Lab Report
Final Project
GIS 5571

Title: ***Assessing Wildfire Risk in Los Angeles County: A Multi-Criteria Spatial Analysis***
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Author: Kyle Smith
Date: 12/17/24

Project Repository: kylejsmith4/GIS5571/Final Project
Time Spent: 112 hours

Abstract
This study develops a multi-criteria decision analysis (MCDA) model to assess residential wildfire risk in Los Angeles County at the parcel level. Using geospatial data on vegetation, slope, and weather conditions, the model integrates residential land use and Wildland Urban Interface maps to identify high-risk areas. The findings reveal that a hyper-local model can be developed, but further refinements are needed to enhance accuracy and reliability compared to existing verified datasets.

Problem Statement
Can we develop a model of residential wildfire risk in Los Angeles County at the parcel level?

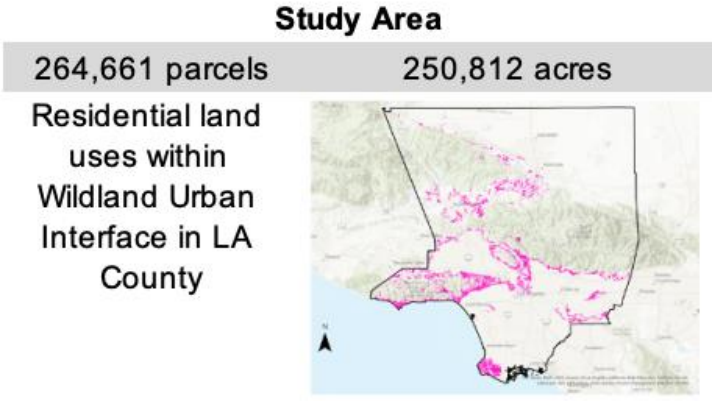
#	Requirement	Defined As	(Spatial) Data	Attribute Data	Data	Preparation
1	Vegetation	MCDA model input	Vegetation type Polygons	Risk Scores by vegetation type(1-5)	Link	Clip, Filter & Reclassify & convert to raster
2	Weather conditions	MCDA model input	Red Flag Warning archive Polygons	Risk Scores by # of RFWs by region (1-5)	Link	Clip, Filter & Reclassify & convert to raster
3	Slope	MCDA model input	DEM	Slope Degrees, Risk Scores (1-5)	Link	Clip, calculate slope, Reclassify
4	Residential Land Use	Study Area input	LA County Land Use Polygons	Filter residential uses within project area	Link	Clip and filter
5	State Fire Hazard Zones	Verification data	State Fire hazard Zone Polygons	Calculate verification with project dataset	Link	Clip and filter
6	Wildland Urban Interface	Study Area input	WUI Polygons	Filter Los Angeles County and Hazard level	Link	Clip and filter
7	LA County boundary	Study Area input	LA County boundary polygon	County boundary	Link	Use for clipping and framing visual outputs
8	Fire Risk Score Map for LA County	Produced by project model (MCDA)	Points	Point data with risk score attributed (1-5)	N/A	Raster calculator, reclassify, calculate statistics, data to points
9	Sensitivity Analysis raster	Sensitivity Analysis	Points and raster	Point data of various weighting scenarios	N/A	Features to raster, raster calculator, analyze change raster, reclassify, calculate statistics
10	Verification	Model verification	Points and Polygons	County of point data, polygon size, risk value, fire hazard value	N/A	Merge, Calculate statistics

