Wildfires destroy millions of acres of land every year, along with the communities who live in those areas, cost hundreds of millions of dollars in suppression and rehabilitation efforts, and are a trend that is predicted to increase for decades to come. So far this year there have been over 50,000 wildfires in the United States, burning more than 9,000,000 acres of land (www.ncdc.noaa.gov). There are numerous concerns a park manager must consider when determining how to control fires and mitigate the effects: where do fires get ignited? What type of land fuels their flames? Who is at risk? What must be done for the recovery process? Upon first reflection these seem daunting questions. How do you predict a wildfire? In the past, men would spend solitary summers in a remote watchtower, poised, waiting to spot the smallest plume of smoke (Science News Letter, 1936). Now, however, with the evolution of technology, communities don’t have to rely on human eyesight to stay safe. GIS technology can model fire behaviors and predict burn spread.

A Geographic Information System (GIS) can overlay different information layers to produce risk and hazard identification maps. A risk identification map predicts the probability of an area burning and the potential impacts on the area from that fire (Stratton, 2006). LiDAR fly-over images of post-fire burn areas can be mapped into vector data of historical burn areas (Arroyo, et al., 2008). Historical burn data, along with other data such as ignition sites (i.e. where fires have started in the past), land-use and roads are layered to quantify an area’s susceptibility to wildfire ignition. Hazard identification is mapped in much the same way by layering data such as fuel type (vegetation type), slope, aspect, wind, etc. to predict potential wildfire intensity and path for a given area (ESRI, 2006).

These analyses are fairly accessible and user-friendly. State and federal government databases contain information needed to compute risk and hazard maps, the information is free and open to the public. A variety of software exists to run these
models. FARSITE is a common fire simulator that is free to download, open sourced, and runs data that can be uploaded from any database (Papadopoulos, 2011).

GIS, along with fire simulation software, can precisely simulate fire ignition and propagation, making it a great tool for park managers. One of the best ways to rehabilitate and manage old forests is prescribed wildfires, which encourages new growth. Before executing a wildfire, managers can create hazard identification maps to predict the path a fire will take and secure the perimeters of the prescribed burn area. Even under extreme weather conditions, such as high winds and hot weather, wildfires can be accurately mapped (Massada et al., 2009). Risk identification maps can target areas most susceptible to wildfire and managers can conduct prevention efforts through education (ESRI, 2006). Such efforts include banning bonfires, warning visitors of their destructive actions, or providing safety information to the communities who reside in those high-risk areas.

As housing development increases, people are moving further into wilderness areas. As a result, humans are having a greater impact on fire ignition; Romero-Calcerrada et al. (2008) found that wildfire risk was higher in areas near human-wilderness interface. Because there is a greater likelihood of wildfire in areas where people live, it is important to alert residents of the potential wildfire dangers. Hazard maps show fire spreads faster when shrubs are dense and land is steep, whereas natural barriers, such as ponds and roads, slow spread. This type of information on a hazard map would be important for a buyer in the market to purchase land (Bhandary & Muller, 2009). In fact, most states in fire prone areas provide risk and hazard maps to the public.

With the expected increase in wildfires over the next few decades, it is imperative to predict fire behavior and monitor fire spread. GIS has come a long way in fire modeling, but I think there are further avenues that can be explored. An interesting study conducted by Castrillon et al. (2010) used FARSITE as a plug in to view fire modeling in three dimensions. This technique could open a whole new way to view and monitor wildfires. Using satellite images of the fire and active remote sensors picking up
signals from obstacles in the fire’s path, managers could view wildfires in real-time. Theoretically, then, they could watch real-time fire suppression efforts and report on which areas need focus, if there are any threats imposing on the workers, etc. But, even without 3D real-time visualization, GIS is an accurate and reliable tool to combat the seemingly unpredictable nature of wildfires.
Annotated Bibliography

These authors give a general overview of fuel modeling and how it is mapped through different approaches, focusing on a remote sensing application. They highlight fire models used in different countries, which stresses the fact that fuel models are only appropriate for site similar locations. They outline historical approaches of fuel mapping by field work, aerial photo interpretation using infrared color, and emphasize remote sensing as a comprehensive method for modeling. LiDAR is an effective active sensor which can estimate fuel types and offer information on shrub level fuels, problems that are universal. They suggest a combination of remote sensing and fieldwork is the most ample method of fuel mapping.

