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It is being supported by the in-kind work and contributions of the Editorial Board. There is still the need for a dedicated journal serving those with a direct interest in all disciplines of search and rescue including: rope rescue, water (flat, swift and marine), ice rescue, wilderness search and rescue, structural collapse rescue, trench collapse rescue, cave rescue, dive rescue, motor vehicle extrication, canine search, technical animal rescue, air rescue, search theory, search management, and mines rescue. JSAR exists to fulfil that need.

Article submissions from these and other SAR disciplines are welcome. Launching this journal on the internet offers a relatively cost-effective means of sharing this invaluable content. It affords the prompt publication of articles and the dissemination of information to those with an interest in SAR.

JSAR will provide a forum for the publication of original research, reviews and commentaries which will consolidate and expand the theoretical and professional basis of the area. The Journal is interested in theoretical, strategic, tactical, operational and technical matters.

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Editorial

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Welcome to the June 2025 edition of the *Journal of Search and Rescue*. It is with sincere gratitude and humility that I write this inaugural editorial, having recently joined the editorial board. To be invited to serve in this capacity is both an honour and a privilege, and I take this opportunity with a strong sense of commitment to the values, purpose, and community that this journal represents.

For many of us involved in Search and Rescue, the work is not merely technical or operational; it is profoundly human. It demands decisiveness, collaboration, and resilience under pressure. Contributing to the academic foundations that support such work is not simply an intellectual pursuit—it is a practical necessity. The journal's role in advancing that foundation remains vital, helping to shape approaches that improve safety, efficiency, and preparedness across the sector.

We meet this mid-year edition at a time of significant global complexity. Geopolitical tensions, mass displacement, and humanitarian emergencies continue to rise in frequency and severity. Compounding these are a growing number of large-scale transportation incidents—across aviation, maritime, and terrestrial contexts—which present logistical, environmental, and interagency coordination challenges of increasing scale. These realities underscore the need for SAR systems that are not only informed by sound research but supported by robust operational capabilities.

In this environment, it is essential to remember that effective search and rescue is grounded not only in academic insight, but also in professional knowledge, realistic training, operational competence, and the readiness to respond with clarity and assurance. Evidence and experience must inform one another—this is where real progress occurs. The strength of SAR lies in its blend of scientific rigour and situational adaptability, and it is in this intersection that the journal continues to play a pivotal role.

As a long-time follower of this publication, and now as an editor, I am continually inspired by the breadth and quality of insight shared in its pages. It is a reminder that no single discipline, organisation, or nation holds all the solutions—but by fostering a spirit of shared learning, we continually move closer to excellence in practice.

The *Journal of Search and Rescue* remains a vital space for scholarship, dialogue, and innovation. My hope is that it will continue to serve as a forum where research translates into action, where voices from across disciplines are heard, and where the collective knowledge of this global community can be harnessed to meet the evolving demands of the field.

To all who have contributed, reviewed, and supported this journal—thank you. It is your dedication and expertise that sustain this platform. I look forward to working with you and learning from you as we move forward together.

Stay safe, stand ready—and thank you for all that you do.

Dr Alun Newsome, Editor

Head, Belt, Boots: Obtaining Consistent Probability of Detection in Human Visual Search

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Abstract

A key lost-person search method is the "grid team," a line of searchers moving abreast through the woods. The optimum spacing for such searchers is not clear, however. We have determined the spacing necessary for searchers to see their immediate neighbors' head, belt, or boots at sites in West Virginia in the summer and in Pennsylvania in the summer and winter. An analysis of the probabilities of detection (PODs) expected from previously or newly measured effective sweep width (*W*) values in those locations for each of these spacings suggests that each offers a consistent and useful POD for a given search object that does not appear to be affected by location or season by an operationally significant amount.

KEYWORDS: SAR, effective sweep width, probability of detection, search theory

Literature Review

In lost person search, limited staffing makes balancing speed with thoroughness an imperative. Despite profound advances in our ability to predict the behavior of missing people in the woods (Koester RJ, 2008), we still must prioritize search efforts geographically via the educated guess of extrapolating from past search subjects' behavior. If we knew a given area contained a missing person, then no probability of detection (POD), no thoroughness of effort, would be wasted. But searching a given area with the metaphorical fine-toothed comb does a search subject no good if they aren't there.

Using the Bayesian equation:

1. POS = POA X POD

we achieve success (probability of success, POS) by maximizing our ability to search the correct area (probability of area, POA) as well as our ability to detect the subject (POD) (Koopman BO, 1980). These factors mean that, when we search a segment (an area searchable by a single modality within a 6-hour operational period or less) we must achieve a high enough POD so that its POA after we are done has been lowered significantly. Significance in this case meaning that another segment in our larger search area now has a higher POA and priority. But this must be done without searching so slowly that we linger too long in an empty area.

A workhorse search technique in ground search and rescue is the "open grid team," sometimes called a sweep search team. In this method, a group of (very) roughly 6 searchers array themselves in a line abreast, with a fairly large distance between each. They then move forward, maintaining that spacing as they search. Often the team will need to pivot and repeat several times to cover an assigned search segment (NASAR, 2018).

