 when Congress authorized the President to set apart reserves of forested land from the public domain, which were initially under the management of DOI. Six years later, the Organic Administration Act of 1897 authorized what became the National Forest System "to improve and protect" federal forests. The Forest Service was formally created in 1905 by an act of Congress (16 USC 472) to serve as the custodian of federal forests and to provide quality water and timber for the nation's benefit, transferring federal forest reserves and their management from DOI to USDA. The Forest Service's mission has been expanding since then to encompass many uses and needs. Its adopted "multiple use" mission and approach means that resources should be managed under the best combination of uses to benefit the American public, while ensuring the productivity of the land, and protecting the quality of the environment. The current Forest Service mission is to "achieve quality land management under the sustainable, multi-use management concept to meet the diverse needs of people" (*U.S. Government Manual* http://www.gpoaccess.gov/gmanual/index.html). The Forest Service has about 30,000 employees. As shown in Figure 2-6, it manages 155 national forests, 20 national grasslands, and 8 land utilization projects that encompass 191 million acres in 44 states, plus the Virgin Islands and Puerto Rico.

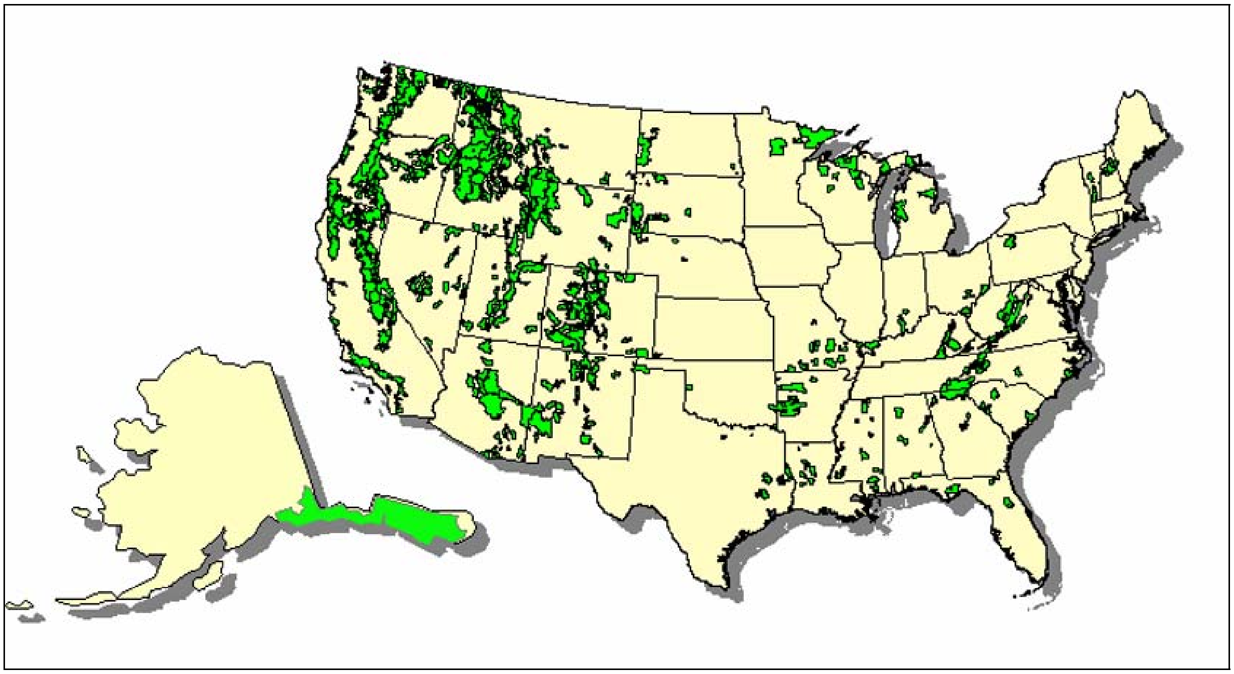

Figure 2-6. U.S. Forest Service Lands
Courtesy of the U.S. Forest Service

The Forest Service (and its predecessors) has historically been the lead agency within the federal government for wildfire. While forest and timber management have had the lead influence, fire also has played a key part in the evolution of the agency's culture. For example, as shown in Figure 2-7, of the almost 7 million acres reported burned by wildfires during the 2002 fire season, over 2.4 million were on Forest Service lands, which is more than all of the DOI agencies combined. As previously shown in Figure 2-3, the Forest Service dominates the federal wildland fire budget, with approximately 70% of the total in FY02. It has the largest firefighting force and resources of any federal agency, including hotshot crews, repellers, helicopter attack units, smokejumpers, and engine crews. The Forest Service owns and operates 44 aircraft and contracts over 800 aircraft annually, from small lead planes that guide the giant air tankers, to helicopters to small single-engine air tankers. (http://www.fs.fed.us/fire/aviation/)

Within the Forest Service, the forests are the focal points for fire program operations. The headquarters office for fire management, the Fire and Aviation Management Office, is administratively located under the Deputy Chief for State and Private Forestry (S&PF)

and is located in Washington, D.C. Forest Service Headquarters largely exists to provide policy direction and coordination. It is a staff office and does not have line authority over the forests' fire programs. The large increases in funding from the NFP have caused the Forest Service to increase its management and oversight resources for the fire program. To oversee its implementation of the NFP, the Forest Service has established an NFP Implementation Team, headed by the National Fire Plan Coordinator. Both the Associate Chief for Natural Resources and the S&PF Deputy Chief provide direction to the Team. The Team addresses the following specific fire management functions: community assistance; planning and analysis; firefighting; hazardous fuel reduction; rehabilitation and restoration of burned areas; fire research; implementation roles of regional teams, and; business operations.

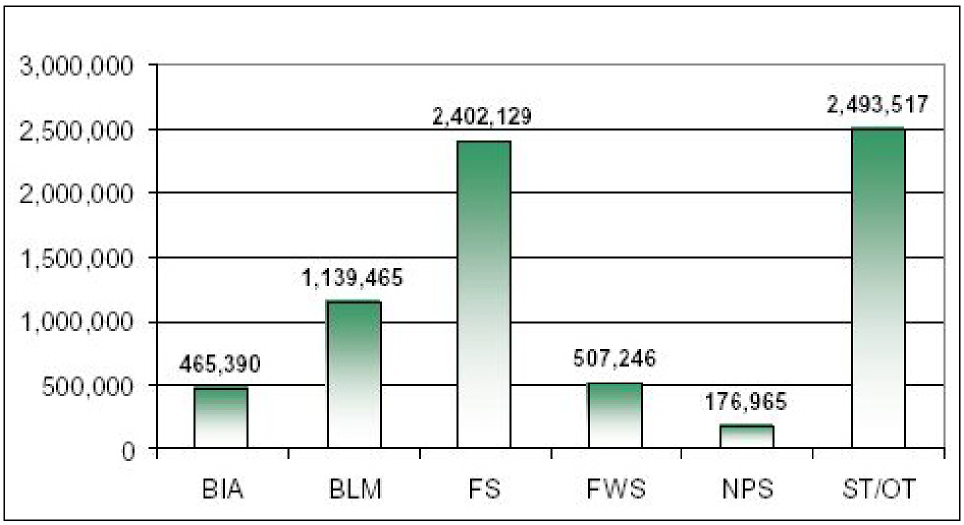

Figure 2-7. Number of Acres Burned by Agency in 2002

For almost 100 years, the primary focus of wildfire efforts was on suppression, and the Forest Service carried out a large portion of this work. The policy shift from suppression of all fires to balancing fire approaches by using fire for resource benefits has been a challenge for a large agency with an established culture. Current requirements are for the agency to be able to meet both needs, since proactive suppression of wildland fires is often the only realistic option for lands near human settlements.

In addition to its leadership role in fire suppression, the Forest Service is considered a leader in the overall federal fire management program. It maintains this role for several reasons. First, it is the second to BLM as the largest land management agency, constituting what is known as the National Forest System. Second, it is the only federal agency with fire research and support functions. Third, it is the only federal agency with authorization to participate in wildfire suppression on foreign lands. Fourth, until recently, it was the only agency with state and/or local government assistance programs specifically designed for wildfire management (through the National Fire Plan (NFP), DOI was authorized to have a grant program for rural fire departments). Moreover, Forest Service land is considered prime federal government real estate in terms of such attributes as old growth forests, critical habitats for many threatened or endangered species, and sources of an increasing portion of the nation's water supply.

2.3.2 Department of the Interior

DOI is the largest land management department in the federal government. It also has various natural resources management and research responsibilities similar to a state department of natural resources. Few land management functions are managed directly at the departmental level, as DOI agencies have their own statutory missions, authorities, and staffs. DOI agencies operate independently in many respects, but there are some DOI coordination mechanisms in place that facilitate internal and external coordination.

DOI has an Interior Fire Coordination Committee (IFCC) that guides and coordinates development of wildland fire policy and helps standardize procedures, methods, and practices among DOI's land management agencies. Former Interior Secretary Babbitt established the Office of the Wildland Fire Coordinator at the secretarial level in January 2001. The role of this Office is to coordinate and integrate the fire management programs of the four DOI land management agencies and related activities in the U.S. Geological Survey (USGS) and the Bureau of Reclamation. The Office also is authorized to review the agencies' fire program appropriations requests and allocations, and coordinate these programs with the Forest Service, state governments, and other stakeholders. The Office reports to the deputy secretary, and organized a National Interagency Steering Group. The group consists of representatives from the DOI land management agencies, other DOI offices, and the Forest Service's National Fire Plan Coordinator. It meets frequently to discuss, assess, and facilitate implementation of the National Fire Plan.

While remaining smaller than the Forest Service, DOI's role in fire is growing. In addition to growing activities in its four land management agencies, USGS has provided an increasing level of support to the department and others regarding fire, particularly since the National Fire Plan was put in place. An annual $10 million grant program was established by the DOI through the NFP for rural fire departments in FY 2001. As discussed below, Interior's role also expanded with the establishment of the Predictive Services unit at the National Interagency Fire Center (NIFC), including the hiring of 20 fire meteorologists to help inform wildland fire managers and responders.

2.3.2.1 Bureau of Land Management

During the 1800's, Congress began withdrawing public lands from eligibility for settlement by designating them as forests, national parks, and wildlife refuges. The General Land Office was created in 1812 to oversee the disposition of public lands. In 1934, Congress passed the Taylor Grazing Act, which created the U.S. Grazing Service, to manage the remaining public rangelands. The Bureau of Land Management

(BLM) was formally created in 1946 by consolidating the U.S. Grazing Service with the General Land Office, under a presidential reorganization plan (60 Stat.1097).

The 270 million acres managed by BLM consist of all public domain lands of the federal government that have not been disposed of or reserved for specific purposes, such as national forests, parks, wildlife refuges, and Indian reservations. Most BLM land is located in 12 western states and Alaska. Figure 2-8 shows lands managed by BLM and other DOI agencies with land managed by the Forest Service. Under the Federal Land Policy and Management Act of 1976, BLM has a multiple use mission to manage and “sustain the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations,” similar to the Forest Service’s mission. The agency’s management responsibilities include such functions as recreation opportunities, commercial activities, fish and wildlife habitats, wild free-roaming horses and burros, transportation systems, and wilderness areas and wild and scenic rivers.

BLM has the largest fire management program in DOI. It receives the largest amount of wildland fire funding, and serves as the fiscal mechanism for other DOI agencies to receive their related funding. BLM's primary wildfire role continues to be managing wildfires on the lands under its management. BLM also has wildland fire management responsibility for an additional 124 million acres of non-federal land. Similar to the Forest Service, various approaches are used regarding wildfire suppression, but efforts also include mitigation, preparedness and recovery. BLM uses fire to reduce fuel loads, but mechanical thinning is its primary tool for such purposes.

BLM has 12 "state" offices, some of which include more than one state's boundaries. Each state office has district offices and some have district and area offices. Efforts are underway in some states to eliminate the area offices in order to streamline operations and eliminate this bureaucratic level. Operational responsibility for the fire management program rests in these local offices. BLM’s National Office of Fire and Aviation is located at NIFC (see below). The Office's director serves as the managing federal official at NIFC, and administratively reports to the BLM director. Like the Forest Service and other DOI agencies, the national office is primarily a policy body except for the operations on site.

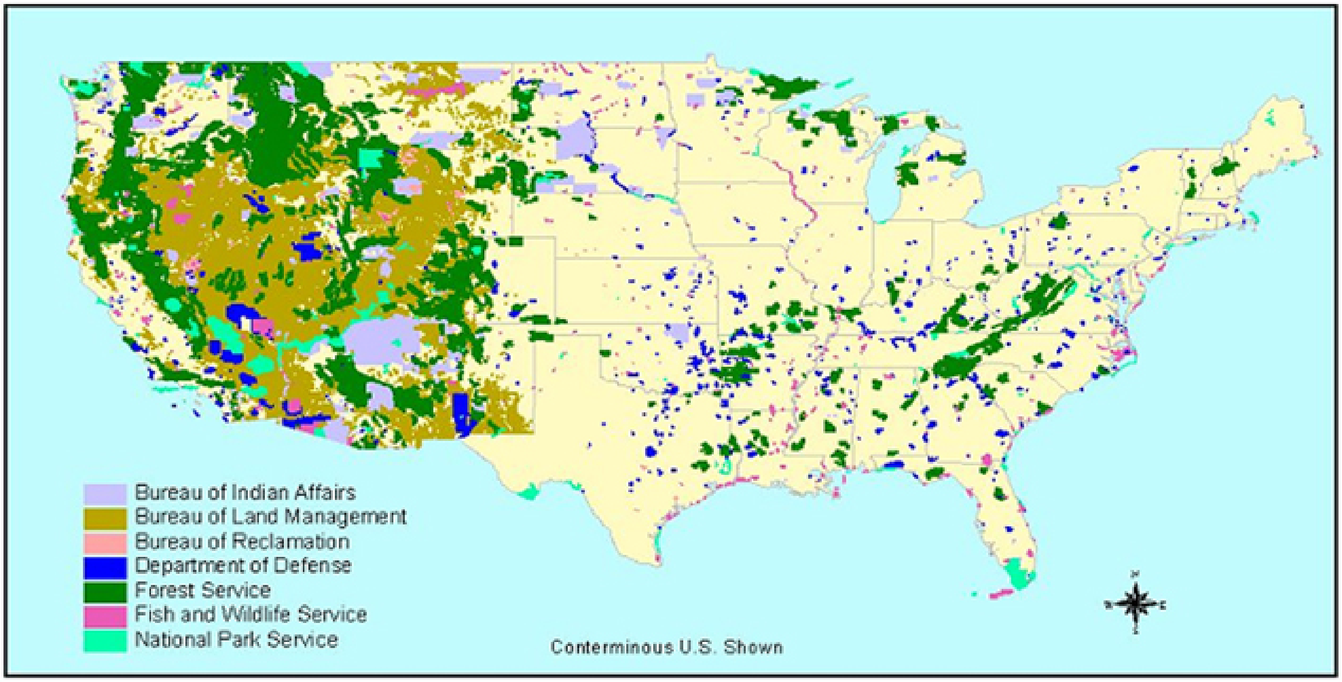

Figure 2-8. Lands Managed by Federal Agencies in Conterminous U.S.

2.3.2.2 National Park Service

Although Congress created the Yellowstone National Park in 1872, there was no system of national parks until it enacted the National Park Service Organic Act on August 25, 1916. This act created the National Park Service (NPS) as a bureau within the DOI. NPS's role was defined to promote and regulate the use of national parks, monuments, and reservations, and to conserve the scenery, wildlife, and natural and historic objects in them. The purpose of these areas also is to provide human enjoyment today, but to leave them unimpaired for future generations. This single-use mission for its public lands differs from the multiple-use mission shared by the Forest Service and BLM. Using its Organic Act and subsequent legislation (such as the Historic Sites Act of 1935 and section 110 of the National Historic Preservation Act), NPS has identified its central responsibilities as threefold: preservation, research, and education.

The National Park System has 383 units, encompassing 81 million acres located in 49 states, the District of Columbia, and five territories. There are numerous designations for units within the System, while NPS's 54 National Parks are the largest and most well known. The parks are generally large natural places having a wide variety of attributes, and may include significant historic assets. Mining, hunting, and other consumptive activities are prohibited in the parks. The largest unit is the Wrangell-St. Elias National Park and Preserve in Alaska. With 13,200,000 acres, it makes up over 16% of the entire System. Some of the other units include national preserve, national monuments, national battlefields, national recreation areas, national historic sites, and national seashores. The smallest unit managed by NPS is the Thaddeus Kosciuszko National Memorial, Pennsylvania, which is 0.02 of an acre.

All the federal land management agencies are stewards of natural resources and watersheds, but NPS is most exclusively focused on protecting nature and has developed a “light on the land” philosophy. NPS is more reluctant than the others to use “unnatural” mechanical or chemical means to achieve land management objectives and risk the potential adverse consequences for natural ecosystems. NPS uses prescribed fire to meet specific land-use or resource management objectives, including fuel treatment and reduction, site preparation, seedbed preparation, species conservation, forest stand thinning, wildlife habitat improvement, livestock forage enhancement, watershed stabilization, maintenance of ecosystem health and numerous others. Nonetheless, where risks associated with fire are too great, NPS will use mechanical and chemical thinning, such as in the WUI.

While all of the land management agencies operate in a decentralized fashion, sometimes to the consternation of those attempting to understand overall conditions, park superintendents typically have an even greater level of autonomy than that of other agencies' land management unit leaders. Similar to the other agencies, the units have operational responsibility for the agency’s fire management program. To provide national leadership, NPS established the Fire Management Program Center (FMPC), located at NIFC. Like the national fire offices in the other land management agencies, FMPC exercises no line authority over the fire management programs within the parks. Instead, it influences program outcomes primarily through policy formulation and interpretation, strategic initiatives, interagency coordination, and budget allocations.

2.3.2.3 Fish and Wildlife Service

The roots of the Fish and Wildlife Service (FWS) date back to the U.S. Commission on Fish and Fisheries, created in the Department of Commerce in 1871, and the Division of Economic Ornithology and Mammalogy (created in the Department of Agriculture in 1885 and later renamed the Bureau of Biological Survey). These programs had been established to address the worsening reduction of the nation's fish and wildlife resources during the end of the 1880s. These problems and resulting organizations were some of the earliest in the conservation of natural resources in the U.S. Though these agencies operated for several decades, the Bureaus of Fisheries and Biological Survey were not moved to the Department of the Interior until 1939. They were subsequently combined to create FWS in 1940. Its official mission today is to work with others to conserve, protect and enhance fish, wildlife, and plants and their habitats to benefit of the public.

FWS manages 91 million acres of federal land and employs approximately 7,500 people at facilities across the country, including a headquarters office in Washington, D.C., seven regional offices, and nearly 700 field units. Among these are national wildlife refuges, national fish hatcheries and management assistance offices, law enforcement and ecological service field stations (http://www.fws.gov/who/). The single-use mission of FWS has helped shape the role of fire within the agency. The goal of wildland fire management in FWS is to plan and make decisions that help accomplish the mission of the National Wildlife Refuge System. Because of its biological management mission and the nature of its land types, FWS is not as active in fire suppression as the other land management agencies. However, FWS has historically had an active prescribed fire program to help with habitat preservation and restoration. FWS is the only land management agency with more acres burned each year by prescribed fire than wildland fire.

FWS similarly operates as a decentralized organization and its field units, which are responsible for day-to-day management of the fire management program, report to a system of seven regional offices throughout the country. The FWS National Office of Fire and Aviation also is located at NIFC and is led by the Service Fire Management Coordinator who is the chief of the Fire Management Branch, Division of Refuges. This Office is responsible for providing technical direction and coordination of fire management planning, policy development, and procedures agency-wide. The Office does not have line authority over the fire management programs within the field units.

In addition to its land management role, FWS also is uniquely authorized to serve an important regulatory role that influences the federal fire management program in other agencies. In 1973, Congress enacted the Endangered Species Act (ESA) to protect threatened and endangered plants and animals. FWS and the National Marine Fisheries Service (NMFS), located in the Department of Commerce, have responsibility for administering ESA. This regulatory function places an increasingly important constraint on fuels management programs in all agencies.

2.3.2.4 Bureau of Indian Affairs

Congress created the Bureau of Indian Affairs (BIA) in 1834, but related government action dates back to 1775 when the Continental Congress established a Committee on Indian Affairs. The Secretary of War was given responsibility for Indian affairs 11 years later. BIA was housed in the War Department until an 1849 act established the Home Department of the Interior, and responsibility for Indian affairs became a civilian rather than military responsibility in the government.

BIA provides federal services to about 1.4 million American Indians and Alaska Natives who are members of 557 federally recognized tribes and native villages in the 48 contiguous states and Alaska. BIA administers about 43.4 million acres of tribally owned land, 11 million acres of individually owned land, and over 0.4 million acres of federally owned land held in trust status. The bureau's mission is to "enhance the quality of life to promote economic opportunity and to carry out the responsibility to protect and improve the trust assets of American Indians, Indian tribes and Alaska Natives" (www.doi.gov/bureau-indian-affairs.html).

BIA uses fire for public safety, wildland fire protection, hazardous fuel treatment, and ecosystem health purposes. Prescribed burning has been a long-standing practice among the tribes. Historically, American Indian tribes actively used fire to alter vegetation patterns. The major difference between BIA's and the other land management agencies' fire programs is the involvement of the tribes in all phases of fire management. The enactment of Indian self-determination legislation in 1975 caused BIA's transition from direct service provider to contract administrator for programs contracted by tribes. Tribes, under Public Law 93-638 compacts and contracts, now run most BIA programs, and the fire program is no exception. Many tribes have assumed responsibility for their fire management programs.

BIA's 12 regional offices and the organizations within those regions provide support and oversight to the tribes' fire management activities where the tribes have assumed responsibility for the program, or otherwise provide direct fire management services. Within BIA, there are about 2,500 seasonal and permanent fire management positions that represent approximately 40% of the total bureau workforce of 6,000. Similar to the other DOI agencies, BIA's National Office of Fire and Aviation at NIFC provides overall direction to the fire management program. Also like them and the Forest Service's headquarters offices, BIA's fire organization does not have line authority over the bureau's fire management programs.

2.3.3 Department of Homeland Security

While the five land management agencies are considered to be the leading organizations with direct wildland fire roles, the Federal Emergency Management Agency (FEMA) also has direct fire roles. It also has some GI/GIT efforts, but they do not relate to fire, so they are summarized here rather than in the next section. In accordance with the Robert T. Stafford Disaster and Emergency Assistance Act (PL 93-233 as amended), FEMA is the lead agency for emergency management in the federal government. FEMA was incorporated with 21 other federal organizations into the new Department of Homeland Security (DHS) that was created late in 2002. The department brings together approximately 170,000 federal employees into the new 15th Executive Department of the government.

FEMA is retaining its name and is part of the Emergency Preparedness and Response organization within DHS. A key authorized and continuing role of FEMA is to provide nationwide assistance to Presidentially-declared disasters. Although the President rarely declares wildland fires as major disasters, several recent fires are exceptions. The Cerro Grande Fire was particularly noteworthy because of the extent of the damage caused by a government authorized prescribed fire. The Cerro Grande Assistance Act charged FEMA with establishing the Office of Cerro Grande Fire Claims to investigate, consider, ascertain, adjust, grant, deny, or settle any claim for monetary damages incurred by the fire's victims. FEMA received a $500 million appropriation for this purpose.

DHS has undertaken several efforts that relate to emergency management generally and impact wildland fire. For example, FEMA has traditionally been the overall coordinator of the Federal Response Plan (FRP) for emergency response in the federal government to implement the Stafford Act. The FRP is a signed agreement among 27 federal departments and agencies and the American Red Cross that provides the mechanism for coordinating delivery of federal assistance and resources to augment efforts of state and local governments overwhelmed by a major disaster or emergency.

The plan designates 12 emergency support functions, including ESF #4, *Firefighting*. Various federal organizations have been assigned primary and support roles for each of these functions. According to the FRP, "*Firefighting* detects and suppresses wildland, rural, and urban fires resulting from, or occurring coincidentally with, a major disaster or emergency requirement Federal response assistance" (http://www.fema.gov/rrr/frp/). The Forest Service is the primary agency responsible for ESF #4, with BLM assigned to serve in a support role. National support is provided through the National Interagency Coordination Center (NICC) in Boise, Idaho. FEMA authorization is used in cases of wildfires that the President has declared as disasters in order to channel disaster assistance, and this triggers the transmittal of funding and aid for both responding governments and the impacted public. With recent work as part of FEMA's incorporation into DHS, an interim version of the FRP was issued in January 2003.

DHS is also working on the development of a new National Incident Management System (NIMS) that is to be used for all disaster response. Federal fire responders have been increasingly asked to respond to non-fire emergencies, so this will likely have an important impact on the wildland fire community. Efforts have been made to build upon and correlate the new NIMS with the wildland fire community's National Interagency Incident Management System (NIIMS), as described in Chapter 5. However, arrangements and relationships between the key leaderships and two systems are yet to be determined (Greene, 2003). A draft NIMS approach is under review in 2003.

FEMA also includes the U.S. Fire Administration (USFA), which was created by Congress to reduce life and economic losses due to fire and related emergencies through leadership, advocacy, coordination and support. Most of USFA's emphasis is on structural fire needs across the country, providing public education, training, technology and data initiatives. However, USFA's efforts also directly relate to wildland fire as it maintains statistics about fire departments and fires across the country, which includes wildland fire components. The Federal Fire Protection and Control Act of 1974 (15 U.S.C. 2201 et seq.) authorizes USFA to provide grants to local fire departments around the country. Funding through this program has expanded in recent years due to increased recognition of fire department needs, and more recently, due to the fact that local fire departments are often known as "first responders" for homeland security events. As a result, $360 million was appropriated for the grant program in FY 2002, and another $750 million in FY 2003. Fire departments that participate in wildland fires have received funding through this program, and a few have used the funds for GI/GIT efforts.

Most of FEMA's efforts over the years, and those of its state counterparts, have been focused on disaster response, similar to the land management agencies for wildland fire. However, the rising number and severity of natural disasters over the past decade has prompted increased federal action to reduce threats imposed by disasters, including wildland fire. For example, the Disaster Mitigation Act of 2000 (Public Law 106-390) amended the Stafford Act to reinforce the importance of pre-disaster mitigation planning for reducing losses. It provided a mitigation fund to states and localities for assistance in implementing mitigation measures. Requirements and provisions for local, tribal and state plans were also established, including funding and incentives.

Programmatic responsibility for these mitigation and planning efforts within FEMA is in its Federal Insurance and Mitigation Administration (FIMA)(http://www.fema.gov/fima/). FIMA has various programs related to GI/GIT as described below:

- The Flood Mapping Modernization Program for NFIP is one of the largest programs in FIMA, and its funding has grown in recent years ($200 million requested for FY 2004). It is one of the largest mapping projects in the civilian part of the federal government (http://www.fema.gov/mit/tsd/ctp_main.htm).

- The Multi-Hazard Mapping Initiative was authorized in the Disaster Mitigation Act of 2000, though it is a much smaller effort. Though fire was not specifically mentioned in the Act, some staff efforts are underway to include fire as one of the disasters considered and mapped. Web site development is underway.

- HAZUS (Hazards U.S.) is a tool to proactively mitigate hazards and prevent associated losses (http://www.fema.gov/hazus/). A natural hazards loss estimation methodology that uses GIS was developed to compute estimates of damage and losses. A new HAZUS - MH tool is under development for wind and flood disasters but there are no plans or funding at this time to include fire in the program.

- Project Impact was a program established during the Clinton Administration that provided funding to individual localities to help them mitigate emergencies before they occur. Some of the communities focused on wildland fire needs and several grantees used funds to upgrade and expand their GIS capabilities to address disasters before they occurred.

DHS also is establishing a department-wide approach to GI/GIT under its Chief Information Officer. Geospatial data has been identified as one of the top three priorities under his purview. A Geospatial Management Office (GMO) is being established under the CIO during 2003 to develop an enterprise solution (Kalweit, 2003).

2.4 FEDERAL AGENCIES SUPPORTING WILDLAND FIRE AND GI/GIT ACTIVITIES

Several federal agencies, academic researchers and others provide support to or analyze federal wildland fire management in general or regarding GI/GIT. In addition, several support and research efforts are underway at the international level. For example, the Disaster Management Support Group of the G-7 Committee on Earth Observation Satellites (CEOS) has conducted research and investigations to determine remote sensing capabilities that can be applied to wildfire management, as discussed in Chapter 4. In addition, the U.S. General Accounting Office (GAO) has conducted many investigations regarding fire, and recently completed an investigation about GI/GIT for wildland fire (U.S. GAO, 2003d). Recent studies have also been undertaken by committees of the National Research Council to investigate and make recommendations to advance the application of remote sensing, though none have specifically addressed wildland fire (NRC 2001, 2003). The wildland fire community also commissions various studies, with some topics relevant to aiding in the understanding of GI/GIT issues and needs.

Each of the five land management agencies described above has some GI/GIT capabilities throughout their organizations, though much of the expertise is located at the regional or field level. Three of the agencies, FS, BLM and NPS, also have GI/GIT capabilities to support central fire response operations that are located at NIFC.

The land management agencies also are beginning to establish regional fire GIS contacts and capabilities. BLM, NPS and BIA have made agency wide decisions to identify such contacts in each region, and are in the process of implementing this approach. Some Forest Service regions also have at least one regional fire GIS person at the regional office. Additional agencies conduct work related to wildland fire as described below, including some GI/GIT efforts.

2.4.1 Department of Agriculture – U.S. Forest Service

The Forest Service is unique among the federal land management agencies because it is much larger in terms of overall fire budget. It also is the only one with an authorized role to provide support for fire management to federal agencies, state governments, other countries, and virtually the entire fire management community. This responsibility includes direct interaction with State Forestry Organizations (SFOs) and others for many aspects of fire and forestry, which is under the State and Private Forestry part of the agency like Fire and Aviation Management described above. Research, modeling, simulation and related work is conducted under the research part of the agency, and various information, technology and support resources are organized under the National Forest System (NFS) part of the agency. NFS also supports several wildland fire activities within individual land management units.

The Forest Service is known to include the largest forestry research organization in the world, with an increasing part of this work focused on wildland fire. This research work includes fire behavior and prediction, fire affects, fire chemistry, and other dynamics of fire management. This research organization has a regional network of offices located throughout the country. Much fire research work is conducted under the auspices of the Missoula Fire Laboratory, a part of the Rocky Mountain Research Station. Other parts of the Forest Service, many of which are also located in Missoula, also provide support to fire management. For example, the Missoula Technology Development Center (under NFS) conducts tests on hydraulics, trucks and chemicals, while Fire and Aviation Management has a center that includes sophisticated smoke jumping simulation capabilities. The Forest Service also has wildland fire research activities in other offices located around the country, such as at the Riverside Forest Fire Laboratory in California.

The Forest Service also provides support for fire through its Engineering Staff, a part of the National Forest System (not Fire and Aviation Management). It includes employees and contractors located in northern Virginia and Salt Lake City. The deputy director of Engineering serves as the official representative of the federal government to CEOS concerning wildfire needs. The Engineering Staff also is the official channel by which classified assets of the Department of Defense (DoD) are deployed for all federal fire suppression efforts.

The Engineering Staff has two GI/GIT field units in Salt Lake City, including the Remote Sensing Applications Center (RSAC) and the Geospatial Services and Technology Center (GSTC). They both provide support to the Forest Service for many GI/GIT activities, though RSAC provides more information products for the fire community. RSAC has three defined missions, including to provide (1) technical support in evaluation and development of remote sensing, GPS, imaging processing and related technologies, (2) project support and assistance in the use of remote sensing and related technology, and (3) technology transfer and training. RSAC has been increasing in size in recent years. It now includes about 40 individuals, with over half as contracted employees. The relative proportion of RSAC work that relates to fire also is growing.

RSAC work is organized in one of five areas, with support for fire coming either from the Operations Group which has done imagery work to aid in assessing burn severity, and the Liaison and Special Projects group, which includes providing support for fire monitoring through the infrared program, satellites, and classified work. RSAC priorities and activities are directed by the FS Remote Sensing Steering Committee (RSSC), whose mission is to provide national leadership and guidance within the agency for the efficient use and application of digital remote sensing and its integration into GIS. It prepares national guidelines, develops projects, and sponsors them for demonstrating the efficient use, application and integration of remote sensing into GIS. These efforts include training and awareness through workshops, publications, and other technology transfer efforts. More information about RSAC's fire work is included in Chapter 4 and Chapter 6.

2.4.2 Department of Commerce

The National Oceanic and Atmospheric Administration (NOAA) is the primary part of the Department of Commerce that is aiding wildland fire efforts. This work is primarily conducted by the National Environmental Satellite, Data and Information Service (NESDIS), and the National Weather Service (NWS). NESDIS is the world's largest civil operational, environmental space organization, and operates the U.S.'s geostationary and polar-orbiting environmental satellites. It provides data products for many different users, and has been developing some products specifically for fire.

NWS provides weather forecasts for many users, but also to fire managers for defense against the critical effects of wind and other weather-related events. These and other elements of weather information are contained in "spot" forecasts that NWS issues to fire management officials. These are primarily used to help plan and manage prescribed burns. NWS provides several other meteorological forecasts to support the land management agencies fire management efforts including:

- **Red Flag Warning**. A Red Flag Warning is issued when forecasted weather conditions together with existing environmental conditions could result in extreme fire behavior or, as in the case of dry lightning, extensive fire starts within 24 hours.
- **Fire Weather Watch**. A Fire Weather Watch is issued when Red Flag conditions are expected within 72 hours.
- **Pre-suppression Forecast**. Pre-suppression forecasts are issued once or twice daily during the fire season. This is a narrative forecast of upcoming weather conditions for use in planning for suppression of wildfires.
- **Land Management Forecast**. These narrative forecasts are issued outside fire season and are used in planning for a variety of land management activities.
- **National Fire Danger Rating Forecast**. This is a point forecast issued for a selected observation site. These forecasts are used as input for the National Fire Danger Rating System, which generates indices that are used to determine the fire danger for a given area and to plan for the necessary human and other resources needed to fight wildfires.

NWS meteorologists, who specialize in forecasting fire weather and support major wildfire suppression, provide weather advice at individual fire Incident Command centers. They and other meteorologists are referred to as "I-mets". General NWS forecasters, who provide all types of forecasts such as public, aviation, marine and other, usually provide the forecasts for prescribed fires. NWS also has staff and facilities located at NIFC.

The department also is the administrative home for the Office of the Federal Coordinator for Meteorology (OFCM). Congress established OFCM in 1964 (Public Law 87-843) to ensure the effective use of federal meteorological resources, to lead the systematic coordination of operational weather requirements and services, and to support research among the federal agencies. Work is carried out through an interagency staff that works with representatives of federal agencies. Currently, all 15 federal agencies and departments that are involved in meteorological activities work with the office, including the Departments of Agriculture, Commerce, Defense, Energy, Interior, State, and Transportation, EPA, FEMA, NASA, the National Science Foundation, the National Transportation Safety Board, the Nuclear Regulatory Commission, OMB, and the Office of Science and Technology Policy.

The Federal Committee for Meteorological Services and Supporting Research provides direction for the office. It is chaired by the undersecretary of Commerce with responsibility for NOAA, and includes senior policy executives from the 15 participating agencies. The development and deployment of the Weather Surveillance Radar, the 1998 Doppler (WSR88-D), is an example of a tri-departmental program coordinated by the OFCM.

2.4.3 Department of Defense

The Department of Defense (DOD) manages about 38 million acres at bases and installations around the country and has fire management responsibility for those lands. DOD also has aided federal response efforts both domestically and internationally during severe fire seasons. National Guard units are often deployed on some of the largest wildfires because of the lack of sufficient civilian firefighting personnel. For example, military assets were used during the severe 2000 fire season for 45 days.

DOD also has provided informational support to wildland fire operations through imagery and other resources as deemed necessary. Efforts have been underway since the end of the Cold War to declassify "national assets" for use during emergencies. The Forest Service was one of the first agencies to garner approval for this access to wildfires, and it is the official channel by which classified DOD assets are deployed for all federal fire suppression efforts. Use of military assets for wildland fire and other civilian applications are conducted through the Civilian Applications Committee (CAC), which is chaired and staffed by the U.S. Geological Survey (USGS).

Other parts of DOD have also had some involvement with fire or GI/GIT efforts. The National Imagery and Mapping Agency (NIMA) conducts many imagery activities and is becoming more involved in domestic areas since September 11, 2001. Each of the armed forces also has some internal GI/GIT capabilities. More specifically for fire, the National Reconnaissance Office (NRO) worked with the U.S. Geological Survey (USGS) in the late 1990s to develop a Hazard Support System (HSS) to assist in the detection of fires. Funding decreases limited HSS's development and testing efforts, though some interest was expressed in further development of the system, because of its potential to harness many different sources of information and provide effective early warning.

2.4.4 Department of Energy

The Department of Energy’s (DOE) National Laboratories also have become involved with wildland fire. Three of the largest labs, the Lawrence Livermore National Laboratory (LLNL), the Los Alamos National Laboratory (LANL) and the Pacific Northwest National Laboratory (PNNL), have been increasingly active at using GIT to address direct wildfire needs. For example, in 1999, LLNL and LANL developed an initiative for a National Wildfire Prediction Program (NWPP) (Bradley et.al., 1999). The intent of the proposed program was to provide guidance for fire managers throughout the country and assist them to efficiently use limited firefighting resources. The program aimed to build upon existing physics-based weather and fire models, the emergency response infrastructure, and computer and telecommunications science.

LANL found their involvement was necessary to protect their property and assets in the well-known Cerro Grande Fire in May 2000. A month later, a wildland fire near PNNL's Hanford site in Washington State burned 164,000 acres before it was contained. These fires posed high risks because of the nature of these facilities and the materials located within them, such as nuclear supplies and waste, which could cause catastrophic damage.

Large investments continue to be made by the federal government for work conducted at DOE facilities, including support for 9,000 staff. Opportunities exist for technology transfer to the wildfire community. For example, LLNL has a National Atmospheric Release Advisory Center (NARAC), which supports emergency response planners by providing real-time emergency assessments of the impacts of inadvertent or intentional releases of hazardous material into the atmosphere. As discussed above, LANL and LLNL have prototyped advanced methodologies to predict and model wildfires. This capability could be leveraged to assist in wildfire assessment, particularly for smoke dispersion and health impacts.

2.4.5 Environmental Protection Agency

The effects of wildland fire on the quality of natural resources and the environment are increasingly recognized by public and governmental decision makers. For example, air quality, water quality, forest health, wildlife and habitats are increasingly impacted and the public demands attention to these impacts. The Environmental Protection Agency (EPA) and state environmental quality agencies are becoming more involved with fire management issues due to the environmental conditions, impacts and regulations associated with wildfire. More fires are being recognized for their harm to air quality and watersheds, which can increasingly impact municipal water systems.

EPA and its state counterparts share responsibility for administering the Clean Water Act and the Clean Air Act, which were enacted to restore, protect, and enhance the quality of the nation’s water and air, respectively. These laws and other environmental laws such as the National Environmental Protection Act (NEPA) and the Endangered Species Act (ESA) add significant requirements for federal fire management programs. They have become important factors as land managers increasingly conduct fuels treatment projects, particularly when using prescribed fires, which can impact air and water quality. As a result, EPA and its state counterparts are becoming more involved in these deliberations and evaluations both before and after a prescribed burn, and tools are being established to understand, monitor, and potentially mitigate these impacts.

2.4.6 U.S. Geological Survey

The U.S. Geological Survey (USGS) provides support to the Department of Interior and others in the wildland fire community. USGS data, technology and other resources are being brought into more federal government missions, including wildfire management efforts, so that the utility of these federal investments and resources can be maximized.

Most recently, USGS has been helping at homeland security efforts, but also is providing assistance in land management functions.

Many parts of USGS now have fire-related projects, including biological resources, hydrology, geography and others. Its fire capabilities are in remote sensing and other mapping technology, particularly for fuels mapping and burn severity, but also in other areas, such as fire impact assessment, restoration and rehabilitation, fire ecology, and technical support for data collection and monitoring during fires. The agency has an Integrated Fire Science Team to help ensure the staff working on various projects is aware of each others' progress, needs and results. USGS also has sponsored three wildland fire workshops. The most recent one was in November 2002 and allowed staff to explain and receive feedback on their projects, as well as provide opportunities for land management agencies to describe their needs that could be aided by USGS. USGS also participates in a rising number of interagency fire groups and efforts.

USGS specifically strengthened its GI/GIT efforts regarding wildfire management during the 2000 fire season. Additional automated tools were needed to best prioritize and allocate resources to multiple wildfires that were occurring simultaneously. In order to help provide information on the status, location, and proximity of wildfires to values at risk, USGS teamed with others to create GeoMAC, which includes technical experts in the application and utilization of computer and satellite mapping capabilities. Initial GeoMAC participants included federal agencies (e.g. USGS, Forest Service, BLM, FWS, NOAA, etc.) and private corporations (e.g. ESRI, ERDAS, Sun Microsystems, and IBM). While there have been some changes since GeoMAC was established, it now provides mapping software applications, computer hardware and technical expertise (http://geomac.usgs.gov/AboutGeoMAC/TheNeed.html). GeoMAC has both an Internet and Intranet site (http://wildfire.usgs.gov) that supplies information to the general public and to wildland fire managers. A variety of maps, an Internet map server, imagery, contact information, and other technical information are provided on the sites to support fire management and public information activities. The sites are heavily used during fire seasons to provide informational updates to policy makers, the media and public, and as part of fire response efforts at individual fire and higher levels.

Since the initial development of GeoMAC, USGS has continued to support the site as a public information tool supported by the land management agencies. USGS also is helping other regional fire organizations to develop GeoMAC-like capabilities for wider usage. USGS also is helping with National Fire Plan (NFP) implementation, such as work on the information system to manage and monitor projects funded and undertaken under NFP. USGS is striving to do more research that is relevant to fire and is conducting more technology transfer efforts to increase the utility of the results of this work.

USGS also traditionally has the lead role within the civilian federal government to acquire access to DOD informational assets for wildland fire and other civilian applications. It chairs and staffs the Civilian Applications Committee (CAC), which helps the Forest Service gain access to DOD information for fire response. In addition, as discussed previously, USGS teamed with DOD's National Reconnaissance Office regarding the Hazard Support System (HSS), which was initiated to provide government agencies with early warning of wildland fires, though this system is now dormant.

2.4.7 National Aeronautics and Space Administration

The National Aeronautics and Space Administration (NASA) has strengthened its efforts to partner with federal agencies with fire management and other responsibilities in order to provide them with valuable applications from science and other activities within NASA. For example, as further described in Chapter 4, a widely acclaimed NASA application is the operational use of the MODIS sensor to provide rapid delivery of current information about fires (http://activefiremaps.fs.fed.us/). NASA also recently signed an agreement with USDA that provides overall authority for interagency efforts to facilitate and encourage remote sensing and other NASA applications at USDA, which will include wildfire. An additional agreement and working arrangement is under development between NASA and the Forest Service to encourage further work together.

2.4.8 National Institute of Standards and Technology

The Fire Prevention and Control Act (PL 93-498) authorized the National Institute of Standards and Technology (NIST) to conduct research on all aspects of fire. It has a Building and Fire Research Laboratory that is located at NIST's main campus in Gaithersburg, Maryland. With over 100 full time staff, work at this lab addresses various aspects of fire, though the primary efforts there are to address structural fires. For example, the lab is conducting a congressionally authorized investigation about the fall of the World Trade Center. However, NIST’s fire physics and related research also is applicable to wildland fire, such as development of wildland urban interface (WUI) fire modeling. It is necessary to incorporate many different types of fuel (trees, decks, siding, roofs, landscaping, etc.) to fully understand fire spread and risk of ignition. Researchers also are investigating how to incorporate information recorded by fire alarms into tactical decision making on individual fires. Wildland fire work at the lab is being conducted with assistance and funding from other agencies, including the Forest Service.

2.5 HISTORICAL FIRE COORDINATION MECHANISMS IN THE FEDERAL GOVERNMENT

The federal government has developed several interagency approaches and mechanisms to help manage its wildland fire programs. In some cases, they only include federal entities. However, state governments, acting through the National Association of State Foresters (NASF), have also been a part of many of these efforts based on the long standing relationship between the Forest Service and State Foresters dating back to the early decades of the century.

Historically, most interagency wildfire approaches have specifically addressed fire response, while others have recently emerged with other and broader roles. Moreover, more of these approaches are including other stakeholders beyond federal agencies and State Foresters. Below is an overview of long term federal interagency mechanisms. Newer and broader efforts and mechanisms with a wider range of participating organizations are described in Section 2.9.

2.5.1 National Interagency Fire Center

The Forest Service and BLM established an Interagency Fire Center in 1965 to improve fire and aviation support for wildfire suppression in the Great Basin and Intermountain West. With its success, other agencies joined the center in the 1970s. Known today as the National Interagency Fire Center (NIFC) and located in Boise, Idaho, seven agencies (Forest Service, BLM, NPS, FWS, BIA, NWS, and DOI's Office of Aircraft Services) work together to coordinate and support joint wildland fire and disaster operations (http://www.nifc.gov). It is the nation's management and logistical support center for wildland firefighting. NIFC's participating agencies are responsible for exchanging information, support, protection responsibilities, and training. Each agency, although co-located, operates and conducts activities in their own manner. NIFC primarily operates as a focal point for federal wildfire response, though state governments are also represented as the National Association of State Foresters (NASF) has an office there.

As discussed in Chapter 5, a key part of NIFC is the National Interagency Coordination Center (NICC), which is staffed by personnel from various federal agencies. NICC staff quickly locate and mobilize emergency personnel, equipment, supplies, and aircraft for fire suppression efforts. NICC works with and is supported by 11 Geographic Area Coordination Centers (GACCs), Geographic Area Coordination Groups, and Local Unit/Interagency Dispatch Centers located throughout the country, as discussed in Chapter 5.

2.5.2 National Wildfire Coordinating Group

The National Wildfire Coordinating Group (NWCG) was formed in March 1976 by a cooperative agreement between the secretaries of Agriculture and the Interior. As shown in Figure 2-9, the five land management agencies, the U.S. Fire Administration, NASF, the Intertribal Timber Council, and the Research part of the Forest Service are the voting members of NWCG. The National Fire Protection Association and international partners (Australia and New Zealand) serve as non-voting members. The purpose of the group is to improve the efficacy and efficiency of all federal and state wildland fire management agencies in the U.S. It helps to coordinate programs of the agencies and provides a formalized system through which policies, guidelines, and standards on substantive fire management issues can be developed. Each agency determines if and how it will adopt NWCG proposals (http://www.nwcg.gov/).

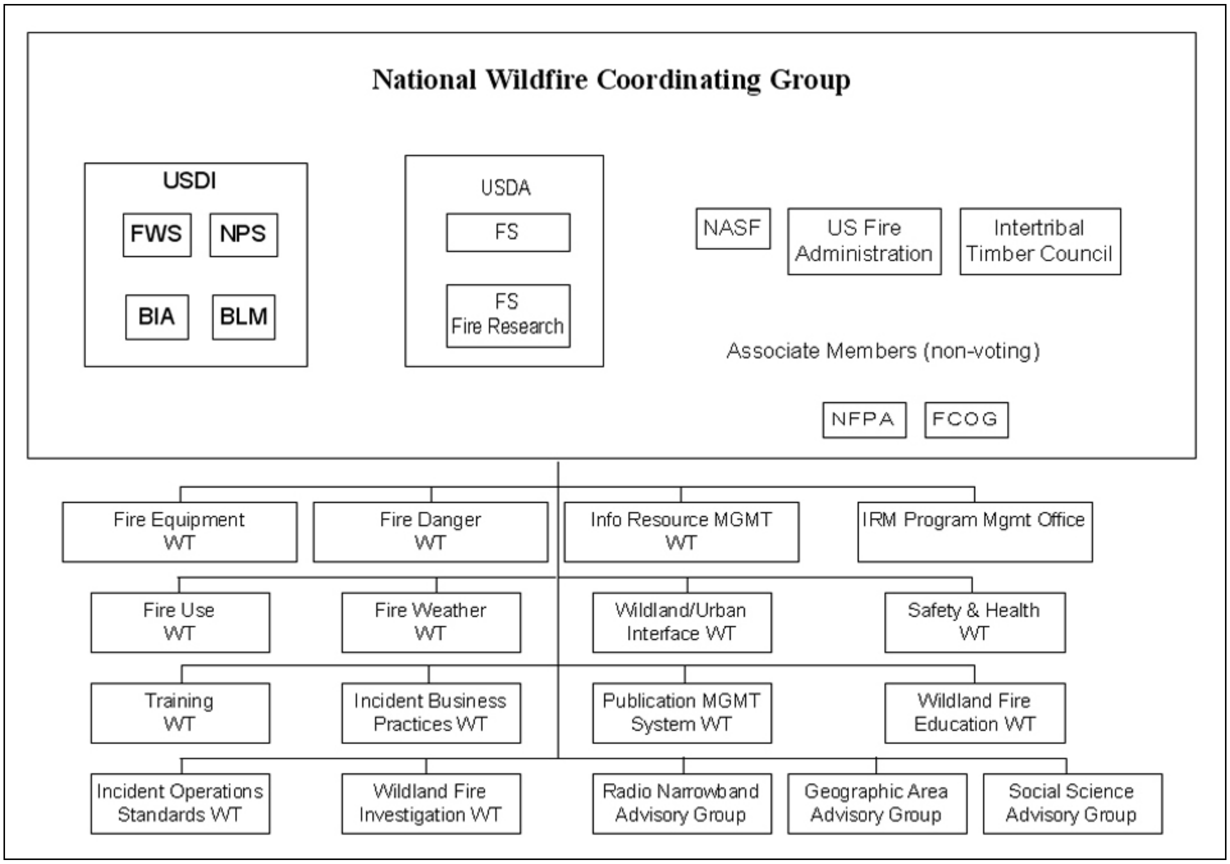

Figure 2-9. NWCG Organization

NWCG has 15 working teams that explore various fire management and related issues. As described in Chapter 5, one is the Information Resource Management Working Team (IRMWT), which created a Geospatial Task Group to provide all the NWCG Working Teams with quality information and advice concerning the use of geospatial data, applications, and processes in support of interagency wildland fire management.

2.5.3 Joint Fire Sciences Program

While each of the above coordination mechanisms is primarily focused on fire suppression and response, a Joint Fire Sciences Program (JFSP) was established pursuant to direction by the Appropriations Committees in FY 1998. The JFSP was created for the Department of Interior and the Forest Service to develop a scientific basis and rationale for implementing fuels management activities. The focus was on developing approaches that would lead to the development and application of tools for fire managers. A goal of the program was to establish the process and oversight structure needed to identify and meet fire information and technology support needs for a national interagency fuels management program.

JFSP is directed by a governing board and a stakeholder advisory group, with a small support staff within BLM. Part of JFSP's work is to entertain and fund research proposals that address locally and regionally important science and technology needs concerning fuels management. Funding and support for this program has continued to grow since its creation, and it has provided resources for several fire GI/GIT activities and studies.

2.5.4 Other Coordination Mechanisms

As indicated above in Section 2.3, additional coordinating configurations have been put in place since adoption of the National Fire Plan and 2001 Fire Policy, such as the DOI Office of the Wildland Fire Coordinator and various interagency coordinating groups. Some of these interagency efforts involve state and local government representatives. State Foresters have long been participants in some of these interagency efforts. However, additionally, representatives of other organizations are increasingly involved as well, such as the Western Governors' Association (WGA), the National Association of Counties (NACo), the National Association of Fire Chiefs (NAFC), and others as described later in this report.

2.6 STATE GOVERNMENTS

The majority of wildfires, in terms of the number of fires, are not located on federal lands. For example, as shown in Figure 2-1, approximately 75% of the reported fires in 2002 were on state or private lands. The vast majority of fires are small, with only a very small number burning over 100,000 acres and causing significant damage. However, as shown in Figure 2-10 for 2002, three states experienced fires with nearly one million or more acres burned.

State governments have long been important partners with the federal government in wildland fire management, with expanding efforts in recent years. State governments are typically responsible for fires on lands they manage, but often also have these roles on private and even some federal land as discussed below. States also have various additional roles regarding wildland fire.

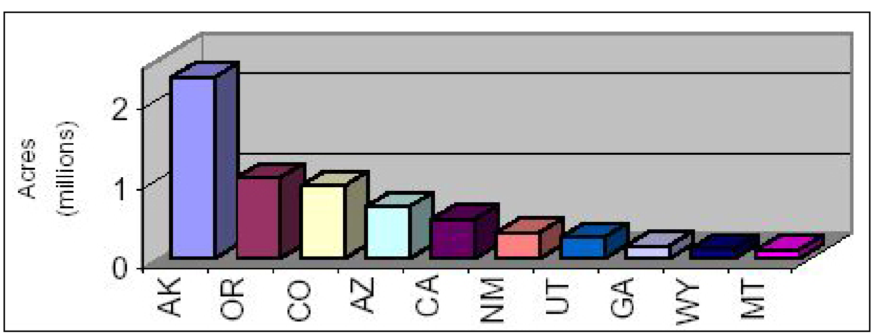

Figure 2-10. Acres Burned in 2002 (by state)

2.6.1 General Description and State Policy Directives

The role of state governments in wildland fire management varies from state to state and is primarily determined by state statute. Arrangements also have evolved, determined in part by the existence and capabilities of fire management personnel and available resources in the vicinity. Statutory directives determine the authority of state wildland fire organizations as compared to local jurisdictions. For example, in Colorado, sheriffs are directed by state statute to assume charge thereof or to assist other governmental authorities in the case of any forest or prairie fire.

Some states, such as California, provide a broad level of state government responsibility and authority for fire management, while other states are more limited. The California Department of Forestry and Fire (CDF) includes the traditional role of a State Forestry Organization (SFO), including management of some state lands and oversight and assistance over private forested lands, as well as state wildland fire management, which is its largest function. However, unlike most other states, CDF's role also includes that of a state fire marshal's office, which addresses structural fires and primarily works with local fire departments.

2.6.2 State Agencies and Organizations with Direct Wildland Fire Management Responsibilities

SFOs have traditionally been the lead organizations for wildland fire management in states with wildfire roles and responsibilities. Al 50 states have a designated State Forester. All but three of the SFOs (South Dakota, New York and Massachusetts) have wildland fire under their jurisdiction (Warnecke, Nanni, Nedovic-Budic, Stiteler, 2002). SFOs vary significantly in size, responsibilities, and operating practices, but they all play a significant role in wildland fire management, even in states where fire is not within their organization. They are often located within a state department of natural resources, lands or agriculture. SFOs are responsible for a wide range of land management functions similar to the federal land management agencies.
In addition, unlike federal agencies, many SFOs have forestry and wildfire authority over private lands as well as state lands. For example, the Florida Department of Forestry is responsible for wildland fire suppression not only on state lands (800,000 acres) but also on all private lands (26 million acres). Some SFOs also have fire suppression roles over federal lands, as does the Oregon Department of Forestry for Oregon's BLM lands. Most SFOs are primarily concerned with protecting, preserving, and enhancing their forest assets for the economic benefit of the state, and their wildland fire efforts focus mainly on fire suppression.

SFOs use state resources for their wildland fire programs, but they also receive significant funding from the federal government for those activities. The National Fire Plan has significantly increased federal funding of the states' fire programs. For example, of the over $1.9 billion Congress appropriated in FY 2001 to implement the first year of the National Fire Plan, over $75 million was designated for state assistance, which was to be allocated to the SFOs. This figure was increased to almost $82 million in FY 2002. This funding level compares to less than a third of this figure in the largest previous year.

2.6.3 State Agencies Supporting and Impacting Wildland Fire Activities

Similar to the federal government, state agencies that do not have direct responsibility for wildland fire management, also have important roles in the states' overall wildland fire management programs. The state counterparts to FEMA, the state Emergency Management Agencies (EMAs), which operate in a similar fashion and in tandem with FEMA, have overall responsibility for disaster response at the state level, which includes wildland fire. While the SFOs are responsible for suppressing wildland fires, the EMAs often are responsible for responding to the consequences of those incidents.

The relationship between SFOs and EMAs vary by state. Particularly in severe fire seasons, problems may exist with integrating the efforts of those who fight the fires (the SFO/fire organization) and those with the capacity to provide the support to address the consequences of the fire (the EMAs). Sometimes EMAs or SFOs may not be fully aware of, or work with, each other about their related activities and decision-making processes. This situation is due in part to past conditions when many states did not have active EMAs and far fewer homes were considered to be in the wildland-urban interface (WUI). In some states, the state and federal wildland fire agencies have not yet determined the most appropriate or helpful roles for various emergency management organizations, or EMAs in particular. For example, when there are severe fires that threaten populated areas, the public needs information on smoke, road closures, evacuation procedures, and where to seek emergency shelter, food, etc. EMAs have systems in place and are experienced in providing such assistance. Good working relationships between SFOs and EMAs can increase the effectiveness of these services, which are critical during fire and other disasters.

Florida is an example of a state in which a strong relationship has been promoted between its SFO and EMA. The Division of Forestry and the Division of Emergency Management worked together to develop *Guidelines of the State Emergency Response Team for Wildfire* (May 2001) which outlines coordination under the Division of Emergency Management that is required to support the Division of Forestry during wildfire events. It serves as a good example of a coordinated approach. The document describes the roles and responsibilities of the Division of Forestry, the Division of Emergency Management, the Florida Fire Chiefs Association, and the State Fire Marshals Office, and the procedures to be followed with respect to:

- Activating the State Emergency Operations Center (SEOC)
- Unifying under a single command structure in responding to, controlling and suppressing wildfires
- Providing public information during SEOC activation
- Providing logistical support to the unified command during wildfire events
- Ensuring the flow of information
- Requesting fire suppression assistance

Other state agencies have active roles in wildland fire management. State Fire Marshals and State Insurance Commissioners are the lead agencies for determining risk, particularly for structural losses due to fire. This topic is of increasing concern and decisions about whether or not to let a fire burn, and will be of growing importance in the future.

State environmental and/or natural resources agencies also have important roles in the states' wildland fire management programs. As described above regarding related federal agencies, these state agencies can have a significant impact on prescribed burn activity in terms of the amount of air and water pollution that is or could be generated or allowed. State planning agencies can play a big part in wildfire mitigation as part of growth management decisions and strategies.

Organizations using GIT are at an advantage because they can use these tools to better communicate, manage, analyze and integrate often otherwise disparate information, which leads to better and more informed decision-making by wildland fire management. These organizations also might have information of indirect value to the fire management program, such as moisture content of vegetation. For example, these data can be ingested into computer models that relate to fuels buildup, helping to determine the likelihood of a major fire when factored together with weather, wind and other conditions on the ground.

2.6.4 Nationwide Organizations of States Addressing Wildland Fire

The states have organized themselves into some key nationwide and regional organizations that are active and growing in their influence regarding wildland fire as discussed below. States also have worked with other stakeholders in their states to establish innovative approaches to wildland fire coordination within their boundaries, with some examples provided below.

2.6.4.1 Western Governors' Association

State Governors are recognized as having a leading role concerning wildland fires, particularly in the western states. Established in 1984, the Western Governors' Association (WGA) is an independent, non-partisan organization of governors from 18 western states, two Pacific-flag territories, and one commonwealth (http://www.westgov.org/). WGA serves as a forum where its members can develop both long- and short-term strategies for issues facing the region.

Western Governors began to increase their influence on fire conditions during and in response to the 2000 fire season. Following a meeting with the Secretaries of Agriculture and the Interior in September 2000, WGA members worked with representatives of the Forest Service, DOI, State Foresters and other interested stakeholders to develop support for expanded effort and funding to address wildland fire conditions in the country. Their support had marked influence on Congressional interest and resulting financial support for fire needs. This is reflected in the large increase in federal funding for fire for Fiscal Year 2001 known as the National Fire Plan. WGA also was a leading participant in development of a ten year plan for improving forest ecosystem health in the West, entitled *A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment – 10-Year Comprehensive Strategy* (http://www.westgov.org/wga/initiatives/fire/default.htm). The plan was endorsed by WGA and the Secretaries of Agriculture and the Interior, and transmitted to the Congress on August 13, 2001 (see Section 2.9).

WGA and the western Governors have maintained their interest and support concerning wildland fire since then. This effort has included having an instrumental role in the Implementation Plan developed for the *10-Year Strategy*, sponsorship of meetings and other events to foster dialogue and reach consensus on related issues, and several occasions at which Governors testify about the needs for federal action and funding to address current and future needs. Most recently, WGA sponsored a Forest Heath Summit in June 2003 to encourage progress with local projects that address fuels accumulation in the west and minimize damages from wildfires. The Governors also have encouraged action concerning the growing drought conditions, with a bill proposed in this summer to address this growing concern regarding fire and other matters.

The interest and activity of WGA regarding fire is extending to other regions of the country. WGA is recognized as the strongest of the regional groups of Governors because of the several common issues and perspectives that they share. However, the Southern Governors' Association, has begun to take policy actions in this regard, and has been invited to participate with WGA in several wildland fire-related activities.

In separate action, western Governors expressed support for GI/GIT with the formation of a Geographic Information Council in 1999 and subsequent adoption of related resolutions (http://www.westgov.org/wga/initiatives/westgis/default.htm). The Council was formed when each Governor selected a key representative to the group. The Council was initiated in part due to a project undertaken with NASA that included a workshop to discuss state remote sensing needs. Other western issues and needs have also been addressed with subsequent meetings and projects.