Wildfires that ravage through forests also destroy many homes and lives. Bhandary and Muller examine risk factors for a house’s susceptibility to fire in Colorado. They used remote sensing to collect pre-fire and post-fire IKONOS images of an area. They also collected geo-referenced data in these areas (vegetation, roads) and information extracted from DEMs (slope) to overlay the photos. Using regression analysis, they found house susceptibility to wildfire was positively associated with vegetation density and slope. They also found houses were less prone to burn if they were close to a fire department and were located on wide, accessible roads. Developers should be aware of these risk factors when planning housing construction.

3D visualization of wildfires could be an important evolution of GIS technology, which would enable a unique fire management technique. These authors explore that possibility in the Canary Islands with a 3D visualization based on Capaware framework. The study involves combining GPS coordinates of various resources and FARSITE information, such as wildfire perimeter mapping and flame height, into a Capaware system to produce 3D visualizations. Capaware is an open-source framework, so it is an easily accessible resource for managers to use. This is a very promising development and one that would be interesting to further investigate.

Housing development is growing and moving into wilderness areas, as a result, homes are increasing their vulnerability to damage from wildfires. These authors studied an area in Wisconsin where homes border the wilderness and examined houses’ risk to wildfire based on fuel type and weather. They used fuel data from LANDFIRE, weather records and census block data and mapped risk assessment using FARSITE. They compared structure risk for both normal weather and extreme weather conditions. Results indicate more structures were at risk under extreme weather conditions than normal weather conditions and this effect increased when in grassy and herbaceous areas (as opposed to forests). Thus, during zoning and development planning, it is important to keep extreme weather implications in mind.


There are a ton of fire modeling software systems currently in use. This paper focuses on explaining and comparing 23 of the various simulators that exist which model wildfires. The authors base their comparisons on literature that utilizes certain fire simulators and report on the user details and difficulty. They focus on such comparisons as mapping landscape slope, fuels and wind. Some of the more recognized models compared are FIRE!, FlamMap and FARSITE. Based on quality of mapping, software language, precision of mathematical models used to map and software accessibility, FARSITE was found to be the most accurate fire modeling software. For managers who may not be fully trained in GIS or related software, it might be cumbersome to just figure out which software package they should use. This article does a nice job describing each simulator and giving their input for the most user-friendly option.


With a growing trend of urbanization into forested areas it is important to examine human-caused impacts on wildfire ignition. Romero-Calcerrada, et al., studied causal factors of wildfires in Madrid, where abandoned farms are being developed for residential areas. They used ArcView ™ to look at the effects of socio-economic and spatial variables on wildfire ignition. By weighting each variable (using a Bayesian model) they were able to determine which was the strongest predictor of fire source. They found proximity to urban areas has a strong and direct relationship with ignition risk, while areas still abandoned have a negative relationship with ignition risk. This suggests that wildfires in Madrid are mainly associated with human activities and development. Fire modeling, which has traditionally focused on variables such as fuel, slope and wind, should consider adding socio-economic measures into the model.
Stratton, R.D. Guidance on spatial wildland fire analysis: Models, tools, and techniques. 2006. USDA Forest Service, Rocky Mountain Research Station, General Technical Report 183: 1-15. This paper is unique in that Stratton is providing instructions and suggestions for managers who want to use GIS and remote sensing for fire modeling. He starts by outlining some software tools such as FARSITE, FlamMap, etc. and describes what they map and how they are useful. He then talks about information needed for fire mapping: fire ignition history, fire area history, and where to find this information. He then explains, step by step, how to import data into the different software and run some analyses. This seems to be a very important paper for those managers who have not received much GIS training and need some instruction for understanding fire modeling.

Wang, Y.Q., Zhou, Y., Yang, J., He., H.S., Zhu, Z., & Ohlen, D. 2009. Simulation of short-term post-fire vegetation recovery by integration of LANDFIRE data products, DNBR data and LANDIS modeling. Annals of GIS 15:47-59. One caveat associated with fire modeling is the fact that geo-referenced data can be based on areas pre-landscape changing fires, as a result, data is not up to date. It is costly and time consuming to recollect data, so Wang, et al., examined a method of short-term post-fire vegetation recovery. They looked at pre-fire and post-fire Landsat images of the Stanford Fire in Utah measuring geo-spatial data such as burn severity, vegetation types, etc. They found a combination of LANDFIRE, DNBR data and LANDISv4.0 produce an effective modeling of vegetation recovery in short-term, post-fire analysis.

Other References

