Cliff Erosion Analysis around Beverly Beach

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CE 513

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Introduction

Cliff erosion is a major concern in Beverly Beach, Oregon. In order to assess potential impacts to Highway 101, it is of interest to analyze erosion rates and develop models to predict future outcomes. Lidar is a technique that uses visible or near-infrared laser energy to measure the distance between a sensor and an object, therefore we can use Lidar data to get the surface ground model, by comparing Lidar data from different years, we can learn about the topographic changes during this period thus predict the erosion of the cliffs.

Site Description

The Area Of Interest (AOI) is located in Beverly Beach, North of Newport OR, very close to Highway 101. the coordinates are 44°43’30.3’’N, 124°03’29.9’’W, and the address of the nearby houses is 12204 NE Beverly Dr, Newport, OR 97365. The area of AOI is about 289,959 ft².

AOI is located on a sandy beach, next to the Highway 101 on the right side and a river inlet on the north side. The erosion of the cliffs has been so severe that the closest point is only 8 feet from the travel lane of Highway 101.

Fig 1. Area of Interest (Cliff on the Beverly Beach)

Data

Lidar data used to compare erosion was got from NOAA CSC's Digital Coast Data, they area point data, one from 2002 and another from 2016. Table 1 shows detail information.

	2022 Lidar Dataset	2016 Lidar Dataset
Source data collected by	NASA/USGS	USGS
Lidar system used(make, model)	NASA Airborne Topographic Lidar 3(ATM3)	Optech Orion M300
Reported horizontal accuracy(at 95% confidence level)	+/- 0.8 meters at an aircraft altitude of 700 meters	+/- 21.1cm
File creation data	Nov29, 2011	Oct 28, 2016
LAS version	1.2	1.4
Point Density (pt/m^2)	0.48	16.6
Point Spacing (m)	1.45	2.25

Table 1. Metadata of two Lidars

NHDFlowline data was get from Oregon SPTIAL DATA LIBRARY, and hydrology subbasin data also from here. These data contain StreamRiver, connector, pipeline and Coastline etc.. The project projection is UTM Zone 10, the Horizontal Datum is NAD83 and Vertical Datum is NAVD88, unit is meter.

GIS Methods

The core approach of this project is the acquisition and processing of LiDAR data. The project involves the import of external tool package, ArcGIS is already rich in default tools, but the import of external toolkits will help us solve problems better. The tool package I used in this project named LAS tool package, the lasinfo tool in it was used to output the information of data I got. Some useful information, like point densities , could be found here.

LP 360 tool is a critical tool that gives us a visual representation of the dotted Lidar data. By visualizing the presentation, we can clearly see the difference between the lidar data of different generations, and the same can be done with the naked eye for the comparison of cliff erosion. Sometime, the old data like 2002 data in this project, has never had point classification performed, we can use “lasground” tool to separate ground and above-Ground points, so that we can get a more accurate data. Fig 2 shows the original Lidar data looks in LP360 tool in ArcGIS Pro, and Fig 3 shows it’s shape after using “lasground” tool.