2.6.4.2 National Association of State Foresters

State Foresters in several states began dialogue and meetings that evolved to become the National Association of State Foresters (NASF) in the early years of the last century. NASF is a non-profit organization that represents the directors of the SFOs from all 50 states, 8 U.S. territories (American Samoa, the Federated States of Micronesia, Guam, the Northern Marianas Islands, Palau, Puerto Rico, the Republic of the Marshall Islands, and the U.S. Virgin Islands), and the District of Columbia (http://www.stateforesters.org). NASF focuses its efforts, with its partners, on discussing, developing, sponsoring, and promoting (1) programs and activities that will advance the practice of sustainable forestry and the use of forest products; (2) the conservation and protection of state and private forest lands and associated resources; and (3) the establishment and conservation of forests in the urban environment. NASF has several active committees, an annual conference and other gatherings throughout the year, and works with three strong counterpart regional associations of State Foresters. As evidence of the importance of fire matters, more State Foresters desire to be members of the Fire Committee than any other committee (Hull, 2003).

Unlike WGA, which has just become involved with fire matters in recent years, NASF has traditionally been very involved with the federal fire community, and has been the leading and sometimes the only non federal participant in fire matters. NASF has a particularly close relationship with the Forest Service for many programs in addition to fire. As an example of the close relationship between State Foresters and the federal fire community, NASF is the only non-federal member of the National Fire and Aviation Executive Board though the National Wildfire Coordinating Group has other non federal members. Moreover, former Montana State Forester Don Artley served as NASF's representative, and at one point chaired NWCG. He now serves as NASF's Fire Director and is located at NIFC.

NASF has not acted officially as an organization regarding GI/GIT, but two of the three regional associations of State Foresters have done so since 2002. NASF's Fire Committee and others have also addressed this issue, with the Fire Committee considering provision of funding to support web-based communications among GIT users in SFOs. State forestry representatives participated in the Forest Service's annual GIT conference in 2003 and discussions are underway about further efforts at the regional and national level. A project has been underway with support from NASA to understand current and potential applications of these data and technology for state forestry applications, including fire, with a recent report documenting extensive GI/GIT activities among most SFOs (Warnecke, Nanni, Nedovic-Budic, and Stiteler, 2002). (http://www.esf.edu/forest/policyIndex.html).

2.6.4.3 National Emergency Management Association

The National Emergency Management Association (NEMA) is the professional association of state emergency management directors (including the territories and the District of Columbia) (http://www.nemaweb.org/index.cfm). NEMA is committed to:

- Providing national leadership and expertise in comprehensive emergency management,
- Serving as a vital information and assistance resource for state and territorial directors and their governors, and
- Forging strategic partnerships to advance continuous improvements in emergency management.

NEMA provides a similar role as NASF in terms of providing opportunities for peer networking, policy research, education, forums to share and discuss best practices, and addressing federal and national issues. This is done while advocating an "all hazards" approach to emergency management. NEMA has had a close working relationship with

FEMA as NASF has had with the Forest Service for many years. It is organized into several committees such as for legislation, mitigation, readiness, preparedness, training, response and recovery, and others. Members meet twice a year and develop issues and proposals for presentation to Congress and FEMA. NEMA has not been officially involved in wildland fire direction and coordination to date. However, it is recognized that with the growing linkage of fire matters with other emergency management and homeland security concerns, opportunities and discussions are growing for NEMA to work more closely with NASF.

GI/GIT matters have been raised among and discussed by the members of NEMA similar to WGA and NASF. Several of its committees have had related discussions, and the Readiness Committee created a Technology Subcommittee which will address these matters with related interoperability issues.

2.6.5 Interstate Compacts

Many states have leveraged their fire and emergency management resources by joining compacts with nearby states. Such compacts provide for a streamlined approach to provide and/or receive mutual aid assistance to help respond during a fire or other disaster. In 1996, Congress approved the establishment of the Emergency Management Assistance Compact (EMAC) in Public Law 104-321. Compacts are essentially mutual aid agreements and partnerships between states for dealing with disasters. EMAC offers an efficient way for states to send personnel and equipment to help disaster relief efforts in other states. States can ask for whatever assistance they need. Under EMAC, states requesting such assistance are responsible for reimbursing all out-of-state costs and are liable for out-of-state personnel. As of 2003, 48 states, Washington D.C and two territories have ratified EMAC. The only requirement for joining it is for a state's legislature to ratify the language of the compact. States are not required to provide assistance unless they are capable of doing so (http://www.emacweb.org/EMAC/About_EMAC/About_Emac.cfm).

Fire compacts primarily exist in regions of the east where federal resources are less prevalent. The Northeast Forest Fire Protection Commission consists of seven northeastern states and three Canadian provinces, and is the oldest fire compact organization in the nation. Similar compacts exist in the Southeast, Mid-Atlantic, Great Lakes, and other regions in the country. The states of Montana and Idaho recently formed a smoke compact to minimize air quality hazards from fires. State compacts are often considered to be an economical and easier way to gain fire assistance than using federal resources, particularly since neighboring states can be very close and staff can travel quickly and easily to another state to provide assistance. Another reason to ask another state for help is that firefighters from neighboring states often are more familiar with the conditions and culture of the requesting state than are federal employees who may be from the other side of the country. The compacts undertake various projects on behalf of their member states. For example, the Northeast and Mid-Atlantic Compacts have undertaken fire studies including mapping of past fires and other data to help understand fire risks.

2.6.6 Internal State-based Coordination Approaches

Many states have developed approaches and mechanisms to coordinate various aspects of wildland fire management activities within their borders. In particular, these approaches effectively include broader emergency management leaders and participants outside their state government that are stakeholders regarding wildland fire. A few are discussed below.

2.6.6.1 California FIRESCOPE

FIRESCOPE (Firefighting Resources of California Organized for Potential Emergencies) was established after the disastrous 1970 wildland fires in Southern California (http://firescope.oes.ca.gov/). It is a cooperative effort that involves all agencies in California with firefighting responsibilities. Cooperators include the BLM State Office in California, the California Department of Forestry and Fire Protection, Kern County Fire Department, Los Angeles Fire Department, Los Angeles County Fire Department, Orange County Fire Authority, Sacramento Fire Department, Ventura County Fire Departments, U.S. Forest Service, California Highway Conditions, California Department of Transportation, FEMA and others.

FIRESCOPE's goal is to create and implement new applications in fire service management, technology and coordination, with an emphasis on incident command and multi-agency coordination. This statewide program was a model for interorganizational fire approaches at the national level and continues to serve the needs of California firefighters today.

FIRESCOPE has a committee formalizing standards for the use of GIS for mitigating large-scale emergencies in California. Included in these standards is the position description for a GIS Technical Specialist, who will become part of the Incident Command System. Potential standard mapping output from this position could include incident boundaries and areas, resource locations, incident history, manmade and natural features, and other valuable data.

2.6.6.2 Florida District Wildfire Services Councils

In response to the 1998 wildfires, the Florida Division of Forestry developed Wildfire Services Councils (DWSC) in each district to provide a liaison between their local district office and local emergency response agencies to plan for coordinated wildland fire preparedness and response within a forestry district. Membership of these councils includes:

- The Division of Forestry (chair)
- A regional disaster response representative of the Florida Fire Chief's Association
- Local fire department chiefs

- County emergency management directors
- Federal agencies that provide fire response resources within the district
- Representatives of private forest landowners who provide fire response resources
- Area Department of Emergency Management coordinator
- Statewide Department of Emergency Management fire liaison
- Area representative of the State Fire Marshal's Office

At a minimum, these councils meet twice a year. They are responsible for developing a District Wildfire Response Plan to tie together the County Operating plans in order to provide better coordination between the counties within the forestry district on wildfire response. Coordination between District Wildfire Response Plans occurs at the state level via the State Wildfire Response Plan. For example, the mission of the Central Florida Prescribed Fire Council is to promote public understanding of and responsible use of prescribed fire. The Council encourages an information exchange related to techniques and experiences with prescribed fire. It includes 18 "cooperators" who represent federal, state, and local governments and the private sector.

2.6.6.3 Wyoming National Fire Plan Organization

Governor Jim Geringer created the Wyoming National Fire Plan Organization as a three-tiered organization to help the State of Wyoming develop an integrated capacity to implement the National Fire Plan. Under this approach, the Executive Team is chaired by the Governor and includes the federal land management agencies and the state's Indian tribes. It was established to coordinate statewide activities as well as individual federal, state, and local ownership mitigation projects, as well as to provide a coordinated public information message pertaining to National Fire Plan implementation. The Wyoming Fire Plan Action Team includes representatives of the agencies on the Executive Team plus the state's municipal league and county association, EPA, the State Forester, and the state Office of Federal Land Policy. A Local Project Implementation Team is formed for each project in the program to include representation from the affected local fire departments, landowners, associations, businesses, and the general public. The local teams perform tasks similar to the action team, but at the local level.

2.6.6.4 Minnesota Incident Command System

In 1984, the State of Minnesota established the Minnesota Incident Command System (MNICS) to facilitate joint fire training and resource sharing among agencies. The role of MNICS was later expanded to include fire dispatch and coordination, the fire cache, and rural fire department support. Participants in MNICS include the Minnesota Departments of Natural Resources and Emergency Management, the Minnesota Fire Chiefs Association, and the federal land management agencies with a presence in the state—the Forest Service, NPS, FWS and BIA. All members have representatives at the Minnesota Interagency Fire Center in Grand Rapids, Minnesota, which is the focal point for MNICS operations.

2.7 LOCAL GOVERNMENTS AND REGIONAL ASSOCIATIONS

Local governments have more important roles and greater responsibilities for wildland fire than ever before. In many cases, this is due to the growing incidence of fires in the Wildland Urban Interface (WUI). Fires in these areas are some of the most costly to suppress, and recent experience has shown that the loss of life and property is increasing from these events. An important and mounting issue is that state and federal government organizations do not have response authority for structural fires, even though wildfires involving structures are a growing percentage of the total number of fires. These fires can amount to as many as 70% or more in urbanized states.

As discussed below, local governments have many authorities and activities that can direct and influence wildland by minimizing damage and losses, but at the same time, enable fire to be an essential component of ecosystems. Regional associations have limited roles to date in wildland fire, but offer potential for regional planning approaches to wildland fire and assistance delivery. Local governments often initiate numerous mechanisms to coordinate wildland fire-related activities. Many of these are informal, but nevertheless contribute in a large way to local wildland fire efforts. For example, Boulder County, Colorado hosts the Northern Front Range Wildfire Cooperators. It is an informal group of people affected by wildfire in this region working to help address matters in a collaborative way. Other coordination mechanisms are more formal, with some discussed below.

2.7.1 Local Agencies with Direct Fire Management Responsibilities

Localities with fire management responsibilities include sheriffs and emergency management organizations in the nation's over 3,000 counties, as well as municipal and volunteer fire departments in thousands of municipalities, towns and townships, and rural fire districts. The nation has over 80,000 units of local government, but information is limited to how many of them have helpful firefighting capacities for wildland fire, because many are very small organizations.

Fire departments are increasingly recognized as "first responders" for many wildland fire incidents as well as being relied upon for other emergency management and homeland security needs. While these departments are considered crucial in protecting communities from wildland fire both before and during a fire incident, concerns are growing about the capacity of fire departments to meet expanding needs. A needs assessment was conducted by the U.S. Fire Administration (USFA) and the National Fire Protection Association (NFPA) in 2002, and provided the most recent documentation about the number and capabilities of the nation's fire departments (USFA and NFPA, 2002). The report indicated that 84% of local fire departments provide some wildland fire protection. This percentage increases to 90% in communities less than 2,500 people. It is estimated that the country is served by approximately 28,000 rural fire departments, with rural defined as serving communities with populations under 10,000. Many of them are strictly volunteer departments without, or only one or two, paid staff that operate separately from local government structures. Moreover, not all of these departments have taxing authority, so they have very limited funds and resources for events of any kind.

The perceived importance of rural and volunteer fire departments for wildland fire and other response needs is resulting in large increases in funding from the federal government. The National Fire Plan in the FY 2001 budget provided additional resources, which has been sustained in the FY 2002 and 2003 budgets, including over $13 million of Forest Service funding and $10 million through the Department of Interior. This funding is augmented by the markedly increased grant program of the U.S. Fire Administration, which is available for all the nation's fire departments. The program received a sizable increase to $360 million in FY 2002, and another $750 million in the FY 2003 budget.

The USFA and NFPA assessment in 2002 was recently complemented with a June 2003 assessment completed by NASF and others that focused specifically on the changing role and needs of local, rural, and volunteer fire departments for wildland fire in the WUI (NASF, 2003a). The report was prepared for Congress as one of several implementation items for the *10-Year Comprehensive Strategy for Reducing Wildland Fire Risks to Communities and the Environment,* as discussed later in this report. It identifies four critical issues in need of urgent attention in order to operate safely and effectively in the WUI, including efficient interagency response, initial attack and emergency communications capability; wildland fire training; and coordinated federal and state assistance. A long-term approach is encouraged that integrates:

- Prevention and suppression,
- Hazardous fuels reduction,
- Ecosystem restoration, and
- Community assistance from the local level on up.

These strategies are based on the conclusion that public investment in strengthening the preparedness of local firefighting resources offers a greater immediate return in improved protection and effective suppression response than any other component of the*10-Year Comprehensive Strategy* or the National Fire Plan. By investing in these local resources, it is concluded that three key desired outcomes will be successfully achieved: healthier watersheds, healthier communities, and diminished risk and consequences of severe wildland fires.

While most volunteer fire departments struggle to obtain funding for basic fire protection needs, other fire departments have been successful at developing their own GI/GIT capabilities. This 2003 assessment includes an example of how GIS is used to identify and address individual properties at risk of fire in WUI. More examples are presented in Chapter 3 of this report. GI/GIT also is used to enhance firefighters training and public education programs. Some departments are developing their GI/GIT capabilities to use in the field at fire events.

In addition to fire departments, a growing number of local governments have active planning, open space and watershed protection organizations and programs that have direct roles regarding fire. They often provide resources to assist in fire events on these lands and may share costs with responding fire agencies. One example of this is Boulder County, Colorado, home to more than 100,000 acres of local open space, plus many more protected acres that begin along the Continental Divide providing a major water source to the communities below. The city has a Wildland Fire Management program that was initiated in 1990 with the hiring of a Wildland Fire Coordinator. The program is funded by both the City of Boulder Fire Department and Mountain Parks and Open Space, and is critical in establishing a comprehensive program to address the threat of wildfire to the community and on the city's 43,000 acres of public lands.

This program is successful because of the close working relationship between local, state, and federal agencies. Several hundreds of city and county firefighters have been trained in wildland firefighting techniques with the assistance of this program. Mutual aid agreements have been developed through the program for dealing with over 30 fire districts in the county. The interagency effort also supports a helicopter program that benefits the city, the county, the U.S. Forest Service and other public lands. Paid local staff consists of a Division Chief of Wildland Fire, Wildland Fire Management Officer, Wildland Fire Mitigation Supervisor, Prescribed Fire Management Specialist, and a Seasonal Mitigation Crew.

2.7.2 Local Agencies Supporting and Impacting Wildland Fire Activities

In addition to local government organizations with direct fire response roles, other local offices have important support and mitigation responsibilities. Offices with GIT capability often help provide maps and other information indicating areas at risk and predicting wildfire behavior. Provision of this information to landowners and response organizations can be helpful in mitigation and preparedness efforts. GIT is becoming a widely used tool to assist with public education, assist with fire or disaster training, and support land use and land management planning. Often this requires a cooperative effort among different departments and agencies. Local county tax assessor offices often provide base parcel information, including the dollar values used in damage and community risk assessments. Transportation, utilities, and public works departments often provide infrastructure information and also can benefit by modeling evacuation routes and preparedness exercises. Public utility companies and private delivery companies may provide their own geospatial data to help.

The perceived importance of local and regional land use planning and building departments in wildfire mitigation and disaster planning is growing, as evidenced by the increase of attention given to the subject at planning conferences and training offerings. The increase is also seen in the growing number of communities that are updating their comprehensive plans, policies, codes, regulations, and education programs. Fire response is challenged by years of development unprepared to coexist with the challenges of the WUI. These planning departments and their elected local community leaders have begun to see the need to improve development that is rapidly overwhelming the capabilities of fire protection, increasing areas at risk, and creating challenges for forest and other wildland management. The desire is growing to build sustainable communities that are disaster resistant and now even “Firewise,” the name of a current federal program to reduce harm from wildland fire as described in Chapter 3. Various planning tools, such as local codes and GIT capabilities, are helping to achieve this desired outcome.

Planning and building inspection agencies have critical roles because they oversee the type and density of development and the building materials utilized, which can have a significant impact on the flammability of homes in the WUI. For example, a growing number of municipalities do not allow wood shake roofs, and "defensible space" is strongly encouraged. However, it is important to note that many rural governments have limited zoning ordinances or building codes, and even when they do have such requirements, enforcement can be limited. Many people move to rural areas to avoid government, which makes it difficult to effectuate development restrictions and building requirements that can reduce the risk and severity of wildfire damage. Today’s local governments and regional council of governments such as METRO in Portland, Oregon and the Denver Regional Council of Governments (DRCOG) are well equipped with GI/GIT to assist in wildland fire matters. These offices increasingly serve a variety of requests, including demand for disaster planning for all hazards.

2.6.3 Nationwide Organizations of Localities Regarding Wildland Fire

Several local government organizations have important and growing roles regarding wildland fire. The National Association of Counties (NACo) has traditionally been the leading local government organization working with the federal land management agencies regarding public lands issues, including fire. NACo is a membership organization of just over 2000 of the nation's counties. Elected county commissioners are key participants and leaders of NACo. NACo has both active legislative and program delivery aspects to the organization. It has an active Public Lands Committee and been asked to serve on various wildland fire groups and studies representing local government. However, NACo admittedly has very limited internal resources and expertise in this regard, and does not have any programs to work with or aid its member counties or others with these matters (Beddoe, 2003).

While NACo represents most of the nation's counties, many of the nation's municipalities are represented by the National League of Cities (NLC) and the National Association of Towns and Townships (NATaT). These organizations and most municipalities have not been participating in wildland fire groups as discussed in this report. However, they have important concerns about these matters, for example in terms of watershed protection, because most of the nation's potable systems are managed by municipalities. However, interest and concern is growing. For example, NLC's Energy, Environment and Natural Resources Committee had had some discussions about wildland fire at their 2003 meetings.

Local interests are also reflected in other organizations. The International City/County Management Association (ICMA) has had an informal “gateways communities” group, comprised of local government managers that are near federal lands and at risk of wildland fire and loss. Wildland fire is an important issue to local managers. For example, Phoenix, Arizona City Manager Frank Fairbanks has chaired panels authoring several of the National Academy of Public Administration (NAPA) reports about wildland fire that have been funded by the federal government that are referenced in this document.

The International Association of Fire Chiefs (IAFC), one of the oldest fire organizations, was founded in 1873 and has more than 12,000 members. It represents the majority of the nation's large fire services, both urban and rural. Most of its focus is on structural fire like other fire organizations at the local level, but IAFC also is increasingly concerned about wildland fire, particularly in the WUI. Wildfire is the only type of fire that is growing in numbers in the United States. IAFC has a Wildland Fire Control Committee and has been asked to represent local fire departments in various initiatives sponsored by federal and nationwide efforts, including the 2003 assessment of fire departments conducted by NASF as discussed earlier. IAFC also signed a cooperative agreement with the Department of Interior in September, 2003 to help address WUI fires through new IAFC workshops and training. Additional firefighter organizations include the National Volunteer Fire Council and the National Fire Protection Association, with a description of NFPA provided below.

2.8 OTHER WILDLAND FIRE STAKEHOLDERS

Additional stakeholders have important roles regarding wildland fire, and are being asked to participate with government leaders to develop collaborative approaches. Some of these organizations are briefly identified below.

2.8.1 Tribal Governments

Tribal governments are increasingly deciding to assume responsibility for wildland fire management on their lands rather than having the Bureau of Indian Affairs (BIA) do so. Tribes have perhaps the longest cultural history of fire use to help manage their land as any sector in the United States. Because they have sovereign rights to manage their land as they best see fit, tribal governments continue to use fire regularly as a management tool. Tribal governments are represented on federal fire groups by the Intertribal Timber Council. Many tribes have become sophisticated users of GI/GIT for fire, land management and other applications.

2.8.2 Non Governmental Organizations

Several non governmental organizations have an interest in or are active stakeholders in wildland fire management efforts. Two example organizations are discussed below.

2.8.2.1 The Nature Conservancy

The Nature Conservancy (TNC) is a private, nonprofit organization which operates in 27 countries and owns approximately 1,400 preserves throughout the world (http://nature.org). TNC's mission is to preserve plants, animals, and natural communities and their habitats that represent diversity on the planet. It has developed an integrated conservation process consisting of four fundamental components: (1) setting priorities through ecoregional planning, (2) developing strategies to conserve single and multiple conservation areas, (3) taking direct conservation action, and (4) measuring conservation success. TNC works actively with various federal and state agencies and others.

In order to accomplish its mission, TNC has developed an active fire program, using prescribed fire on approximately 450 sites annually, burning from 60,000 to 70,000 acres per year. Many of these burns are conducted in partnership with federal, state, and/or local governments. TNC has also studied the impact of wildfires due in part to its large role in managing data about the nation's vegetation. However, this responsibility was recently transferred to NatureServe (http://www.natureserve.org/), which uses GI/GIT to assist in this regard. TNC also is becoming active in educating the public about wildland fire, and has an active GIS program.

2.8.2.2 The Wilderness Society

The Wilderness Society has been active regarding wildland fire and has studied wildland fire occurrence and other fire conditions over time (http://wildfirecentral.org/). It has participated in various collaborative approaches to wildland fire, such as efforts to develop the *10-Year Strategy* with the Western Governors' Association and others. The Society is noteworthy because it was asked to represent all environmental groups in a presentation before the Wildland Fire Leadership Council in October 2002, and because it has made extensive use of GIS to portray the findings from its work.

2.8.3 Professional Associations

The wildland fire community has associations that represent firefighters and others that also have had a long term, and growing interest and activity in wildland fire.

2.8.3.1 National Fire Protection Association

Founded in 1896, the National Fire Protection Association (NFPA) is an international, nonprofit membership organization whose mission is to reduce the worldwide burden of fire and other hazards on the quality of life by developing and advocating scientifically based consensus codes and standards, research, training, and education. Its membership includes in excess of 75,000 individuals from around the world and over 80 national trade and professional organizations (http://www.nfpa.org).

NFPA's activities generally fall into two broad, interrelated areas: technical and educational. Its technical activity includes developing, publishing, and distributing more than 300 codes and standards that are intended to minimize the possibility and effects of fire and other hazards. Nearly 250 technical committees develop the codes and standards under the approved process of the American National Standards Institute. NFPA's codes and standards are widely used as the basis for legislation and regulations at all governmental levels. Several NFPA codes, such as the Fire Prevention Code, have attained worldwide recognition.

NFPA's educational activities are focused on motivating and enabling the public to be safer. For nearly 80 years, NFPA has sponsored Fire Prevention Week. Another well-known NFPA program is its Sparky the Fire Dog®Web site, which teaches children about safety. NFPA also publishes a wide range of handbooks, reference books, textbooks, field guides, and training and public education materials.

Since the early 1940s NFPA has collected, analyzed, and reported detailed fire experience data through on-site investigations of incidents of technical or educational significance. The NFPA's Fire Protection Research Foundation role is to provide practical, usable data on fire risk and state-of-the-art fire safety methods. The Foundation pursues its mission through research in two primary program areas:

- *New Technologies and Strategies*. The Foundation probes the frontiers of fire protection technology and fire safe human behavior.
- *Fire Risk Assessment.* The Foundation supports improved databases, risk and hazard assessment, and cost-risk-benefit methods. Major initiatives have developed a comprehensive fire life safety risk assessment methodology, and test protocols for firefighter protective equipment (http://www.nfpa.org/Research/index.asp)

NFPA is a core member of the Firewise program and leads up staff work in its efforts (http://www.firewise.org/). As described in Chapter 5, the program is an effort to educate the public and communities about fire, including how to minimize damage from wildland fires. Many participants in the Firewise program use GIT to assist in educating people about existing conditions and fire risks.

2.8.3.2 International Association of Wildland Fire

A more recent organization that is specifically addressing wildland fire is the International Association of Wildland Fire (IAWF). It is a nonprofit corporation formed to promote a better understanding of wildland fire, and built on the belief that an understanding of this dynamic natural force is vital for natural resource management, for firefighter safety, and for harmonious interaction between people and their environment. IAWF is dedicated to communicating with the entire wildland fire community and providing global linkage for people with shared interest in wildfire and comprehensive fire management (http://www.iawfonline.org/). IAWF also publishes the International Journal of Wildland Fire, which had a dedicated issue regarding GIT in 2001.

2.8.4 Industry Stakeholders

While most of the attention to forest management has focused on federal and other public agencies, private companies or individuals own the vast majority of forested land in the United States. Of the 747 million acres of forested land, either the forest industry (68 million acres) or other private landowners (363 million acres) own 431 million acres. Large landowners sometimes have fire response capabilities, and they conduct mitigation and preparedness projects for their lands. In some cases, they have conducted more fuels management projects than federal landowners. As a result, the wildfire danger on private lands is sometimes perceived as less severe than the danger on public lands.

An increasingly important private sector stakeholder in wildland fire is the insurance companies who are getting more involved in wildfire claims because of the increased incidence and severity of fires in developed areas. Insurance companies have been working through the Institute for Business and Home Safety in discussions about wildfires, and the Insurance Services Office has studied WUI hazards (Kovacs, 2001). State Farm Insurance is an example of a company that is using an assessment prepared by the state of Colorado as a baseline to assess conditions. GI/GIT is used to help determine, on a property by property basis, what improvements are needed to reduce wildfire hazards. It has recently been reported that the company is giving policy holders two years to clear brush and trees from around their homes or risk loosing insurance coverage for those homes at severe risk (National Fire Protection Association, 2003). The Colorado Forest Service is working with State Farm and local fire departments to help homeowners in this regard.

Utility companies also are increasingly involved in wildland fire operations because their infrastructure may be in the path of wildfires due to a larger number of wildfires occurring in developed areas. Additional safety issues are present if utilities are not part of response efforts, because situations such as live electric wires could pose severe danger to firefighters and others. Typically, local units fighting fires are responsible for contacting local utility companies to coordinate any needed power shut downs. Opportunities exist for better information sharing about the location of such infrastructure and coordination of these notifications. Emergency management agencies at the state and local level are often experienced in such efforts for other disasters and could help with fire. In addition, by involving these agencies, all participants would be in a better position to deal with the consequences of shutting down power to a geographic area.

Over the past few years, additional industries are more involved in wildland fire, in response to growing needs and perceptions of efforts. Private consultants offer many services such as risk assessments, wildfire mitigation plans, prescribed fuel treatments and evaluations of land management approaches. Many of these companies and others use GI/GIT to assist in this work, particularly to advance user-friendly approaches to address fire in WUI areas.

2.9 RECENT NATIONAL WILDLAND FIRE COORDINATION DIRECTION AND MECHANISMS

Section 2.5 above discusses wildland fire coordination mechanisms that have been established by the federal government for several years. While state and other entities have been asked to participate in some of these efforts (most notably the National Association of State Foresters), these groups have primarily been dominated by federal interests and needs. At the same time, most of these mechanisms and attention have primarily focused on fire suppression and response, though with increasing attention to prevention, preparedness, training and fuels treatment, including more recent authorization for the Joint Fire Sciences Program in 1998. With a growing expansion of wildland fire concerns to address even more matters, there has been a need and direction to broaden the base of stakeholder involvement and focus to set national wildland fire policies.

As described in Section 2.2, the National Fire Plan, 2001 Federal Fire Policy, Forest Service Cohesive Strategy, and subsequent Interagency Cohesive Fuels Strategy serve together as the leading federal policy directives for wildland fire in the United States. Congress has not addressed wildland fire through specific legislation, but instead has done so through annual agency appropriations, particularly beginning in FY 2001, which became known as part of the National Fire Plan. However, key Congressional direction issued at that time and supported strongly since then is that state and local governments and others must be important parts of wildland fire policy setting and management. The Conference Report for the FY 2001 Interior and Related Agencies Appropriations Act (PL 106-291) specifically directed that federal work be conducted with the Governors on a long term strategy to address wildland fire and hazardous fuels needs, with states and localities serving as full participants in this effort.

2.9.1 10-Year Comprehensive Strategy and Implementation Plan

Following this Congressional direction and continuing support by western Governors, WGA convened meetings of representatives of the Forest Service, Interior, National Association of State Foresters (NASF), National Association of Counties (NACo), Intertribal Timber Council, and other interested stakeholders to develop a plan for improving forest ecosystem health in the West. The interests and concerns addressed were broader than any such effort to date to address wildland fire, including several diverse interests ranging from environmental groups to agricultural industry participants. The resulting report, *A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment – 10-Year Comprehensive Strategy* represented much dialogue to achieve consensus (Western Governors' Association, 2001). The Strategy was endorsed by WGA, the Secretaries of Agriculture and the Interior, and the participating organizations. It was transmitted to Congress on August 13, 2001 and includes the following primary goals:

- Improve prevention and suppression
- Reduce hazardous fuels

- Restore fire-adapted ecosystems
- Promote community assistance

The essential points emphasized to Congress are: (1) the states should be fully represented in all prioritization, implementation, and decision making activities at the national, state and local levels; (2) all funds provided by Congress should be made available for expenditure across the landscape including all land ownerships; and (3) after emergency response measures are underway, work should begin in the collaborative development of a strategy for fuel reduction and forest restoration on landscapes at risk from catastrophic fire.

To help implement the intergovernmental collaboration required by this Strategy, the document proposed a collaborative three part framework that outlined the following roles and responsibilities at the national, regional, and local levels:

- *National Level*—The secretaries of Agriculture and Interior will implement the stated goals in full partnership with the governors. The secretaries will also work closely with the governors and Congress on policy and budget matters affecting implementation of the strategy.

- *Regional Level*—Regional, state, local, tribal, or area administrators or other federal officials, tribal leaders, and governors will collaborate and coordinate across jurisdictions to facilitate accomplishments at the local level.

- *Local Level*—Successful implementation will include stakeholder groups with broad representation including federal, state, and local agencies, tribes and the public, collaborating with local line officers on decision-making to establish priorities, cooperate on activities, and increase public awareness and participation to reduce the risks to communities and environments.

Following the completion, endorsement and delivery of the *Strategy*, work began on an *Implementation Plan* that was released in May, 2002 (Western Governors' Association, 2002). The Implementation Plan provides the framework for measuring progress toward achieving the Strategy's goals and associated actions. The plan further described the collaborative framework outlined above and states that a community based approach is needed to conduct locally based projects based on involvement of all jurisdictions and landowners. For each of the above four goals, implementation outcomes, performance measures and implementation tasks (and due dates) were defined that could be monitored and measured. An example of a specific task delineated in the plan is the assessment of fire departments described above. Work continues to be underway on many of these tasks. Other tasks are focused specifically on what is termed the Wildland Urban Interface (WUI), and the direction to develop an accurate list and definitions for identifying WUI areas. While GI/GIT is not specifically mentioned here or anywhere in the Strategy or Plan, it is considered to be a resource to aid in these tasks.

2.9.2 Wildland Fire Leadership Council

At the same time that work was underway on the Implementation Plan described above, various concerns were being raised in studies by the U.S. General Accounting Office (GAO) and the National Academy of Public Administration (NAPA) in their recent reports (GAO, 2002; NAPA, 2001). Conclusions were that the overall leadership framework and mechanisms for implementing the National Fire Plan and the 2001 Federal Fire Policy were insufficient to meet needs. In its review of progress and needs concerning the Fire Policy, NAPA recommended that a national wildland fire policy implementation council should be established at the secretary level of the two departments (NAPA, 2001). GAO similarly concluded that a single focal point is needed, and that Congress should consider establishing the council recommended by NAPA (GAO, 2002).

Following these recommendations, the Secretaries of Agriculture and Interior signed a Memorandum of Understanding to establish the Wildland Fire Leadership Council (WFLC) on April 10, 2002 (http://www.fireplan.gov/wflc_nfp2c.html). The MOU provides that the Council will be dedicated to "achieving consistent implementation of the goals, actions and policies in the National Fire Plan and the 2001 Federal Wildland Fire Management Policy" (Norton and Veneman, 2002, p. 1).

As shown in Figure 2-11, WFLC's scope and involvement is broader than the other two interagency fire groups discussed above. Federal members are at the secretarial and agency director level. It also has a broader representation by including representatives of both states and counties, though other local interests are not represented. WFLC attention extends to mitigation efforts, including projects focused to reduce risks in advance of fire, as well as recovery efforts after fires, rather than more strict focus on suppression and response efforts like the other groups.

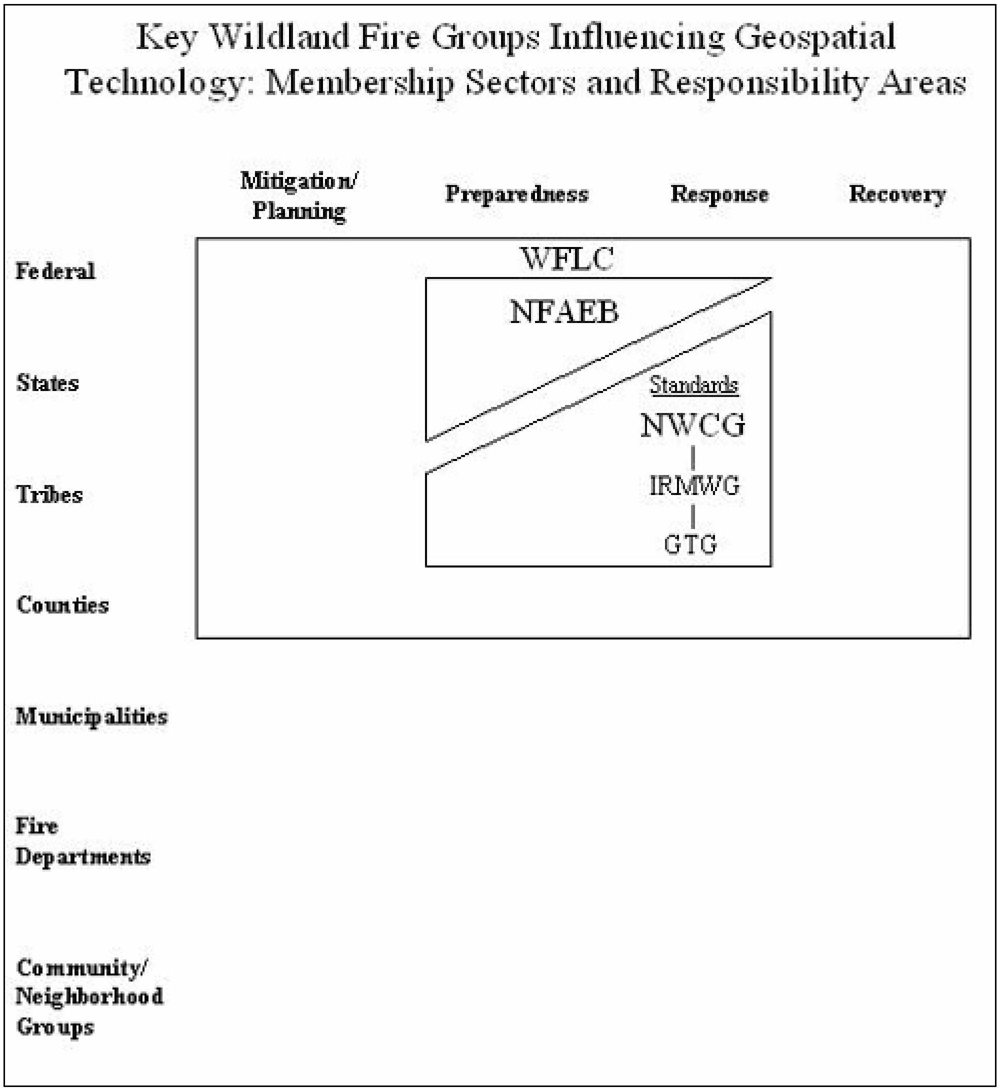

Figure 2-11. Key Wildland Fire Groups Influencing Geospatial Technology: Membership Sectors and Responsibility Areas

The MOU creating WFLC does not specifically address GI/GIT, but one of the goals of the Council is the "development of common data elements and common reporting systems to support performance management and accountability, and another is the development of common procedures for mitigating wildfire hazards in the wildland urban interface" (Norton and Veneman, 2002, p. 1-2). WFLC has not specifically addressed GI/GIT in its short tenure, but it has acted upon data issues by adopting common definitions. Moreover, at its recent June 20, 2003 meeting, an action agreed upon at the meeting was the "need to develop a display that better demonstrates the juxtaposition of fuels treatments to communities" (WFLC, 2003).

While it is difficult to predict, the range of issues being addressed by WFLC may lead to the conclusion that WFLC should address and provide some direction regarding GI/GIT in the future. As described in the following chapters, the Geospatial Task Group (GTG) focuses on GI/GIT for wildland fire and has had several accomplishments during its relatively short tenure (http://gis.nwcg.gov). However, GTG's role and focus are defined by NWCG and it serves under its auspices. This situation has essentially limited GTG's scope to address a narrower definition of GI/GIT's applicability to wildland fire than exists today, and also limits its ability to address the growing need for coordination of data efforts among all phases of wildland fire management. Moreover, the progress and enthusiasm of GTG participants is tempered by limited resources and no staffing to date.

These conditions were recently reviewed by GAO in a dedicated investigation about GI/GIT for wildland fire, entitled *Geospatial Information: Technologies Hold Promise for Wildland Fire Management, but Challenges Remain* (GAO, 2003d). A key recommendation in the report is that the Secretaries of Agriculture and Interior direct WFLC to endorse and oversee "efforts to develop an interagency geospatial strategy . . . in all phases of wildland fire management" (GAO, 2003d, p. 41). Specific attention and action in this regard is being planned.

3.0 MITIGATION, PLANNING, AND PREPAREDNESS

This Chapter reviews the mitigation, planning and preparedness phases of wildland fire, which is increasingly recognized as a complex, but growing component of wildland fire management. New approaches, resources and techniques are proving their value in terms of increased awareness and actions that can be taken before a fire takes place or becomes large in order to reduce the size, severity and damage caused by fire. The chapter includes identification of some of the current issues, approaches, and resources used for mitigation, planning and preparedness. Also included are examples of GI/GIT use in this regard, as well as user needs, limitations, and priorities concerning greater use of GI/GIT for mitigation, planning and preparedness.

3.1 INTRODUCTION

In terms of fire management, mitigation can be defined as those activities that lower the risks and reduce the effects of disasters. Planning can be defined as those activities that define the desired future condition of the land and resources and the means of achieving that end state. Preparedness can be defined as those activities undertaken to plan for a coordinated and effective response effort to wildland fire incidents; thus, minimizing social and economic disruption, and loss to life, property, and resources. To successfully prepare for wildfire disasters requires the combined and coordinated partnership efforts of all levels of government, the public and private sector, professional and voluntary organizations, and academia.

Preparedness efforts and actions include those taken to increase the capability of organizations and individuals responsible for wildland fire to aid in response and minimize damage and disruption. Preparedness includes policy and strategic planning, resource readiness (equipment, information technology, and communications systems, etc), as well as training, exercises and simulations for wildland fire. It also includes short-term data and information readiness, such as weather monitoring and modeling (including wind velocity and direction, relative humidity, temperature, precipitation, lightning, etc), in addition to current data about natural, physical, and human resources and characteristics as often also needed for mitigation. Such information is needed to understand and predict wildland fire probability, potential, behavior, and effects for fire danger ratings and potential cost and loss estimations. This information is also needed for real time use prior to and after an ignition of one or more wildfires. Preparedness includes applying the combination and analysis of information resources and predictions to preplan and preposition resources to increase the effectiveness of response efforts, and particularly initial attack, which often makes a critical difference in minimizing the size and cost of fires. These resources improve the readiness and preplanning for fires that can make a large difference in their size, severity and impact.

Mitigating hazards in a sustainable way is the most effective way to reduce the cost and consequence of a disaster. Preventing or reducing possible damage from wildfire disasters involves identifying and assessing the hazards and risks; creating public awareness; providing training and education; developing plans and strategies; updating or improving building codes; controlling land use through policies, regulations, and proper design; providing incentives and resources; and developing and implementing fuels management and forest health programs. It also involves discovering ways to improve preparedness, response, recovery, and reconstruction. To successfully mitigate wildfire disasters requires the combined and coordinated partnership efforts of all levels of government, the public and private sector, professional and voluntary organizations, and academia.

As discussed in Chapter 2, $1.6 billion was spent in 2002 on fire response efforts in the United States. Fires during the 2002 season caused a loss of more than 800 homes. With severe droughts expected to continue in forested areas with heavy fuel loads and stressed conditions, and increasing growth pressures into the urban and rural fringes, communities are facing growing problems. Land managers must now respond with greater resources and to more difficult fire management situations than ever before. Frustrated officials are complementing suppression efforts by investigating and implementing mitigation approaches to help. Today, mitigation efforts around the country range from increasing public awareness with education, to reducing the fuel loads through forest health projects, to training and preparing firefighters and communities for wildfires, and importantly, to applying land use authorities and planning tools to address land development, particularly in areas considered to be in what is commonly known as the Wildland-Urban Interface (WUI).

Effective hazard mitigation, like all aspects of fire management, relies on planning. Comprehensive, coordinated planning needs to occur in all aspects of the fire management program. This need ranges —from overall land management planning, to fire suppression planning, to planning for prescribed fires, to rehabilitation and restoration planning.

Preparing communities and their agencies who will respond in the time of disaster involves:

- Analyzing the wildfire hazards and their possible primary and secondary impacts,
- Developing emergency operating and contingency plans,
- Training emergency and planning personnel,
- Developing exercises to evaluate contingency and operating plans,
- Educating the public about threats to life and property and of evacuation plans,
- Developing emergency warning, communication, and information systems, and
- Providing program guidance and funding to local fire departments and emergency responding agencies.

3.2 CURRENT MITIGATION, PLANNING AND PREPAREDNESS APPROACHES, RESOURCES AND ISSUES

Fire mitigation, planning, and preparedness includes many activities undertaken to gather, monitor, manage, use and disseminate information about wildland fire. This also includes the implementation of plans, strategies, and programs that reduce the hazards and risks of wildland fire using this information. This section includes brief descriptions of key issues, factors, approaches, and resources in this regard.

3.2.1 Fire and Climate Interaction

The relationships between climate change science and wildland fire has been presented in many investigations. The effects of global warming may have a direct effect on the incidence, location, and severity of wildland fires due to changing weather patterns and warming effects, and vice versa.

Several research entities focus on the interaction of climate and fire. For example, the Program for Climate, Ecosystem and Fire Applications (CEFA) was established to build on these efforts to address wildland fire. CEFA was formed on October 1, 1998 through an assistance agreement between the Nevada State Office of the Bureau of Land Management (BLM) and the Desert Research Institute (DRI). As of November 2000, a new five year assistance agreement was signed with the BLM National Office of Fire and Aviation to continue basic climate studies and product development for fire management at the national level. CEFA resides within the Division of Atmospheric Sciences of DRI, and works closely with the Western Regional Climate Center (WRCC) (http://www.cefa.dri.edu/, 2003). The primary functions of CEFA are to:

- Perform studies and applied research to improve the understanding of relationships between climate, weather, fire and natural resources.
- Serve as a liaison between the decision-maker (user) and the scientific research community by providing product training, education, assisting in technology transfer, and eliciting user feedback.
- Improve operational fire weather forecasting and smoke prediction using new knowledge of climate and meteorology.
- Provide a source for fire, ecosystem and related climate information.
- Provide a human dimensions component including risk, impacts, hazard assessment.
- Develop decision-support tools for fire applications.
- Provide a societal interactions component.
- Provide climate and weather information directly for fire and ecosystem decision-making and strategic planning.

3.2.2 Fire Meteorology

Weather is a critical component of wildland fire that has a direct influence on ignition, behavior and effects. Weather data is made available to the fire community in various automated ways and is augmented by human observation, often through lookouts located on the ground or in towers. Federal organizations with weather responsibilities are concentrated in the National Oceanic and Atmospheric Administration (NOAA), which is located in the Department of Commerce (DOC).

DOC also is the administrative home for the Office of the Federal Coordinator for Meteorology (OFCM), which was established by Congress in 1964 to ensure the effective use of federal meteorological resources, to lead the systematic coordination of operational weather requirements and services, and to support research among the federal agencies. For example, the development and deployment of the Weather Surveillance Radar, the 1998 Doppler (WSR88-D), is an example of a tri-departmental program coordinated by the OFCM. Centers of excellence have been established to provide weather support for specific forms of natural disasters, such as National Hurricane Center in Miami, Florida and the Center for Severe Weather in Oklahoma, which primarily addresses tornados. A similar center of excellence does not exist for wildland fire weather.

3.2.2.1 Fire Support Activities by the National Oceanic and Atmospheric Administration

NOAA includes the National Weather Service (NWS) and the National Environmental Satellite Data and Information Service (NESDIS), which operates government-owned weather satellites and includes the National Climatic Data Center in Asheville, North Carolina. NESDIS products are used for several monitoring applications before and after wildland fires (McNamera, Stephens and Ruminiski, 2002), as discussed later in this report.

In addition to these capabilities, NWS provides direct support to the fire community. It formerly included most of the nation's premier fire meteorologists and an associated program, but this function diminished recently. NWS still has some fire meteorologists located in some parts of the United States and has a facility located at NIFC. NWS meteorologists who specialize in forecasting fire weather and support major wildfire suppression provide weather advice at Incident Command centers. Questions about the adequacy of NWS resources to meet growing requirements for weather data to support wildland fire activities caused the Department of Interior to develop its own internal meteorological capacity as described below.

3.2.2.2 National Predictive Services Group

The interagency National Interagency Coordination Center (NICC) described in Chapter 2 houses the core of the National Predictive Services Group (NPSG) at (http://www.nifc.gov/news/nicc.html). Predictive Service Units are located at NICC and each of the Geographic Area Coordination Centers (GACCs) to promote safe, efficient and cost effective fire management practices. NPSG's charter document (http://www.nifc.gov/news/pred_services/Main_page.htm), states that:

> *The National Fire Plan provided for the development of Predictive Service Units at the GACCs and the NICC in order to integrate climate, weather, situation, resource status and fuels information into products that will enhance the ability of managers to make sound decisions for both short and long range strategy development and resource allocation decisions, and ensure the safety of*

firefighting and emergency personnel. The concept behind this effort was to blend the functions of intelligence, meteorological forecasting and other analyst capabilities into one cohesive group called "Predictive Services" in order to place a new emphasis on predictive capability at the Geographic Area and National levels.

Furthermore, the objective of the group is to:

1. Provide a communication linkage among key users throughout the wildland fire community of predictive service products and research.
2. Provide an interagency forum to manage, develop, address and make recommendations for innovations, enhancements, training, standards and timelines of predictive service products and services.
3. Serve as an advocate for initiatives coming forward from the field or subordinate working groups for interagency management support and implementation.
4. Provide coordinated programmatic leadership as directed by the Geographic Area Center Managers for the Predictive Service community (including intelligence officers, meteorologists, coordinators and analysts) on issues such as research needs, information flow and access, product guidelines and standardization, problem identification, and issue resolution.
5. Develop a framework for using climate, weather, situation, resource status, and fuels information to provide decision support tools, which will allow all levels of the multi-agency coordination system to allocate resources in support of wildland fire management operations. This framework will contain, but not be limited to the following:
    a. Assess customer needs and requirements.
    b. Standardize products to meet local, geographic and national needs.
    c. Develop standards for predictive service products spanning short (1-10 day) and long (30-90 day) time periods.

The Predictive Services website also provides National Wildland Fire Outlook Assessments in the form of monthly and seasonal outlook maps and narratives and daily outlooks and briefings for the various Geographic Area Coordination Center regions. The outlooks are based on multiple data inputs, including atmospheric models, lightning potential, and other meteorological parameters obtained through the National Weather Service. The site also provides access to national fire maps created through other federal groups such as the U.S. Forest Service, NOAA and USGS.

3.2.2.3 Remote Automated Weather Stations

About 1,500 interagency Remote Automated Weather Stations (RAWS) are located throughout the United States and augment the activities of the fire meteorologists described above (http://www.fs.fed.us/raws/). These ground-based weather-monitoring units are based on an established technology but have only been used on a large scale in recent fire seasons. RAWS are strategically located, with a concentration of them in the western states (Figure 3-1). Most of the RAWS are stationary 30-foot permanent fire stations, which are heavy aluminum towers on tripods. They resemble “lunar landers” and weigh about 800 pounds. The remaining RAWS are mobile units that are similar in configuration, but can be moved to be near and monitor wildland fires. RAWS collect, store, and forward data on an hourly basis through a NOAA GOES satellite to the National Interagency Fire Center (NIFC) in Boise, Idaho.

Incident command gets RAWS data either through the Weather Information Management System (WIMS) (http://famweb.nwcg.gov/) or through Internet sites like ROMAN (http://www.met.utah.edu/roman/) or the National Weather Service (NWS) (http://raws.boi.noaa.gov/rawsobs.html). The Incident Meteorologist assigned to the wildfire incident may also use the RAWS data access utility provided by the NWS-operated AWIPS/NOAAPORT system. (Shelley, 2003) A RAWS subscription service is also available to approved users.

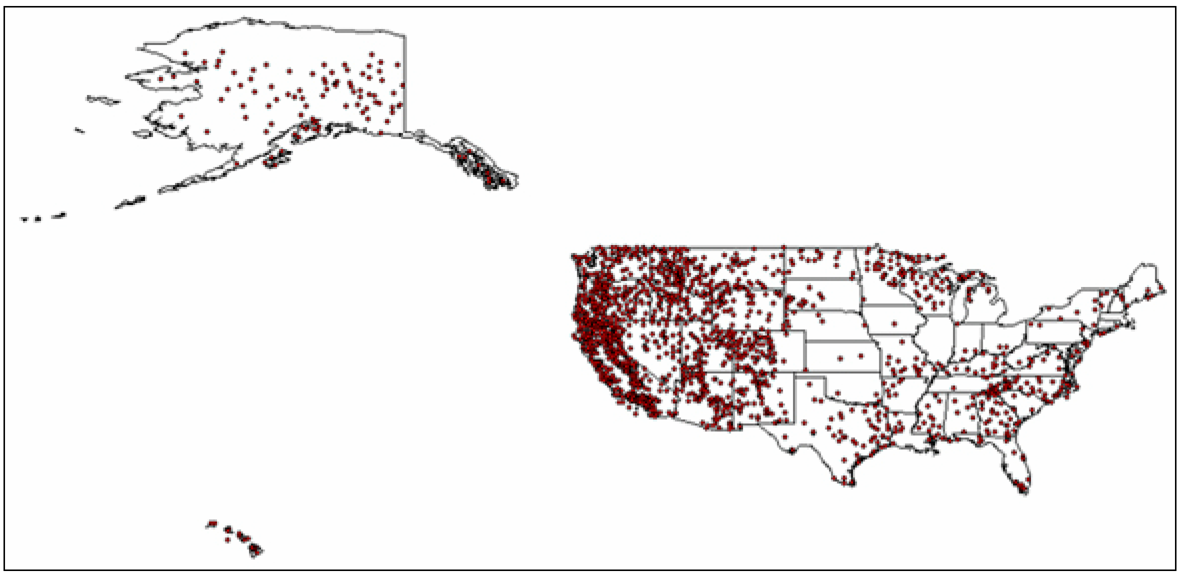

Figure 3-1. Locations of RAWS Units in the United States
Most of the stations represented as red dots are permanent locations.

Fire managers use RAWS data to receive real-time data. RAWS sensors monitor wind speed and direction, wind gusts, precipitation, air temperature, solar radiation, relative humidity, and fuel moisture. RAWS data can also be used to help predict fire behavior and monitor fuels. RAWS units cost about $12,500, and are often in isolated areas accessible only by all-terrain vehicles, helicopters, snowmobiles, or on foot (RAWS Fact Sheet, 1999).

Because of the ability to provide data that fire behavior specialists require to help ensure the safety of firefighters and the public, RAWS also have a crucial response role to play in the response to wildfires. While historical data from existing RAWS units are important in the development in fire behavior forecasts for a particular fire, the ability to place mobile RAWS units in remote locations during ongoing fires also is important. Such units provide important data to supplement what human observers and other methods can provide for the forecast of fire direction and intensity.

3.2.2.4 WeatherData, Inc.

For over 20 years, the corporation WeatherData, Inc. has provided weather data and weather risk management solutions to the private sector. WeatherData, Inc. has developed several products for weather alarm systems. One in particular called SelectWarn™, is a "command center" system that monitors up-to-date lightning, weather and ground sensor/gauge data through a GIS interface. It is also enabled with alarm capabilities and a telephone notification system. The system can be customized to fit a unique application, which makes it particularly interesting for wildfire applications. While it is not being used by federal organizations for wildfire fire alarm notification, a potential exists to use this technology to help alert residents in developed areas about fires detected in their vicinity.

In 2003, WeatherData, Inc. released a report entitled "The Hidden Costs of Unnecessary False Alarms" which defined false alarms into two categories: unavoidable and unnecessary. Unavoidable false alarms are those due to limitations in science, while unnecessary false alarms are those that are issued to the wrong recipients. The technology developed at WeatherData, Inc. could help to better determine the properties for which an alarm should be generated. The significance of this is that by more accurately defining for where the alarm should be given, mobilization and response costs could possibly be minimized.

3.2.3 Hazard Identification and Risk Assessment

An understanding of the inherent risks associated with hazards must begin with an understanding of what the hazards are, what areas could be affected by these hazards and to what extent. Wildfires are a natural occurrence and become hazards only when they present a threat to communities or valued resources. In addition, emergency management also now takes a multi-hazards approach such that often there are secondary hazards associated with the primary hazard. These secondary hazards in the case of wildfires are often flooding, soil erosion, and air/water pollution. Before any education program can speak of the risks, an understanding of the nature and location of the hazards must be clearly demonstrated. This is one of the ways in which GI/GIT can and does benefit hazard identification and risk assessments tremendously.

Figure 3-2 provides examples of a hazard map and a risk map. The map on the left of this figure shows Fire Levels of Concern (LOC) and is the primary output of a risk assessment. It is derived by integrating environmental effects with suppression costs and other factors (http://www.spaceimaging.com/solutions/fire_risk/index.htm#). The map on the right is a Wildlife Hazard Map, which identifies wildfire hazard based solely based on vegetation conditions (http://www.co.larimer.co.us/wildfire/wildfire_maps.htm).

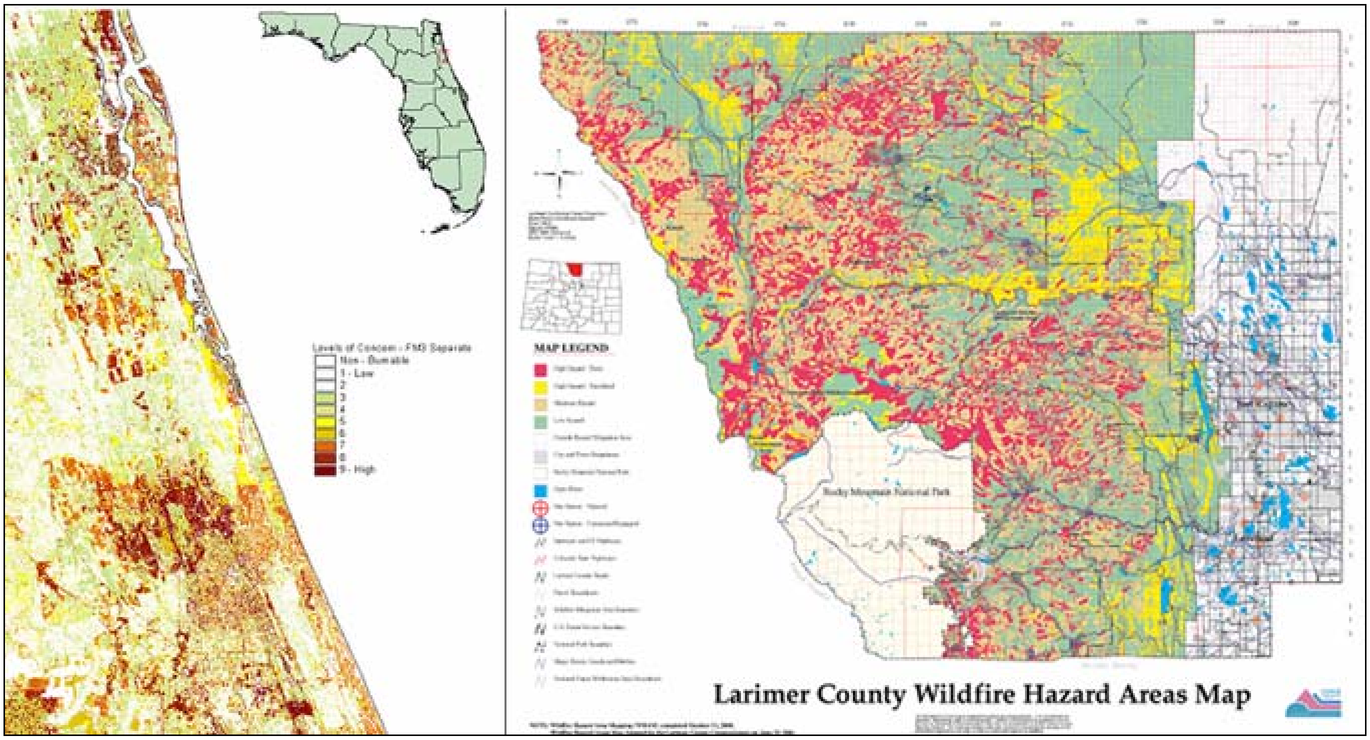

Figure 3-2. Risk Map and Hazard Map

Definitions of wildland fire hazards, vulnerability and risks can vary as shown in Figure 3-3. These differences present challenges to fire assessments, and particularly in communicating results to intended audiences. Important questions arise as part of these processes, such as:

- Does a 'high wildfire hazard' category in one part of the country or of a region have the same meaning in another?
- Is the federal definition of 'risk' the same as what is understood to be the risk to a community?

The answer can be "no" to both questions. Moreover, as GI/GIT is increasingly utilized in these assessments, differences in the quality, accuracy, currency, precision, integration, aggregation, and other factors associated with the data and technology can mean that results vary, even when reporting the same conditions and risks for the same geographic area. Lessons learned are that these factors need to be identified and addressed as part of such assessments to ensure accurate communication and understanding of information provided through such efforts.

Definitions

Hazard:

An event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, or other types of harm or loss.

Vulnerability:

The level of exposure of human life and property to damage from natural hazards.

Risk:

The potential losses associated with a hazard, defined in terms of expected probability and frequency, exposure, and consequences. (FEMA/APA, 2000)

Risk: The probability of an event occurring. (U.S. Forest Service)

Figure 3-3. Definitions of Hazard, Vulnerability and Risk

The occurrence of wildland fire, whether prescribed or naturally caused, presents inherent risk. As evidenced by the Cerro Grande Fire, a miscalculation of the level of risk for any given fire can prove catastrophic. Federal resource managers consider risk at various points within the fire management program: in land management, fire management, prescribed fire planning, wildland fire situation analyses, and in burned-area rehabilitation plans. The federal land management agencies revised their risk management guidelines and training, and introduced other improvements to their risk management requirements after the Cerro Grande Fire (National Academy of Public Administration, 2001). For example, the National Park Service (NPS) now requires that individuals not associated with the development of a prescribed burn plan must review such plans before a burn is approved, and new procedures have been instituted to improve risk assessment and complexity analyses.

3.2.3.1 Federal Fire Efforts to Characterize and Model Risk

Historically, the federal fire community has conducted many efforts to characterize and understand wildland fire risk. It has developed and used many programs, and most recently have applied software and models to help determine fire risk and danger, as well as evaluate resources and other needs for addressing potential fire scenarios. While new advances in fire modeling often use GI/GIT in a focused way, several other older models and systems that do not explicitly implement this technology are still in use.

For example, ratings of fire danger have been conducted since 1932 to help understand, prevent and mitigate fire risks, and a national system was introduced in 1964 (Andrews and Bradshaw, 1997). Various versions and updates of the National Fire

Danger Rating System (NFDRS) have been utilized and modified since then to best understand and prepare for fire, most recently incorporating more and better meteorological information as derived from the new Predictive Services Unit described above. The intent of these fire danger ratings is to produce indexes that indicate fire potential for a large area. Though widely used, there is much dissatisfaction and little consensus about the purpose or application of NFDRS and the data included to develop the ratings (Andrews and Bradshaw, 1997). Moreover, no procedures have existed to validate or test its performance.

Similar issues and concerns exist about the inadequacies of other models that have been used over the years. While not specifically addressing risk, some models aim to predict and determine needed resources to help understand, prevent and fight fire, such as the National Fire Management Analysis System (NFMAS) and the Fire Effects Information System (FEIS). Many of these early systems were not able to take full advantage of GI/GIT because it was not readily available or easily useable when they were developed. Work is now underway to develop an interagency, landscape-scale fire planning analysis and budget tool known as the Fire Program Analysis System (FPA). As discussed in Section 3.2.4, this tool will be performance-based, and will provide managers with a common interagency process for evaluating the efficacy of alternative fire management strategies and resources to meet land management goals and objectives.

