

Hanging off the Edge: Vulnerability Analysis of Erosion Along the Central Coast of California

Background



Coastal bluff erosion, the landward migration of the cliff face, is a significant problem faced by coastal California communities. The coast of California is iconic, home to thousands of residents, and plays a major role in the tourism industry. However, erosion is occurring at astonishing rates. The United States Geologic Survey (USGS) in a study (1) published in 2007 reported that the average amount of cliff retreat along the central coast of California was 17.7 m

during the approximately 70 years of study (1929-2002). This winter the City of Pacifica, just south of San Francisco, declared a state of emergency as the heavy El Nino storms caused significant erosion forcing people out of their homes that were left nearly or literally dangling off the edge. Analysis of susceptibility to cliff failure was based on the variables of lithology, slope, elevation, and land cover. It was suspected that areas of steep slope, greater elevation, sedimentary material, and developed would be more susceptible to significant erosion.

Methods

For this project all of the data collected was clipped to the extent of the counties: Marin, Monterey, San Francisco, San Mateo, and Santa Cruz. The data on the lithology of California was simplified into basic rock types: igneous, metamorphic, and sedimentary. This data was then converted to a raster in order to be put into the model. Elevation data from the USGS was converted to slope using the Slope tool. The same elevation data was brought into the model. Data from the NLCD Land Cover Raster was brought in. All of the rasters were reclassified so that each raster had three classification rankings. Determination for how to reclassifying elements of each raster was based on knowledge of the area and geologic principles. The weighted overlay tool was used to analyze the composite affect.

Reclassification Scheme

Factors	1= High Vulnerability	2	3= Low Vulnerability
Slope (% Rise)	30-53%	13-30%	0-13%
Lithology	Sedimentary	Igneous	Metamorphic
Land Cover	Developed (Open, Low), Shrub, Grasslands, Woody Wetlands, Herbaceous Wetlands	Developed (Medium), Barren Land, Pasture, Cultivation, Deciduous Forest	Developed (High), Evergreen Forest
Elevation (m)	1,924-412	272-412	-58-272

Table 1: Reclassification scheme for analysis factors

Weights Assigned

Factor	Slope (% Rise)	Lithology	Land Cover	Elevation
Weigh Percent	20%	30%	20%	30%

Table 2: Weights assigned to each factor using the Weighted Overlay Tool given suspected impact on erosion processes.

