Proposal

Inferno Analytics

COA Fire Dept

Travis County Watershed Vulnerability Indexing

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1. Introduction

1.1 Summary

Travis county is the 5th largest county in Texas with a population in 2018 of 1,248,743 (World Population Review). To ensure the safety and health of all the residents, the county has begun to take precautionary steps to fight wildfires and protect their watersheds. The City of Austin Fire Department has created vulnerability indexes that focus on areas at risk of wildfires but have not looked at how these areas could affect the watersheds. In cooperation with The City of Austin Fire Department: Wildfire Division, Inferno Analytics will create a vulnerability index of Travis county showing areas that are at risk of wildfires and how much of an effect that area will have on its surrounding watershed.

1.2 Purpose

The purpose of the project is to develop a vulnerability index for watersheds that effect water quality where wildfires began. Water quality of the city of Austin can be contaminated by post wildfire events. Having a vulnerability index for the water sheds will allow the City of Austin Fire Department to more easily determine areas of high risk of contamination.

1.3 Scope

The scope of study is Travis County and the surrounding areas of influence. The areas of influence are upstream rivers and creeks. They include Berrent, Hays, Blanco Counties.

2. Literature Review

Wildfire destruction to homes, watersheds, and habitats have become more prominent from the growth of Wildland-Urban Interface (WUI) areas. The WUI is defined as the area where homes meet with undeveloped woodland vegetation (Radeloff et al. 2005). As Travis county continues to build out its suburban neighborhoods into undeveloped land to accommodate the increasing population, wildland-urban interface areas will continue to grow. Wildfire growth within woody wildlands varies with vegetation, with certain plant species more conducive for spreading wildfires. (Calvino-Cancela et al. 2016). Forestry areas, shrublands, and open woodlands show a high risk for ignition and spread of a wildlife. Wildfires play a crucial ecological role for many ecosystems by preventing undergrowth and dead biomass from over accumulating. By suppressing these natural events over the last century, large amounts of biomass have been allowed to accumulate on the forest floors while undergrowth became overgrown. Ecological succession was hindered without periodic clearing by fire, allowing certain species to become overly prominent. The Ash Juniper, a native tree to Texas that struggles to maintain itself on frequently burned land, is one drastic example. Once the fires have burned through the vegetation, the fires will begin to impact the soil composition making them Hydrophobic.

Hydrophobic soils are those that repel water, a phenomenon that occurs with extreme wildfires. The phenomenon is well understood and is caused by waxy plant material vapors that infiltrates pore-space within soils before cooling and clogging the pore-space with an impervious wax (Moench and Fusaro 2012). Coarser soils are at a higher risk of developing hydrophobicity than finer soils because of their lack of soil moisture before the fire and the vegetation that was present (Moench and Fusaro 2012). The greatest impact of hydrophobic soils is decreased infiltration, that subsequently results in increased runoff. With higher flow velocities from increased runoff, the potential for soil entrainment increases. Without vegetation to reduce flow and to shield sediments, soils begin to erode and flow toward streams. Hydrophobic conditions can remain from a year to several decades depending on the severity and extent of the wildfire.

Slope plays a major role in the spread of wildfires in that the wind is a major driving force. Fires move faster going uphill than they do going downhill, because down slope winds are typically weaker than up slope winds (Auburn). The fires will continue to move faster and more intense if the slope continues to get steeper, because of a greater amount of radiant and convective heat. Also, when the fires are moving uphill the flames are closer to the biomass, which means the flames can move faster through the tree canopy without any resistance. Past studies in Travis county classified areas with a slope between 20-25 percent will have a high risk of spreading the fires at a fast pace and areas with a slope between 10-15 percent have a moderate chance of spreading the fires (AFD). After slope affects the severity of a fire, left over materials directly flow into nearby watersheds.