Input Data

#	Title	Purpose in Analysis	Link to Source
1	Fire Perimeters	Fire perimeters are downloaded from an API as polygon features. Clipped to LA County boundary, filtered to 1980–2023, classified by decade and containment data.	Link
2	Los Angeles County Boundary	The county boundary is downloaded as a polygon dataset. Serves as the spatial extent for clipping other datasets.	Link
3	Residential Land Use	Land use polygons for 2019 are downloaded. Clipped to WUI boundaries, filtered to include residential land uses, and merged to create a unified dataset.	Link
4	Wildland-Urban Interface (WUI)	The WUI boundary is downloaded as polygon features. Clipped to LA County boundary, filtered based on the 'HAZ NUM' attribute to isolate relevant areas.	Link
5	Vegetation	Vegetation data is downloaded as polygons. Converted to raster format and reclassified into risk categories (1–5) based on vegetation type.	Link
6	Slope	A digital elevation model (DEM) is downloaded. Slope calculated from DEM, converted to raster format, and reclassified into risk categories (1–5).	Link
7	Red Flag Warnings	Archived red flag warnings are downloaded as polygons. Converted to raster format and reclassified based on the count of warning events.	Link
8	State Fire Hazard Zones	Fire hazard zone polygons are downloaded. Clipped to LA County boundary and used for validation purposes.	Link

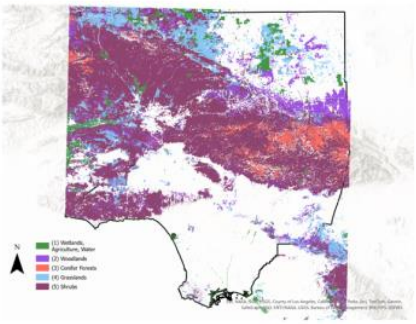
Methods

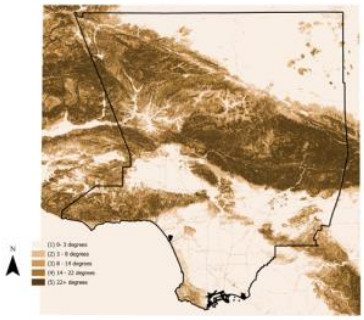
The process begins with data preparation and setting up the study area, which is the entirety of Los Angeles County, CA. First, the most current and complete land use dataset (2019) is downloaded and filtered to isolate parcels within the Wildland-Urban Interface (WUI). The WUI is a zone of transition between unoccupied land and human development.

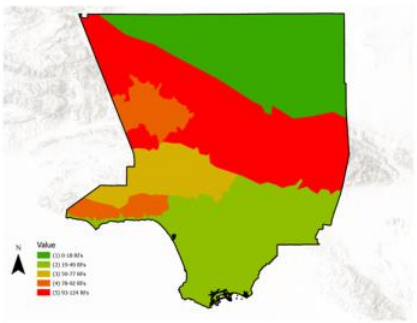


With the data prepared, a multi-criteria decision analysis (**MCDA**) model is constructed next. The input layers used are vegetation type, slope, and the number of red flag warnings. Each dataset is converted into a raster format and reclassified into risk categories ranging from 1 to 5 (high risk). The more flammable vegetation types are assigned a higher score, the steeper slopes are assigned a higher risk scores, and the frequency of red flag warnings are assigned a risk score by region. The input layers are assigned weights reflecting their importance in wildfire risk: vegetation (40%), weather (35%), and slope (25%). These layers were combined using a raster calculator to produce a composite wildfire risk score for each parcel.

Vegetation	Slope	Red Flag Warnings





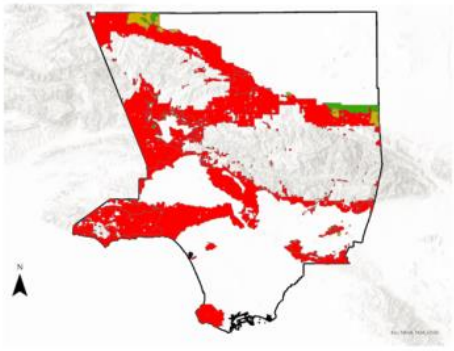


Risk Score	MCDA (1-5 scores)		
	Vegetation	Red Flag Warnings	Slope (degrees)
1	Shrubs	0-18	0 - 3
2	Grasslands	19-49	3 - 8
3	Conifer Forests	50-77	9 - 14
4	Woodlands	78-92	15 - 22
5	Wetlands, Agriculture, Water	93-124	>22

