Terrain Based Probability Models for SAR
Executive Summary

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To read the full paper that is summarized here, please visit:
http://www.mra.org/member-services/grant-information/current-grants/terrain-models

Introduction

There has been work within the land SAR community to develop lost person behavior models based on factors such as expected travel distance, elevation change and dispersion angle. Comparatively little effort has gone into quantifying the effect of terrain, particularly in cases where small changes in position can have a disproportionate impact on the probability of a find. In order to further explore this area of research, I compared incidents from the International Search and Rescue Incident Database (ISRID) against a variety of geospatial data, including road, trail and stream locations, elevation data and vegetation coverage. Unlike most SAR research to date, find locations were examined independent of a subject's last known position or possible travel route.

75% of find locations studied came from Oregon, with the remainder from New York and Arizona. Additionally, most analysis was focused on backcountry incidents involving the ISRID hiker, hunter and gatherer groups. The applicability of these results to other locations, terrain types and subject categories remains an open question.

Feature	**Uninjured**	**Injured**
Roads	3x	1.5x
Trails	5x	7x
Lakes	2x	2x
Streams	2x	3.5x
Capillary Streams	–	1.5x
Stream / Trail Interfaces	7x	12x
Low Points	2x	5x
High Points	1.5x	2x
Ridges	2x	–
Drainges	1.5x	3x

Table 1: Probability multipliers for various terrain features. Road and trail probabilities in particular will be higher during on-feature hasty searches and lower when searching nearby.

Findings

Probably the most notable finding is that injured and uninjured subjects tend to be found in different locations. While this is likely due to a combination of greater injury rates in certain terrain and different behavior once injured, it is not possible to separate the two causes. Either way, the data presented here allows searches to employ a targeted mix of higher probability of detection (POD) searching in areas injured subjects are likely to be, and lower POD searching elsewhere.

While estimated terrain probabilities are provided in Table 1, these numbers are approximate. Among other factors, most features' probability:

- Decreases with track offset (distance from a feature)
- Increases with distance from the initial planning point (IPP)
- Increases with the vertical relief of the surrounding terrain

The results listed here provide some high probability quick wins. However, ultimately only 60%-80% of subjects are found on high points, low points, ridges, drainages or within 100m offsets from roads, trails and streams. While that initially sounds impressive, those features account for 45% of the search area (Figure 2).

These results also cast doubt on several commonly practiced search strategies:

- Transitioning directly from hasty to area searching. Over half of all injured subjects not found on a road or trail were found within 80m of a stream, at a low or high point, or in a drainage. At 20% of the search area, these features cannot all be hasty searched, but should still be prioritized over traditional area segments.
- High POD searching along roads and trails, but not natural features. While roads and trails should be hasty searched first, evidence supports giving streams and drainages equal weight to manmade features during focused high POD search activity.
- Large area assignments centered on a road and trail network. Linear features only had elevated probability to approximately 100m out; focusing on areas within 1/4 or 1/2 mile of roads and trails did not appear to be an effective strategy.

One recommendation for integrating these findings into established search management practices is to adapt the common bicycle wheel model into a spiderweb: dense searching at the core surrounded by a web of linear features, with several long-ranging stringers at the periphery. That general form can be maintained as the search expands; instead of distinct hasty and area search phases, a broader mix of targeted search tactics would remain deployed throughout an operation.

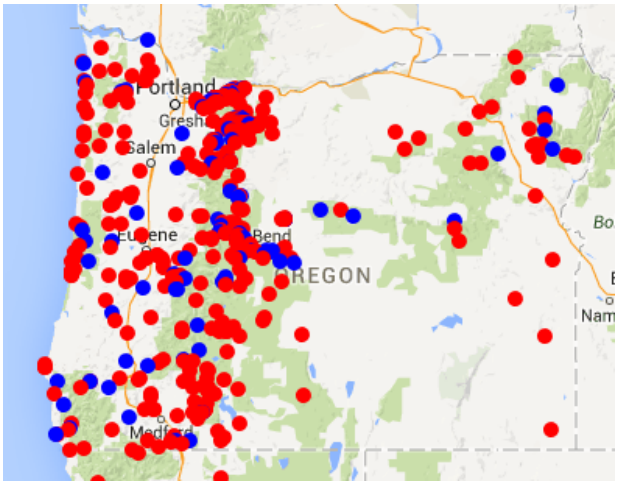

Figure 1: Locations of backcountry foot incidents in Oregon. Uninjured subjects are red, injured or deceased ones are blue. These incidents comprised the bulk of the data examined.

