# A Tool to Estimate Potential Sample Volume and Density per Altitude Band for Avian Radar

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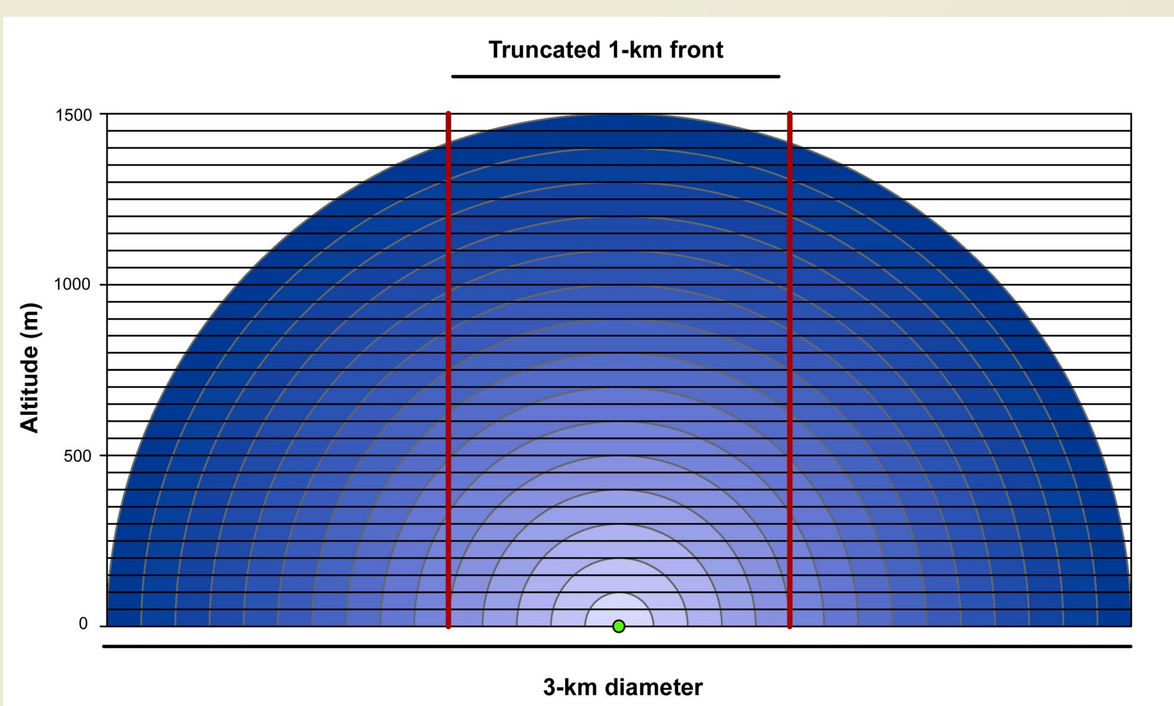
As a means of standardization, avian radar studies often report target counts as the number of targets per 1-km front. We are aware of two methods to calculate this metric:

1) the "**truncated**" method, cuts the sampled space at 500 m on both sides of the radar unit;
2) the "**mean**" method, divides the total number of targets by the diameter of the surveyed semi-circle.



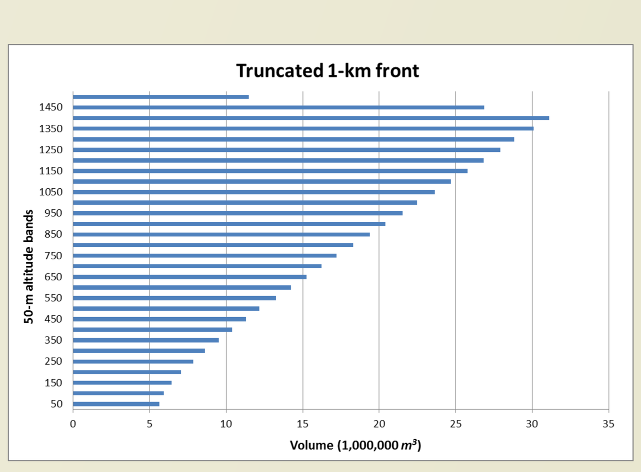

These approaches may be problematic because:

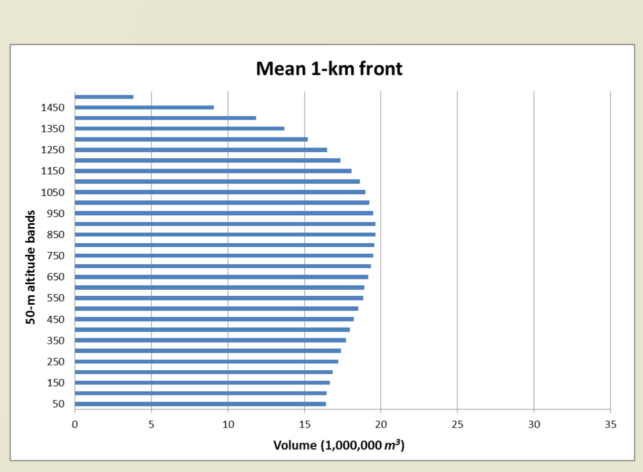
- the radar beam expands as it travels away from the unit —resulting in greater sample volume with distance, and;
- the energy available to detect targets is dispersed with distance, thereby reducing the probability of detection(Schmaljohan et al. 2008[1]).

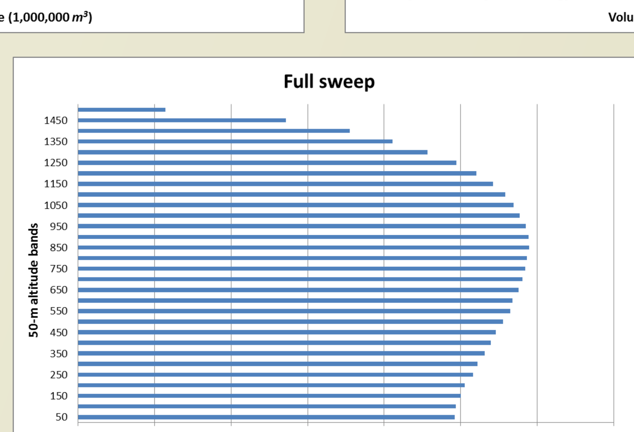
Given these issues, we developed a model as a first order correction and applied it to data collected in 2011. We used this information to compare altitude profiles, density estimates, and examine the effect of signal attenuation with distance.

## Volume per Altitude Band and the 1-km Front

The two methods of calculating a 1-km front result in different distributions of sample space among altitude bands and are compared to a full sweep of the radar beam.



