# GIS-Based Community Risk Assessment

## Tools for wildfire prediction and mitigation

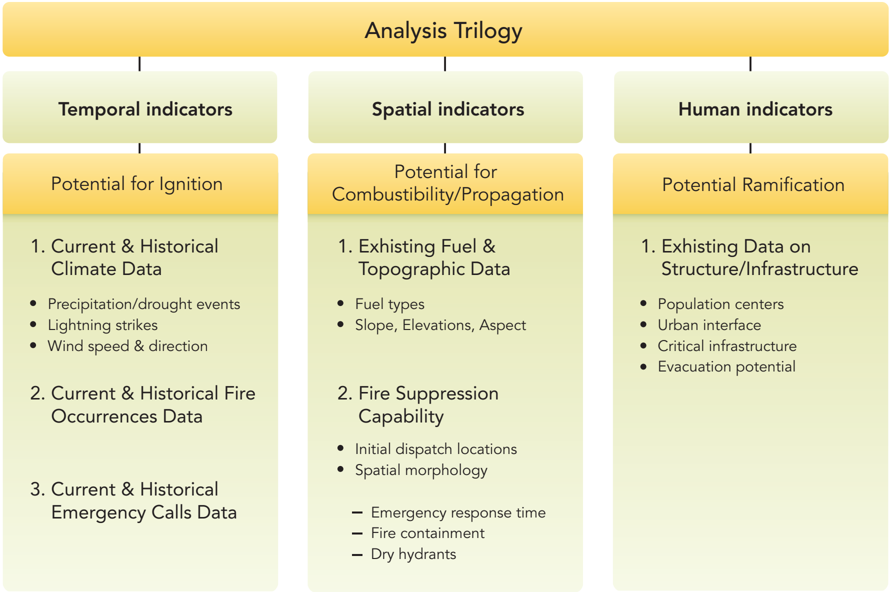
By Ahmed Abukhater, Esri Global Industry Manager for Community Development

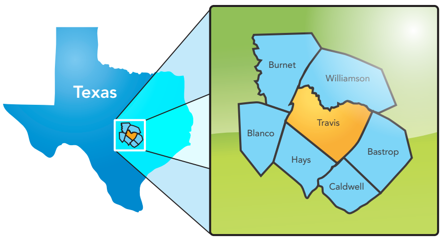
Wildfires are one of the most notoriously destructive and devastating natural hazards in the United States.

Planners and policy makers need tools that enable them to assign land uses and identify community assets to avoid wildfire hazards in the communities most susceptible to natural and man-made disasters. GIS can provide these effective planning tools and insights to prepare for natural and man-made disasters and mitigate their impact. Both policy makers and the community at large can plan for pre- and postdisaster response and mitigation efforts.

Numerous wildfire methodologies primarily focus on predicting where fire is most likely to occur based on historic data and spatial characteristics of the environment. What's missing is knowledge of the impact of wildfire on vulnerable populations and critical infrastructure. To that end, predicting fire hazards by modeling areas that are most vulnerable to fire and measuring the impact on the community's assets and human and physical resources is both important and warranted to mitigate wildfire hazards and associated costs and fatalities.

↓ The analysis trilogy: factors used for the analysis




↑ The study area was Travis County, Texas.

Improving emergency response in areas most susceptible to frequent fires—based on data interpolation and prior delineation of these areas—can help save lives and precious resources. Given the importance of forest-urban interface fire prediction and mitigation, this article describes how to conduct a community risk assessment from a planning point of view and proposes a GIS-based multiple-criteria evaluation (MCE) framework for analyzing, predicting, and ultimately mitigating the impact of wildfires.

### Assessing Wildfire Impact

This article references a study for developing a systematic methodology for assessment of wildfire impact on a community's critical assets, including human capital and infrastructure assets. In particular, this study conducted spatial modeling and representation of wildfire hazard analysis and spatiotemporal interpolation of communities at risk; developed a standardized planning support system (PSS) for methodology of GIS-based regional molding of Wildfire Susceptibility Index (WFSI) for planning and policy making; identified areas at risk and vulnerable communities; and provided better assessment tools and capabilities for future land-use planning and policy making.

