A GIS Assessment of Erosion Vulnerability for Unofficial Trails in the Columbia River Gorge

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Geog 593 Digital Terrain Analysis
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Abstract

The city of North Bonneville, located along the Columbia River Gorge in Skamania County, Washington, is a small town surrounded by scenic natural landscapes. Community leaders of North Bonneville have a vision of becoming a hub for outdoor recreation and a connector to the Pacific Crest Trail and other regional trails. In an effort to advance their vision, a recently founded local community organization named the Bonneville Trails Foundation (BTF) is encouraging the United States Forest Service (USFS) to approve and formalize several existing unofficial trails located just north of the town, known to locals as the Aldrich Butte trail complex. In April of 2017 a focus group was held with community members, trail builders, and the USFS to get feedback about which of the informal trails should be formalized. Following that process, further analysis of trail hazards was requested by the USFS. There are many criteria that the USFS and WTA would like to consider when choosing where to build trails in this area. However, for the scope of this project I will be doing a GIS analysis of the vulnerability of trails to erosion processes to access potential hazards and sensitive areas in the trail complex. I will use a model developed by Józefaciuk & Józefaciuk (1996), Wawer & Nowocien (2007), and A.M. Tomczyk, (2011) that uses slope steepness and soil type to determine water erosion hazards. The potential water erosion indicator is based on soil properties as defined by Wawer & Nowocien (2007). I will determine slope by using a 2 meter DEM obtained from the Washington Department of Natural Resources, and use a soil classification layer from the Soil Survey Geographic (SSURGO) database obtained from the U.S. Department of Agriculture to determine soil type. Trails will be segmented, and each segment assigned a hazard ranking. Finally, each of the unofficial trails will be evaluated for overall erosion vulnerability, and recommendations will be made toward a trail formalization process.
Study Area:
North Bonneville, WA

Unofficial trail system (shhh, it's a secret)
Bonneville Trail Foundation (BTF)

Discovery Trails of North Bonneville

Other important partners
1. Which trails of North Bonneville’s unofficial trail complex would the community want to formalize?

2. Are these trails actually viable for the formalization process
   a. Are they safe for people?
   b. Are they safe for the environment?
   c. What about land ownership?
   d. etc
Mapping the Unofficial Trails:

BTF “Trail Gnomes” + Garmin GPS Unit (not to scale) = Trajectory
Resulting map of the unofficial trails (7 total)
Public Participation in Trail Selection & Evaluation

Focus group in North Bonneville

1 hour, 16 participants
Expert, Intermediate, and Novice users
Representatives from the Forest Service, Army Corps of Engineers, and Washington Trails Association
Now... what can GIS analysis tell us?

- Land Use
- Environmental Vulnerability
- Potential Hazards (Landslides, Erosion)
Process Outline:

- Gather Data
- Lit Review for Appropriate Model
- Analysis
- Conclusions
Data

- LiDAR/DEM/DTM at WADNR’s Lidar Portal: http://lidarportal.dnr.wa.gov/
- Trail, road, land use, and stream/river data from the Friends of the Columbia Gorge, U.S. Forest Service and Washington Trails Association
Identifying an Appropriate Model

Aleksandra M. Tomczyk

Fig. 4. Steps in the calculation of the environmental sensitivity model of Corse National Park.

Very simplified for my project

<table>
<thead>
<tr>
<th>Soil groups and their susceptibility to soil erosion</th>
<th>Slope (°)</th>
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<tbody>
<tr>
<td>Degree of potential water erosion hazard</td>
<td>0–3</td>
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<tr>
<td>Very high susceptibility: Loess and loess-like soils</td>
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<tr>
<td>High susceptibility: Loose sands, sands, gravelly sands</td>
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<tr>
<td>Average susceptibility: Weak sands, loamy sands, gravelly sands, loess, calcareous loess</td>
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<tr>
<td>Low susceptibility: Light loams, average loams, calcareous loams</td>
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</tr>
<tr>
<td>Very low susceptibility: Heavy loams, clays, rocky soils, heavy soils with non-calcareous skeleton, peats</td>
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Process Breakdown

