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ORIGINAL RESEARCH

Deriving Effective Sweep Width for Air-scent Dog Teams

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Objective.—We sought to obtain the first effective sweep widths (ESWs) ever measured for an air-scent search dog unit to compare their performance to historical data from human searchers and to initially test the validity of atmospheric convection as a limiting factor in air-scent search.

Methods.—We used GPS tracks and waypoints to measure lateral hit and miss distances for the dog teams during blinded, randomized training tasks during a 6-year period, calculating ESW using the crossover method. During the tasks we collected weather data for determining convection. We used nonparametric statistics and least-square regression to compare the dog ESW data with historical human data and weather conditions.

Results.—The mean value of ESW for the 4 teams under all conditions was 95 m (95% CI, 44 to 145). The dog teams' performance was statistically superior to human visual searchers in detecting search subjects in low-visibility colors, but not subjects in high-visibility colors. A nonparametric correlation test of ESW vs convection gave $P < .05$, suggesting that convection may be an operationally significant factor in air-scent dog performance.

Conclusions.—The ESW methodology is applicable to air-scent dog teams, potentially allowing search managers to make decisions in applying resources operationally, as well as improving accuracy of planning calculations. In addition, the methods described appear to be capable, given more widely representative data, of making valid statistical comparisons between different search modalities and weather and other factors.

Key words: SAR, dog, probability of detection, sweep width

Introduction

The typical lost-person search must use limited resources in a triaged manner, applying search efforts to segments of the potential search area that the search management team estimates are most likely to contain the search subject. (A search segment is a subarea of a larger search assigned to a single modality to search in a single task.) Search efforts throughout the duration of an incident may leave some segments unsearched, in an attempt to maximize the overall probability of success (POS) for the search effort using Bayesian logic.[1,2]

Standard-of-practice methods for search-and-rescue (SAR) management attempt to optimize overall POS via the following equation[1,2]:

$$\text{OverallPOS} = \Sigma(\text{POC} \times \text{POD})$$

POC, the probability of containment, is the probability that the subject is present in a given segment of the overall search area. POD, or probability of detection, is the probability that the search modality used in that segment will detect the subject under the given relevant environmental and other conditions.[1,2] The POC $\times$ POD calculation is performed for every search segment, then summed to find the overall POS for the entire search area.

A major weak link in the overall POS chain is determination of POD. Most ground searches in North America continue to rely on estimated PODs from search team leaders, a method that is subject to great inaccuracy.[3,4] To address this problem, Frost, Koester, and others have adapted the effective sweep width (ESW) methodology from earlier military practice to ground SAR (GSAR) use.[3,4] The method produces a distance-scaled parameter, ESW, which multiplied by search effort (sum of the distance moved through the search segment by each search modality used) and divided by the size of the area searched gives a coverage value (C). Coverage, in turn, allows calculation of objective PODs via a negative exponential function.[2]

The ESW methodology promises a significant advancement in determination of accurate PODs for

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gauging the efficacy of previous search efforts and for planning future search efforts to maximize overall POS. However, its adoption has been slow. Among a number of reasons may be that most search incidents are brought to a conclusion rapidly, and so do not require formal overall POS-based search planning. Another is that to date no sweep-width data have been obtained for air-scent dog teams, a major search resource in many parts of the United States.

In this study, we obtain sweep-width values for 4 air-scent dog-and-handler teams in western Pennsylvania, comparing their performance with data from our earlier study of human searchers in some of the same terrain.[5] We demonstrate how seasons and subject clothing color change the relative strengths of these 2 important search modalities, shedding light on resource utilization in reflex searches as well as those that have not yet progressed to mathematical planning.[6] We also suggest how local atmospheric convection conditions may affect air-scent dog performance.

Unlike the possibly better-known trailing dogs that follow scent on the ground, air-scent dog teams find search subjects by detecting airborne scent from downwind of the subject. The idea is for the handler to move the dog, who is operating off-leash, across the wind, such that the dog detects the subject and moves in to find him or her, then signals the handler (Figure 1). A number of tactics may be used to achieve a crosswind path: straight-line grids starting at the downwind edge of a more or less level area; moving along with contour lines to take advantage of daytime updrafts or nighttime downdrafts; or a search beginning with the perimeter of the area, subsequently bisecting it based on the handler's subjective opinion of whether and where the dog is detecting scent.[7] Our methods are applicable to any of these tactics. In this study, we allowed the handlers to choose their own path and tactics based on local wind and terrain as they do in actual searches, so that the results would be operationally relevant.

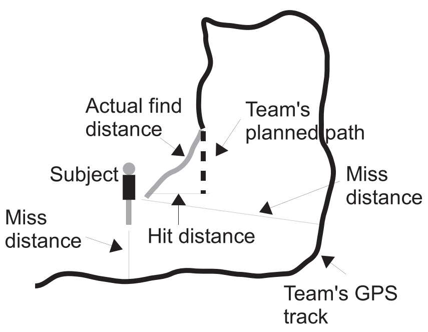

Figure 1. Schematic representation of air-scent task/scoring detection opportunities. Note path of team is arbitrary, for illustration only.

A robust literature supports the idea that turbulence is a major limiting factor in olfactory search in a number of species and media, being the major source of dilution of scent signals at the scale of macroscopic organisms.[8–10] Convective turbulence—turbulence caused by the sun heating the ground, with the air in contact with the ground warming and subsequently rising, thus breaking up plumes of scent or other atmospheric contaminants—is a major contributor to atmospheric turbulence in daytime conditions such as those in which we measured air-scent dog performance. Previously, Graham[11] used field calculation methods developed for the US Forest Service[12,13] to measure the effect of convection on air-scent dog performance at fixed detection distances. Although this report suggested that convection was a major limiting factor in air-scent dog performance, it did not include statistical analysis and did not appear in a peer-reviewed journal. Because these tables are in operational use in some quarters and the literature strongly supports that convection will be important, we designed our data collection to include the weather observations necessary to make an initial test of Graham's hypothesis.

Methods

The GSAR model for determining ESW, in which a relatively large number of searchers walk through an arbitrary course set by the course designers, is not practical for air-scent SAR dog teams:

1. It would not allow the handlers to use tactics to work the terrain and wind for scent transport, possibly degrading the dog's search efficacy.
2. It would require an unwieldy number of human search subjects, as unlike human searchers, dogs cannot be realistically tested against mannequins of similar size and shape to humans.
3. Acquiring enough operational air-scent dog teams to obtain useful results in a single experiment is likely to be a major challenge.
4. The limited weather sampled in a single experiment would likely result in limited application for the results.

We addressed these issues by returning to the earlier methodology[14] in which the known position of the search object (in our case, a live human) is compared with the measured track of the detector—in the earlier study, aircraft tracked via microwave radar; in ours, the track of the handler was measured by GPS (see Figure 1). We calculated all ESWs via the crossover method.[1,2]

We collected data at 107 daytime tasks recorded at regularly scheduled training sessions during a period from June 27, 2004, to March 27, 2010, thus sampling