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GIS Technology:
Supporting the Wildfire Mission

Esri, 380 New York St., Redlands, CA 92373-8100 USA
TEL 909-793-2853 • FAX 909-793-5953 • E-MAIL info@esri.com • WEB esri.com

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Introduction

Wildland fire agencies throughout the world face an ever-increasing set of complex challenges. Housing development continues to expand into wildfire-prone environments. Climate change appears to be influencing more frequent drought conditions. Increases in population and land use are resulting in greater wildfire risk. As a result, more intense wildfires with higher threat levels to people and property can be expected. In addition, government agencies must increasingly deal with budget reductions that impact fire personnel and resources.

Over the last several years, adoption of information technology has dramatically increased. This is a result of two emerging trends among wildfire agencies: more effective analysis of complex data and easier delivery of actionable information in different formats. These two trends offer managers, administrators, and frontline personnel greater options to improve decision making for fire preparedness and response.

The remainder of this paper will examine how geographic information system (GIS) and related technologies now provide support for all aspects of the wildland fire mission. It demonstrates how better information, used throughout organizations, assists both strategic planning and tactical functions.

The Evolution of GIS Technology for Wildland Fire Management

For years, GIS technology primarily supported wildland fire agencies through planning and map production. GIS continues to be an essential tool for incident management. Most incident management teams have fire GIS technical specialists who are certified according to the National Wildfire Coordinating Group (NWCG) Wildland Fire Qualification System Guide (PMS 310-1). Their experience is documented with a position task book (http://www.nwcg.gov/pms/taskbook/planning/pms-311-77.pdf). National standard operating procedures have also been developed to ensure consistency in the following map products (http://www.nwcg.gov/pms/pubs/GSTOP7.pdf):

- Situation/Planning
- Incident briefing
- Incident action plan
- Transportation
- Fire progression

These maps are updated at least twice daily depending on incident complexity. Optional map products can be used for public information, structure protection, damage assessment, and aerial operations. These are created in the GIS unit, which is part of the situation unit organized under the planning section. Another important map depicts landownership and areas listed by agency responsible for fire protection.

Today, GIS technology has expanded and provides comprehensive capabilities that support all aspects of the wildland fire management program. GIS enables wildland fire

professionals to manage complex operations by delivering four critical capabilities that support the entire mission.

Planning and Analysis

Wildland fire programs are expensive. The US congressional General Accountability Office recently contended that "wildfire suppression costs have tripled in a decade. Getting the most out of finite budgets is a must for wildfire agencies. Strong planning and analysis [are] key. Better preplans and mitigation programs can be generated, carried out, and shared with any one person or outside organization."

Wildfire management plans cannot be effectively developed without comprehensive hazard and risk analysis that identify the potential wildfire impact and values at risk. An effective hazard assessment requires access to the appropriate data, which may include historical records, vegetation, soils, elevations, imagery, resource values, and weather patterns, to name only a few.

It is difficult to synthesize and analyze complex data to effectively develop integrated wildland fire management plans. GIS streamlines this process by integrating, storing, and analyzing all the data necessary to quickly produce hazard assessments that drive planning.

Hazard assessment enables managers to visualize and understand potential high-intensity wildfire areas; resources and values at risk; and urgent actions required for hazard reduction, fire prevention, rapid suppression response, and other mitigation programs.

As hazards and potential wildfire damage are understood, the risk or likelihood of wildfire ignition helps determine planning priorities. Historical fire locations are helpful in understanding where ignitions have occurred in the past. Current land-use features (e.g., power lines, roads, industrial areas, recreational use, housing areas) figure into wildfire risk. Various combinations of these factors help indicate what areas have a higher likelihood (risk) of wildfire ignition. As hazards and potential risks are identified, plans can become more accurate and effective. Landscapes that have many hazards and are at high risk become top priority for vegetation removal, fire prevention programs, code compliance, and verification that fire suppression resources are located appropriately to enable aggressive response. GIS is used to model actions to evaluate the most effective planning strategy for each landscape.

The analysis can also guide the development of appropriate training, safety, and accountability programs. Under extreme fire conditions, policies may be implemented directing defensive strategies to lessen firefighter exposure. GIS is used to model wildfire intensity and growth to determine critical areas where policy and/or suppression strategies should be deployed. These GIS spread models can also be used in training exercises to determine appropriate actions in hazardous areas. The complexity of wildfires requires the best tools possible for safer, smarter, and more efficient response.