When specifically addressing risk in their planning and management efforts, the land management agencies have different approaches to categorize fire risk. For example, the Forest Service has categorized fire risk by three broad condition classes:

- Condition Class 1 (Low Risk). Human activity has not significantly altered historical fire regimes on these lands, or adequate land management activities have successfully maintained ecological integrity. These areas usually pose relatively low public safety and ecological risks; they need little corrective management. They can be safely maintained using prescribed fire.
- Condition Class 2 (Medium Risk). Human activity has moderately altered historical fire regimes on these lands, and/or land management actions have been ineffective, partially compromising ecological integrity. These areas pose a moderate public safety and ecological risk from severe fire, requiring moderate levels of restoration treatments such as mechanical fuel removal or prescribed fire.
- Condition Class 3 (High Risk). Ecological integrity of these lands has been significantly compromised and fires are a high risk factor because of their potential risk to human values (such as public safety and health, property, or economies) and natural resource values (such as watersheds or species composition). (U.S. Forest Service, 2000)

Another approach, that has been used by BLM, is to identify areas of similar fire behavior, values, and management objectives called “polygons.” There are at least four classifications of polygon plans for the purposes of wildland fire and vegetation management:

- *A-polygons* are areas where wildland fire is highly undesirable. Fire has the potential to create great losses and result in high suppression costs. Within the A-polygons, fire suppressions and prevention and education actions will be aggressive to keep ignitions to a minimum and fires that do start to a small size. A-polygons are often WUI or intermix communities or neighborhoods. Concentrated FIREWISE (see below) and related preparedness education and hazard mitigation efforts will be directed to those areas.
- *B-polygons* are areas where wildland fire is undesirable under current conditions. Fuel accumulations have created conditions under which wildfires are likely to burn with unacceptable intensity and duration. Rates of spread may present serious threats to public safety or fire containment. Fire prevention and suppression efforts will be aggressive in these areas. Although under current condition, the potential for catastrophic fire is significant, appropriate fuels management programs may permit restoration of fire-adapted landscapes in which wildland fire is acceptable or desirable. Prescribed fire (and other hazard mitigation) will be concentrated in the B-polygons. Over time, B-polygons might be converted to C-polygons.
- *C polygons* are areas where wildland fire is acceptable and often desirable. These are restored fire-adapted landscapes where fire can play a constructive role without creating significant negative side effect. Prescribed fire might be used regularly in C-polygons to maintain fire-adapted conditions and achieve management objectives. Suppression of unplanned fires will be more measured with careful consideration of costs and benefits. Prevention efforts will be directed toward certain identified high-risk activities and times of grater risk of ignition.
- *D-Polygons* are areas where wildland fire is acceptable or desirable and where the potential for damage is insignificant. Prevention and fuels treatments will be relatively uncommon in these areas. Fires that start may be managed to enhance natural resource or ecological values. Suppression will be limited to times and situations where continued burning might pose some special risk to values outside the polygon. (BLM Colorado State Office, 2001)

The federal fire community has over 30 decision support models to address “risk”, but these models are limited in that that only primarily aid in understanding potential fire behavior, growth, effects, and fuels treatments. However, as concluded through research conducted by the National Academy of Public Administration (NAPA), these models do not support a comprehensive risk assessment approach (NAPA, 2001). Each model focuses on just one component of risk, usually hazard. They provide a narrow assessment of the risk to a given area, typically only addressing lands managed by a particular agency and land management unit. Figure 3-4, developed by NAPA, provides a brief description of five leading decision support models used by the federal government to help in this regard. These models have been used for fire planning and to support risk assessments, and some utilize GI/GIT as an important component.

The models in use are also limited because they primarily only address natural resources rather than all nearby resources, such as physical structures, infrastructure and other socioeconomic variables. A more complete assessment of risk would also include the probability of ignition, and physical, social, and economic values and costs of potential damage.

While existing fire models are limited in scope, another problem is the how the models are used in practice. In many case, the resources needed to run them, such as data, technology, and expertise, are not necessarily available to federal field managers. For example, it is commonly understood that a third or fewer of the National Forests have the satellite imagery and data necessary to run FARSITE, a PC-based fire growth simulation program that models the spread and behavior of fires. Even if used by neighboring land management units, models may produce different results when crossing the boundary from one federal land management unit to others because the land management agencies have not developed common standards for interpreting and applying the data (NAPA, 2001).

While these tools have typically been used by federal agencies for small geographic areas for several years, risk assessments are now being conducted by federal, state, local and other entities for broader geographic areas as described below. These assessments aim to understand potential fires and harm across larger areas than individual federal land management units and to compare relative risks for different locations.

Decision Support Models to Understand Fire Behavior and/or Effects		
NAME	**DESCRIPTION**	**ADVANTAGES/DISADVANTAGES**
BEHAVE	BEHAVE can predict fire behavior at a given point on the ground given different environmental conditions, such as fuel loadings, fuel moisture, wind, and slopes. By using this model, fire managers can project the behavior of active fires, plan prescribed fires, and assess consequences to fire behavior of fuel management activities such as prescribed burning.	Widely available and used for managing wildfires and planning prescribed fires. However, it is outdated and does not have the capability to monitor events such as crown fires. Revised program, *BehavePlus*, being developed to calculate conditions at a given point on the ground.
FARSITE	PC-based fire growth simulation program, models the spread and behavior of fires considering variable terrain, fuels, and weather. Through FARSITE, managers are able to project	User-friendly and can automatically compute fire growth and behavior for long time periods under different terrain, fuels, and weather conditions. Lacks skilled users and requires a large amount of spatial data and

	short and long-term behavior, plan for potential fires, and communicate wildland-urban interface concerns.	satellite imagery which must be organized and available *before a fire*.
FOFEM	FOFEM stands for "first order fire effects model." It is a computer program used to predict the effects of prescribed fire and wildfire in forests and rangelands throughout the United States. FOFEM is primarily meant to help managers plan and carry out prescribed burns by providing quantitative, site-specific predictions of the following: tree mortality (by species, size, and flame length); fuel consumption (for duff, woody fuels, and live fuel including canopy); and smoke (for crown or surface fires, site specific emission factors, and combustion efficiency).	Easy to use, applies to most vegetation types and geographic areas, synthesizes and makes available a broad range of available research results, incorporates planning and prediction modes, and provides a wide range of data. However, it is not linked to any other models, such as those for fire behavior, smoke dispersion, post-fire succession, or erosion.
FFE-FVS	Fire and Fuels Extension to the Forest Vegetation Simulator (FFE-FVS) compares the effects of different fuels treatments and can be used to evaluate trade-offs between various treatment options. This model is available for Northern Idaho, Western Montana, Eastern Montana, Southern Oregon, and Northeastern California; it will soon be available for Utah, the Central Rockies, and the Western Sierras.	The Forest Vegetation Simulator does not appear to have been used in burn plans; but it could be.
FLAMMAP	FLAMMAP uses the same data as FARSITE, with the difference that FLAMMAP makes the calculation of fire behavior for each raster (grid) cell.	Easier to use than FARSITE. FLAMMAP was developed in 1998, but the model is not used very often now because little documentation is available about it. FLAMMAP is being rewritten as a fully supported program.

Figure 3-4. Decision Support Models to Understand Fire Behavior and/or Effects
Courtesy of National Academy of Public Administration, 2001

3.2.3.2 Local Approaches to Determine Hazards and Risks From Wildfires

Local hazard and risk assessment mapping efforts are growing as many localities are struggling to address their concerns about the rapid development into fire prone areas. Many examples provided in this report and others show how local governments have needed to be innovative due to frequent lack of funding, resources, and accurate, up-to-date information. The successes of these efforts have been due largely to intergovernmental and multi-jurisdictional cooperation, and the use of local and/or state planning or GIT resources. As a result, there are a wide variety of hazard and risk assessments and maps under development. For many localities, the limiting factor can be the level of detail, accuracy and precision of accessible data sets.

The type and extent of “values at risk” can also differentiate the mapping techniques used and the factors involved. For example, in California, wide roads in the mountains are acceptable providing they have stringent landscaping or defensible space requirements. The mountain backdrop in Colorado would be considered “scarred” under similar requirements. Accessible roads can be less of a priority due to the aesthetic and social values that exist in various areas. Some examples of localities active in hazard and risk assessment mapping include Boulder, Colorado; Prescott, Arizona; Colorado Springs, Colorado; Teton County, Wyoming; Gallatin County, Montana; the Kenai Peninsula, Alaska; and many communities within the states of Florida and California. Figures 3-5 and 3-6 provide some examples of these local approaches.

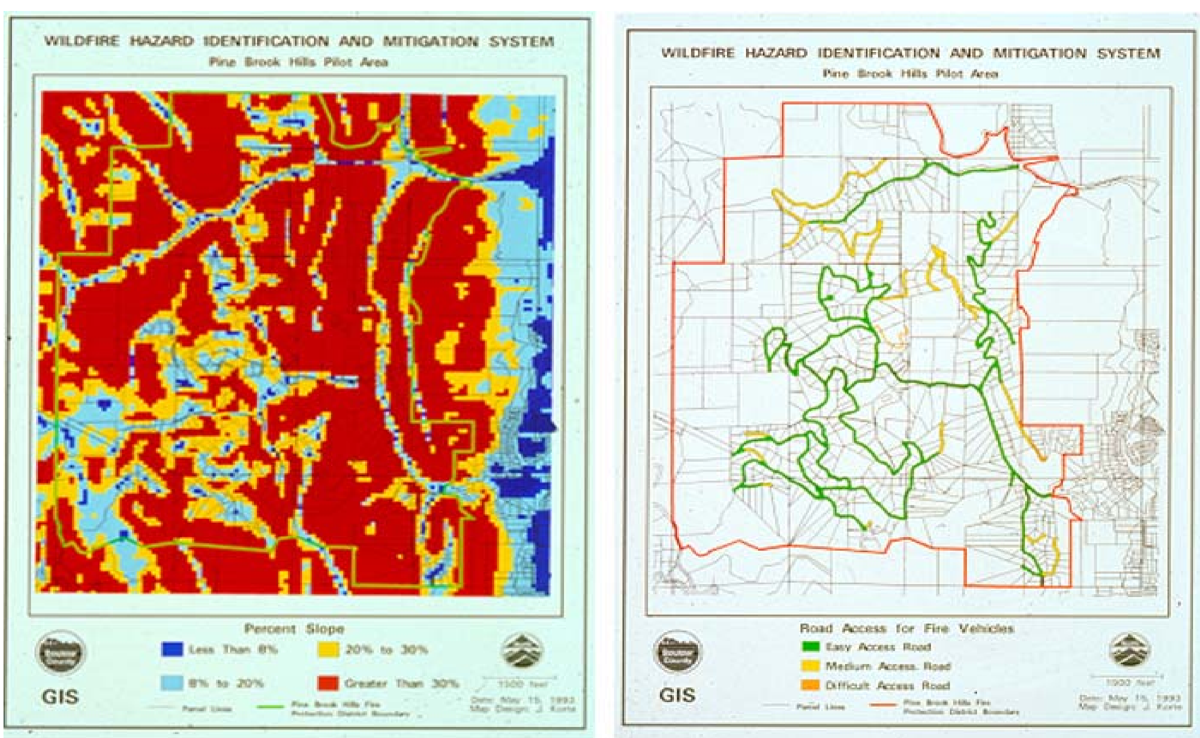

Figure 3-5. Example of Local Community Approach to Fire Mitigation: Pine Brook Hills Pilot Area, Boulder, Colorado

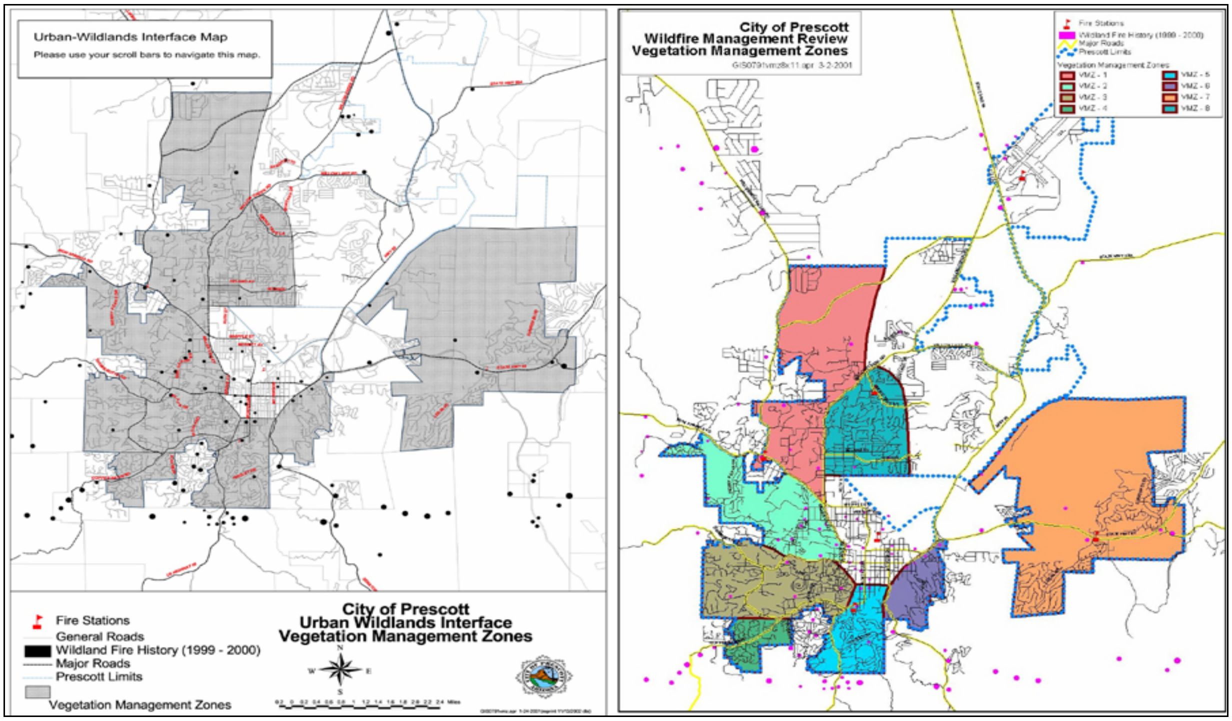

Figure 3-6. Example of Local Approaches to Fire Hazard Mapping: Prescott, Arizona

3.2.3.3 Nationwide and State Efforts to Identify "Communities at Risk"

An important requirement specified by Congressional appropriators in the FY 2001 act that authorized the National Fire Plan was for the Secretaries of Agriculture and Interior to jointly publish in the Federal Register by January 2001 a list of all "urban wildland interface communities" near federal lands that are at risk from wildfire. However, as reported by the U.S. General Accounting Office, the agencies did not establish well-defined criteria to identify these WUI communities, and deferred this responsibility to state and tribal governments (2002). They also permitted state and tribal governments to apply different data and criteria for identifying communities.

By May 2001, the states identified over 22,000 communities considered to be at high risk from wildfire, but the disparities in approach meant that the lists could not be compared or accurately combined. The Forest Service and Interior evaluated the lists and reduced the number of communities to 11,376, and then assigned each one with a numeric value based on factors listed in the Federal Register notice. In the end, this approach, along with California and Idaho's refusal to prepare lists, resulted in over half of the communities in the highest risk category to be located in three southern states (Georgia, North Carolina, and Tennessee) that are not commonly considered as being at high risk compared to other states. Moreover, it essentially was impossible to determine the specific location of the communities. However, these lists were almost used to help prioritize the locations of fuels treatment projects. GAO concluded that neither department agency based their approach on a consistent national prioritization of communities at risk from wildfire (2002).

The Wilderness Society (2003a) concludes from its research that a “Community Protection Zone” (CPZ) should be determined for each community at risk for wildland fire and can be mapped with GI/GIT (Aplet and Wilmer, 2003). The Society found that despite the importance of these areas, they have not been quantified or mapped across the landscape. It conducted an analysis to identify the nationwide extent of this CPZ, including the location and ownership of these areas (http://wildfirecentral.org). With these findings, the Society concluded that the wildland fire policies focused on federal lands will not likely protect communities because most of the CPZ (85%) is on not on federal land (Ibid., p. 19).

The definition and location of “communities at risk” remain unclear, so it is difficult to address risk needs from a national perspective. As reported by GAO, the Forest Service does not have uniformly applied definitions for fuels reduction or wildland urban interfaces, so "individual forests may have their own definition or no definition at all which could result in inconsistent data" (2003, p. 3).

As discussed in Chapter 2, the *10-Year Comprehensive Strategy Implementation Plan* of May 2002 has several implementation tasks. Two of the tasks are related to communities at risk:

- Develop nationally comparable definitions for identifying at risk wildland urban interface communities and a process for prioritizing communities within State or Tribal jurisdiction.

- Develop and maintain an accurate prioritized list of all communities designated by states as being at risk of wildland fire, including contact information.

The National Association of State Foresters (NASF) issued "Field Guidance - Identifying and Prioritizing Communities at Risk" to meet the first task listed above (2003b). While the use of mapping and GIS is not specifically directed, it states "ideally, the results of this effort would be displayed on a map or series of maps" (page 2). The guidance provides a suggested process to identify: (1) communities at risk on a state by state basis and categorize them into high, medium and low risk zones, and (2) identify fuels reduction and ecosystem restoration projects which have the potential to reduce the risk to a specific community or communities. The document states that "(o)ne effective approach is to map the four factors" (fire occurrence, hazard, values protected, protection capabilities) using high, medium and low ratings and then overlay the maps to determine geographic areas to show the highest levels of the first three of these factors, and the lowest level of protection capability.

The NASF guidance provides more encouragement for GI/GIT use than federal direction to determine “communities at risk”. It appears that a “community” can no longer be a subdivision, roadway, state or other poorly-defined area, and each one must be an area governed by a specific local jurisdiction. However, more direction and guidance could be provided to encourage and increase data quality, consistency and usefulness. Such direction could help to ensure that individual state results could be accurately displayed using GIS to increase awareness and understanding, both by the public and other governments. This approach also would help to ensure that results could be compared across states, and aggregated by region and/or at a nationwide level. In terms of the delineation of areas at risk, standardized definitions and methods of determining the locations of incorporated local units of government would be helpful, including appropriate precision in the geopositioning of corresponding boundaries, even if GIS was not being used in the process. Common measures of subunits of these governments also could be established to ensure effective comparisons and delineation of differing conditions across counties and other large jurisdictions. For example, zip codes or other methods might help accommodate more detailed results within communities. Suggested methods to document and incorporate the results of local assessments also could be provided to increase the ability to do comparisons and provide useful examples for others to learn from.

In sum, more direction and standardization of definitions, data and geopositioning would help to ensure that the results of such work can be compared, aggregated, displayed and analyzed using readily available GI/GIT capabilities. Even if a State Forestry Organization (SFO) does not have these technical capabilities, use of data standards and quality assurance approaches are necessary to ensure accurate display, use and understanding of the results. Help and base data could be acquired from other sources, such as from statewide GI/GIT coordination entities, other state agencies, the Forest Service, nearby universities, or others to conduct this work so that results would also be useful for an SFO to meet internal needs. No plans exist at this time to provide more detailed direction in this regard, but there will be some effort to assess progress according to this guidance (Hubbard, 2003).

The Wildland Fire Leadership Council (WFLC) reviewed and approved the guidance prepared by NASF at its June 20, 2003 meeting "pending modification to include minimum required factors for determining community hazard" (2003, p. 1). However, no direction was provided for specification regarding the location of these hazard factors. However, in a later action that day, WFLC identified the "need to develop a display that better demonstrates the juxtaposition of fuels treatments to communities; accomplished, in progress and planned" (2003, p. 1). GI/GIT also could help meet this need.

3.2.3.4 Insurance Industry Response to Wildfire Risk

Wildfire losses have not been significant enough in the past to warrant efforts from the industry to do more with private property owners. That is still true today, but some of the companies within the industry are beginning to see the “potential” losses from the rapid development occurring in the WUI. Unique to the business of providing insurance is that companies do not collaborate with one another. Therefore, individual companies appear to be taking different approaches to the wildfire dilemma. Pressure has been mounting from mitigation efforts to have insurance companies do more with their policy holders, either by providing incentives or affecting the costs of providing insurance.

State Farm Insurance Company, which has 23% of the state insurance market in Colorado, has adopted an approach which utilizes GI/GIT. It is working with the Colorado State Forest Service to apply the Colorado Wildland Urban Interface Hazard Assessment to meet its needs. Fourteen hazard rating zones were created using 1:100,000 scale vegetation data for the state. The highest rating zones (12-14) were then intersected with an overlay with the policy holder locations. On-site surveys of properties are being conducted to see what would be needed to reduce the hazards at each site. Policy holders are given notice that they will have 18-24 months to remediate the property. The purpose of this approach is to educate policy holders as well as protect lives, properties, and the firefighters; along with the goal of not losing a single policy holder (Niccolai, 2003).

3.2.4 Federal, State and Local Land and Fire Management Planning

To some extent, fire management planning occurs at all levels of government, but it is a specific requirement for federal land management units. At the federal level, the 2001 Federal Fire Policy requires that each area of burnable vegetation managed by the federal land management agencies be covered by an approved fire management plan (FMP). Without an FMP, federal land management agencies do not have the option of using fire to produce resource benefits; they must suppress all fires.

The general intent of FMPs is to tier them to land management plans to integrate fire with the land unit's natural resource objectives. A land management plan is the overarching plan for managing a land unit, describing the desired future condition of the land and resources within each land unit. These plans serve as the broader decision documents for federal land managers.

The federal land management agencies use different terms for their land management plans. For example, the Forest Service's forest management plans are mandated by the 1976 National Forest Management Act. NPS has general management plans for its parks and BLM has land use plans. BIA has integrated resources management plans, and FWS has comprehensive conservation plans. The content of federal land management plans varies across the agencies. However, in general, they are comprehensive documents that may take years to produce. The cost for one plan can exceed $1.5 million. The process to develop or update a land management plan requires a public comment process, and it is often delayed by legal actions initiated by individuals or groups who object to some aspect of the plan. Updating federal land management plans occurs on a periodic, but infrequent schedule. For example, the Forest Service's schedule for updating forest management plans is every 15 years. Many federal land units have out-of-date land management plans. However, the Federal Fire Policy, as described in Chapter 2, states that an outdated land management plan should not stop the land management agencies from developing a FMP.

Each federal land management agency has prepared its own guidelines for developing an FMP, and they also vary considerably. Research conducted by the National Academy of Public Administration (NAPA) found that the quality of FMPs lacked consistency from place-to-place and from agency-to-agency (2001). GAO has also investigated FMPs, finding that over half of the existing plans are not compliant with the Federal Fire Policy, and many are out of date as they do not identify areas at high risk (GAO, 2002).

Currently, both the Forest Service and DOI are placing increased emphasis on completing and updating FMPs. However, both NAPA and GAO found that federal FMPs are confined to the land within each federal land unit's boundary. This is contrary to the direction in the Federal Fire Policy to develop and implement FMPs across agency boundaries to ensure consistent approaches to similar situations.

Various models can be used in fire planning efforts to determine resource requirements, but these tools can be dated. For example, the National Fire Management Analysis System (NFMAS) has been used by the Forest Service for many years and similar systems have been used by different fire agencies, but they had several limitations as they became more and more outdated.

A new tool recently authorized and currently under development to assist in fire planning and resource allocation is known as the Fire Program Analysis (FPA) System. It is being developed for use by all federal land management agencies at a landscape-scale for fire planning, analysis and budgeting. As shown in Figure 3-7, FPA will use modeling to ensure that alternative fire management strategies and resources that are required to meet land management goals and objectives are measurable and can be met. It will also model the effects of various strategies through time.

FPA will enhance current fire program analysis systems by incorporating new technology and modifying existing components. Using GIS, each land management unit will be capable of displaying data elements and themes and use this information in the graphical display of simulation model outputs. The land management unit will create GIS-compatible digital data to model fire program strategies and assess its potential success in meeting long term goals (e.g. vegetation type, fire history, fuel models, resource values to be protected). FPA is being designed based on a report entitled *Developing an Interagency Landscape-scale Fire Planning Analysis and Budget Tool*, which is commonly referred to as the "Hubbard Report" (commonly named after Colorado State Forester Jim Hubbard who represented NASF on the team developing this report (Hubbard et.al., 2001). Other participants included the five land management agencies and the University of Montana's School of Forestry. The report included a review of the wildland fire budget and planning models as was suggested by the U.S. Office of Management and Budget, as this was a way to improve the consistency and accuracy of these processes (http://www.fs.fed.us/fire/gis/Documents/Hubbardrpt.pdf).

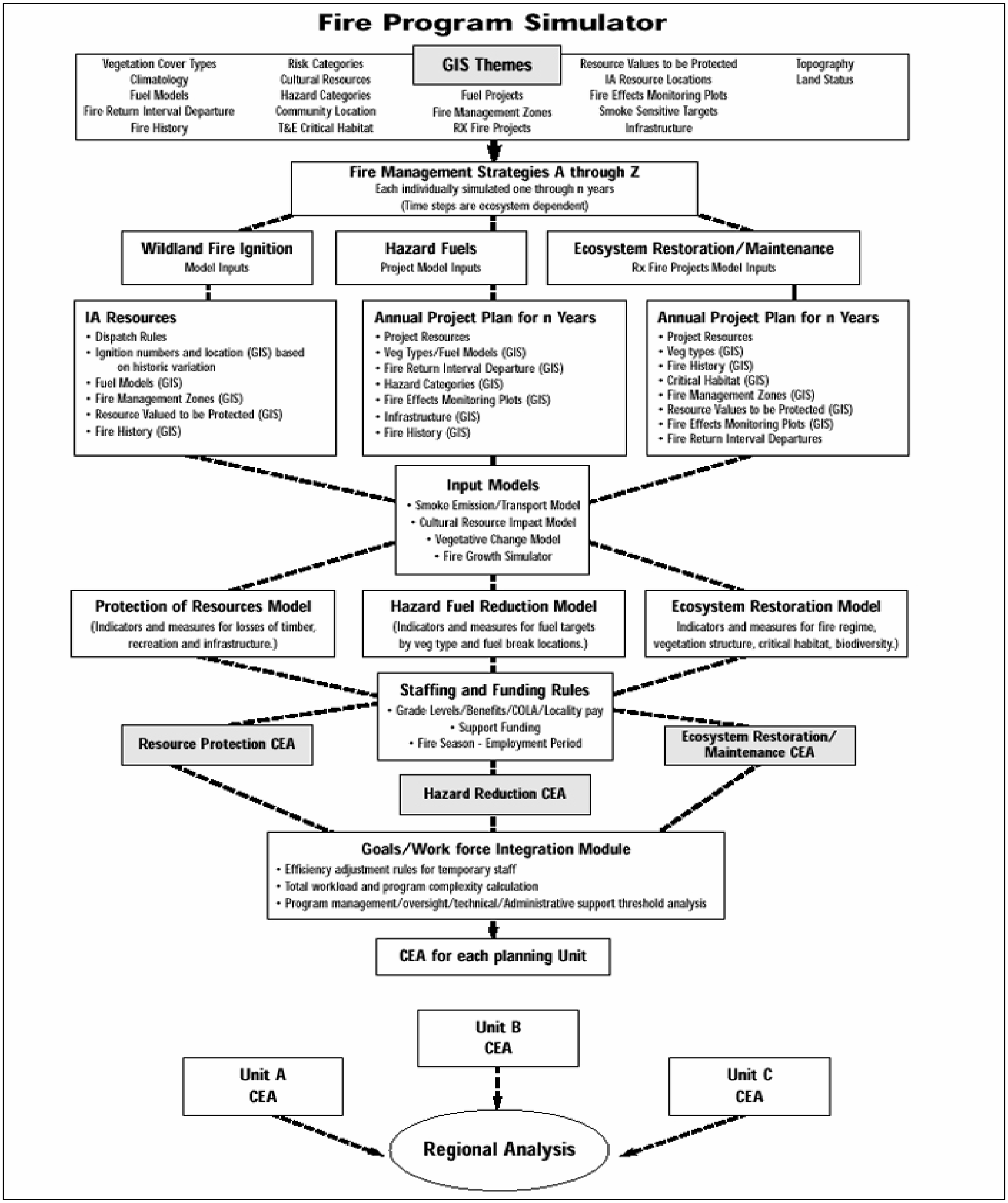

Figure 3-7. Fire Program Simulator
From Hubbard et.al., 2001

The level of fire management planning performed at the state and local levels varies widely. Some states, like Wyoming, do not have an overall state fire management plan. However, Wyoming does perform overall assessments that look at structure locations, vegetation, and fuel types and compares such data to resources in order to identify gaps. In Minnesota, most fire management planning relates to maintaining mobilization and suppression capabilities during the year. The state also has done some detailed planning on fuels over the years. In Montana, each of its 56 counties has a fire plan that focuses on how to respond for suppression purposes.

Perhaps the most comprehensive state fire planning process has been conducted by the California Board of Forestry and the Department of Forestry and Fire Protection (CDF). The California Fire Plan also has been updated over time (http://www.fire.ca.gov/FireEmergencyResponse/FirePlan/executive_summary.html). The overall goal of the plan is to reduce total costs and losses from wildland fire in California by protecting assets at risk through focused pre-fire management prescriptions and increasing initial attack success. It has five strategic objectives:

- To create wildfire protection zones that reduce the risks to citizens and firefighters.
- To assess all wildlands, not just the state responsibility areas. Analyses will include all wildland fire service providers—federal, state, local government, and private. The analysis will identify high risk, high value areas, and develop information on and determine who is responsible, who is responding, and who is paying for wildland fire emergencies.
- To identify and analyze key policy issues and develop recommendations for changes in public policy. Analysis will include alternatives to reduce total costs and losses by increasing fire protection system effectiveness.
- To have a strong fiscal policy focus and monitor the wildland fire protection system in fiscal terms. This will include all public and private expenditures and economic losses.
- To translate the analyses into public policies.

Colorado recently initiated a comprehensive statewide planning effort for fire management. The legislature enacted a statute, effective May 26, 2000, that authorizes every county to prepare, adopt, and implement a county-wide fire management plan that encompasses all state and county properties. The plans are to outline the counties' fire management policies for prescribed burns, fuels management, or natural ignition burns. The plans are to be developed in coordination with the county sheriff, the state forest service, and other appropriate state and local government entities. They also must provide an opportunity for public comment before the plan is adopted and implemented. The counties may include federal and private lands in their plans per existing agreements with those entities. However, the plans cannot infringe on the ability of agricultural producers to conduct burning on their property. BLM has developed a document, Q*UICK FIRE PLAN: Community-Based County Fire Planning*, which is used to work with Colorado counties on countywide fire planning. It also has awarded $15,000 grants to eight Colorado counties to help them implement the legislation. Some Colorado counties were ahead of this state initiative. For example, Boulder County has a comprehensive land use plan that addresses fire generally as a natural hazard and a fire plan that is updated annually.

3.2.5 Fire Prevention, Education, and Training

Fire prevention and education have been among the earliest efforts in the fire community to address fire danger and risks. The "Smokey the Bear" campaign was initiated in the early 1940s and is recognized world wide for its success at informing the public about the dangers associated with fire, and the need to take personal action to help prevent forest fires. Fire danger ratings have been conducted since 1932 and have been useful as the public recognizes them on signs near areas at risk though the systems used to provide these ratings have limitations as described above.

Fire prevention today includes education and training provided to firefighters, governments, and the public. Building on the success of the Smokey program, emphasis is placed on personal responsibility. However, in addition to safe campfires, today's focus is also on encouraging landowners and jurisdictions to take action to prevent damage to their interests and assets due to a catastrophic fire. For example, homeowners are encouraged to complete a form and address matters identified in woodland home forest fire hazard ratings. These ratings typically include ratings for fuel hazard, slope hazard, structure hazard such as roofing materials, means of access for emergency vehicles, safety zones, which are often termed "defensible space" and other related factors.

An important and growing prevention and education initiative to inform communities and homeowners is the Firewise program (http://www.firewise.org/). It was developed in 1986 in direct response to the growing incidence of wildland fires that impact and cause severe damage in communities. It was developed after the 1985 fire season in which the states of California and Florida had extensive fires that destroyed 1,400 homes. In Florida, 400 of those homes were lost on May 24, known as “Black Friday.” From the research conducted within the program came the realization that a set of conditions (weather, humidity, type of vegetation, building construction, road constructions, and lot size) define the WUI that exists or could exist in nearly every community in the country. There also came the realization that the way to affect fires in the WUI is through local responsibility and giving everyone a piece of this responsibility.

Aided with both federal funding and other sources of support, the Firewise program is an active effort to engage many stakeholders in preventing fires, including local and state governments, the private sector and the public. First initiated in Montana, the program is chartered by the National Wildfire Coordinating Group (NWCG) and is managed by the National Fire Protection Association (NFPA), both described in Chapter 2. The federal land management agencies developed the Firewise program through cooperation and alliances with many organizations, such as NASF, the Institute for Business and Home Safety, State Farm Insurance, American Planning Association, the

American Red Cross, and Home Depot. The vision underlying the program is that people *will act* to preserve wildlife habitat and the safety of their home and family, the environment, and natural aesthetics. Such anticipated action is based upon people's awareness of where WUI conditions exist and the perils of living there, the capabilities of the nearby fire and emergency management services, and sources of technical advice, community and financial assistance (http://www.fire.nps.gov/fmoconf/presentations/martin/WUIStakeholdersNew.pdf).

Essential components of the program include conducting workshops in which participants learn about land use planning; creative mitigation measures for hazards where development is located near forested and other highly vegetated land; wise home construction and landscaping; collaborative decision making; and how to incorporate Firewise planning into existing and developing areas of communities. A key element of the workshops is that participants also learn how to use ArcView software and are provided with data derived from satellite imagery. Incentives are also being developed whereby Firewise participation can help reduce insurance ratings (Bailey, 2001).

The use of effective and accurate dissemination methods is key to fire prevention and education programs that utilize GI/GIT. Too often, there is a wealth of information available to the public or to training programs, but there is a failure to communicate in a manner that motivates and promotes understanding of the information. Caution must be given to avoid inconsistent and confusing messages. Two examples of this are the common use of the terms "defensible space" and "high hazard/high risk", but the differences that exist in the explanations of their meanings.

GI/GIT has the advantage of presenting information in such a way that the homeowner and firefighters can understand its whereabouts in the context of their neighbors and districts. A homeowner looking at a hazard rating given to his property on a map can discover how his neighbors' hazard ratings may be affecting his property or vice versa, and thus may be more inclined to mitigate his site conditions to participate as part of a community's efforts. In the case of the Boulder Wildfire Hazard Identification and Mitigation System (WHIMS) project discussed in Section 3.3.4, neighbors began working together on fuel treatments to their properties after seeing maps generated using GI/GIT which showed existing and potential conditions for their neighborhoods.

Firefighters also can use GI/GIT to become more educated about the areas they serve and provide maps with prevention information as they interact with residents in these areas. Where once dependent upon the county or city departments to provide GI/GIT resources and tools, urban and rural fire departments alike are applying for grants to develop their own tools and information based upon the needs of their districts and resources. Local fire districts are finding ways to use more accurate and complete information for training, pre-event planning, community education, fuel treatment projects, and real time events. For example, with improved education and training, fire trucks are now becoming equipped with GPS, better maps and even laptops and palm pilots with GIS capabilities.

3.2.6 Local Governments and Communities

Local governments are increasingly confronting issues associated with what is commonly known as the “Wildland Urban Interface" (WUI), where human development is located near wildland areas. However, these interface areas exist in both rural and urban settings. Communities of all sizes face increased growth pressures and sprawl into fire-prone areas. Local communities that have seen or experienced wildfires are beginning to understand that they can no longer afford or depend on suppression as the sole means to address wildfires. As with the other levels of government, this understanding is leading to more efforts and resources being devoted to improving mitigation, planning, and prevention.

Leading local fire management issues include coordination and communication among many agencies and jurisdictions, and at all levels within them. Issues also include managing large areas of open space, implementing fuels management objectives, and educating and working with the community. Many local fire managers are involved with mitigation, planning, and prevention activities such as promoting prescribed burning and fuels reduction, and using hazard and risk assessments in public outreach. Having accurate information and coordinated communication to implement prescribed fire is becoming more critical as communities are ever more fearful of the “Cerro Grande Fire” type scenarios.

Local officials are being pressed to address interface issues, but are not sure about best approaches and sometimes are limited by state statutes. Growth issues are a growing priority for many local officials, but changes are being made at state levels to encourage and direct local governments to plan for hazards to build safer communities, and to provide for fuels management programs in the overall scheme of growth management.

Local emergency management and planning departments increasingly use GI/GIT as outputs become more accurate and understood. Identifying and locating hazards have become important in the education process as well as in developing plans, policies, and strategies that result in community action. Planning and building departments are finding opportunities to address hazards by improving building codes, land use design and regulations. Planners have a wide variety of tools to approach development in WUI areas, but need to understand issues of structure survival, the process of home ignition, forest health, and emergency needs. Planners must balance these issues with competing goals such as visual impacts, private property rights, and affordable housing. To develop or change codes and design, planners need supporting documentation that is current and accurate.

With the exception of some areas such as in California, many interface areas in the country are either without local fire protection and are assisted by state and federal agencies, or depend on local volunteer fire districts to respond to the initial wildfire calls outside developed areas. Most localities depend upon mutual aid assistance with nearby fire departments, and state and federal field offices. Local departments often are short on financial resources, training, personnel, and equipment. Public education typically consists of handing out pamphlets and brochures and holding district meetings with the community. Often local districts confront residents that are not year-round habitants, are new or moving, are from urban areas “escaping” to rural environments, are unfamiliar with wildfires, and/or have little time or opportunity to benefit from advice provided by local fire districts. These fire districts depend heavily on wildfire assistance from outside resources, such as state forestry and federal land management agencies.

Local residents are often migrating and need continuous education efforts. Though they are generally supportive of mitigation messages, they lack motivation especially since insurance tends to provide coverage of any property loss, regardless of the cause. While past claims due to wildfires have been negligible compared to other hazards, this is beginning to change as the ‘potential’ losses from catastrophic wildfires continues to grow at an alarming rate. Several insurance companies have begun to rethink providing insurance to homes deemed to be either in high hazard areas or of high risk. State Farm in Colorado is working with the Colorado State Forest Service to use a hazard assessment methodology to determine affected policy holders (National Fire Protection Association, 2003). The Institute of Building and Housing Safety (IBHS) has been exploring the insurance industry connection to community responsiveness to mitigation programs. GI/GIT provides opportunities as the Institute examines hazard and risk assessments and the effectiveness of local building and planning departments’ implementation of building and land use codes.

While public land agencies are trying to improve the health of the natural resources they manage, local communities have to respond to the public seeing more smoke in the air and trees being cut, as well as to confront the dangers of escaping prescribed burns. This is resulting in more demands for assurance that the information provided to communities is accurate, current and thoroughly communicated. GI/GIT provides resources and tools to help communities and land management agencies inform and work more effectively with each other.

Concerns and needs at the local level are the subject of a study underway at the National Academy of Public Administration (NAPA). The study is focused on gathering input to design a wildfire hazard mitigation incentive program to promote planning for strategic fuels reduction on the most fire prone wildlands, planning for high priority wildfire hazard reduction around communities, and joint firefighting preparedness strategies in fire prone areas. GI/GIT is not part of the focus of this work, but it may identify opportunities for further development and enhancement of these capabilities at the local level. A final report is expected early in 2004.

3.2.7 Warning Systems for Wildland Fire and Other Emergencies

Public warning systems, issues and needs have received increasing attention in recent years, particularly as needs are growing (for example since the unanticipated events of September 11, 2001) and technological improvements are increasing. The leading agencies in the U.S. with responsibility for issuing warnings for natural disasters are the National Weather Service (NWS) and the U.S. Geological Survey (USGS). Warning systems are important tools to keep the public, particularly those at risk, informed about many conditions and threats, including from wildland fire.

In addition to warnings about immediate threats, these systems also are useful to provide information about secondary impacts, such as post fire effects on health and safety, and risks to property and natural resources, such as from burned watersheds. For example, Burned Area Emergency Rehabilitation (BAER) early warning systems are established to reduce risk of damage from flooding and related phenomena. These systems consist of networks of hydrologic devices, including precipitation and/or flow gages, and can include satellite-telemetered data collection sensors with GOES/DOMSAT satellite transmitters, ground readout delivery systems and solar power modules. For example, USGS quickly set up such equipment in 2002 for the Interagency BAER Team for the Missionary Ridge Complex Fire near Durango, Colorado, due to the high risk of damage after the fire. The NWS and the LaPlata County Emergency Preparedness Department agreed to monitor the data and take emergency action based on the results in an effective partnership (Williams et. al., 2002).

Wildland fire warning systems vary considerably in how the public is informed about threats in their vicinity. Approaches now in use range from door-to-door, in-person notifications to sophisticated, automated, and thus, real time methods, such as Reverse 911 systems described below. Several opportunities exist to make fuller use of GI/GIT for warnings about emergencies, including wildland fires.

3.2.7.1 Public Warning Approaches, Issues and Needs

Several issues have been raised about current public warning systems because the effectiveness of warnings has been questioned. For example, NWS uses common warning terminology for various types of weather and other emergencies for many years, including tornadoes, hurricanes, severe thunderstorms, other high wind events, snowstorms and blizzards, other precipitation events, fire, floods, extreme hot and cold, and other conditions. However, differentiation between terminology for watches, warnings and forecasts is blurring due to advances in science and technology and (Subcommittee on Natural Disaster Reduction, 2000, p. 20). Moreover, demand is growing for additional and more precise information when warnings are issued so recipients can evaluate their potential risk before taking action (Ibid.).

Through an investigation of warnings systems, *Effective Disaster Warnings* (http://www.fema.gov/nwz00/effective.shtm), the Subcommittee on Natural Disaster Reduction (SNDR) of the National Science and Technology Council's Committee on Environment and Natural Resources also found that "warnings are effective only if they are accurate and result in appropriate action," with a principal conclusion that "warnings are most effective when delivered to just the people at risk." (Subcommittee on Natural Disaster Reduction, 2000, p. 18).

More recently, a document was issued by the Partnership for Public Warning entitled *A National Strategy for Integrated Public Warning Policy and Capability* (http://www.partnershipforpublicwarning.org/ppw/docs/nationalstrategyfinal.pdf) Partnership for Public Warning, 2003). It similarly concluded that current public warning systems do not reach enough of the people at risk, while often reaching many people not at risk. The partnership recommended in the document that a national strategy be developed to ensure a single, common and integrated warning architecture.

A key problem in meeting the critical need to reach all appropriate recipients (and not others) is that many existing warning systems provide very general information about the potential location of impacted areas. This limitation is particularly evident in the Emergency Alert System (EAS), which is one of the most widely used warning approaches in the U.S. EAS was set up as a public-private approach to enable the President to have the capability to address the nation on very short notice for national emergencies. Participants include over 14,000 radio and television stations, as required by law. Though EAS has never been used in this nationwide capacity, it is used over 100 times a month at state and local levels. EAS uses Specific Area Messaging Encoding (SAME), which identifies up to 31 different counties or 1/9th sections of counties in each transmission. Many areas are not able to use the subcounty designations, so warnings are issued for entire or multiple counties, with many people receiving messages that are not relevant for them (SENR, 2000; Partnership for Public Warning, 2003). The *Strategy* also includes additional problems with EAS. While EAS is more widely used for phenomena other than fire, these conditions and related research point to the limited effectiveness of warning systems that do not provide accurate and sufficiently precise location information to achieve the intended result of action on the part of people in harm's way.

Other systems also are used for issuing warnings, but have similar problems with the generality of geographic areas that are notified. Sirens frequently warn the public of tornadoes and other disasters, and advances have been made using GI/GIT to ensure that persons at all affected properties are able to hear the sirens and other areas are not duplicated too inappropriately or extensively. Several other warning mechanisms are being investigated and expanded as warning devices, such as pagers, telephones, computers, television, radio, etc., but the locations of such approaches similarly need increased precision to be effective. Growth in land use development near forests and other wildlands means that needs and opportunities to use GI/GIT and more sophisticated and precise warning systems are increasing with time.

Additional problems are inherent with warning systems in the U.S. today. The *Strategy* states that there are several disparate and incompatible alert networks developed by states, counties and municipalities. However, few standards, protocols, or procedures exist for developing and issuing warnings. As a result, warnings from different sources use different terminology to communicate the same concerns and recommended actions. Lack of technical and procedural interoperability among warning originators, system providers, warning recipients and delivery systems are growing challenges

(Partnership for Public Warning, 2003). Moreover, while a mix of public and private organizations are involved in current approaches,

> *(T)he absence of a coherent national warning strategy means that companies have become hesitant to expend development funds on new warning products, and investors have become wary of the warning industry. In the last few years, many of the largest communications companies have reduced or eliminated their investment in public warning, at a time when the need has never been clearer or greater. Sales and new product creation are inhibited by uncertainty about future national policies and standards, as local governments wait for state and federal governments to tackle the issues that must be addressed before they can implement truly effective solutions" (Partnership for Public Warning, 2003, p. 30).*

While neither of these documents specifically address wildland fire, the need for all hazards warning approaches is articulated. Both documents also provide examples and conclude that new capabilities are possible through new technologies. However, large challenges are identified to provide accurate, understandable, specific and informative warnings with compatible and consistent procedures and processes for collecting and disseminating warnings in secure ways.

GI/GIT could enhance the precision and overall effectiveness of warnings issued via existing and future systems. Reverse 911, as described below, is an example of an approach that uses GI/GIT to help specifically warn only those needing such warnings. Moreover, as stated in the SNDR report, if locations of imminent danger are known more precisely, and evacuation is required, warning messages could be customized to provide directions as relevant for each recipient's location (SNDR, 2000, p. 33). Accurate geospatial data could be a critical resource to establish the integrated approach recommended in the *Strategy* described above. The need for policy attention and action is recommended by these documents, including to take full advantage of technological advancements for delivering more effective warnings to people at risk.

3.2.7.2 E/R 911 Approaches and Issues

More and more localities are implementing Enhanced 911 (E911) systems to ensure that the location of emergency callers can be known to phone responders whether or not callers identify their location. This service is also being expanded to cellular phones in addition to land telephone lines. The Federal Communications Commission is enacting regulations to provide the same safety features for cell phones as for land lines, with locations needed within about 100 yards. Both systems require detailed roads and addressing data for their service areas (Marble, 2001). Many E911 initiatives have experienced implementation problems and issues due in part to the complexities of thoroughly building and georeferencing address databases. However, several experiences with poor databases and interlocal complications near jurisdictional borders have resulted in loss of life and are encouraging further action to address these problems. The need for this emergency service is increasing demanded by the public and government policy makers. For example, a bipartisan E911 caucus now exists in

Congress, and discussions have been underway to require states to use funds earmarked for E911 for this purpose rather than diverting funds to other government needs. Virginia is an example of a state that is implementing a statewide approach to cellular E911, including use of geospatial data as a informational foundation for this work.

As localities modernize their communications systems, including E911, they pose excellent opportunities for the fire community. There typically are problems and needs for interagency communications and coordination with local governments during fires to ensure effective fire response and communications with these stakeholders and the public. Additional opportunities exist for fire organizations because existence of E911 systems means that Reverse 911 (R911) systems can be used. With R911, GI/GIT can be used to identify an area and a specified set of addresses at risk. In these cases, landowners can be automatically called on the telephone, virtually in real time, to alert them of danger. R911 can be an effective tool to automatically call and inform residents of various nearby dangers, including fire risks, using this quick, efficient and inexpensive approach as risks become evident. Many applications are under development for R911 in anticipation of widespread E911 capabilities.

3.2.7.3 Disaster Warning Approaches, Systems and Future Directions

Fire warning devices are an important tool to keep the public informed about conditions and threats, particularly those at risk. Devices to inform the public about pending wildland fire in their vicinity vary considerably and often need to be modernized using GI/GIT. They can be quite sophisticated, such as for R911 systems discussed above. Sirens are frequently used to warn the public of disasters and have been managed using GIS to ensure that persons at all affected properties are able to hear the sirens and other areas are not duplicated too extensively. Growth in land use development near forests and highly vegetated areas means that needs and opportunities to use GI/GIT and these technologies are increasing with time.

3.2.7.4 Emerging Automated Fire Alert/Alarm Systems

The private sector is attempting to develop products and services to warn homeowners living in WUI areas about nearby fires. The company Ambient Control Systems, Inc. now offers a product called FireALERT, which is an early warning wildfire detection and wireless linked alarm system deployable near the buffer zone of developed properties (http://www.ambientalert.com/products.html). According to company literature, the system can recognize a fire in less than four minutes, whereupon it instantly dispatches a wireless alarm signal, reporting the fire's location and direction to a central monitoring station via repeaters and satellite links (http://www.ambientalert.com/firealert.html). The system is also enabled with GPS technology.

3.3 GI/GIT RESOURCES USED IN WILDLAND FIRE MITIGATION, PLANNING AND PREPAREDNESS

GI/GIT can assist in piecing together fire history from global to regional to local levels, and also help in understanding the hazards, the risks, and potential fire spread and damage. In particular, remote sensing image archives have been found to be especially useful in analyses for global fire effects and vegetation changes over time. GIS and other GIT are particularly useful in analyzing local or regional fire history, and are good tools for incorporating these data with newer data sources collected in the field. Urban development also can be tracked. Building and infrastructure information often now found in GIS, permit tracking systems and other systems are invaluable when planning in WUI areas. As discussed in Chapter 5, GI/GIT also can assist during a wildfire event as emergency responders use it in the field to make suppression and resource decisions. Damage assessments done after fires also apply GI/GIT, as discussed in Chapter 6. Resulting information during and after fires can be subsequently used to mitigate, plan and prepare for future events, as has been done in the cases of the Oakland and Cerro Grande fires.

3.3.1 Foundational Geodata for Fire Mitigation, Planning and Preparedness

Governments at all levels, including local, state and federal, have basic foundational data that is needed for multiple business purposes in their organizations. For example, local governments need roads, parcels, utilities (e.g., gas, electric, cable, water and sewer), critical facilities, zoning, land use designations, tax assessor information (e.g., age of structures, size, etc.), and other subdivision information where applicable. Figure 3-8 shows a newly platted subdivision where the road was determined to be providing more protection if it were to be located on the perimeter of the development rather than internal to the lots. More and more departments are requiring that development plans be either submitted in electronic format or else be scanned and entered into a development permit tracking system so they can be used with existing local data managed in a GIS database.

Over time, local governments and regional entities have developed a wealth of data for a variety of needs such as infrastructure and land use planning, open space and watershed planning, tax assessments and economic planning, and emergency services and preparedness. In addition, changes often are closely monitored to understand trends and potential future growth patterns. This information is typically the most accurate and current that is available about WUI areas. While such data are developed and maintained for other purposes, they also can be used for many applications in all phases of fire management and are invaluable when planning in interface areas.

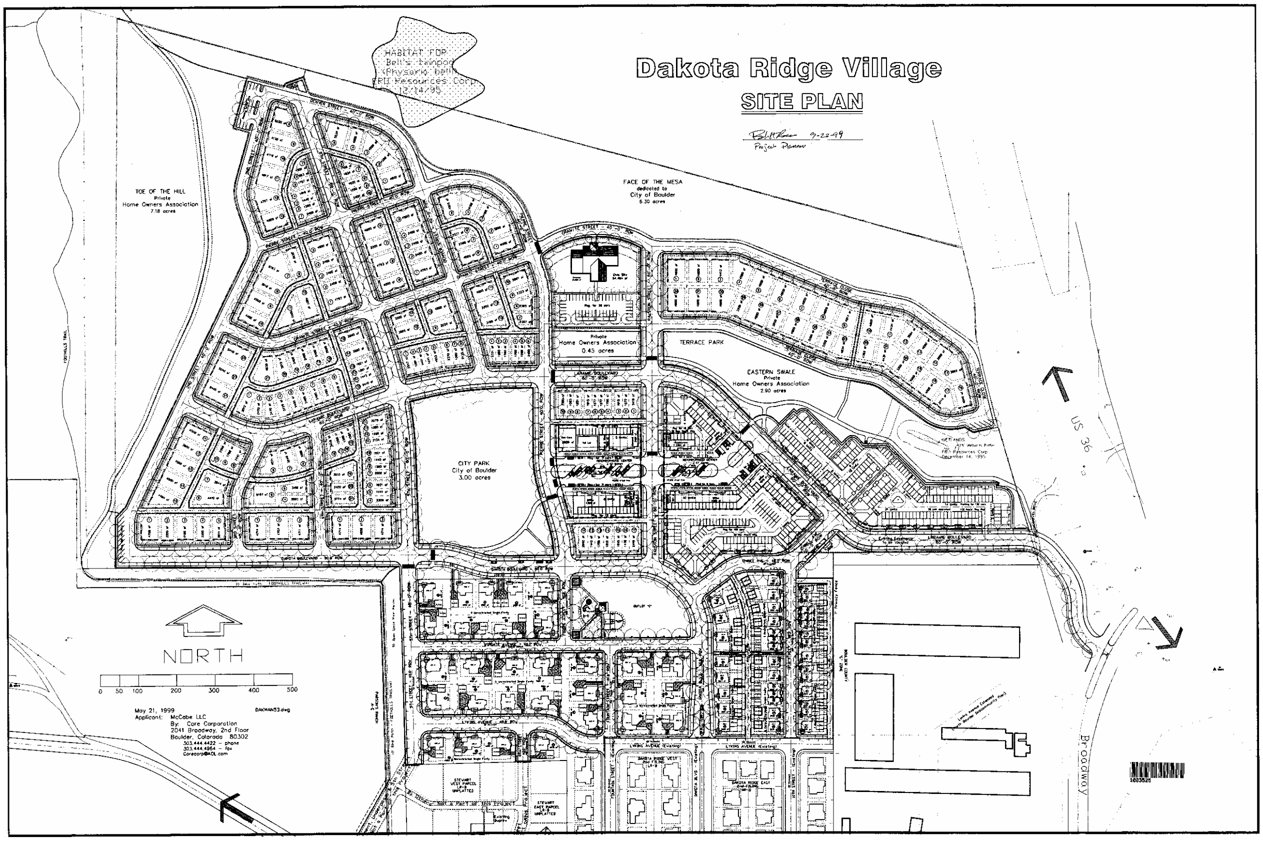

Figure 3-8. Subdivision Design Providing Road Access for Potential Fire

3.3.2 GI/GIT Use to Understand Fire History

One example of how satellite data are being used is to gain retroactive understanding of fire history, such as from the National Oceanographic and Atmospheric Administration (NOAA) (Gutman et. al., 2001). NOAA maintains several satellite sensors that are generally used for atmospheric observation and analysis. Fire observations can also be recorded by satellites based on image data collected in middle infrared wavelengths, which is much more sensitive to “hot spots” in a sub-pixel than are data collected in the thermal infrared wavelengths (Gutman et. al., 2001).

Both the GOES geostationary satellites and the AVHRR polar-orbiting satellites that are described in Chapter 4 have been used for retroactive analyses in this capacity, although each type of satellite has its respective advantages and disadvantages for use in fire detection and monitoring. GOES satellites are in geostationary orbit in the western hemisphere, so global understanding of fire history is limited. However, GOES provides frequent observations during the day and night, allowing for a more complete record of fire from start to finish. AVHRR satellites are advantageous because they can provide a better global fire detection capability, but unlike GOES, lack the spectral capability needed for accurate fire temperature and fire area measurements (Gutman et. al., 2001). Chapter 4 also provides information about the visible Operational

Linescan System (OLS) on board polar-orbiting DMSP satellites. These resources have been successfully used to detect fires burning at night. However, OLS observations are sometimes hampered by environmental and atmospheric conditions.

Although each sensor has its respective strengths and shortcomings for fire observation, there nevertheless exists a very large body of data collected from these instruments over the past 20 years at NOAA (Gutman et.al., 2001). These NOAA data can be further processed in order to obtain a baseline of fire products. These products would then be used by climate researchers studying land cover changes over time, and also by scientists monitoring present fire activity (Gutman et. al., 2001).

GIS also is very useful in analyzing fire history over a region. For example, in a 1998 study by Canada's Yukon Department for Renewable Resources (Yukon DRR, 2000), a spatial data model was used to depict forest fire history from 1946 to present. A single Arc/Info© GIS coverage and was created and information fields were attributed from historical information and map data showing fire locations and characteristics throughout the decades. An overlapping fire history was found for the region, and the coverage that was created was capable of query and use with other geospatial data sets.

When mapping or other recorded data are not available, spatial analyses can still be performed from the use of data collected in the field. In a recent study done at the Lake Duparquet Research and Teaching Forest (FERLD) in Quebec, Canada, a low-temporal spatial analysis of lacustrine charcoal accumulation rates was done to reconstruct fire history and geography in Quebec. This will allow a better understanding of the overall effects of fire and climate interactions (FERLD, 2001). This and other research done at FERLD has helped piece together the fire history within the region. A map showing the past 400 years of fire was also generated using fire scars and age determination of trees that colonize burned sites after a fire (FERLD, 2001a). Consequently, it was found that a significant decrease in fire occurrence has been observed over the last 100 years (FERLD, 2001a).

Various systems are used to record and display fire history. As shown in Figure 3-9, state governments use differing approaches with varying geographic precision to document the location of fires over time.

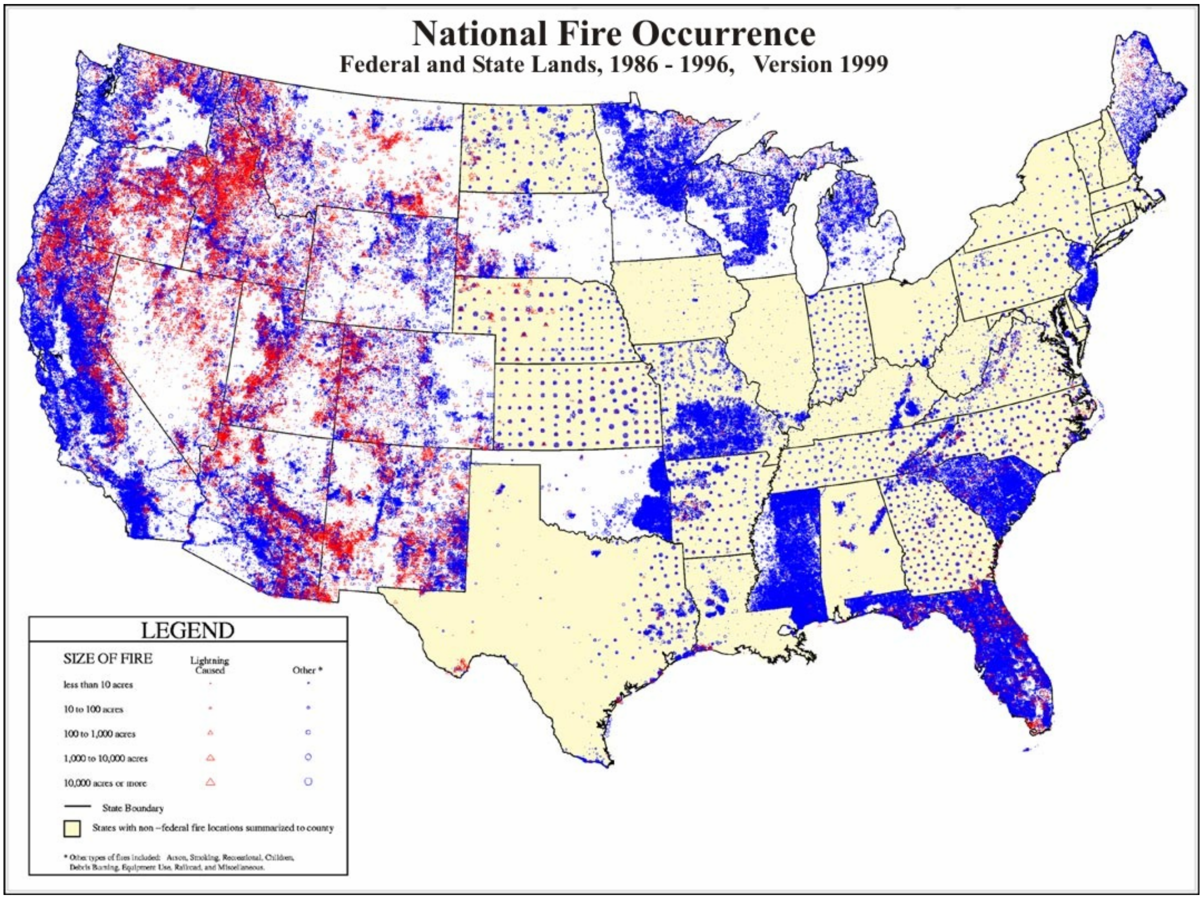

Figure 3-9. National Fire Occurrence Data from 1986 to 1996

3.3.3 Vegetation, Fuels Conditions and Treatment Progress

A key activity to mitigate wildland fire is known as fuels management. Fuels treatment includes prescribed burning, mechanical thinning and other efforts to reduce the likelihood of catastrophic fire in a particular area. Where to conduct fuels treatment is based in large part on vegetation, fuel load and other conditions on the ground, as well as nearby areas at risk. Fuels also are a major factor in determining the size, behavior, severity and impact of fires. As a result, an understanding of fuel conditions is considered essential for addressing fires before they happen and while they are burning. While fuels include many types of materials in areas with human settlements, most attention has addressed vegetation in natural areas.

Vegetation conditions have long been observed by using satellite remote sensing such as from the Landsat series and are a key component of risk modeling. Similar to land cover studies, such imagery can be interpreted to determine, in a general manner, the types and conditions of vegetation on the ground. Forestry was one of the earliest GIT applications in the nation as needed for monitoring and managing resources (Warnecke, Nanni, Nedovic-Budic, and Stiteler, 2002). Vegetation studies were a key part of this work and led in part to similar work for fire. GIT work has been conducted for fuels and fire purposes for almost a decade (Green et. al., 1995).

The accuracy of vegetation and fuels mapping efforts is highly dependent upon the degree to which field data accompany these processes, but useful results have been determined in several such efforts over the years. In addition to vegetative data, fuels efforts typically also include determinations of fuel type and amount, biomass, fuel moisture content, combustion and heat release rates, aerosol emission characteristics, and fire history. These data can help determine variations from the normal fire regime for the area of interest, comparisons to normal fuel levels in the subject area and elsewhere at the same time, and probability of fire ignition and spread into high-risk areas. To date, several fuels studies have been conducted at various scales and with varying levels of accuracy based on the inclusion of other data resources such as field data. Chapter 4 discusses the use of satellite imagery for fire detection. Some of the imagery discussed can also be used for mitigation, such as NOAA's AVHRR data, which is used to measure vegetative stress and is frequently used to determine fire danger ratings. Much work has been conducted by the U.S. Forest Service and others to understand fuel conditions in both large and pilot project areas.

