**Wildfire risk and exposure modeling using geographic information system in Khalkhal and Kowsar municipalities**

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**Extended abstract**

**Introduction:** Wildfires are a natural and necessary phenomena in many forest and rangeland ecosystems, helping to shape landscape structure, improve the availability of soil nutrients, and initiate natural cycles of plant succession. However, it also can result in significant, long-lasting impacts to ecological, social, and economic systems. Wildfire activity is strongly influenced by four factors – weather/climate, fuels, ignition agents and human activities and is often quoted as an increasing issue around the globe. It is necessary, therefore, to identify and understand the risks posed by wildfires, and to develop cost-effective mitigation strategies accordingly. Wildfires have proven to cause considerable damage to natural environments in Ardabil, NW Iran in the last years, and the prevalence of such events is anticipated to increase in the future. Wildfire exposure analysis refers to assessing the wildfire intensity and burn probability in locations where highly valued resources and assets (HVRAs) are present. Fine scale wildfire exposure and risk maps are fundamental to landscape managers and policy makers for prevention, mitigation and monitoring strategies.

**Data and Methodolog:** In this paper, we provided 100 m resolution wildfire risk and exposure metric raster grids for the fire-prone municipalities in South Ardabil province corresponding to a fire simulation modeling and a geospatial analysis with a geographic information system, along with complementary historic ignition and fire area data (2005-2018). Wildfires were simulated using the minimum travel time (MTT) two-dimensional fire growth model (Finney, 2002) as implemented in FlamMap (Finney, 2006) simulator. From given input data including topography (i.e., aspect, elevation and slope) and fuel model (i.e., surface fuel model and cover fuel characteristics), MTT finds the shortest path via a straight line by calculating travel times from each cell corner to every other cell corner on the landscape, and then calculates fire behavior on flowpath segments. Six weather scenarios were defined by wind speed, azimuth, and frequency derived from historical observation during fire season (June–September) in the study area (40°, 70°, 100°, 130°, 160° and 190°). The wildfire scenarios were created with a fire period of 5 hours, which is the common average duration, and 0.01 spot probability. We performed six FlamMap runs (i.e., one run per fire weather scenario), using for each run a 4,500 fire ignition pattern drawn from the ignition probability grid (IP) based on the pattern of the historic ignition locations (2005-2018) in the study area. The ignition probability grid was created with ArcGIS using the inverse distance weighting algorithm (ArcMap Spatial Analyst) with a search distance of 5000 m. The search distance was the minimum value that would generate a nearly continuous map of ignition probabilities for the burnable areas. We then simulated 4,500 fire events within the study area, randomly drawing from the frequency distribution of burn periods and weather scenario for each fire. Fire risk parameters (burn probability (BP), conditional flame length (CFL) and fire size (FS)) were generated with FlamMap Minimum Travel Time (MTT) algorithm considering fire weather conditions during the last 14 wildfire seasons in the study area. Moreover, we estimated fire potential index (FPI) to spatially analyze where large fires likely initiate. In these simulations, weather conditions were held constant, and fire suppression efforts were not considered due to the lack of the information. Output analysis, as well as input data assembling are facilitated by other advanced models and tools as ArcFuel 10 (Ager et al., 2011), implemented for ArcGIS 10.4.1.

**Findings and Conclusions**: Average BP, CFL and FS ranged from 0.00007 to 0.0025, 0.05 to 1.6 m, and 54.7 to 360.3 ha, respectively, that highlighted a large variation in the fire exposure factors in the study area. The simulation outputs suggested wide variation in wildfire exposure to the land cover types. The results revealed low burn probabilities for the national forest managed lands and national forest protected lands; however, agricultural and private lands with large parts of unmanaged grasslands have high fire potential in terms of fire intensity, which means that if an ignition occurs, an intense fire is expected. The calculated FPI showed two major areas with the highest values, where historic ignitions were high, and where large areas of faster burning fuels were present. The results of this study can be useful for analyzing potential wildfire risk and effects at landscape scale, evaluating historical changes and future trends in wildfire exposure, as well as for determining fuel treatment strategies to mitigate wildland fire risk. Further implementation could allow the development of burn probability and fire exposure models at landscape scales. Additional case studies on fire prone regions in Iran are needed to refine existing, and develop new methods for deriving fuels maps for the expanded application of wildfire risk and exposure modelling.

**Keywords**: MTT algorithm, Fire risk, Historic ignition, Burn probability, Landscape scale