The study area was Travis County, Texas. With nearly a million residents, the county encompasses the cities of Austin, Jonestown, and Round Rock. It includes major population, business, and educational hubs such as the University of Texas at Austin.

## Geospatial Methods and Analyses

This analysis is composed of three key indicators: temporal, spatial, and human. These represent the potential for ignition, fire combustibility, and propagation (or how fast the fire spreads) and possible ramifications for the community. The analysis captures not only the risk and probability of wildfires but also the magnitude of impact on the community.

The potential for ignition is measured by the temporal indicators including current and historical climate data about precipitation, drought events, lightning strikes, wind speed and direction, current and historical fire occurrence data, and current and historical emergency calls data.

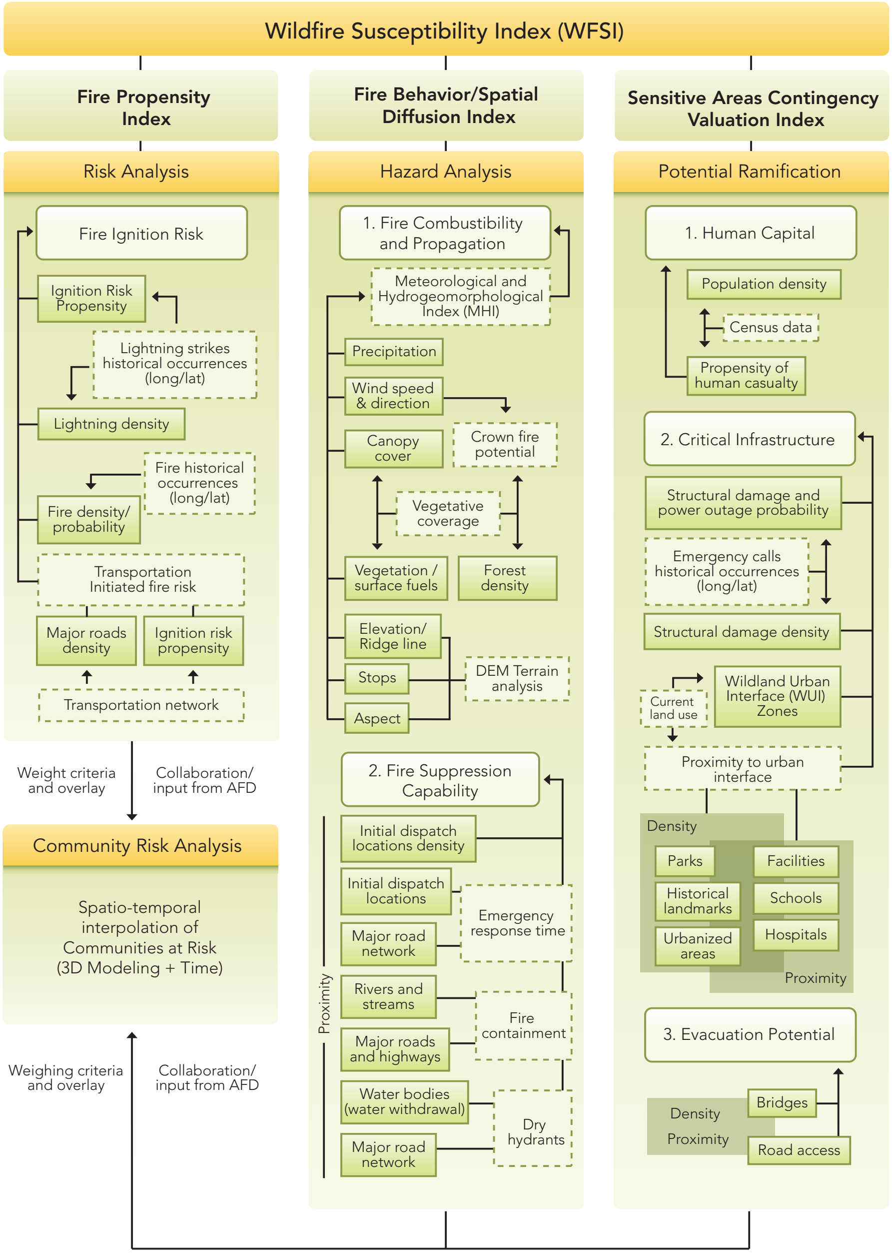
The potential for fire combustibility and propagation is measured by a set of spatial indicators including existing fuel and topographic data (such as fuel types, slope, elevation, and aspect) and fire suppression capability (such as initial dispatch locations and spatial morphology data about emergency response time, fire containment, and dry hydrants).

