Using Multicriteria Analysis to Assess Potential Fire Risk in the Deschutes National Forest

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Introduction

The cost to fight forest fires in the United States has increased more than 30% in the last 20 years. As severe weather events become more frequent, fire fighting costs are expected to rise. Predicting where fires will occur can help reduce federal and state spending by focusing fire reduction strategies in high risk areas. These management strategies not only reduce the spread of fires but can save lives, property, and the loss of timber revenue.

Though lightning can ignite forest fires, it is estimated that more than 90% of forest fires are due to human activities. GIS has been used to predict fire risk locations using a variety of different models. This study used multicriteria analysis (MCA) in ArcGIS to determine high fire risk areas in the Deschutes National Forest (NF) using available US Forest Service (FS) and US Geological Survey (USGS) data.

Methods

Study Site:

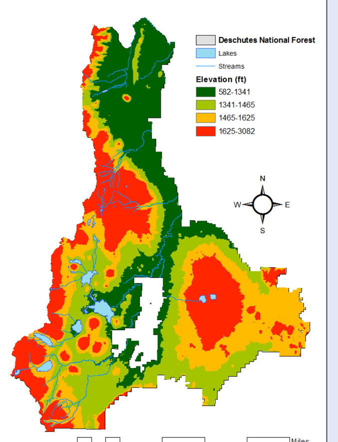
Deschutes NF is located in central Oregon along the east side of the Cascade Mountains. It is 1,948,459 acres of coniferous forest, juniper woodlands, high elevation alpine environments, lakes, and meadows. This diverse landscape attracts a large amount of tourists during the summer months who visit this forest to partake in a variety of recreational activities such as fishing, hiking, camping, boating, and horseback riding.

Variable Selection & Reclassification:

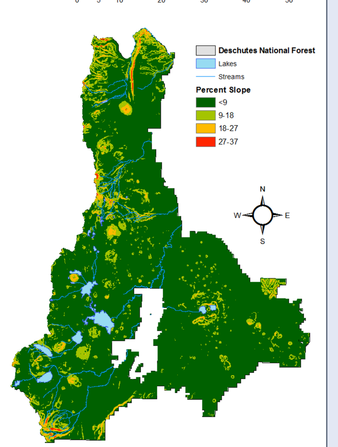
We used variables that typically have an impact on fire risk, including topographic characteristics, climatic characteristics, proximity to anthropogenic features such as roads, recreation sites, and towns, and vegetation and soil data. We standardized our variables using the Reclassify tool allowing the fire risk variables to be compared directly to determine the high fire risk areas. All data was reclassified on a scale of 1 to 4, with a value 4 indicating a value that contributes most to fire risk and a value of 1 given to criteria that contributes the least to fire risk.

Topographic Variables

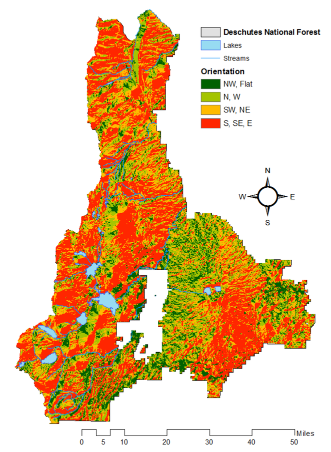
1. ***Elevation*** – A higher elevations weighted as higher fire risk than lower elevations. Higher elevations experience harsh and windy weather which dries the landscape and spreads fires. Lower elevations tend to exhibit more poorly-drained soils and less overall sunlight so they were weighted lower.



2. ***Slope*** - Impacts both the rate and direction of a burning fire, with fires on steeper slopes moving faster than a flat surface (Kushla et al. 1997). Slope was weighted to give a higher risk for areas with steeper slopes than areas with a flat surface.



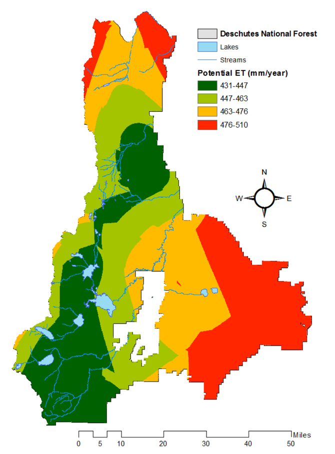
3. ***Aspect*** - East-facing slopes receive direct sunlight earlier in the day than west-facing and south-facing slopes are exposed to more sunlight than north-facing. Aspect direction was weighted to give more risk to east and south facing slopes which receive more direct sunlight throughout the day, thus soil and vegetation should be drier and represent a higher fire risk.



