Communication and Implementation of GIS Data in Fire Management: A Case Study[1]

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Abstract

Remotely sensed data and Geographical Information Systems (GIS) can be an effective tool in fire management. For the inclusion of these tools, fire management and research personnel must be effective in communication regarding needs and limitations of the data and implementing that data at various scales. A number of personnel can be involved within fire management including land managers, landowners, natural resource professionals, and researchers. Remotely sensed data and GIS can be an effective tool for bridging those involved in fire management. One barrier can be the lack of communication or understanding as to what individual entities provide. We present a case study of the Walnut Fire Complex involving the Southwest Regional Gap Analysis Project (SWReGAP), Bureau of Land Management (BLM), and New Mexico State Forestry. Each entity has different objectives, but effective communication can allow specific data to be incorporated into management. Data obtained from BLM and New Mexico State Forestry and provide SWReGAP with additional data for an enhanced land cover map. This map can then be used as a tool for large-scale fire management as presented in the case study.

Introduction

Wildfire management responsibility has evolved from a "save the local community - protect your own backyard" and let the backcountry burn philosophy of the late 19th century to a full-scale industry in the early part of the 21st century. This change was caused mainly by past practices of total wildfire management and increase of urban/interface growth throughout the west. Wildfires that threatened the communities of the old west (prior to the 1920s) were quickly suppressed because of the fear of catastrophic fires burning entire towns and destroying the lumber, fuel wood, pastures and other natural resources needed for communities to survive.

When the U.S. Forest Service was created in the late 1800s, this protection responsibility was one of its primary functions. Other agencies and entities soon accepted responsibility for wildfire suppression, as these duties became part of their enabling legislation. In New Mexico this was no different. The Taylor Grazing Act (1934) provided the emphasis for the BLM and other agencies of the U.S. Department of the Interior to begin fire management. State Forestry organizations (e.g., New Mexico), State Land Offices (e.g., Arizona), or local sheriff's departments (e.g., Colorado) were statutorily given responsibility for wildfire suppression on

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private and state lands. This is now a complex situation because these agencies and organizations must interact due to the complex nature of wildfire management. Total wildfire suppression has shifted to wildfire management in which not all wildfires are suppressed. This meets a paradigm shift in natural resource management strategies.

Another paradigm shift has included technological advances in fire management and fire planning. One such technological advance is the use of geographic information systems (GIS) and remotely sensed data. The use of these technologies has further advanced fire management and planning. The abundance of data and availability of software has allowed these tools to become commonplace not only within the office but in the field before, during, and after fires. Critical to proper use and incorporation of these technologies is the understanding of their limitations.

Limitations to the implementation of GIS data are centered on the concepts of scale and resolution. This includes not only the actual differences in scale between datasets, but also the resolution at which datasets were derived. Scale refers to the representation of the data based on the actual features on the ground. The detail of a large scale data layer (e.g., 1:24,000 topographical map) and smaller scales (e.g., 1:100,000 land status map) have been used for years in fire management. As a smaller scale is used some detail is lost in favor of displaying a larger landscape in which to put the management in context. Resolution refers to the size of the pixel used within imagery. There are many remotely sensed imagery products available for use including Enhanced Thematic Mapper Plus (ETM+) and Digital orthophotoquads (DOQ). ETM+ is derived from a satellite that acquires images of the same area every 16 days. The resolution of the images obtained is 30 m (30 x 30 m pixel). At finer scales there are DOQs or georectified aerial photographs. These can have a resolution of 1m (pixel=1 x 1 m).

Setting the Stage

In southwestern New Mexico, the complex scenario of interagency agreements is somewhat simplified because there are a limited number of participants. The USDA Forest Service is represented by the Gila National Forest, with responsibility for over 3.3 million ac (1.3 million ha). The BLM is represented by two field offices. The Las Cruces Field office is responsible for over 5.5 million ac (2.2 million ha). The Socorro Field office is responsible for over 1.5 million ac (600,000 ha). Three National Wildlife Refuges are also represented. White Sands Missile Range (Department of Defense) is represented, but due to the secure nature of work at the range, limited assistance is needed. The remaining state and private land falls under the jurisdiction of the New Mexico Energy, Minerals, and Natural Resources Department, Forestry Division, Socorro District, which maintains joint power agreements with all the federal agencies, along with local county governments, to supply suppression resources to agencies when needed.

