Introduction:

The central Texas hill country area is unique in the sense that it is a semi-arid wooded savanna type ecosystem with a quickly developing population. The population growth in the area is largely responsible for interrupting the natural fire regime of the area causing the stockpiling of fuel. This combined with the hilly topography and large areas of woodland which have been managed without much fuel removal sets the stage for potentially destructive wildfires. This is evidenced by the massive fire which burned much of Bastrop County in 2011. GIS gives us the ability to analyze spatial data in a way that allows us to better manage our environment so that disasters such as the Bastrop fire should become few and far between. The purpose of this project is to use GIS along with the principles of suitability analysis to create a deterministic map which displays the potential wildfire hazards of the greater Austin area.

Data & Sources: (All necessary metadata was downloaded and can be provided upon request)

County Shapefile – Texas Parks and Wildlife
(tpwd.texas.gov/gis/data/downloads)

Average Annual Precipitation Shapefile (1981 – 2010) – Texas Water Development Board
(twdb.texas.gov/mapping/gisdata.asp)

Land Use/Land Cover Raster (2011) – USGS National Map
(nationalmap.gov)

Digital Elevation Model
Bulk Canopy Density Raster (2012)
Disturbance Occurrence Rasters (2010 – 2014) – Landfire.gov (USGS, DOI)

Data Pre-processing:

County Shapefile: The seven counties which define the greater Austin area were isolated and exported to be used as the extent/mask/clipping feature for all other data and analysis. This shapefile was then projected to NAD_1983_UTM_Zone_14N (meters), which is the coordinate system that all other files are projected to in order to facilitate accurate analysis.

Digital Elevation Model: The digital elevation model (DEM) was downloaded with a 30-meter resolution which was used as the standard resolution for all raster data used in this project. The extract by mask tool was used to clip the DEM to the county shapefile, and then projected to UTM_Zone_14N using a bilinear resampling method to preserve the continuity of the data. The projected DEM was used as the snap raster for all other raster data. Additionally, a hillshade raster was derived from the DEM using the hillshade tool for cartographic use.

Land Use/Land Cover Raster: This classified raster clipped to the county shapefile using the extract by mask tool. Then it was projected to UTM_Zone_14N using the nearest resampling method to preserve its classifications and snapped to the DEM to ensure accurate analysis.

Bulk Canopy Density Raster: Followed the same pre-processing steps as the LULC Raster.

Disturbance Occurrence Rasters (2010 – 2014): Followed the same pre-processing steps as the LULC Raster.

Average Annual Precipitation Shapefile (1981 – 2010): The precipitation shapefile was clipped to the county shapefile and projected to UTM_Zone_14N. Then it was rasterized using the rainfall in inches as the value (10 classes) and snapped to the DEM using a 30-meter resolution. This was done to facilitate the suitability analysis using raster data.

Analysis & Methods:

The goal for this project demands that the environmental variables be classified and combined in a way which reflects the spatial variability of fire hazards for the study area. This requires the use of GIS to manipulate the data in way that facilitates a logical combination of the variables past that of the pre-processing steps. These steps, methods and justifications are described below.

Disturbance Occurrence Rasters: Five separate rasters displaying the occurrence of vegetation disturbances are being used in this analysis to restrict the hazard areas due to the lower probability of fire in areas recently burned. These data are classified to include areas of varying degree of disturbance. For this analysis, we are going to simplify (reclassify) these areas to a binary value, disturbed and not disturbed. Then the rasters are summed up using the raster calculator to give weight to any areas of recurring disturbance. This process resulted in a disturbance raster with four values signifying the number of years a cell was disturbed as can be seen in the figure below.

Rowid	VALUE	COUNT	AREA_SQKM
0	0	1692577	15233.1939
1	1	373611	336.2499
2	2	3425	3.0825
3	3	38	0.0342

*Area was calculated with the field calculator using the expression: ([COUNT] * 900) / 1000000

Land Use/Land Cover Raster: The most recent LULC data available from the USGS is being used in this analysis to identify land cover types and rank them based on the likelihood of wildfires occurring within each type. This will ensure that cover types which are unable/unlikely to burn in a wildfire are not included in the resulting hazard areas. To this end, the LULC classification raster was reclassified into a base 10 ranking system where 10 signifies most likely to burn and 0 signifies not burnable.