Vulnerability Analysis

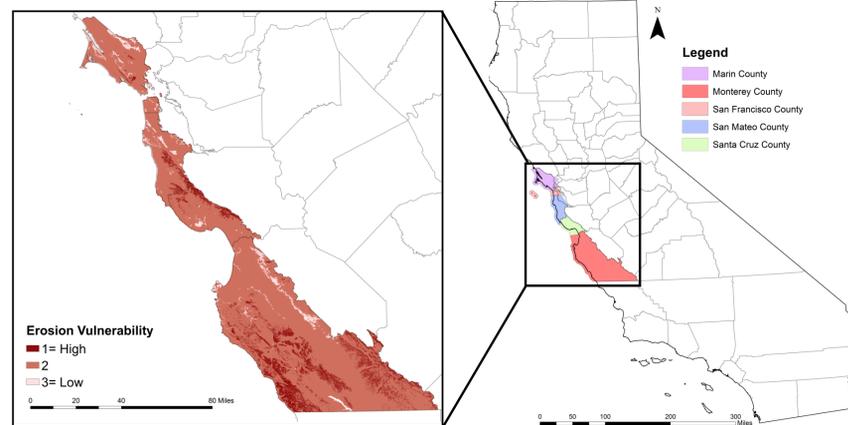


Figure 2: Erosion Vulnerability Analysis

Figure 1: State of California with study area shown

Analysis Factors

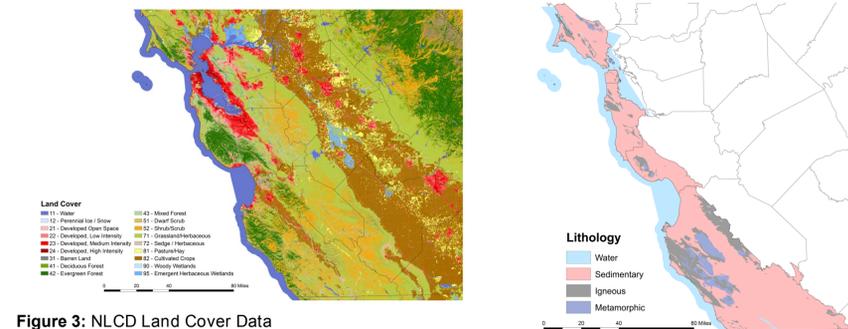


Figure 3: NLCD Land Cover Data

Figure 4: Simplified lithology of California

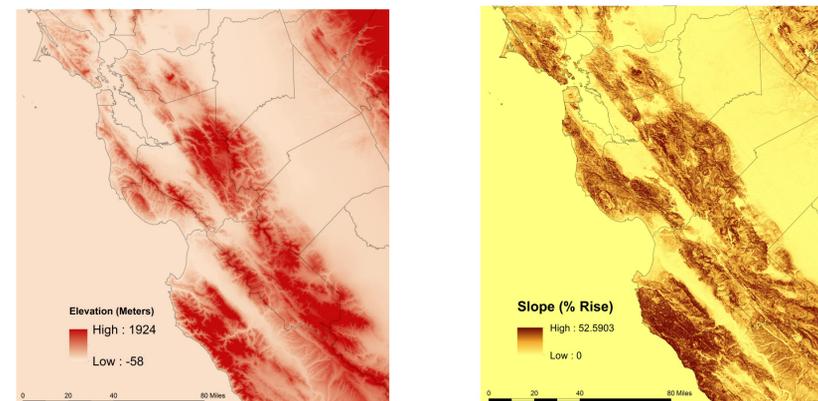


Figure 5: Elevation profile

Figure 6: Slope profile

Results and Limitations

The results for this model only show direct harm to coastal erosion on a very small scale; further, there is a lot of extraneous data that is classified as being vulnerable to erosion despite being several miles inland. When investigated right on the coastline of California, there are some very evident locations where vulnerability to erosive processes is high. In particular the southern part of the map, in Monterey County, shows significant area that is very vulnerable. Northern Marin County (just south of San Francisco) shows areas that are classified as having low vulnerability. For the most part though, all of the area along the coast is ranked as being moderately vulnerability to coastal erosion. The parts more inland from the coast showing vulnerability to erosion are likely a result of elevation and slope profiles that are related to coastal mountain ranges.

While providing a reasonable model for understanding threats of potential coastal erosion, there are many simplifications that limit the study. One of the main limitations of this study concerns the over simplification of the geology of the California coast. For the purposes of this study, lithology was classified as either sedimentary, igneous, or metamorphic when; in actuality not all sedimentary rocks with erode in the same manner as some are more well cemented than others. Another limitation of the study is what the impact of waves are on the coast. Better analysis would have been able to include wave data, and would have ideally included mean velocity of the wave. Additionally, as evidenced by the rapid erosion in Pacifica this winter, major and sporadic storm events can have significant impact on erosion rates. Lastly, the weights assigned to each piece of data is generalized and in unique situations there can be a host of confounding factors.

Conclusion

The discrepancy in the results modeled compared to the results hypothesized, is due to the challenge of classification. Further because erosion occurs at such a fine scale (often less than 1 meter per year) there is a challenge rectifying that with larger scale data. However, it is important to recognize the effects that erosion can have on coast lines. Given the data reported by the USGS (1) coastal erosion cannot be ignored. Further, the results of this analysis show that it is challenging to predict just where erosion will be the worst. Therefore, it is necessary possible erosion is taken as a potentially serious threat to coastal communities.

Projection: NAD 1983 UTM Zone 10N
Data Sources: California Department of Transportation (2015), USGS (2005, 2011), NLCD Land Cover (2011)
Photograph: Fimrite, Peter. "Pacific Ocean Devours Pacifica Cliffs in Aerial Photos over Decades." *SFGate. San Francisco Chronicle*, 3 Feb. 2016. Web. 08 May 2016. Photograph Josh Edelson, AFP/Getty Image
1:Hapke, C.J., and Reid, D., 2007, National Assessment of Shoreline Change, Part 4: Historical Coastal Cliff Retreat along the California Coast: U.S. Geological Survey Open-file Report 2007-1133.

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