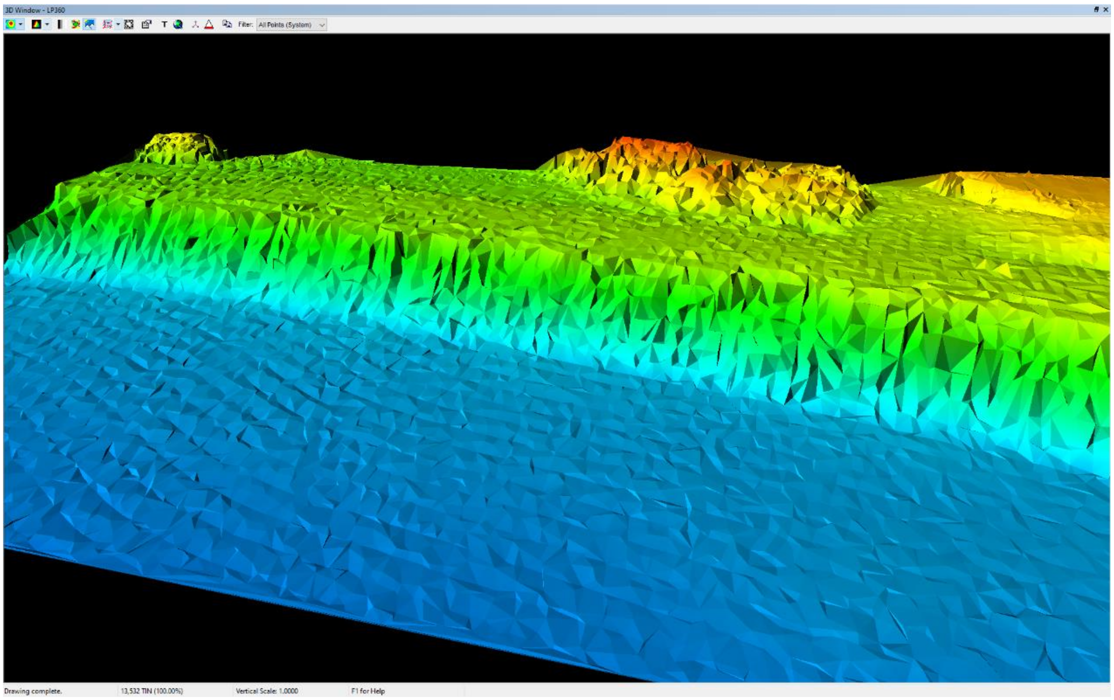

Fig 2. The surface layer from 2002 Data

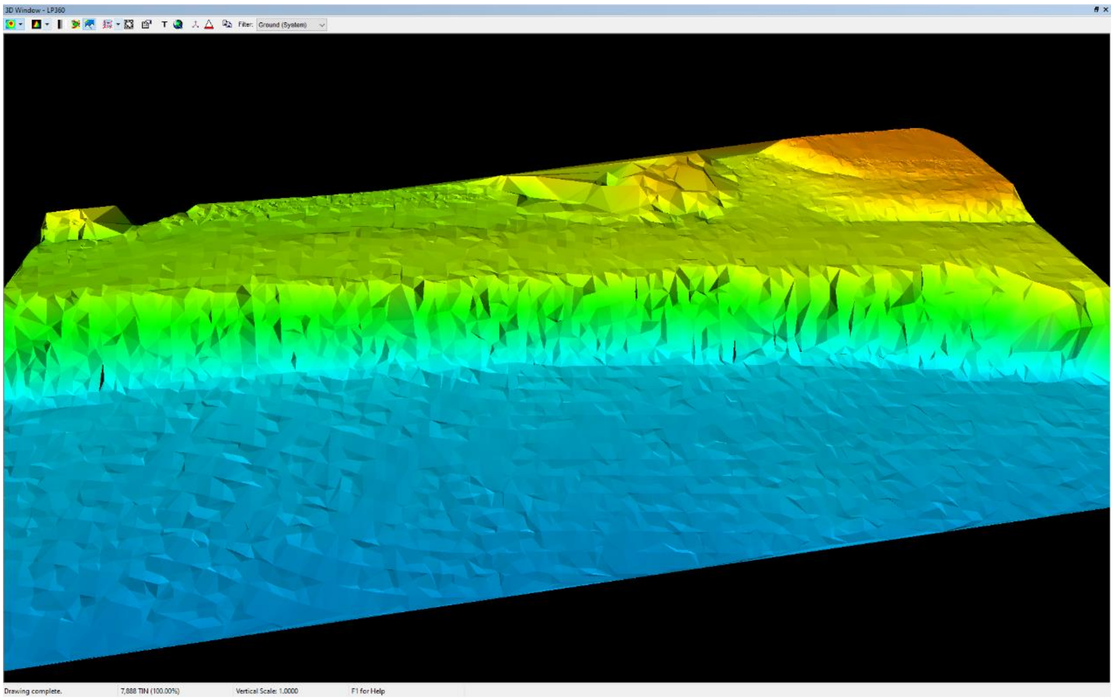

Fig 3. 2002 Data after processing

After Adding 2016 Data on 2002 data, creating a normal transect for the AOI and then I got the shape changes of cliff from 2002 to 2016. Through measurement tool in ArcGIS, the are of changes were easy to be collected. By creating more transects, I can collect more erosion data, and finally estimate volume changes per meter length of shoreline using the formula:

$$\frac{V}{L} = \frac{A_1 + 2A_2 + 2A_3 + \cdots + A_n}{2(N-1)}$$

Due to a descriptive map is required, so the data from Oregon Data Library could be use to construct basin-flow map and topographic map. The previous methods is what I learned from outside the class, as an extended learning part of this project, however, this part is completely from the usual lab, raster calculation and change the symbology of the flow lines to graduated symbols according to the flow is the most practical method that I learned this term. Unfortunately, the NHDFlowline data I found did not have information on water flow. The flow chart was shown in Fig 5.

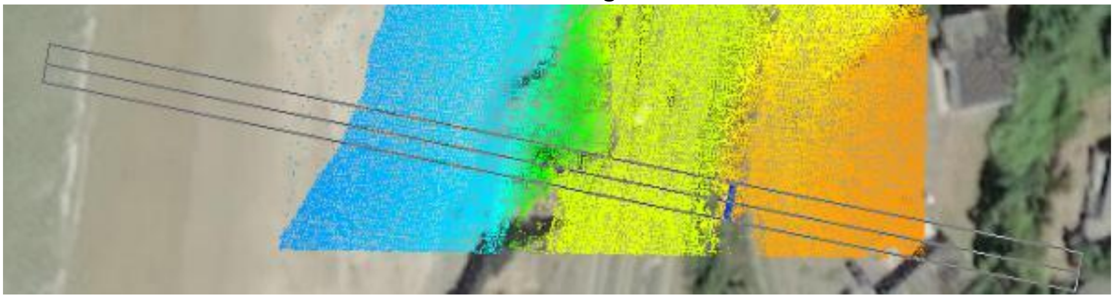

Fig 4. The South end transect

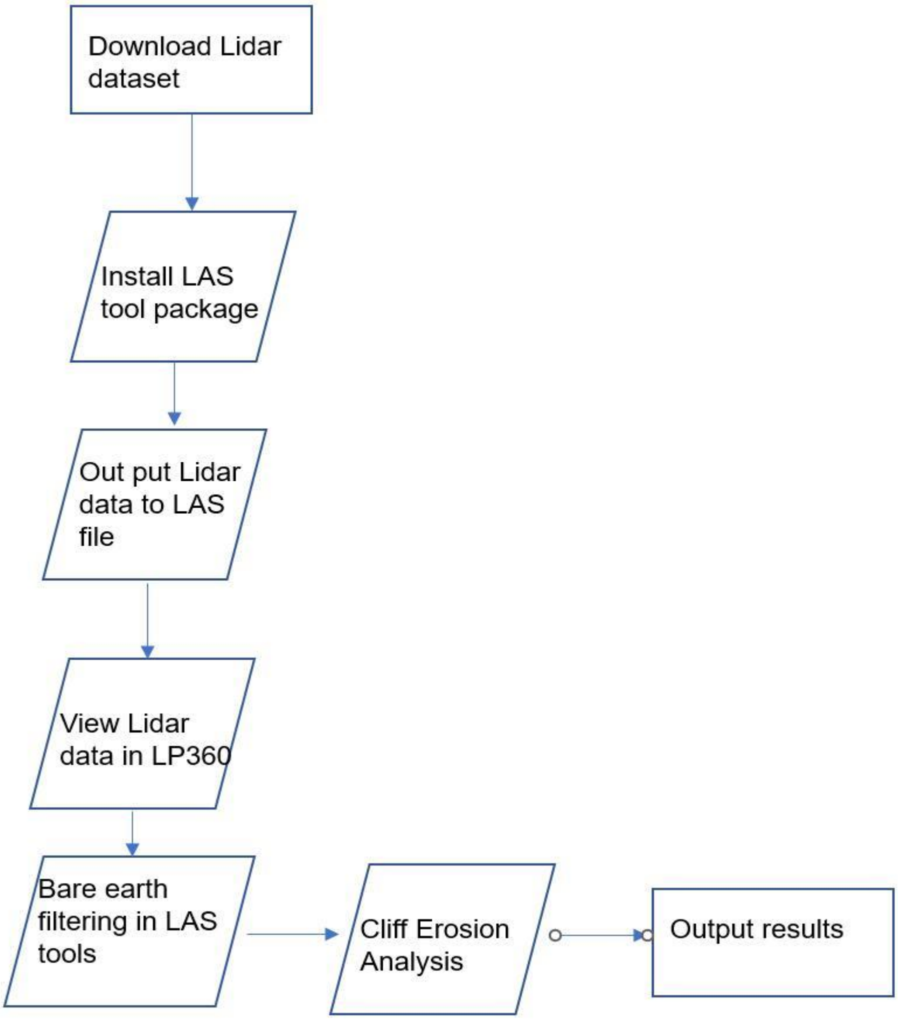

Fig 5. Main steps flow chart during the project

Results

Screenshots of the transects from AOI from south to north are shown below, the bule line is 2002 data, and the purple line is 2016data. Also, Table 2 shows the data collected for the area of difference in the transects. The max horizontal and elevation change happened in the south end of the AOI. The n which is the number of transects I got is 18, and the final result I got is : between 2002 and 2016, the volume of cliffs eroded per meter of length was 180.135 cubic meters.