Data Management

Data management is the development, execution, and supervision of plans, policies, programs, and practices that deliver valuable information. For wildland fire, data management is gathering, storing, processing, and distributing information to people when and where needed across systems through a well-designed computer system architecture.

GIS provides powerful capabilities to allow access to all types of information based on geography through a map display. This can include response strategies, land management plans, photos, media, and contact lists. In addition to static documents, GIS can acquire, manage, and display dynamic data (camera feeds, weather, traffic, hospital status, automated vehicle location [AVL], incidents, sensors, etc.) as well as other online GIS data to provide situational awareness. As the use of digital devices expands, social media (Twitter, text messaging, etc.) provides a new source of information. Obtaining social media reports directly from the scene of an incident by eyewitnesses who are near or impacted by the event adds to the importance of good data management practices. When social media is integrated into a geospatial context (mapped based on location of the source), it can often be quickly referenced and better understood and acted on (if appropriate). It is also beneficial when geographically clustered social media messages are visualized on a map display with similar content concerning unfolding events. This may help validate existing plans and actions or indicate a need to mitigate unexpected changes. However social media is used, having the ability to manage this type of data and visualize it geographically facilitates determination of its relevance.

The expanding use of social media not only aids responders but also allows collaboration with stakeholders. Social media offers another means of improving the flow of information to the public, especially when there is a heavy demand for information. It requires that responders manage and possibly define what data is authoritative and what is unedited as well as blend information without judging content. For emergency responders, this is on the frontier of how information is produced and consumed.

The management of resources requires inventorying and organizing data. Managing large numbers of different types of resources is essential to the wildland fire management mission. Resources can include fire suppression as well as civilian assets (and their locations) including firefighting apparatus, trucks, buses, bulldozers, water tenders, portable showers, food, and sanitation. These types of assets can be inventoried and integrated into GIS and made accessible based on location. The appropriate resource required for an emergency (determined by its proximity to the incident) can be dispatched for timely response. One of the most difficult challenges for incident management is maintaining the location and status of the resources needed. Managing resources requires current and accurate data.

Situational Awareness

Situational awareness is being alert to what is happening and understanding how changing events and actions will impact response.

Wildland firefighters often find it difficult or impossible to maintain complete situational awareness. Terrain (limited visibility beyond nearby slopes and ridges), smoke, unreliable radio communications, and the need to focus on immediate operations can compromise situational awareness. It is also difficult for supervisory personnel to maintain situational awareness when crews and equipment are deployed over large geographic areas with many burning sites. Crews and apparatus may unknowingly be placed on the verge of exposure to dangerous conditions. Over the last decade, various technologies have come together to provide decision makers and operations personnel with a common operating picture of events that is timely, more detailed, and fairly complete—the kind of picture on which critical decisions can be based successfully. Along with other technologies such as GPS and satellite data communications, GIS can provide situational awareness for personnel on the scene and in supervisory positions.

This can be particularly important for personnel assigned to geographic areas with which they are unfamiliar. A number of recent investigations in fatal and close-call fires have revealed loss of situational awareness as being a contributing factor.

Situational awareness is improved with dedicated planning. GIS provides information that incorporates multiple datasets to help define safe and achievable objectives. A GIS-enabled display supplies situational awareness through the fusion of data on vegetation, resource values, fuel inventories, topography, GPS, and so forth. During fire suppression operations, a GIS-based situational awareness display enables operations personnel to quickly see and understand values at risk, safety zones, escape routes, risk assessments, fuel breaks, predicted spread, and so forth. When dynamic data feeds are added to the view (weather, GPS, vegetation conditions, camera feeds, etc.), firefighters are able to maintain situational awareness during critical operations. The result is better decisions that can be quickly displayed, shared, and understood by those who need to support fire suppression operations.