While enhancements in automated remote sensing processes are being made, determination of vegetation, particularly fuel conditions, may be the "greatest challenge to a comprehensive wildfire behavior prediction system (Hanson et.al., 2000, p. 169). Adding to the complexities of conducting such work about natural conditions is the fact that other conditions also need to be considered as contributing to fuels, such as structures and hazardous materials that may be located near them (such as tanks of gasoline). These factors are increasingly important as concerns about fire risks near developed areas become more severe and evident to scientists, practitioners, and the public alike.

On a local level, communities are including fuel model factors into their hazard identification and risk assessments. While the vegetation type serves a purpose in fire management, the fuel model type indicates the type, the density of the canopy cover, and the undergrowth, and has a greater role in the modeling and hazard rating capabilities needed in today’s risk assessments. With this important distinction between vegetation type and fuel model type, Figures 3-10 and 3-11 are examples of how communities are utilizing fuel model data.

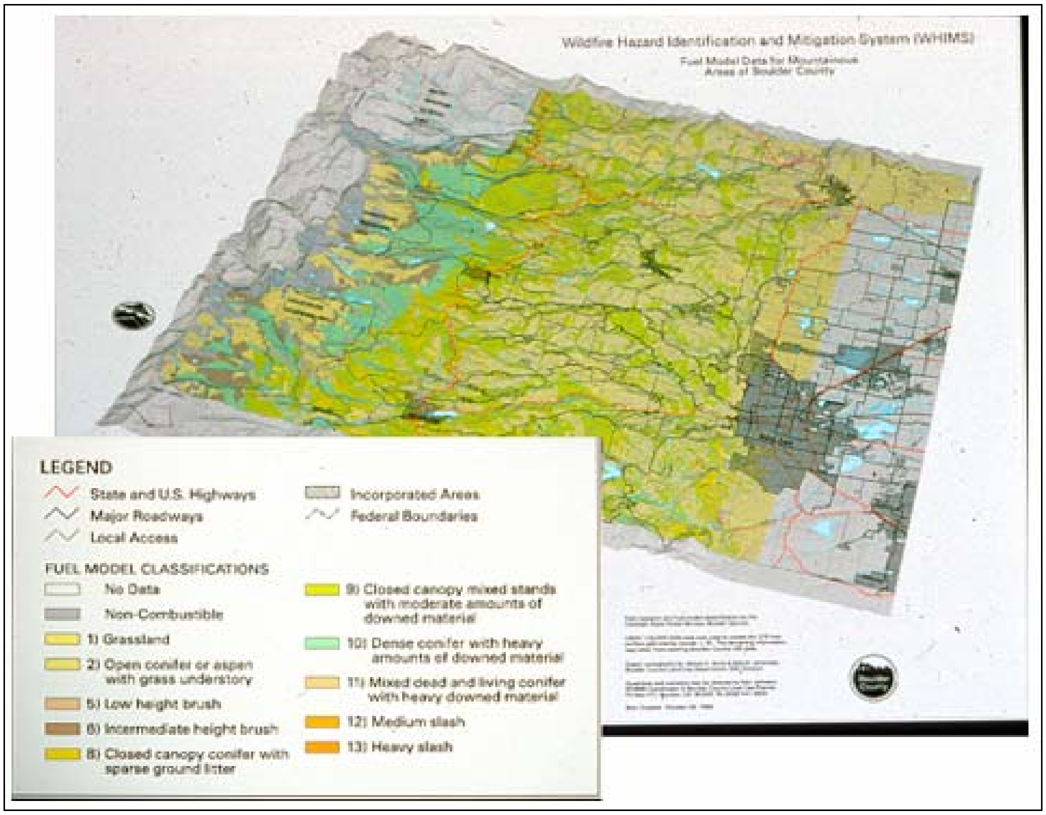

Figure 3-10. Boulder County, Colorado Fuel Model Map

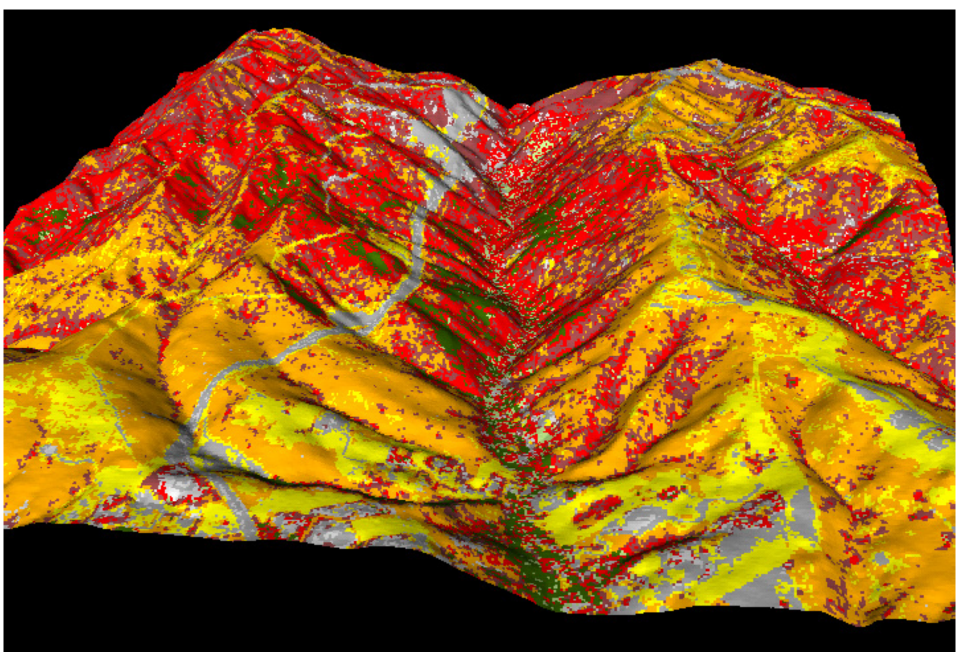

Figure 3-11. 3D Map from Fire Fuels Model
Courtesy of Space Imaging, 2003
Fire fuels models are key inputs for fire behavior modeling and fire risk assessments.

3.3.4 Fire Hazard and Risk Assessments at the State and Local Level

GI/GIT supports hazard and risk assessments by providing the capability to gather, manage, analyze, and produce information from the many factors that determine the wildfire hazards and risks to both communities and natural resources. Many departments now depend upon GIT to provide information to aid in mitigation, planning, and prevention. One of the earliest innovators has been the California Department of Forestry and Fire (CDF). Legislation dating back to the early 1980s required CDF to map different classifications of fire hazards with areas of state fire prevention responsibility (such as outside of large incorporated areas). These efforts were intensified with additional legislative direction in the early 1990s, due in large part to the Oakland Hills fire in October, 1991. To date, it continues to be the single most damaging wildland fire in the nation in terms of losses because in one day it destroyed 2,621 homes and 758 apartments and condos, and caused 25 deaths. The legislature directed that working with local fire authorities, CDF should address long-term hazards by mapping Very High Fire Hazard Severity Zones within local responsibility areas. GIS was used in both efforts, combining various data to determine and communicate these areas and risks.

Since the Oakland fire, CDF and related efforts have helped in part to cause local governments with fire risks to be some of the most competent in the use of GI/GIT for fire than other localities. A key component of the California Fire Plan adopted in 1995 was to increase the usage of GIS by firefighters on the ground. The approach was that armed with this technology and related data, they would be able to best determine areas of highest risk. For example, Marin County has used data to help determine the severity of wildland fire and its impacts, the amount of vegetation and fuels, past levels of service, weather patterns, and the number and kind of assets or values at risk (Amdahl, 2001). Many data sources are used with GIS in each of these factors to model conditions and develop potential scenarios. An action plan was developed from this work, including vegetation management, land use strategies, public education, ignition management, and fire engineering, which includes preventative control measures such as strategically placed fuel breaks, maintained fire roads, defensible space, fire safe roofing materials, and land use planning (Amdahl, 2001). CDF has worked with local officials from other jurisdictions, and they too have adopted such sophisticated approaches to fire risk and mitigation efforts (Marose, 2001). Some efforts have included using this information to influence decisions made by the insurance and construction industry, in addition to that of governments.

Another innovator in fire risk efforts and use of GI/GIT has been the Florida Division of Forestry. The state faces growth and fire pressures similar of that of California. A Fire Risk Assessment System (FRAS) is being developed to identify and define wildland fire risks, map fuels, model and map areas where fuel can be reduced and update the model for fuel and land use changes. Landsat imagery is being used to map fuels, and a fire susceptibility index is being developed. This index is based on fire occurrence potential, which is derived from factors such as topography, weather, etc. as shown in

Figure 3-12. An important feature of this effort is the extensive fieldwork used to help map fuels as accurately as possible. In addition, a fire effects index is being developed from cultural resource sites, utility corridors, hazardous waste sites, threatened and endangered species habitat, urban interface, managed timber, expensive operations, sensitive areas, and other factors. These data are also being used for preparedness and to aid in fire response (Hendrix, 2001), and are the critical local component determining values at risk. The method of technology transfer was through an ARCVIEW 3.x interface as well as the "published results". Figure 3-12 shows the major FRAS inputs and outputs. Figure 3-13 shows an example of the final output, "Levels of Concern", for Lee County in south Florida.

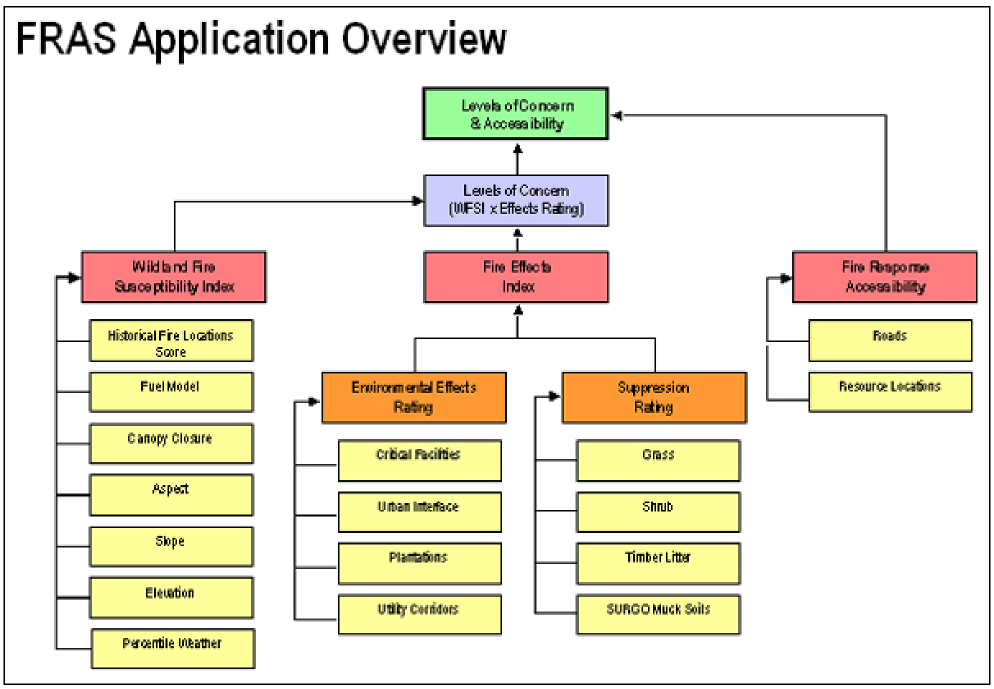

Figure 3-12. Major Inputs and Outputs of the Florida Fire Risk Assessment System (FRAS)

Other state agencies, including both emergency management agencies and state forestry organizations, are collecting data and mapping for statewide and regional analyses, and to assist local agencies especially those short of resources to conduct their own analyses. A growing number of local agencies are using GIT for many of the same needs but at a more detailed level.

In Colorado, an assessment which determined risk areas focused in the region known as the "Front Range," is referred to as the "Red Zone" assessment. It used GI/GIT to aid mitigation, planning, and prevention efforts to help address forest health and interface issues for this region with rapid growth. The Colorado State Forest Service uses this "Red Zone" as a guide to analyze the areas of greatest risk and highest firefighting priorities. Terrain, slope, aspect, forest conditions, fuels, and housing density were all considered in the Red Zone assessment. A buffered area of potential damage was determined, averaging 2 miles wide, around places where a catastrophic fire could occur. As shown in Figure 3-14, the project centered on the areas of highest housing density, which are the urban and suburban areas along the Front Range. The Red Zone assessment has been widely used. For example, a Denver Post reporter used GIS software to calculate the population of the Red Zone and break down that population by county.

The more recent Colorado Wildland Urban Interface Hazard Assessment, a multi-agency effort, has built on the successes of earlier hazard methodologies and assessments. The educational value to convey wildland fire danger was among the successes of the Red Zone work. In the new state WUI hazard assessment methodology, a more accurate housing density layer has been created and all the counties in the state have been used. Among the final outputs are a Risk, Hazard, and Value (RHV) map displaying areas of concern that are at risk of catastrophic wildland fire (Edel, 2002), as shown in Figures 3-15 and 3-16.

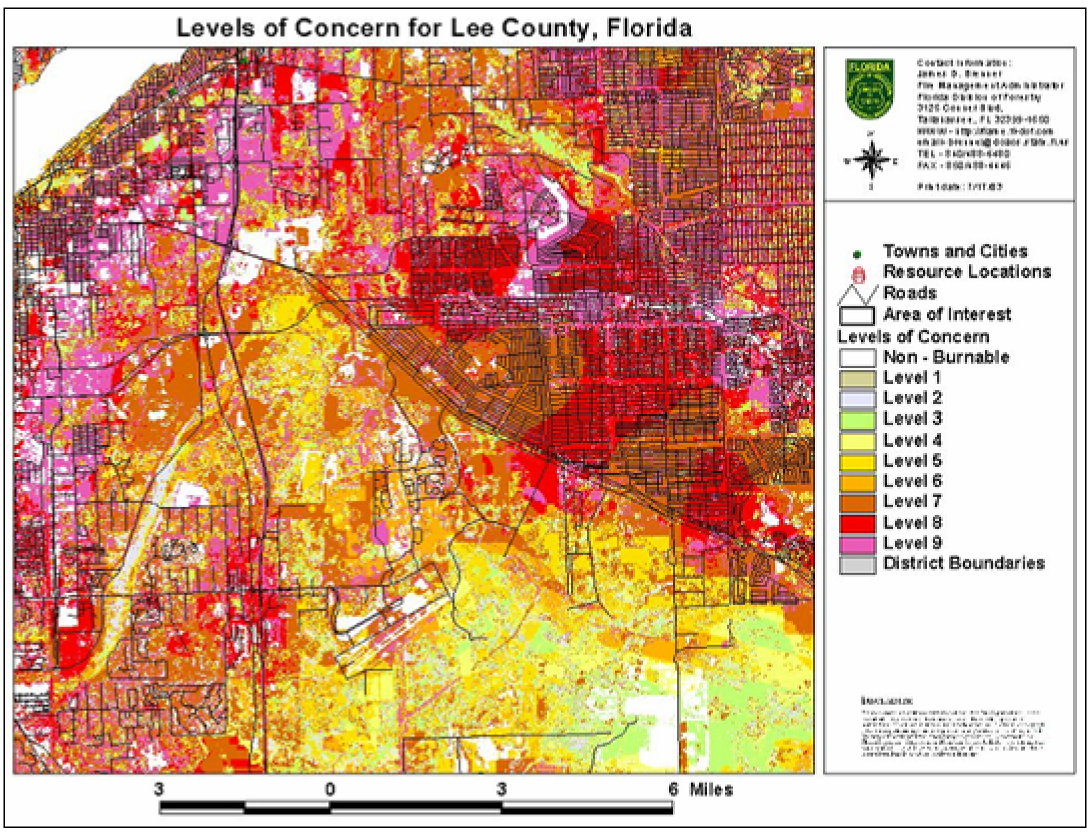

Figure 3-13. FRAS Output Example
A "Levels of Concern" Map for Lee County, Florida

A local effort now recognized nationally for its early beginnings at wildfire hazard mapping and success in using GI/GIT is found in the Boulder County, Colorado Wildfire Hazard Identification and Mitigation System (WHIMS) (Boulder County, 2001). The ideas for the system began in 1991, which at that time mapping the hazards at an individual parcel level in a community was done for the damage assessments after the Oakland fires (Johnson, 2003). The Boulder community was forced to address its wildfire interface issues after the devastating Black Tiger Fire in 1989, which claimed 44 homes and over 2,000 acres in its striking mountainside backdrop. The Boulder County Wildfire Mitigation Group had been looking for a way to educate and motivate its residents to mitigate their hazards. By 1991, the county had conducted over ten years of detailed data development effort with GIS using tax assessment records to develop a full cadastral database complete with detailed information about individual parcels. Boulder County also mapped fuel types as part of the WHIMS project, and had over 450 square miles of forested areas using aerial photos and topographic maps at the 1:24,000 scale. These fuel maps were then verified by Colorado State Forest Service interns in an intensive field survey conducted over a 9 month period (Johnson, 2003).

WHIMS is recognized as being one of the first approaches in the country to use parcel data for wildfire hazard mapping before, rather than after an area was impacted by fire as is more often done in damage assessments. Since 1991, over 6,000 homes have been surveyed and mapped, fire districts continue to use the data for training and preparedness activities, and it is still a strong public education tool that has spurred many fuel treatment projects at the local level. Information learned from associated surveys and mapping has been used to help change several planning policies, building policies and codes. The effort also demonstrated the need for the county's first wildfire mitigation coordinator and a county-wide wood chipping program. Today, Boulder is one of many communities with wildland fire mapping and mitigation programs that are making more and more use of GI/GIT to assist in these efforts, as discussed earlier in this chapter.

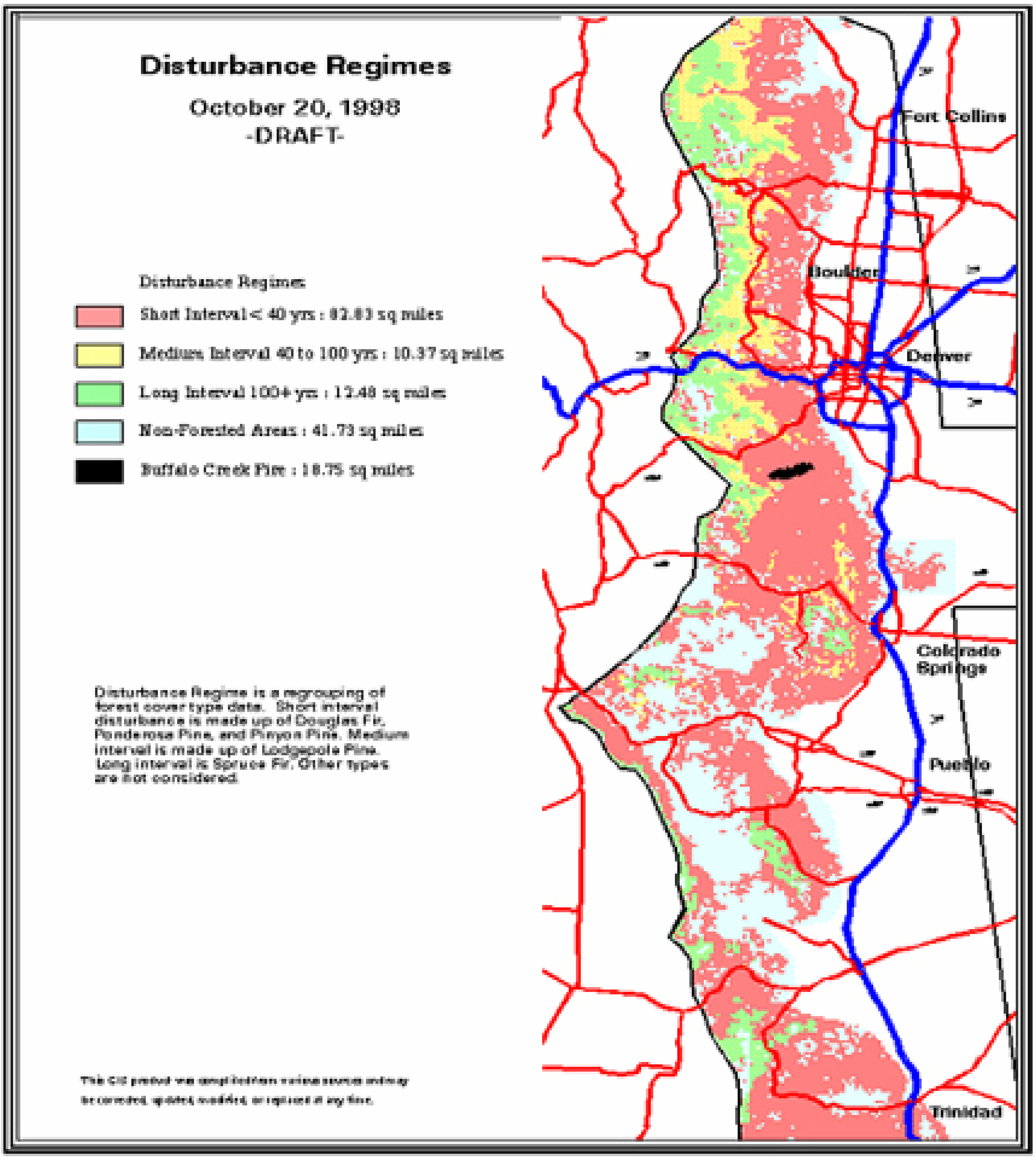

Figure 3-14. Front Range Red Zone Assessment Map, Colorado

In addition to such state and local government efforts, the national Firewise program also uses and promotes local use of GI/GIT. As described above, GIS is used as a tool in classes and other aspects of the program, but some local and state governments have gone beyond the basic use of GIS developed through the program to develop additional applications. For example, Minnesota's Division of Forestry has developed extensive GI/GIT expertise to help implement the Firewise program throughout the state.

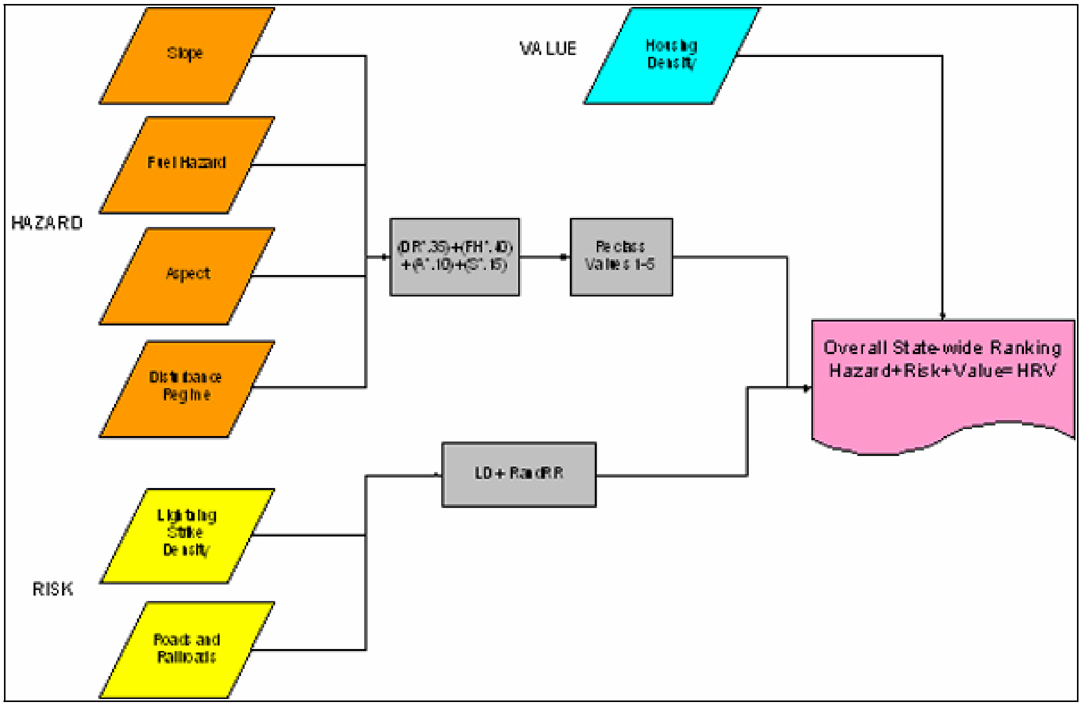

Figure 3-15. Colorado Wildland Urban Interface Hazard Assessment
Courtesy of Colorado State Forest Service

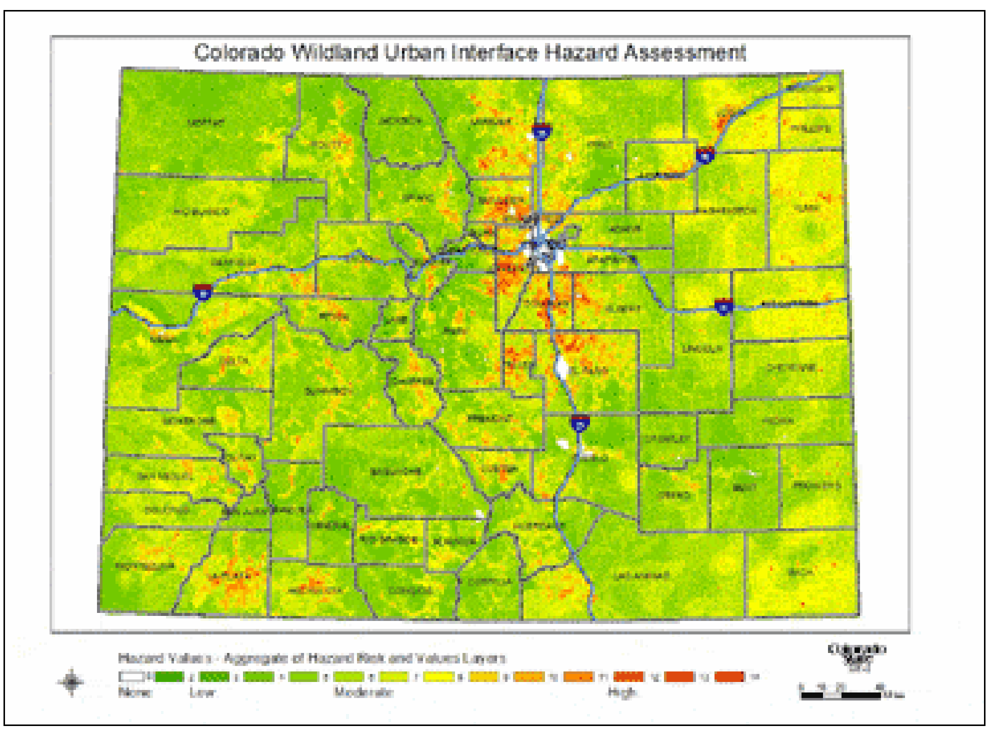

Figure 3-16. Colorado Wildland Urban Interface Hazard Assessment Map
Courtesy of Colorado State Forest Service

3.3.5 Fire Hazard and Risk Assessments at the National and Regional Level

While more and more governments are both conducting risk studies and utilizing GI/GIT in this regard, the need for comparable risk assessments is increasingly recognized. Various risk projects have been conducted at the federal level. A recent effort, known as LANDFIRE, includes development of an assessment that can be used across the west, and ultimately the nation. Following work in two pilot test areas, LANDFIRE is now proposed as both a consistent nationwide assessment of risk based on vegetation, but also an effort to provide national data layers and models that can be used for planning, mitigation, and response activities. LANDFIRE has the potential to contribute significantly to national, regional, and local level ecological analyses. It provides a science based methodology, including development of vegetation data using Landsat 7 imagery, and supplies the necessary digital data layers needed to conduct additional modeling such as for fire spread and behavior modeling. Current work is underway at the Forest Service's Missoula Fire Lab and the U.S. Geological Survey's EROS Data Center, with a proposal to expand efforts significantly to speed up work and deliverables.

At the same time that LANDFIRE was being tested, plans were underway to conduct the Southern Fire Risk Assessment (SOFRAS), which is based in part on the Florida Fire Risk Assessment System (FRAS) described above. Authorized in late May 2003, SOFRAS is sponsored by the Southern Group of State Foresters, but also with federal fire funding like LANDFIRE. SOFRAS is similar to FRAS in that it will allow state and local fire management planners to identify the potential for severe fire and risk across the thirteen southern states participating in the project. As part of the project, two publications will be produced which will illustrate the harmful and beneficial effects of fire in the south. SOFRAS will be completed in 2005 if full funding is made available.

Figure 3-17 compares the major objectives, project deliverables, models, and challenges for LANDFIRE, the Southern Fire Risk Assessment (SOFRAS), and the Florida Fire Risk Assessment (FRAS). All three of these projects have similar goals, but there are some differences. LANDFIRE is a data and model development project, while SOFRAS and FRAS not only provide data, but also provide a mechanism to change and manipulate the data through a mapping interface. Efforts are underway to reconcile and maximize results from these projects.

3.3.6 Fire Simulation, Behavior and Effects

GIT has been used virtually since its origin to analyze natural resources, and particularly forestry conditions and management alternatives. It is a powerful tool because it enables ecosystems and resource managers to simulate multiple and alternative future conditions across a specific area. Forestry and fire are critical parts of ecosystem management. As discussed above, fire has a key role in forest ecosystems throughout the world, with both wildfires and prescribed burning affecting ecosystem relationships and management activities.

Various models are used to help simulate fire and understand and predict fire behavior and effects. A growing number of them require fuels data derived from imagery and GIS to model conditions and likely scenarios. This is a key element in determining mitigation needs and locations for fire treatment. Fire behavior and propagation is well recognized as a function of vegetation, terrain characteristics, and local weather conditions; in particular, wind and moisture. While important to mitigate wildfires, it is also a key input for determining the location and timing of fuels treatment programs, such as prescribed burning. The public understands and accepts that wildfire can be an "Act of God" and that there is a growing need for fuels treatments. However, they have little tolerance for prescribed burns that get out of control, such as described in Chapter 2 about the Cerro Grande Fire in Los Alamos, New Mexico in 2000. The public has even less tolerance for fires that should not have been ignited in the first place due to unfavorable, high-risk conditions. Fire managers must ensure that they are making the wisest and informed decisions in terms of igniting and allowing prescribed fires to burn, and GIT is becoming a critical tool to meet this need.

Like the use of remote sensing and other GIT for forestry and other natural resources monitoring and management applications, fire simulation models have also been under development for over 20 years. The first BEHAVE model was designed based on work conducted in the early 1970s. Newer versions continue to be used by some units of the U.S. Forest Service to predict fire behavior, plan for prescribed burns, guide fire response tactics, and aid in planning and training. However, BEHAVE and similar models have inherent disadvantages, for example they depend on "upwind velocities in steady and homogenous conditions of fuel and topography" (Hanson et. al., 2000, p. 165).

During the early 1990s, the Fire Area Simulator (FARSITE) was developed to conduct a higher level of complexity in fire behavior modeling. A key component of FARSITE is that it interacts with various GIS software packages and appropriately incorporates some important conditions on the ground, such as topography that are not considered accurately with BEHAVE and similar models. FARSITE also incorporates the use of fuels and weather data and has the ability to spatially display results and use the query capabilities in GIS for fire modeling and analysis. Recent work in fire modeling and GIS includes evaluations of differing fuels treatment prescriptions and their impact on fire growth and behavior in order to help design and understand future fire treatments (Finney, 2000).

Project Name/ Scope	Purpose	Deliverables	Data Deliverables	Computer Models	Challenges
LANDFIRE National	• Provide geospatial data and predictive models for characterizing vegetation conditions, fuel conditions, fire regimes, fire hazard and risk across landscape. • Implementation of the National Fire Plan. • Develop a consistent, accurate, and replicable methodology for information extraction from satellite imagery. • Develop fuels layers needed for real-time wildfire firefighting. • To provide communities the data for fire management planning.	• Rapid Assessment • Reference Database • Scientific Publications • Interactive Web Site • Tools for Scaling • Models and Methodology • Technology Transfer	Historic Natural Fire Regimes Fire Regimes Condition Classes Biophysical Settings Potential Vegetation Types Current Vegetation Types FARSITE Data Layers Fire Potential Ecosystem Status Structural Stages Cover Types Fire Hazard & Potential Canopy Height and Density	Biogeochemical model (LF-BGC) Fire potential model (FIREHARM) Landscape Simulations (LANDSUM) Climate and Weather (Daymet)	Funding State involvement Science Driven Integration with Local Level Projects Uncertain Concern with Regional Applicability of Models Contracting and Cooperative Agreements Project Management
SOUTHERN FIRE RISK ASSSESSMENT ***Southern Group of State Foresters (FL, GA, LA, TX, VA, SC, NC, AR, TN, KY, MS, AL, OK)***	• Identify the potential for severe fires and high losses within the region. • Identify areas where detailed inter-agency planning may be necessary. • Provide a model for fine scale analysis. • Prioritize for tactical analyses or treatment. • Graphical display of fire concerns within the region to support fire management funding. • Communicate wildland fire management concerns to the public.	• Reports on Fire in the South • Risk Map • Dispatch Tool • Crosswalk for Fuels Methodology • Change Detection Methodology • Technology Transfer	Levels of Concern Fire Hazard Values at Risk Wildland Fire Susceptibility Index Fire Occurrence Area	Using Flammap for Fire Behavior	Funding for Additional Phases Data Availability Age of Data for Fuels Crosswalk Integration with LANDFIRE and Florida Fire Risk Assessment Life of GIS Platform
FL FIRE RISK ASSESSMENT SYSTEM Florida	• Define Risk Areas • Interagency Planning Needs • A Model for Local Level Analysis • Prioritization for Treatment • Assist in Fire Management Funding • Public Communication tool: “ARE YOU LIVING IN THE RED?”	• ARCVIEW Extension • Published Results Data • Accuracy Assessment of Fuels • Change Detection Methodology • Technology Transfer	Wildland Fire Susceptibility Index Urban Interface/Intermix Levels of Concern Fuels (Anderson’s Standard 13) FARSITE Data Layers Fire Occurrence Areas	Using Flammap for Fire Behavior	Funding for Fuels Update Integration with LANDFIRE and Southern Risk Assessment GIS and Fuels Maintenance and Data Updating Training of Field and Support Staff Refinement of Change Detection Methodology Life of GIS Platform

Figure 3-17. Comparison of LANDFIRE, Southern Fire Risk Assessment, and Florida Fire Risk Assessment System

Fire effects are also a key element to be modeled and understood, and is increasingly done with GI/GIT. In addition to damage on the ground, concerns are growing about other fire impacts, such as on air quality. Managing and predicting smoke for prescribed burns can help fire management organizations minimize public health and safety effects, and comply with air quality regulations. As a result, many trajectory and plume dispersion prediction models are being investigated for application in fire management (Hanson et.al., 2000).

Structure ignition modeling is important to the growing concerns of development and planning in interface areas. The Structure Ignition Assessment Model (SIAM) was developed to examine the interaction between wildfire effects and structures (Cohen, 2000). While this model was designed for calculating these physical interactions, Boulder County planning and WHIMS fire staff proposed the possibility of introducing and combining geospatial data with the SIAM model (Johnson, 2003).

3.4 GENERAL LIMITATIONS, NEEDS AND PRIORITIES FOR MITIGATION, PLANNING AND PREPAREDNESS

Compared to the other phases of wildland fire management discussed in subsequent chapters, the general limitations, needs and priorities for mitigation, planning and preparedness have had less attention in general, and concerning GI/GIT. Overall fire needs and opportunities regarding mitigation, planning and preparedness are continuing to be discovered and developed. The wide range of issues, stakeholders and existing and potential applications in mitigation, planning and preparedness mean that identification and understanding of GI/GIT limitations, needs and priorities is likely more complex for this phase compared to the others.

3.4.1 GI/GIT Impediments Concerning Mitigation, Planning and Preparedness

Despite growing usage of GI/GIT for mitigation, planning and preparedness, several limitations exist. For example, some problems include resolution capabilities, accuracy, currency, limited resources to obtain data and imagery, limited documented findings pertaining to structure loss and ignitability, availability of wildland-urban interface (WUI) fire effects models, gaps in data, user capabilities, and changing priorities and funding. Moerover, fire behavior and other models have yet to be designed for structures in the interface, and thus may not fully depict current hazard conditions. Referring to overall limitations concerning hazard and risk assessments, Klaus Jacob (2000, p.1-2) states

> *Not all hazard-generating processes are independent of time or human influence. Even if hazards did not vary with time, the associated risks would inevitably increase since populations and hazard-exposed assets increase with time. … Quantitative probabilistic hazard assessment is generally based on the record of past hazardous events and used to account for present and near-future hazards. However, the catalog of hazardous events is not always the only input to the assessment. Sometimes, generalized models based on the historic record that account for the physical processes in the region are used. To be maximally*

effective, the latest scientific knowledge must be applied when estimating future hazards and risks.

Understanding of user needs, and correlation of these needs with available data and technology, has proven to be very challenging for mitigation, and particularly compared to other phases of wildland fire or other emergency management. Understanding the growing number of stakeholders and potential impacts of such events is increasing complex, particularly as more and more entities have their own data and GIT capabilities. In addition, private ownership of model and software development may yield new advancements with GI/GIT, but may also limit the ability of communities and agencies to have access without substantial financial resources.

Several policy and institutional issues concerning the adoption of these resources, and moreover, implementing the results derived from their use, continues to challenge governments at all levels. A key and growing issue is the plethora of risk assessments now underway at various local, state and federal levels as discussed above. The inputs and outputs of these assessments can differ, resulting in misinterpretation and misunderstandings by the public and/or decision makers. Such differences should be acknowledged and addressed through coordinated and reconciled approaches, particularly when differing assessments cover similar locations on the ground.

For example, Nick Morgan, a senior planner from Jefferson County, Colorado described this situation in his paper at the 2002 Colorado American Planning Association conference, entitled “Lessons learned from recent Colorado wildfires - What wildfire mitigation tools are working and what are not?” He pointed out that site specific planning could be done based on a detailed analysis of wildfire hazard maps, but there are problems in relating wildfire hazard mapping to others’ efforts. He said that Jefferson County has a wildfire hazard overlay zone and strict regulations apply within it, but the zone does not match the hazard areas identified by the Colorado State Forest Service. Moreover, this problem is compounded when the state produces maps showing a five-mile buffer area. While these problems do occur, the value of hazard mapping is still viewed as beneficial mitigation tool. The paper includes the findings of a survey that was circulated to all 64 Colorado counties in August 2002, which included the following question about useful mitigation tools (Morgan, 2002):

> *Wildfire mitigation planning includes interrelated issues such as hazard mapping, access, vegetation management, water supply and building materials. What specific mitigation tools relative to these issues do you encourage, require or plan to introduce?*

With 20 respondents, the leading responses to this question, in sequential order, were:

1. *Wildfire hazard mapping*
2. *Requiring thinning at time of platting*
3. *Requiring that access is to County road standards*
4. *Use of the Wildland Urban Interface Code*

Research also can have important implications for appropriately conducting hazard assessments and risk mapping. U.S. Forest Service fire researcher Jack Cohen (2000) offers findings that may differ from the direction of many wildfire hazard mapping approaches. Cohen's conclusion is that because home ignitions depend on home ignitability, the behavior of wildland fires beyond the home or community site does not necessarily correspond to the potential for WUI fire losses. Highly ignitable homes can be destroyed during lower intensity wildfires, whereas homes with low home ignitability can survive high intensity wildfires.

Cohen's conclusion has implications in order to reliably identify and map the potential home destruction during wildland fires. The term "wildland urban interface" suggests that residential fire destruction occurs according to a geographical location. However, Cohen (2002) believes this misrepresents the physical nature of the wildland fire threat to homes. The wildland fire threat to homes is not where it happens related to wildlands, but how it happens related to home ignitability. Therefore, to reliably map the potential for WUI home fire loss, home ignitability must be a principal mapping characteristic. The information related to potential home destruction must correspond to the home ignitability spatial scale. That is, the information must relate to those characteristics of the home and its immediate site within a few tens of meters.

Figures 3-18 and 3-19 illustrate the requirements needed for truer representation of the threat to homes (Cohen, 2003). Figure 3-20 shows the impact of home ignitability as some structures burned and while others nearby did not as a result of the Cerro Grande Fire in New Mexico. These results reveal the need to incorporate additional factors and information in models to increase the validity and usability of their outputs.

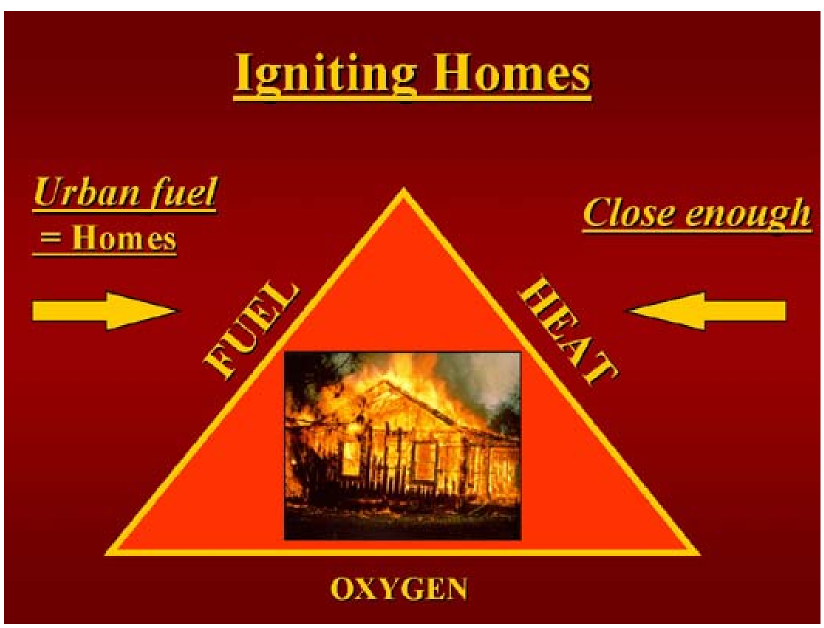

Figure 3-18. The "Fire Triangle"

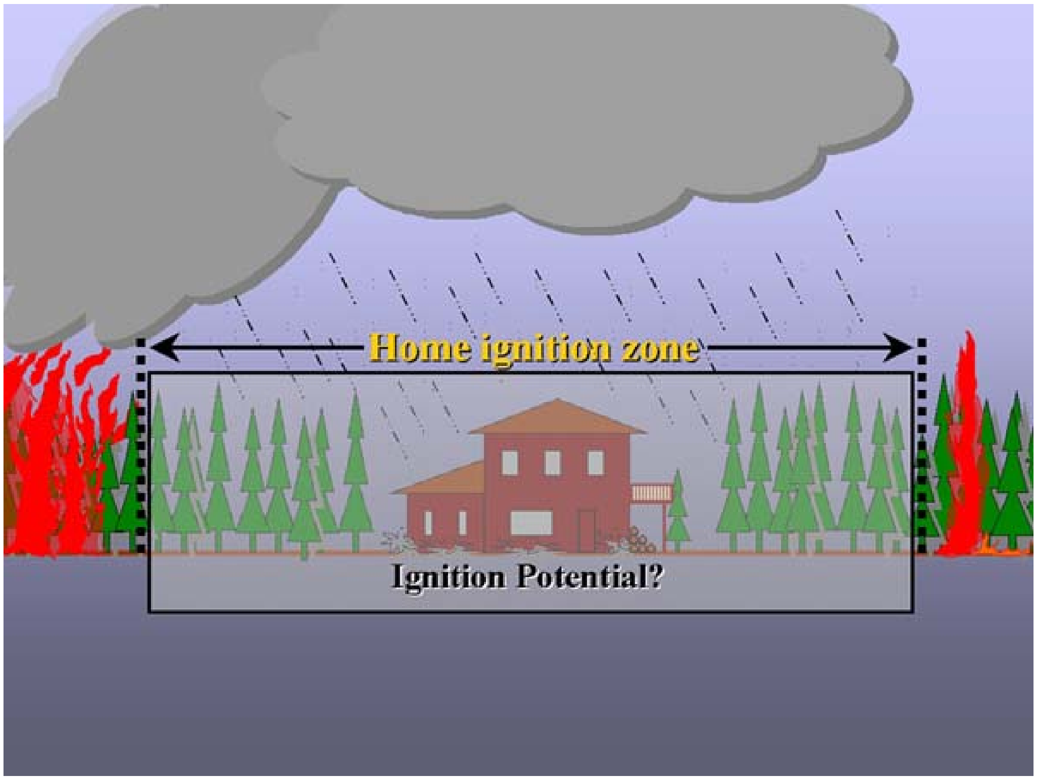

Figure 3-19. The Home Ignition Zone

Figure 3-20. Burned Homes in Los Alamos, New Mexico from Cerro Grande Fire, 2000

Data limitations are an important impediment to the full use of GIT for mitigation, planning and preparedness. As described in this chapter, information about vegetation and fuels conditions is a particularly critical input to various decision making models to understand potential fire behavior as well as to conduct hazard and risk assessments. However, many parts of the country, including those with critical interface areas, lack sufficient vegetation and fuels data, though some examples of current programs to address this need are included in this chapter.

3.4.2 Mitigation, Planning and Preparedness Needs in the User Community

Several efforts are needed to enhance the use and effectiveness of GI/GIT for mitigation, planning and preparedness, such as:

- Efforts and actions to increase the capability of organizations and individuals responsible for wildland fire management to aid in response and to reduce damage from wildfire
- Policy and strategic planning
- Improved communications between all agencies and jurisdictions
- Hazards (fuels) treatment efforts such as prescribed burns
- Wildland fire danger rating, prediction, probability, potential behavior and effects and potential cost estimations, but also for real-time use prior to and after an ignition of one or more wildfires.
- Resource readiness (equipment, information technology and communications systems, etc.)
- Training, exercises and simulations for wildland fire - including wildfire disaster simulation exercises for planners, responders and others
- Safety efforts to improve the ability of response organizations and personnel to manage wildland fire incidents in a safer manner
- Land use tools and design concepts that address structure losses in catastrophic wildland fire disasters supported by quantifiable and accepted research findings
- Fuel type mapping, aerial photos and imagery for wildland-urban interface areas (both public and private lands)
- Fire behavior models for wildland-urban interface scenarios

Overall, data and information readiness is needed in various time frames. In the short term, data are needed for weather, meteorological and atmospheric monitoring and modeling (e.g., data on wind velocity and direction, relative humidity, temperature, precipitation, lightning, etc), as well as data about existing natural, physical and human resources conditions and characteristics as described above. Such information is required as direct input to understand wildland fire probability, potential behavior and effects as needed for fire danger ratings and potential cost estimations, but also for real time use prior to and after an ignition of one or more wildfires.

At the Sixth [Natural Hazards] Roundtable Forum sponsored by the National Academies in Washington D.C. (2002), the topic of “Alerting America: Effective Risk Communication” was discussed. The intent of the forum was to provide a broad view on risk communication, facilitate understanding across relevant disciplines and professions and offer a basis for future risk communication action and research. One of the presenters at the 2001 Roundtable, David Cleaves, then National Program Leader for Fire Systems Research at the U.S. Forest Service (Cleaves, 2001), explained that

> *National leadership in science can better describe the national WUI problem and how its intersects with large scale processes such as global climate change; encourage integration of knowledge about natural and technological hazards; develop and advocate a national vision and agenda for hazards research; mobilize the science community to use natural disasters as "knowledge creation" opportunities; and develop a common, results-oriented model for planning research, development, and application in wildland fire and other natural hazards.*

Cleaves' summarized the research needs specific to wildland fire hazards with key questions on the problem extent; management of fire events in the interface; social, political, and institutional dimensions; hazard behavior, exposure modification, and prediction and warning systems (Cleaves, 2001).

Beyond these matters specific to fire, more research about hazards, vulnerability, and risk assessments is needed, along with a multi-hazards approach that incorporates consideration of additional factors than are traditionally included. While new assessment technologies have been developed over the past decade and some of these systems are widely used, it is largely unknown if and how they are affecting landscape or community-wide planning, or planning for specific development projects. This information can be essential in justifying sustainable land use choices to local officials and to aggrieved landowners, particularly if challenges are brought to court (Burby, 2002).

Concern is growing nationally and worldwide about the need to reduce disaster vulnerability as the impact and cost of wildland fires and other events continue to grow. The Subcommittee on Disaster Reduction (SDR) of the National Science and Technology Council's Committee on the Environment and Natural Resources recently completed an interim report which found that the economic impact of disasters in the United States is conservatively estimated to be at least $20 billion annually in terms of loss of life and property, disruption of commerce, and response and recovery costs (SDR, 2003). SDR concluded that focused effort is needed to develop a national science and technology framework including (1) integrated observations through "a comprehensive, integrated, global earth-observation system", (2) hazard mitigation science and technology, (3) risk assessment, and (4) risk communication (Ibid., p. 4). Subsequent findings and conclusions are planned based on further analysis of conditions, issues and needs.

3.4.3 Priorities for Mitigation, Planning and Preparedness Technologies and Programs

As discussed above, the determination of data development needs and priorities for this phase of fire management is difficult, and has resulted in the identification of numerous needs. Perhaps first is the need to address the data limitations described above. The need for vegetation and fuel mapping is increasingly recognized, but focused attention and action is needed to ensure such data are current and sufficiently precise as needed at multiple scales to serve as input to various models and assessments. Other needs include foundational geospatial data in terms of vector data and imagery for wildland urban interface areas (both public and private lands), fire behavior models for scenarios in these interface areas, and qualitative studies with quantifiable research results on and models to address the interaction between structures and fire (i.e., what results in structure loss). The need for scalable, temporal, synchronized and integrated data that can used for multiple applications continues to grow as demands for accurate and current data increase at local, state, regional and nationwide levels.

In addition to these and other data needs, many of the resources and capabilities needed to use such data and run fire models, such as technology and expertise, also are not available to federal field managers, much less state and local governments. Many entities are conducting hazard and risk assessments, but may lack necessary expertise to ensure reliable and useful results. Lack of capabilities extends to other uses as well. For example, insufficient capabilities, combined with insufficient policy and management level attention, mean that the use of even the same models may produce different results. This is particularly problematic when crossing the boundary from one land management unit to another and for lands with different ownerships because common approaches and standards for interpreting and applying data often do not exist in addition to data, technology and expertise limitations.

While these conditions and needs continue to be a major deterrent to full use of GI/GIT at this time, several innovative organizations are making effective use of these resources and tools as described in this report. A key priority in order for GI/GIT to be utilized more consistently and effectively for widespread mitigation, planning and preparedness is for wildland fire leaders to ensure that the results and impacts of existing approaches and lessons learned are communicated to the broad community. Multiple jurisdictions need to clearly understand the consequences of their land development policies and decisions in terms of fire risk and potential for catastrophic fires and serious damage.

Specific federal and state government action is needed to increase local government awareness and capacity to mitigate, plan and prepare for wildland fire. Despite the innovative local government examples provided in this report and elsewhere, most localities do not have sufficient access to necessary data, technology, expertise or other resources to understand, much less mitigate, or otherwise address their wildland fire needs. John Steffenson, Federal Land and Resources Manager at ESRI (2003), suggests that technical capacity must be strengthened in local governments with WUI areas. He points out that community members in the Seeley and Swan Lakes area of western Montana thought that when they received federal grant money, that federal and state agencies would provide a “road map”, data, and suggestions. Instead they felt they had to “figure it out” themselves. Steffenson believes that much could be done to facilitate this process, particularly since many of the communities most at risk are small and rural, with minimal, if any, technical capability.

Steffenson proposes that planning and collaboration among various members of the federal wildland fire community could result in a technical assistance grant program to substantially reduce the time and effort needed by some of these local communities to bridge this “learning curve” and facilitate the implementation of fuels and other mitigation projects that bring real benefits and enhanced risk profiles. He suggests that community technical assistance grants could be “a flexible mixture of technical assistance, data and technology designed to assist local communities in leveraging federal and state data, applications and technical assistance resources for the purpose of developing local plans implementing projects on the ground” (Steffenson, 2003). Given that the nation’s state forestry organizations have been recently charged with determining “communities at risk”, but some of them also have limited technical capacity, a similar program is likely needed for them to ensure that available data, technology, expertise and other resources are utilized to most accurately understand and address growing wildland fire issues and needs. Such grants could also encourage collaboration and sharing of data with other agencies within such local and state governments to maximize use of existing data and technology investments and minimize long term data maintenance requirements and costs.

Experience shows that GI/GIT is and can make a key difference to ensure that government decision makers and the public are aware of the potential risk of wildland fire and the potential future impacts of land development. It also has and can be used more fully to help encourage wise land use policy and site decisions. However, GI/GIT use is essentially in its infancy in this regard. With integrated leadership approaches and effective institutionalization at local, state and federal levels, GI/GIT can make a significant difference in the future to address and mitigate overall - and increasing - growth management and wildland fire mitigation, planning and preparedness challenges in the United States and beyond.

4.0 DETECTION

This chapter includes an identification of some of the basic user needs for GI/GIT in wildland fire detection, how they are being currently used, and what is needed. It also presents numerous detection methods, particularly those affiliated with the use of remote sensing and other GIT, that have been shown to be of value to the wildland fire management community both in the past and in the present.

4.1 INTRODUCTION

Detection of wildland fires is a crucial component of fire management. Many methods are currently used in this regard, ranging from reports by nearby citizens, to fire tower lookouts, to sophisticated remote sensing approaches. Citizen reporting is the leading way that most fires are detected and reported today. Dedicated telephone numbers for fire reporting are advertised to the public. These calls are generally received by state fire management organizations in the eastern United States, and by area or zone interagency or single agency dispatch centers in the western states. Local emergency management organizations, increasingly with 911 and E911 capabilities, also often receive fire calls, as do local fire departments.

While most fires are reported by citizens, the detection of wildland fires that are not adjacent to an area frequented or visible by people is one of the large challenges in wildland fire management. These fires can be the ones that become large and catastrophic, thus causing the most damage to life and property. Without detection methods in place in remote areas, awareness of ignition and spreading fire may come too late for effective containment and suppression. As discussed below, fire lookout towers have traditionally been the most commonly used tools to allow fire management personnel to detect fires over a large area, but modern tools also hold promise as lower-cost alternatives.

4.2 IDENTIFICATION OF USER REQUIREMENTS FOR DETECTION

There is consensus among the fire management community that rapid detection of fires after ignition is needed in order to best manage fire. This will particularly help to determine appropriate initial attack and suppression plans, approaches and resource deployment to minimize loss of life and property. There are mixed reviews about how effective current detection approaches are in the U.S. At the same time, the initial premise of the policy of immediate suppression has been evaluated and has shifted. Until recently, the primary approach to fire management has been to emphasize and conduct strong initial attack and suppression. Early detection is a critical and leading need when immediate and strong suppression is the definitive policy direction.

However, as described in Chapters 1 and 2, federal direction, policy and practice has shifted to let many fires burn if they do not threaten life or property. This change has essentially served to reduce the need for detection of fires. Federal land management units have increasingly been directed to adopt fire management plans, which increasingly include provisions for allowing fires to burn if in low risk areas. While it is important to know the location of fires, there is less need for detection of fires in designated Wilderness and other remote areas if there are no nearby risks. While allowing naturally caused fires to burn is the adopted policy in these areas, even some human-caused fires are being allowed to burn.

The emphasis on and adoption of policy endorsing fire use for ecological reasons is growing, with federal agencies also igniting their own fires with fuels treatment such as prescribed burns. Except in areas where fire is in high-risk areas, potentially influencing life and property, this shift in federal policy is reducing somewhat the perceived need for fire detection. At the same time, there is a growing need for fire monitoring for overall fire management purposes during fire season and the other phases of fire management as discussed in this report. Even with this federal government de-emphasis on suppression, it is important to detect and monitor new fires in order to manage and allocate fire suppression resources. In addition, growing land use development near vegetated areas markedly increases fire risk and potential harm, in turn strengthens demand for better and more rapid-fire detection approaches.

The relative importance and requirements for fire detection also varies by fire management organization, stakeholders and location. While there has been less emphasis on suppression at the federal level in recent years, in part causing less interest in detection, other organizations have strong needs for detection of wildland fires. Overall, state governments have a much stronger emphasis on conducting effective initial attack and suppression, which clearly can be aided by early detection of fires. While federal agencies primarily address fire management as part of their land management responsibilities, state governments often manage their public lands for differing purposes than the federal government and they also have responsibility for wildland fire on private lands. Many state lands, particularly in the west and the south, are often managed to generate revenues to support critical government functions such as K-12 education. In these cases, fire is perceived as destroying valuable timber resources, so there is a stronger emphasis on fire suppression to save these resources. There is a strong interest in suppressing a fire before it gets out of control. Most private landowners that manage their lands for revenue purposes from forestry operations have a similar view and perspective. Since states are generally responsible for protecting state and private lands, they emphasize initial attack and suppression of fires more than federal landowners. Local fire departments, typically the first responder at a fire, similarly express the need for immediate and strong suppression.

Consequently, while federal agency representatives have expressed mixed needs for better detection, state and local fire organizations have supported firm policies of immediate suppression and expressed strong need for more effective detection approaches. Many fires are never reported, and most of those that become known are reported by the public. Texas State Forester Jim Hull, who served as recent chair of the National Association of State Foresters (NASF) Fire Committee, estimates that "much less than half the wildfires in most states are reported to anyone" and that "reporting of rural wildfires is archaic at best" (Hull, 2000, p. 2). State fire organizations also have become aware of and expressed support for technological advances to improve detection. For example, a few years ago, in response to learning about the potential of the Hazard Support System (HSS) as discussed below, Hull stated that "much of the nation has very limited early wildfire detection capability", and "real time detection and reporting of wildfires by satellite was the greatest breakthrough in rural fire protection in the last 50 years" (Hull, 2000). Hull represents the perspective of many state foresters and fire managers, particularly given his role as past chair of the NASF Fire Committee.

Regardless of this relative importance of detection compared to other aspects of fire management and related needs, some investigations have been conducted to date to determine specific user needs regarding wildland fire. Early detection has been a particular need and focus of some of this work. The requirements for fire detection need to be defined by users to help the research and business communities understand what will best suit the needs for detecting wildland fires and improve existing tools. Key factors and requirements for fire detection tools include the method of alarm delivery, the time of alarm delivery, minimum detectable fire size, false alarm rates, risk to personnel, and relative costs of detection methods.

The Committee on Earth Observation Satellites (CEOS) sponsored such an investigation which determined that needed information includes location within 1 km, detection of fires of 0.25 acres in size, fire intensity (amount of energy released), and the integration of these data with meteorology, topography, fuels and other data. This effort found that fires must be detected within 5 minutes with a spatial resolution of 250 meters, and no greater than a 5% false alarm rate.

The user requirements study conducted for the FUEGO system, as described below, determined that detection must be within 15 minutes for a minimum size of 50 square meters, must have an accuracy of 300 to 500 meters, and must have no greater than a 10% false alarm rate. Additional work is needed to understand the user community needs. This can be accomplished through proceedings from fire management workshops, interviews with fire managers, evaluation of tools and data that are currently used, and research on what has been done in the past.

The Rochester Institute for Technology (RIT) recently determined detection requirements for a Wildfire Detection and Monitoring System (WDMS) (McKeown, 2002) based on information from several sources, as shown in Figure 4-1.

Case	**Description**	**Fire Size**	**Fire Temperature**	**Probability of Detection**	**Probability of False Alarms**	**Time to User**
Nominal (required)	Open flame visible to the sensor	1 meter circular	1000K	0.95	0.05	6 to 12 hours
Goal	Smoldering ground cover or limbs	0.25 meter circular	600K	0.98	0.02	<1 hour

Figure 4-1. Summary of Fire Monitoring Requirements

4.3 WILDLAND FIRE DETECTION TOOLS

Many tools have been and are currently used by the wildland fire community to help detect and monitor wildland fires. These tools range from very manual approaches to highly sophisticated methods, and a combination of approaches is commonly used.

4.3.1 Fire Lookouts

Fire lookouts are an important part of the mix of wildland fire detection and response tools. While being phased out in some parts of the country, approximately 500 fire lookout towers continue to be operational today. In addition to being located in these towers, fire lookouts are important individuals and have an essential function within fire fighting operations in any wildland fire incident.

A lookout is able to observe and record the locations of actual fires and lightning strikes, as well as receive lightning strike data from offices with Internet access to products such as Lightning Explorer™ described below. While aircraft overflights and satellite passes are important tools, particularly after a lightning storm, the constant presence of a lookout provides potentially more rapid detection of and response to new wildfires.

Lookouts are often required to be familiar with and provide information about nearby natural features and barriers, surrounding topography, weather, smoke color and direction, and essential information about fire. Lookouts may provide critical fire behavior observations, as well as information about safety zones, firelines, anchor points and escape routes. Lookouts also provide continual visual information on a fire's behavior, as long as meteorological conditions such as inversions or storms do not block their view.

Lookouts have critical communications roles, both in detection and during fire response. They may be required to relay information between dispatch and fire crews in remote areas, because standard issue communications devices may be blinded electronically by terrain. In this case, lookouts may be required to transmit critical information about air support, adjoining crews, or other resources. The prominent position of most lookouts provides most lookouts with the line of sight necessary to augment radio communications with cellular telephone communications.

Under some weather conditions, such as high winds, essential aircraft may be grounded because conditions are too unsafe for them to fly. In these cases, lookouts can be even more important to observe conditions and gather data for fire behavior specialists and incident commanders.