Wildfires disrupt the routine hydrological processes of an area resulting in an increased debris flow traveling directly into watersheds. After a wildfire burns an area, the amount of runoff intensifies. This leads to a wide variety of burned materials flowing into a watershed. Elements such as ash settle onto lakes and rivers which can compromise drinking water, increased sediment load runoff flows into watersheds, and erosion risk increases within a watershed (USGS). While wildfires have the potential of degrading water quality in the short term with increased nutrient loads from falling embers and ash, it's the sediment load from erosion in the months to years to follow that has the largest impact. Higher sediment load increases water treatment costs, reduces reservoir capacity, impacts wildlife habits, and can result in fish kills. The degree to which water quality is degraded is multifaceted and is a combination of slope, biomass burned, and the hydrophobic degree of the soil after the fire. To create a model to represent the amount of risk wildfires present to water quality in Travis county, risk factors were determined through the literature.

Through our preliminary research, the highest risk factors have been identified as the availability of biomass, the slope of the landscape, the soil grain-size, the type of dominant vegetation, wildland-urban interfaces locations, and prevailing wind direction. A watershed vulnerability index will be designed to reflect these risk factors and identify which wildlands are of greatest concern to water quality in Travis County.

3. Data & Methodology

3.1 Data & Projection

The geographical center of the study area is roughly 10 miles to the northwest of downtown Austin, and 1.5 miles northeast of Bee Cave, TX, at 30° 19' 12" N, 97° 56' 15" W (Figure 1). The data will be projected using a custom Transverse Mercator projection with the central meridian set to the longitudinal center of the study area. Data used in this study (Table 1 on the next page) was collected exclusively from online sources with the majority being provided by the Texas Natural Resources Information System’s (TNRIS) online GIS database.