Wildfire management has to be based on recent and accurate mapping of not only jurisdictional boundaries, but also vegetation and fuel boundaries. A current field map with this information would provide wildfire managers on the ground as well as in dispatch and command type settings with valuable information. Currently, no regionally consistent land cover maps exist for the five southwestern states. This lack of regional data causes planners to rely on various maps often with differing scale and resolution. The SWReGAP objective of a regional land cover data set will provide this data layer (Boykin and others 2000).

Maps derived from satellite imagery have several limitations when applied to fire management and other natural resource endeavors. Scale and resolution of the map, both thematically and spatially, may or may not be sufficient for various aspects of fire management. Accuracy is also variable depending on the land cover mapped and the methods used. Land cover maps do not make calculations regarding fuel loads, canopy cover, or stem density. These are implied based on the thematic classification of the pixel, but variation exists and fire managers must be aware of these assumptions.

We focus on three cooperators in southwestern New Mexico with varying objectives from ecosystem sustainability to fire suppression to conservation of plant and animal species. These cooperators are BLM, New Mexico Energy, Minerals, and Natural Resources Department, Forestry Division (State Forestry), and the New Mexico Project of the SWReGAP. We discuss the cooperative integration between the three for current fire management and future fire planning.

Objectives

Bureau of Land Management

The BLM goal of fire management is based on using the full range of fire management activities to achieve ecosystem sustainability, including interrelated ecological, economic and social components. The BLM recognizes fire as a critical natural process and integrates fire into land and resource management plans and activities on a landscape scale, and across agency boundaries. The BLM response to a wildland fire is based on ecological, social, and legal consequences of the fire. The circumstances under which a fire occurs, and the likely consequences on firefighter and public safety and welfare, natural and cultural resources, and values to be protected dictate the appropriate management response to fire. The BLM uses wildland fire to protect, maintain, and enhance resources and, as nearly as possible, be allowed to function in its natural ecological role. The use of fire is based on approved Fire Management Plans and follows specific prescriptions contained in operational plans. Protection of human life is the single, overriding priority. Setting priorities among protecting human communities and community infrastructure, other property and improvements, and natural and cultural resources is based on the values to be protected, human health and safety, and the costs of protection. When people have been committed to an incident, these human values become the highest value to be protected.

New Mexico State Forestry

State Forestry is statutorily responsible for fire management on all private and state lands. Suppression strategies are based on the value of the resources at risk (structures, natural resources, watersheds, timber, grazing, recreation, etc.) and all tactics are determined by using the appropriate suppression response (control, confine, or contain) with safety to firefighters and the general public the major concern. Cost effectiveness is also important. In areas where wildfire management plans have been completed and approved by the landowners or New Mexico State Land Office, suppression is replaced by aggressive management where possible if all involved have agreed to the objectives and public safety and cost effectiveness is insured.

Southwest Regional Gap Analysis Project

The SWReGAP is a regional update of the National Gap Analysis Program's mapping and assessment of biodiversity for the five state region of Arizona, Colorado, Nevada, New Mexico, and Utah. It is a multi-institutional cooperative effort coordinated by the U.S. Geological Survey. The primary objective is to use coordinated mapping approaches to create detailed, seamless GIS datasets of land cover, predicted habitat for native terrestrial vertebrate species other than fish, land stewardship, and management status, and to analyze this information to identify those biotic elements that are underrepresented on lands managed for their long term conservation (gaps). Creation of a seamless land cover dataset is underway using the National Vegetation Classification System (NatureServe 2000) and labeling land cover based on ecological systems and alliances (Boykin and others 2000).

Case Study–Walnut Fire Complex

The Walnut Fire occurred in 2002 in southern Hidalgo County in extreme southwestern New Mexico, in an area commonly called the bootheel. The southern half of the county is made up of several medium sized ranches (approximately 5,000 ac) along with one large (over 300,000 ac of deeded land) ranch known as the Gray Ranch. This ranch has had a long history, at one time being part of the Diamond A Cattle Company that encompassed a large part of southern New Mexico. In 1992, the ranch was sold to the Nature Conservancy who then sold it to the non-profit Animas Foundation. Due to this ranch's rich and diverse habitat types, species and location, the new ownership wanted to return natural wildfire to the landscape. This management strategy was different than past management which grazed up to 16,000 head of livestock and suppressed any wildfire. This new strategy caused concern from smaller ranchers who maintained wildfires had no boundaries and felt threatened by this change in management.

