Sweep Width for Land Search

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Puzzles in WiSAR

Wilderness Search & Rescue (WiSAR) has been slow to use formal search theory; indeed there is some hostility. "Search theory isn't practical!" This is partly true – it takes work to apply theory to new domains.

However, there has been good work in the past decade, particularly in empirical measurements. WiSAR now has over two dozen measurements of *sweep width* – the key theoretical measure of detectability. But sweep width experiments take many man-hours to generate a measure for a single combination of environment and target. Consider that terrain and vegetation can change drastically several times in a kilometer, and it is clear that we must find some approximation.

There is a fast approximation known variously as "critical separation", "detection range", and most precisely, "average maximum detection range". We show empirically that it is strongly correlated with sweep width – a result that generated several **puzzles**:

- Why do the sweep widths appear to be 1-2 times the quickly-measured (average) maximum detection range for an *alerted* searcher?
- What is "average maximum detection range (AMDR)" anyway?
- Can we use AMDR to estimate sweep width? When? How?
- What is the proper lateral range curve for a ground searcher looking for standard targets in canonical wilderness environments?
- What sweep widths should we use in these settings?

We begin to answer these puzzles.

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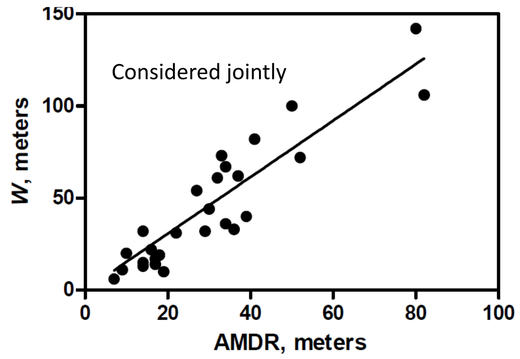
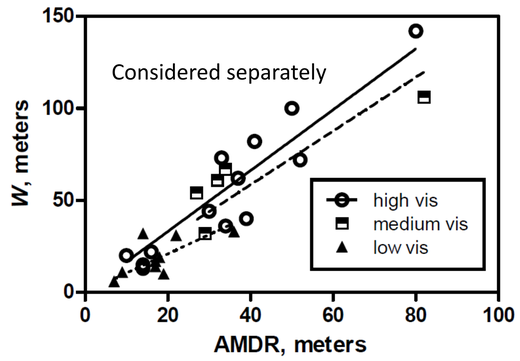
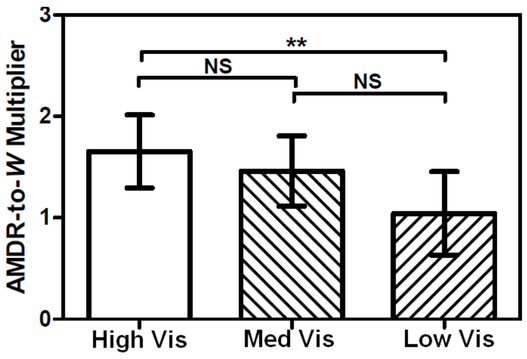
Sweep Width & Detect Range

The first two charts show the correlation between measured sweep width *W* and the average detection range (AMDR, or *r*) sampled from 8 points around the compass, in 27 WiSAR sweep width experiments. The third chart suggests that high-vis and low-vis targets form separate groups.







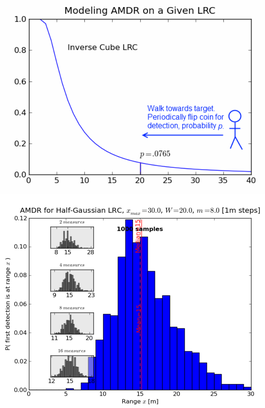
Modeling AMDR

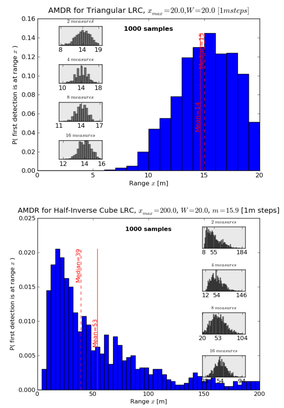
The previous column suggests we can use AMDR as a quick proxy for sweep width. But why? AMDR is for an alerted *searcher*, and sweep width measures real-world (fatigued) detection performance. How can we explain the correlation?

We model the maximum detection range, as a stochastic detection process with an assumed Lateral Range Curve. The model generates a distribution of maximum detection range. Then AMDR is the average of *n* measurements, usually *n*=8.

In the following figures we abbreviate AMDR as "*r*" for range. We depict the model, and show results for Triangular, Gaussian, and Inverse Cube lateral range curves.

Modeling AMDR (aka *r*)





We summarize the result in a table (LRC is Lateral Range Curve, *W* is sweep width, *r* is AMDR):

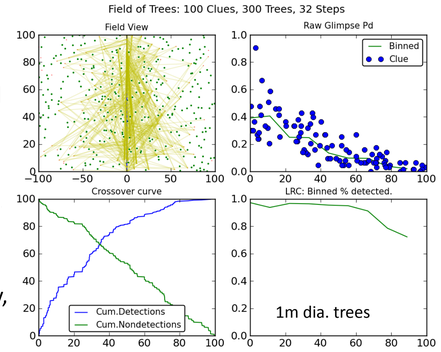
LRC	W	r	Result
Cookie Cutter	20m	10m	$W = 2 \times r$
Triangular	20m	14m	$W \approx 1.4 \times r$
Gaussian	20m	15m	$W \approx 1.4 \times r$
Inverse Cube	20m	55m	$W \approx 0.4 \times r$

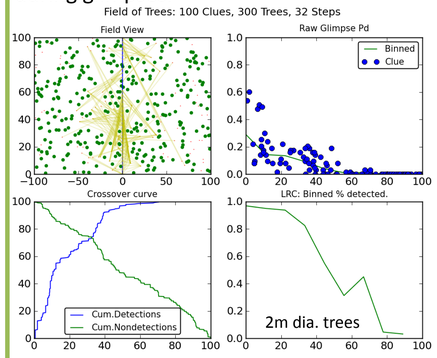
So:

- Field data (left) suggest
- Stochastic simulations of mean detection range (above) appear to rule out Inverse Cube [and other long-tail distributions.]
- Data appear favor **thin tails** and **convex curves**.

Simulating the LRC

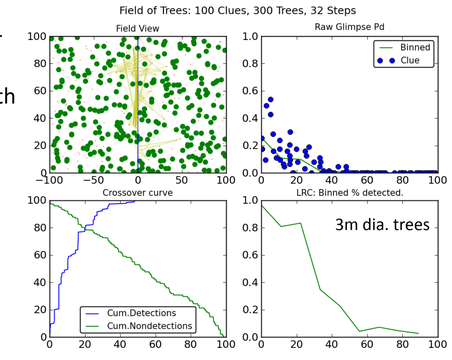
We simulate sweep width experiments (and visual search) by scattering clues in a field of trees, and having the searcher walk down the centerline making periodic **glimpses**. So far the model is highly idealized – no visual extinction, perfect acuity, and perfect attention during glimpses.





Each quad-chart shows the field with detections, a histogram-based count of glimpse detection, the "crossover" point between cumulative detections and cumulative non-detections, and a histogram-based **Lateral Range Curve** (LRC).

As the trees get larger the LRC moves from **nearly cookie cutter** with skinny trees to **nearly triangular** (Gaussian?) for 3m.



So: we have strong preliminary results and need to follow up with designed tests.

References

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