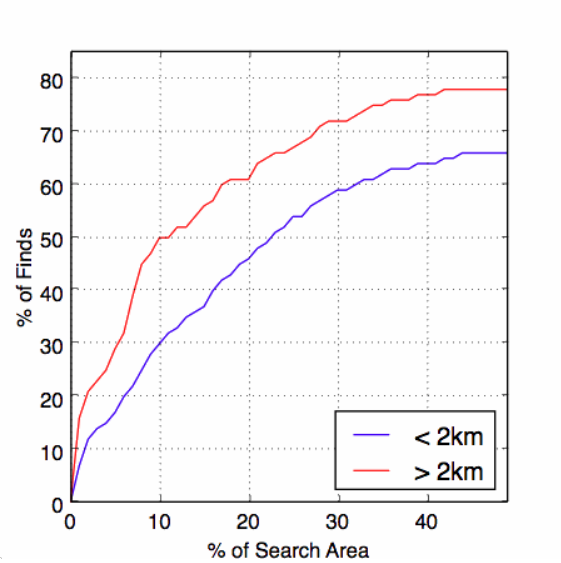

Figure 2: Terrain provides some high probability quick wins, but ultimately only 60%-80% of subjects are found in high/low points, ridges/drainages, or 100m from roads, trails or streams, at 45% of the total search area

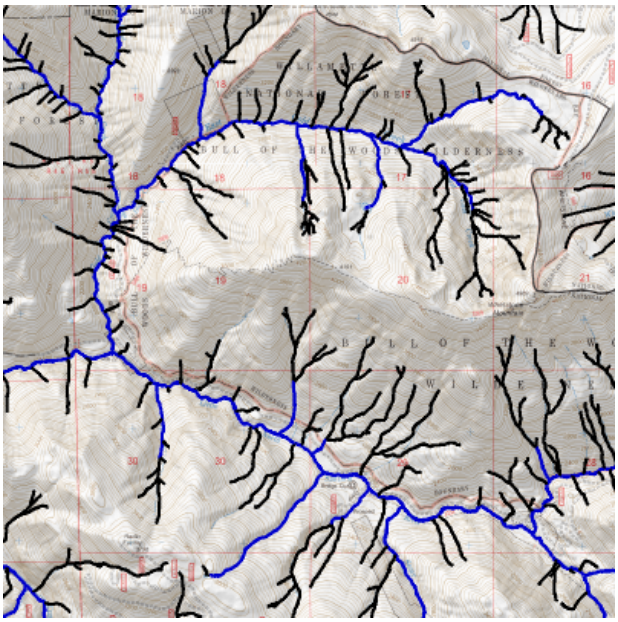

Figure 3: Example of higher PDEN streams (blue) and lower PDEN capillaries (black).

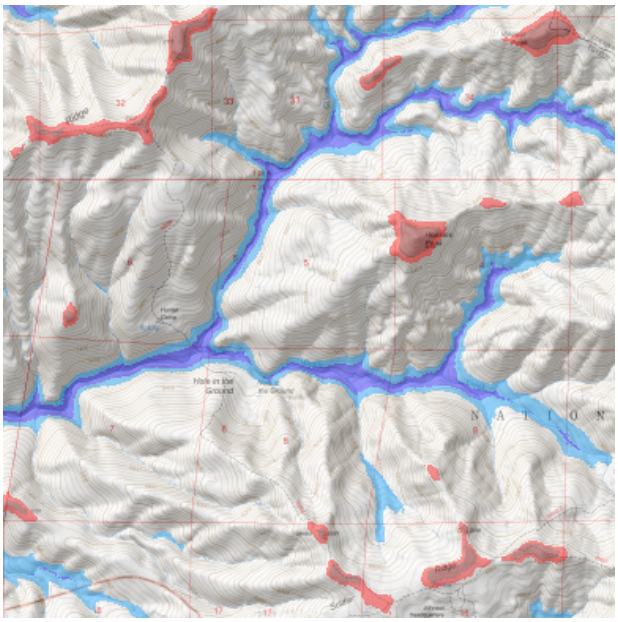

Figure 4: Example of low (blue) and high (red) points, in an area with well-defined canyons.