4.3.2 Automated Lightning Detection

4.3.2.1 Federal Aviation Administration's ALDARS

The Federal Aviation Administration (FAA) has been developing the Automated Lightning Detection and Reporting System (ALDARS) since the late 1990s. The purpose of the ALDARS project was to eliminate the observation of lightning at airports by collecting, processing and distributing National Lightning Detection Network data to Automated Weather Observing Systems (AWOS). Since 1998, the ALDARS has been enabled for use with FAA Automated Data Acquisition Systems (ADAS) (FAA, 2003). It is now operational at all Automated Surface Observing System (ASOS) sites and numerous AWOS sites. (http://www2.faa.gov/asos/newdevel.htm)

A few years ago, the National Weather Service (NWS) Forecast Office investigated the ALDARS and provided a document describing their findings (NWS, 2003). According to this report,

> *The contractor Global Atmospheric, Inc. is responsible for operating 106 lightning detection sensors across the U.S. These sensors make up the National Lightning Detection Network (NLDN). By triangulation and computing different times of arrival of lightning strikes, they are able to accurately locate cloud-to-ground lightning strikes to an accuracy of 1/4 of a mile. While the sensors detect cloud-to-cloud flashes they are unable to accurately locate them. Cloud-to-cloud strikes are not reported. The NLDN detects 80 to 90% of all cloud-to-ground lightning strokes. The lightning data are transmitted via satellite communications on a near continuous basis to each Air Route Traffic Control Center (ARTCC). The Level 0 lightning data is then processed by the ALDARS software. The software strips out all strikes that don't occur in the ARTCC's area of responsibility. The software then compares the latitude and longitude of all strikes with the latitude and longitude of all ASOS and AWOS in its area of responsibility. If the ALDARS software detects lightning within 5 NM of an ASOS or AWOS, it sends a lightning information message to the ASOS via the AWOS Data Acquisition System (ADAS). This message informs the ASOS there is a thunderstorm within 5 NM (TS). If the lightning strike was beyond 5 miles but within 10 NM of the airport reference point, the message would be VCTS. These phenomena are carried in the body of the METAR/SPECI. Lightning between 10 and 30 miles of a site would be reported with direction in remarks. This information would be incorporated into the remarks of the METAR and SPECI reports. The ADAS updates the lightning information for each ASOS once a minute.*

The report also indicated that NWS may shift several of their ASOS sensor sites to ADAS and ALDARS communication lines, but long-term plans are undetermined.

4.3.2.2 LightningStorm.com

Commercialization of ALDARS-based technology was initially begun by the company, Global Atmospherics, Inc., which also maintained the ALDARS sites. The spin-off company, now owned by Vaisala, Inc., and called Vaisala Thunderstorm, provides a host of products for fire prevention and many other industries and services. Several products and services are available for the fire community. These products range from online lightning notification, real-time lightning and tracking data, tracking software, verification reports, and analytical services. In addition, alerts can be given via email, Internet or pager, and archive data can be acquired through an online service.

The system works by using lightning information from the NLDN and ALDOS configuration for the continental United States. NLDN is constantly detecting lightning discharges to the ground, and these discharges are recorded at the Network Control Center for the NLDN, which then sends the discharge information to a relational database at Vaisala Thunderstorm. The data can then be displayed through a subscription-based visualization utility called Lightning Explorer©.

Lightning Explorer© prepares a new lightning activity map every 30 minutes (Vaisala Thunderstorm, 2003) which is based on the previous 2 hours of activity. There are related visualization and analysis tools available on a subscription-basis, including Lightning Observer© and Lightning Advisor©, which offer more enhanced capabilities than Lightning Explorer©.

The notification services, which also are subscription based, are known as Lightning Watch©, Lightning Warning© and Lightning Alarm©. Through these services, alarm notices are sent out, or the user can visit the website to see where lightning has struck. An analysis service knows as Strikenet© is also available. Full descriptions of these products can be obtained at http://www.lightningstorm.com/tux/jsp/login/index.jsp.

Several federal and state agencies have contracted with this company and made use of these products since the mid 1990s. Three federal agencies have these contracts, including the BLM, BIA and the Forest Service. However, access to these data has posed problems, for example at interagency offices. A growing number of dispatch offices throughout the nation are interagency, with employees of multiple agencies working together. According to their contracts, each of these agencies within the office that intend on using the NLDN data for operations must have their own site license. The users cannot share these data even if they work next to each other in the same office. State agencies also are not allowed to participate in the federal lightning contracts. Some entities, such as the Oregon Department of Forestry, have established their own independent contracts to receive these data. The company has been strict in this interpretation of their contracts in terms of data sharing. However, recent advances are being made in related technologies. Other companies entering the lightning detection market could be used in the near future (Sielaff, 2001).

4.3.3 Airborne Infrared Detection

There are several sources of fire detection data derived from aerial observations. These data resources are in increasing demand. They are generated from sensors or video instruments that are flown on helicopters or airplanes and relayed to the wildland firefighter and fire management teams.

Airborne infrared detection units have been used by the U.S. Forest Service since 1966. Its National Infrared Operations Group is located at the National Interagency Fire Center (NIFC) in Boise. The primary function of this group is to conduct infrared detection and mapping missions over wildland fires in the contiguous United States, Alaska, Canada and Mexico. It provides multi-agency support for all five federal land management agencies as well as state and local governments. Two aircraft are available to provide infrared data collection.

The infrared scanners used today can detect hot spots at least 600 degrees Fahrenheit, as small as 6 inches in diameter, and can cover almost one million acres in an hour, depending on the flight height. Data are usually gathered at night, when the temperature difference between terrain and fire is greatest, and provided to infrared interpreters after the aircraft has landed. Data also have been dropped to the ground through a drop tube in the aircraft, but new advancements are moving towards digital data delivery. The interpreters then take the data and superimpose it onto topographic and other maps. In 1998, costs per flight ran between $5,000 and $10,000. During the fire season, infrared interpreters work through the night to produce resulting fire maps for the morning fire briefings that are held each day. Investigations and tests are underway to use line-of-sight data links and commercial satellite services to improve digital data telemetry capability and speed data transmission, as well as test these instruments on unmanned aerial vehicles (Ambrosia et.al., 2003).

Demand for these data resources is growing as evidenced in the 2002 fire season. A total of 778 missions were scheduled at the national or regional level, but of these, 175 were Unable to Fill (UTF) due to the following reported reasons:

1. Weather (12 missions),
2. No infrared interpreter available (12 missions),
3. No flight time available (34 missions),
4. Infrared equipment problems (19 missions)
5. Low priority (39 missions)
6. No reason notes (34 missions)
7. Aircraft maintenance (9 missions)
8. Pilot trade out (2 missions)
9. Aircraft mechanical down (13 missions)
10. FBO no service (1 mission)

Some of these UTFs can be placed in multiple categories. Hence, an accomplishment rate of 82-85% was reported for all requests submitted. The total time flown by both aircraft used in infrared missions was 1400 hours, all of which occurred safely and without any problems (Van Buren, 2002).

Infrared imagery is often used in combination with other products, such as digital orthophotography. Digital Raster Graphics and Single Edition Quads also are very valuable, as they show other topologic features such as elevation and land surface features (Malcolm, 2003). Additional digital data layers also are available through USGS and others to complement the imagery.

Summaries of the airborne infrared systems being used today are described below.

4.3.3.1 Fire Logistics Airborne Mapping Equipment (FLAME)

The FLAME system was developed in the late 1980s by NASA's Jet Propulsion Laboratory, and is still used to detect hot spots at least 8 inches in diameter and 600 degrees Fahrenheit. The output products are in Continuous Strip Imagery and can be delivered on VHS tape. The FLAME system gathers data in two bands; a 3-5 micrometer (i.e., middle infrared) wavelength band and an 8-14 micrometer (i.e., thermal infrared) wavelength band (NIFC, 2001). FLAME is now only planned for use as a backup system to the Daedalus system described below.

Total Field of View	Ground Coverage	Detectability	Fire Location Method	Aerial Platform
120°	6.5 Statute Miles at 10,000 Ft AGL	8 inch 600°F Hot Spot @ 14,000 Ft AGL	Target Discrimination Marks (TDM) & Super Pixel	King Air B200 King Air B90 Citation Jet Lear 35/36 (with modifications)

Figure 4-2. The FLAME System Characteristics

4.3.3.2 Phoenix

The Phoenix system can be described as an upgrade to the FLAME system because it is more compatible with industry-standard hardware and has greater geometric accuracy. Phoenix uses the same scan head as that of the FLAME system. The output is more advanced than that of the FLAME, as it contains more information pertaining to the geometry of the data, which may be sufficient for second and third order geometric correction. Relative fire temperature levels are also stored in the data, which will allow it to be used for further scientific study and applications (NIFC, 2001).

The Phoenix system produces data in both hard copy and digital format. Digital data is in GeoTIFF form, but the potential for an additional JPEG 2000 compression format is currently being considered (Greenfield, 2003). In the summer of 2003, one Phoenix system was damaged. The Daedalus system has been used to fill in for both Phoenix systems while the damaged unit is repaired (Van Buren, 2003).

Total Field of View	Ground Coverage	Detectability	Fire Location Method	Aerial Platform
120°	6.5 Statute Miles at 10,000 Ft AGL	8 inch 600°F Hot Spot @ 14,000 Ft AGL	Edge marks and Pixel Enhancement. Geo-referenced .tiff files.	Citation Bravo Jet King Air B200 King Air B90

Figure 4-3. The Phoenix System Characteristics

4.3.3.3 Daedalus

The Daedalus Aerial BiSpectral System (ABS3500) was built by private companies and is still maintained by them. The National Infrared Operations Group currently has two of these systems. Thermal data is collected and output in both hardcopy and digital formats. The sensor can detect an 8-inch, 300 degree Fahrenheit hot spot when flown at 14,000 above the ground (NIFC, 2001). As mentioned earlier, the Daedalus is used to fill in for the Phoenix system when it is not available.

Total Field of View	Ground Coverage	Detectability	Fire Location Method	Aerial Platform
86°	3.5 Statute Miles at 10,000 Ft AGL	8inch »300°F Hot Spot @ 14,000 Ft AGL	Fire Pixel Enhancement	King Air B200 Citation Jet Lear 35/36

Figure 4-4. The Daedalus System Characteristics

4.3.3.4 Other Systems

During fire seasons, these products can be supplemented by classified assets provided by the Department of Defense (Smith, 2001). These resources consist of "derived products" because the original source imagery is not legally available to the civilian community. Arrangements have been made through the Civil Applications Committee (CAC) of the federal government for these products to be available specifically for wildfire. During the 2000 fire season, the worst on record, the classified data stream was held open for these products for 45 days in a row (Dull, 2001). This is the longest and most extensive use of these products for a civilian use at any time until then. However, a concern expressed is that no integration of infrared data resources with these classified products occurs, and while there is a growing array of data products available, there is insufficient integration as needed for many fire management purposes. This is a particularly important need for detection and response given that time is critical in these phases.

In addition, the private sector is developing airborne systems that are being tested by the government to augment the above in-house approaches. For example, one company, Airborne Data Systems, tested integration of various technologies for the Forest Service using its system known as Spectra-View©. Multi-spectral imagery was produced with three-meter accuracy from five cameras located on a plane. In the field test, the individual scenes were processed in less than a minute and joined together to produce maps of a given area. Image processing software was used for additional post processing. Plans are to use new downlinking advances to allow the images to be transmitted to fire managers from the plane in order that it can be merged with other data resources. Complemented with GPS receivers, these real time data can be used to help define fire response plans (Fuhr, 2001).

4.3.4 Current Satellite Sources for Fire Detection

Reviews of satellite sensors and related algorithms that can be used in wildland fire detection, monitoring, and post-fire assessment have been documented in several sources. For example, a report completed in 2001 for RIT's FIRES project, entitled *Satellites, Sensors and Current Algorithms Used for Satellite-Based Fire Management,* includes a review of these sensors (Institute for the Application of Geospatial Technology, 2001). Figure 4-5 replicates a table from this report which indicates satellites and sensors used for wildland fire management, including detection and other applications.

Satellite/Sensor	Detection	Monitoring	Post-fire Assessment	Band Type	Spatial Resolution (m)	Country of Origin
ADEOS I and II (GLI)	X	X	X	Multispectral	250-1000	Japan
ATSR		X	X	Multispectral	1000	UK
Terra/ASTER			X	Multispectral	15-90	USA/Japan
DMSP/OLS	X	X		Nighttime visual	2500	USA
GOES	X	X	X	Multispectral	1000-4000	USA
IKONOS			X	Multispectral	1,4	USA
IRS			X	Multispectral	5,20	India
JERS-1			X	Multispectral	18	Japan/Australia
Landsat			X	Multispectral	30	USA
Meteosat	X	X		Multispectral	5000	Europe
NOAA/AVHRR	X	X	X	Multispectral	1000	USA
SeaWifs	X	X	X	Multispectral	1100-4500	USA
SPOT		X	X	Multispectral	20	France
Terra/MODIS	X	X	X	Multispectral	250 – 1000	USA

Figure 4-5. Satellites and Sensors Used in Wildland Fire Management
From IAGT, 2001

4.3.5 Current Algorithms Used in Satellite-based Detection Systems

Several algorithms are commonly associated with the few satellite-based detection systems in current use for wildland fire. These algorithms are used with AVHRR, DMSP/OLS, GOES, and MODIS sensors described below. Brief descriptions of the algorithms used with these satellites are in the following paragraphs, with more thorough descriptions in the aforementioned report (Institute for the Application of Geospatial Technology, 2001).

4.3.5.1 Advanced Very High Resolution Radiometer (AVHRR)

The Fire Identification, Mapping and Monitoring Algorithm (FIMMA) is an automated algorithm to detect fires using Advanced Very High Resolution Radiometer (AVHRR) data from NOAA's polar-orbiting satellites. It was developed at the NOAA/NESDIS Office of Research and Applications, and was a modification of a algorithm developed at NASA's Goddard Space Flight Center in 1996. The algorithm involved two steps:

1. Identification of potential fire pixels by thresholds applied to pixel data, and
2. Elimination of false signals by a spatial heterogeneity test.

The modified algorithm included the addition of a band 3 – band 4 threshold for the identification of "hot" brightness temperatures, a spatial heterogeneity test for band 3 brightness temperatures and a sun glint test from the MODIS fire algorithm. Specifics of the algorithm are at http://orbit-net.nesdis.noaa.gov/crad/sat/surf/fire/fire.htm. FIMMA had been tested using worldwide AVHRR images, and specific errors have been identified (http://orbit-net.nesdis.noaa.gov/crad/sat/surf/fire/fire.htm).

NESDIS produces fire images from AVHRR data, and a prototype for a global near-real time fire monitoring system has been developed at NOAA/NESDIS. An operational monitoring system based on FIMMA is a goal of NESDIS researchers, and is planned to serve as a prototype for MetOp (a European Space Agency meteorological satellite data (http://www.esa.int/export/esaME). FIMMA also has been evaluated for use in NOAA's Hazard Monitoring System (HMS) described below (McNamara, Stephens, and Ruminiski, 2002).

Modification of the algorithms developed for AVHRR (Eidenshink and Faudeen, 1994; Flasse and Ceccato, 1996; Justice et.al., 1996; Prins and Menzel, 1992) have since been used by other domestic and foreign agencies, including the Canada Centre for Remote Sensing (http://www.ccrs.nrcan.gc.ca/ccrs/tekrd/rd/apps/em/fires/foreste.html). The Finnish Meteorological Institute has been using a Forest Fire Alert System based on NOAA AVHRR and ERS-2 ATSR sensors since 1993 (http://www.vtt.fi/aut/rs/proj/FF-Operat/). These are just a few of many international initiatives and programs using AVHRR-based fire detection algorithms and alarm systems.

4.3.5.2 Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS)

Since the early 1970s, the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS) has been used to detect fires burning at night. Until recently, DMSP data was not used for fire detection because the U.S. Air Force had a 72-hour waiting period for data. Today the waiting period is 3 hours, and nighttime OLS data is being used for fire management projects in near real time.

A description of the DMSP-OLS fire detection algorithms developed by Elvidge et.al. (2000) is at: http://dmsp.ngdc.noaa.gov/html/projects/fires_desc.html. The algorithm uses visible and thermal infrared bands on board the OLS to detect nighttime fires. The

OLS thermal band is not optimally designed to detect fires. However, by analyzing a time-series of visible OLS images, it is possible to define a reference set of “stable” lights, and fires can then be identified as lights detected outside of this stable reference set. Conditions that affect the detection of fires with DMSP-OLS include sunlight, moonlight, clouds, and solar glare. A flow chart showing the data processing steps is available (http://nasda.ceos.org/materials/gofc/Chris_Elvidge/gofc/gofc8.html).

The NOAA-NESDIS National Geophysical Data Center (NGDC) operates the permanent archive for data acquired by DMSP. OLS instruments are on board two satellites that operate in day-night orbits on DMSP satellites F12 and F14 (http://www.ngdc.noaa.gov/dmsp/fires/globalfires.html).

4.3.5.3 Geostationary Operational Environmental Satellite (GOES)

Since 1991, the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison has used multi-spectral data from Geostationary Operational Environmental Satellite (GOES) satellites to detect and monitor fire and smoke in the Western Hemisphere. GOES-8 has been the predominantly used satellite, and investigations have been focused on fire activity in South America.

Because GOES scenes cover a large area, an algorithm was developed to automate the fire identification process and reduce the tedium of manual processing. Hence, the Automated Biomass Burning Algorithm (ABBA), was created to characterize sub-pixel biomass burning in South America. ABBA is a multi-spectral algorithm that uses dynamic local thresholds derived from GOES imagery and ancillary databases to locate fire pixels. The algorithm also provides estimates of the sub-pixel area and the mean temperature of the fire. The GOES-8 ABBA fire product includes: fire location, estimates of fire size and temperature, 3.9 and 10.7 micron observed brightness temperatures, background brightness temperatures, albedo statistics, ecosystem type, and a flag for non-processed fire pixels to indicate the reason for not processing (http://cimss.ssec.wisc.edu/goes/burn/detection.html).

One of the first uses of the Wildfire ABBA was in the Viejas fire in southern California in January 2001. Automated new blaze detection was conducted, successfully pinpointing blazes a half-hour after their ignition. The data was available on the web in less than 90 minutes, at http://cimss.ssec.wisc.edu/goes/burn/wfabba.html. This detection was aided by combining it with land cover maps derived from 1 km NOAA AVHRR data to produce an image showing fire location and overlaid with annotation to help users identify map features. (Appleton, 2001).

GOES-8 data has also been implemented into another algorithm developed by CIMMS named the Automated Smoke/Aerosol Detection Algorithm (ASADA), which is used to map smoke and other aerosols. ASADA includes single and multi-band difference thresholds, contextual information, solar zenith angle-corrected albedo, and solar and satellite viewing geometry to distinguish smoke and haze from multi-level clouds, low-level moisture, and sun glint. The GOES-8 ASADA product consists of composite imagery and grids that provide a summary of the extent of smoke and aerosol coverage and smoke albedo estimates which give a general estimate of smoke intensity (http://cimss.ssec.wisc.edu/goes/burn/detection.html).

The Navy's SPAWAR Systems Center in San Diego, California is currently using ABBA to generate fire products every half-hour for the entire Western Hemisphere as part of the Fire Locating and Modeling of Burning Emissions (FLAMBE) project. Plans involve the incorporation of MODIS and ATSR data to cover remaining areas. More information is at http://aerosol.spawar.navy.mil/flambe/flambe_mainmenu.htm.

4.3.5.4 Moderate Resolution Imaging Spectroradiometer (MODIS)

More than most others, the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor has achieved successful and wide use for wildland fire detection and monitoring. The sensor is located on board the Terra and Aqua satellites, and provides four daily observations. Information at http://modis-fire.gsfc.nasa.gov/ describes the current fire detection algorithm used by MODIS researchers. Current MODIS fire products are a resultant product of activities associated with the long-term AVHRR research for AVHRR-derived fire products.

As an example of MODIS use by the fire community, the U.S. Forest Service's Remote Sensing Applications Center (RSAC) has developed a one-stop Internet site for MODIS fire data products. The MODIS Active Fire Mapping Program website, known as "Firemapper" (http://firemapper.sc.egov.usda.gov/), provides information on current large fires, active fire maps, fire animations, and fire imagery as observed by MODIS sensor on both the Terra and Aqua satellites.

Many MODIS fire products are created through collaborations between NASA, NOAA, the University of Maryland and the U.S. Forest Service. Many of these products today are a result of the Rapid Response Project, the goal of which was to enhance the use of MODIS for wildfire detection and monitoring. Christopher Justice and Yoram Kaufman were the Principal Investigators on the MODIS Fire and Thermal Anomalies products (Kaufman and Justice, 1998). MODIS was tested experimentally until 2000 when it was used operationally during that year's fire season with the configuration shown in Figure 4-6.

During recent fire seasons, both the Terra, and most recently, the Aqua satellites have transmitted daily images of wildland fires in the western U.S. to NASA. Information is delivered within a few hours of the time that the satellite passes over the region. These images show the locations of active fires, where burn scars were still smoldering, and where smoke from the blazes was spreading. The images are then transmitted to the Forest Service and others, including posting in various forms, including on the Firemapper website identified above.

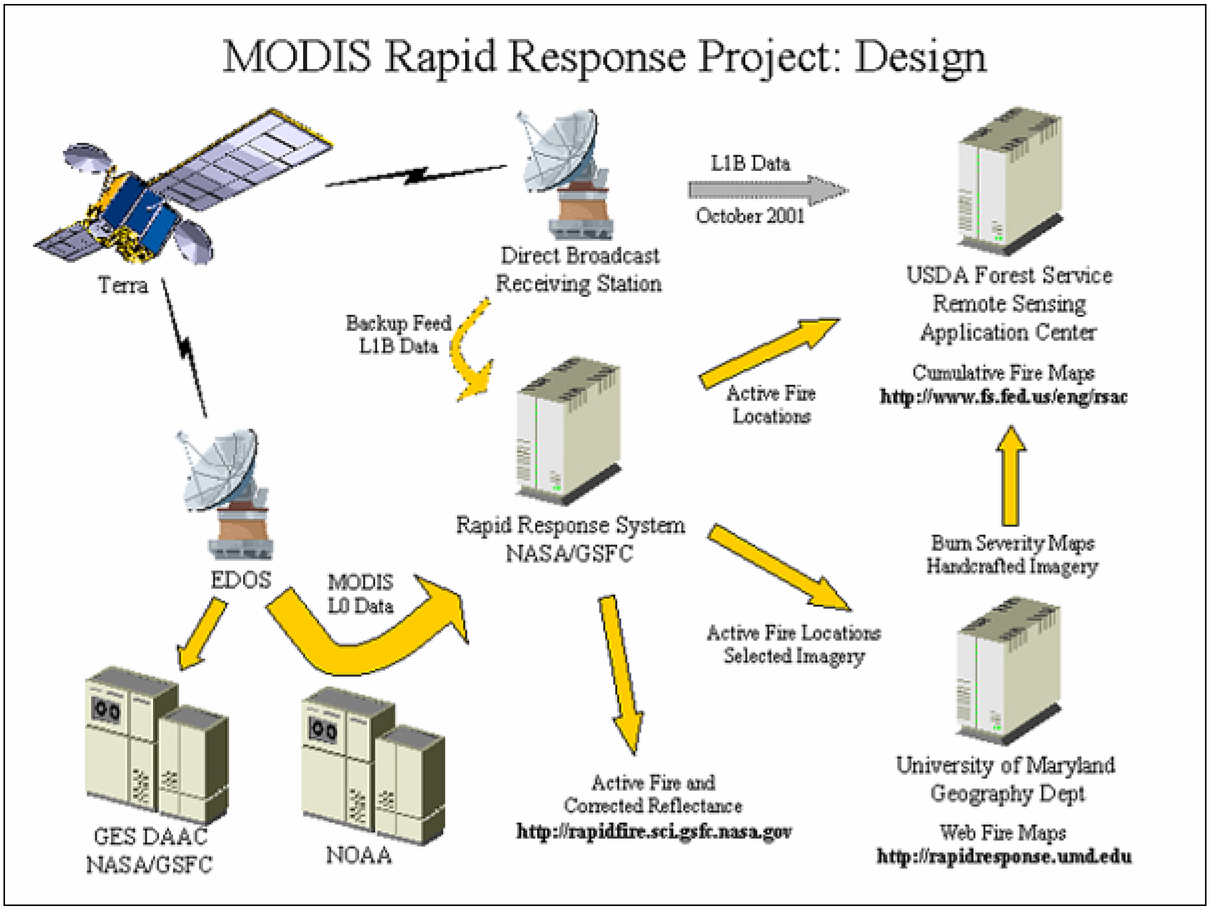

Figure 4-6. The Initial MODIS Rapid Response Project System Design

Information products available on the Firemapper website include:

- **MODIS Active Fire Maps** These maps are developed according to GACC areas. A PDF file of JPEG images can be downloaded daily that show the locations of fires over the past 24 hours. Archives are also accessible from this site.
- **NIFC Large Incident Maps** These maps are created daily and show all fires on a national scale. Wildland fires are distinguished differently from controlled burns. Both fire types are named on these maps. Information on fire locations is based on data provided by NIFC, and is comprised of MODIS observations which are verified by ground personnel.
- **Current Detections** These national maps show the locations of the fires (See Figure 4-7) but are also accompanied with a table that contains latitude, longitude, distance to human settlements, and other information useful in locating the fire. These fire locations are produced by the MODLand Rapid Response system using the algorithm described by the MOD14 Users Guide.
- **MODIS Fire Imagery** This product is produced by the U.S. Forest Service RSAC and is the result of an automation process. The imagery can be obtained through Internet links. Only images of fires over 10,000 acres are processed and made available through this site. Images are GeoTIFFs for true color bands 1-4-3 and

false color infrared bands 7-2-1. Generic binary files for these 7 bands are also available.

- **MODIS Swath Quicklooks** This utility allows the user to select a day and time of a MODIS observation of the western U.S. so that a thumbnail of the swath can be viewed and/or downloaded. True color, false color, and Normalized Difference Vegetation Index (NDVI) MODIS images are available four times per day.
- **MODIS Active Fire Detection GIS Data** This product is a zipped ESRI Arc Interchange file of all MODIS fire observations. An archive of 2001 and 2002 observations are available, and the 2003 observations are updated and re-posted daily. See Figure 4-8 for an example of this database as it appeared on July 15, 2003. The GIS data layer is accompanied with an attribute table that contains latitude, longitude, date, and other information corresponding to each observation point.
- **MODIS Active Fire Animations** These animations show the seasonal locations of fire of selected areas in the U.S. Available animations include for June-September 2002 for the Northwestern GACC, and April-August 2002 for the Southwestern GACC, and October 2003 for the southern California fires.

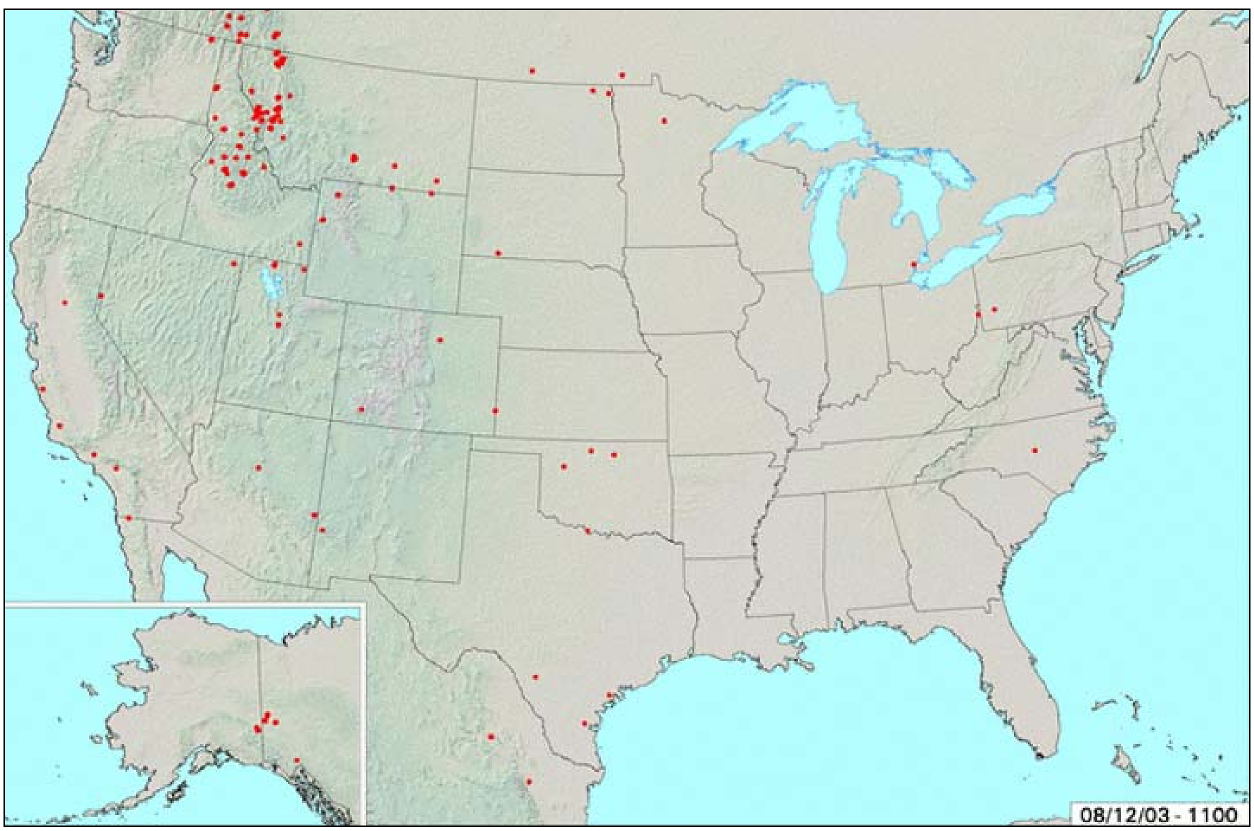

Figure 4-7. MODIS Detections as of August 12, 2003

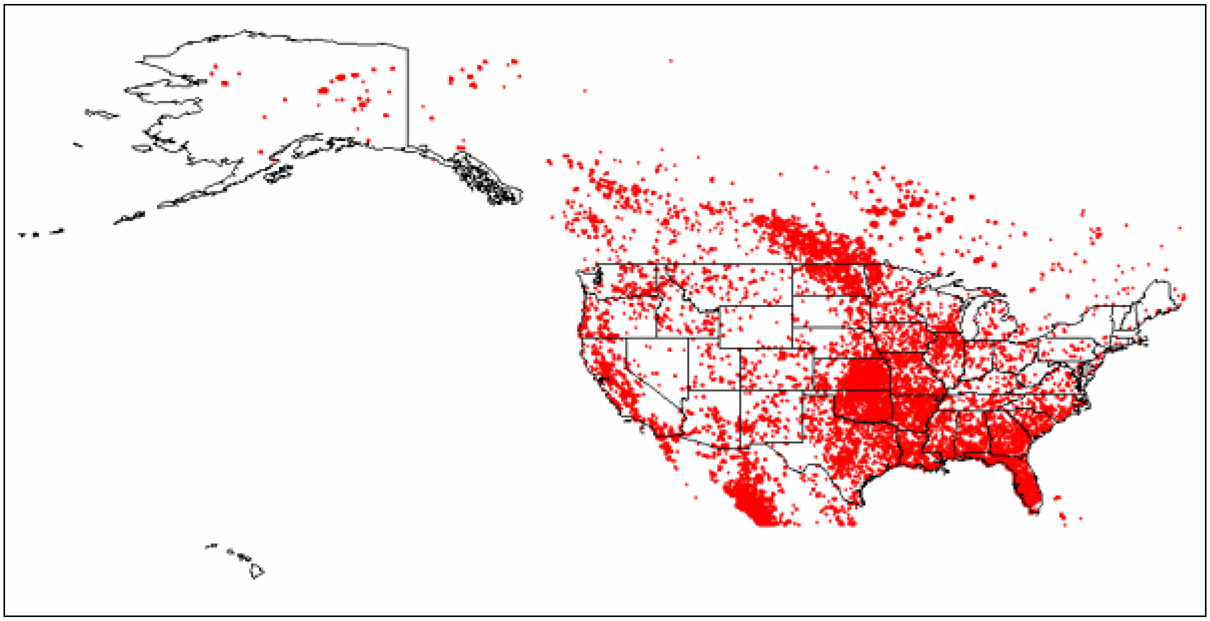

Figure 4-8. MODIS Active Fire GIS Data
These data points represent all MODIS fire observations for 2003 until July 15, 2003, when this figure was created by IAGT.

4.4 CURRENT AND PLANNED DETECTION SYSTEMS

Many of the detection systems now in use vary widely in terms of their level of complexity and targeted users. Most of these detection systems and configurations are supported by federal government funds. Descriptions of these and some non-federally funded systems are provided below.

4.4.1 Global Observation of Forest Cover (GOFC)

The Global Observation of Forest Cover (GOFC) organization was originally developed as a pilot project by the Committee on Earth Observation Satellites (CEOS) as part of their Integrated Global Observing Strategy (http://gofc-fire.umd.edu). It is now a project of the Global Terrestrial Observing System (GTOS). Their main objective is to "provide ongoing space-based and in-situ observations of forests and other vegetation cover for sustainable management of terrestrial resources and to obtain an accurate, reliable, quantitative understanding of the terrestrial carbon budget" (Justice, 2001).

GOFC has long been involved with the research and exploration of global space-based forest fire detection systems. Although it has not developed an actual detection system, the group has sponsored publications, presentations, and conferences on such systems. It also supports the development of these technologies through research and prototype development. The organization provides access to several different datasets and data portals through which international forest researchers and wildland fire managers can obtain useful information.

4.4.2 FUEGO

FUEGO is a proposed European system for wildland fire management support that is planned by the Ingeneria y Servicios Aerospaciales, S.A. (INSA) for operation in 2006 (INSA, 2001). INSA has specified the need for rapid detection of wildland fires in Europe as an essential part of the user requirements for the proposed system. The system is based on a constellation of "mini-satellites" that are designed to provide early fire outbreak detection and hi-resolution fire monitoring.

FUEGO development is funded by several European sources and is being driven by planned system users who are dispersed worldwide. User needs were collected from attendees at past conferences and through questionnaires and interviews with potential users from around the world. Figure 4-9 summarizes these findings and needs of potential system users (http://www.insa.es/fuego/).

Fire Detection	
Detection time	Average alert time in the range of 10-20 minutes
Fire size	Minimum detection size of fire of 50 m^2
Fire alarms	False alarm rate of 5%. The system must produce confirmation of the fire together with other information related to the outbreak
Fire Monitoring	
Fire dimensions	Minimum image size of 50 Km
Fire line resolution	Resolution of 35 to 50m and geo-location accuracy in the same range
Monitoring requesting	Reception of monitoring information for on-going fires larger than 25 ha (hectares) in the areas of risk in an automatic way, without previous request.
Fire perimeter intensity measurement and evolution	In large fires with more than 25 ha burned, a picture of the fire line temperature every 90 minutes covers the user needs
Accuracy for fire perimeter location	The geo-location of monitoring products should have accuracy of the order of magnitude of the pixel (35 to 50 m)
Hot spot monitoring	Within the fire scene, a map of the hot spots that could re-ignite new fires
System Service	
Continuous surveillance	The availability of the service outside the fire campaign and during night time is very much appreciated
System coverage	Coverage of the 100% of the high-risk areas that in Europe represent 30 Mha
Low maintenance cost	The system must be reliable, with simple and cheap maintenance.

Figure 4-9. User Requirements of the FUEGO System

FUEGO plans to offer fire detection and monitoring, cloud coverage, risk monitoring, fire evolution analysis, damage assessment, detection alarm, fire evolution prediction, and secondary services like volcano monitoring, large area fire incident inventory, and frost detection.

Although this program is advertised to be for the global fire management community, FUEGO seems to be most focused on detection and monitoring activities in southern Europe. The FUEGO User Committee has one representative from each Mediterranean country, although other countries or states are invited to join.

4.4.3 Real Time Emergency Management via Satellite (REMSAT©)

MacDonald Dettwiler, Inc. developed the Real Time Emergency Management via Satellite (REMSAT©) system in partnership with the British Columbia Forest Service and the Canadian Space Agency under contract to the European Space Agency (Space Daily, 2000, http://www.remsat.com).

REMSAT© is a multi-faceted field conditions data detection, monitoring and relay system that combines satellite and communication technologies from multiple countries for wildland fire management (MacDonald Dettwiler, 1999). REMSAT© improves communications between fire-fighting field crews and the field command post, delivers updates position and status information on aircraft, equipment, and personnel, and provides additional information on the emergency areas such as satellite imagery or aerial photography. REMSAT is well documented, and has undergone significant field-testing and evaluation in actual wildland fire situations.

4.4.4 Hazard Support System/Firesat

A Hazard Support System (HSS) was envisioned by U.S. Geological Survey (USGS) scientists in the early 1990s as a new, real-time, way to detect wildland fires and volcanic eruptions. They theorized that the sensitivity and coverage of the Nation's ballistic missile warning satellites, fused with that of the world’s environmental weather satellites, could enable early detection of these events in an unprecedented way. For wildland fires, the goal of this system was to provide early detection and notification of fires that were less than few acres in size when they are most easily suppressed. Early funding was provided by the Department of Defense (DOD) and later aided by some civilian funding through USGS and other agencies. Official development of HSS began in 1997 with a $23.6 million appropriation to DOD. The National Reconnaissance Office (NRO) was asked by DOD's leadership to develop HSS and USGS accepted responsibility for hosting and operating the system. A contract was issued to develop an operational prototype later that year.

HSS was envisioned, developed and tested to provide continuous monitoring of the United States for wildland fire outbreaks and resulting smoke. It works by utilizing data from relevant satellite sensors, particularly the U.S. ballistic missile warning satellites and environmental weather satellites. It also uses other data such as such as lightning, fire danger and fire potential, and fire fuel moisture and depth projections in a system architecture that incorporates signal processing algorithms and multi-sensor data fusion

(MEDEA, 2000). The data are then relayed in real-time to the USGS Advanced System Center in Reston, Virginia, where they are processed and analyzed. Sensor-specific algorithms are used to identify signatures of potential fires (MEDEA, 2000). Confidence estimates are then developed for each potential detection event based on several variables. These include signal intensity, geospatial co-location or recurrence, incidence relative to areas of high fire activity, and the possibility that the detection maybe from non-fire sources (MEDEA, 2000). It was envisioned that a detection-warning message would be sent to the responsible federal or state fire agency via the Internet including a derived probabilistic estimate of its confidence.

Though some users expressed strong interest in and support for HSS as discussed above (Hull, 2000), overall interest was mixed, particularly on the part of federal land management agencies. Funding decreased significantly in 2000 after the prototype was completed. USGS was directed to end development of the system in June, 2000 and it was officially terminated in August, 2000, though the satellite downlink remained intact. During this time, the Executive Office of the President requested that MEDEA conduct an independent study to "determine whether the underlying concept of the Hazard Support System remains viable, and to explore whether there are any fundamental technical reasons to preclude completion of a program of development and testing." A declassified report was issued in this regard in September 2000 (MEDEA, 2000, p. ES-2).

Many findings were generated and are included in the MEDEA report, with the following overall conclusions:

1. Under favorable conditions, the system can detect moderately intense wildland fires of fractional acre sizes;
2. Its technical capabilities to detect and localize wildland fires are not yet well understood;
3. Environmental factors (e.g. clouds, high humidity, sun glint) can significantly degrade system capabilities;
4. The system does not yet appear to meet the needs of the fire management community, particularly as regards false alarm rates and location errors (both too high);
5. There are reasons to believe that its performance capabilities can be improved with further development, although important limitations will remain; and,
6. The underlying concept is viable and the system has potential to become a useful, even important, tool for state and federal wildland fire management organizations (MEDEA, 2000, p. ES-1).

The report further concluded that many factors influence the likelihood that HSS would accurately detect a particular fire. These include the inherent limitations of a system originally designed for another purpose (e.g. constellation geometry and data quality), processing capabilities, environmental factors such as cloud cover and humidity, and fire characteristics such as intensity and size. However, MEDEA noted that HSS did provide earlier detection of a significant number of fires during the 2000 fire season than conventional methods. False alarms were identified as an important issue, primarily due to solar effects, but questions were raised as to whether the system performance was tested at night or in early morning hours when other methods have limited functionality. MEDEA found that HSS could be improved by a restructured development and testing process that involves the end-user community. Testing should be conducted at the scientific and field levels, and should explore the trade-offs between detection and false alarm rates. MEDEA also suggested that continuation of the program be funded from budget accounts that are outside those which support operational fire suppression. If the program was to be restarted, MEDEA proposed that the HSS should be used for a broader range of dual-use applications of civil and national security remote sensing systems.

While HSS development ceased in 2000, the custodianship of what remained of the project among the civilian agencies was transferred from USGS to NOAA in 2001. NOAA incorporated it under the auspices of the National Hazards Information Strategy (NHIS), a broader effort underway within the agency and with others. While HSS was a multi-million dollar effort when it was transferred to NOAA, it was with a much smaller funding level for Fiscal Year 2001. Efforts were underway to operate the system at a demonstration level within the broader NHIS effort. NOAA simultaneously was working with the fire community with limited funding to provide support for remote sensing enhancements to existing federal fire programs, such as through the new Predictive Services group at NIFC and the GeoMAC web site. However, funding was not continued in Fiscal Year 2003, so these initiatives were not continued at NOAA.

Most recently, what is left of HSS has been transferred to the new Department of Homeland Security (DHS), though without funding. Within this context, HSS is now sometimes referred to as "Firesat", as suggested by Congressman Curt Weldon of Pennsylvania, who has been a long time advocate of the project. The President's proposed Fiscal Year 2004 budget does not include funding for the project, but some discussions are underway to include it in future appropriations action by Congress.

4.4.5 Hazard Mapping System (HMS)

NOAA's Hazard Mapping System (HMS) is an interactive processing system that allows trained satellite analysts in the Satellite Analysis Branch (SAB) within NOAA's Satellite Services Division (SSD) to manually integrate data from various automated fire detection algorithms with GOES, AVHRR, MODIS and DMSP/OLS images. HMS products are updated daily and posted on the web-based map server site (http://www.firedetect.noaa.gov/viewer.htm). Individual fire layers are from the following sources:

1. GOES Wildfire Automated Biomass Burning Algorithm (WF-ABBA) (http://www.ssd.noaa.gov/PS/FIRE/Layers/ABBA/abba.html)
2. AVHRR Fire Identification Mapping and Monitoring Algorithm (FIMMA) (http://www.ssd.noaa.gov/PS/FIRE/Layers/FIMMA/fimma.html)
3. MODIS Fire Algorithm (http://www.ssd.noaa.gov/PS/FIRE/Layers/MODIS/modis.html)
4. DMSP/OLS Algorithm (http://www.ssd.noaa.gov/PS/FIRE/Layers/OLS/dmsp_ols.html)

NOAA's Air Resources Lab is seeking to make the system operational. At present, the information on fire location and position should not be used for tactical decisions, but it can be used as a guideline for strategic planning activities. State air quality agencies and others have begun use of it to identify health impacts of smoke from both wild and prescribed fires.

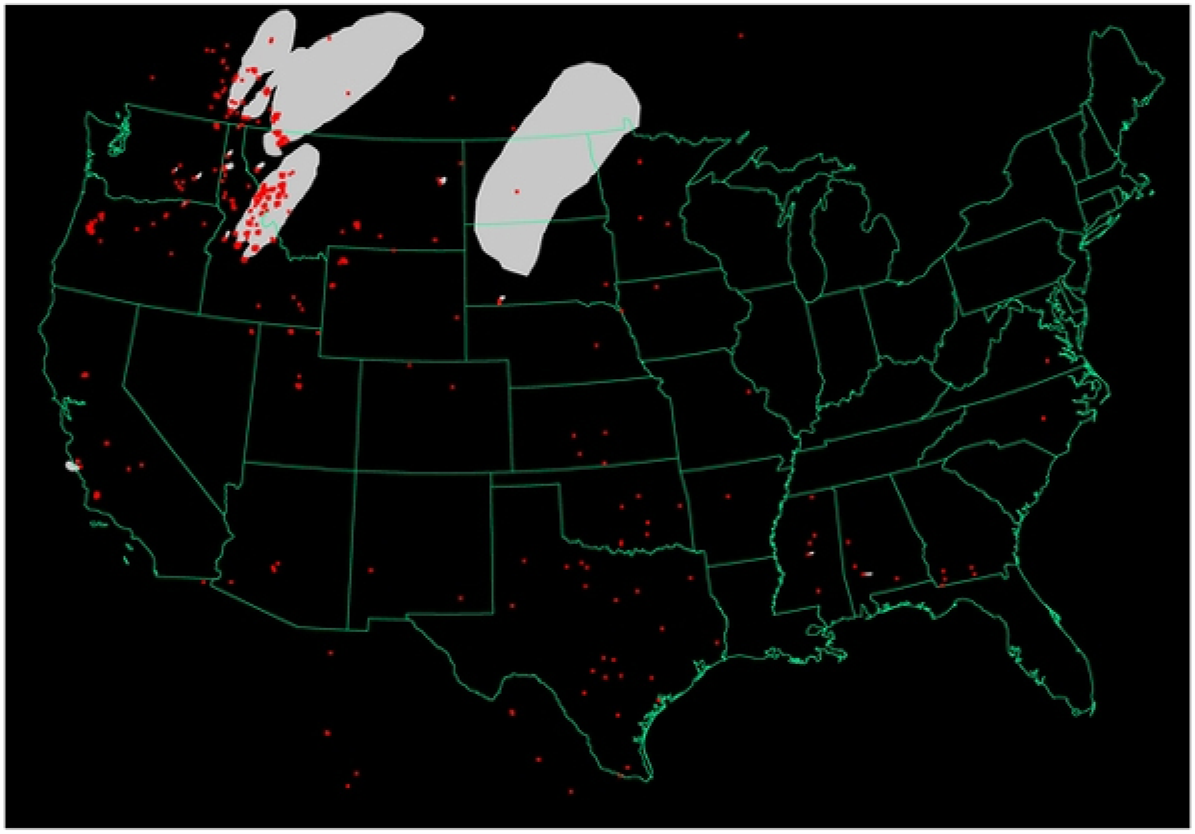

Figure 4-10. Example of HMS Output on August 12, 2003
Fires are in red, and are shown in increased size so that they are more visible. Smoke is shown in gray.

Fires from the automatic detection algorithms inside the U.S. have been treated with quality control measures by remote sensing analysts. In addition, the daily HMS product is created between 1 pm and 11 pm so that the previous day's data is complete for the next day's fire shift (http://www.ssd.noaa.gov/PS/FIRE/hms.html).

There are some limitations to HMS, namely (McNamara, Stephens, and Ruminiski, 2002):

1. There is no way to discriminate between wildfires and controlled burns
2. The 3.9 micron imagery can not "see" through clouds other than thin cirrus
3. Small fires, those not burning very hot, and those burning below a thick canopy may go undetected

4. Smoke is harder to detect in standard visible imagery during the middle of the day with a high sun angle or against a surface with a high albedo
5. Fires may be masked by a hot or highly reflective background, especially in the western states

Fire and smoke location data from the HMS, ABBA, FIMMA and MODIS can be downloaded in ASCII text, graphic or GIS formats through the Internet site http://gp16.wwb.noaa.gov/FIRE/fire.html.

4.5 GENERAL LIMITATIONS, NEEDS AND PRIORITIES FOR DETECTION

Much research and product evaluation has been conducted concerning the use of GI/GIT in wildland fire management, particularly for detection. However, there still remains a significant gap in understanding what is needed by end users and the fire management community. Debate continues about the need to actually detect fires upon initial ignition, though support for remote monitoring of fires as they progress seems to be growing as capabilities are increasingly recognized.

For example, as discussed in Section 4.3.3, demand for infrared photography products has been strong in recent fire seasons. Moreover, the fire community has been unable to fill several of these requests. The high number of these requests reveals strong demand and unmet needs for remote sensing products. This requires attention by fire managers and corresponding opportunities for related and enhanced remote sensing products to emerge and be supported.

However, as indicated by the CEOS fire group, existing satellite sensors with wildland fire detection capabilities are underutilized, and the capability exists to generate and distribute daily wildland fire information products at varies scales from existing sensors (CEOS, 2000). Although several programs and products have been created, such as the recent results from the MODIS sensor as described above, others have not proliferated even though new approaches show promise technologically. For example, the Hazard Support System (HSS) program, which showed promise and had significant support from state officials, did not receive funding support beyond 2002.

In addition, even in some cases where data from satellite sensors have proven to be useful for fire management, there appears to be limited support, adoption, funding or institutionalization in practice. For example, much MODIS work is still funded as experimental, rather than as an operational part of doing business. It is problematic for users to become reliant on such products because funding might cease. Moreover, some fire management organizations and their leaders are not even made aware of the potential capabilities of these systems, much less do they have avenues to provide what would likely be valuable input (Long, 2003).

Overall, the wildland fire community lacks sufficient opportunities to learn about or have input into research efforts concerning the use of GIT, and particularly remote sensing for fire management. Due in part to constant change in products, costs, benefits, and lessons learned, there is limited awareness on the part of potential users and little confidence in selecting one product over the other. In general, funds have been limited to support interactions between the fire research community and end users, and this situation is particularly evident in fire detection products.

4.5.1 Limitations of Remote Sensing in Detection

The use of satellite remote sensing as a tool for the detection and monitoring of wildland fires has shown great promise. The use of a space-borne system can have many advantages over an airborne system. In particular, it can be significantly more cost-effective, is attractive as a continuous data source, and shows promise for automated or semi-automated fire detection and alarm dispatch activities. However, most of the sensors currently in use for fire management were not created for fire detection, monitoring, and alarm systems. They were found later to have a relevance to these applications. Hence, to extract relevant information from these sensors requires a significant amount of data synthesis and best results are often dependent on favorable environmental conditions.

Although some dedicated space-based fire detection sensor systems are planned for the future, current conditions seem to indicate that satellite data is best used as an ancillary tool for fire detection and monitoring. Currently, what limited advocacy does exist within the fire management community for satellite data seems to be focused on fire monitoring and post-fire assessment. In this application, time is a less critical issue than for active fire response and suppression, and data from satellite imagery is more feasible than that obtained through aerial surveys or fieldwork.

4.5.2 Detection Needs in the User Community

As concluded in an evaluation of HSS (MEDEA, 2000), although the system was found to hold significant potential success with further development, one of the main limitations of the system at the time of evaluation was that it did not appear to meet the needs of the fire management community. In particular, false alarm rates and location errors were considered to be too high. While some testing was conducted in a few states, if HSS (or “Firesat” as described above) were to reemerge, participants would need to involve the user community to a greater extent. In addition, testing of the system should involve both structured scientific testing as well as testing in the field, as was done with the REMSAT© system during the Canadian fire season of 2000.

For example, in order to determine the needs of the user community, INSA researchers investigated needs for the FUEGO program. Determination of these needs serves as an example of the types of information that could be obtained. Requirements that FUEGO researchers determined as needed variables included (INSA, 2001):

FIRE DETECTION

- Detection time
- Fire size
- Fire alarms

FIRE MONITORING

Fire dimensions
Fire line resolution
Monitoring requesting
Fire perimeter intensity measurement and evolution
Accuracy for fire perimeter location
Hot spot monitoring

SYSTEM SERVICE

Continuous surveillance
System coverage
Low maintenance cost

In terms of sensors that may potentially be of use to fire management, similar questions should be asked of the research community so that they can anticipate and incorporate the possibility that these sensors best meet the needs of fire users. Opportunities may exist for the fire community to contribute assistance to these efforts if more actively providing input to the activities of the research community.

4.5.3 Priorities for Detection Technologies and Programs

Some immediate needs for fire detection technologies and programs are updated definitions from the user community on what is needed to improve wildland fire detection and monitoring. Many organizational levels in various agencies and government entities are involved in wildland fire management and are potential users of new detection capabilities, but these advances are only useful if applied to meet fire needs. Debate continues about the need for improved detection capabilities, but there is a growing need and acceptance of remote sensing technology for monitoring fire. However, this acceptance has had limited translation into institutionalized and funded support and programming for remote sensing, and particularly to develop integrated remote sensing products for wildland fire as suggested above. New information resulting from these advances could make a significant contribution if incorporated as part of the fire management decision making process to meet intended management objectives for individual fires, such as to contain them, and minimize impacts in terms of suppression costs and damage.

As in many similar cases, research and development often is done with insufficient guidance from end-users and managers, such as evaluation of hardware, software, training, facilities and related programs in place or planned in various institutions; or, full consideration of decision making needs and processes for which the new advances could be applied. In some cases, such as described here about fire detection and monitoring, important advances may be made, but are unknown to decision makers and managers, so operational funding and programming remains limited.

As concluded in a recent study about wildfire suppression costs by the National Academy of Public Administration (NAPA) (2002), technology deployment in the fire community is largely decentralized and ad hoc. New efforts are needed to focus on getting the outcomes of research and development efforts "into the field more quickly, systematically and efficiently", including through the development of "technology transfer and education professionals" (NAPA, 2002, p. 54). Opportunities exist to investigate and synthesize practical experience and research efforts. These findings could be provided to the user community in the context of current efforts and needs to garner their input and in turn help address detection and related needs.

Funding is a particularly critical issue that deserves attention from the user community. As suggested in the MEDEA report about HSS, this type of system should have funding from a source that is separate from that supporting operational fire suppression. Otherwise, end-user acceptance of new systems would be unlikely. This also could likely be true of other advances. As concluded in the recent NAPA study, support (and thus funding) for technology transfer in the fire management community has been limited, as well as for the actual development of applications (2002).

More detailed investigation about current and planned use, capabilities and expenditures concerning existing fire detection and monitoring systems and technologies, as well as advances derived from research programs, could provide insight for new options. This would be helpful to help understand where opportunities exist to improve the allocation of funding into programs that are currently lacking, and to also find new applications for existing detection and monitoring technology and capabilities.

In addition to limited awareness about related internal research efforts and practical experience within and among the federal and state fire community and other federal agencies, members of the user community may be insufficiently unaware of GI/GIT research conducted at academic institutions and by organizations outside the U.S. Commercial companies may also be generating products that are built to serve a specific purpose, not knowing that these products also may be helpful to the fire community for additional applications.

Efforts to inform and engage the wildland fire user community about current and planned research and existing practical applications concerning GI/GIT use for fire detection would help to build essential support for funding and programs in this regard, and in turn, improve fire management results from GI/GIT usage.

5.0 RESPONSE

While the last chapter specifically addressed fire detection, this chapter reviews the overall fire response phase of wildland fire, which is considered to be the most extensive and costly component of wildland fire management. The chapter describes some current response approaches and resources, examples of GI/GIT use for fire response, user needs and limitations concerning greater use of GI/GIT, and suggestions for successful implementation to maximize effectiveness and benefits of using these data and technologies.

5.1 INTRODUCTION

Wildfire management organizations are ultimately emergency response systems, but unlike other response services (police, ambulance, urban fire), they deal with natural processes that have both beneficial and detrimental impacts on humans, property, and the ecosystems from which they exist. The goal of fire suppression and control is to prevent unwanted ignitions, to modify the environment in which a fire burns, to extinguish small fires before the become large, and to respond appropriately to escaped and large fires (Pyne, 1996). The response phase deals primarily with the latter two of these goals. Wildland fire response is a far-reaching activity that spans across many organizations and resource providers, and has a great impact on the public. It includes those activities undertaken to monitor and manage wildland fire incidents and effects, inform the public, and provide immediate disaster assistance. Response activities include:

- Initial attack
- Resource deployment,
- Fire Incident Command System (ICS) management
- Fire reporting

These efforts include diligent monitoring of current and forecast weather conditions, including potential lightning activity, wind speed and wind direction. Knowledge of fire location, size, and perimeter, as well as current and anticipated fire behavior, direction and intensity, is crucial for making appropriate decisions and deploying adequate fire suppression resources to control wildland fires. Accurate predictions of wildfire impacts to values at risk are essential to determine and establish fuel breaks, fuel treatments, firefighter safety zones, and potential evacuations. Data and information developed during the mitigation and preparedness phases can contribute to the overall success of the response phase.

Local emergency officials are often the first to respond to wildland fires and other emergencies, and then may request state and federal disaster assistance. Having in place a coordinated disaster response system with access to information and communication will enhance the effectiveness of all emergency management, including fire. Activating operations plans and emergency procedures, coordinating with mutual aid agencies (personnel, resources, and equipment) and communicating with local and state officials about response needs and status reports are necessary response procedures. States have cooperative mutual aide agreements among nearby states (through interstate compacts and otherwise), and with local governments and federal partners, which provide an effective means of initiating and maintaining response coordination.

Suppression, a key component of response, is well documented as the most expensive aspect of wildland fire management, costing over $1.6 billion in the 2002 fire season alone, with costs increasing over time as discussed in Chapter 2. Aggressive suppression, along with fuels reduction measures, is considered to be needed to reduce the devastating ecological, social, and economic effects of wildfires. As described in the above chapters, initial fire response is generally left to state and local governments if available. Some of these entities have the capability to conduct a strong initial attack and overall suppression effort, while others do not. However, fire response policy and practice, particularly regarding suppression, is undergoing changes in response to decades of strong fire suppression efforts and corresponding impacts.

The policy direction on federal lands is no longer to immediately suppress a fire when it is detected, but to accurately observe, ascertain and monitor conditions in order to make wide decisions about whether, to what degree and how to conduct initial attack and suppression. This policy shift occurred in the late 1990s due to forest health conditions across the county, the number of catastrophic wildfires, and the escalating cost of suppression. Rapid initial attack and suppression is typically ordered if a fire threatens property, lives and or high value natural resources. Alternatively, fires may now be allowed to burn in Wilderness Areas, National Parks and other remote areas if resources are not threatened, especially where a land management unit has an approved fire management plan allowing for a fire to burn in designated areas with limited risks. In some such cases, a minimal level of resources may be deployed to manage and keep some control of a fire in order that it does not get out of control.

To assist in this implementing this new policy and approach, six fire use management teams were recently organized. These teams serve as national resources that can be deployed to assist in managing and monitoring fires with a goal of control rather than suppression, as well as to assist with prescribed fires undertaken to meet fuels management needs. For the wildland fires in which suppression is the objective, the majority are extinguished rapidly before they get beyond the local management unit's ability to control them. However, a few wildland fires do go out of control, can cause huge losses, and often result in the need to deploy vast resources to stop them.

The approach and chain of command for wildland fire response is well established after decades of refinement. Alternatively, the role, approach, scope of utility, and application of GI/GIT in the response phase is unclear to management, and therefore, remains ad hoc and inconsistent in practice. While certain response activities seem to have a close connection with GI/GIT for some purposes in many agencies and parts of the country, the application of geospatial tools for planning, management, and tactical needs and public information purposes vary considerably and may not be sufficiently maintained or reliable due to insufficient management focus and resource commitment. Moreover, other aspects of fire response have only a cursory use of modern GI/GIT. Issues, needs, and opportunities are being identified in order to make a more standard, consistent, and effective use of GI/GIT capabilities for many aspects of wildfire response.

5.2 CURRENT FIRE RESPONSE APPROACHES, SYSTEMS AND RESOURCES

Fire response includes any activities undertaken to acquire, monitor, manage, use and disseminate information about wildland fire incidents, resources and effects in order to meet the needs of defined fire suppression and management missions. This section includes brief descriptions of the current response approaches, systems and resources utilized for wildland fire response.

5.2.1 Coordinating Organizations for Fire and GI/GIT

The National Interagency Fire Center (NIFC), as described in Chapter 2, is the physical location where organizations responsible for many aspects of wildland fire management and coordination in the United States are located. It could be the place that would be best poised administratively, organizationally, and technically to incorporate and deploy advanced techniques into the workflow of the partnering organizations and their existing detection and response network. Agencies located at NIFC include the Bureau of Indian Affairs, Bureau of Land Management, Fish and Wildlife Service, and National Park Service within the Department of Interior, the Forest Service within the Department of Agriculture, the National Weather Service, the Office of Aircraft Services, and most recently, the Federal Emergency Management Agency (FEMA). The National Association of State Foresters (NASF) and The Nature Conservancy (TNC) also have staff located at NIFC. As described in Chapter 2, most of these organizations are members of the National Wildfire Coordinating Group (NWCG), along with the Intertribal Timber Council. NWCG was created in 1976 to facilitate the development of common practices, standards, and training among the wildland fire community (NIFC, 2001a).

The National Fire and Aviation Executive Board (NFAEB) was created to more broadly coordinate various fire programs of the federal agencies, while NWCG concentrates on standards issues. NWCG helps to coordinate programs of the agencies and provides a formalized system through which substantive fire management issues can be addressed and resolved, though like with NIFC, each agency determines whether and in what manner it will adopt NWCG proposals (http://www.nwcg.gov/). Alternatively, one of NFAEB's key roles is to help make resource deployment decisions in a coordinated way, including the joint chartering of interagency information systems.

5.2.1.1 NWCG Information Resource Management Working Team

NWCG has established 15 working teams to explore, address and provide recommendations on various aspects of wildland fire management, including operations, equipment, and training. An important group is the Information Resource Management Working Team (IRMWT), whose mission is to identify policy-level information issues that affect, or are likely to affect, interagency fire management activities, and to provide advice to NWCG members on how to address those issues through information and communication systems. Its mission also is to provide recommendations for the development, use, implementation, and processes related to information technology's use in wildland fire.

The IRMWT has a staff office known as the Program Management Office (PMO). It was formed in September 2000 to provide products and services to establish and maintain an NWCG enterprise architecture consisting of principles, rules, and standards that guide development of wildland fire information systems. The PMO is an interagency staff so it is not driven by agency-specific needs. The PMO reports to the IRMWT.