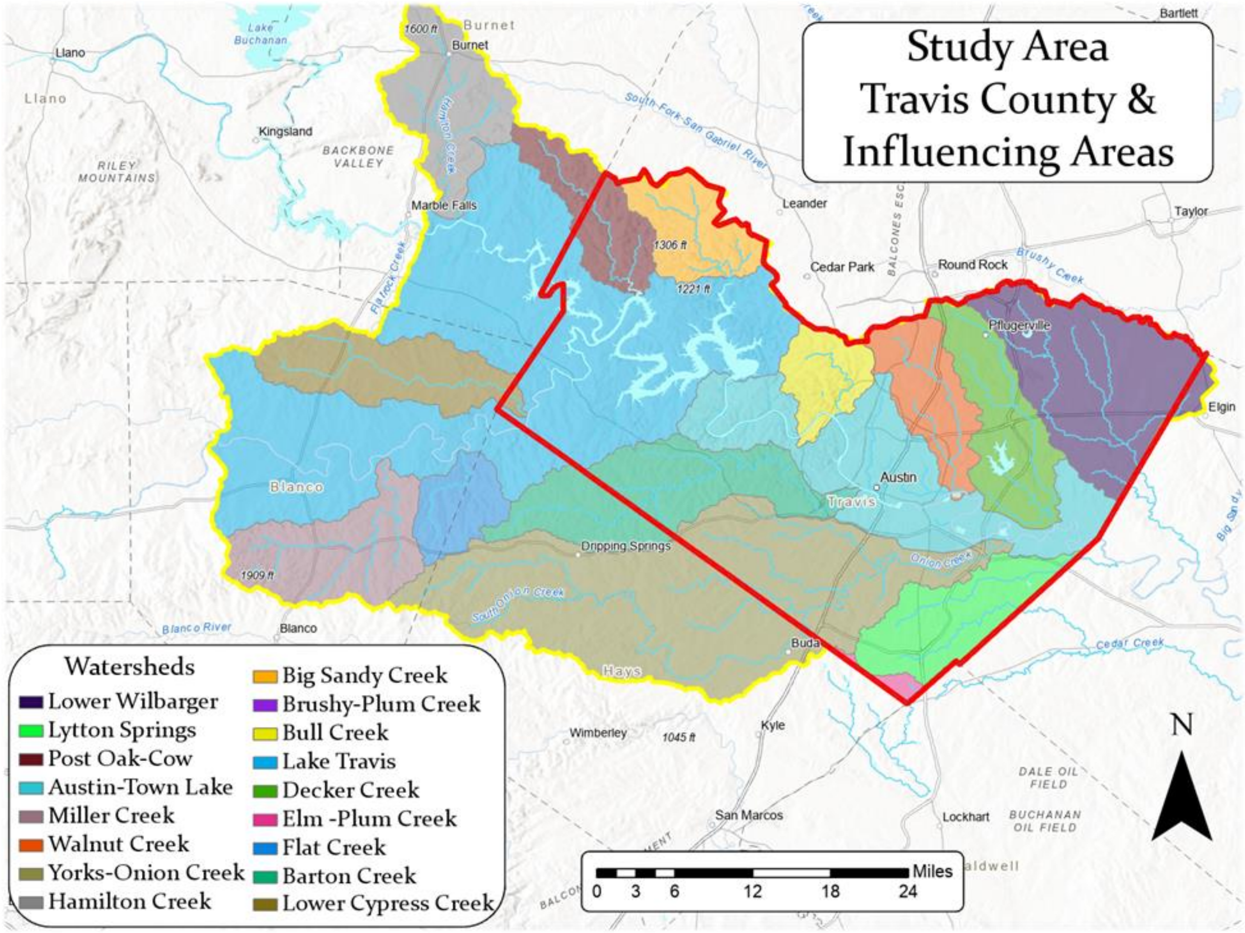

Figure 1 Map of the study area with Travis County outlined in red and influencing areas outlined in yellow

Table 1 Data Master List

Elements	Attribute(s)	Spatial Object	Status	Source
DEM	Elevation	Raster	Acquired	USGS, 2013
HUC12	Area, Name	Polygon/Raster	Acquired	USGS, 2014
Streams	GNRIS, Segment Distance	Polyline/Raster	Acquired	TNRIS, 2014
Waterbodies	Area, Name	Polygon	Acquired	TNRIS, 2014
Soils	Type, grain size, depth	Polygon	Acquired	USDA, 2019
Road Network	Type, Name, Length, GID	Polyline	Acquired	TxDOT, 2020
Biomass	Carbon per sq. meter (C/m^2)	Raster	Acquired	GFW, 2000
Municipal Inlets	Name, Location	Point	Acquired	TCEQ, 2019
Counties	Name, Location	Polygon	Acquired	TxDOT, 2019
Land Cover	Feature	Raster	Acquired	USGS, 2016
Impervious Cover	Impervious %	Raster	Acquired	USGS, 2016
Wild-Urban	Location	Unknown	Available	AFD, 2020
Wind	Wind directions	CAD	Acquired	NOAA, 2020
Fire Stations	Name, Location	Point	Acquired	COA, 2019

The Digital Elevation Model (DEM) raster's are from the United States Geological Survey's (USGS) 2013 National Elevation Dataset. The Hydrologic Unit Code (HUC) watersheds were also produced by the USGS but will need to be further broken down for this analysis. Streams and waterbodies were produced by the TNRIS in collaboration with the USGS and the Environmental Protection Agency (EPA). Biomass was produced by Global Forest Water (GFW) in 2000, making it very outdated; we are still in the process of seeking out more up-to-date data. Soil was provided by the United States Department of Agriculture (USDA) and doesn't contain any attributes other than a 3-digit code representing the soil type. The Texas Department of Transportation (TxDOT) produced the road network and the county lines, while the City of Austin (COA) produced the location of Fire Stations and Municipal Water Supply Inlets. We are currently seeking out the Wildland-Urban Interface data but know of its existence. Directional wind data in CAD format was provided by the National Oceanic and Atmospheric Administration (NOAA) and will be converted to a file that is accessible in GIS in order to determine prevailing summer-time wind direction.