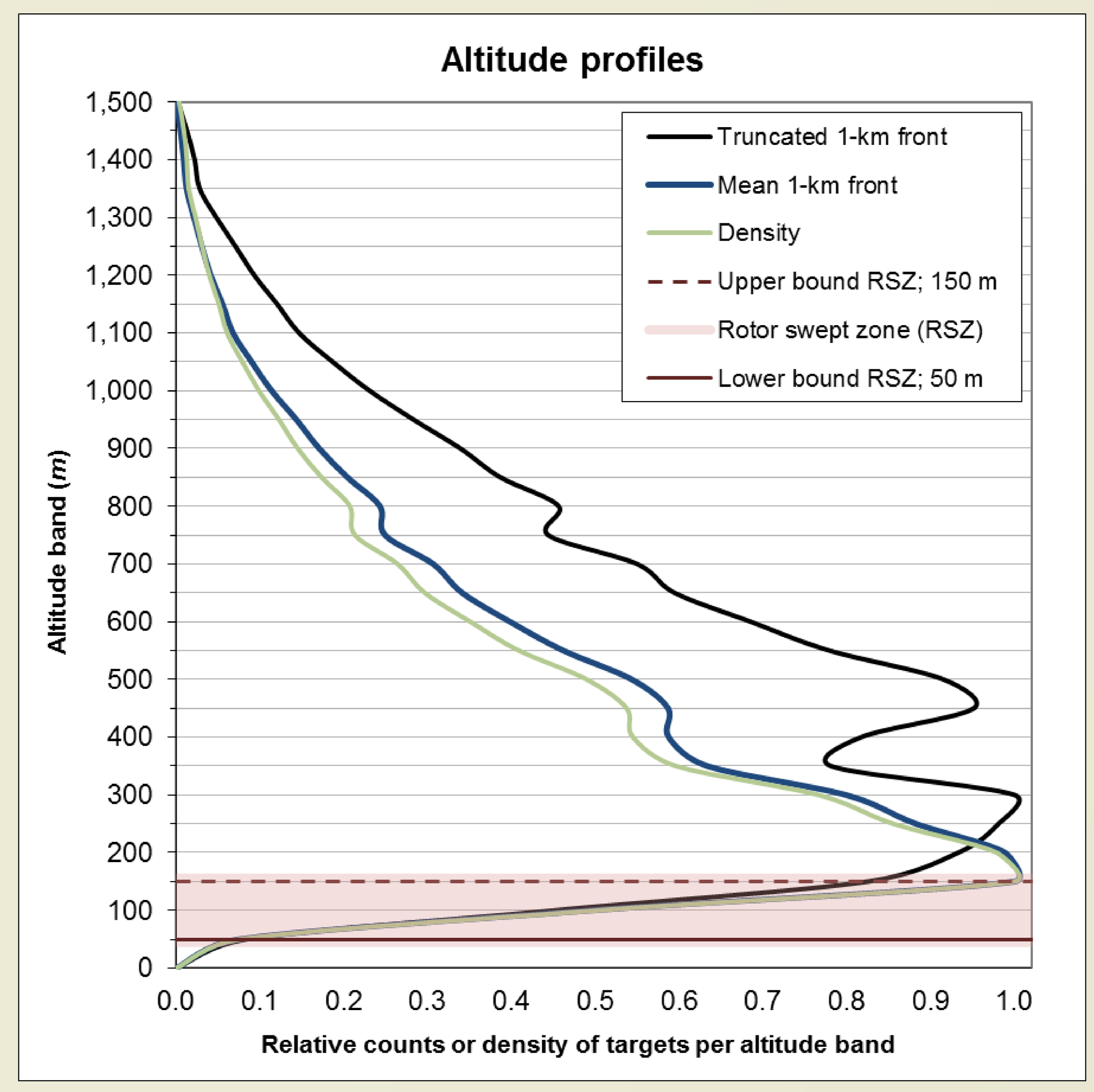



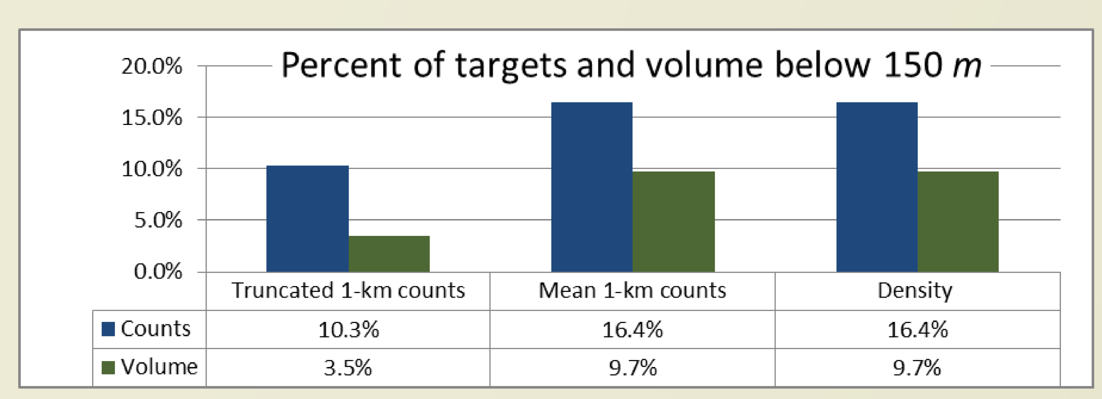




Schmaljohann, H., F. Liechti, E. Baechler, T. Steuri, and B. Bruderer. 2008. Quantification of bird migration by radar - a detection probability problem. Ibis 150:342-355.