As shown on Figure 5-1, the IRMWT has two subgroups, the Data Administration Working Group (DAWG) and the Geospatial Task Group (GTG). The DAWG is comprised of Data Stewards from other working teams with efforts underway to have standard enterprise architectures and data standards. The DAWG works closely with the PMO to conduct its work.

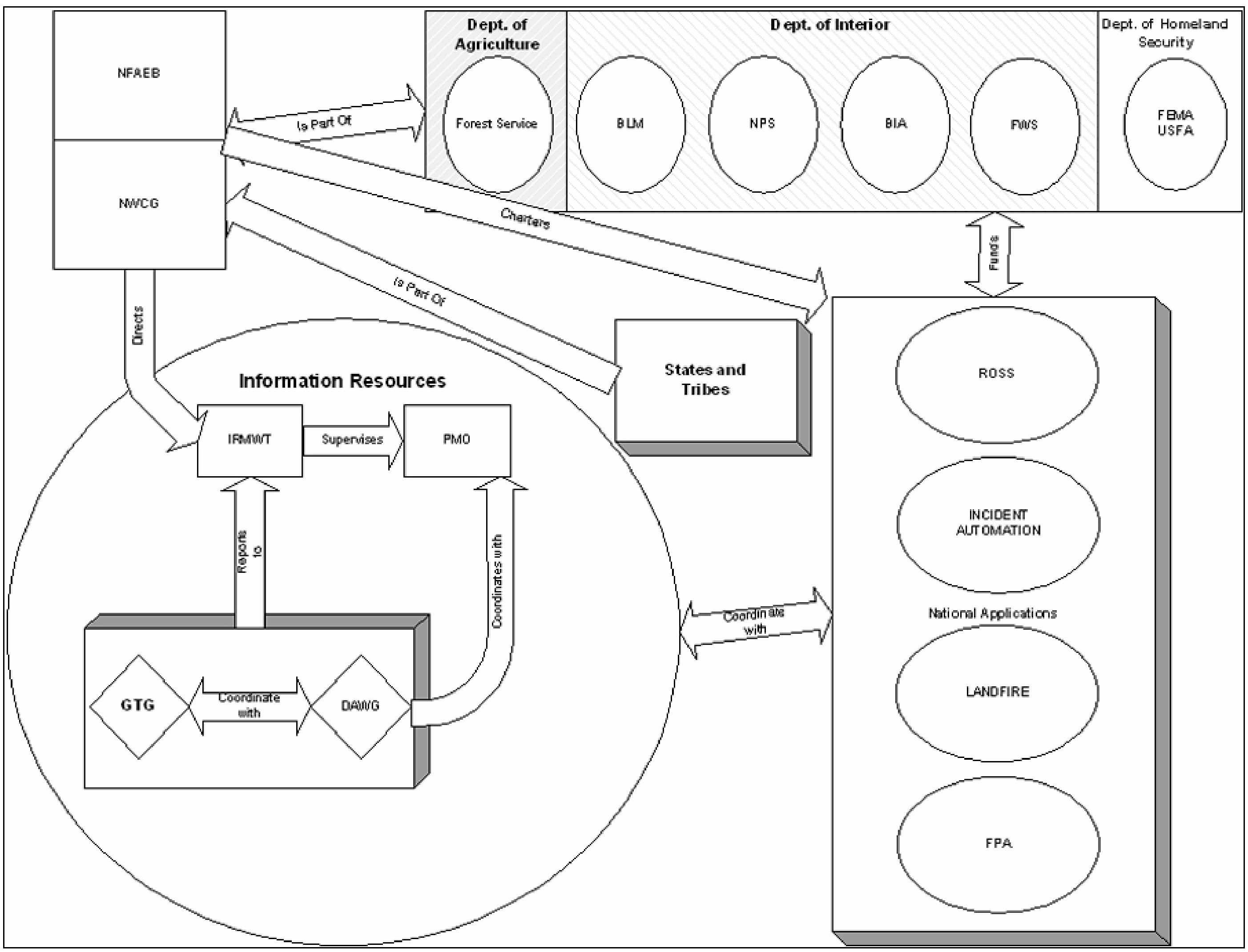

Figure 5-1. Wildland Fire Coordination Groups and Information Resources
Courtesy of Joe Frost, U.S. Forest Service Fire GIS Coordinator

5.2.1.2 Geospatial Task Group

GTG was created by the IRMWT because GIS was increasingly utilized in incident command support, and the inconsistent nature of its use was becoming recognized. It became apparent that there needed to be a forum for discussion. GTG's role is to provide IRMWT and the NWCG with information and recommendations concerning the use of GI/GIT, and to provide all the NWCG Working Teams with quality information and advice concerning the use of geospatial data, applications, and processes in support of interagency wildland fire management (http://gis.nwcg.gov).

GTG members represent most of the agencies on NWCG, including two state representatives (Susan McLellan of the Florida Division of Forestry for the eastern states, and Skip Edel of the Colorado State Forest Service for the western states). According to its charter, GTG’s objects and goals are to:

- Provide a coordinated interagency point of contact for the NWCG IRMWT regarding the use of GIS in support of wildland fire management.
- Coordinate with all NWCG Working Teams to assure proper and efficient use of GIS in the support of wildland fire management.
- Develop and maintain an interagency list of data, applications, hardware, and human resources available to support wildland fire management.
- Recommend interagency standards and processes to ensure that quality data are available for use in fire management activities.
- Provide coordination and interface among NWCG, federal, and state agencies concerning the use of geospatial technologies in interagency wildland fire management.
- Encourage, recommend, or coordinate the development of geospatial data and applications to support interagency fire management.
- Encourage, recommend, or develop strategies to manage and store geospatial data.
- Provide awareness, education, and information on the application of geospatial data and analysis in support of wildland fire management to the interagency fire management community (http://gis.nwcg.gov/jspapps/jsp/gtg/documents/gtg_charter.pdf).

GTG is increasingly asked to address and act upon various GI/GIT issues as usage and challenges increase. It has several initiatives underway, many of which are discussed later in this chapter. As shown in Figure 5-2 the GTG, DAWG and PMO work together, but not exactly in the same way because of differences in scope, reporting arrangements, and resources. Unlike the IRMWT, which has the PMO as a dedicated staff as described above, GTG has no staff resources to conduct its work. Moreover, GTG's relationships with developing interagency information systems may or may not exist. For example, a direct coordination relationship exists between GTG and the group developing the Fire Program Analysis (FPA) system, which was discussed in Chapter 3. Alternatively, there is no official working relationship established between GTG and the Resource Ordering and Status System (ROSS), discussed later in this chapter.

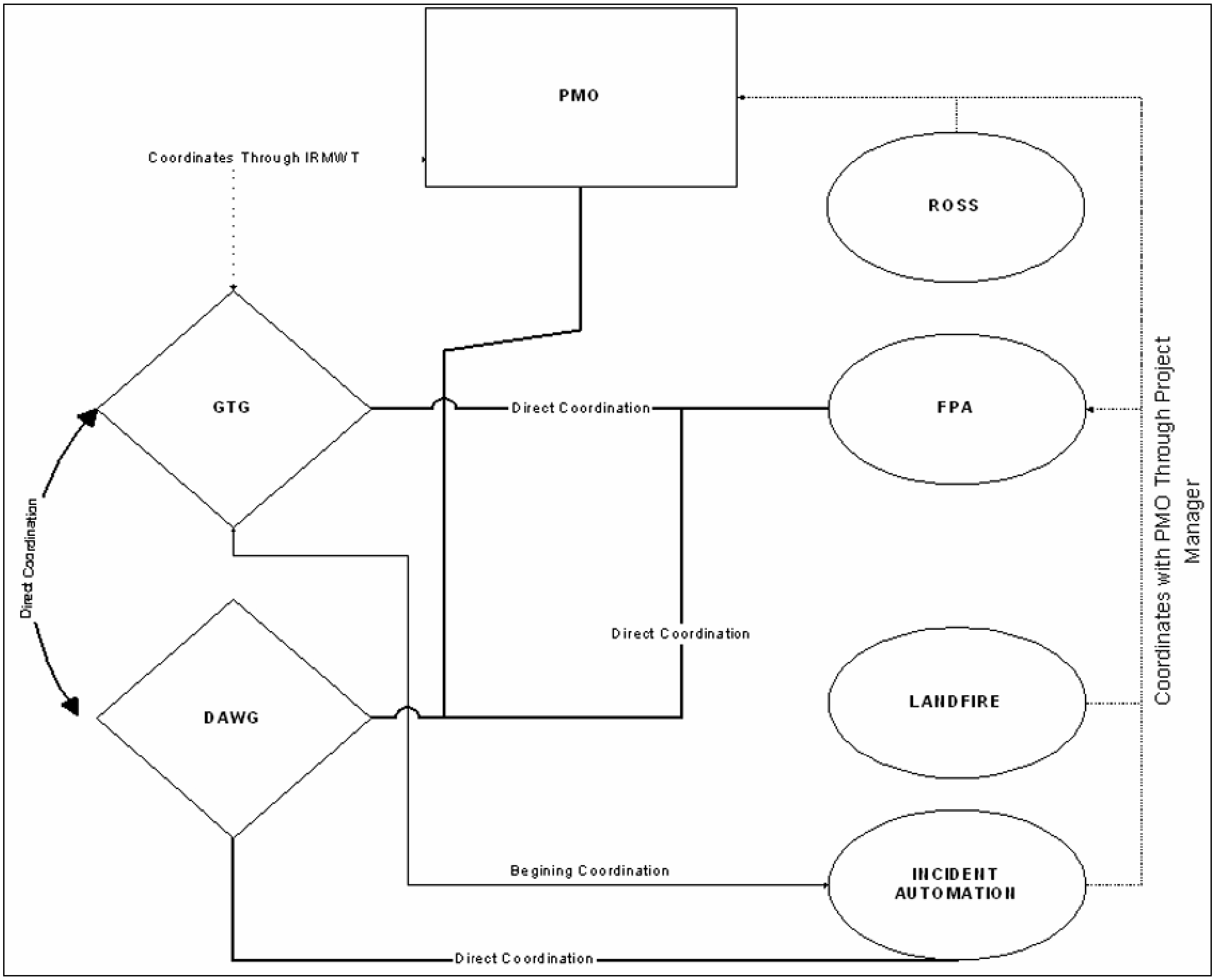

Figure 5-2. Wildland Fire Information Resources Groups and Projects
Courtesy of Joe Frost, U.S. Forest Service Fire GIS Coordinator

5.2.1.3 National Interagency Coordination Center

Work by the National Interagency Coordination Center (NICC) is one of the key functions that occurs at NIFC. When wildland fires are deemed to be of national proportion, NICC is the operation that coordinates and makes key resource deployment decisions at the nationwide level. These decisions include determining critical priorities concerning where limited resources will be dispatched when there are more needs than available resources, as was the case in particular during the 2000 fire season. NICC capabilities are used to quickly locate and mobilize emergency personnel, equipment, supplies, and aircraft for fire suppression efforts. NICC works with and is supported by eleven Geographic Area Coordination Centers (GACCs), that are located regionally throughout the country, and in turn work with local dispatch centers. There are three tiers of resource deployment centers and decision making that begin with locally-based federal and state dispatch offices. NICC has established the following resource ordering protocols (from NIFC, 2001b):

1. Federal and state dispatch offices located throughout the United States receive requests for personnel, equipment and supplies to support fire and non-fire emergency incidents.
2. When these local dispatch offices can no longer fill the orders, they then turn to one of the eleven Geographic Area Coordination Centers (GACCs) to fill the requests.
3. When GACCs can no longer meet the requests because they are supporting multiple incidents, or when GACCs are competing for resources, the request for equipment and supplies are referred to NICC.
4. NICC coordinates supplies and resources across the U.S., and provides support to incidents in foreign countries. The National Multi-agency Coordinating (MAC) Group establishes priorities. The federal and state representatives for this group are responsible for responding to wildland fire and other events.
5. Based upon the "closest forces" and "total mobility" concepts, NICC will request the closest available qualified resources, regardless of agency affiliation.

In addition to coordinating resources among the GACCs, NICC can also dispatch helicopters, air tankers, infrared imagery aircraft, and large jets for crew transport, teams, and equipment. NIFC is also a conduit for spatial and image data that is used by wildland fire managers. The center provides updated fire maps, fire statistics, and education services. As described in Chapter 2, NIFC is also the site where the Joint Fire Science Program is housed. This program is designed to provide a scientific basis and rationale for implementing fuels management activities, with a focus on activities that will lead to development and application of tools for fire managers (NIFC, 2001c).

5.2.1.4 Geographic Area Coordinating Groups

In addition to the NWCG, the secretaries of Agriculture and Interior also chartered Geographic Area Coordinating Groups (GACGs) to serve a similar role at the regional level. Membership in the GACGs generally consists of the federal agencies within the geographic area and representatives from the state forestry organizations (SFOs) in the region. However, some of them have broader representation, such as the Pacific Northwest Coordinating Group (PNWCG), which also includes the State Fire Marshals and representatives from the local fire chiefs in Oregon and Washington. Some of the GACGs also address issues beyond coordinated suppression efforts, such as PNWCG which has developed a joint federal/state response to the National Fire Plan.

5.2.1.5 Geographic Area Coordination Centers

As shown in Figure 5-3, eleven GACCs exist throughout the country, each one serving a specified geographic area (http://www.fs.fed.us/fire/links2.shtml#gacc). The primary mission of each GACC is to provide cost-effective and timely coordinated efforts for emergency response for all incidents within the specified geographic area. Each GACC interacts with the local dispatch centers as well as with NICC and neighboring GACCs. When local personnel and equipment are not adequate to manage a wildland fire, the responsible agency will contact its GACC, which will locate the needed resources within its geographic area and dispatch them to the fire. The GACCs also are responsible for determining needs, coordinating priorities and facilitating the mobilization of resources from their areas to other geographic areas, as needed. If a GACC cannot meet the requests for resources within its region, it refers requests to NICC.

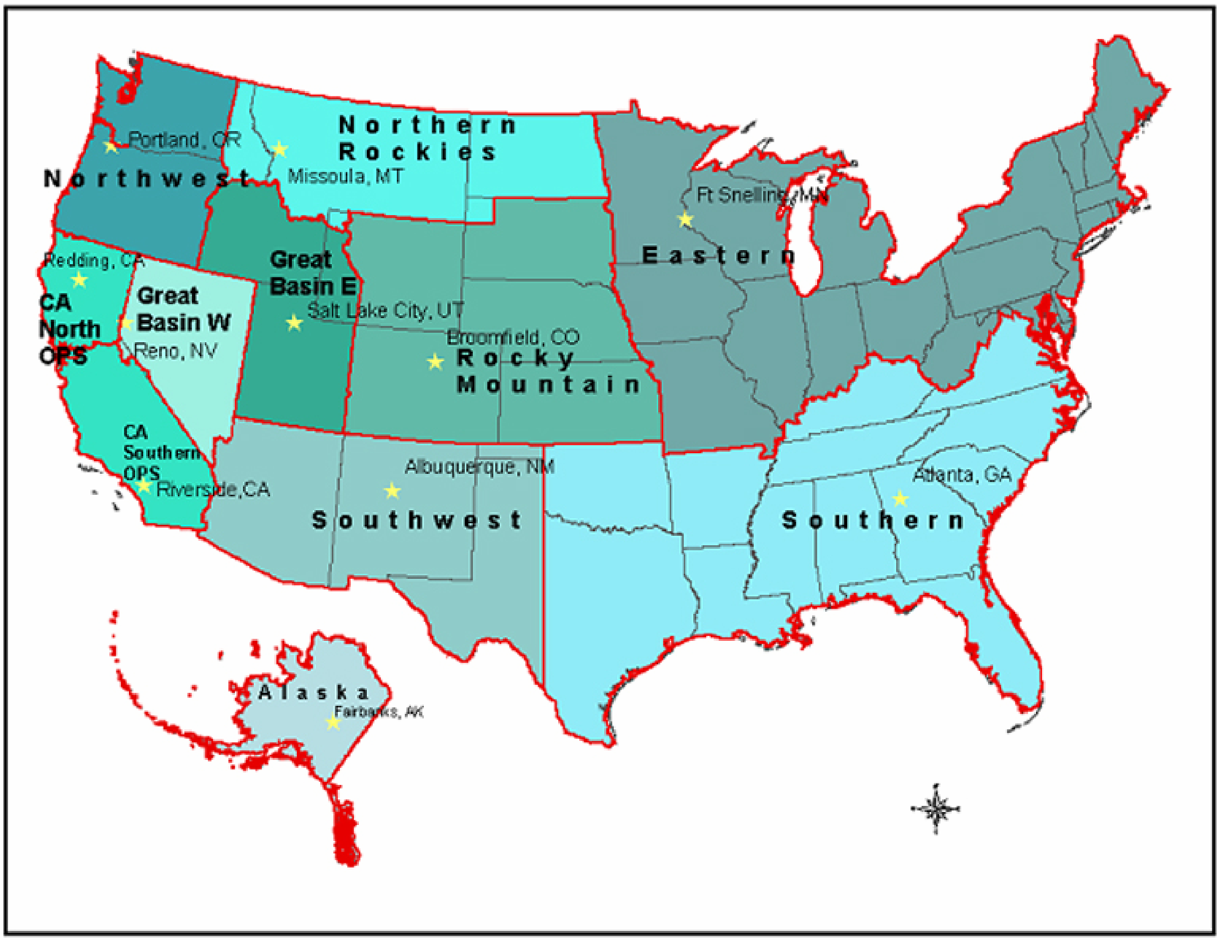

Figure 5-3. Map of Geographic Area Coordinating Centers (GACCs)

Each GACC prepares an intelligence report that consolidates fire and resource status information received from each of the local dispatch centers in its area. This report is sent to NICC and to the local dispatch centers and area and agency managers.

5.2.1.6 Local Unit/Interagency Dispatch Centers

These centers are located throughout the country, as dictated by the needs of fire suppression agencies. The principal mission of a local dispatch center is to provide safe, timely and cost-effective coordination of emergency response for all incidents within its specified geographic area, particularly for initial attack and the ordering of additional resources when fires escape initial attack. Local centers provide information to their GACC and others. Some local dispatch centers are also tasked with law enforcement and agency administrative work for non-fire operations.

5.2.2 National Interagency Incident Management System and Incident Command System

One of NWCG's major roles over the years has been the implementation and support of the National Interagency Incident Management System (NIIMS). It provides a total systems approach for response in a variety of emergency situations, including fires, floods, earthquakes, hurricanes, tornados, tsunamis, riots, hazardous material spills, and other natural or human-made incidents. NIIMS provides support in fires by providing additional support to wildland fire protection agencies when needed. A key part of NIIMS is the Incident Command System (ICS) (http://www.fs.fed.us/fire/operations/niims.html). ICS is based on a number of central ideas, including:

- the development of common terminology to facilitate interagency communication;
- modularity in nature to enable flexibility,
- defined span of control to strictly define functions for participants,
- an integrated telecommunication system,
- unified command to enable interagency centralization,
- consolidated action plan for both tactical and support activities for a set time period, establishment of specific incident facilities, and
- comprehensive resource management, including equipment and resources.

The ICS methodology is flexible, comprehensive, and a universal approach to coordinating operations. There are five functional areas in ICS as shown in Figure 5-4. Each part has associated roles and responsibilities, including command, operations, logistics, finance, and planning. The concentration of the GI/GIT use has customarily been within the Plans Section. Other key parts include training, qualifications and certifications for ICS positions, publications, and supporting technology.

ICS is an onsite management system applicable to fire and other emergencies, and provides an effective means of managing and coordinating multi-agency responses to such events. ICS includes a standard and commonly accepted organizational structure, staffing and qualifications, training requirements, procedures, and terminology. It helps to mitigate incident risks by providing accurate information, strict accountability, planning, and cost-effective operations and logistical support for wildland fires and other emergencies However, as discussed below, neither NIIMS or ICS specifically address GI/GIT, thus contributing to its inconsistent use in wildland fire.

As discussed in Chapter 2, recent efforts are underway in the new Department of Homeland Security to enact new version of these systems for homeland security, such as a new National Incident Management System (NIMS). A draft of this system is now under review. Concerns have been expressed by the fire and broader emergency management community about potential inconsistencies in these systems, and by the GI/GIT community about the need for both approaches to address and promote consistency in the growing use of geospatial data and technology in incident management.

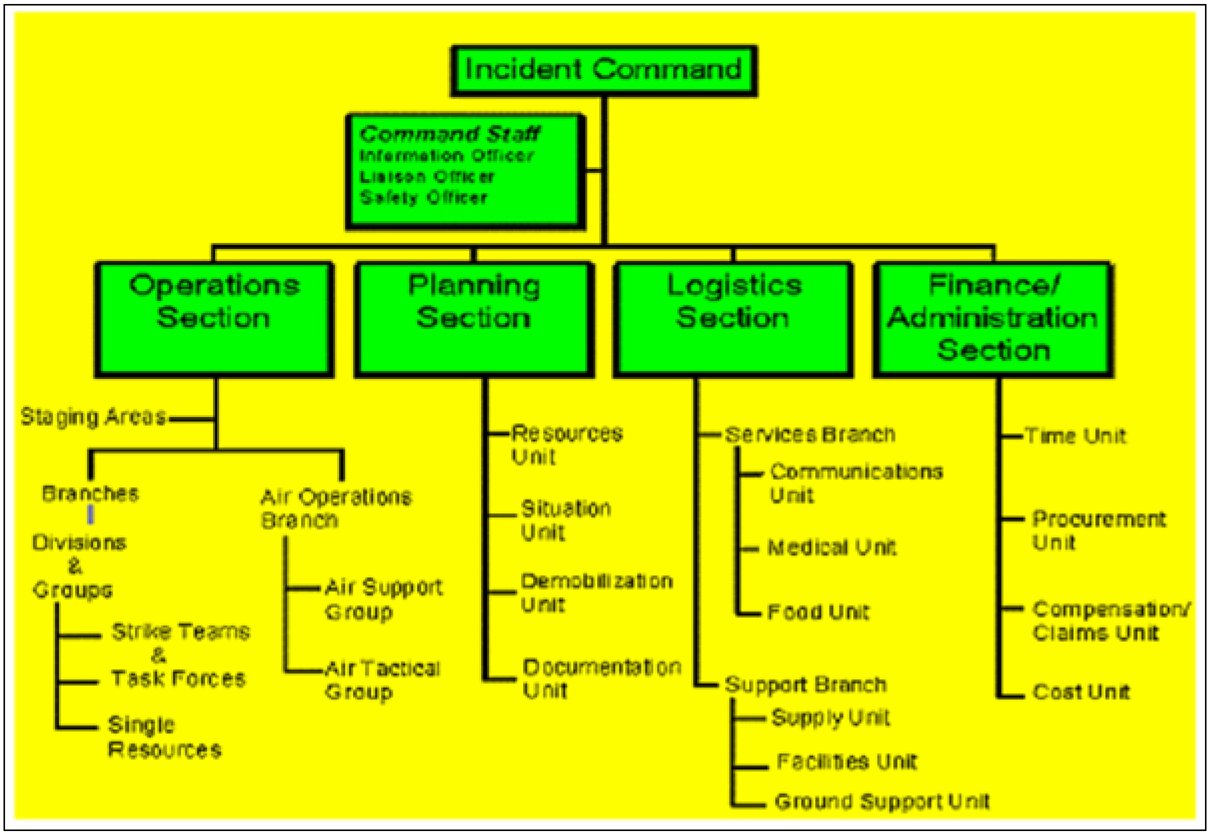

Figure 5-4. Incident Command System (ICS) Organizational Chart

5.2.3 Incident Management Teams

Incident Management Teams (IMTs) are comprised of standardized staffing resources. The standardization of these positions and their established reporting hierarchy and roles are critically important components of ICS. Type 1 and Type 2 Incident Management Teams (IMTs) are most common nationwide, though some parts of the country have Type 3 teams. When assigned, IMTs serve administrators of a local administrative unit or a group of units and abide by the policies of the agencies for which service is being provided (Eastern Great Basin Coordination Center, 2001). Teams are strategically located, with a majority located in the western states. Some state forestry organizations also have their own state based teams, such as California, Florida and Oregon. Teams are managed on an annual rotational basis through the Geographical Areas and can consist of members from a wide variety of federal, state, county, and local agencies. The major difference between the three types of IMTs is the complexity of the incident or associated potential risks.

Type 1 IMTs include those that meet required qualifications locally within a specific region or state, and secondly, those that are known as "National" Type 1 IMTs. The National Teams represent the highest level of incident management expertise in the nation, participate in a national rotation throughout the GACC areas, and may be mobilized in any kind of incident. Normally they are ordered and assigned to high-complexity incidents involving multiple agencies or jurisdictions, complex logistical support needs over extended duration, high-level political involvement, and high-risk resources, public safety, or life/property (Eastern Great Basin Coordination Center, 2001) (http://www.r5.fs.fed.us/fire/team1/about.htm). As a general rule, Type 1 National Teams manage large wildland fires with over 500 people assigned and address the most complicated logistical, fiscal, planning, operational and safety issues. The Command and General Staff on National Teams must successfully complete Advanced Incident Management training at the National Advanced Resource Technology Center in Marana, Arizona before participating on these teams. They are also staffed to be fully functional in all ICS sections, have expertise to manage complex air operations, and can expand to support numerous divisions and groups for extended periods of time.

Type 2 IMTs are staffed to manage incidents complex enough to exceed the capabilities of a Type 3 team, but of less complexity than would require a Type 1 team. Type 2 Teams generally manage less complex wildland fires, have less than 500 people, and address less complicated management issues. All ICS Section Chiefs positions are staffed, but management experience is generally less than in Type 1 Teams. Type 2 IMTs generally have limited capability to manage complex air operations. They are best used for short duration incidents or for those that are not the highest priority, for whatever reason. These IMTs are complemented with additional resources that are deployed on the front lines of wildland fire as described below.

Fire use management teams (FUMTs) are identical in core incident command structure as other IMTs. However, their mission and objectives diverge significantly. While fire response IMTs focus on suppression, FUMTs focus on the application of prescribed fire and planned use of wildland fire to meet specific resource objectives, including habitat improvement, fuels reductions, and species regeneration. In most cases fire use must be specified in resource management plans of the managing agency prior to applying fire use techniques. Ultimately the application of fire use in prescribed fire or managed wildland fires through the aggressive use of fire and mechanical fuel treatments can dramatically reduce severe wildfires and improve ecosystem health.

GI/GIT is well integrated into FUMTs through mapping, analysis, and reporting. GIS staff are utilized on FUMTs to support fire behavior prediction modeling, such as using FARSITE software discussed in Chapter 3. The NWCG Fire Use Working Team is chartered to advocate the use of wildland fire to achieve land management objectives, promote greater understanding of the role of wildland fire and its effects, and to recommend and maintain a fire use qualification system.

5.2.4 Hotshot Crews

Interagency Hotshot crews are professional wildland fire suppression teams that are specifically trained, organized and equipped for rapid response to wildfire situations (http://www.umt.edu/globalfirenet/nationalpage.htm). Hotshots are diverse teams of career and temporary agency employees who work in difficult fire environments. Hotshots uphold a tradition of excellence and have solid reputations as diverse, multi-skilled professional firefighters. The nation's 70 hotshot crews are employed by several agencies and are housed by individual agencies even though the may have members from other organizations. These agencies include the U.S. Forest Service (53 crews), Bureau of Land Management (8 crews), National Park Service (2 crews), various Native American Tribes (5 crews) and State Forestry Agency crews (2). Hotshot crews started in Southern California in the late 1940s. The name was in reference to being in the hottest part of fires.

Hotshot crews utilize pulaskis, chain saws and fire to create a "fuel break" between the fire and unburned fuel. Trees and brush are cut down and the ground is scraped to mineral soil to create a line the fire cannot cross. However, wind driven fires can cross almost any barrier including rivers and mountain ranges, so sometimes the crews just hold what they can and wait for the wind to die or the weather to change.

Hotshot crews travel throughout the west by truck, van or plane, and either hike or are flown in by helicopter to remote sites. Crew members pack all the water and supplies needed during a 12 hour (or longer) shift and sleep on the ground near where they work. Personnel must be available 24 hours per day, and 7 days a week during the fire season.

Information and communications are critical components of hotshot work. They ideally maintain contact with fire dispatchers at all times in case additional firefighters or supplies are needed or if they run into problems. Most crew members carry pagers or cellular phones to stay in contact in case of a fire assignment. However, there have been numerous reports of crew members not being able to be in complete contact with others during fire incidents due to communication systems problems. Hotshot crews utilize GI/GIT when made available to them. Information provided to the crews varies significantly. Sometimes, but not always, they are given copies of topographic maps or images. More and more crews utilize devices such as GPS receivers and mobile units, but issuance of these resources also are not standard operating procedure for them.

5.2.5 Smokejumpers

Smokejumpers are uniquely trained firefighters who jump out of airplanes and parachute using square shuts (BLM) or round shuts (USFS) in order to attack wildland fires in remote areas (http://www.nwlink.com/~rhubble/smokejumpers/). Smoke jumpers are a national resource and they are occasionally used as Type 1 crews. There are about 400 smokejumpers nationwide at any one point in time, which are employed by either the Forest Service (7 bases) or BLM (2 bases). Smokejumpers are not required to be qualified as hotshots, but this hand crew training is an ideal background. The jumpers are deployed in teams ranging from two to 16 people (Bureau of Land Management, 1998).

Once a team reaches the area in which they are to fight a fire, the plane circles while the jumpers decide the safest way to attack. A smokejumper "spotter" in the plane drops weighted paper streamers from the aircraft to determine the speed and direction of the wind. The airplane then climbs to 3000 feet and two jumpers exit the plane on each pass over the jump spot, with repeated passes until all of the jumpers are on the ground. After the jump, cargo boxes with tools, food and equipment are dropped nearby. Once on the ground, working conditions are similar to that of hotshot crews, but likely are in more remote locations. Also similar to hotshots, they ideally maintain contact with fire dispatchers at all times during fires via radios to access assistance. However, they similarly have experienced communication systems problems and may not be in adequate contact with others.

Smokejumpers typically have little information about their intended and actual surroundings when they are deployed. This is perhaps because they are often deployed quickly and much attention is necessary to ensure that all required equipment is included,. They may not have copies of topographic maps of their work areas, much less nearby areas incase a fire changes course and they need to determine alternate safety zones or escape routes (Chamberlin, 2001). During the 2002 fire season, efforts were made to provide some version of topographic maps such as from a commercial source, and to provide GPS receivers upon request, such as at the Forest Service's Missoula Smokejumper Center (Naubunsee, 2003). However, use of GPS receivers continued to be optional at the center in the 2003 season. Some training is provided at this site, but it is informal and lacks standardization for all smokejumpers.

Geospatial data and devices such as GPS receivers can help smokejumpers to identify and communicate their location for guidance and planning, and to let others know if problems occur and assistance is needed. Until recently, if a smokejumper wanted to use a GPS receiver, he had to provide his own. As discussed below, such information is a critical requirement for smokejumpers, firefighters on hotshot and helicopter crews, and others on the ground. Many firefighters risk their lives but remain insufficiently equipped with information and associated technology to ensure their safety, though firefighter safety is specifically indicated to be the wildland fire community's top priority.

5.2.6 Resource Deployment

The National Fire Equipment System (NFES) includes a fire cache with over 5000 items, including materials, tools, equipment, and supplies that support 10,000 firefighters and wildland fire operations. The eleven Geographic Area Coordination Centers (GACCs) use the system with NIFC to track and order items that move among the GACCs as needed to respond to fires. These resources are managed, serviced and repeatedly distributed by the GACCs, with the inventory capable of being recycled in less than 24 hours. Each year the approximate $13 million inventory may turn over three or four times, with 75% of the items returned and serviced for use again, thus avoiding new purchases and expenditures.

Despite the success in recycling items at NIFC and the GACCs, resource ordering procedures have become dated, with efforts now underway to replace the ordering system that originated almost 20 years ago. Current procedures rely heavily on paper order forms and dispatch officials closest to a fire that must make repeated telephone calls, faxes and emails to determine which crews, supplies, planes and special equipment are available. Many calls and other contacts are made, and distortions and errors can be included in information as it is passed along the way. This is particularly problematic because each dispatcher in the ordering chain must complete their own copy of the order form. In addition, there is no standard method of reporting resource status.

As a result, the Resource Ordering and Status System (ROSS) was developed and has been deployed during the 2003 fire season. ROSS is unique because it is one of the first large scale interagency information systems in the nation involving so many federal and state agencies, and particularly because it must operate at multiple levels within each agency and the many interagency dispatch offices. When fully operational, it will be used at nearly 400 dispatch offices across the country that are affiliated with NWCG. ROSS will automate the resource ordering and status reporting process, and give responders an instant view of what resources are available and where. It will read the NFES cache catalog, enabling periodic downloads of current cache inventories, but they have two separate databases. It is a web-based application developed in Java that exchanges data through Extensible Markup Language that was designed by Lockheed Martin Information Systems. It includes several commercial off the shelf products, but according to some in the fire community, it does not make full use of current GIS capabilities at this time. Problems also have been reported about data imprecision and inaccuracies in terms of the reported location of key resources when these data are plotted out on a map because some are "located" hundreds of miles away or not even in the United States. Moreover, ROSS does not eliminate the need for computer-aided dispatch (CAD), E911 or R911, which also are used for fire (Gray, 2001).

5.2.7 Communications Systems

Dispatch centers are located around the country and are a key component of the communications mechanisms used in wildland fire management. As described above, personnel at these centers have a key role to determine and communicate resource requirements. The principal mission of a local dispatch center is to provide safe, timely and cost-effective coordination of emergency response for all incidents within its specified geographic area, particularly for initial attack and the ordering of additional resources when fires escape initial attack. Some local dispatch centers are also tasked with law enforcement and agency administrative work for non-fire operations. Local centers provide information and make resources requests to their Geographic Area Coordination Centers (GACC) and others as conditions require.

The primary mission of each GACC is to provide timely coordinated efforts for emergency response for all incidents within a specified geographic area. Each GACC interacts with the local dispatch centers as well as with NICC and neighboring GACCs. When local personnel and equipment are not adequate to manage a wildland fire, the responsible agency will contact its GACC, which will locate the needed resources within its geographic area and dispatch them to the fire. The GACCs also are responsible for determining needs, coordinating priorities and facilitating the mobilization of resources from their areas to other geographic areas, as needed. If a GACC cannot meet the requests for resources within its region, it refers requests to NICC.

Information is a key component of the role of these centers. Each GACC prepares an intelligence report that consolidates fire and resource status information received from each of the local dispatch centers in its area. This report is sent to NICC and to the local dispatch centers and area and agency managers. ROSS will improve resource ordering, status reporting, deployment, and management, and allow the identification of available resources to be conveniently identified through a computer interface.

Automation of the communications systems at dispatch centers varies, as does the integrated use of GI/GIT. Some fire organizations and centers use computer aided dispatch (CAD) systems. CAD also is increasingly used by other governmental dispatch operations for other emergencies, including by counties. A key benefit of integrated CAD is the ability for sophisticated algorithms and intelligent data to determine nearest resource, accessibility, and time constraints when identifying response resources. For example, the California Department of Forestry and Fire (CDF) is currently implementing a new GIS-based dispatch system statewide. To help, CDF is enhancing existing road data to include 95% of addressable locations within CDF's area of response (Marose, 2001). The South Carolina Forestry Commission also is widely recognized for its innovative CAD system for fire dispatching. Some GACCs also have been very innovative in this regard. However, observations are that several aspects of the dispatch centers and GACCs could benefit by greater modernization and use of GI/GIT and CAD to help them accomplish their missions. As stated above, ROSS will not eliminate the need for CAD systems.

Several different devices are used to support communications at dispatch centers and on the ground, including land line telephones, fax, email, cell phones, and other methods. The National Incident Radio Support Cache (NIRSC) provides the standard communication equipment for IMTs and the crews described above. NIRSC possesses portable low-power communication equipment for fire management personnel such as the firefighters described above. NIRSC also has 1,200 communications “kits” that contain a range of equipment, including basic public address systems to advanced wireless and satellite telephony, depending on the specific purpose of the kit for fire management. The cost of these kits and associated test equipment totals over $24 million (NIRSC, 2001). The NIRSC also repairs and maintains over 6,000 hand-held radios. NIRSC also provides equipment to other groups in cases of non-wildland fire related national natural or nuclear disasters. NIRSC is a key component of the National Fire Equipment System described above. Like those resources, the radios are managed, serviced and repeatedly distributed by the eleven GACCs, and are utilized several times during each fire season.

NIRSC equipment is a critically important communications resource, but several problems have been raised, including by firefighters and representatives of local governments. Many firefighters are concerned that radio networks can have dead zones where communications are not possible, and radios may be put in service even if they have malfunctioned in the past. Available radios also may not be necessarily compatible with those of many state and local agencies who are switching to 800-megahertz radios (Marble, 2000). The issue of incompatible radios also is a concern of other emergency responders, and effort is underway to address this matter as part of homeland security and other emergency management work.

5.2.8 Aviation Resources

In addition to the caches of materials located at each of the eleven GACCs are the aircraft owned and contracted for by the U.S. government. Aircraft are a critically important and expensive resource in firefighting that can make a very significant difference in keeping fires small and less expensive. Aircraft are used to conduct aerial reconnaissance, to taxi firefighters, and to drop various supplies, retardants, and ignition devices. The two types of aircraft, fixed wing (airplanes) and rotary wing (helicopters), are differentiated within their category by their payload; each having their particular strengths (Pyne, 1996). In addition to hauling supplies and firefighters and dropping retardant, helicopters are used for laying fire hose and depositing incendiaries. Much of the federal governments aviation fleet come from vintage or retired military aircraft, although aircraft of civilian origin contribute to the fleet as well. States have access to acquire and refurbish decommissioned aircraft though the federal excess property program.

The Modular Airborne Fire Fighting System (MAFFS) is a system owned by the Forest Service and operated via NICC in Boise. MAFFS is also guided by the U.S. Department of Defense. The Air National Guard and Air Force Reserve use MAFFS when they are called upon to assist with wildland firefighting during extreme conditions. The objective of the program is to provide an emergency capability to supplement commercial air tanker support on wildland fires through airborne delivery of fire retardant, which is dropped accurately and safely on a designated target. MAFFS is to be used as a reinforcement measure when suitable contract air tankers are not readily available. The cost of MAFFS per hour is approximately $5000 (Associated Airtanker Pilots, 1999). Additional aircraft are available for fire response, such as the Russian "Water Bomber", a fast, long range Ilyushin jet cargo air tanker holding either 100,000 or 130,000 pounds of liquid that can be filled and ready for takeoff in 15 minutes.

Several air tanker and helicopter crashes during the 2002 season have increased recognition that new approaches are needed. While some issues are associated with the fleet itself, a part of the problem seems to be that the federal government does not provide sufficient direction and resources to prepare or maintain helpful information about conditions on or near the ground that could interfere with operations, such as topography, power lines, and other hazards. Some Forest Service regions direct that each forest maintain a current flight hazard map and update it annually. In these regions, copies are directed to be available where ever flight planning, flight tracking, aircraft dispatch, or flight mission briefings occur, such as dispatch offices, aircraft bases, temporary helibases or special project sites. GIS use is encouraged, as well as development of a flight hazard layer depicting local hazards. The specific content of these maps is described in this direction, including all airports, landing strips, heliports, maintained helispots, avoidance areas, restricted area, flight hazards (e.g., utility lines which cross drainages, television translators, towers, etc.), as well as medical and air ambulance facilities. However, compliance with this directive does not appear to be widespread, and it only exists in some regions.

5.3 GI/GIT RESOURCES USED IN WILDLAND FIRE RESPONSE

The several detection systems described in the previous chapter and the response systems described above join together to provide logistical and resource support to wildland firefighters. Satellite and aerial imagery, maps, digital data products, GIS and GPS are becoming useful for many aspects of wildland fire management. The response phase of fire management can utilize all of the resources identified for detection, but integration, delivery and effective utilization of all useful information is a key challenge and growing requirement. Focus on detection is directed toward obtaining the best information available in terms of accuracy, currency and geopositioning. The response phase is additionally oriented to monitoring frequent changes in conditions, and effectively managing a vast array of data and resources to minimize loss of life and property as well as costs.

Currently, GI/GIT is often used in response activities such as in the monitoring and reporting of smoke and fire conditions, the location of safety zones, logistical support for firefighters on the fire front, and the prediction and forecasting of smoke plume impacts. GIT is also used to report the locations of fire perimeters, the size of fires, hot spots, fire behavior, intensity, and the location of fuel breaks. GI/GIT assists in planning, managing and deploying resources to ensure their most effective utilization. GI/GIT use in the response phase includes the many aerial and satellite based observational activities for detection as described in the above chapter as well as these additional applications. They have served to provide incredibly useful graphical intelligence that support communications internally and with the public as "a picture is worth a thousand words." Virtually any response activity that involves the use of tools or information containing a geographic component can be helped by GIT and by the equipment needed to facilitate the use of these data. The following subsections describe several uses of GI/GIT for fire response.

5.3.1 GI/GIT to Support Incident Command Needs

Computer generated maps using GIS and related computer technology are becoming invaluable tools, which was realized in particular during the fire season of 2000 and every year since. They have served to provide incredibly useful graphical intelligence that support communications internally and with the public as "a picture is worth a thousand words." The types of information supported by incident maps are the location of fire perimeters, their intensity, areas of potential spread of fires through fire behavior analysis, aviation safety and communications, and the fires' proximity to communities using census population data. Computer generated maps are in high demand by the Incident Management Team members and their hand crews, Fire Information Offices, Line Officers and the public. They are used to assist operational decision making requirements, identify impacts to values at risk such as homes and other structures, enhance aviation communications, and identify temporary flight restriction areas.

Fire perimeters are key data for many fire response and reporting needs. They are mapped more accurately and in a timely manner than ever before using satellite imagery and GPS technology. FTP sites facilitate the transfer and exchange of raw data. A complete fire perimeter library can be compiled and ultimately fed into a fire occurrence database. Email and web sites are utilized to mass distribute finished map products to key individuals and managers, such as through GeoMAC and related sites, as described below in Section 5.3.6. Web pages and local newspapers increasingly also use GI/GIT to keep the public informed with current maps, photos, evacuation information, fire weather information and general news on fire information.

In 2002, a group of researchers from the University of Montana and GTG participants, conducted an on site investigation of GIT utilization on wildfire incidents (Burchfield et.al., 2002). They visited several wildfires of varying size and complexity for the purpose of gathering and analyzing information collected in the field on the effectiveness of GIT in support of wildfire management. Their findings were divided into two sections: the utility of this technology, and the requirements for successful application. The investigation confirmed that GIS and GPS were useful in providing timely cartographic products to the incident command team with acceptable reliability in most cases. GIT was found to be especially useful decision support on larger, more complex campaign fires; simultaneously providing a continual information stream to the public and legislators. The specific map product needs varied from incident to incident. The integration of GIS with infrared products was considered as a useful data information stream, such as combining delayed field-based perimeter data with near real time aerial photography. Several incident commanders indicated that GIT was not being utilized to its greatest potential as there was much work for a few map products. GI/GIT was reportedly more widely used for cartographic purposes, and less so for strategic decision making. More extensive usage could provide further refined information and sophisticated spatial analyses to aid in many aspects of fire response.

Under the sponsorship of NWCG, an additional effort is underway to broadly consider, determine and address fire incident automation needs. This effort is informally organized at this time because funding and project management decisions have not yet been made. However, it could help to more fully determine, elaborate and advance current and future GI/GIT uses and issues in this broader incident automation context.

5.3.2 GI/GIT Staffing and Training

While many staff in ICS positions and others have used GIS and other GIT during actual fire incidents, a key problem to date has been that there is no requirement for GIS, GPS or other modern GIT capabilities as part of the ICS personnel qualifications standards. Computer generated maps have been in high demand by Incident Commanders, various staff members and their hand crews, Fire Information Offices, Line Officers and the public. However, lack of specific qualifications, standards and protocols for GI/GIT, and particularly for staffing, have led to several problems discussed below (Geospatial Task Group, 2000).

A key component of wildland fire response is to maintain a high standard of qualification by individuals participating in the ICS. To this end, a national interagency fire qualification system was developed. Under the guidance of NWCG, this collective certification process outlines minimum qualifications necessary for each recognized position responding to both wildland and prescribed fire assignments. The goal is to establish minimum interagency training, skills, knowledge, experience and physical fitness standards for all recognized positions. The "Wildland and Prescribed Fire Qualifications System Guide" (PMS 310-1), details the necessary qualifications, as well as trainee requirements. To complement these defined minimum qualifications, formal training curricula were developed for nearly every position in fire management (Pyne, 1996). The system is a "performance based" system, in that the primary criterion is successful performance by an individual as observed by a qualified evaluator and documented in an approved position task book. Each agency is responsible for tracking the qualifications of individuals within their organization. The national Incident Qualification System (IQS) assists in this process.

There are a set number of positions recognized through NWCG, and a multitude of "technical specialist positions". The primary difference between the two is that technical positions support fire management but the minimum qualifications are not set by the official fire qualification system due to the "special skills" associated with them. These technical specialists range from aviation fuel specialist to archeologist. Specialists are considered to be qualified from their field or profession. Although, no minimum qualifications are identified by the fire qualifications system, familiarity with the incident command system (ICS) is suggested. Recommended courses are Introduction to ICS (S-100) and Wildland Fire Suppression Orientation for Non-Operations Personnel (S-110).

Many positions throughout ICS, both technical and NWCG, utilize GIT. The Geographic Information System Technician (GIST), Infrared Interpreter (IRIN), Fire Behavior Analyst, Long Term Fire Analyst, and Computer Technical Specialist (CPTS) utilize these tools extensively. The GIST, IRIN, and CPTS are technical specialist positions while the others are not.

The GIST position has evolved as GIS software became increasingly available and recognized as a needed support tool during the late 1990s. Fire incident mapping is critical to appropriate allocation of resources as well as strategic planning for both wildland and prescribed fires. A mnemonic was created to facilitate resource ordering. However, many GIS technicians were called to incidents that were not qualified, or did not understand what was expected of them or the context in which they were working. This was due to the lack of standardization for incident support mapping in regards to key roles, responsibilities, knowledge, skills and expectations.

As explained in Section 5.2.1.2, the Geospatial Task Group (GTG) was chartered to address the problem of standardization, and specifically to assure proper and efficient use of GIS in the support of wildland fire response. In order to identify the extent of the issue, several workshops were conducted to garner input from the multitude of players; from incident commanders to GIS technicians and agency coordinators. The results have been published in several reports (Burchfield, et.al., 2002; Geospatial Task Group, 2002). The GTG, as well as California's interagency FIRESCOPE program (discussed in Chapter 3), is working diligently to define the knowledge and skills required for the GIS Technical positions, including thorough examples of the numerous maps that may be required. A summary of suggested GIS Technician Skills is shown in Figure 5-5.

Knowledge	Description	Skill
GIS Software	Advanced knowledge and skills in standard GIS software: ESRI ARCVIEW 3.x or ARCGIS 8.x.	Master mapping and editing functions. Attribute fire perimeter with standard information, including fire name, collection date, and collection method.
		Ability to utilize the standard mapping extensions or tools available for the ESRI GIS product line.
Cartographic Products	Timely create incident maps for use at incident for overhead team, public, and field needs.	Ability to produce, at minimum, the 5 major maps: Incident Action Plan Map, Briefing Map, Transportation Map, Facilities Map and Situation Unit Map at varying sizes.
		Incorporate ICS symbology into map products using industry standard GIS tools.
Data Acquisition	Ability to obtain relevant GIS base layers needed to produce informative map products.	Acquire from pertinent GIS data local unit, Internet providers (public and private), clearinghouses, FTP sites, and others sources.
Standard Data Formats	Ability to integrate relevant GIS data (vector and raster) from different standard industry formats into incident mapping efforts.	Determine and integrate standard GIS formats such as shapefiles, coverages, feature classes, grids, geotiffs, geojpeg, Mr. SID, digital ortho-quarter quads (DOQQ), and USGS digital raster graphics (DRG).
Use of GPS	Familiarity with GPS, accessories, and software tools to facilitate downloading and integration into GIS.	Ability to collect and manipulate GPS data, create fire perimeters, and other pertinent incident data in order to incorporate into GIS.
Projections	Understand the concept of geographic projections. Have the ability to determine projection type and take appropriate actions.	Identify and incorporate GIS data into appropriate projection. Re-project data into all ESRI supported North American projections in order to use on incident.
File Naming Conventions	Follow standard file naming conventions for incident GIS data.	Ability to utilize standard file naming convention identified for Incident.
Communication:	Communicate effectively with ICS staff (Situation Unit Leader, Plans Chief) in a timely manner.	Ability to identify hardware, software, data, and any other needs and communicate to appropriate person.
Hardware/Networking (Recommended)	Some knowledge of basic hardware and networking concepts.	Familiar with HP plotters and knowledge of installing and supporting basic functions of network.
ICS Training Classes	♦ Introduction to ICS (I-100) ♦ Wildland Fire Suppression Orientation for Non-Operations Personnel (S-110) Video ♦ Incident Command System Basics (I-200)	OR Red Card Certified
Other Training	Display Processor (S-245) one day GIST Training Course GPS for ICS	

Figure 5-5. Summary of Needed GIS Technician Skills
Courtesy of the NWCG IRMWT-Geospatial Task Group (GTG)

Provision of staff with GI/GIT capabilities to fire camps has been a significant challenge to deploy and fully utilize this technology. Standard GI/GIT qualifications, equipment requirements and data protocols and availability are key needs that have been addressed in some fire organizations, though they are not nationwide requirements today. For example, the California Department of Forestry and Fire (CDF) has created a GIS Technical Specialist job series class from which qualified staff can be ordered like other resources. As regular practice, CDF assigns one or more of these individuals to each Incident Management Team (IMT). CDF also annually provides a CD of relevant statewide data specifically for use on fires, and has standardized symbols and some customized fire-related GIS tools that staff are trained to use. Other states and federal agencies are also moving in this direction, but more slowly, and could benefit greatly if national standards could be established and recognized by fire management leadership.

As noted earlier, other positions also utilize GI/GIT to support the fire management community during the response phase. A particularly important one is the Infrared (IR) Interpreter. As described in Section 4.3.3, the National Infrared Operations Group at the National Interagency Fire Center (NIFC) in Boise has a long and well established history. A tremendous investment has been made to maintain the fleet of airplanes, upgrade the hardware and software of the IR equipment, and to have trained technicians to run the IR scanner, as shown in Figure 5-6. On an incident, it is necessary to have an IR interpreter to assist in the development of fire perimeters and to identify the location of hotspots during the course of the incident.

Figure 5-6. Infrared Interpreter at Work
Courtesy of the U.S. Forest Service
(http://www.fs.fed.us.fire/niicd/Infrared/Infrared.html)

Standardized training is a crucial issue for fire GI/GIT staff. In order for staff to effectively and efficiently create the cartographic products (or analysis) necessary to support the Plans Section, standardized training needs to be supported and sponsored by the fire management community. Moreover, awareness about standardized training is needed by other parts of the fire community. It is particularly necessary to inform incident commanders and other fire leaders about the realistic and appropriate use of GI/GIT, and the resource requirements and infrastructure to support it, including dedicated staffing.

Due to the lack of training targeted to applying concepts, knowledge and skills of GPS and GIS, two courses were developed: GPS for ICS and GIS Technical Specialist. The Geospatial Training Advisory Group (GTAG) has been informally established to coordinate these courses with sponsorship by the BLM National Training Center.
A GIST course was developed in California in 1998, and has gone through several iterations since then to become a highly sought after course by fire and technical personnel throughout the country.

The purpose of the GPS course is to provide both incident command staff and firefighters with a working knowledge to use GPS receivers for field mapping applications. Students plan and execute GPS missions to practice the skills needed to provide geospatial data support to the ICS. Other than this class, it is expected that field units will provide necessary GPS training to individuals. However, GPS use is proliferating in fire as described below, and many staff using GPS have not taken this class or any formal GPS training. As a result, standard data approaches are not used and data may need to be reconciled if errors and discrepancies are discovered, as discussed in Section 5.3.3.1.

A course that is targeted to Fire Behavior Analyst and Long Term Fire Analysts is FARSITE: Fire Area Simulator Course (S-493). This course teaches how to use the software application FARSITE, which allows analysts to predict fire behavior based on weather, fuel, topography, and canopy, all within a mapping interface. Although not a dedicated GIS course, FARSITE does utilize digital geospatial data with GIS and may require some support by GIS technicians on fires. For this reason, GIS technicians, coordinators and managers are encouraged to audit the course.

5.3.3 GI/GIT Equipment

Appropriate equipment is another key issue to successfully utilize GI/GIT at fire camps. Reports are that simple lack of color copiers at fire camps has meant that duplicated copies of maps may not show vegetation, a key factor in terms of fire potential, behavior and safety (Cox, 2001). Again, each incident varies in complexity and needs. However, having standardized hardware outfitted with appropriate software and core data would substantially ease the process. Over the past five years contractors have found a niche in providing outfitted trailers ready to produce required map products in a short period of time. However, this has been shown to be expensive so alternatives are being evaluated by fire management agencies; including the development of complete incident command kits that would support all technology aspects of the incident. A proposal by IBM was submitted to the U.S. Forest Service to create all risk National

Incident Mapping Information Kits suited to varying needs of the incident (IBM Team, 2002).

The purpose of the Incident Management Kits would be to provide the computer systems infrastructure to automate tasks performed by the interagency Incident Management Team, including federal, state and/or local representatives. These tasks are performed in the management of the business aspects of the incident, such as resource procurement and tracking, finance management, and payroll and other human resource management. In addition, the kits will enable incident management staff to more effectively manage tactical planning and information dissemination aspects of the incident, including management of shift plans and dissemination of data, including GIS, Incident Action Plans and Web site updates. To meet this purpose, IBM recommended the kits be (IBM Team, 2002):

- Composed of commercial-off-the-shelf components,
- Pre-tested with a common systems (hardware, software and networking) baseline,
- Able to be deployed from an Agency equipment cache and shipped rapidly to a new incident,
- Unpacked and operational in a short time at the incident (hours instead of days or weeks) and able to remain there until de-mobilization or no longer needed,
- Reconditioned quickly back to the common systems baseline for re-deployment to the next incident, and
- Capable of an annual technology update refreshment.

It also is necessary that the kits be self-contained and turnkey, with all the necessary components, including: equipment, network, software, and peripheral bundles for maximum effective management of the business aspects of the incident. The Southeast Region (8) of the U.S. Forest Service may prototype this system in the near future. This type of preplanning and prepositioning of equipment needs would significantly increase the successful utilization of GIT, providing a standard that all the IMT's across the country could adopt.

The Oregon Department of Forestry (ODF) is one of several organizations that have addressed GI/GIT equipment needs by equipping GIS on a mobile vehicle that can be taken in the field to provide fire mapping support (Kinslow, 2001). The Department currently has two trailers that provide space and equipment for fire mapping and analysis services at fire camps. Morning and evening shift maps are created as well as briefing material, special request maps of the fire and adjacent areas, and applications such as slope analyses, orthophotography overlays, acre calculations, and ownership breakdowns. The trailers carry multiple laptop and desktop computers, printers, plotters, appropriate GIS software, and data needed to produce the basic cartographic products (http://www.odf.state.or.us/gis/pdf/firedebrief801.pdf). Another example is the Minnesota Department of Natural Resources, which has a tow-behind GIS trailer to support emergency incidents and provide on-site spatial information (http://www.ra.dnr.state.mn.us/mapmobile/).

5.3.3.1 GPS Receivers

Global Positioning System (GPS) receivers are increasingly utilized in many aspects of fire response. If an individual has such a receiver, depending upon its grade and quality, then that firefighter knows and can transmit, either automatically or via communications devices, their precise location to others. This can be a critically important set of information for safety as well as in deployment of resources to fight fire. More and more vehicles used for fire are equipped with GPS receivers in order to facilitate their tracking and deployment by fire managers.

GPS receivers are also utilized to gather and record key information about fire incidents. A critical part of fire response is the need to accurately know the location of fire perimeters. This is one of the most critical data elements and functions on a fire. Perimeters are often being checked several times a day, and particularly for fire managers to make critical resource deployment decisions at the fire meetings held each morning, known as the “6AM briefings”. However, there is no federal fire management requirement that GPS be used for this task, and other methods can be utilized. There is a definite growing trend that GPS be used for fire perimeter mapping, and some state fire management organizations require it, but teams may not have an individual qualified in the use of GPS to conduct this work as this is not a requirement either. Several problems often result, such as different datums, inaccurate readings, and other discrepancies. These differences must be reconciled, taking critical time away from more important tasks.

However, GPS is being used for additional data collection and applications in some locations. For example, GPS receivers are being used to record the location of hot spots on the ground that then can be compared to information from other sources. The existence and location of burned, burning or threatened structures is also often recorded via GPS. This information can then be shown on a map using GIS to help incident commanders make key fire response decisions. Critical physical features concerning fire, such as roads and streams, are also recorded and displayed. For example, the Oregon Department of Forestry is using GPS receivers in this way, and complementing them with the use of digital cameras so that images of the hot spots obtained at certain GPS points are available at fire camps for decision-making (Kinslow, 2001).

5.3.3.2 Other Mobile Devices

While GPS has been applied for several fire seasons in some parts of the country, a common challenge has been that separate equipment was used; including GPS receivers, lap top computers, radios and cell phones, as well as associated cables, adapters, batteries and other equipment to ease use in the field. These separate systems were utilized in order to gather, display and communicate information. More recently, devices in the form of palm-held wireless units (PDAs) are increasingly becoming more useful to response personnel in the field, particularly as recently linked to GPS receivers. Fire managers can use these integrated devices to receive updated information and maps to help guide their teams to strategic fire lines or to safety. Digital maps, weather information, text messages, as well two-way voice communications, can be sent to a single device to provide advanced decision-making support in the field, providing that wireless data is retrievable in remote locations.

Mobile devices have been deployed in the field for fire management in several places throughout the U.S. For example, Compaq iPAC© units are used by personnel at the Confederated Tribes of Warm Springs, Oregon (Crocker, 2001). These iPAC© units have been fortified with ESRI ArcPad©, a palm-based GIS software, and were also linked to Garmin© GPS units. The combined unit can weigh as little as a pound and fit into the pocket of a flight suit. This group used these devices in various firefighting support activities, including finding the location of lightning strike points that were downloaded onto the palm devices from the Internet. The GPS-enabled iPAC© was also fortified with maps to be used in the field to help the user know where they and the fire front was at any given time. GPS has also been used in an experimental capacity in fire engines, bulldozers, and helicopters so that operators could radio their position back to fire bases.

Figure 5-7. Mobile Mapping Tools Used for Wildland Fire

Combinations of PDAs and GPS receivers with existing data have been particularly helpful during and since the 2001 fire season. For example, benefits at the Viejas fire in southern California that year included the integration of mapping and GPS functions so that positional information was automatically displayed as moving cross hairs on an actual map, rather than as numerical coordinates (Appleton, 2001). Zooming in on the map enables firefighters to see their specific position on the ground. Fire perimeters are also drawn without manual input, while the observer can enter fire area information such as the status of nearby structures using either a keyboard or handwriting recognition software. In addition to this use on the ground, others used similar devices while on board helicopters that are monitoring and defining the perimeter of the fire from the air. This real-time information gathering and display from both sources are then transferred directly back to fire camps. Other useful information during this fire was the automated detection of the fire using GOES-10 imagery for new blaze detection as described in Chapter 4 (http://cimss.ssec.wisc.edu/goes/burn/wfabba.html).

Another useful tool are thermal infrared devices such as Raytheon's Palm IR 250™ that play a role in helping firefighters define the perimeter of the fire and also detecting spot fires by "seeing" hidden hotspots. The device is handheld by a crewmember on a helicopter or by a firefighter on the ground and can be used in conjunction with a GPS unit to map hotspots otherwise obscured from sight. Detection and subsequent extinguishment of such hotspots is critical to avoid blowups in adverse weather conditions (http://www.raytheoninfrared.com/newsroom/Douglas.htm).

Several issues and challenges exist in order to make widespread use of this technology and approach. Despite successes, ground truth and field observers are still needed to confirm information. One challenge in using mobile devices in helicopters is the effort required to ensure pilots work in UTM coordinates rather than geographic ones. Significant rounding errors are sometimes found when using geographic coordinates, which may pose a threat to accurate response to fires (Crocker, 2001).

5.3.4 Supporting Infrastructure for GI/GIT

In order to provide coordination within and between federal wildfire management agencies, dedicated fire GIS positions have been established by US Forest Service, Bureau of Land Management, Bureau of Indian Affairs, and the National Park Service. These positions are at the state, regional or national level. The Fish and Wildlife Service is the only major federal land management agency that does not have a fulltime, dedicated fire GIS specialist. While differing by agency, staff in fire GIS coordination positions typically facilitate the development of agency operating procedures, GIS data standards, conduct training, coordinate conferences and workshops, design databases, conduct analyses, provide recommendations to management on key technology issues, and conduct other tasks related to both information technology and fire mapping support. With leading national fire GIS representatives positioned at NIFC and other federal centers such as those in Denver, there is an opportunity to help develop and support a needed strategic framework for effective GI/GIT utilization nationwide. State governments also recognize the need for dedicated fire GIS analysts and GIS coordinators, and more and more are creating these positions. This provides the needed interface between state and local partnerships as well as with federal cooperators.