3.2 Data Preprocessing

All data was first clipped to a spatial extent of 29.85°N - 30.85°N, and 98.6°W - 97.25°W), to reduce the overburden of large datasets by defining a broad region that contains the study area and a reasonable distance beyond; the spatial extent will be further constricted at the end of the analysis. The National Elevation Dataset, a collection of USGS 10- and 30-meter Digital Elevation Models (DEMs), will be utilized with a raster resolution of 10 meters, however, this may later change if it is determined to be computationally demanding due to the extent of the study area. Four DEM raster's were mosaicked together and any sinks, along with small imperfection that were present on the raster, were 'filled' to ensure reliable hydrological analysis results. As previously was discussed, the soil layer only contains a 3-digit code representing soil-type, a table of attributes will need to be manually created and joined with the soil shapefile based on the 3-digit code.

3.3 Spatial & Hydrology Analysis

Terrain feature and hydrologic features representing slope, aspect, flow accumulation, and flow direction (Figure 2) will be generated with use of the preprocessed raster. Watersheds will be further broken down to a higher resolution for the analysis and a series of stream layers at varying resolutions will be produced.

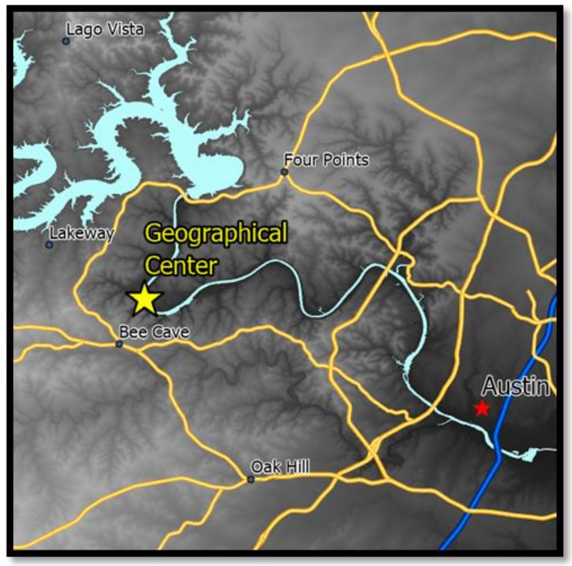

Figure 2The yellow star represents the geographical center of the Study Area

The DEM will also be used to produce a triangulated irregular network (TIN), producing a 3-D base map where the final results of the analysis will be draped upon.

A raster showing the distances upstream from each water supply inlet will be created. With the collection of flow distance rasters, a new raster will be created that retains the lowest cell values. Low cell values represent a low distance to the nearest water supply inlet and have a higher potential of degrading water quality.

The prevailing summer-time wind direction will be determined and represented in our final analysis through aspect. Hill faces that look into the direction of the winds are most at risk for wildfire outbreaks and will represent areas at higher risk in the final analysis.

3.4 Cost Distance Analysis

A roadway network will be superimposed onto the land cover raster to represent surfaces with the lowest costs to traverse. Land cover will be reclassified to express a traversing cost based on the difficulty of traversing a particular terrain. The cost distance raster will be necessary to carry out the accumulated cost analysis to determine the cost-distance from the closest fire station. Cells with higher values represent a location that is more difficult to access, potentially making those areas more vulnerable to uncontrolled wildfires.

3.5 Vulnerability Assessment

3.5.1 Factors

At present, the important physical parameters that are being considered for the Vulnerability Assessment are; (i) Slope, (ii) Biomass, (iii) Vegetation type, (iv) Soil, (v) Flow distance to a municipal water supply inlet, (vi) Distance to a fire station in terms of cost, and (vii) Summer time prevailing wind direction represented by aspect (figure 3).