The potential ramifications for the community are measured by existing data on population centers, urban interface, critical infrastructure, and evacuation potential.

A community survey was conducted, and several meetings with the local community were held to collaboratively determine the importance of each of these indicators in the analysis. The relative importance for these factors was represented by the weights assigned to them.

This analysis trilogy translates into a

A conceptual model for the Wildfire Susceptibility Index (WFSI) methodology



| Risk Statement | Contributing Factors | Derivative Data | Trigger Event | Valuation Methodology | Response Strategy |
|---|---|---|---|---|---|
| Firenado potential | Elevation | DEM | Fire propagation | Very low (1): 93-170m<br>Low (2): 170-230m<br>Moderate (3): 230-290m<br>High (4): 290-350m<br>Very high (5): 350-483m | - Very low<br>- Fire containment: creating natural and artificial fire breaks (such as rivers and highways)<br>- Dumping water from the sky |
| | Slope | DEM | Fire irruption | Very low (1): 0-5%<br>Low (2): 5-15%<br>Moderate (3): 15-30%<br>High (4): 30-45%<br>Very high (5): 45-133% | |
| | Aspect (wind direction) | DEM | Fire propagation | Very low (1): N, flat<br>Low (2): NE, NW<br>Moderate (3): E, W<br>High (4): SE, SW<br>Very high (5): S | |
| | Fuel | Vegetative coverage | Fire irruption | Very low (1):FBPS 97, 98, 99<br>Low (2): FBPS 96<br>Moderate (3): FBPS 10, 11, 12<br>High (4): FBPS 6, 7, 8, and 9<br>Very high (5): FBPS 1, 2, 3, 4, 5 | Improving structural fire safety:<br>- Using fire resistant materials<br>- Exits clearly marked<br>- Entrances ate not blocked by any flammable materials<br>- Access for a large fire truck<br>- Reducing vegetation encroachment around buildings |
| Fire spread & damage | Response time | Road access and initial dispatch locations | Fire irruption | Very low (1): < 5 min<br>Low (2): 5-8 min<br>Moderate (3): 8-10 min<br>High (4): 10-15 min<br>Very high (5): > 15 min | Early warning system:<br>- Local officials issue burn bans<br>- Issuance of red flag warnings<br>- Reverse 911 calls for residents (alerting to evacuate) |