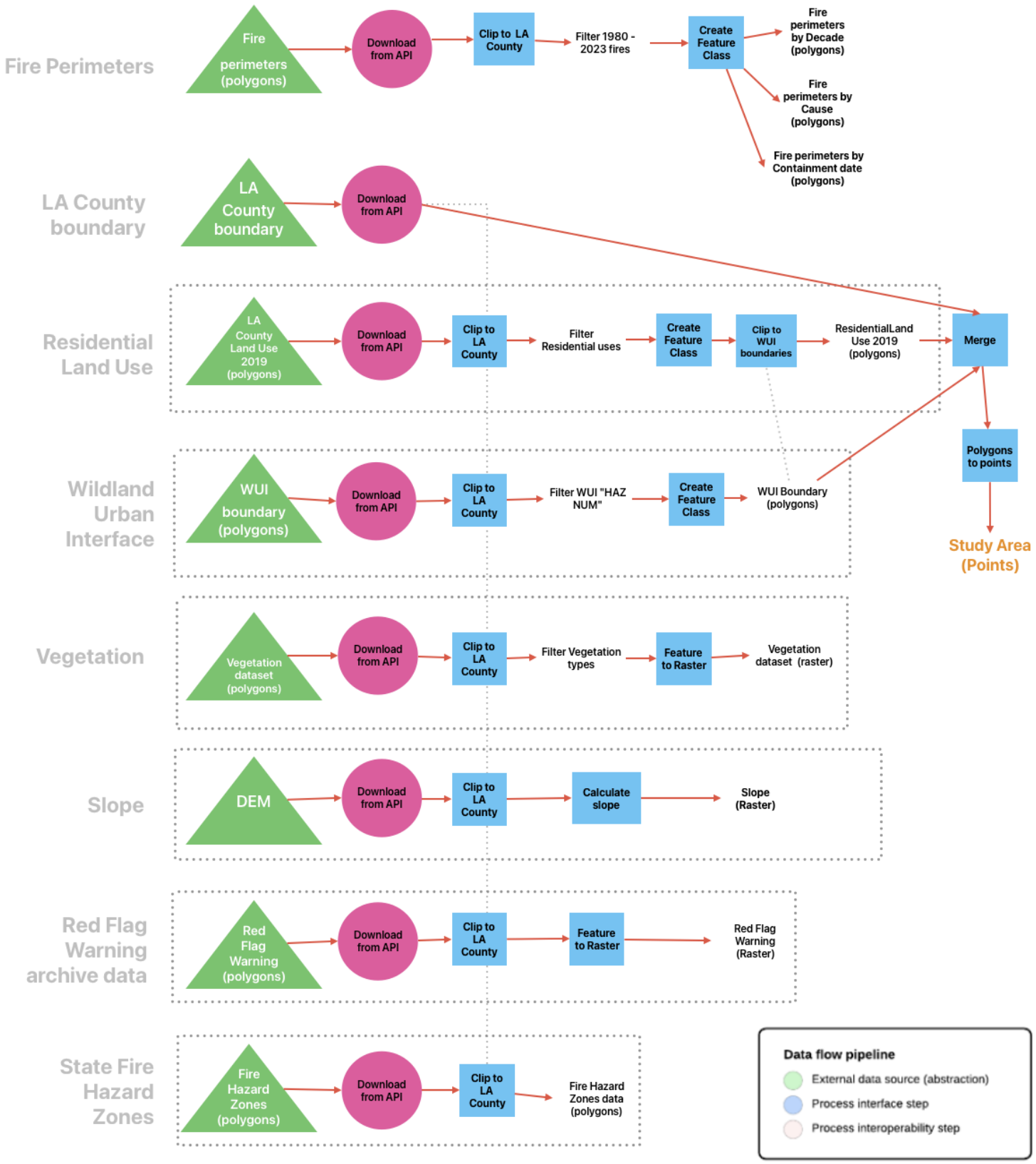
A **sensitivity analysis** was conducted next. For each scenario (listed below), the risk score raster was recalculated, analyzed, and summary statistics were generated. To **validate** risk scores, the data is compared statistically and visually against established state fire hazard zones.