## Altitude Bias

The distribution of volume among altitude bands for the **truncated** 1-km front results in an upward bias in the band with the maximum number of targets. In the below figure, a value of 1 indicates where the maximum occurred.

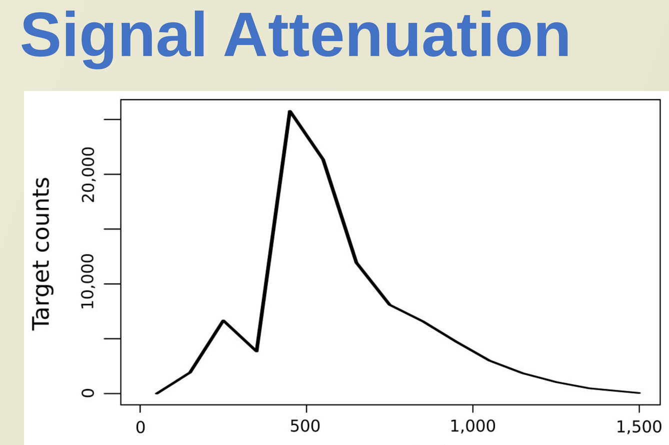


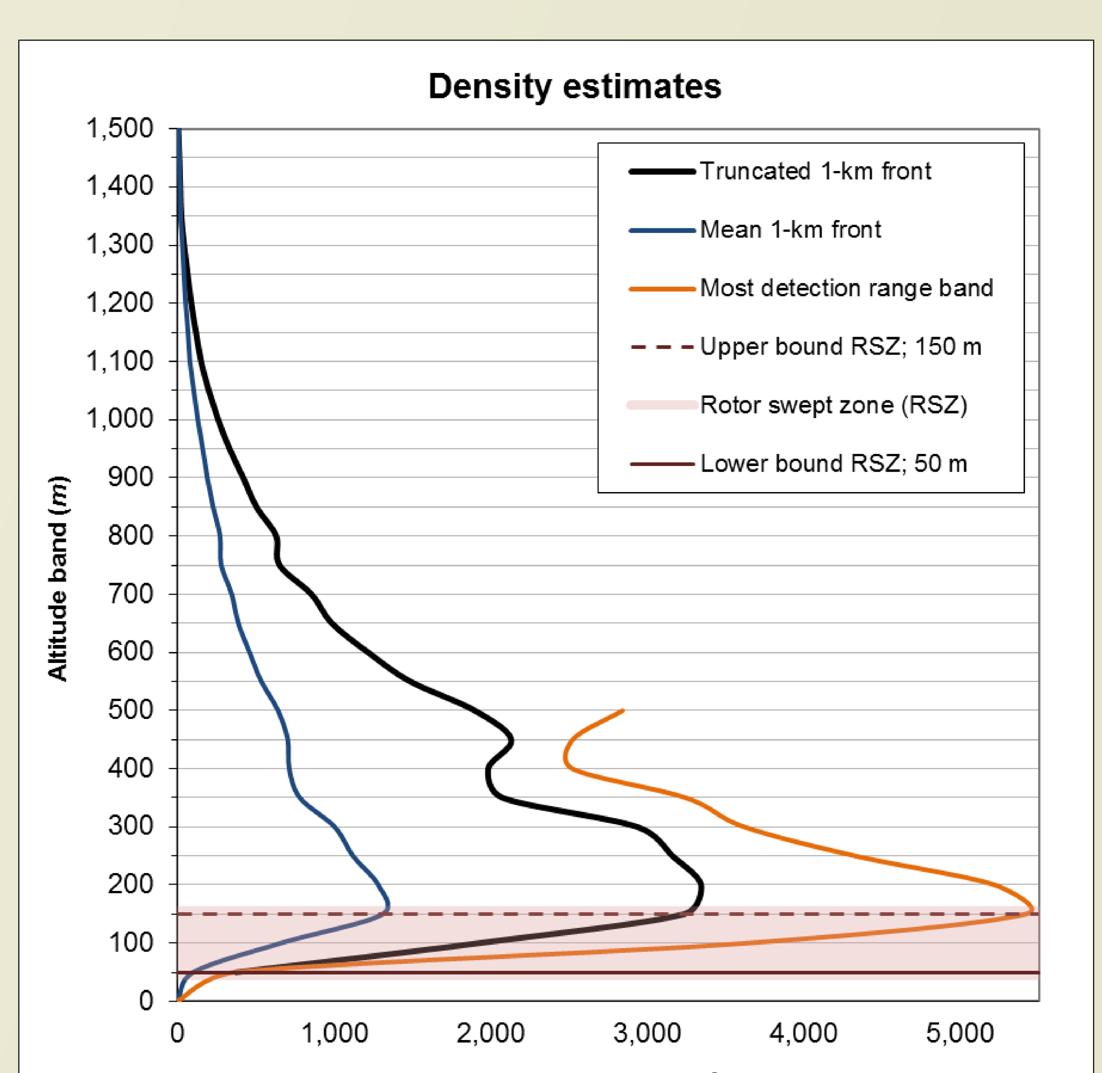

| | Truncated 1-km counts | Mean 1-km counts | Density |
|---|---|---|---|
| Counts | 10.3% | 16.4% | 16.4% |
| Volume | 3.5% | 9.7% | 9.7% |

## Density Estimation and Signal Attenuation

Not all range bands are created equal. Signal attenuation likely contributes to reduced counts with range.

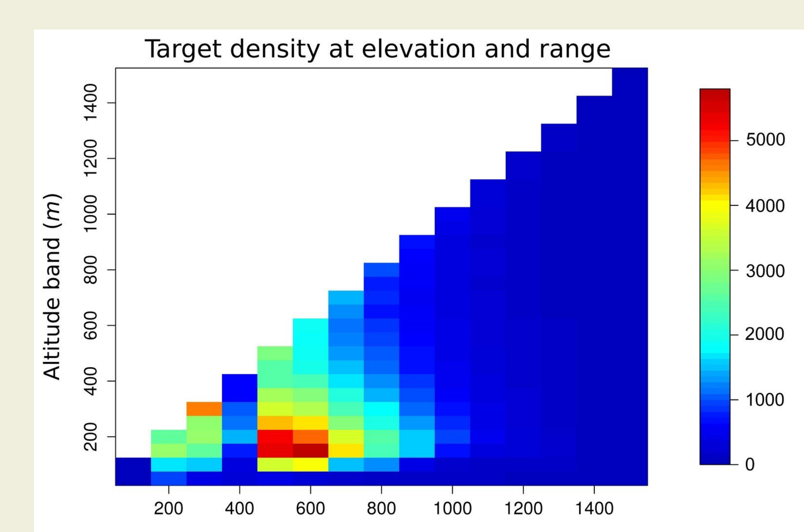



The two 1-km front methods resulted in different density estimates. Selecting a single range band limits the effect of signal attenuation and a band can be chosen to avoid other detection issues such as side lobes.




## Key Findings

- The **truncated** method resulted in a biased estimator.
- The **mean** method resulted in a low density estimate—likely due to incorporating range bands with signal attenuation.
- The 3-dimensional approximation of sample space is closer to truth than the 2-dimensional 1-km front metric.
- This tool allows flexibility to account for signal attenuation and improve density estimates.
- Our 500 m range band likely provided the best estimate of density because errors were held constant while the strength of the signal was strong.
- This tool showed where we had the most detection and how a side lobe at 400 m affected counts (see figure below).




## Model Development

The volume swept by avian radar depends , in part, on the opening angle of the radar beam and the radar's maximum range of detection. To estimate total survey volume we integrated a pie-slice shaped area, defined by the maximum range and opening angle, from horizon to horizon using R software. Calculating the volume contained within altitude bands is more complex. Therefore, we used Monte Carlo integration to estimate the volume of these bands. This tool will be publicly available soon.

Contact me: timothy_bowden@fws.gov with questions or requests