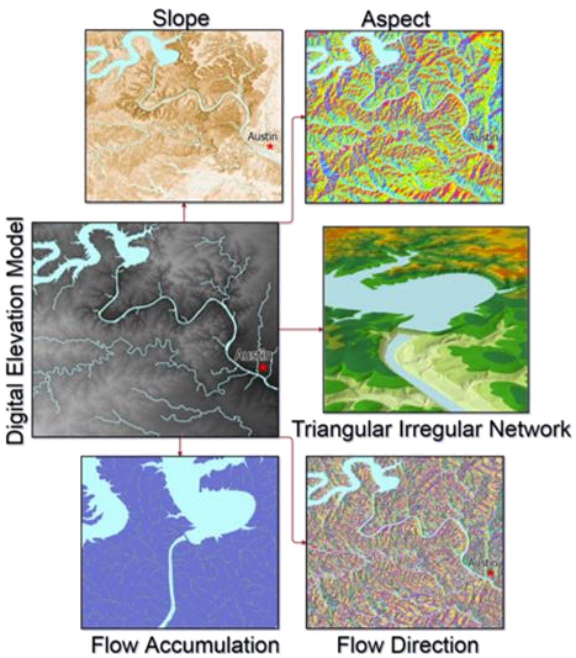

Figure 3 Several analyses that require a DEM to function.