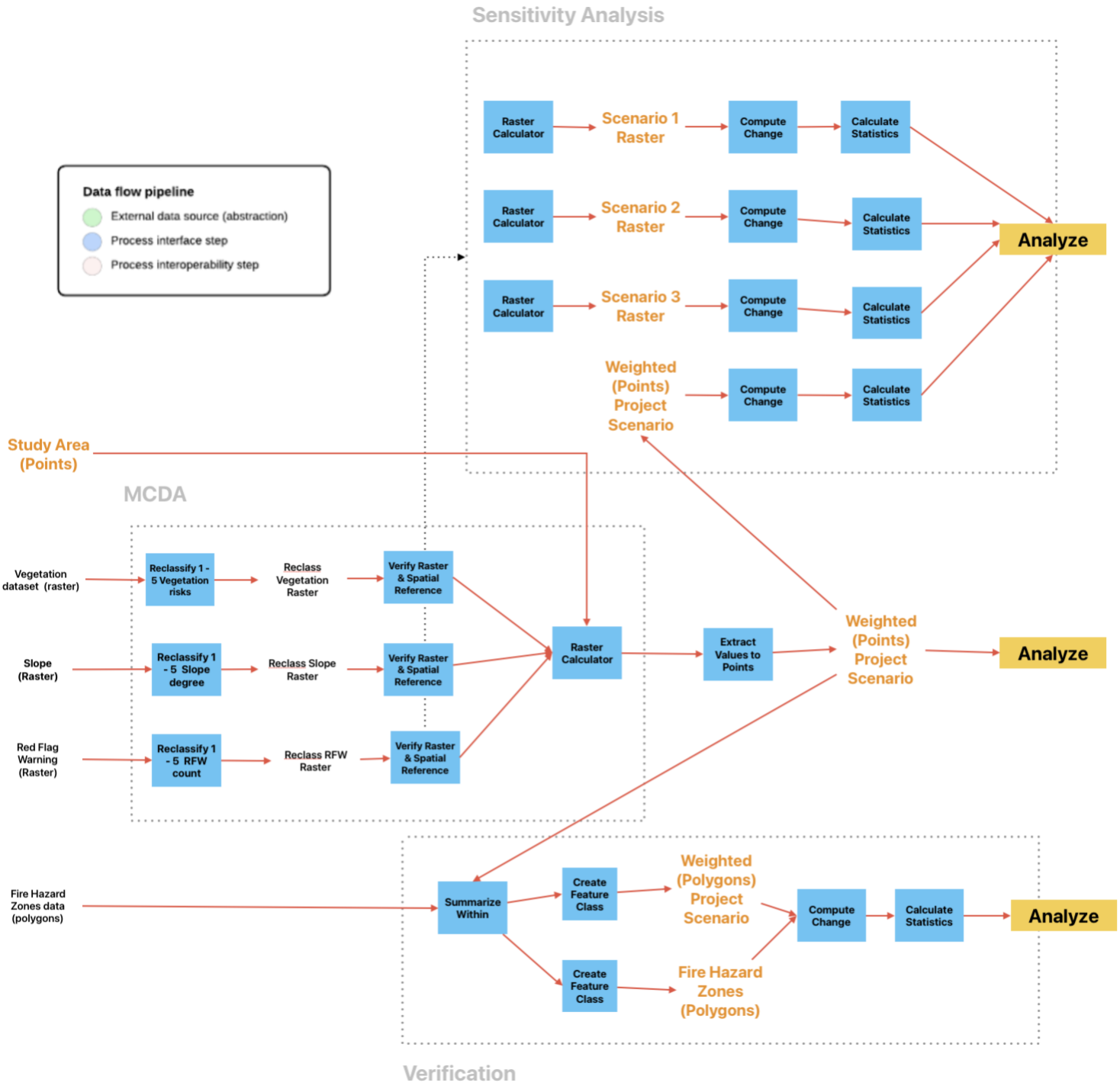
Risk Weights	Vegetation	Red Flag Warnings	Slope
Project	0.40	0.35	0.25
Scenario 1	0.50	0.30	0.20
Scenario 2	0.30	0.40	0.30
Scenario 3	0.33	0.33	0.33