The U.S. Geological Survey (USGS), and particularly its Rocky Mountain Mapping Center in Denver, provide added GI/GIT infrastructure to the wildland fire agencies in numerous ways. For example, the center hosts and sponsors internet websites like GeoMAC as discussed below, conducts GIS analyses and map prototyping, provides support staff for administrative functions, and supplies digital data for use with GIS. USGS's EROS Data Center, in Sioux Falls, South Dakota, also aids fire management because it supplies raw and processed satellite imagery and other data products to the Department of Agriculture and Interior through prenegotiated contracts. The Forest Service's Remote Sensing Application Center (RSAC) in Salt Lake City provides additional remote sensing support such as imagery analysis, imagery processing, image processing methodologies, and associated training, as described in Chapter 4.

5.3.5 Geospatial Data, Standards, and Tools for Incident Support

Rapid access to needed foundational geospatial data of the area of an incident is paramount to the successful cartographic presentation and information representation required of incident mapping support. These data typically include roads, hydrography, urban locations, jurisdictional and land ownership boundaries, topography, and digital othophotography, which also are useful for other phases of fire as discussed in Chapter 3. These data are needed to produce the primary maps for the incident action plan (IAP). Most of these data are available at a minimum scale for the entire country through both public and private data sources. Access to statewide core data layers at a central location, such as state GI clearinghouses, would be extremely beneficial. For example, GIS technicians deployed to an incident could access needed information prior to arrival on site. Due in part to this need, a federal FTP site was established to facilitate such information flow, though it could provide more access to state data resources where available (ftp://ftp.nifc.gov).

Much geospatial data is created during individual incidents, such as fire perimeters, fire progression, hotspots, operational division breaks, camp and facility locations, and safety zones. Data management requires diligence and appropriate documentation, but time, resources and protocols are limited to do so. As additional map products are requested and become commonplace, such as inspection maps, vegetation and fuel maps, and other maps, strict adherence to standard naming conventions and the use of a standard computer folder structure becomes increasingly essential.

Data standards are being worked on by GTG for those datasets and field definitions that are considered to be part of “GIS”, such as fire perimeters (Geospatial Task Group et.al., 2002), as well as individual item definitions for geospatial referenced data. Fire GIS technicians need to coordinate with fire business area leads to create useable and standardized data that is useful for not only immediate decision support, but also can be integrated into enterprise databases for long-term planning, research, and analysis. However, Brown et.al. (2002) found that the federal fire occurrence data to be extremely challenging in terms of identifying useable records due to poor recording procedures by the agencies.

Gollberg et.al. (2001) reiterates this need in their recommendation for standards and protocols among land management agencies for fuels mapping and modeling across multiple temporal and spatial scales. The recommended GIS product line that is being used by federal and state fire management agencies is Environmental Systems Research Institute (ESRI). Contracts have been established between the Forest Service and the Department of Interior with ESRI providing unlimited site license and technical support which assists greatly in accessing tools to perform mapping, reporting, analysis, and basic image processing if needed. ArcView© has been ESRI’s flagship desktop mapping application for over a decade. It is user friendly and provides the needed functionality for incident command support. Enhancements or add-ons, created both by ESRI and the user community, provide the added GIS functionality, whether it is data editing, map templates, canned reports, or sophisticated analysis. The standard extension used with ArcView© is Ventura Tools, custom software developed in Ventura County, California. This toolset provides GIS technicians with the ability to rapidly produce needed map products for fire incident support using standard ICS symbology. This toolset is taught in the GIST mapping course. ESRI's more advanced mapping interface, ArcGIS ©, will require time for GIS technicians to develop their skills to provide maximum effectiveness on incidents. GI/GIT professionals will likely always contend and be challenged with the continual evolution of information technology.

5.3.6 GeoMAC

The Geospatial Multi-Agency Coordination Group (GeoMAC) was organized late in the summer of 2000, and developed an Internet based mapping tool that also became known by the same name. It was originally "designed for fire managers to access online maps of current fire locations and perimeters in 12 western states" to assist in making resource deployment decisions (GeoMAC Project Oversight Team, 2001). The desire for information on the status, location and proximity of wildfires to values at risk prompted the formation of GeoMAC with the Great Basin Coordination Group.

The U.S. Geological Survey (USGS), ESRI and others teamed up to develop GeoMAC with only $200,000 in initial funding. It became operational in approximately two months. It represented an unprecedented collaboration by the participants, including donations from various companies. While original developed for the Great Basin Area, its scope was quickly expanded to the entire west during the 2000 season.

GeoMAC, still in operation, is an Internet based mapping application that allows fire coordination centers, incident command teams, and the public, to access information using a standard web browser (http://www.geomac.gov). Fire perimeter data is updated daily based on information from incident intelligence sources, GPS measurements, infrared aerial imagery, and satellite imagery. The status, location and proximity of wildfires to values at risk are also provided. By using a standard web browser, users can download specific data regarding their selected area of interest. The user can turn off and on several map layers, zoom in and out of an area, and download available map data. Users also can download other information maintained in relational databases. Additional data layers, such as fuel status, fuel type, consumed acreage, aircraft hazard maps, links to remote weather station data, and other information have been envisioned to be added to GeoMAC.

Now sponsored by the Geospatial Task Group of the National Wildfire Coordination Group (NWCG), GeoMAC remains housed at the USGS Rocky Mountain Mapping Center. The GeoMAC team includes technical experts in GIS and remote sensing from several agencies in addition to USGS, including BLM, Forest Service, NPS, BIA, FWS, NOAA, and private corporations including ESRI, ERDAS, Sun Microsystems and IBM. An important limitation of GeoMAC has been due in part due to the fact it evolved outside the mainstream fire community. This USGS facility does not operate 24 hours a day, so the ability of the system to provide accurate and reliable information to meet real time needs is incomplete. However, the site is frequently accessed for many purposes. GeoMAC's future development is in terms of data enhancements and access capabilities.

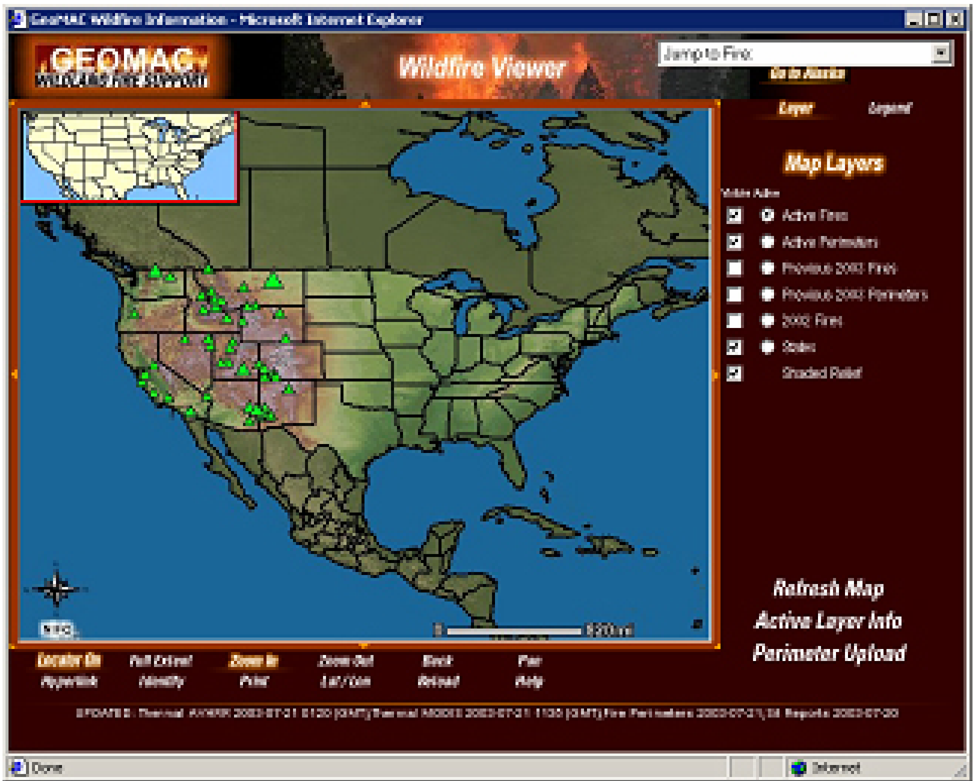

Figure 5-8. The GeoMAC Website
(http://www.geomac.gov)

5.4 GENERAL LIMITATIONS, NEEDS AND PRIORITIES FOR RESPONSE

Information is a critical requirement for many aspects of fire response, ranging from firefighters on the ground, to fire managers responsible for multiple simultaneous fires, to informing and involving nearby jurisdictions and the public in response efforts. The use of GIT, and particularly GIS and GPS, is well developed and used in many subsets of federal fire organizations and advanced state forestry organizations, but significant implementation, widespread adoption, and institutional issues continue to challenge fire response. As compared to detection, most work for response has been conducted on an experimental basis in the field. Significant benefits have been realized and are better understood at a practical level than what is known in the user community about detection technologies. However, focused and organized opportunities and funding for fire management leaders to address new challenges and to make maximum use of GI/GIT for response have not been established. As a result, several limitations and issues continue to exist and require policy and institutional attention by fire management and other government leaders.

5.4.1 Limitations Concerning GI/GIT Use in Response

Several limitations impact the degree to which GI/GIT is used and its effectiveness for fire response. Policy and institutional issues are key concerns in this regard. Experience is that most fire teams during the last two fire seasons requested maps created using

GIS (Geospatial Task Group, 2000). This demand was largely generated because fire staff became familiar with the utility and capabilities of GI/GIT during the unusually severe 2000 fire season, and virtually all resources (and funding) available were deployed to respond. Many fire officials newly realized that GI/GIT resources were essential tools to accomplish their response objectives. However, lack of an institutionalized approach meant that in many cases existing federal offices and fire staffs were overwhelmed with requests that were impossible to meet, particularly given the data resources that were required to meet these needs. Insufficient leadership attention, specific policy direction to address this issue, and appropriate funding, means that an ad hoc approach continues and frequently exist at one or several levels of fire response organizations.

Staffing capabilities have been a key issue concerning information use and dissemination, and GI/GIT in particular. The degree to which a team has individuals qualified in GI/GIT as part of the team can make a huge difference in terms of GI/GIT deployment and effectiveness. More and more staff has GIS skills and experience, such as "Fire Behavior Specialists," but a key problem to date has been that there is no requirement for GIS, GPS or other modern GIT capabilities as part of the Incident Command System personnel qualifications standards or as a standard of any other nationwide organization such as a federal agency. See Figure 5-9 for FARSITE analysis capabilities that are conducted by Fire Behavior analysts. GPS use is less resource-intensive and likely even more prevalent than GIS. But there is no requirement or assurance that a team will even have an individual qualified in the use of GPS to help conduct fire perimeter mapping, one of the most critical functions and data requirements for fire response to conduct critical resource deployment decisions. As a result of the high availability of GPS receivers but insufficiently informed users, many instances of errors and inappropriate data and datums have been experienced, causing additional problems for GIS users (Geospatial Task Group, 2000).

Important lessons can be learned from some state fire management organizations and smaller units of the federal government that are making such capabilities a standard requirement. The Oregon Department of Forestry has three fire teams, each with two qualified GIS members of the team (Kinslow, 2001). Each of the California Department of Forestry and Fire's fire teams has a dedicated fire GIS Technical Specialist, and a specific job series has also been created for these individuals (Marose, 2001). Moreover, a key component of the California Fire Plan is that firefighters with experience in the field should be trained to use GIS, thus effectively combining knowledge about and experience with fire on the ground with this technical capability to maximize effective utilization of GI/GIT (Amdahl, 2001). The Florida Division of Forestry with their four IMTs has chosen to draw from an established pool of trained individuals. While no federal agencies have made GIS a skill requirement across their organizations, there are some advances. For example, the Bureau of Land Management and the National Park Service recently created fire GIS staff position at each of their regional offices to help their land management units. Wider adoption of this approach and a defined job series and requirements for qualified GIT positions as an official part of the Incident Command System would be a big help to advance effective GI/GIT use in fire response.

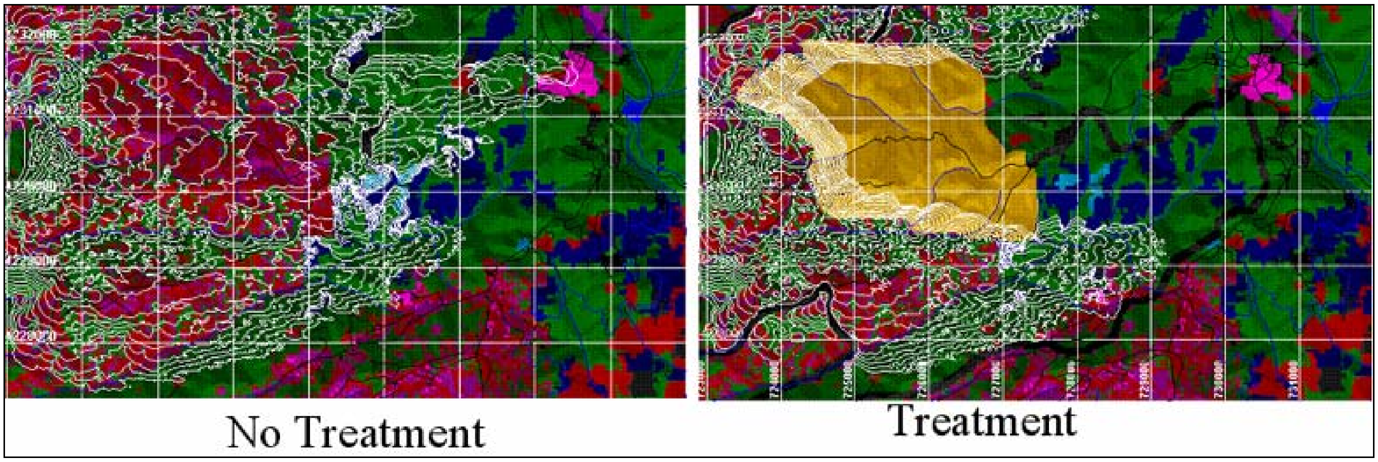

Figure 5-9. FARSITE Analysis for Planning

Lack of supporting infrastructure, in the form of equipment, space and technical connectivity to conduct GI/GIT work, is another frequent limitation. This is a problem at both centers and fire camps. Lack of appropriate equipment has been so prevalent in some cases that individuals dispatched to fire camps need to bring their own laptops and desktops to their assignments. This situation means that other problems surface. External computers may not be able to access needed data on internal Intranets, and sometimes they cannot even access Internet connections. Heightened security restrictions since 9/11 also have restricted access. Communications systems also need to be reliable to transmit critical information, but several firefighters have reported that radio networks can have dead zones where communications are not possible. Reports are that radios may be put in service even if they have malfunctioned in the past.

Non-existent or inconsistent data standards, protocols and procedures for GI/GIT also have led to several problems (Geospatial Task Group, 2000). In terms of GPS use, issues associated with geospatial projections that include differing datums likely mean that data will need to be reprojected. The ramifications of incorrect GPS use is becoming increasingly apparent. Reports are that frustrations are experienced by technicians who are unequipped or unskilled to do reprojections, while managers are frustrated by what seems like, but is not, simple adjustments. Overall lack of central policies, planning, management, and standards for data within and among agencies meant that fires often could not be mapped across land unit boundaries, or even more difficult, in an interagency context.

Most of these problems continue to be problematic in GI/GIT generally. However, they are particularly noteworthy and troubling concerning fire management, and especially in fire response, because there is a strong need and pressure on staff to conduct and produce accurate work in as close to real time as possible to meet response needs, particularly when lives, property and resources are at risk.

5.4.2 Response Needs in the User Community

Firefighters on the ground, whether they are smokejumpers, members of hotshot crews, helicopter crews or members of other teams, require timely and accurate information to safely and efficiently accomplish their jobs. Inadequate information can threaten and has contributed as a key factor in firefighter fatalities, and has caused additional risk to countless others. Many firefighters follow the Lookouts, Communications, Escape Routes, and Safety Zones (LCES) safety standard for wildland fires. Each of the four LCES components includes information as a critical requirement to ensure safety. For example, all firefighters are trained to always ensure that they have at least one and even better, multiple escape routes and safety zones. However, this is difficult when much fire and smoke is in the area and firefighters are often unaware of topography, vegetation (and fuels), and other surface features which can dramatically impact whether or not zones and routes exist, or if streams and other surface water is available nearby that can help save lives if necessary. Firefighters also know that these conditions have a key influence on fire behavior, which again can mean the difference if a fire has a "blowup" and becomes life threatening.

Lack of such critical information has been a key factor in recent fires with fatalities. For example, four firefighters were killed in the Thirtymile Fire, about 30 miles north of Winthrop, Washington in July 2001. According to the Thirtymile Fire Accident Investigation Team report, "significant causal factors" included "lack of situational analysis/inaccurate assessment" of fuels, fire behavior and fire potential, as well as "lack of escape routes and safety zones" (http://www.fs.fed.us/fire/fire_new/safety/investigations/30mile/). Unofficial reports are that firefighters did not have a map and did not know that they were located at the dead end of a road, which certainly would limit escape options. Critical factors, including topography, vegetation and fuels, as well as weather, make the difference in fire behavior and size, and whether a fire blows up and becomes catastrophic. These factors were also key influences in the South Canyon fire in western Colorado when 14 firefighters were killed in July 1994 (Butler et.al., 2001). In that fire, 49 firefighters were at the site and the fire claimed one quarter of their lives. Inadequate communications and resources deployment also were key factors (Maclean, 1999), though information also can be observed as a significant part of these causes of this tragedy as well.

Many firefighters risk their lives but are insufficiently equipped with information to ensure their safety. In addition to the examples above, whole crews and teams and their leaders need accurate, current and precise information to make critical fire response decisions as well as to ensure the safety of firefighters, potentially causing loss of life, property and resources. For example, a helicopter crew chief who wished to remain nameless indicated that sufficient mapping resources are often not provided, thus limiting the ability to plan ahead for next steps and to ensure safety. He also said that maps of larger areas are typically needed, particularly to ensure multiple safety zones and escape routes, but often are not provided unless a leader strongly requests this information from others.

Communication systems also need to be reliable to transmit critical information, and can be aided by having a mapping component such as was developed for GeoMAC rather than the previous conference call approach to make critical decisions. This is particularly needed because the entire fire response infrastructure in the United States, as defined through the Incident Command System and the tiered dispatch approach under the National Interagency Coordination Center (NICC), requires the transmittal of accurate, precise and current information in order to make critical resource allocation and deployment decisions. Advances are being made in this regard, but continued modernization of these business processes with enhanced GI/GIT applications is needed.

Fire monitoring is a critical need at all levels of fire response organizations to ensure that fire staff are aware of fire perimeters, hot spots, progress and behavior; areas at most risk; and smoke locations and predictions. Such accurate and current information is particularly needed to be as accurate, precise and in as close to a real time basis as possible in order to determine priority protection areas and make resource allocation decisions. Needs and opportunities exist to more fully deploy the approaches and systems described in this and Chapter 4 in order to more fully utilize them as needed across the country.

In addition, several aircrafts are now being tested for their worthiness to help monitor fires but they are not yet available. The future availability of unmanned drones are of particular interest to the fire community. For example, the Mylar and Styrofoam Helios platform could be positioned as high as 100,000 feet over fires and equipped with multiple cameras to provide useful images (Nile, 2001). This prototype is now under development for Mars missions but could be useful for fire (http://www.dfrc.nasa.gov/Projects/Erast/helios.html). Another example is the Altus II unmanned plane, which was recently announced and tested for potential use in firefighting. The plane sends thermal imagery though a satellite link and downloads the data through the Internet. The image is georegistered and built up in proportion with the ground in order to be laid down exactly over a map with known locations of every pixel.

While new data will be useful, there also is a strong need to delivery existing data in new and integrated formats, rather than some traditional formats. For example, information also is a key component of the role of GACCs and dispatch centers. Each center prepares intelligence reports and orders resources to fight fire. But, as described above, these centers need integrated and synthesized information about fire conditions, resources available and deployed, and likely scenarios in order to best accomplish their missions. Limitations in approaches at these centers mean that integrated data may be difficult to access as discussed in the sections above. Some innovative centers have established web sites to manage and disseminate key information in order for the centers to better allocate resources, such as was the original reason for GeoMAC as described above. However, the degree of modernization of communication systems at these centers varies. Needs and opportunities to coordinate efforts with local government dispatch centers, in particular E911 systems, are growing to ensure effective fire response and communications with these stakeholders and the public. Efforts to enhance compatibility of radios with many state and local agencies are also needed to ensure coordinated response efforts among agencies and levels of government.

Fire warning devices are another important need to keep the public, particularly those at risk, informed about fire conditions and threats. Devices to inform the public about pending wildland fire in their vicinity vary considerably and need to be modernized using GI/GIT in many cases. They can be quite sophisticated, such as Reverse 911 systems, which use GIS to identify a specified set of addresses at risk in developed areas. In these cases, landowners are automatically called on the telephone, virtually in real time, to alert them of danger. Sirens are frequently used to warn the public of disasters. Some have been managed using GIS to ensure that persons at all affected properties are able to hear the sirens and other areas are not duplicated too extensively. Growth in land use development near forests and highly vegetated areas means that needs and opportunities to use GI/GIT and warning technologies are increasing with time.

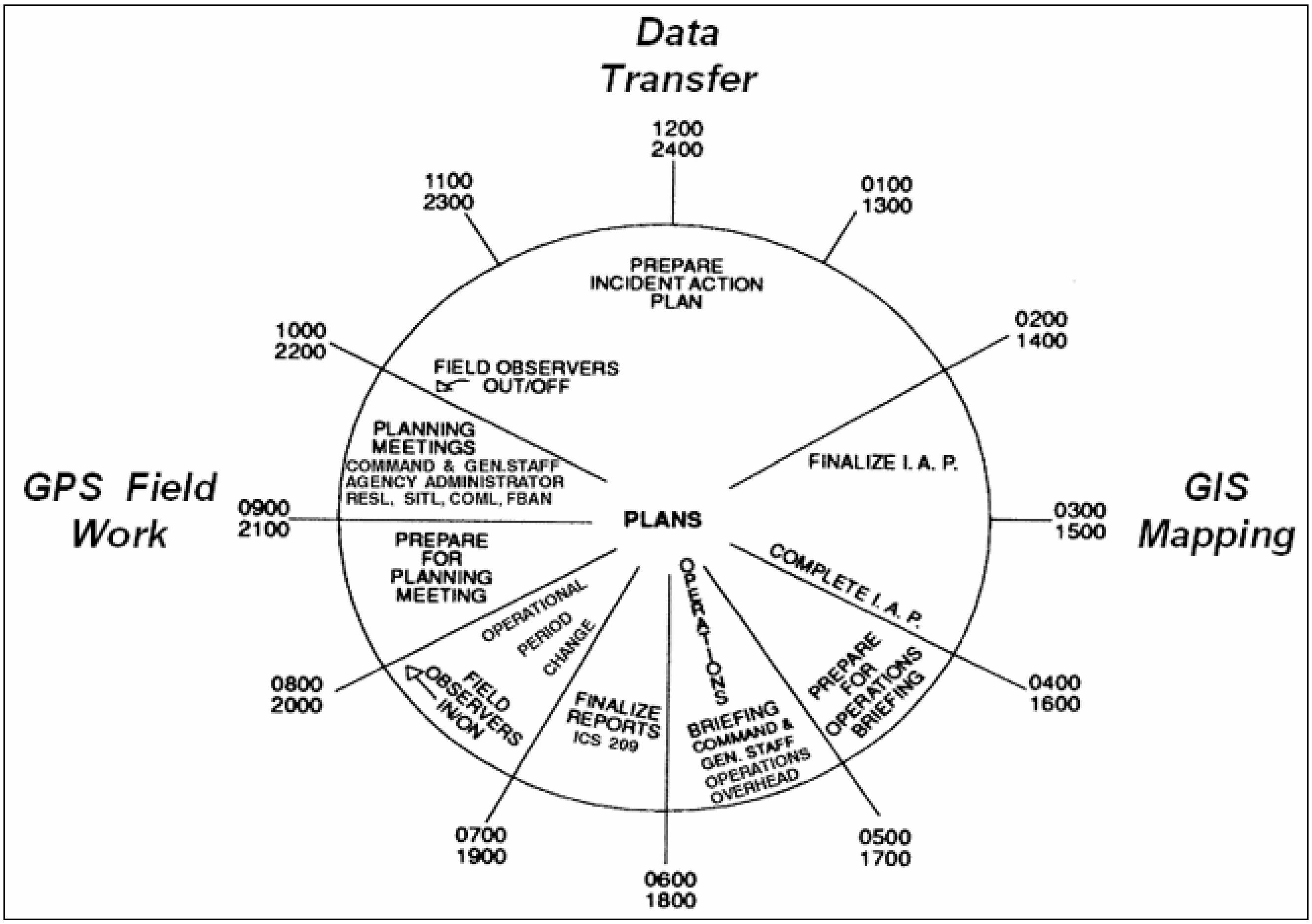

Figure 5-10. Work Cycle of Data Collection, Data Transfer, and GIS Map Delivery

Fire information also is needed during the response phase to ensure useful community relations and to keep the overall public informed. Fire information officers need images, both digital photos and digital maps, to speed the process of keeping key stakeholders (1) from individual citizens to elected local, state and federal officials and the news media, and (2) informed on a fire's location and movements. There continues to be refinement and improvement to the tools needed out in the field as illustrated by the Los Angeles County Fire Department on fires in southern California (http://www.esri.com/news/arcuser/0703/initial1of2.html). Timely delivery of map products is essential on an incident, as illustrated in Figure 5-10, showing the work cycle of data collection, data transfer, and GIS map delivery.

5.4.3 Priorities for Response Technologies and Programs

Leadership attention and action concerning policy and institutionalization issues are the key requirements for wildland fire response. Unlike detection, the use of GIT, and particularly GIS and GPS, is well developed and is becoming more known. Demand now far exceeds supply, though opportunities do exist for greater exploitation of and benefits from advancing technological capabilities. As reported above, the ad hoc approach to how GI/GIT has been adopted to date in some organizations has led to unnecessary mistakes and wasted resources and time in many cases, thus causing countless other problems.

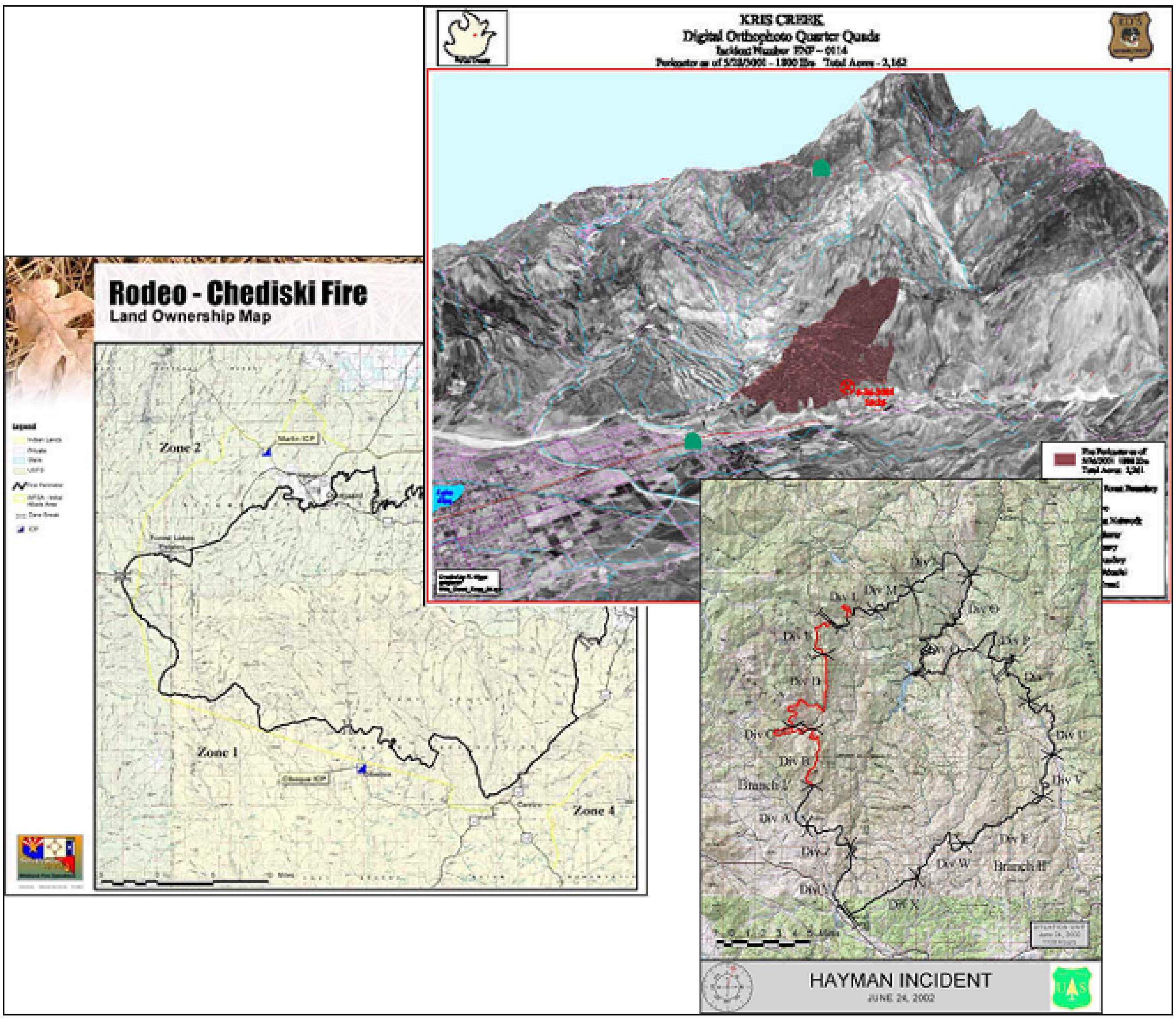

Figure 5-11. Example GIST Map Products

Focused and organized opportunities and funding for fire management and agency leaders to address new challenges due to the growth of GI/GIT are needed. This approach would help ensure that consistent and reliable approaches are developed, and that GI/GIT adoption is implemented in ways to maximize effectiveness and results. Policy and institutional attention and action are needed by fire management and federal agency leaders to address the limiting factors discussed above. Because implementation can be difficult to achieve, interagency consistency is needed to develop and implement the following specific and priority approaches for GI/GIT usage for fire response:

- GI/GIT staffing requirements in key teams, centers and agency offices
- Consistent GI/GIT personnel requirements and job series classified through the Incident Command System approach
- Minimum supporting infrastructure, in the form of sufficient and consistent equipment, space and technical connectivity on the ground and with multiple agency and interagency centers and offices, including those with direct fire roles and general agency home offices where much useful data traditionally resides and can help fire response activities
- Consistent data standards, protocols and procedures for GI/GIT use
- Readily available data products about preexisting fuel conditions that can be easily integrated and used with current fire data and projections
- Mechanisms to integrate various data inputs in as close to real time as possible during fire response, including remote sensing, GPS, observations, digital camera output, etc

Short term and long term recommendations have been identified by GTG (2002) with the primary intent to implement short-term accomplishments and lay the framework for the development of a national interagency long-term strategic plan for using geospatial technology for incident support. Short term goals include:

1) Facilitate the identification of a GIST ICS position by referring it to the Incident Operation Working Team for review and action,

2) Add the GIST training program to the NWCG Training Working Team's agenda for development and maintenance, with associated actions and results, and

3) Appoint and fund a group to coordinate the identification of the minimum spatial skills, organization, and data needed to meet incident management business needs, including initiation of a website to include minimum data requirements with web links to data sources.

An important long term goal is the development of a national interagency five-year geospatial strategic plan, specifically for incident support, however it really needs to be broad in scope in order to encompass all wildfire management activities. This plan can be dynamic to accommodate changes in technology but will provide a needed framework as GI/GIT and fire management evolves. This is seen as an important mechanism for providing broader long term benefits.

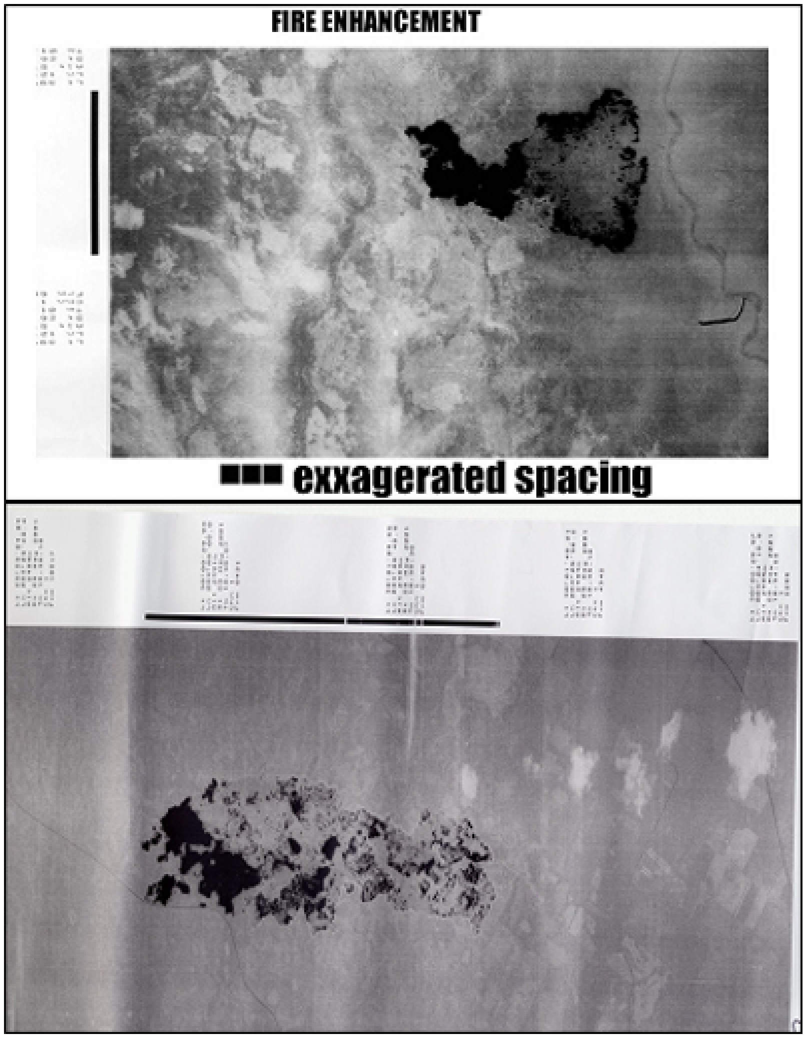

Figure 5-12. Infrared Scanner Output

Many lessons can be learned from the experiences and practices of innovative fire organizations located throughout the United States. For example, an increasing number of state governments, such as California and Oregon as described above, are institutionalizing many of the above approaches. Parts of federal agencies have also implemented innovative approaches that serve as models for the federal government as a whole. Fire organizations welcome innovative approaches from other organizations to enhance connectivity and, in particular, to facilitate the sharing of capable and reliable resources in other areas when fire response requirements demand external assistance. Also, the National Association of State Foresters plays a pivotal role in furthering the institutionalization of GI/GIT in fire response by encouraging interstate and intergovernmental approaches. This is necessary to facilitate coordination among all states on key application development issues, but also to interface on the local, regional and national level as major technology policy and implementation decisions take place.

6.0 RECOVERY, REHABILITATION AND RECONSTRUCTION

This chapter reviews the recovery, rehabilitation and reconstruction phase of wildland fire. This phase is a relatively recent, but expanding and growing component of wildland fire management. This increase in importance is occurring both in general and specifically in the use of GI/GIT in this regard. The chapter includes identification of some of current recovery, rehabilitation and reconstruction approaches and resources; examples of GI/GIT use; and needs, limitations and suggestions concerning greater use of GI/GIT for these applications.

6.1 INTRODUCTION

Recovery, rehabilitation and reconstruction includes those activities undertaken to assess, restore and rehabilitate a burned or otherwise impacted area or community after a wildland fire has occurred. It also includes long-term post-disaster assistance and planning. Recovery, rehabilitation and reconstruction activities include damage assessment and monitoring of fire effects, reshaping development patterns, and mitigating future fire effects in these areas. These efforts include rehabilitation and restoration of natural areas based on fire ecology and ecosystems needs, restoration of public infrastructure, human and social services for the citizenry, and private sector economic restoration. Efforts also include coordinating the efforts of private relief agencies, civic groups and volunteers; conducting damage assessments, preparing disaster declarations, and initiating mitigation planning. The cost of recovery, and the ability of local governments to cover those costs, determines the difference between local, state and federally declared disasters.

Recovery can be improved with good planning prior to a fire or other disaster, such as reconstructing more disaster-resistant communities, and improving forest health conditions. Key to recovery, rehabilitation and reconstruction is the "window of opportunity" that comes after a disaster occurs. Success of recovering and preventing future disasters means having the tools and programs in place that are ready to take advantage of the short-lived heightened awareness by officials and the public to effectuate change and mitigate future wildfire hazards, as discussed in Chapter 3. A multi-hazards approach that is prepared to deal with the associated hazards of wildfire, such as flooding, also adds to a successful approach to recovery.

6.2 CURRENT RECOVERY, REHABILITATION AND RECONSTRUCTION APPROACHES AND RESOURCES

6.2.1 Post-Fire Management Efforts

Compared to the other phases of emergency management, the fire community has a more recent official history in terms of conducting large-scale fire recovery, rehabilitation and reconstruction. However, the need for such efforts can be extensive, because flooding, mudslides, erosion, and loss of vegetation diversity are increasingly common effects of fires. Severe fires can cause virtually all vegetation, soil and even ground below the surface to be burned, resembling to some extent lands covered by volcanic eruptions or what can be imagined as the surface of a planet other than Earth. Moreover, the effects of fires can last for many years, seemingly with little change in the black appearance on the surface of the land. Assessment efforts are conducted immediately after a large fire to determine fire severity, identify if any watershed resources could be at risk from sediment runoff and other effects of the fire, and if life, property, or natural resource values are otherwise threatened. If this assessment determines that an emergency exists, then rehabilitation efforts are implemented. Some efforts also occur if an emergency does not exist, but available resources are much more limited for these efforts.

Post fire rehabilitation work is broadly defined as efforts to improve wildlands that are unlikely to recovery naturally from the effects of wildfires. Generally defined, rehabilitation can range from immediate emergency stabilization actions to long term restoration efforts (U.S. Forest Service and Department of Interior, 2002). Work often can be implemented over several years following a particular fire. Activities can include reforestation, road and trail rehabilitation, fence replacement, fish and wildlife habitat restoration, invasive plant treatments, and replanting and reseeding with native or other desirable vegetation. An increasing priority is to protect watersheds for potable drinking water systems. Some recent fires, such as in Colorado in 2002 and elsewhere, posed unprecedented risks to such watersheds and systems, which is requiring increased attention, understanding of potential impacts and corresponding actions.

The most extensive federal fire rehabilitation efforts are conducted through the Burned Area Emergency Rehabilitation (BAER) program. Only a small fraction of all fires are declared to require such attention. If authorized, efforts are conducted virtually immediately to address primary concerns identified in the initial assessment described above. For example, only 82 of the thousands of fires in 2000 had BAER projects. The purpose of these efforts in particular is to help accelerate natural recovery to prevent or reduce early watershed damage.

BAER projects are only implemented if the burned area is of a large size, if it was particularly hot and the soil has been severely burned, and if important in-stream and downstream water resources are at risk (particularly potable water systems). Work is often initiated on the ground within a week of the first assessment and determination that a BAER approach is required to address the effects of a particular fire. BAER teams, often referred to as "black" teams, are organized to conduct rehabilitation work. These teams are similar to the Incident Management Teams described in Chapter 5. Due to the quick response plans and actions that often are necessary, BAER teams are beginning to rely on early assessments of conditions on the ground developed in part by using remote sensing as described below.

6.2.2 Experience from Other Types of Emergency Management

Progress is being made since the noteworthy Oakland fires when damage assessments were performed to learn how to rebuild safer communities once faced with the actual disaster. Now, assessments are being performed before, as well as after, such events and with more knowledge of what information to collect, including attention to additional impacts beyond natural areas addressed by BAER and most rehabilitation efforts.

For example, the Federal Emergency Management Agency (FEMA) sent teams to Los Alamos, New Mexico during the Cerro Grande Fire to collect data and provide an analysis for the recovery and reconstruction phases following the disaster. Lessons learned are that greater attention is needed to reduce risks and prevent future fires in susceptible areas. What happened in Los Alamos is an example of why building "disaster-resistant communities" (as increasingly called for in FEMA's programs) is critical. Planning for post-disaster recovery and reconstruction must be done using hazard identification and risk assessments, public education, consensus and partnership building, visioning, and identifying risk-reducing activities. Community planning is essential for creating these disaster-resistant communities.

GI/GIT can help conduct effective local planning by using applicable information and tools so that development plans can be based on sound site planning, building design and construction, and that landscaping is designed and implemented that reduces the risks of living in a forested environment. Post-fire studies have shown that these conditions contribute to determining why some homes burn and others do not, though they may be located near or even next to each other.

Having reconstruction plans in place for Los Alamos and other fires prior to these events could have enhanced land-use choices and decision making during rebuilding. Unfortunately, this careful process may be adversely affected by the federal government’s willingness to compensate victims quickly for their losses to allow rapid replacement of their structures. Communities are also pressured to get people back into their homes and businesses open as soon as possible, leaving little time to plan for improvements to better deal with future emergencies, much less deal with historic preservation issues.

Local planning and building departments are not prepared to handle the massive amount of building permit applications that occur after emergencies, and often contract out building review functions during disasters. As a result, contractors may have little or no familiarity with local codes, so they essentially may offer little review or input about rebuilding plans to avoid future problems. The publication *Planning for Post-Disaster Recovery and Reconstruction*, jointly published by the American Planning Association (APA) and the Federal Emergency Management Agency (Schwab et al, 1998), is an invaluable tool for planners interested in establishing plans before wildfires threaten their communities.

Documents such as the *National Mitigation Strategy: Partnerships for Building Safer Communities* (FEMA, 1995), and *Disasters by Design: A Reassessment of Natural Hazards in the United States* (Mileti,1999), make recommendations for needed actions to further mitigation and the reconstruction efforts for communities facing catastrophic wildfires and other disasters. Included among these recommendations are a long list of strategies that need hazard identification and risk assessments, as well as applied research and technology transfer. Such assessments are described as the “cornerstones of mitigation” (FEMA, 1995). The later report makes similar conclusions, adding that computer-generated decision-making aids lend support to sustainable hazard mitigation (Mileti, 1999).

An example of a recent approach to include these considerations in planning for potential wildfires is California's Fire Plan Workgroup's "Community Fire Plan Template Outline" that is available in draft form (http://www.cafirealliance.org). The use of local fire plans is recommended, as well as the use of a planning process that supports local recovery, rehabilitation and reconstruction approaches. A key assumption of the advocated approach is the notion that good planning comes from an informed knowledge of what needs to be done, and where the resources are to get needed information. GI/GIT is considered an important part of this approach.

6.3 GI/GIT RESOURCES USED IN WILDLAND FIRE RECOVERY, REHABILITATION AND RECONSTRUCTION

6.3.1 Wildland Fire Approaches

As described above, efforts associated with fire recovery, rehabilitation and reconstruction are relatively recent, with most fire community efforts concentrated on rehabilitation such as the BAER program. Effects of fires are assessed virtually immediately to address primary concerns before greater damage can occur. If the determination is made that a BAER project is warranted, then significant resources, in terms of staffing, data, technology and equipment are made available in order to assess, conduct and monitor this work. GI/GIT has become a critical resource in both the U.S. Forest Service and the Department of Interior agencies in order to conduct BAER work.

An assessment of the severity of burns is usually one of the most critical and first efforts undertaken by a BAER team. This is an important consideration because it serves as a key measure of the fire's impact on the ecosystem and it helps to determine the potential for flooding and the specific areas where the flooding originates within the burned area. A burn severity or intensity map is one of the first and most important data products to be developed, with requirements to have this work completed as quickly as possible (Lachowski, 1997). This burn map usually is prepared using imagery, and is generally complemented by detailed ground measurements. Various imagery is used for this process, including infrared photography, digital orthophotography, Landsat imagery, SPOT panchromatic imagery, Ikonos imagery and other sources. Work also is underway to develop products from MODIS that can be helpful in this effort.

Imagery also is used to assess soil conditions and as input to soil erosion models to help assess future damage and risk, as well as the need for rehabilitation activities. GI/GIT also has been used with models to determine potential damage from erosion, such as mudslides and reservoir contamination. Other BAER efforts that use imagery include assessing structural and other damages and planning future work on the ground to accelerate natural recovery and prevent further watershed and environmental damage. GPS and GIS complement these efforts as similar critical components of the BAER process. Monitoring the results of BAER work also is a critical part of the process, including the effects on stream channels, new plant coverage, and other factors. It seems that GI/GIT could be used more for this effort.

The U.S. Forest Service conducts support work for its BAER teams, while the U.S. Geological Survey does so for the Department of Interior agencies. The BAER staff at the Forest Service's Remote Sensing Applications Center (RSAC) also develop Burned Area Reflectance Classification (BARC) maps to aid BAER efforts. These thematic maps are satellite-derived classifications of post-fire conditions. The BARC has four classes: high, moderate, low, and unburned, and is available in both raster and vector GIS format (http://www.fs.fed.us/eng/rsac/baer/barc.html). BARC maps are created by comparing pre-fire and post-fire Landsat satellite imagery. Landsat bands 4 (near-infrared) and 7 (mid-infrared) brightness values are used to compare the intensity of burned areas. In the pre-fire Landsat scenes, band 4 brightness values for vegetation will be very high while band 7 brightness values for vegetation will be low. In post-fire scenes, the opposite is true.

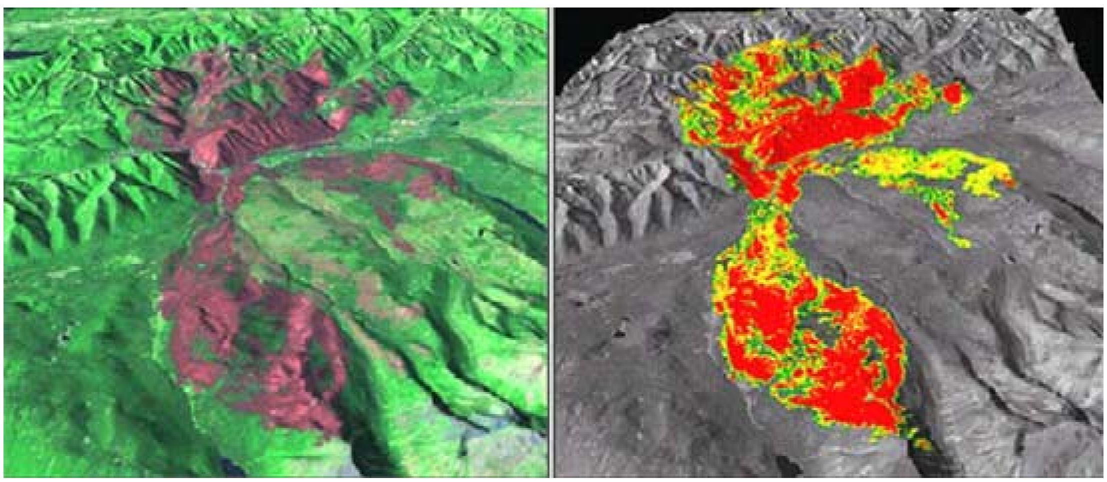

Figure 6-1. Moose Fire Burn Severity Assessment
http://www.fire.org/firemon/Lav3_Methods.pdf

Much success was reported during and after the 2002 fire season about the use of remote sensing for conducting these pre-assessments of conditions to help BAER teams on the ground to prioritize and conduct rehabilitation work. In total, RSAC provided images for 70 emergency stabilization projects covering over 2.6 million acres in this one year. In addition, the Geospatial Service and Technology Center (GSTC), also in Salt Lake City, developed and tested a web-based application that provides maps and information for use on these projects to assist in determining appropriate actions for burned areas.

Despite some differences in goals between the Forest Service and the Department of Interior agencies for the imagery interpretation for these burned areas, consistent processes and methods are being developed. The technical teams doing this support work at the Forest Service (for its teams) and the U.S. Geological Survey (for the Interior teams) are working together so that results and relative accuracies can be compared. It seems that remote sensing, complemented with carefully designed field work, could be more extensively used and institutionalized as part of an objective process to monitor and evaluate conditions and results of work on the ground, particularly since a key strength of remote sensing is to monitor change over time. Moreover, it seems proven benefits and coordinated work among the agencies in this effort is an example that could be replicated to benefit other aspects of wildland fire management.

6.3.2 Experience from Other Types of Emergency Management

Federal fire efforts primarily concentrate on rehabilitation efforts as described above for wildlands. However, recovery and reconstruction of communities is very active at the local level, with the assistance of funding and resources from state and federal levels. Recovery efforts associated with other types of emergencies seem to be more advanced than for wildland fire.

Immediately after a disaster, the “window of opportunity” with the heightened awareness from the impacts of the event allows for improving land use and building codes for various hazards, including wildland fire. This opportunity can be for existing and new development or redevelopment, and demands accurate information about before and after the event, and to identify potentially less hazardous conditions in order to effectuate change. Localities with extensive and current GI/GIT resources, including detailed information at the parcel level, can apply these resources for several aspects of recovery and reconstruction efforts.

Building and fire codes are important for structure survival during a wildfire by addressing construction and fire protection. Some localities record building plans and materials as part of their GIS, so this information is useful for response as well as recovery efforts. Land-use and development ordinances and regulations also are important because they often address issues such as bulk and density standards and design guidelines, which are not covered by building codes. They also provide requirements for use and site reviews, conditions of approval, establish out-of-city service extensions and annexation conditions, and set subdivision requirements for wildfire concerns. GI/GIT is often used to manage information about these conditions, and along with such requirements enable planners to balance concerns about the building site, the landscape, the structure, and fire protection.

Opportunities for wildfire mitigation through land use vary depending on the status of a particular development. Redeveloped areas can easily accommodate underground electric lines, different building and landscaping requirements, and improvement measures for street and access conditions. New developments are able to address these concerns and also accommodate for proper siting, infrastructure, and building and landscaping/fuel modification requirements for protection against fires. Easements and open space requirements provide additional protection. The data management and analytical capabilities inherent in GIS can be used with other GIT to determine the best locations and development characteristics to provide the best fire protection, and particularly to balance this goal with other development factors, such as to minimize costs, and maximize the views from and beauty of development sites.

As shown in Figure 6-2, local government planners have a "toolbox" of techniques and potential requirements that can be employed when considering changes to be made during reconstruction after disasters such as wildfires (Cohen, Johnson and Walther, 2001). GI/GIT is a critical resource to help apply these techniques and potential requirements. While these tools need more analysis and evaluation about their effectiveness to mitigate problems, they provide useful examples of actions that are and can be taken by local jurisdictions to minimize fire damage.

Local Government "Planner's Toolbox" for Wildland Fire
(Cohen, Johnson and Walther, 2001)

Overlay Zone District. A wildfire hazard overlay zone is a useful tool for planners in fire-prone areas because an area of concern is delineated for specific goals and implemented with specific codes such as an Airport Influence Overlay Zone. The overlay can identify where home ignition potential is greatest and/or other factors that influence fire behavior that makes the likelihood of fire occurrence more probable. The information most needed for determining an overlay are the components of wildfire hazards and fire behavior (i.e., slope, aspect, fuel types, site features, characteristics of the Home Ignition Zone (HIZ) [as defined by Cohen (2002)],as well as vulnerability, risks, infrastructure and fire protection).

Bulk and Lot Size. For more densely populated areas or small lot subdivisions, yard setbacks can keep homes a safe distance apart, as can increasing the minimum lot size. The survivability of clustered or multi-family developments may be increased by combining better building standards and sufficient setbacks within the HIZ. Possibly more modeling could help demonstrate how these requirements affect the survivability of homes and could better provide a visual understanding of appropriate design for areas in what is commonly known as the Wildland Urban Interface (WUI), as discussed in Chapter 3. Setback distance and lot size should be based on the HIZ needs and adjusted for sloped areas. Steeper slopes will increase the HIZ area because flame lengths will be greater and provide a closer source of ignition. Open space requirements can be included to provide an area where vegetation can be managed within the HIZ.

Nonconformity Standards. Nonconforming structures, lots, and uses may hinder mitigation efforts. If a fire home damages a nonconforming structure, it may have to be rebuilt to its prior state with the exception of any newly adopted codes. Conflicts might arise if a code says nonstandard architectural building features can be replaced if the exterior materials and architectural style of the replacement match that of the original feature. Those may not always be conducive to a structural survival goal.

Development Reviews: Criteria, Conditions, Standards. Site plans and application requirements should be used to review the HIZ in more detail. A checklist of criteria for the development review process should say that the development is consistent with the wildfire hazard overlay zone and/or that it minimizes the wildfire threat. Architectural, landscaping, and infrastructure plans are often a requirement of such reviews, and should address the HIZ. Conditions of approval can further control the development with specificity to the project site. Maintenance conditions can also be useful.

Design Guidelines. Many communities struggle through the process of adopting design guidelines for residential development because they can be viewed as restricting the rights of private property owners. If possible, the same guidelines should be used to address ignition potential within the HIZ, but flexibility is often needed to achieve a fire-safe design. Workshops such as FIREWISE are held around the country to help planners generate better ideas for design guidelines. Consistency of these guidelines with historic preservation guidelines often is appropriate, but should be considered carefully in WUI areas.

Administrative Reviews and Variances. Minor modifications to previous reviews as well as variance reviews can provide opportunities to improve fire mitigation within the HIZ. Setback variances should address criteria that do not conflict with the HIZ (i.e., placing structures too close to another, little room to manage landscape in HIZ

Subdivision Regulations. WUI concerns should be carefully dealt with in subdivision regulations. Requirements can vary greatly, so the goals of home survival in the HIZ should be the key basis for meeting them. Lot design and size; siting away from dangerous topographic features that place development at higher risk, open space/fuel management areas; building, landscape, and infrastructure design; and fire protection requirements are all valuable components to improving the survival potential of homes.

Annexation. Sprawl into wildlands with development not designed for wildfire survival continues to increase the WUI threat. When annexing new land into a community, approval criteria and conditions should subject new development to addressing wildfire concerns. Vacant land will offer the best opportunity to determine and provide for appropriate zoning, design, fuel management, and fire protection options.

Figure 6-2. Local Government "Planner's Toolbox" for Wildland Fire

GI/GIT is becoming a valuable resource to collect, manage, and analyze information about existing and potential structures, public facilities, infrastructure, zoning and other conditions, and development requirements in communities. It also is being used to understand potential dangers due to fire and other disasters, and to determine the impact, viability and appropriate locations of potential measures such as those delineated in this "toolbox". GI/GIT also can be used to help decide what changes can and should be made by local jurisdictions and property owners to make a difference in terms of risk of damage from wildfires.

More and more local jurisdictions are adopting wildland fire ordinances and regulations for lands within their jurisdiction that are accompanied by precise maps showing areas of varying risk and differing requirements in order to address perceived risks. Determination of these areas and requirements are based in large part on evaluations of scenarios and alternatives using GI/GIT resources; particularly utilizing analytical capabilities to combine and analyze often disparate data to most accurately understand conditions and risks, as discussed in Chapter 3.

Communities that have experienced wildfire disasters often find the task of reconstruction overwhelming. Building permits and development reviews are often pushed through quickly in order to rebuild and get people back in their homes and businesses. Unfortunately, this can lead to emergency ordinances that shorten or even eliminate the reconstruction's monitoring and review process. If so, opportunities to effectuate change to minimize future damage can be lost. Also with the help of GI/GIT, planners can prepare in advance for this situation by determining community needs for rebuilding and how to reduce potential damages before damaging wildfires occur.

6.4 GENERAL LIMITATIONS, NEEDS AND PRIORITIES FOR RECOVERY, REHABILITATION AND RECONSTRUCTION

6.4.1 Limitations of GI/GIT in Recovery, Rehabilitation and Reconstruction

While GI/GIT is being used as described above, particularly for BAER work, it is not well funded or institutionalized as part of regular business processes. However, a key reason for this is that an overarching problem with wildland fire recovery, rehabilitation and reconstruction work is that it is a relatively recent endeavor compared to other wildland fire phases described in the above chapters. Many aspects of recovery, rehabilitation and reconstruction work are not defined or agreed upon. This situation is evident across relevant federal agencies, but also among state and local governments. Common direction, procedures, reporting approaches, accountability measures, and even definitions, do not exist in large part, though such work has been underway concerning a growing number of fires. Federal land units are required or strongly encouraged to monitor rehabilitation treatment effectiveness, but the effectiveness of these efforts is difficult to determine. For example, the U.S. General Accounting Office (GAO) recently investigated fire rehabilitation activities. It concluded that the effectiveness of emergency stabilization and rehabilitation treatments can not be determined "because most land units do not routinely document monitoring results, use comparable monitoring procedures, collect comparable data or report monitoring results to the agencies' regional or national offices" (GAO, 2003, p. 5).

According to GAO, neither the Department of Agriculture for the Forest Service, or the Department of Interior for the other four land management agencies, provides specific standardized guidance on how land management units should conduct such monitoring, so differing methods are used, even for identical treatments, and "rarely document monitoring results" (Ibid, p. 42). While it appears that treatments are reasonable, plans are approved without "comprehensive information on the extent to which a treatment is likely to be effective given the severity of the wildfire, the weather, soil and terrain" (Ibid, p. 46). GAO found that the Forest Service started development of a database of monitoring results, but among its limitations is that it will not provide information necessary to determine the conditions under which treatments are most effective, such as soils characteristics or vegetation types, nor would it provide a means for sharing data with other Forest Service offices. GAO recommended that the Secretaries of the departments specify the type and extent of monitoring data that local land units should gather with methods to do so, and require their agencies to collect, analyze and disseminate the results of these data through an interagency system (Ibid, p. 47).

The problems associated with this lack of definitions and specificity also are recognized at the highest levels in the fire leadership. For example, the Wildland Fire Leadership Council (WFLC) directed, and the agencies developed, standardized definitions for emergency stabilization, rehabilitation and restoration (U.S. Forest Service and Department of Interior, 2002). Several additional actions are underway as well to address these concerns.

A pervasive problem with data in the fire community, reflected in this phase and others, is the lack of precision in terms of the location of fires, projects or other conditions. For example, a new system is under development to manage and monitor fire projects, known as the National Fire Plan Operations and Reporting System (NFPORS). It will be used in particular to record and report on rehabilitation and related projects. However, its design provides for limited specificity in terms of the location and type of actions that are being undertaken, and in what present and past conditions. Moreover, it will be difficult to compare and analyze these projects in the context of other conditions due to the ambiguity of these locations. Application of GI/GIT is particularly difficult in this situation because a key advantage of such data and technology is to record the location of conditions and analyze them in the context of other conditions.

Beyond these limitations, a critical problem in the use of GI/GIT for recovery, rehabilitation and reconstruction is the need for almost immediate input to conduct this work. There has been limited use of satellite imagery and other GIT for this phase of fire management until the last few years, such as is now being done for BAER assessments. This is largely because this phase is a small and recent component of fire management activities compared to the other phases described above. While advances are being made as described above and hold promise for the future, requirements for timing BAER work are very strict and must be adhered to given the severe nature of fire damage that might exist. The CEOS study discussed in Chapter 4 included findings that an impediment to using civilian satellites is their low resolution for the areas on the ground to be studied (CEOS, 2000). However, an effective approach adopted by the U.S. Forest Service in their work conducted for BAER teams is to use the best and most appropriate imagery available, so both public and commercial satellite data products are being used.

GIS and GPS also are recognized to be key resources that are beginning to be used extensively in individual BAER projects. In fact, experience shows that this usage has resulted in data problems, such as redundancies and conflicts that extend beyond BAER work to land management efforts. For example, one National Forest GIS manager (who asked not to be identified) indicated that since sizable financial and other resources are made available to BAER teams, they find it easier to create new data rather than contacting others to acquire and use existing data. This individual pointed to a pile of reports prepared as part of an extensive BAER effort that were approximately two feet thick due to the severity of the fires addressed. The reports were full of maps generated by using imagery, GPS and GIS, but he indicated how unfortunate it was that the data did not reconcile with the Forest's data resources for the same locations, and thus had limited utility in both the short and long term. As a result, future assessment, monitoring, recovery and rehabilitation work would be conducted based on inconsistent data. He described future problems that would result for the Forest given such inconsistent data resources. Such experiences reveal problems associated with often duplicative and/or conflicting data, as is often the case when the government develops and maintains redundant systems due to differing policy, institutional and program direction and approaches.

Further limitations exist at the local government level. Most local governments and their planning departments do not put a priority on planning for disasters and recovery unless they have experienced a major disaster, or if the community is an area with frequent disasters. Many planning departments are struggling with priorities that focus their time more on growth and transportation issues than planning for disasters. This condition is often especially true in rural communities or those with smaller planning and building departments, even though these areas may be at some of the highest risk for fire and associated damage, such as in Montana. In the current economy, many local planning departments are also reducing staff. Top planning priorities are to address growth and development issues, so planning for recovery and reconstruction after disasters is becoming a luxury even for larger departments.

GI/GIT limitations also exist at the local level. Costs prohibit many communities from acquiring and using accurate and current geospatial data and technology. Several issues are associated with such costs. Accessibility of data and knowledge of resources are key constraints, and data compatibility between local governments and other fire agencies at state and federal levels can be a large limitation. Comprehensive and enterprise-wide GI/GIT organizations exist in only some governments, with planning departments often having more limited resources than other local departments. In many cases, the only way for localities to acquire and be current with technological capabilities is to receive grants from state and federal agencies, though most jurisdictions do not benefit accordingly. GI/GIT usage can be very ad hoc and disparate across local governments, particularly as relevant for fire.