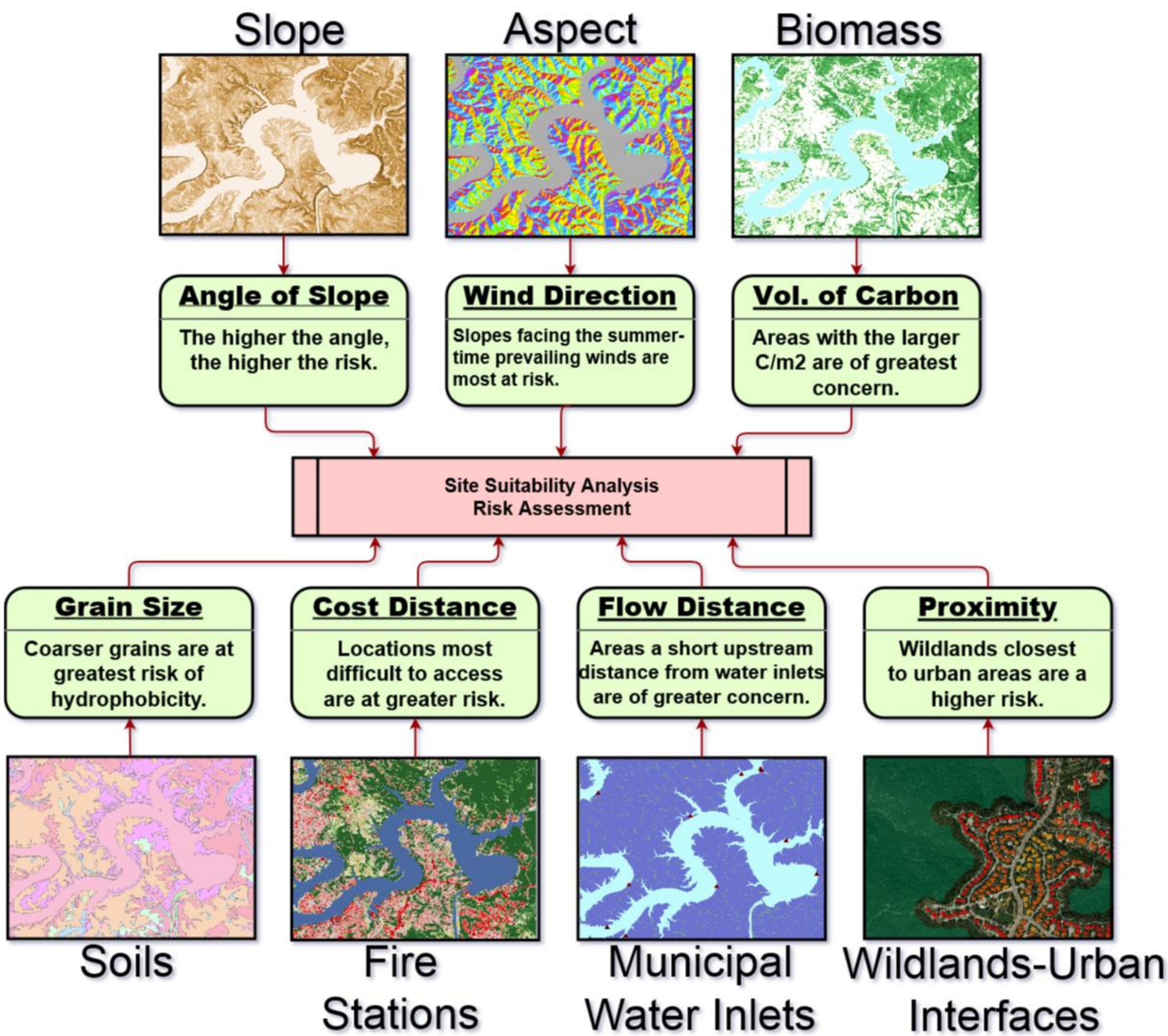

Figure 4. The seven parameters for the Site Suitability Analysis.

3.5.2 Ranking and Weighted Values

Currently, the overall ranking and weighted values for the analysis have only been theorized, however, slope, biomass, and soil are currently perceived to collectively have the highest impact on the results.

3.5.3 Site-Suitability Analysis

Using a raster calculation that has yet to be determined, we will seek to quantify and rank locations from 0-10 based on their risk of degrading water quality. The classification breaks method has yet to be determined for the analysis. We will attempt to drape the final results over a triangular irregular network, a continuous 3d surface, to help visualize the results with elevation expressed through the 3d topography.

3.5.4 Expectations

Slope and biomass have been identified as variables that will have a large impact on our results, allowing us to run a preliminary analysis with fewer variables (Figure 4 below). From this analysis, it is our expectation that the analysis will result in a largest hotspot that will stretch from Cow Creek at the Balcones Canyonlands National Wildlife Refuge east past Lago Vista (violet ellipse) and spreading south beyond Jonestown along the western edge of Lake Travis out east past Four Corners along FM2222 and the Bull Creek Greenbelt (green ellipse). A secondary large hotspot we expect is see is along the Barton Creek Greenbelt Wilderness Area up north into the municipality of West Lake Hills (blue ellipse). A densely powerful hotspot currently exists near Bee Cave along a densely vegetated cutback along Lake Austin (red ellipse). Other smaller hotspots are expected around the Pedernales State Park, Reiner County Park, and in the source region of Onion Creek on the southern edge of Travis County into Hays County.