Land Cover/Land Use	*Original Classification Value*	*Ranked Classification Value*
Open Water	11	0
Developed, Open Space	21	0
Developed, Low Intensity	22	0
Developed, Med Intensity	23	0
Developed, High Intensity	24	0
Barren Land	31	1
Deciduous Forest	41	9
Evergreen Forest	42	10
Mixed Forest	43	9
Shrub/Scrub	52	7
Herbaceous	71	5
Hay/Pasture	81	5
Cultivated Crops	82	3
Woody Wetlands	90	5
Emergent Herbaceous Wetlands	95	3

Fuzzy Membership Calculations:

Fuzzy classifications are a way to calculate continuously variable surfaces based on a ranking scheme where values of 1 are considered full members and values of 0 are considered non-members. This is a way of analyzing overlapping variables which contribute to potential outcomes such as this study. This is a description of the execution of this method along with the specifics of its calibration.

Ranked Disturbance Raster: This raster was fuzzified using the small membership type with a midpoint of 1 and a spread of 2. This calibration ensures full membership to areas which have not been disturbed with decreasing membership for increasing frequency of disturbance. The justification for this choice is rooted in the principles behind recurrence intervals and ecological succession. The likelihood that disturbance revisits an area recently disturbed is less than that of one that has not been disturbed in a longer time. Range of values is 0.1 – 1.

Ranked LULC Raster: This raster was fuzzified using the linear membership type with crisp values set at 1 and 9. This calibration ensures full membership to land cover types ranked 9 or higher and decreasing membership toward values of 1 or less, which aren't considered members at all. The justification for this is purely based on the reclassified rankings organizing the land cover classes by woody vegetation and wetness of environment. The likelihood that a wooded area burns is greater than that of a barren field. Range of values is 0 - 1.