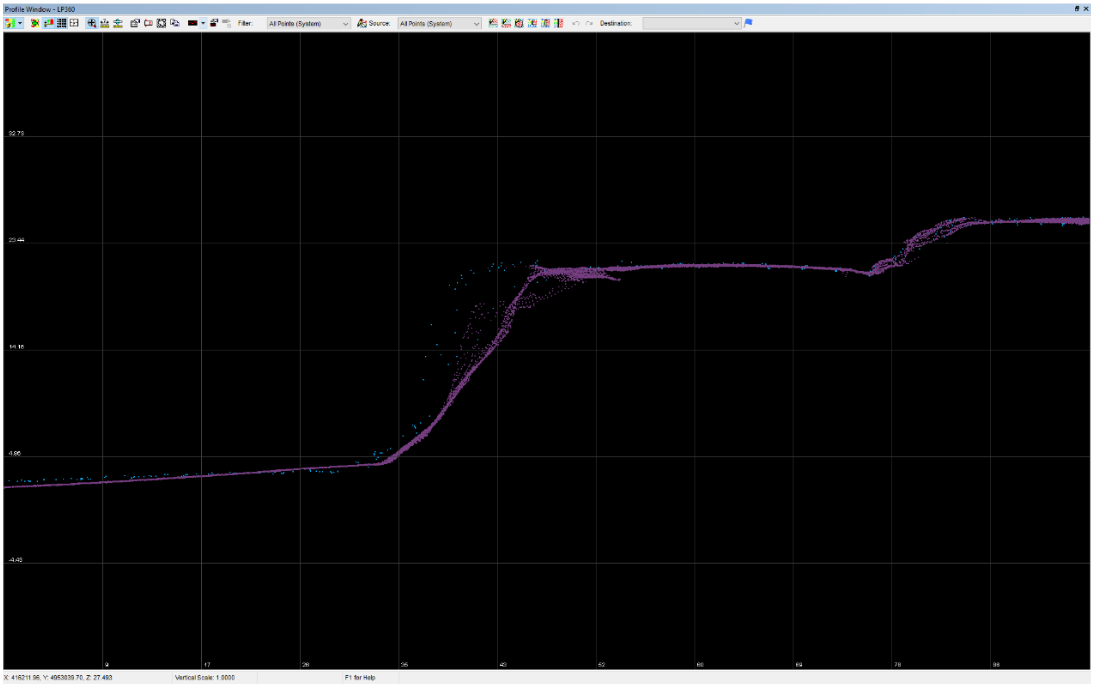

Fig 6.The comparation in south end

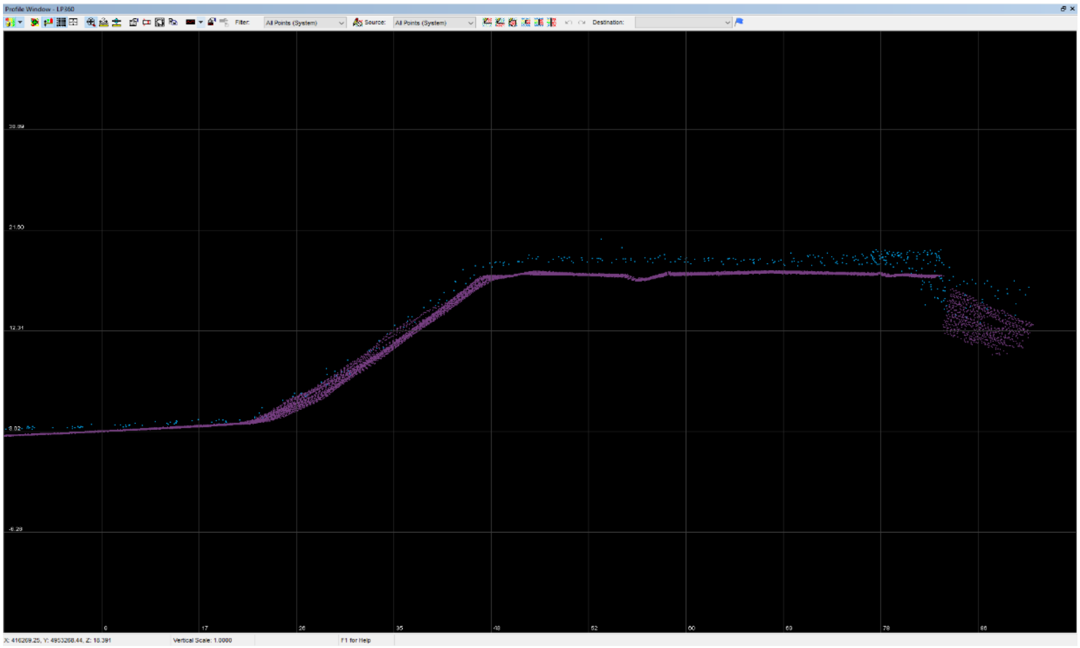

Fig 7. The comparation in north end

A	B	C
herizon	vertical	area
6.843	9.173	40.331
5.94	8.949	29.654
0	0	0
3.612	2.708	18.066
2.711	1.955	4.525
0	0	0
2.417	3.387	8.078
2.786	3.986	7.175
2.632	3.609	7.076
5.94	3.835	14.579
3.589	6.467	10.305
4.063	10.003	13.51
5.414	6.617	15.738
2.556	2.331	9.585
2.256	3.835	6.083
2.932	7.754	7.354
2.482	6.618	10.712
3.459	8.12	12.166
2.256	5.714	6.968
2.407	2.257	3.743
3.159	3.384	7.583
3.612	3.911	12.435
2.336	3.084	5.446
2.641	2.857	10.999
4.361	6.618	24.262
2.783	3.009	6.666
2.261	1.731	9.779
2.107	2.783	5.974
2.707	3.009	9.22
2.783	3.011	6.018
3.534	4.963	14.464
2.406	6.695	6.633
4.587	5.083	14.569
3.911	4.436	18.543
2.558	2.707	9.329
2.566	2.558	7.889
2.407	2.406	6.082
2.633	2.782	7.325
2.933	2.857	5.388
2.482	2.481	2.496
3.91	3.009	10.82
3.162	2.481	8.662
1.736	0.841	1.532
2.403	1.431	2.569
2.556	4.662	4.594
0	0	0
2.791	1.504	2.987
2.261	1.579	1.958
3.158	1.356	3.199

Table 2. The erosion data collected in Excel

Discussion

The results of the erosion survey are an alarming figure, with a maximum erosion of 6.8 meters horizontally and 10 meters vertically between 2002 and 2016, and the current edge of the lane of the highway 101 in the cliff is only 8 meters, which means that in another 20 years the edge of the road could collapse. Therefore, necessary reinforcement, maintenance and preventive measures must be taken. In this project, due to the technical limitation in 2002, the point density of Lidar data was not dense enough and the data was not accurate for the earth surface with weeds or debris, so the final result may be inaccurate, but a general estimation based on the Google Earth measurement data and comparing the results can verify the accuracy of the results. For future studies on erosion, shortening the years of comparison may make the data more accurate.

