Identifying Geological Hazards in the Harrop Procter Community Forest Area

Introduction

The goal of this project was to evaluate land characteristics and identify areas that may require further ground analysis to confirm susceptibility to geological hazards. For simplicity, the term “landslides” will be used as a generic term to describe geological hazards.

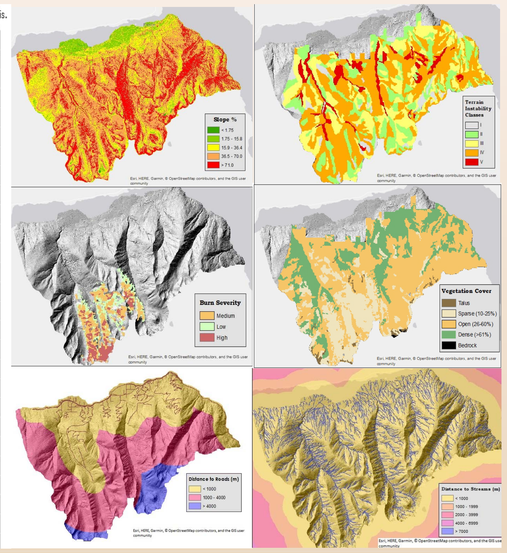
Understanding the locations of these potentially sensitive sites may help in protecting aquatic and terrestrial ecosystems, public safety, community drinking water, road infrastructure, and economic opportunities. It may also help in identifying areas where mitigation efforts may reduce the impacts of geological processes.

Criteria for Analysis

Slope, terrain instability, vegetation cover, distance to roads, distance to streams, and burn severity were all considered in this analysis and were rated on a scale of 1-5 based on their importance in influencing landslide susceptibility (Table 1). A value of 1 indicated low susceptibility and a value of 5 indicated high susceptibility.

Table 1. Parameters[1] for the landslide susceptibility analysis.

Criteria		Susceptibility Rank
Slope	< 1.75%	1
	1.75-15.8%	2
	15.9-36.4%	3
	36.5-70.0%	4
	> 70.0%	5
Terrain Instability	I	1
	II	2
	III	3
	IV	4
	V	5
Burn Severity	Low	1
	Moderate	3
	High	5
Vegetation Cover	Talus	5
	Sparse (10-25%)	4
	Bedrock	3
	Open (26-60%)	2
	Dense (> 61%)	1
Distance to Roads	< 1 km	5
	1-4 km	3
	> 4 km	1
Distance to Streams	< 1 km	5
	1-2 km	4
	2-4 km	3
	4-7 km	2
	> 7 km	1



Methodology

A *Fuzzy Overlay* analysis was selected for this project due to the uncertainties involved in landslide susceptibility mapping. Fuzzy Logic enables complex phenomena with no discrete boundaries to be modeled by using Spatial Analyst tools that consider potential data inaccuracies. Data was first converted into a raster format, then quantified using the *Euclidean Distance Spatial Analyst Tool* and the *Reclassify Spatial Analyst Tool*. Each criterion was then ranked and reclassified using manual breaks to reflect the weighted criteria in Table 1.

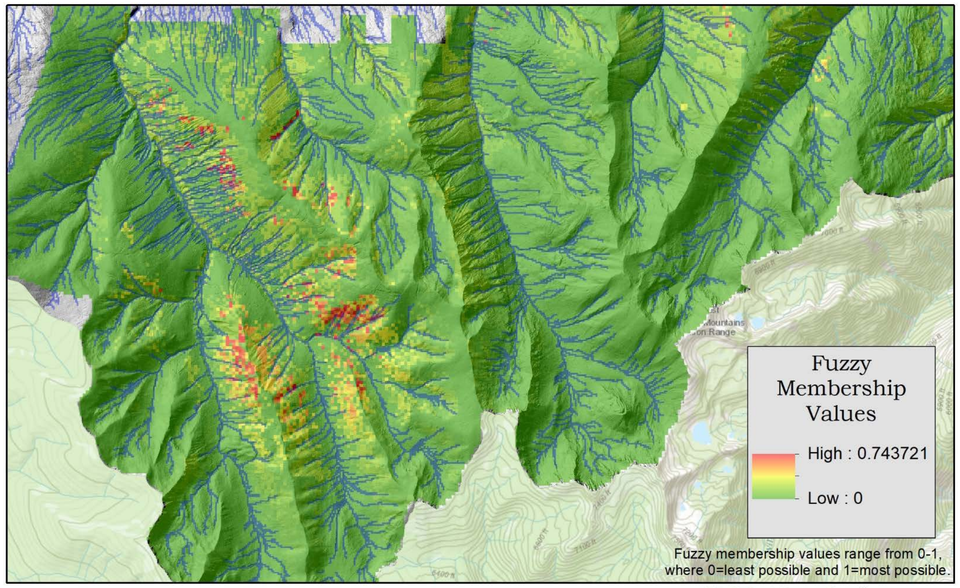
The *Fuzzy Membership Spatial Analyst Tool* was then applied to each layer (Table 2); this classified each factor into a common scale of 0-1 in which 0 indicated a low possibility and 1 indicated a high possibility (of an occurrence).

Table 2. Details of Fuzzy Membership Spatial Analysis

Factor	Fuzzy Membership Type	Other information
Slope	MSLarge	Default values
Terrain Instability	Large	Midpoint[7]: 3
Burn Severity	Large	Midpoint: 3, Spread: 5
Vegetation Cover	Large	Midpoint: 3, Spread: 5
Distance to Roads	Small	Midpoint: 1500[8], Spread: 3
Distance to Streams	Small	Midpoint: 3500, Spread: 5

Each fuzzy membership layer was then combined using the *Fuzzy Overlay Spatial Analyst Tool* to generate a final surface. On the HPCFA map, slope, terrain instability, and vegetation cover were combined with the “Fuzzy AND” overlay type, then combined with the distance to roads and distance to streams layers using the “Fuzzy PRODUCT” overlay type. On the map considering the Harrop Creek wildfire, this process was repeated except the burn severity layer was incorporated into the criteria in which the “Fuzzy AND” overlay type was used.