Fire Hazard Zones (Validation)



Data Flow Diagram

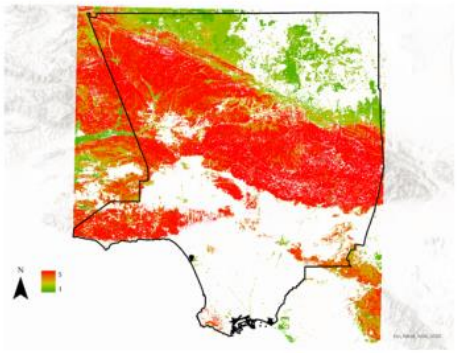


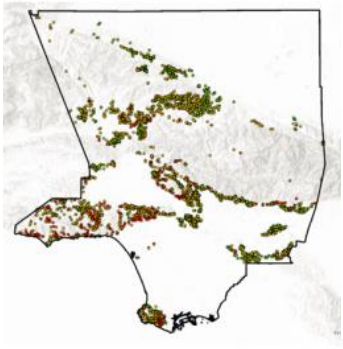

Sensitivity Analysis
Data flow pipeline
External data source (abstraction)
Process interface step
Process interoperability step
Raster Calculator
Scenario 1 Raster
Compute Change
Calculate Statistics
Raster Calculator
Scenario 2 Raster
Compute Change
Calculate Statistics
Raster Calculator
Scenario 3 Raster
Compute Change
Calculate Statistics
Weighted (Points) Project Scenario
Compute Change
Calculate Statistics
Analyze
Study Area (Points)
MCDA
Vegetation dataset (raster)
Reclassify 1 - 5 Vegetation risks
Reclass Vegetation Raster
Verify Raster & Spatial Reference
Slope (Raster)
Reclassify 1 - 5 Slope degree
Reclass Slope Raster
Verify Raster & Spatial Reference
Red Flag Warning (Raster)
Reclassify 1 - 5 RFW count
Reclass RFW Raster
Verify Raster & Spatial Reference
Raster Calculator
Extract Values to Points
Weighted (Points) Project Scenario
Analyze
Fire Hazard Zones data (polygons)
Summarize Within
Create Feature Class
Weighted (Polygons) Project Scenario
Create Feature Class
Fire Hazard Zones (Polygons)
Compute Change
Calculate Statistics
Analyze
Verification

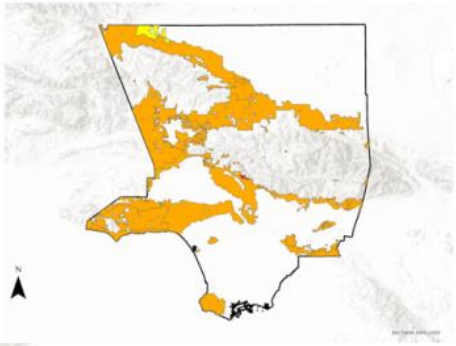
Results

Upon completion of the MCDA analysis, a raster with risk scores across parcels reveal a mean value of **2.3,** with a significant portion of parcels classified as moderate to high risk. The risk score can also be shown in points and polygons.