1. Divide trail system into equal segments, rasterize
2. Calculate slope and flow accumulation calculation for study area
   a. Identify stream networks
3. Vulnerability Ranking
   a. Reclassify slope and soil type data
   b. “Combine” tool to get new values
4. Zonal statistics to find pour points
5. Watershed delineation
6. Zonal statistics to aggregate vulnerability ranking to watershed
7. Join zonal statistics table to trail data
# Vulnerability Ranking Step 1

## Reclassify Values

### Soil

- **Map unit symbol and name**
  - 1: Aridic Cryorthents, 5 to 65 percent slopes
  - 2: Aridic Cryorthents, 0 to 5 percent slopes
  - 3: Aridic Cryorthents, 6 to 15 percent slopes
  - 4: Aridic Cryorthents, 0 to 5 percent slopes
  - 5: Aridic Cryorthents, 6 to 15 percent slopes
  - 6: Aridic Cryorthents, 0 to 5 percent slopes
  - 7: Aridic Cryorthents, 6 to 15 percent slopes
  - 8: Aridic Cryorthents, 0 to 5 percent slopes
  - 9: Aridic Cryorthents, 6 to 15 percent slopes
  - 10: Aridic Cryorthents, 0 to 5 percent slopes
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  - 12: Aridic Cryorthents, 0 to 5 percent slopes
  - 13: Aridic Cryorthents, 6 to 15 percent slopes
  - 14: Aridic Cryorthents, 0 to 5 percent slopes
  - 15: Aridic Cryorthents, 6 to 15 percent slopes
  - 16: Aridic Cryorthents, 0 to 5 percent slopes
  - 17: Aridic Cryorthents, 6 to 15 percent slopes
  - 18: Aridic Cryorthents, 0 to 5 percent slopes
  - 19: Aridic Cryorthents, 6 to 15 percent slopes
  - 20: Aridic Cryorthents, 0 to 5 percent slopes

### Slope

**Slope Values**
- 0 - 3
- 3.0000000001 - 6
- 6.0000000001 - 10
- 10.0000000001 - 15
- 15.0000000001 - 20
- 20.0000000001 - 86.20941162

### Vulnerrability Score

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Vulnerability Ranking Step 2

Combine Tool

\[
\text{OutRas} = \text{Combine([InRas1, InRas2])}
\]
Vulnerability Map

Legend

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Erosion Vulnerability

Map created by Sanhi Akanuma
Data from Jacobs Mayer,
US Forest Service,
US Department of Agriculture
and the Washington Dept of Natural Resources
Delineate Watersheds Along Trail Complex
Zonal Statistics

Zone layer
- Defines the zones (shapes, values, and locations).

Value layer
- Contains the input values used in calculating the output for each zone.

Output
- The result of the statistic applied to the value input (Maximum in this example).

Example inputs and output from Zonal Statistics

Vulnerability Values Aggregated to Watersheds by Sum

Sum
Results
Results

Trails Most Vulnerable to Erosion:

1. Cedar Mountain to PCT Connect
2. Cedar Falls
3. Cedar to Hamilton Loop
4. West Aldrich Summit/Cedar Creek Access
5. Cedar/Hamilton Creek Confluence
6. East Aldrich
7. Proposed N. Bonneville to PCT Connection
Conclusion

- Several trails in the complex are vulnerable to erosion.
- Trails crossing creeks tended to be more vulnerable, but not exclusively.
- Results matched hazard areas that were pointed out during our focus group (ground truth)
Lessons Learned/Best Practices

1. Scope project conservatively
2. Chose model with discretion (ask an expert! ask two!)
3. Be aware of spatial resolution discrepancies
4. No analysis is complete without groundtruthing
Sources


Thanks to Bonneville Trails Foundation, Jake Meyer, Renee Tkach, and the community of North Bonneville.