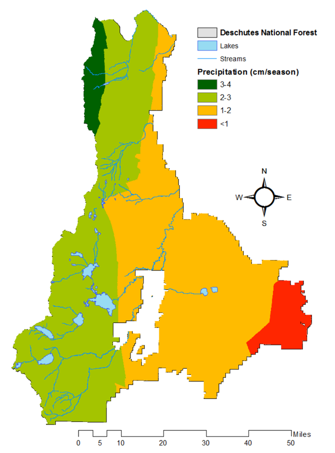
Climate Variables

Used simple Kriging to interpolate surfaces from 266 USGS gauging stations that are located inside of and within 100 miles of the boundary of the Deschutes NF.

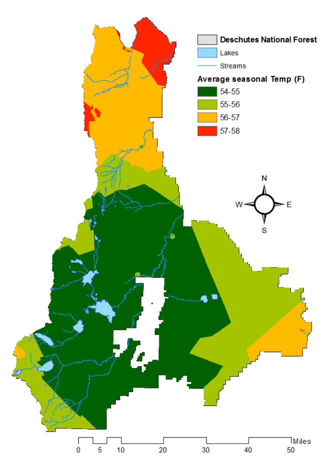
1. ***Temperature*** **-** Calculated from 8000m PRISM data for the watershed basin that contained each gage. Used the thirty-year mean for the hottest months, July, August, and September. Areas with a higher temperature were weighted higher risk than areas with a lower temperature.



2. ***Precipitation***- Calculated from 8000m PRISM data for the watershed basin that contained each gage. Used the thirty-year mean for the hottest months, July, August, and September. Though precipitation during this time of year are generally low, areas with a higher amount of precipitation were weighted as having less of a fire risk than areas that experienced the least amount of precipitation.

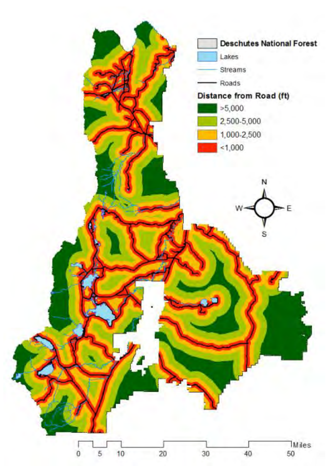


3. ***Potential Evapotranspiration (PET)*** - Calculated using the Hamon (1961) equation, which uses the mean monthly air temperature and latitude. The mean monthly air temperatures for 1961 to 1990 (excluding extreme temperature values) were used with 1km grid PRISM modeling to calculate the PET (mm/year) if a constant source of water was available. Higher PET = drier landscape due to increase evapotranspiration. Areas with a higher estimated annual PET were given a higher fire risk value than areas with the lowest value.

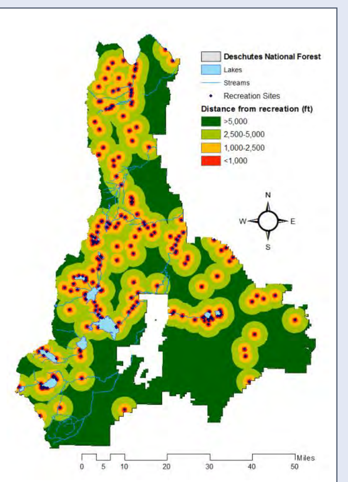


Human Risk Variables

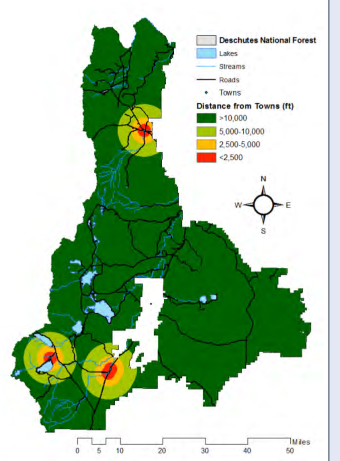
1. ***Roads*** - Includes highways and existing National Forest System Roads classified as suitable for passenger cars, or as having a high degree of user comfort, or moderate degree of user comfort. We used the Euclidean distance tool to create a surface that was reclassified to give the highest fire risk to areas that were within 1,000ft of roads.



2. ***Recreation Sites*** - Existing and operational recreation sites included campgrounds, trailheads, picnic areas, horse camps, interpretative sites, swimming sites, viewing sites, lodges and hotels, day use areas, and boating sites. We used the Euclidean distance tool from recreation sites, using maximum distance and reclassified based on distance from the recreation site. Areas within 1,000ft of the recreation site were weighted as the highest risk.