As a result, GI/GIT usage is uneven, and resources and capabilities vary considerably even within the same state or among neighboring jurisdictions. Some localities are making significant advances with GI/GIT to address fire mitigation and recovery needs. However, in many cases, GI/GIT use can be characterized as being experimental for this phase of fire and generally, rather than having institutionalized approaches with comprehensive data and planning processes in place to make a difference during the recovery or other phases of wildland fire.

Another limitation is that there are more and more GIS-related software packages available, but there is a general lack of models for evaluating different alternatives and scenarios for fire. These models could be used with geospatial data to aid planners in determining risks at the local level and local requirements to minimize danger and harm. Moreover, fire departments have expressed the need for modeling capabilities in the field to understand fire behavior and potential impact on existing structures to make real time decisions when making triage decisions about individual properties during fires.

These conditions mean that there is a growing need to assist communities to develop their GI/GIT capabilities in the early planning stages as opposed to waiting until after a

Presidential or other declaration for a disastrous wildfire. Not only are the costs of obtaining data and technology preventing many communities from utilizing the potential of GI/GIT, local governments need assistance with the training, staffing, and maintenance that comes with such capabilities. Planning departments also need such technology to be able to easily integrate with their existing systems, as well as the data managed by government-wide GI/GIT organizations (if they exist) and other departments within their jurisdiction. Some of the more rural local communities must look for assistance, such as from their regional planning agencies or council of governments, or state emergency management or planning agencies.

The federal land management agencies often have significant GI/GIT capabilities in many of their field offices near WUI areas and local jurisdictions. However, their goals and priorities do not necessarily include providing support and assistance to local communities to develop and correlate data, or other work that could be done to address WUI and development issues. However, federal field offices may have appropriate, but underutilized, capabilities to help localities with GI/GIT and WUI needs. There is a growing need for more support, especially for rural communities and the increasing number of communities with budget limitations. Such assistance could help communities to show the economic and other short and long term benefits from investing in and using GI/GIT capabilities in order to justify associated expenditures.

Despite these limitations, GI/GIT has and can be used to help accomplish many recovery, rehabilitation and reconstruction needs, including:

- Damage assessment and monitoring of fire effects, and mitigating future fire effects in these areas,
- Rehabilitation and restoration of natural areas based on fire ecology and ecosystems needs,
- Restoration of public infrastructure, human and social services for the citizenry, and
- Private sector economic restoration.

The California Fire Plan Workgroup's "2003 Community Fire Plan Template Outline" provides a comprehensive list of the questions that should be addressed in the planning phases of recovery, rehabilitation, and reconstruction (http://www.cafirealliance.org). The questions presented for each of the planning topics provide an insightful listing of data and other needs that exist for many local communities that are asked to and should develop local fire plans.

6.4.2 Needs and Priorities for Recovery, Rehabilitation and Reconstruction Technologies and Programs

Despite these limitations, it is likely that GI/GIT will become an increasingly utilized tool for recovery, rehabilitation and reconstruction. Significant resources recently have been made available for this work when BAER projects are initiated, which could be an excellent role model for other applications. It is also likely because associated data and analysis processes for rehabilitation activities are relatively new and do not suffer from what can be a legacy of older approaches that exist in the other phases of wildland fire management. While the need for using GI/GIT may not be as severe as it was stated in Chapter 5 for response, the need for that phase may be more evident because of the more obvious deficiencies discussed, and the overall larger resource commitment, and government and public attention, to fire response activities.

In terms of technical requirements, the CEOS study described above identified improvements needed for this phase (CEOS, 2000). This includes inexpensive and comprehensive high-resolution multi-spectral imagery that is available daily, as well as the ability to influence the scheduling of satellites in order to increase the timeliness of imagery access as needed for rapid assessment requirements. Near infrared data would be helpful for mapping fire intensity, and high-resolution radar would be helpful to access data through smoke and clouds. The need for affordable and rapid access to high-resolution data was also identified for additional applications, such as burned area assessment and rehabilitation. GI/GIT could also be useful for monitoring progress during and after recovery, rehabilitation and reconstruction efforts.

Priorities also include the need to address usage of GI/GIT from a policy and institutional perspective for this phase of fire management. Imagery work conducted for BAER projects in recent years is being recognized as a successful approach to meet needs, but associated funding and approaches are not yet institutionalized. Even more complicated in some respects is the situation within local governments. Financial constraints are deepening in the nation's localities, and this situation is impacting GI/GIT investments and usage because funding and staffing levels often are declining. Community assistance is increasingly advocated at the federal and state level, but it is unclear if and when this will translate to attention to enhancing local capacity at using GI/GIT and implementing new planning approaches described in this chapter. The technical grant assistance program discussed in Section 3.4.2 for mitigation also would aid this phase of fire. It may be some time before problems discussed here fully surface and are addressed in this phase of fire management. Meanwhile, the experiences indicated above are likely to be replicated. However, recognition is growing about the problems and taxpayer costs associated with structures continuing to be built and rebuilt in fire prone areas.

Success at using remote sensing for BAER work may result in other related applications that deserve further attention. Effective results at using remote sensing for conducting pre-assessments of conditions to help teams on the ground to prioritize and conduct such work are increasingly recognized. It seems that remote sensing, complemented with carefully designed field work, could be more extensively used and institutionalized as part of an objective process to monitor and evaluate results on the ground, particularly as a key strength of remote sensing is to monitor change over time.

Another key benefit of this BAER imagery experience could be recognition that such imagery also could likely help in fire response work. This is particularly the case in large fires where extensive resources need to be quickly and most appropriately determined, prioritized and deployed, and federal leaders are demanding greater accountability for large fire costs. It seems that imagery provides the most accurate and current "picture" of conditions in order to make objective decisions at a strategic level, both for individual fires and when making resource deployment issues when balancing multiple fires.

Moreover, data availability, management and analysis capabilities inherent in GI/GIT could be applied to enhance corresponding decision making and monitoring of results.

Another opportunity and potential priority could be to use such imagery to help conduct early and almost real-time damage assessments as are often needed for government and other recovery efforts, as well as by the insurance industry to help manage their coverage. As described in Chapter 3, the insurance industry is beginning to apply GI/GIT to determine risks and rates, and to encourage proactive actions by landowners to address hazardous conditions on their properties. This usage could be extended to apply remote sensing for early damage assessments.

Federal, state and local leaders can address growing wildland fire challenges with new approaches, and advancing information and technology. GI/GIT can be effectively used in many aspects of fire recovery, rehabilitation and reconstruction efforts, but this requires policy and management attention and action at all levels. Consistent and reliable data and data management approaches need to be developed across boundaries and for multiple purposes and phases to minimize redundancy, and ensure effective use of GI/GIT in the long term to best meet wildland fire management needs.

7.0 CONCLUSIONS

This report has provided information useful for policy makers, managers and others working in wildland fire, as well as GI/GIT professionals in fire and other aspects of governance. It is a unique resource providing information about key directives; local, state, federal and other stakeholders; and inter-organizational mechanisms regarding and impacting all phases of wildland fire in the United States. It also provides GI/GIT experiences, approaches, issues, needs and opportunities in each phase of emergency management for wildland fire management. This chapter identifies key conditions, issues, needs, opportunities and suggestions to enhance future GI/GIT usage and benefits, and to help respond to increasing needs for policy direction regarding GI/GIT in wildland fire, such as indicated by the U.S. General Accounting Office (GAO) in its recent report on this topic (2003d).

7.1 OVERALL WILDLAND FIRE CONTEXT IMPACTING GI/GIT TODAY

Wildland fire in the United States today is characterized by an increasing incidence and severity of fires, with extensive complexity in terms of direction, organizations and factors influencing governmental approaches and achievements. Response costs are rising for individual, and particularly large and catastrophic fires. A growing number of people and acres of property are threatened and damaged as population growth and fire risk increases in areas near wildlands. In addition, the overall cost of fire seasons is growing, with the $1.6 billion cost for the 2002 season the highest on record to date. Federal funding provided to the wildland fire community grew dramatically in 2001 through the National Fire Plan, and has remained essentially at this level since then.

These conditions have caused increasing attention and requests by governmental leaders in both the executive and legislative branches for objective goals and measures, greater coordination of work, quantifiable results, and more accountability for actions and costs related to fire. As discussed in this report and concluded by others, some progress has been made, but too often the federal fire agencies respond with unclear and sometimes differing strategies, and generalities in terms of definitions, direction, task articulation, actions, and performance reporting measures. For example, as discovered by the U.S. General Accounting Office (GAO), many in the federal fire community are unsure whether they are guided by the *10-Year Comprehensive Strategy* developed with the states and others, the Interagency Cohesive Strategy (both discussed in Chapter 2) or strategies of individual agencies, all of which have some differences in goals and objectives (2002, p. 18).

The definition and prioritization of communities at risk, determination and prioritization of fuels treatment projects, resource allocation methods, content of fire plans, and assistance to communities are just a few examples of generalities in direction, documentation of results, and other text prepared by fire agencies (Ibid.; GAO, 2003; GAO, 2002; GAO, 2000b). Lack of clear and synchronized strategic direction, combined with generalizations about conditions, can result in imprecise knowledge of risks and needs. It also means that capabilities to make informed decisions are compromised, though growing demands, issues and concerns concerning wildland fire management warrant improvements, particularly as tradeoffs and prioritizations are increasingly necessary.

At the same time, the wildland fire community is increasingly called upon and is responding to non-fire emergencies, such as the 9/11 terrorist attacks, the Colombia Shuttle recovery effort, and disease and insect outbreaks. Moreover, as discussed in Chapter 2, strengthening efforts to address homeland security are also impacting the wildland fire community in terms of increasing demands and potential influence on established fire processes and procedures. Combined with growing fiscal constraints, increased oversight, and demands for accountability and effectiveness, the wildland fire community is challenged as never before to address growing needs and to do more with less.

The wildland fire community and its leading federal agencies have a history of innovation in many respects, with a long successful history of fire suppression, despite a strong tradition of individualized and decentralized agency approaches. Adapting and responding to change has been very challenging for the federal fire agencies. The fire community experienced decades of almost singular attention to fire suppression, coupled with improvements in preparedness to meet this goal. But this approach has been replaced with a broader focus, including attention to the ecological benefits of fire, participation by additional sectors, creation of new interorganizational groups, and action to mitigate and recover from such events. For example, until recently, the National Wildfire Coordinating Group (NWCG) was the leading interagency fire organization since its creation over 25 years ago, complemented by the National Fire and Aviation Executive Board. In 2002, following recommendations by both GAO (2001) and the National Academy of Public Administration (2001), the new Wildland Fire Leadership Council (WFLC) was formed to help implement the National Fire Plan. As discussed in this report, it essentially addresses all phases of fire management unlike NWCG.

As shown in Figure 7-1, WFLC is characterized by this broader role, and also with higher level officials from federal and state governments, and the addition of county government representation through the National Association of Counties (NACo). However, concerns exist in terms of WFLC's potential to make significant differences to meet the challenges ahead. For example, fire risks and costs in the wildland urban interface (WUI) are considered to be leading concerns today. It seems to be increasingly recognized that local government involvement is crucial to address these matters. However, NACo does not have a resourced program to engage its member counties or others in wildland fire matters to effectuate internal change in counties, or to ensure most effective representation of county perspectives at WFLC. Moreover, municipalities are not represented in WFLC, or any nationwide fire groups. The fire community continues to struggle with understanding, considering and including local government perspectives and needs, both at a policy and tactical level.

Another concern about WFLC is that "the document creating WFLC calls for each department to manage its own activities and resources in pursuing objectives, and that disagreements are to be resolved by elevating any disagreements within each department rather than to a single decision maker" (GAO, 2003a, p. 6). While WFLC's

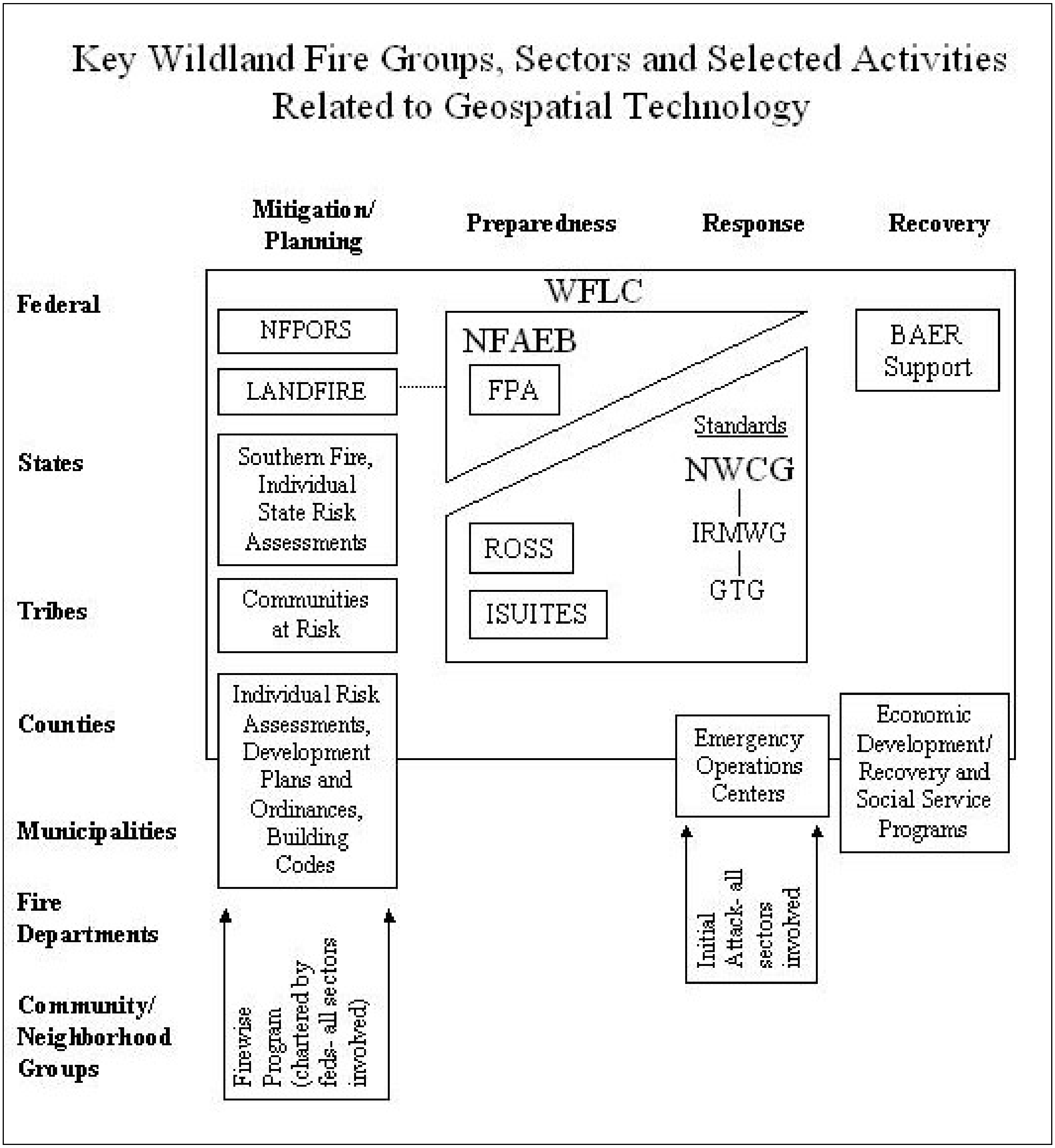

Figure 7-1. Key Wildland Fire Groups, Sectors and Selected Activities Related to Geospatial Technology

tenure has been short to date, this situation might hamper coordination efforts and serve to continue individualized and often fragmented approaches to fire in the federal government. This is compounded by unclear and imprecise knowledge of conditions and strategic direction as described above. It is likely that these conditions will continue to impact GI/GIT utilization and effectiveness for the foreseeable future.

7.2 GENERAL INFORMATION RESOURCES AND TECHNOLOGY CONDITIONS IN THE WILDLAND FIRE COMMUNITY

This policy and institutional context for wildland fire has had a direct impact on the approaches to and current conditions concerning information and information technology (IT) resources in general, as well as GI/GIT. The five federal land management agencies have each adopted their own IT direction and approaches, some more advanced than others, depending on varying topics, issues, timeframes, resources and agency fire and IT leadership. Through time, interagency efforts have been instituted, but they primarily focus on the response phase of fire management under the auspices of NWCG or to support operations at the National Interagency Fire Center (NIFC) in Boise. As discussed in Chapters 2 and 5, the Information Resources Management Working Team (IRMWT) and the Program Management Office (PMO) are the leading entities in this regard. However, their direction is to primarily address standards, though many issues that are raised to them go beyond standards and the response phase of fire management.

Over time, many resources have been devoted to designing and implementing what is now a plethora of fire information systems and models that have been and continue to be developed within one agency or among two or more agencies to meet specific fire needs. The report includes descriptions of some of the current leading systems that are under development by multiple fire agencies. However, as shown in Figure 7-1, these systems often are separately developed to meet specific needs in one phase of fire management, thus reinforcing what is often termed as "stovepiped" information systems.

Demand for improved fire information systems and documentation is growing to achieve greater accountability, but it is difficult to meet Congressional, Office of Management and Budget (OMB) and others' requests and demands for information, both within, but particularly among federal agencies, and even more so when considering other governments. It also is very difficult to develop, and even harder to implement, interagency systems because of differences among agencies and all of the existing internal systems that are directed to be maintained at one or more levels (field, regional and Washington). Staff at the field level often maintain their own systems in order to accurately understand and manage what is happening on the ground. When compared, these systems frequently have redundant or conflicting data, particularly about the same location, but often with differing data definitions and at differing levels of geospatial accuracy, precision and currency due to individual specifications and nuances of each system. As a result, the potential for accurate aggregation of data among systems is often compromised, and thus can not be accurately or reliably done.

An important example of compromised ability to accurately aggregate data concerns the reporting of fire occurrences. For example, while this report and others quote the number and acreages of fires in any given fire season, these statistics differ based upon the source of the data, whether they are provided by individual agencies, interagency organizations, or states. However, fire occurrence data is used for several important purposes, including to document and allocate costs for individual fires, understand fire causes, help to allocate assistance funding, and as input for various management and scientific studies. A recent assessment of federal fire occurrence data by the Desert Research Institute provides some of the most recent findings and examples of problems in this regard (Brown, et.al., 2002). A high incidence of incomplete records was observed, particularly for data about fire cause, and with a downward trend in the quality of records, particularly in the Department of Interior (Ibid., p. 25). This investigation also documented differing approaches to fire occurrence reporting among the agencies, time lags in data reporting, and several data quality control issues. Data quality control was found to be limited in documentation about the number of acres burned as well as the number of fires and their causes.

A crucial problem is that when system development funds are limited, decisions are often made to generalize data elements (similar to the discussion above concerning fire direction and documentation), and particularly to generalize the location of conditions. These decisions result in reduced precision in the geographic location of data elements, thus limiting the utility and aggregation of the data with that from other systems, while also fostering misunderstandings and misconceptions. For example, the new National Fire Plan Operations and Reporting System (NFPORS) is being implemented by all five agencies to track projects, outputs and accomplishments. Fire GIT professionals indicate that data locations recorded in NFPORS are insufficiently precise to be usable on the ground, particularly when "zoomed in" on a map. Latitude and longitude in NFPORS are only recorded to two decimal points, so resulting coordinates are only accurate to 1100 meters. This lack of precision severely limits the utility of the data for communities as well as federal field personnel, and raises concerns about the overall usefulness of the system.

Data locations in the Resource Ordering and Status System (ROSS), now being implemented across fire agencies, reportedly have even more imprecision and potential for inaccuracies in terms of the location of key resources. Informal reports are that when some points in ROSS have been plotted out, they may be "located" hundreds of miles away and not even in the United States. In these cases, field units and local governments must essentially maintain their own records in order to have an accurate understanding of conditions and plans. Such problems with NFPORS, ROSS and other systems essentially reinforce the perpetuation of multiple and potentially redundant and conflicting information systems. They also further negate the ability to combine data from various systems, even when about the same location on the ground.

Another example of unclear and limited attention to the location of conditions has been in the definition, designation and prioritization of "communities at risk," as directed by Congress and described in Chapter 3. Several governmental attempts have been made to determine the nationwide "communities at risk" of severe fire and damage, with strong federal fire policy direction to do so for at least three years, but the definition and location of these areas remain unclear according to these processes and systems (GAO, 2003b; GAO, 2002; GAO, 2001). Essentially, the "five federal land management agencies currently do not know how many communities are at high risk of wildland fire, where they are located, or what it will cost to lower the risk" (GAO, 2001, page 5). As discussed in Chapter 3, new guidance has been issued in this regard, but it is too soon to determine the outcomes of these efforts.

At the same time, with growing concerns and efforts to understand and address potential fire risks, more and more risk assessments are underway at federal, regional, state and local levels. For example, the LANDFIRE and Southern Fire Risk Assessment projects are moving forward as described and compared in Chapter 3. While these efforts to identify the locations of areas at risk are useful, existing differences in goals, data and methodologies may compromise comparisons and the utility of these and other project results.

These data issues are in large part exacerbated with technology developments and opportunities, though technology could go a long way to help address these problems. The fire community faces additional issues in terms of technology deployment and use. As concluded by GAO (2003d), the fire community is characterized by many disparate systems, many with overlapping missions and representing legacy systems based on past direction and outdated technology (some within individual agencies and others at the interagency level as part of NWCG efforts).

While many additional issues and concerns can be expressed about approaches to and current conditions concerning information and IT resources for wildland fire, an additional key observation is what appears to be a limited use of information as a strategic resource, and particularly for decision making. While several decision support systems have been developed for fire, some observers find that they are less important for effective decision making than direct experience. Moreover, very little research has been conducted about how fire managers use decision support systems or their attitudes about them (Machlis et.al., 2002). As more and more information resources and decision support systems are available to fire decision makers, it can be increasingly difficult for them to determine which are most effective and reliable. Yet, modern and comprehensive resource readiness in terms of information and technology in general is a critical and growing need in the wildland fire community.

7.3 GI/GIT ISSUES AND NEEDS IN THE WILDLAND FIRE COMMUNITY

Within these contexts, current approaches to GI/GIT in the wildland fire community can be generally characterized as being ad hoc and inconsistent, but at the same time, with several examples of innovation and attempts to develop, and some success from, coordinated approaches. These conditions and associated issues and needs are evidenced in various ways.

7.3.1 Insufficient Leadership Attention and Action

While there are some exceptions and improvements, insufficient policy and management recognition, vision, attention and action by the federal fire leadership is evident concerning GI/GIT development, usage, challenges and opportunities, which has several ramifications. Several examples exhibit the lack of adequate attention and understanding of these conditions and potential benefits. For example, some information systems now in development do not make full use of GI/GIT, such as NFPORS and ROSS described above, but could be more useful to users. Moreover, it is clear that GI/GIT is not part of “standard operating procedures” for wildland fire. As described in Chapter 5, marked examples are the limited resources and equipment provided to front line fire forces such as hot shot crews and smoke jumpers, and the lack of institutionalization through the Incident Command System (ICS). Even when GIS is used on fires, it is primarily as a cartographic tool, not as a strategic resource for decision making (Burchfield et.al., 2002).

Fire management organizations, and particularly their leaders, are typically not aware of the existing and/or potential capabilities and outputs of GI/GIT, particularly newer systems. Many options are available and are often used on individual fires, but fire decision makers often do not have the knowledge or background to understand tradeoffs and ramifications of various technological options, particularly in terms of imagery. This is a strong concern that has been expressed for example by some State Foresters. Opportunities exist for the broad fire community (federal, state, local and other governments outside the U.S.) to collectively contribute input and even provide support if fire leaders were made aware and part of efforts to determine the potential uses and benefits of modern GI/GIT capabilities.

As described in Chapters 2 and 5, the current interorganizational approach to GI/GIT consists of the Geospatial Task Group (GTG) of the National Wildfire Coordinating Group's Information Resources Management Working Team (IRMWT). GTG focuses on issues under NWCG and IRMWT's auspices. Accordingly, as described above, it primarily concentrates on response needs and standards, with some attention to preparedness such as training. GTG’s scope of attention does not incorporate all existing or potential uses of GI/GIT, or all phases of wildland fire management. GTG also is constrained due to limited resources. It has no staff and a limited budget approved through IRMWT. Beyond this, it only has the resources made available to it through the participation of its member agencies. GTG has accomplished much given its limited scope and resources, and serves as a testimony of the fortitude and capability of its members, but its progress and prospects for the future is stymied as a result. In addition, though IRMWT has more resources and staff, it also appears challenged to address several GI/GIT issues and needs.

At a broader and higher level, the Wildland Fire Leadership Council (WFLC) has not addressed GI/GIT issues, but projects using these data and technology are increasingly brought before them. GAO recently recommended that WFLC take action regarding GI/GIT (2003d), but this has not yet occurred. Some agency fire directors have addressed GI/GIT from a policy standpoint, and implemented helpful organizational approaches within their agencies. Their leadership also helps ensure progress continues to develop common standards and procedures.

7.3.2 Ad hoc Approach to Geospatial Data

The importance of and need for better information is recognized by many in the fire community. For example, at the FIRES workshop in Missoula in November 2001, "intelligence" was identified as one of the leading problems in the fire community, tying with safety and risk management, and it also was identified as the top desired capability (Vodacek, 2002).

Several examples exist of how geospatial fire data resources can be inconsistent, redundant, conflicting, ineffectual and unreliable. Policies, procedures and standards for data vary by agency and may not exist at all, much less implemented on a consistent basis for all fire agencies. Policies and standards often do not exist about minimum data (content, precision or accuracy) requirements. Even when such direction does exist, there is no guarantee that it will be followed, such as if funds are limited and staff have competing demands.

Overall lack of central policies, procedures, processes, and standards for geospatial data within and among agencies means that some fires can not be mapped across land unit boundaries, or even more difficult, in an interagency context, or worse, across differing land ownerships. These problems are compounded when work needs to be conducted in a real time context to meet response needs, particularly when lives, property and resources are at risk. Standard procedures and mechanisms would be helpful to integrate various geospatial data inputs during fire response, particularly in as close to real time as possible.

Team transitioning is a particularly critical time when the lack of common GI/GIT approaches is problematic and very evident, even to the public. The current ad hoc approach means that resources may or may not be used on fires, even if they are large. For example, research conducted by the National Academy of Public Administration found that the second team at the Hayman Fire in Colorado in 2002 did not have GIS capacity, though the first team did. Erroneous expectations were that the same map products would be available to responders (NAPA, 2002). Under current approaches, a newly assigned incident command team may have to search for data resources and may not find any from the team that has left. If GIT has been used, there may or may not be records of metadata and procedures that could help the new team. Since the teams are often busy with departure processes, and there are no requirements in this regard, many new teams are not provided with any data records. Valuable time can be lost during these transitions due to the absence of formal protocols and procedures for data transfer during fires (Burchfield et.al., 2002).

A particular problem also exists in terms of GPS use. Different datums can be used, so data often need to be reprojected because standard approaches do not exist. Frustrations have been reported as many technicians using GPS are unequipped or unskilled to do these reprojections. At the same time, managers can also be frustrated because they do not understand the complexities of what they may think are simple adjustments. GIS staff are often forced to spend time reconciling disparate data and correcting problems rather than other work. An important example is determining the precise location of a fire perimeter, a key data element to regularly measure the size of fires and the allocation of fire costs. As GPS use flourishes, problems with incorrect and differing uses of GPS are expected to increase with the current ad hoc approach.

Insufficient attention to geodata is also evidenced in that data resources are often not used from one fire management phase to others, or effectively accessed from other organizations. Readily available and reliable data products are increasingly demanded about preexisting conditions. These data could be integrated and used with current fire data and projections to best communicate conditions and risks in order for decision makers to make appropriate decisions. However, data development seems to start over with each phase, which typically requires more time and cost than is necessary. GI/GIT that is used for mitigation efforts or increasing fire risk assessments may not be available to fire responders. Data maintained by federal field units may not even be used by BAER teams, since they can find it easier to create new data rather than to contact others to acquire and use existing data. Some efforts are underway by federal fire GIS staff to provide access to common base data about conditions on the ground before a fire starts. Additional and perhaps better data is available from state and local governments, but development of opportunities to access and use such data appears to be in its infancy though more and better data continue to be developed by states and localities. It is difficult to obtain data without focused effort in this regard before, much less during a fire. Data sharing and integration issues are critical matters to address before GI/GIT benefits can be realized (GAO, 2003c).

7.3.3 Growing Technology Proliferation in Fire Response

GI/GIT use is increasingly widespread in the federal and broader fire community despite the above conditions. GI/GIT use is growing in virtually all sectors of society because it is becoming less expensive and easier to use through time, as evidenced with the increase in GPS use as described above.

Growing GI/GIT usage also is because managers at large fires essentially have an "open check book" to procure whatever resources they feel they need to respond successfully. This proliferation shows that managers recognize the need for these resources on fires. But it also reveals insufficient overarching management attention to this issue, including its contribution to the growing costs of fire suppression according to the current ad hoc approach. It also reveals the potential for more effective, efficient and accountable deployment of GI/GIT in fire response throughout the fire community, perhaps including closer and less expensive resources. For example, during the Colorado fires of 2002, some incident commanders felt it was necessary to acquire out of state, private sector fire GIS resources. However, extensive GI/GIT resources and expertise exists in many organizations in Colorado and might have provided cost effective help.

7.3.4 Insufficient Institutional Capacity to Meet Needs

The federal fire community often does not have the necessary institutional, outreach and technical capacity to fully utilize and benefit from existing or new GI/GIT. Appropriate policies, staff expertise, training, exercises and simulations, data, standards, technology infrastructure, and other conditions often do not exist at many levels of wildland fire management. Federal offices and fire staffs are often overwhelmed with requests that are impossible to meet during fire seasons, particularly given the data resources that were required to meet these needs. For example, many of the resources needed to run fire models, including data, technology, and expertise, are not available to federal field managers, or to state and local governments. Moreover, models may produce different results when crossing the boundary from one forest or other land management unit to another because the land management agencies have not developed or implemented common standards for interpreting and applying data.

Various efforts exist to increase connectivity among the federal land management agencies in general, and regarding wildland fire (including by NWCG, more recently by WFLC, and others). However, significant overall differences exist in terms of wildland fire policies, organizational approaches, procedures, and standards, which in turn impact the ability to best deploy and make most effective use of GI/GIT. Federal agencies are inconsistent in their attention, policy, and institutionalization of GI/GIT generally, and also in terms of fire.

For example, while GIS is not a required skill through the Incident Command System, the National Park Service and Bureau of Land Management made the policy decision to establish a fire GIS staff position at each of their regional offices. These decisions were made to provide help to and increase connectivity among their land management units concerning fire matters. The Bureau of Indian Affairs is developing a similar approach. However, analogous positions do not exist in the other land management agencies, making coordination difficult. Federal fire managers also can learn from states that have institutionalized approaches to GI/GIT use for fire response, such as California and Oregon.

7.3.5 Staffing Availability and Capabilities

Staffing is a key issue concerning GI/GIT in general, but particularly for wildland fire. Many short and long term demands are placed on fire GIT professionals, and there is a growing need for more qualified individuals. Capable staff are needed in teams, centers and agency offices during fire seasons, but there often is ad hoc attention to this need. Efforts are being made by the Geospatial Task Group and others to help in this regard. However, a standard suite of capabilities or requirements does not exist for Incident Management Teams (IMTs), nor is there a GIT, GIS, GPS or remote sensing, series, common position description(s), or training requirements. Job descriptions are quite outdated for key informational positions on fire teams such as "Display Processor" (a frequent position classification of staff with GIS expertise since GIS is not a position on teams). As a result, individuals with varying skills have different and inconsistent titles, and inappropriate or unrealistic expectations may exist by managers or others about one or more staff.

Modern and consistent personnel requirements and job series classifications are needed through the Incident Command System. The degree to which a team has individuals qualified in GI/GIT as part of the team can make a huge difference in terms of GI/GIT deployment and effectiveness. More and more staff have GIT skills and experience, such as "Fire Behavior Specialists." However, a key problem to date has been that there is no requirement for GIS, GPS or other modern GIT capabilities as part of the ICS personnel qualifications standards, or as a standard of any other nationwide organization such as a Federal agency.

While GPS use is more prevalent than GIS, there is no requirement or assurance that a team will even have an individual qualified in the use of GPS to help conduct fire perimeter mapping, one of the most critical functions and data requirements for fire response. Geospatial Task Group (GTG) members have found that a result of the high availability of these receivers, but insufficiently informed users, is that many instances of errors and inappropriate data and datums have been experienced, causing additional problems for GIS users. There also may be expectations that GIS staff know more about remote sensing than is realistic.

Another problem resulting from this lack of formal attention to GI/GIT staffing is that many dedicated people with GI/GIT skills are requested and are busy during fire seasons, but their full potential and value is not able to be realized. Fire managers are often unsure how to best and appropriately utilize these staff. GI/GIT staff often have few incentives to improve their skills and conditions other than their internal dedication and perseverance. As described in Chapter 5, GTG is developing and conducting GIS and GPS training classes, which has been helpful to establish some consistency in and goals for "GIS Techs".

Similar training opportunities do not exist specifically about remote sensing for fire. Expertise for fire is primarily located in the central offices of the Forest Service and to a lesser degree in the other agencies, though there are some regional staff with remote sensing expertise. Since expectations seem to be growing that GIS staff are knowledgeable about remote sensing resources and options, an opportunity exists to expand these training opportunities to include remote sensing resources and capabilities.

As described in several of the above chapters, government fire management organizations and their staff often make use of GI/GIT where feasible and resources are available for this purpose. As discussed, there has been particular growth in the use of GI/GIT during and after major fires, and in particularly severe fire seasons. In the cases where significant staffing and related GI/GIT resources are available, typically when responding to major fires, usage has advanced more quickly than in other phases.

While most attention is given to federal staff, GI/GIT expertise exists in many state and local governments. These capabilities vary significantly across the country. However, more and more state forestry organizations (SFOs) have GIS capabilities, which are increasingly applied to fire needs, sometimes with funding assistance from the federal government. In addition, statewide GI/GIT coordination entities, though fledgling in some states, are generally becoming more institutionalized through time and could be valuable resources for wildland fire in addition to SFOs.

Many local governments, particularly poor and rural counties and towns, have limited or no geospatial data of their own and/or no capability to access geospatial data from others. Other local governments have comprehensive and current data systems and technology that could be excellent resources for the fire community. With focused effort and encouragement, wildland fire issues and needs could be a successful driver for enhanced coordination among federal field units and local and state governments, both for GI/GIT and more broadly.

7.3.6 Insufficient Supporting Infrastructure

Insufficient and unreliable equipment, software, space, technical connectivity and telecommunications characterizes many fires today (Burchfield et.al., 2002). Conducting GI/GIT work during fires often is a frequent challenge at both centers and fire camps. Lack of appropriate equipment means that color plotters may not be available so crews do not even have basic information about where vegetation is located (in green) on a quad sheet, which can compromise effectiveness and safety. Some individuals dispatched to fire camps must bring their own laptops and desktops to their assignments, but this can compound communications problems due to password protection protocols, etc. External computers are not necessarily able to access needed data on internal Intranets, and sometimes they cannot even access Internet connections, particularly as security and firewall issues have become more evident since 9/11. Communications systems may not be reliable to transmit critical information.

Lack of management level understanding of, and willingness to address technical infrastructure issues and requirements, can stymie fire response efforts even if staff are available and capable. Technology resources are often procured and handled on a case by case basis on fires, which can produce costly and unreliable results. A standard suite of hardware, software and networking capabilities for geospatial data display, management and analysis (to produce a standard baseline of products) has been discussed but has not been definitively defined or required, but could be very useful.

7.4 GI/GIT OPPORTUNITIES AND SUGGESTIONS IN WILDLAND FIRE

The above conditions, issues and needs reveal additional opportunities for deployment of GI/GIT for fire. A few, but not all examples are identified and discussed below.

7.4.1 Communities at Risk and Local Fire Capacity

Current problems associated with identification and prioritization of individual and parts of "communities at risk" are discussed earlier in this chapter. GI/GIT could make a large difference to improve these conditions. As discussed in Chapter 3, recent guidance developed by the National Association of State Foresters (NASF) to identify and prioritize these areas is an improvement over past direction. However, more direction and assistance could provide for defined measures of the locations of communities and parts thereof using standards to ensure accurate, precise and current georeferencing of their corresponding boundaries, whether or not GIS capabilities are fully utilized. This approach, along with use of common foundational data about conditions and risks, would go a long way to increase capabilities to compare and aggregate conditions within and among states, and nationwide. It also would help to increase the objectivity and utility of the results of these "communities at risk" identification and prioritization efforts, particularly to make resource allocation decisions. Another opportunity exists to help enable insurance companies who provide coverage in Wildland Urban Interface

(WUI) areas to use these results to influence policy holders to increase the safety of individual properties, as is underway in Colorado as described in Chapter 3.

A key concern about communities before fires is to understand the existence of local fire departments and their protection area coverage in terms of specific geographic areas. There has been discussion, grants and other encouragement to work with and increase the capacity of local fire departments. However, it is disturbing that the boundaries of areas served by local departments are not necessarily known in many parts of the country. Whether or not a local department exists nearby or officially serves an area (via an official taxing district) may not be known, though such departments could help with initial attack. It is generally known that many rural parts of the country do not have a local department of any kind, but the actual locations of these areas are not known in many states. In some areas, misunderstandings even exist on the ground among land owners, taxing authorities and fire departments about the specific location of coverage areas. In addition to this problem is the fact that the location of local fire stations, fire fighting facilities and other resources may not exist in any digital databases, so they are not known to state and federal fire forces. This lack of information is additionally disturbing given the increasing role of these local responders for other emergencies.

Efforts within the wildland fire community appear limited to understand or address this lack of knowledge, though the need to understand local fire fighting capacity is increasingly recognized. For example, a key action item in the *10 Year Comprehensive Strategy Implementation Plan* was to "assess the training, equipment, safety awareness and services provided by rural, volunteer or other firefighters who work in the Wildland Urban Interface and report to Congress." This effort was undertaken by NASF in coordination with several other stakeholders, and the resulting final report was recently issued (NASF, 2003b). While the report is informative, neither the direction to do the study, or its content, addresses the critical issue of where such departments and resources do and do not exist.

Direction does not seem to exist to encourage states or localities to acquire, maintain and provide access to information about the location of fire stations, resources, or service areas, or to use GIS in this regard. For example, NASF is managing a survey that is being conducted of local fire departments in each state to provide more information to help address this task in the *10 Year Comprehensive Strategy Implementation Plan*. Unfortunately, none of the questions ask the local departments to identify the location of their headquarters, stations, facilities or areas served. However, each state is managing their own survey effort, and some are adding such questions to the survey instrument. For example, Florida's survey asks for the latitude and longitude coordinates of all headquarters and stations.

It would seem that the existence and location of departments, and their resources and service areas, would be a critical but relatively easy need to accomplish to help achieve the goal of the 10 Year Strategy to improve fire prevention and suppression. Moreover, such information about fire facilities and resources is increasingly considered to be "critical infrastructure" for homeland security. If not asked by a survey, it would seem that provision of such information could be a simple requirement in fire department grant applications through each of the various federal programs available to them. It seems that states would certainly use and benefit by such information, and could be encouraged (also through existing grants) to maintain it in house and provide access (using Internet or Intranet map serving GIS capabilities) to federal fire fighting and emergency response agencies. This information could clearly help in strategic and tactical decision making and management in all phases of fire and emergency management, such as mitigation, planning, preparedness, response and recovery.

It has been reported that homeland security funding is being used to create some geospatial databases about local fire department resources, but apparently without the involvement of the wildland fire community or local governments. Such one-time data collection efforts can have limited utility if arrangements are not made to maintain the currency of such data resources. Real concerns have been expressed that such databases could be out of data and not reliable soon after their creation.

The technical assistance grant program suggested in Section 3.4.2 to increase local and state government capacity to use GI/GIT for mitigation, planning and preparedness also could help in this regard. Such a program could encourage development, maintenance and provision of data about local fire resources to state and federal fire agencies and others for fire, and also other emergency management and homeland security needs.

7.4.2 Fire Preparedness

The Federal Fire Policy discussed above directs land management units to develop up to date fire plans or other plans that identify and address areas at risk. It is well known that these efforts are not complete. While encouraged to address the conditions, resources and needs of nearby areas, a key problem is that federal fire management planning processes have not well addressed adjacent or nearby jurisdictions. Data from the plans often are used in models to determine resource needs, but the models do not consider the fire-fighting resources that are available or lacking in adjacent areas. The new Fire Program Analysis (FPA) system is expected to have some GIS capabilities and will help, but full implementation may reportedly take 4-6 years. Opportunities exist to use GIS to help organize, manage and analyze disparate data across boundaries to better prepare for fire.

The Predictive Services group is emerging to be a helpful resource at NIFC to assist in preplanning and propositioning resources. However, GI/GIT capabilities could be more fully utilized, particularly in terms of web mapping access and services similar to the Wildland Fire Assessment System site (http://www.fs.fed.us/land/wfas/welcome.htm).

Proactive preplanning and propositioning of data resources for fires seems like an approach that could have been beneficial for years, but it seems to continue to be lacking. Efforts are underway now to ensure that individual fires have access to at least digital raster graphic (DRG) images of 1:24,000 scale quad sheets. However, fire responders could be provided with even more thorough, current and precise data if they had consistent access to the data resources maintained by federal land management units and state governments, and particularly if available seamlessly across ownership boundaries. In addition, local data about parcel ownership, addresses, structures, and building materials (via building codes) would be immensely helpful in planning effective and safe wildfire approaches, and particularly when having to make critical tradeoff decisions about saving "values at risk". It also would help to inform the public generally about conditions, and to warn individual landowners about their properties at risk with Reverse 911 if armed with an accurate address database and arrangements with a telecommunications provider.

There does not appear to be direction to land management units to contact nearby localities to make arrangements up front to gain access to data, or offer to aid in maintaining such data to ensure its utility and currency during fires. Instead, it seems the common approach is that requests for data are made in an ad hoc, reactive way, and fire GIS folks become frustrated that local officials may not wish or be able to quickly "turn over" their data sets. It would help if the fire community was more aware of existing GI/GIT resources from and contacts in state and local governments. Federal field staff could then begin dialogue and enter into at least informal data sharing agreements before fires begin. An additional benefit of such an approach is that more and more local and state governments are procuring private imagery for other purposes that also could be used for fire. This could be a very valuable resource to minimize the need for federal agencies to also buy such imagery, and thus reduce the need for taxpayers to pay twice or more for the same or similar products.

7.4.3 Fire Response

Several examples exist of how GI/GIT could be better used for fire response as discussed below.

7.4.3.2 Aviation Resources

Aircraft are essential resources for wildland fire, both for direct response and monitoring. Several air tanker and helicopter crashes during the 2002 season, and growing recognition of the need for modernization of the fixed wing air tanker fleet has raised increasing concern. However, the federal government, and specifically the Forest Service, does not provide agency wide direction to prepare or maintain aviation hazard maps.

It seems that for safety reasons alone, not to mention hard costs of lost aircraft and contents, this information should be readily and consistently available in a easily accessible manner (such as in a digital format for use with GIS). It could be critically important for the effectiveness and safety of the aircraft and individuals within them. There is clearly a need for common interagency and intergovernmental protocols and data requirements to be established and maintained for aviation hazard maps to ensure effectiveness and safety. Lessons could be learned from some Forest Service regions that have such requirements, though compliance may be limited. Additional information could be provided beyond what is required in these regions, such as the condition, usage and capability of air strips. Moreover, these data could be part of preplanning and pre-positioning of geospatial data resources.

7.4.3.3 Asset Management

A growing trend in many industries is to utilize GPS to conduct what is essentially "wireless asset or fleet management". GPS receivers have been long used by trucking, delivery and other companies for many years to increase safety and efficiency, such as by Federal Express and Sears (for appliance delivery and maintenance). GPS has also been used by governments to monitor the movement of hazardous materials and parolees, and by parents to monitor children such as on field trips.

It appears that the federal fire community could make much greater use of GPS to track aircraft and other fire resources for tactical, strategic and/or rapid resource needs. It also could be used to monitor and compare activities (such as dropping water or retardant) to in turn evaluate the effectiveness of these actions in respect to other conditions and variables, and then optimize future response actions. It seems that the precise location of stationary assets would also be helpful for tactical, management and strategic needs.

7.4.3.4 Dispatch

GIS use could enhance dispatch center operations, particularly as this seems to be one of the more under automated aspects of wildland fire management. Simple data resources could be very useful as a resource to help manage activities at these centers, and increase the accuracy and effectiveness of dispatch operations. Beyond digital data about the boundaries served by centers, it would be helpful to have a georeferenced point to show the location of all dispatch centers, as well as the boundaries of all coordination zones. It would also be helpful to have the parcel addresses and other information about values at risk in order to aid in dispatching accuracy and timeliness. It seems that much more could be done in addition to what is being accomplished and envisioned through ROSS, as described in Chapter 5.

7.4.3.5 Communications

A frequently reported fire fighting problem is that radio communications may be hampered due to terrain and other physical conditions on the ground. Yet, many of these conditions may not be recorded or known in advance, thus compromising the effectiveness and safety of impacted fire fighters. Alternatively, digital data could be developed and used with GIS to show all permanent radio towers and repeaters with frequencies as attributes. While initially difficult to do completely, it also would be helpful to map all signal areas (vs. shadows or holes) to know where radios will work and where they would not work. This would enable responders to plan ahead and set up temporary repeaters when needed. These databases could be maintained regularly and would seem to be a critical resource to help address and reduce existing radio communications problems.

7.4.3.6 Firefighting

As of today, GPS still is not "standard issue" for firefighters on the front lines, though it would seem appropriate for hotshot and “helitack” crews and smokejumpers at a minimum for safety reasons. Individual firefighters also require information to best accomplish their jobs. Large investments are made in the training and equipment provided to these individuals, but few resources seem to be invested in empowering them with information to increase their safety (though safety is the top concern unlike in the military) and effectiveness. Inadequate information can threaten and has contributed as a key factor in firefighter fatalities, and has caused additional risk to others, as described in Section 5.4.2 about the Thirtymile Fire in Washington in 2001. Some improvements are being made. For examples, some smoke jumpers now have the option to carry a government issued GPS receiver if desired, and some informal training is provided. However, there is no standard requirement or approach in this regard.

Insufficient information limits the safety and effectiveness of individual firefighters, but also the crews and teams they belong to. Decision makers on individual fires often have incomplete and sometimes conflicting information, such as about fire (such as differing GPS readings and other input about fire perimeters) and conditions and risk on the ground (such as unavailable, inaccurate or outdated information about the existence and whereabouts of infrastructure, roadways, homes, other structures, waterways, etc). Appropriate decision making is compromised as a result. Overall fire monitoring is a critical need, but information may not be readily available about ignitions, lightning, hot spots, weather and wind dynamics, fire progression and behavior, fuel breaks, past fires and treatments, smoke dispersions and predictions, safety zones, access routes, etc. Information needs to be as accurate, precise and current, and available in as close to a real time basis as possible in order to determine priority protection areas, make resource allocation decisions, ensure the safety of firefighters and limit loss of life, property and resources. For example, sometimes tradeoffs must be made between letting some houses burn in order to save others. It seems that such decisions must be based on accurate, current and objective information about conditions and resources on the ground, and that decision makers must be accountable for such decisions.

A growing aspect of this problem of insufficient focus and information for firefighting is that the near crisis level of fire conditions mean that there is a growing need (and opportunity due to better technology) to delivery existing data in new and integrated formats to augment, and in some cases, replace traditional formats. For example, information dissemination and sharing also is a key component of the role of Geographic Area Coordination Centers and dispatch centers. Each center prepares intelligence reports and orders resources to fight fire. These centers need integrated and synthesized information about fire conditions, resources available and deployed, and likely scenarios in order to best accomplish their missions. Limitations in information capabilities at these centers means that integrated data may be difficult to develop and access. Some innovative centers have established web sites to manage and disseminate key information in order to better allocate resources, such as was the original reason for the GeoMAC system. However, the degree of modernization of the communications systems and data integration capabilities varies at these centers.

7.4.3.7 Informing the Public

Extensive needs and opportunities exist to coordinate federal, state and local information dissemination efforts, and particularly with local dispatch centers. This is critically needed, particularly as more and more local governments are merging their operations and have E911 systems. These systems use automated records of the geocoded location for each structure in their jurisdiction. They can be a critical resource to ensure effective fire response and communications, but can be virtually ignored similar to local firefighting resources during fire incidents. Fire warning methods have been necessary over time to alert those in danger, and are increasingly demanded to inform nearby governments and the public about fire conditions and threats. However, efforts to improve and modernize these methods do not seem to have had much attention by the fire leadership. The immediate and continuing popularity of the GeoMAC web site is evidence of this need and to keep the public informed, but also the limited attention by the federal fire leadership until it was initiated by USGS, GIS staff at the fire agencies, and vendors. Additional opportunities exist to make more use of GI/GIT to keep the overall public informed. Fire information officers need digital photos and digital maps to inform individual citizens and elected local, state and federal officials and the news media about a fire’s location and movements.

Another example of the limited attention to provision of information is how individual property owners are notified of imminent risk. In order to contact them in as real time a manner as possible, the approach often used includes extensive travel by staff to essentially "knock on doors" to let people know that a fire may impact their homes. However, new methods and devices, such as Reverse 911 systems, could be much more extensively used. Overall attention to early warning systems has grown since 9/11 as described in Chapter 3, and this focus presents an opportunity for the fire community to help improve conditions for fire and otherwise.

7.4.3.8 Accountability and Cost Containment

GAO has concluded that to determine the appropriate funding needed to fight fires, the fire agencies need to have consistent methods of recording costs, but found that many departments record costs using different approaches (GAO, 2003a). As a result, it is difficult for agency officials, the Congress or other interested parties to develop comparable data for analyzing these costs or make meaningful comparisons of spending trends, further complicating effective oversight and monitoring of fire fighting costs. GI/GIT could easily help in this regard by geographically documenting and portraying the results, which also would reveal performance and future areas of need and issues to be addressed which could help the agencies achieve greater accountability.

More specifically, remote sensing and other GIT have been successfully applied for early assessments of fire conditions as needed for rehabilitation work. An opportunity exists to build on the success of these pre-assessments to help teams on the ground to prioritize and conduct such work. It seems that this experience could be used to consider implementation of remote sensing as key data input to enhance decision making during fires, and to improve objectiveness and quantification of “acres burned”. This would be a more thorough and effective approach than the common and simplistic use of fire perimeters. It seems that determination and evaluations of "acres burned" could be much more accurately determined with remote sensing than existing approaches. Moreover, additional measures could be used to record the size and severity of individual fires, and in turn to portray, compare and analyze such statistics. Exploration of these new information resources might also help to address and more quickly resolve frequent long standing conflicts and costly processes to document and allocate costs after a fire is over. Given the problems documented to date about fire occurrence data and the growing call for greater accountability, it seems that remote sensing and other GI/GIT have much to offer. Greater specificity about burned areas for individual fires and fires in the aggregate for all or parts of fire seasons could be very helpful for fire managers, public officials, researchers and others addressing wildland fire and associated impacts.

7.5 ADDITIONAL SUGGESTIONS

Several needs and opportunities for greater use and institutionalization of GI/GIT for wildland fire are presented in this report, and particularly in this chapter. However, the following approaches and strategies can serve as additional input for future actions.

7.5.1 Information and Technology Management Strategy

Some of the problems documented in this report and elsewhere are increasingly recognized. Improvement of information systems has been identified as a key priority in recent studies about fire management in the United States. Moreover, GI/GIT is increasingly recognized as a critical form of information and related technology that deserves specific attention.

For example, a recent panel of the National Academy of Public Administration (NAPA) evaluating progress and issues associated with the Federal Fire Policy found that (2001, p.118):

> *Federal agencies need greatly improved data collection processes and information systems to adequately support such functions as program evaluation, management accountability, workforce development, and risk management. Many databases are not developed on a national basis; many program managers do not believe they have access to data they need to achieve program objectives; and agency officials have questioned the validity and accuracy of some existing data. In addition, the agencies do not have an efficient interagency, interdisciplinary, intergovernmental strategy for acquiring, managing, and disseminating the data needed to implement many elements of the Fire Policy and National Fire Plan. The best available information technology—geographic information systems, remote sensing, and global positioning systems—has not been widely deployed.*

Based on this finding, the NAPA panel recommended that an information management strategy should be developed to improve, coordinate and maximize the use of diverse data resources created by diverse agencies, organizations and technological capabilities (2001). In a more recent study about cost containment for wildfire suppression, the corresponding NAPA panel similarly stated that an overall information technology/information management framework should be developed for wildland fire management (NAPA, 2002, p. 51). This report also indicated that "the panel believes that geographic information is so important to efficient and effective fire program management that it deserves a special place in the IT/IM framework and has high priority for widespread deployment" (p. 53) to meet needs "at many different scales to meet planning, environmental protection, firefighting, recovery and other needs" (p. 51).

Attention to GI/GIT is growing at policy levels and among fire participants, thus reinforcing the need for this strategy. For example, GAO recently completed an investigation about GI/GIT for wildland fire, and identified the need for strengthened policy direction and planning for GI/GIT (2003d). In addition, a Congressional hearing was held in June about GI/GIT matters in general, with GAO and others providing key testimony in this regard (GAO, 2003c). At workshops held in March and April of 2003, approximately 300 managers, researchers and others gathered to discuss wildland fire-related research needs and barriers to implementation. One of four key conclusions was that applied fire research should be addressed at multiple spatial and temporal scales (White, 2003).

7.5.2 Key Strategic Themes

It is important that a future information and technology management strategy for fire address the unique aspects of GI/GIT. Fire goals, tasks, measurement and evaluation of results and overall accountability could be more actionable, understandable and useful if they had more specificity about the georeferencing of all efforts on the ground, whether about mitigation, planning, response, recovery, or otherwise. A key theme of the strategy should be to illuminate how location can be a key linking mechanism among disparate data to understand conditions, future scenarios and tradeoffs appropriate in decision making.

The strategy also should address all phases of fire as described in this report, all sectors involved with and impacted by wildland fire, and all land ownerships, with particular attention to empowering first responders and modernizing the GI/GIT resources available to them to accomplish their critical role. Attention must be given to the growing need for “all hazards” approaches and the need for strengthened state and local capacities regarding GI/GIT, particularly to address WUI needs.

A key focus of the strategy should be on consistent data and information readiness, particularly to meet real time and short term needs, but also for the long term. Data needs include natural, physical and human resources and characteristics; such as topography (elevation and terrain aspect and shape); vegetation and fuel load (including biomass condition, quality, moisture, and vertical and horizontal structure) and past treatments; roads, utilities and other infrastructure; administrative boundaries and land ownerships; and information about human settlements, such as socioeconomic characteristics, structures, services, resources, etc. In addition, weather, meteorological and atmospheric monitoring and modeling (wind velocity and direction, relative humidity, temperature, precipitation, lightning, etc) in addition to current data about pre-fire natural, physical and human resources and characteristics. Such information is needed as direct input to understanding of wildland fire probability, potential behavior and effects as needed for fire danger ratings and potential cost estimations, but also for real time use prior to and after an ignition of one or more wildfires. This information is needed by the federal fire community, but also must be made easily available to state, local and tribal governments. Efforts also are needed to empower these participants to ensure effective use.

Consideration should be given to enacting an approach similar to what the U.S. Environmental Protection Agency (EPA) developed some years ago. That was to develop and implement a common "locational data policy" across the various media regulated by the agency (e.g., air, water, land, waste, etc.) as a way to encourage multimedia permitting and approaches. It seems that development of a common policy could be initiated and easily started for all federal lands, and particularly for fire. The current cooperative land management records project between the Forest Service and BLM, known as the National Integrated Land System (NILS), is a good step in this direction. Effort could be made to understand the additional common geospatial data needs across each agency (and all federal lands or beyond), and the precision, accuracy and currency needs for these data elements, including at the field level. The continuing inability to definitively define how many acres are managed by each agency, either in total or by state, is one example of existing related data problems and how investments have not made in base foundational data for federal real estate. Problems associated with federal land management data have complicated federal fire data management.

Another suggestion is that the strategy could include analysis of the potential results if federal agencies were required to georeference (using GPS) all points on the ground about which they are working. Standardized processes, methods and quality assurance procedures could be provided to enable accurate data comparisons, integration and incorporation with other data in GIS. This would likely be much simpler and less costly than some other efforts now underway, but could be very useful. In addition to focus on GIS as a system, attention should be on the agencies' often disparate data resources. Approximately 80-90% of the land management agencies' activities take place on the ground, and should have some type of geographic location that could be denoted. This reference point could then be used as a link to data from other systems (GIS and otherwise), to composite data from disparate sources for many strategic, management and tactical uses.

Rather that difficult and costly efforts to build and maintain several systems and databases that only have generalized representations about the locations of projects or other conditions or efforts, key data points (or lines, polygons or centroids of polygons created by points), should have precise locations recorded and managed. These locational data references could be determined, and then data could be maintained by program offices assigned with data stewardship/custodianship roles based on their business functions. In this way, the agencies could be on a compatible path toward an enterprise-wide land management data base of geo data that could be commonly and reliably used by several agencies, staffs and offices, as well as across boundaries and multiple ownerships, including locations of facilities, fire perimeters, airstrips, etc. With these points, data attributes from multiple systems could be referenced, accessible via tables, displayed, linked and analyzed for various needs. Moreover, data developed for one purpose could be easily used for other needs with little additional cost, thus addressing the limitations of many information systems in the land management agencies today as discussed above.

7.5.3 Fire Management Priorities

Several priorities stand out in order to more fully utilize and benefit from the use of GI/GIT for fire management, in addition to the development of this strategy. As reported above, the ad hoc approach to how GI/GIT has been adopted to date in some organizations has led to unnecessary mistakes and wasted resources and time in many cases, and countless other problems as well. Focused and organized opportunities and funding are needed for fire management and agency leaders to address new challenges due to the growth of GI/GIT use. They also need to maximize the cost effectiveness of GI/GIT for fire management in order for consistent and reliable approaches to be developed, and greater adoption and effective use of GI/GIT to occur. Policy and institutional attention and action are needed by fire management and federal agency leaders to address the limiting factors discussed above.

The following list of priorities provides a summary of policy and institutional needs for the response phase of wildland fire, and is applicable for all other phases of wildland fire management:

- GI/GIT staffing requirements in key teams, centers and agency offices
- Consistent GI/GIT personnel requirements and job series classified through the Incident Command System approach
- Minimum supporting infrastructure, in the form of sufficient and consistent equipment, space and technical connectivity on the ground and with multiple agency and interagency centers and offices, including those with direct fire roles and general agency home offices where much useful data traditionally resides and can help fire response activities
- Consistent data standards, protocols and procedures for GI/GIT use
- Readily available data products about preexisting conditions where past fires existed and threaten that can be easily integrated and used with current fire data and projections
- Mechanisms to integrate various data inputs in as close to real time as possible during fire response, including remote sensing, GPS, observations, digital camera output, etc

Data integration on the ground is a key need and requirement to fully exploit GI/GIT potential and realize benefits for all phases of emergency management. Better understanding of fire conditions and risk also stands out as being needed now in order to help determine future priorities.

7.5.4 Focused Technology Transfer and Capacity Building Efforts

The 2002 NAPA panel found that new fire management technology deployment is largely decentralized and ad hoc. Instead, it stated that there are quicker and more efficient ways to develop and deploy new technologies that could cut costs and avoid losses. It recommended that the Wildland Fire Leadership Council act in this regard and "replace the existing ad hoc approach to technology transfer with a professional interagency unit" focused on getting the outcomes of research and development efforts "into the field more quickly, systematically and efficiently", including the development of "technology transfer and education professionals" (NAPA, 2002, p. 54).

Recent studies have also been undertaken by committees of the National Research Council to investigate and make recommendations to advance the application of remote sensing. The large gap between research and widespread usage is particularly evident regarding remote sensing. Efforts are needed concerning both "push" (research capabilities) and "pull" (operational needs) in order for technology transfer to be successful (NRC, 2003). A transition pathway is articulated as the end-to-end set of processes for transitioning research results into operations (Ibid., p. 16). A particularly critical need is to explicitly address human resource needs through the process, as capable people are "one of the most important components of the remote sensing technology transfer process" (NRC, 2001a, p. 32). A key finding is that "acquisition of data is merely the first step in developing successful applications of remote sensing" and "the cost of a remote sensing information product begins rather than ends with the cost of the data" (Ibid., p. 34-35).

Another important conclusion from this NRC work is that "the lack of communication among remote sensing specialists, data users, and potential information consumers is one of the greatest barriers to expanding the use of remote sensing data" (Ibid., p. 20-21). This situation typifies many aspects of GI/GIT, and particularly remote sensing, in wildland fire today. The case for knowledge transfer, in addition to technology transfer, is clearly made. Though not specifically addressed in these reports, they also provide justification for focused institutionalization and capacity building. While GI/GIT is proliferating in many aspects of the wildland fire community, its adoption is clearly ad hoc and inconsistent, and usage is more focused on cartographic than strategic uses. Focused policy attention, as in the recommended strategy described above, must be accompanied by institutionalization and capacity building. This is essential to enable fire leaders and others in the fire community to fully understand, appreciate and ensure that accountable results and appropriate benefits result from fuller use of GI/GIT.

Competing needs, demands, and goals will undoubtedly continue to characterize wildland fire in the United States in the future, along with growing risks and costs according to current trends. Advancing technological capabilities and knowledge about ground conditions, fire characteristics, behavior and impacts will aid decision making and policy setting in this regard. However, much about fire remains unclear and unpredictable, and potential for harmful impacts is growing, particularly with expanding development in wildland areas.

GI/GIT can help address the nation's growing challenges in wildland fire, but it must be implemented and useful across all lands, regardless of ownership, with all levels of government, and effectuated through appropriate vision, direction and institutionalized approaches to maximize results and benefits for all.

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