MCDA Analysis raster	Risk map (points)	Risk map (polygons)

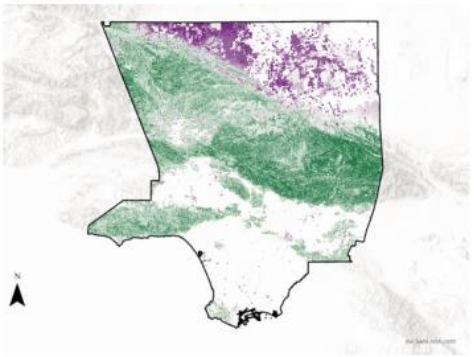


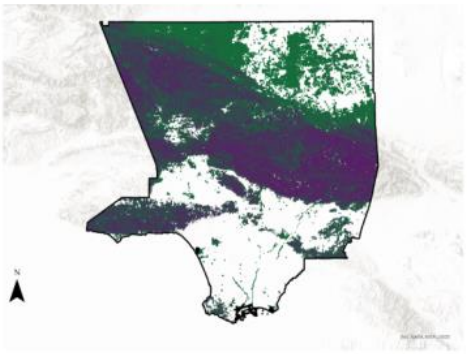


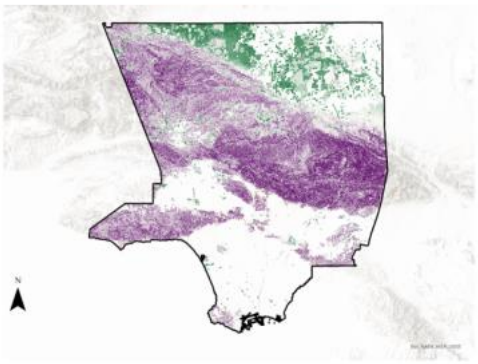


Sensitivity analysis across three scenarios shows a variation in risk distribution. Scenario 1 shows an increased vegetation weight emphasizes with a mean increase of 0.14. This scenario invertedly highlights the greater diversity of plats species in the high desert. Scenario 2 places higher emphasis on weather, which highlights the areas with a higher frequency of red flag warnings, the foothills, canyons, and mountains. The mean risk score increases by 0.14 in Scenario 2. Scenario 3 is a balanced weight distribution, which invertedly emphasizes slope, and has a mean risk score increase of 0.94 from the project scenario. This Sensitivity Analysis highlights how different weighting strategies affect risk distribution.

Scenario 1	Scenario 2	Scenario 3





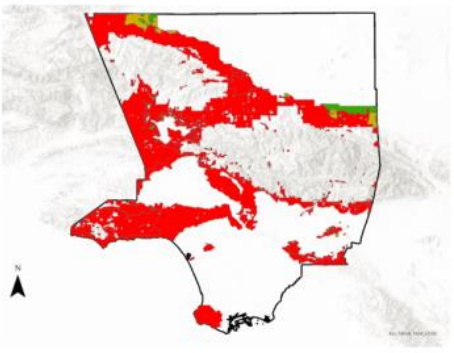


Risk Weights	Vegetation	Red Flag Warnings	Slope	Mean Risk
Project	0.40	0.35	0.25	**2.3**
Scenario 1	0.50	0.30	0.20	**0.14**
Scenario 2	0.30	0.40	0.30	**0.45**
Scenario 3	0.33	0.33	0.33	**0.94**

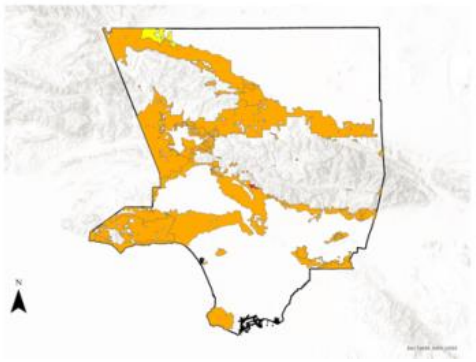
Results Verification

The validation shows a general alignment between the project model's risk scores and historical fire hazard zones established by the State of California. A higher mean risk scores corresponding to "Very High" fire hazard zones. With the state fire hazard zones being separated into three classes, the project model risk mean can be recalculated to a 1-3 scale, from a 1-5 scale. Comparing these means shows a **2.8** mean risk score for the State Fire Hazard Zones (see chart and map below), and an adjusted mean of **1.3** risk score for the project model. The distribution of means is quite large, with the project model's mean quite lower than the state's model. However, the project model is more normally distributed. Finally, statistical analysis reveals a weak correlation (r = 0.107) among the two models, indicating the predictive accuracy is low.