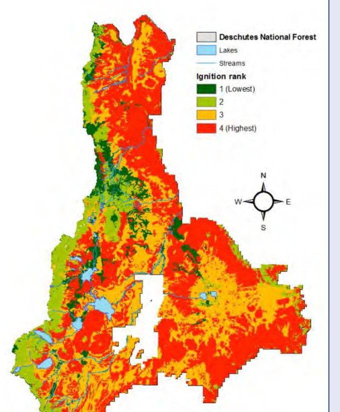


3. ***Towns*** - Sisters, Crescent, Crescent Lake, and Gilchrist are the only cities whose bounds fall within the Deschutes NF boundary. According to the U.S. census, the year-round population for these four towns is just over 2,000 people, with the summer months experiencing an increase in the population due to tourism. Used the Euclidean distance tool and maximum distance to determine the distance from the town points. Since point data was used as the town data rather than a polygon of the town boundary, the reclassification of the distance values was given a larger range to account for areas of the town that extend away from the point location and the potential larger fire risk. The surface was reclassified giving the highest fire risk to areas that were within 2,500ft of the town.



Vegetation & Soils

1. Plant Association Groups - Using USFS plant association group data we were able to account for the typical bio-physical environment. This data captured the plant composition, soil type, features such as rock, water, and glacier, as well as associated environmental conditions. For a description of the plant association group types used in this study, see Grenier et al. 2010. Plant groups were reclassified to rank groups based on their historical occurrence of fire and associated environmental conditions.



Weighted Overlay

The percent influence of each value was dependent upon the type of variable--topographic, climatic, anthropogenic, and vegetation/soil based on a similar study (Eskandari et al. 2013) and used scale values of 1 to 4, similar to reclassification.

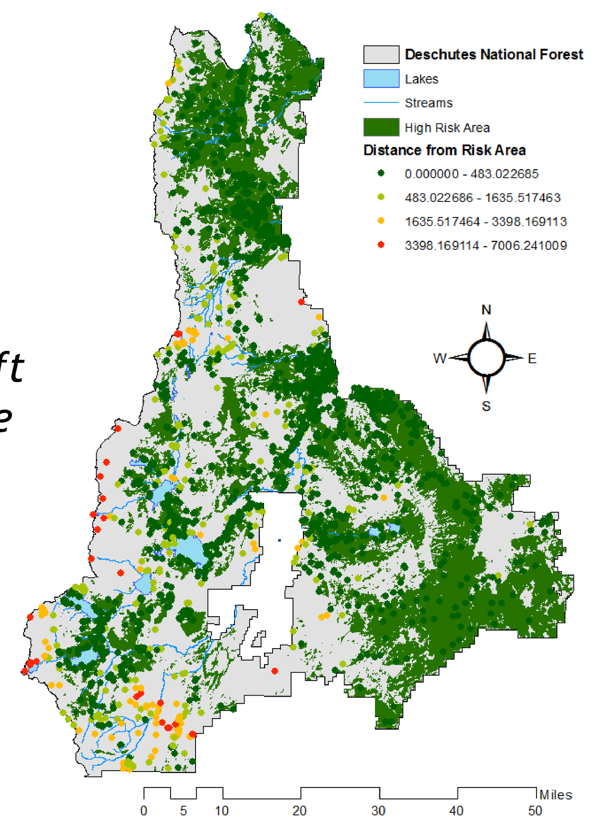
Topographic characteristics were each given a 7% influence, Climate variables were given a percent influence of 8% each,

Human characteristics were each given a weight of 10% each, and lastly, vegetation was given an influence of 26%.

Results

Areas that were found to meet the criteria of high fire risk can be seen below. To check the accuracy of our risk model, we compared our final map to 2,151 GPS fire point locations that occurred between 1980 and 2011. The cause of these past fires was due to human activities such as equipment use, smoking, campfires, debris burning, arson, and children. After finding the distance from the fire points to the location of our high fire risk areas, we found that 63% of the points were inside our high fire risk areas or within 10ft of the polygon, and 66% occurred within 75ft of our high fire risk areas.

High forest fire risk map & human-caused fires occurring from 1980 - 2011. Red & orange dots indicate historical fires that were more than 1600ft from the high risk fire areas.



Conclusion

There were some limitations to validating our model since the final fire risk map was compared to uncorrected FS GPS data. We were able to capture more than 65% of human caused- historical fires, however our results suggest we may be missing variables and our weights of the variables may need to be adjusted. Future studies could implement seasonal wind patterns and recreation, town, and historical fire data in polygon rather than the point form that was used in this study.

These results Illustrate that using multicriteria analysis in a GIS can be a simple method to determine areas of high risk to human-caused forest fire. With adjustments to the weighting, the GIS-based analysis can be used by land managers to quickly determine area that should be prioritized for future management on forest-wide scales

Sources:

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