This caused formation of the Malpais Borderlands Group, a group of local ranchers and Animas Foundation individuals. The group then developed a wildfire management map that designated let-burn areas, suppress areas, and contain areas. In 1997, State Forestry, with assistance from the Las Cruces Field Office of the BLM, completed the Bootheel Wildfire Management Plan (Boykin 1997), that explained and delineated these areas. Fire Management Areas (FMAs) were created based on fuels, topographic landmarks, landownership concerns and priorities, and statutory requirements. The major delineations for the FMAs were based on vegetation types and expected climax successional vegetation and their effects on wildfire behavior. This plan is currently being updated by Animas Foundation personnel with State Forestry and BLM assistance.

Since completion of the 1997 plan, numerous fires have occurred in the region. All managed under recommendations provided for in the plan. The Walnut Fire is an example of using local vegetation types and topography to maximize resource benefits of wildfires, minimize resources damage to surrounding landowners, and minimize cost and exposure to dangerous situations for firefighters.

On 27 June 2002, volunteer fire department engines were dispatched to a fire near Center (*fig. 1*). Initial reports placed the fire near Center Peak within the Gray Ranch and in the Rough Creek FMA.

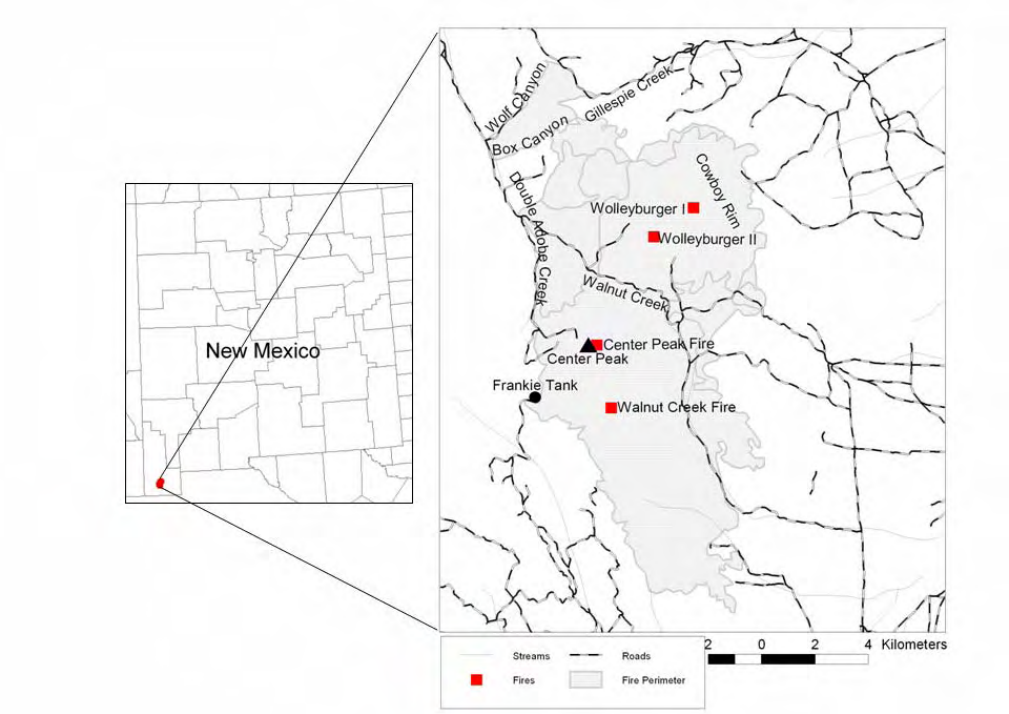

Figure 1—Map of fire extent (shown in grey) with four ignition points of each fire and prominent land marks for Walnut Fire Complex.

Using a land cover map, vegetation communities and fuel models can be used pre-incident to provide firefighters a management context of the fire and the natural and suppression resources available. Because of the varying land management occurring within the Bootheel region, the only available land cover map was from the original New Mexico Gap Analysis Project (Thompson and others 1996). This information coupled with coverages of FMAs and prior agreed upon appropriate suppression response, can provide management with information to facilitate logistical support. An updated more resolved map would further enhance this support.