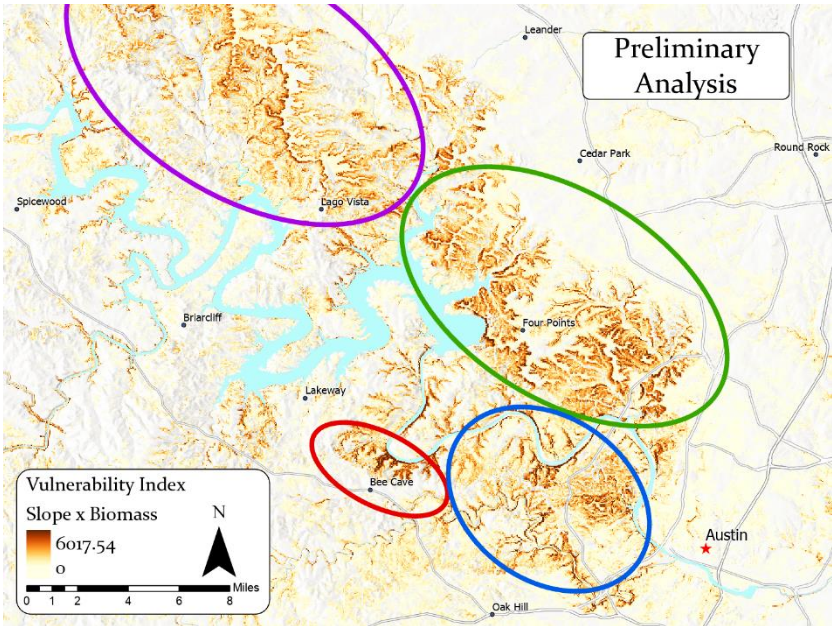

Figure 4 Locations of expected hotspots outlined with an ellipse. Balcones Canyonlands, purple; Bull Creek & Four Points, green; Barton Creek & West Lake Hills, blue; and Lake Austin & Bee Cave, Red.