Appendix

Hladik, C. and Alber, M.(2012).” Accuracy assessment and correction of a LIDAR-derived salt marsh digital elevation model.” *Remote Sensing of Environmen*t, 121, 224-235

Obu, J., Lantuit, H., Grosse, G., Günther, F., Sachs, T., Helm, V. and Fritz, M., (2017). “Coastal erosion and mass wasting along the Canadian Beaufort Sea based on annual airborne LiDAR elevation data”. *Geomorphology*, 293, 331-346.

Troy, C.D., Cheng, Y.T., Lin, Y.C. and Habib, A., (2021). “Rapid lake Michigan shoreline changes revealed by UAV LiDAR surveys”. *Coastal Engineering*, 170, 104008.

“NOAA: Data Access Viewer. “. <https://coast.noaa.gov/dataviewer/ - /> (Mar. 10, 2023)

“Oregon Spatial Data Library.”(2020). <https://spatialdata.oregonexplorer.info/geoportal/> (Mar. 10, 2023)

The Location of Beverly Beach

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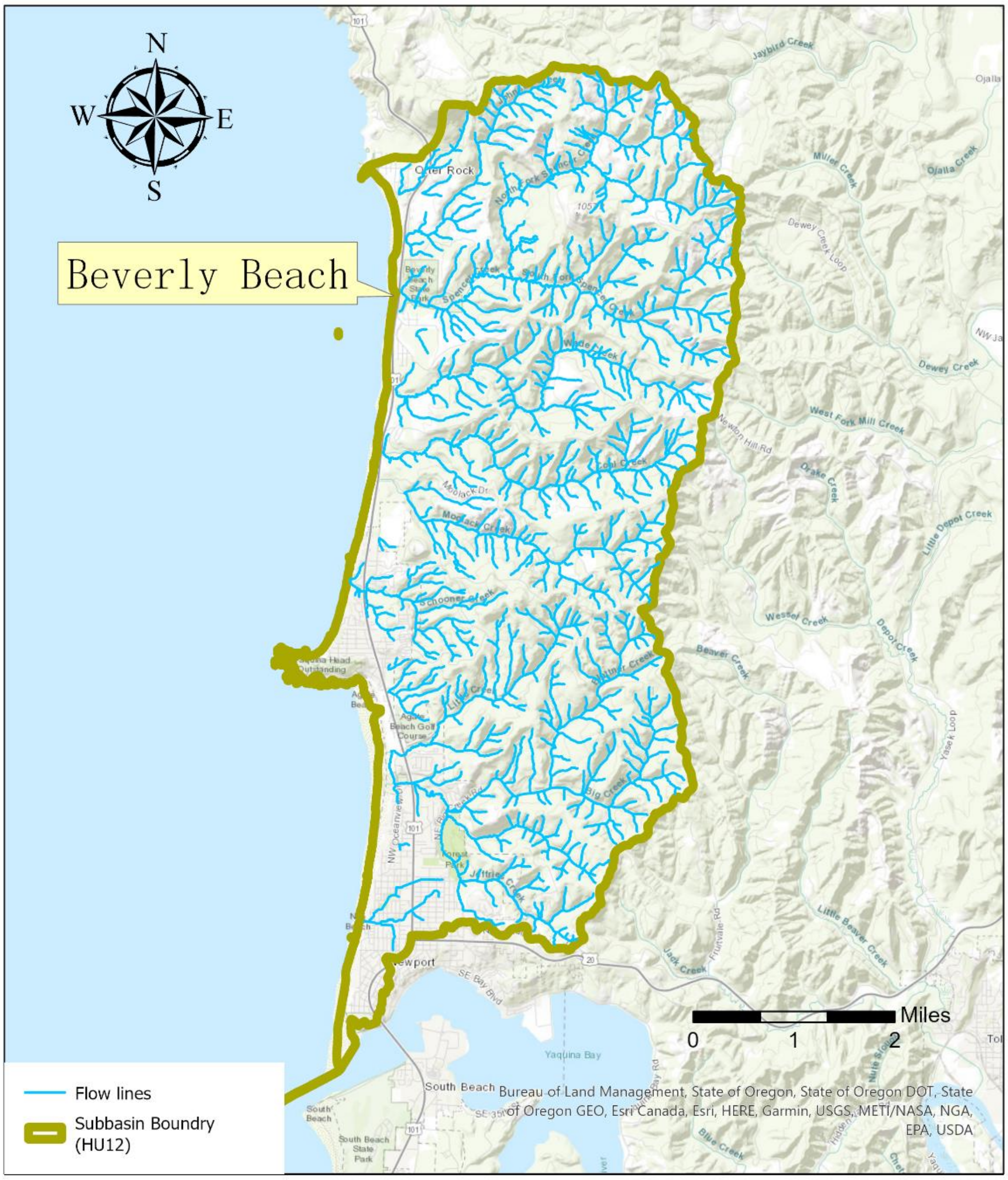

