Location Analysis for Single-Use Mountain Bike Trail

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Proposal

- Find a location for a new single-track mountain bike trail
- Create a trail that is properly designed so it will require minimal maintenance
- Does not interfere with existing recreation opportunities, wildlife, or environment
- Trail that is challenging but can be used by all different skill levels of riders
Forest Park

- Located in NW Portland
- 5161 Acres
- Established in 1947
- Third largest Urban Park in the U.S.
- 70 miles of hiking trails
- 30 miles of bike paths
- No single-track mountain bike trails.

Current Trail System and the Need for More

- Keeps mountain bikers off hiking trails
- Prevents the construction of “commando” trails
- Provides recreational opportunities to more people
Trail Criteria

- Average slope less than 15%
- Maximum trail slope of 30%
- Ideal building hill slope 0-50%, Secondary 50-70%
- Does not interfere with existing hiking trails.
- Avoids drainage paths

Trail building options

- Converting existing trails, opening them up to mountain bikes
- Non-GIS, drawing by hand and flagging-most commonly used.
- Least cost path analysis
- Alternative GIS design
Data Used

- RLIS-contours, hill-shade, streets
- LiDAR Data-DEM, slope, hill-shade
- Portland Parks and Recreation-park boundary, trails

ArcMap, Least Cost Path Analysis
Trail Metrics

Finding ways to describe a polyline.
Metrics-Basics

- Length
- Elevation Change
- Elevation Range

Metrics

Slope
Rise/Run

45° = 100% slope
How Do You Get Slope?

Easy...
Get slope from a DEM in Spatial Analyst>Surface>slope.
Convert trail to raster (trail,1; else, no data)
multiply trail raster against slope raster.
Raster attributes show min. max, std. dev, mean.

Hawth’s tools
(http://www.spataecology.com/htools/to oldesc.php)
Has line overlay on raster tool, eliminates time and space of making rasters of lines.
And it’s FREE!
Slope Metrics

But...

*Hillside* Slope and *Trail* slope are different things
Slope Metrics

Hillslope determines if you can build a trail or not- 0-50%, 50-70%.
Trail slope determines if people can ride it- 10% good, 15% max over 100’.

Trail Slope

- There is no tool for line slope.
- 3-D analyst can create a profile of a digitized line.
- Creates picture of $\Delta X$, $\Delta Y$.
- Can only compare visually.
Determining Trail Slope

- Export data from 3-D Analyst into excel
- Equation:
  \[ \frac{\text{abs}(Y_1 - Y_2)}{\text{abs}(X_1 - X_2)} \times 100 \]
- Gives cellular (cell by cell) percent slope of the line.

Determining Trail Slope

- Overcoming high trail slope is easy over 3’.
- A moving average over 33 cells gives average slope for a 99’ trail section.
- This tells us trail feasibility.
Standard Deviation tells us how varied the data are.

If average slope is 10%, with std. dev. Of 1, 95% of the trail has an average between 8-12%

Knowing elevation and desired slope can give a theoretical "zero variance" length.

Comparing this to the actual straight line distance can show how feasible a trail would be in a specified area.
Issues (with data)

- RLIS contours significantly different from contours created from DEM
- Attempt with Least Cost Path plotted a trail that didn’t adhere to IMBA standards
- Metrics of a fall line
  - On a cellular level
    - Where the trail starts
    - Where it ends
    - Trail angle in relation to aspect

Issues (with data cont.)

- Route optimization for a raster environment
- Underlying data doesn’t necessarily dictate the trail location
  - Steep slopes can be conquered with switchbacks
  - Some obstacles are hidden even in LiDAR data
**Issues (Data and Tools)**

- **Limitations of LiDAR**
  - Highly accurate but contains data that may not make sense
    - Elevation anomalies exist where the "rise over run" can show a 400% slope (this indicates a 20' rise over a 5' run – 100% slope is 45° angle)

- **Digitizing trails**
  - 3D Analyst couldn’t create a slope from an existing line
  - Trails had to be re-digitized to generate slope profiles
  - Digitizing in 3D Analyst is very unforgiving

**Issues (in Forest Park)**

- Forest Park is a difficult place for siting a trail because of
  - Steep slopes
  - High existing trail densities
    - South Park density – 0.001045
    - Middle Park density – 0.001847
    - North Park density – 0.001055
  - Urban park with high user density
  - Conflicts between park users

- **Actual park boundary**
  - Boundary is different depending on who you talk to
    - Josh Darling – Portland Parks and Rec
    - Parts that are incorporated park are actually private property
    - Area considered to be Forest Park is somewhat “fuzzy”
Conclusions

- A lot of factors to consider when choosing the location for a new trail
  - Trail that can be ridden both directions
  - Overall slope under 15%
  - Adequate space for trail
- Is this method of trail siting useful?
  - Accurate LiDAR data shows existing features that can be utilized in the new trail

Conclusions

- What would we do differently?
  - Study area choice
    - Forest Park has accurate data available
    - Terrain makes for difficult trail siting
    - Numerous existing trails, difficult to plot new trail without conflict
    - High user density in an urban park
  - Trail usage data
  - Actual park boundary
Average Slope: 9.81
Max Slope: 21.66
Elevation Range: 253.92
% of trail below 15% slope: 91.64
Conclusions

- Using LiDAR data of Forest Park
  - We were able to create two trails
    - One in the north western section of the park
    - A second crossing the middle section to the south eastern section
- Before a trail could be constructed
  - Ground truthing would be vital
  - Construction cost analysis

References

- Portland Parks and Recreation, www.portlandonline.com/parks
- Friends of Forest Park, www.friendsofforestpark.org/trails
- Chris Bernhardt, International Mountain Bike Association
- LiDAR Data; Kevin Martin, City of Portland
- Forest Park Data; Josh Darling, Portland Parks and Recreation
- RLIS Data, PSU; hill-shade, streets, contours
- Shimano American Corporation; Planning and Managing Environmentally Friendly Mountain Bike Trails. 2006