Methodology Flow Chart

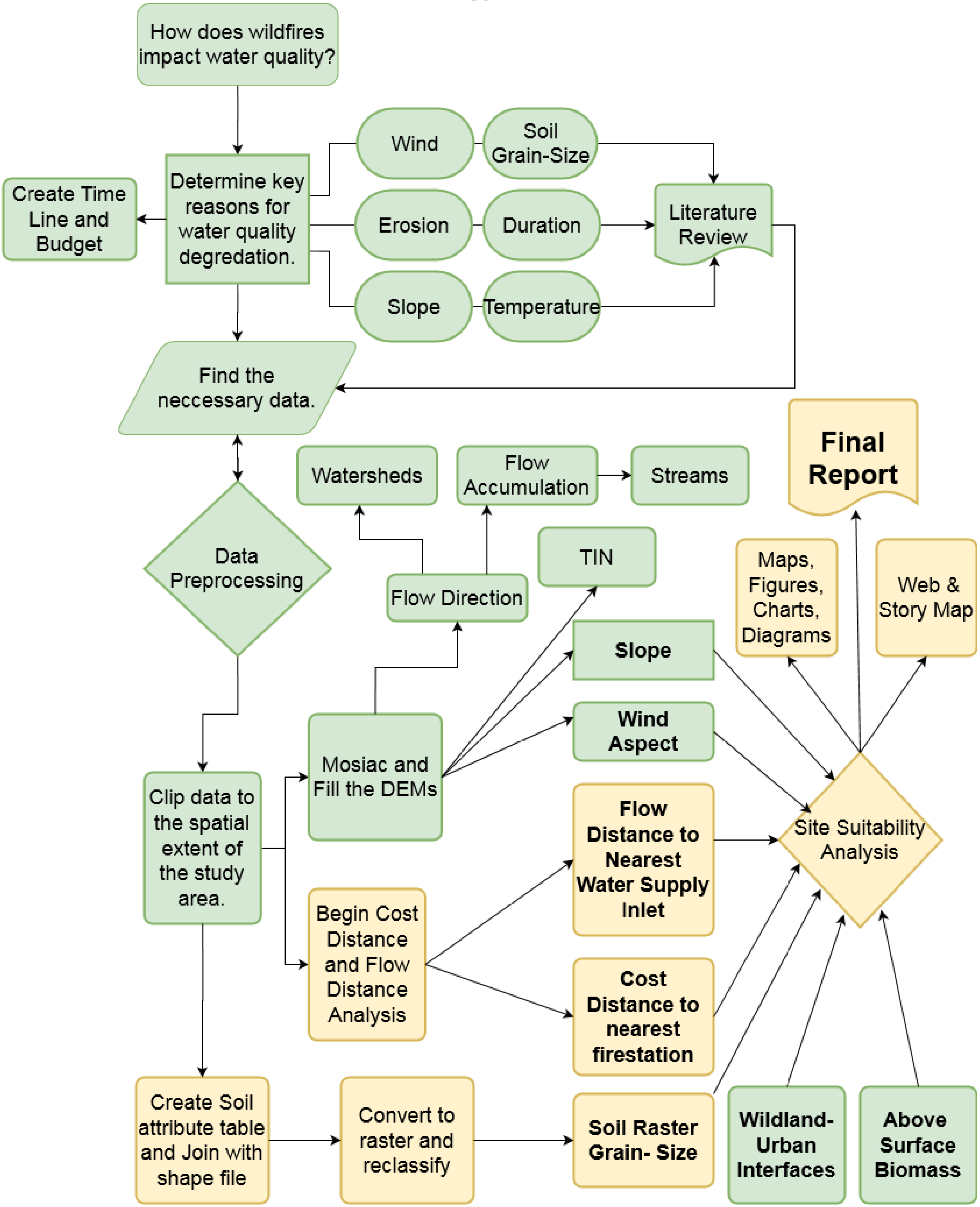

Figure 5 Simplified flow diagram of our overall methodology. Green symbols represent steps already completed while yellow symbols represent steps we have not begun.

Simplified flow diagram of our overall methodology. Green symbols represent steps already completed while yellow symbols represent steps we have not begun.

4. Timeline

January					
Mon.	Tues.	Wed.	Thur.	Fri.	Week-end
27	28	29	30	31	

Process	Weeks
Data Collection	1-4
Pre-Processing	5-8
Data Analysis	9-12
Data Interpreta	13-14

Feburary						
Mon.	Tues.	Wed.	Thur.	Fri.	Week-end	
3	4	5	6	7	8/9	
10	11	12	13	14	15/16	
17	18	19	20	21	22/23	Proposal Presentation
24	25	**26**	27	28	29/1	Due 25 March

March						
Mon.	Tues.	Wed.	Thur.	Fri.	Week-end	
2	3	4	5	6	7/8	
9	10	11	12	13	14/15	
16	17	18	19	20	21/22	
23	24	**25**	26	27	28/29	Progressive Report
30	31					Due 25 March

April						
Mon.	Tues.	Wed.	Thur.	Fri.	Week-end	
		1	2	3	4/5	
6	7	8	9	10	11/12	Austin Fire Symposium
13	14	15	16	**17**	18/19	17 April
20	21	22	23	24	25/26	
27	28	**29**	30			Final Report Due 29 April

5. Budget

Data collectio	# of people	weekly hours*	# of weeks	Total hours	Hourly pay	Total
Manager	1	6	4	21.5	35	752.5
GIS Analyst	4	6	4	80.25	23	1845.75
Total	5	12	4	101.75		
				$ 23.00		$2,598
Pre-Processing						
Manager	1	6	4	24	35	840
GIS Analyst	4	6	4	96	23	2208
Total	5	12	4	120		
Hourly pay				$ 23.00		$3,048
Data Analysis						
Manager	1	6	4	24	35	840
GIS Analyst	4	6	4	96	23	2208
Total	5	12	4	120		
Hourly pay				$ 23.00		$3,048
Data Interpretation						
Manager	1	6	2	12	35	420
GIS Analyst	4	6	2	48	23	1104
Total	5	12	2	60		
Hourly pay				$ 23.00		$1,524
WEbsite development						
webmaster	1	8	3	24	$30.00	$ 720
Hourly pay						
	Project			Total hours	Total Cost	
	Hours + Arc GIS (2)			425.75	$ 20,938	
* = estimated number of hours						

6. Deliverables

Deliverables for this project are all processes and methods utilized for the project. A Detailed final report that will include all Methodology and Data. GIS data layers to include the appropriate attributes and symbology in the format of geodatabase, included will be visualizations and maps of completed projects. Class presentation slides. ArcGIS online web map/story map for the public to view. Professional Poster for display in the Geography and for City of Austin Fire Department Symposium on April 17th.

7. Conclusion

The project will use GIS Technology to visualize and rank a vulnerability index for the watersheds in and around the City of Austin. Literature review will be conducted to find the variables for the index. Creating visualizations, maps for presentation, and a web map for public use. A poster for presentation will also be developed.

8. Reference

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