Elevation and Terrain Around the Beverly Beach

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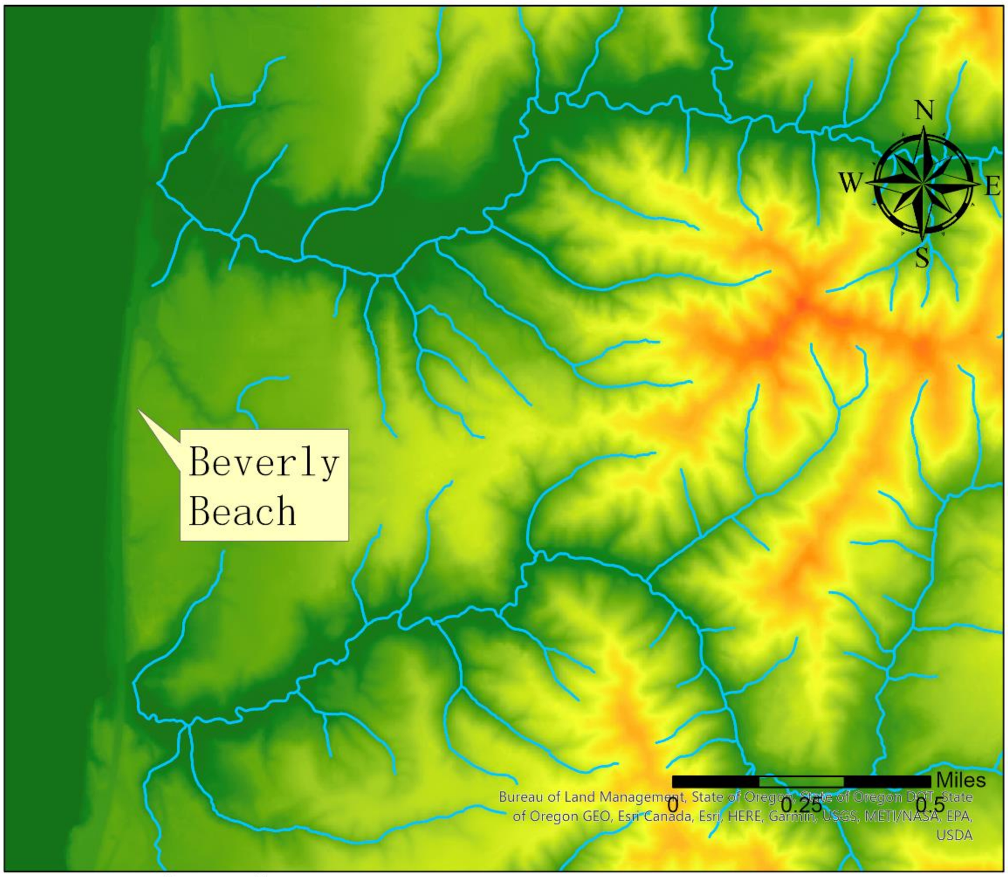

Legend

Flow lines

Elevation

Value

313.321

0.0951773

Comparison of Erosion In The South, Middle and North of the Beverly Beach

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