Two additional ignitions (Wolleyburger 1 and Wolleyburger 2) were discovered on 28 June 2002 northeast of the Walnut fire. On 29 June the Walnut fire was less than 250 ac and still burning in the Center Peak area, while the Wolleyburger Fires were about 100 ac each. Personnel assigned to the fire adopted recommendations for management as outlined in the Bootheel Fire Management Plan (Boykin 1997). Post-fire analysis identified the potential for high intensity burns to the west of the existing fires in the Madrean Lower Montane Conifer Forest, Madrean Closed Conifer Woodland, Madrean Open Oak Woodland (Encinal) Rocky Mountain Montane Scrub & Interior Chaparral and Rocky Mountain Montane Deciduous Scrub based on the New Mexico Gap Analysis Project land cover map (Thompson and others 1996).

On 30 June, allowable areas were identified based on known and presumed fire breaks and behavior. Incorporating digital road coverages and a land cover maps in a GIS would provide additional information to further identify these allowable areas. Additional modeling of vegetation and terrain could identify areas for potential blow ups or hotspots. Further, inclusion of aerial photography and satellite imagery can

provide information for logistical support. The fourth fire of the complex (Center fire) was discovered north of the Walnut Fire and was estimated to be about 50 acres. The Walnut fire's movement toward the southeast was stopped by a change in fuel type. Use of a land cover map and validation by fire personnel may have freed up resources for addition suppression assignments elsewhere.

Fuel type changes on the east flank of the Cowboy Rim area were expected to keep the fire from moving east, and light fuels between Gillespie Creek and the north base of the Cowboy Rim would limit fire growth north. This left the only area of escape from Frankie Tank to Double Adobe Creek. Burn out operations began along the road near Frankie Tank on July 1st. Use of land cover maps in conjunction with fire behavior models may have identified these critical areas long before the personnel actually verified the site from in the air and on the ground.

On 1 July, slurry was dropped to protect a pump jack. Movement east was not a concern as the fuels changed from grass/shrub to creosote/desert pavement. The movement toward this pump jack was unexpected and current land cover maps could have been helpful in identifying exactly how far down hill and to the east that the fire could move. Burn out operations along the road proceeded north. By this time the Wolleyburger fires had joined but were north of the Walnut Creek Road, the Center fire was south of the road, and the Walnut Fire had jumped Lower Walnut Creek and began making runs to the east. The south flank had black lined itself. This is what fire managers had expected, but more resolved land cover maps may have identified these fuels type changes potentially limiting fire growth.

On 2 July, burnout operations continued. All fires had joined during the night, and had moved close to the burnout along the road south of Frankie Tank. Fire management personnel identified Wolf Canyon as the northwest tie between Double Adobe Creek and Gillespie Creek. Wolf Canyon was chosen over Box Canyon due to easier burnouts, lighter fuels, better roads, and increased firefighter safety. Again resolved land cover maps could have identified these features. From July 3 to 4, burn out operations were completed and on 5 July the fire was turned over to the Gray Ranch. Total acres burned were 27,713 with a total cost of suppression at $192,010.

Synthesis

Through discussions and preparation of this manuscript the three parties involved recognized the contribution a land cover map can have to resource planning, fire and natural resource management. Realizing the importance of this land cover map and the need to make the map as accurate as possible, the BLM, State Forestry and New Mexico project of the SWReGAP are working together to try to create this data layer. BLM and State Forestry have provided and continue to provide training site data to assist in land cover map creation.

The Walnut fire complex was managed without the use of a land cover map. We believe it could have been managed more effectively if an accurate land cover map was available and could have been used in the fire management process. Fire managers must assess the validity and application of these types of maps to each individual incident paying particular attention to the scale and resolution of the dataset.

Potential ways for GIS and remotely sensed data to play a part in fire management include prior planning and modeling as well as coordination during the

event. Fire planning and modeling can be conducted in a wide variety of ways, from the simplistic to more complex approaches, depending on constraints of time, budget, or infrastructure. The most simplistic method of using an existing land cover data set is a simple crosswalk from the land cover labels to the fuel models. This can be facilitated when working with the National Vegetation Classification System (NVCS) because of the fire ecology and effects sections provided within the document.

Land cover maps should not take the place of existing processes or procedures. These maps should be implemented with the understanding of the limitations and the scale at which those limitations occur. Further, land cover maps should be recognized as simple predictions of the occurrence of a vegetation type based on substantive ecological and geographical knowledge.

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