Areas of Potential Slope Instability in the HPCFA



Coordinate System: NAD 1983 UTM Zone 11
0 0.75 1.5 3 Kilometers
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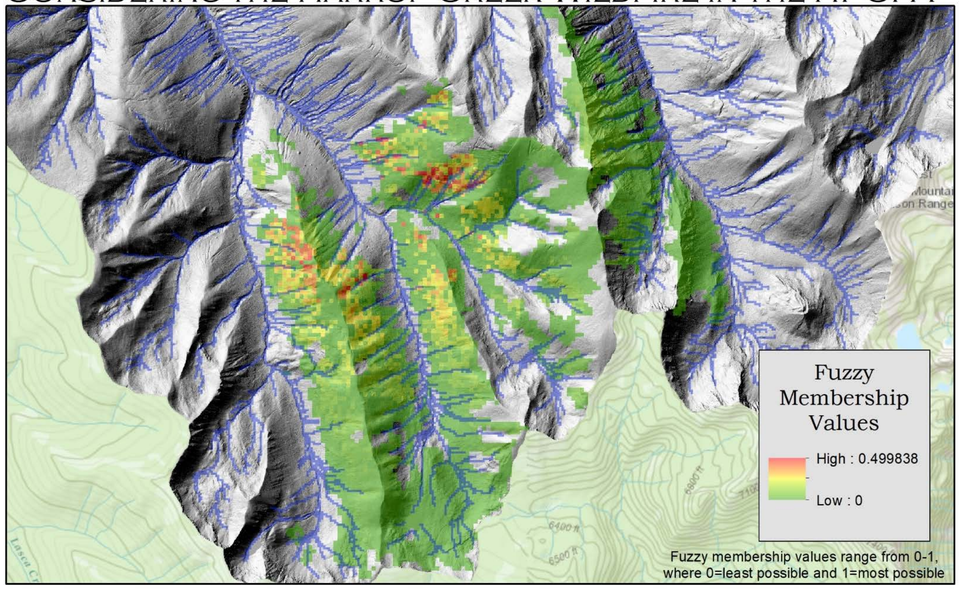
Map produced by: Terri McRitchie
Date created: 2019 March 27

Areas of Potential Slope Instability Considering the Harrop Creek Wildfire in the HPCFA



Coordinate System: NAD 1983 UTM Zone 11
0 0.5 1 2 Kilometers
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Map produced by: Terri McRitchie
Date created: 2019 March 20

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Results & Discussion

Both maps suggest further ground analysis may be necessary to confirm areas of slope instability. This is indicated by the red-colored regions, which suggest that there is a high possibility of a geological process such as a debris slide occurring. The lower fuzzy membership value in the Harrop Creek wildfire map is attributed to the additional burn severity criterion; fewer areas are potentially instable under the specified parameters. Nevertheless, both maps reflect some overlap in areas that may be susceptible to sliding.

There are several headwaters in or near these potentially sensitive sites that should be noted. Most of these sites connect to Harrop Creek or Narrows Creek. Additionally, the entire study area has a proximity to streams less than 1 km. If geological processes occur, this distance to streams suggests a good possibility of waterways becoming impacted. Care should be exercised in assessing these areas to confirm the impacts that may be felt towards aquatic ecosystems, water intakes, road infrastructure, and users of the HPCFA.

Limitations & Assumptions

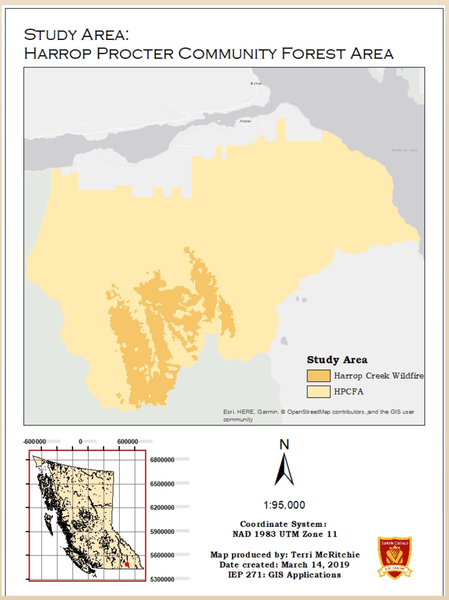
No standard set of criteria defines the potential occurrence of a mass wasting event; therefore, assumptions were made on the criteria used in this analysis based on literature readings and professional advice. It was assumed that the selected criteria had some level of influence on slope instability. The extent that this criteria influenced landslide susceptibility also led to some assumptions in selecting the Fuzzy Overlay types.

Data that would have been helpful but was absent in this analysis included drainage density, precipitation patterns, snowpack, and spatial representations of natural disturbances.

Further Research

This type of analysis may benefit from the creation of a prediction model built with the *ModelBuilder* in ArcGIS. The model may then be applied to other areas of similar terrain, wildfire histories, and landslide disturbances.

Other beneficial research would be to study mitigation efforts such as soil bioengineering techniques to protect sensitive sites from geological hazards.



Citations

Environmental Systems Research Institute, Inc. 2018. Using raster data for site selection: using fuzzy logic for site selection. United States of America: Esri. [accessed 2019 Feb 18]. Online training.

Data obtained by: Tom Bradley, GIS Analyst