↑ Examples of contributing factors

↓ GIS layers used for the analysis

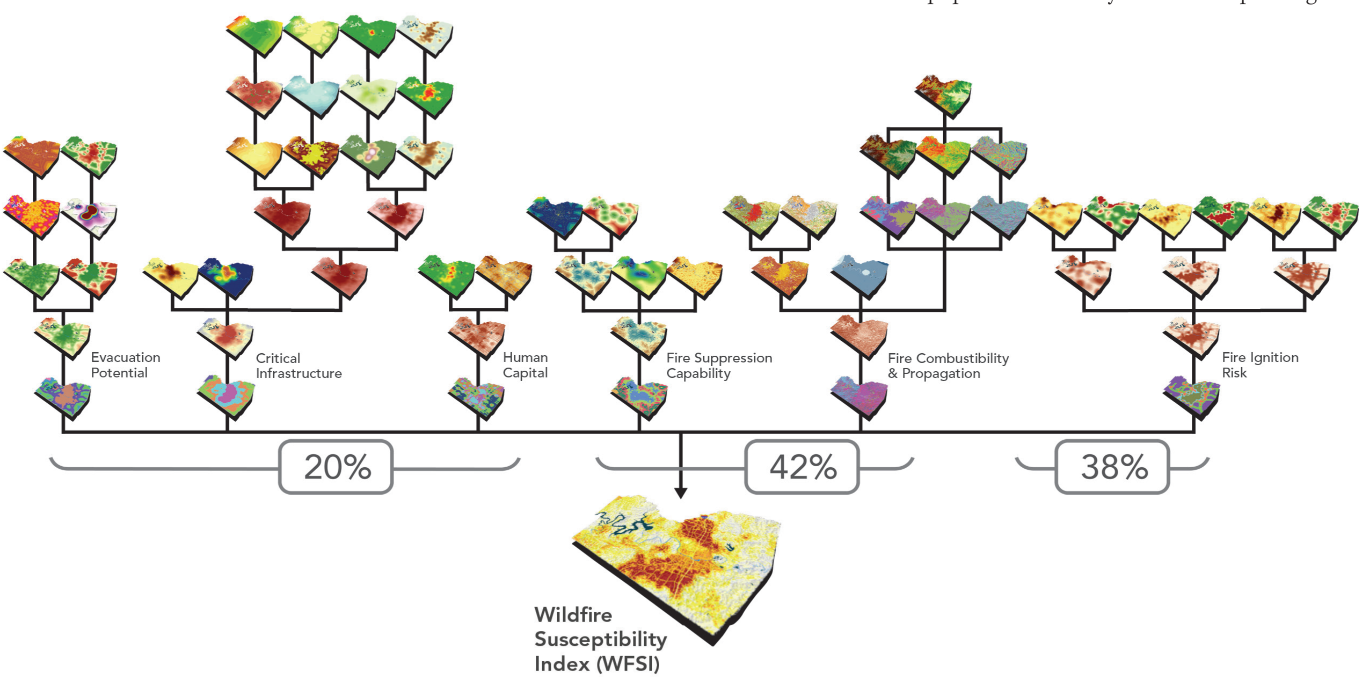
conceptual diagram that includes risk analysis, hazard analysis, and potential ramifications to create a fire propensity index, fire behavior/spatial diffusion index, and sensitive areas contingency valuation index. Each of these three pillars is inclusive of several factors and layers.

Wildfire can cause a blazing inferno with a potential of speed ranging from 30 to 40 miles per hour, which causes the fire to spread rapidly, creating "firenado" potential. Weather conditions, surface fuel, and topography, among other factors, can contribute to this situation.

For Travis County, Texas, weather conditions were characterized as a severe drought pattern. The area has experienced drought for the past 10 years. The area has low precipitation and currently receives only 50 to 60 percent of its normal precipitation.

With regard to surface fuel, Travis County has high forest density and canopy cover with crown fire potential. West Austin is densely covered with trees and brush, highly flammable because of the severe drought conditions.

West Austin also has steeply sloping hills and canyons, and high wind speed and elevation are also factors. Other factors to consider include high fire ignition risk related to transportation and historic wildfire occurrences and the area's high population density. The area's poor egress



is related to the transportation network and urban morphology. The area also has low fire suppression capacity owing to the locations and levels of coverage provided by nearby fire departments.

Each factor was represented by a separate layer that was created, extracted, or derived from other data sources or a combination of sources. The table on page 26 shows a few examples of these contributing factors associated with a risk statement, derivative data, contributing factors, trigger event, valuation methodology (how these factors are categorized in the analysis), and response strategy.

## Analysis Results

GIS was used to create and extract data layers to represent each factor listed in the conceptual diagram and conduct spatial analysis to derive density, propensity, and proximity maps. These maps were consolidated and combined into the six category maps, which were juxtaposed and overlaid (after assigning weights reflecting the community's priorities) to produce the final map representing the WFSI.