Fire Hazard Zones (Validation)



Risk map (polygons)



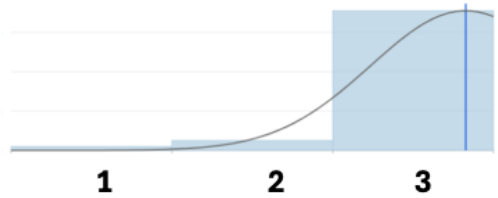
Verification

Risk Scores within Fire Zones (1-3 scale)

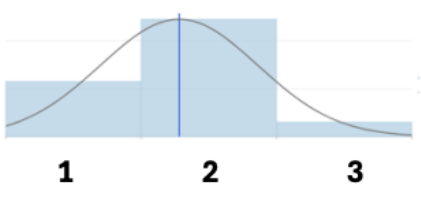
Fire Hazard Zone	Risk Score (Project)
(1) Moderate	**1.07**
(2) High	**1.11**
(3) Very High	**1.38**

Mean	2.8	1.3
Median	3	1.35
Standard Deviation	0.394	0.258

State Fire Hazard Zone distribution (LA County)



Project Risk Score distribution (LA County)



Discussion and Conclusion

Can we develop a model of residential wildfire risk in Los Angeles County at the parcel level?

This study explores the feasibility of developing a parcel-level residential wildfire risk model for Los Angeles County using a multi-criteria decision analysis (MCDA). While the study demonstrates that a hyper-local model is achievable, further refinements are necessary to enhance accuracy and reliability when compared to existing verified datasets. Most parcels in the study area face moderate to high wildfire risk, primarily due to steep slopes and dense vegetation. Although the model broadly aligns with historical data, it requires either improved input data for greater accuracy, a revised weighting scheme, or a narrower focus.

The validation process suggests that the model appropriately identifies the normalized distribution of risk scores when compared to statewide models. However, the wide distribution of means, with a notably lower value for this project's model, may stem from attempting to model parcel-level risk in a large, county-wide study. Furthermore, since state hazard zones are established through algorithms and regional generalizations, it is possible that the state model's mean value is unnecessarily inflated. Developing a more accurate and robust parcel-level model may require greater differentiation in variables and weights than is currently feasible at the county level.

Finally, it is important to note that wildfires are highly likely to increase due to climate change. While not always politically or economically popular, policies should be adopted to encourage (or require) future residential development in Los Angeles County to occur in in-fill locations, rather than extending further into the Wildland Urban Interface.

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Self-score
Fill out this rubric for yourself and include it in your lab report. The same rubric will be used to generate a grade in proportion to the points assigned in the syllabus to the assignment.

Category	Description	Points Possible	Score
Structural Elements	All elements of a lab report are included **(2 points each)**: Title, Notice: Dr. Bryan Runck, Author, Project Repository, Date, Abstract, Problem Statement, Input Data w/ tables, Methods w/ Data, Flow Diagrams, Results, Results Verification, Discussion and Conclusion, References in common format, Self-score	28	**28**
Clarity of Content	Each element above is executed at a professional level so that someone can understand the goal, data, methods, results, and their validity and implications in a 5 minute reading at a cursory-level, and in a 30 minute meeting at a deep level **(12 points)**. There is a clear connection from data to results to discussion and conclusion **(12 points)**.	24	**22**
Reproducibility	Results are completely reproducible by someone with basic GIS training. There is no ambiguity in data flow or rationale for data operations. Every step is documented and justified.	28	**25**
Verification	Results are correct in that they have been verified in comparison to some standard. The standard is clearly stated **(10 points)**, the method of comparison is clearly stated **(5 points)**, and the result of verification is clearly stated **(5 points)**.	20	**20**
		100	**95**