The common operating picture can be further enhanced when response and contingency plans and other documents are linked to their geographic locations. Rapid access to planning information through the common operating picture begins to operationalize the planning process. Examples of how GIS provides accurate situational awareness through a common operating picture include

- Maintaining and displaying the status of emergency and nonemergency events
- Designating and mapping incident locations/perimeters
- Displaying key incident facilities
    - Incident base
    - Incident command post (ICP) locations
    - Evacuation sites
    - Staging areas
    - Drop points
    - Division and branch boundaries
    - Heliports/Helispots
    - Temporary medical facilities
- Maintaining and displaying the status of incident resources
- Displaying predicted perimeter growth models
- Importing and displaying incident updates and damage assessments from mobile devices
- Displaying and printing appropriate incident command system (ICS) action plan maps

Field Operations

GIS applications provide powerful support for tactical operations. They are deployed on all types of mobile devices—ruggedized computers, handheld devices, and many mobile phones—and provide situational awareness and data collection capability in the field

during tactical operations. Mobile applications are typically easy to use and capable of connecting with a server at a central location. As data is added to mobile devices, it is immediately published to the common operating picture for overall situational awareness. As networks expand, bandwidth increases and the deployment of mobile GIS becomes more prevalent. Damage assessment teams use mobile GIS to collect essential data such as destroyed structures, impacts to habitat, vegetation, and slope. This data can be mapped, inventoried, and transmitted to the ICP or headquarters. This can expedite rehabilitation planning through the ability to collect field data that may be coming from a variety of teams in disparate locations and integrate it into a central location. GIS-powered mobile applications provide powerful mission and decision support.

Typical uses of mobile GIS include

- Mobile situational awareness for field personnel
- Landscape plan access
- Damage assessment
- Rehabilitation

Conclusion

Wildfire response starts with a map that can answer these questions: Where is the incident? What is the best route to get there? What is the likelihood of rapid fire spread (based on the wildfire analysis and current weather conditions)? In which direction will it be moving? Upon arrival at the fire, what resources will be threatened? What is the best and safest way to attack it? What values are at risk? How many resources will crews need to suppress the fire? All these issues and related decisions are supported through GIS analysis that is developed in the risk and hazard analysis phase. Geospatial technology supports the specific tactical decisions that must be made on the scene. Onboard computers now have the capability to provide access to preplans and GIS maps. They also can tap into dynamic situational awareness including

- AVL display of fire apparatus locations
- Live weather data
- Other dynamic sensor data

When dynamic data feeds are integrated into existing basemaps (fire hazard maps, value maps, imagery, etc.), fire personnel begin to get comprehensive situational awareness. Situational awareness can be shared via in-vehicle computers, handheld computers, cell phones, and other relatively inexpensive hardware devices. Not only can mobile devices provide situational awareness in the field, but updates can also be easily transmitted from the field to the common operating picture in dispatch or the ICP. Firefighters, upon deployment, are not going to be updating perimeter information, as their focus must be on suppressing the fire. However, field observers, safety officers, division supervisors, branch directors, and others can provide information on fire perimeter changes, proposed drop points, targets for aerial support, threatened wildlife, and more. These capabilities allow improved request accuracy, better situational awareness, and more expedient development of incident action plans for subsequent operations.

Technology will never replace human decision makers. However, it can fill many gaps, which enables better decision making under stressful, time-sensitive conditions. It allows fire personnel to make more accurate, safer, and better coordinated decisions. Today, GIS provides a system that supports all aspects of the wildfire mission.

About Esri

Since 1969, Esri has been helping organizations map and model our world. Esri's GIS software tools and methodologies enable these organizations to effectively analyze and manage their geographic information and make better decisions. They are supported by our experienced and knowledgeable staff and extensive network of business partners and international distributors.

A full-service GIS company, Esri supports the implementation of GIS technology on desktops, servers, online services, and mobile devices. These GIS solutions are flexible, customizable, and easy to use.

Our Focus

Esri software is used by hundreds of thousands of organizations that apply GIS to solve problems and make our world a better place to live. We pay close attention to our users to ensure they have the best tools possible to accomplish their missions. A comprehensive suite of training options offered worldwide helps our users fully leverage their GIS applications.

Esri is a socially conscious business, actively supporting organizations involved in education, conservation, sustainable development, and humanitarian affairs.

Contact Esri

1 800 GIS XPRT (1 800 447 9778)
T 909 793 2853
F 909 793 5953
info@esri.com
esri.com

Offices worldwide
esri.com/locations

esri®
380 New York Street
Redlands, California 92373-8100 USA

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