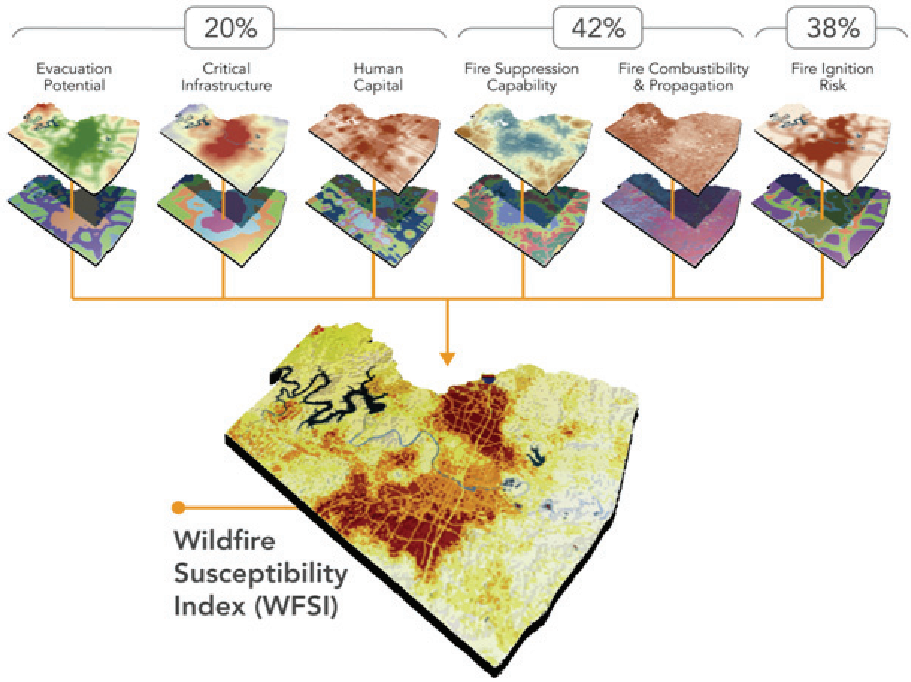
The final map shows areas threatened by extreme and very high potential for wildfire breakouts in red and orange. Areas in north Travis County and west Austin are identified as high-risk areas because of the current drought conditions, dense forest and canopy cover, flammable vegetation, and steep slopes. In addition, these area have concentrations of population and critical infrastructure combined with relative lack of resources and fire suppression capacity.

Representing this information in a three-dimensional diagram helps furnish a better understanding of the level of risk and magnitude of impact on communities affected by potential wildfire.

## Conclusion

This article describes a methodology for conducting community risk assessment for wildfire hazard on a regional scale and provides evidence of the value of using GIS in data management and organization and planning analysis. It is imperative for emergency respondents on one hand and planners and policy makers on the other to take advantage of this type of analysis. GIS helps model areas that are most vulnerable to wildfire.

Process and Decision Workflow (GIS Model Workflow Chart)




↑ GIS analysis results, the Wildfire Susceptibility Index

Knowing where fire incidence is most likely will help emergency services respond in a timely manner to mitigate the impact of fire. Knowing which populations are at risk, communities can determine where to allocate resources most effectively to save money and human lives. Planners can also use this analysis to inform future land use policies and guide decisions regarding future growth areas. The results can also be disseminated to inform future land-use suitability analysis and conflict maps to avoid future expansion in those areas identified as high-risk areas for wildfire hazard. This spatial knowledge is critical for land-use policy and decision making.

GIS is an invaluable tool for conducting this analysis to produce actionable knowledge and intelligence. By integrating data, geoprocessing tools, ModelBuilder, and visualization tools, the impact of human activities on the natural and built environment can be evaluated. State-of-the-art GIS visualization and analytic tools help officials understand and analyze the spatial and temporal characteristics of wildfire.

## For More Information

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**Dr. Ahmed Abukhater** leads Esri's global marketing strategies in planning and economic development. In his role as Esri's community development industry manager, he works to advance the industry agenda through his vision of enterprise GIS, smart growth, business attraction, and economic gardening and revitalization. Abukhater holds a doctorate in community and regional planning from the University of Texas at Austin; a master's degree in urban and regional planning from the University of Illinois at Urbana, Champaign; and a bachelor's degree in architectural engineering. He has authored numerous publications, served on many governing and advisory boards, and received more than 20 prestigious awards for his work.