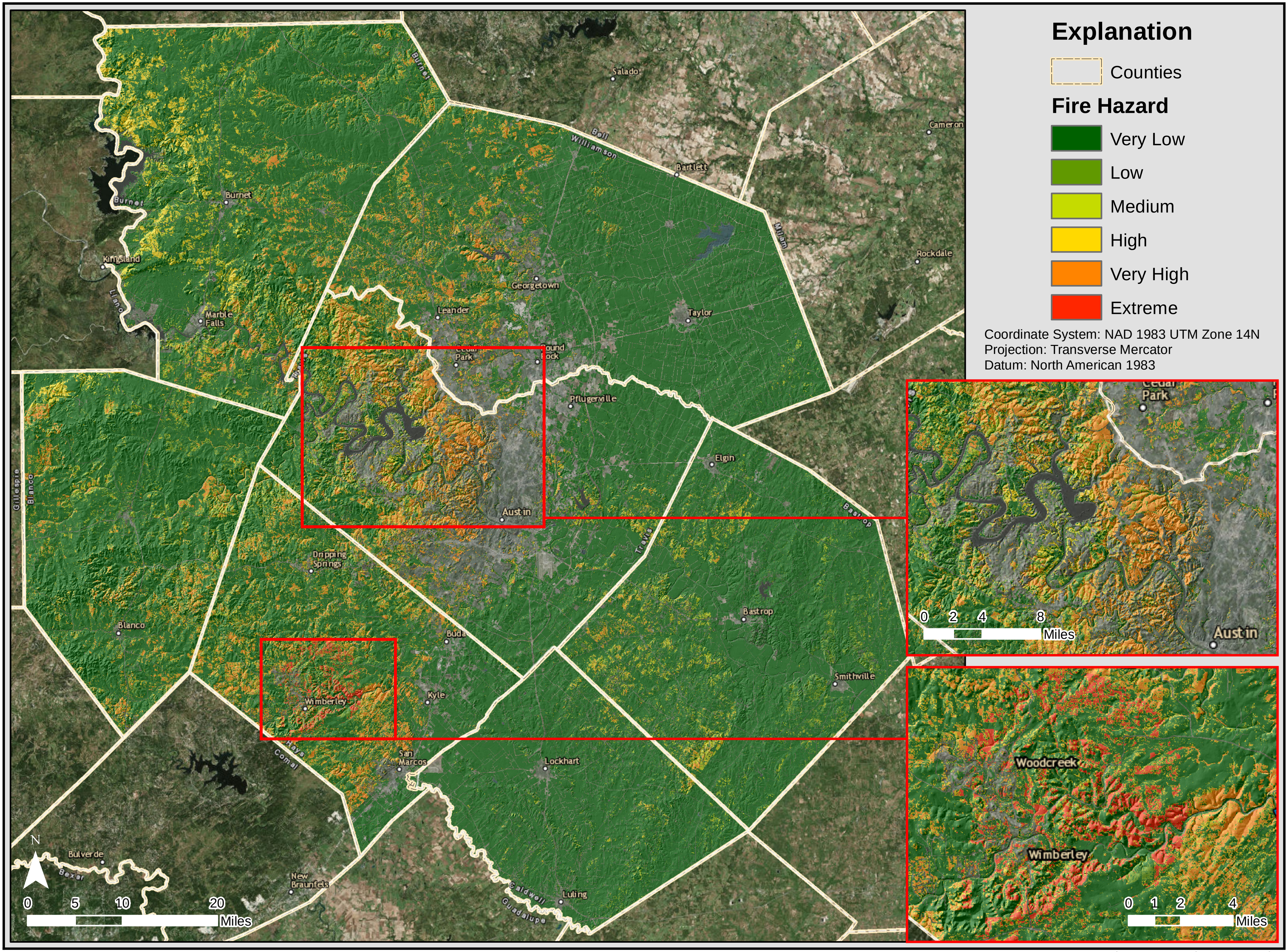
Canopy Bulk Density Raster: Firstly, to avoid No Data values in the resulting raster a value of 0.1 was added to the raster. This was done to ensure that areas such as scrub/shrub and herbaceous were included in the final analysis, and not canceled out in the Fuzzy Overlay step. This raster was fuzzified using the large membership type with a midpoint of 22 and a spread of 5. This calibration ensures nearly full membership to densities higher than 22 kg/m^3 with decreasing membership towards values of 0, which are not considered members. The justification for this choice is based on fuel load and its effects on fire severity. More fuel is nearly a guarantee of a larger fire. Range of values is 1.94038e-012 – 0.973112.

Precipitation Raster: This raster was fuzzified using the large membership type with a midpoint of 32.5 and a spread of 3. This calibration ensures that no value of precipitation is considered a full or non-member. The justification for this is that lightning is among the top causes of wildfires, while rainfall totals rarely equate to diminished occurrence of fires. Range of values is 0.390049 – 0.59605.

Fuzzy Overlay Calculation & Results:

The Fuzzy Overlay tool combines multiple Fuzzy Membership rasters to create a raster which represents the combined effects of the variables included in the analysis. In this case, the tool was run using the product of the variable rasters. The resulting raster approximates fire hazard in the study area based on the four variables used. In order to create a cartographically friendly map the raster calculator was used to turn all values of 0 into No Data cells as they are of no concern for the purposes of this project. It is important to note that the results are not a predictive measure of fire occurrence. They should be seen as the result of a deterministic assessment of overall fire hazard levels in the greater Austin area which reflect upon fuel levels combined with a few variables that are helpful in determining potential wildfire locations. The results were classified into 6 ranks which correspond to the whole number breaks in the overlay calculation results. Range of values is 2.69398e-014 - 0.58003.

Deterministic Fire Hazard Assessment: Greater Austin Area



Map Created on 11.25.16 by Sam Lewis