While open-grid search has proved successful in many deployments around the world, optimal spacing between the individual searchers is tricky to derive. A longer distance spreads the team out and enables them to search areas more quickly; a shorter distance produces a higher POD at the cost of taking longer to cover a given segment. How to balance these is a microcosm of the need to balance speed and thoroughness in a larger sense.

Search managers and field team leaders have used several methods for spacing searchers in a grid team to try to achieve a predictable POD prospectively. In recent years the effective sweep width method has grown to become the gold standard for calculating POD, with multiple reports demonstrating how it produces accurate PODs in field conditions (Koester RJ et al. 2004, Koester RJ 2020, Chiacchia et al. 2023). It relates effective sweep width, or *W*, a distance-labeled parameter, to POD via a mathematical model (Koopman BO, 1980).

While more than one mathematical model has been used to convert spacing via effective sweep width to POD, arguably the most common is the "random search" model, a conservative (i.e., tending to underestimate POD in the absence of corrected *W* values — see Chiacchia et al. 2023) model based on the idea that a searching modality will move through the terrain with a random navigational error:

2. $POD = 1 - e^{-C}$

Where C, or coverage, is:

3. $C = nW/A$

Where n is the number of detectors in a given search effort; *W* the effective sweep width for that type of detector, search object, and environmental conditions; and A is the size of the area being searched.

For a grid team, equation 3 can be simplified to:

4. $C = W/G$

Where G is the grid width — the distance between each pair of searchers in the team, given a single pass of the team through the search area. The issue, then, becomes one of selecting and maintaining a value for G that produces the desired C and POD.

One method for spacing teammates is to effectively ignore prospective POD and simply choose a spacing that minimally trained searchers can maintain. This method is to space searchers to keep each other "within sight." It is relatively easy to use but is not well defined, and so does not provide a consistent distance, let alone a predictable balance between speed and thoroughness. (We should note that in any case adjacent searchers remaining visible to each other is critical, as once one's neighbor moves out of visual range there is no way to determine how big the gap has become and significant command and control issues over the search team arise.)

Another method, called "critical separation," involves placing an object in the area to be searched (or a nearby area representative of it), with the searchers taking positions on opposite sides of the object, moving toward and away until they just lose/regain sight of it in a process sometimes referred to as a "Northumberland rain dance." They then look up to the searcher across from them; that distance is the critical separation to be used to space the team members (Perkins and Roberts 1989). While a practical method for spacing searchers at a useful distance, critical separation suffers from limitations as well. For one thing, the relationship between the object used for the separation exercise and the search object (which may be any number of clues generated by the lost person or the lost person themselves) means that the POD achieved with this method is typically not predictable (Chiacchia 2020). Perhaps more importantly, the method requires searchers to memorize the distance to the searcher opposite them and maintain that distance while moving through uneven terrain and vegetation, all the while searching visually. The difficulty of maintaining any arbitrary spacing can produce errors in POD of 25% or higher (Perkins 2018).

The effective sweep width method enables us to obtain objective probabilities of detection within a specific distance around the detector's path (Koopman 1980, Koester et al. 2004, Koester 2020, Chiacchia and Houlahan 2023). Arguably the most common method for achieving this, as taught in the Fundamentals of Search and Rescue course (NASAR 2018), is to space searchers based on measurement of detection radius (Rd) in a method similar to the rain dance above. Rd is the mean distance at which the desired search object can just be seen by searchers cued as to its location (Koester et al. 2004). As *W* has a roughly linear relationship with Rd (Koester et al. 2014), this method does not require advance knowledge of *W*, which unlike Rd requires many searchers and multiple days of setup, conducting, and tear-down to measure (Koester et al. 2004).

There are disadvantages to the Rd method, however. It relies on an estimated *W* value, whose accuracy depends on the color of the search object (Koester et al. 2014). Also, placing searchers at such an otherwise arbitrary distance again poses the issue of having to measure that distance, as well as to memorize and maintain it while searching. As with the rain dance, this can be difficult in practice (Perkins 2018).

When *W* values are known, effective sweep width may also be directly used to determine spacing. Given a desired POD and measured *W* values for a given search object and environment, we can use this method to calculate the spacing necessary to achieve that POD. While likely producing the most accurate PODs in theory, this method once again requires maintaining a memorized distance while searching, which undermines that accuracy.

Another method, "head, belt, boots," is worth considering. In this technique, each searcher spaces so that their neighboring searchers' heads are just visible through the vegetation and terrain, their belts are just visible, or their boots are just visible. The searchers then maintain spacing in a dynamic way, moving closer together or farther apart to keep the head, belt, or boots target just in sight. Note that heads, belts, boots differs from "keep in sight" described above because in each case searchers are using a specific target on the next searcher over rather than a vague directive of keeping that person more or less in sight, and so offers the possibility of far more consistent spacing.

While still requiring attention on spacing while searching, heads, belts, boots does not necessitate memorizing an arbitrary distance. The required spacing can be instantly recognized and adjusted. Moreover, as one end of an open grid line is typically anchored to a path — a trail or creek or ridge-top that defines the edge of the search segment, or a flag line laid down at the teams' previous pass through the area — typically the team can "dress left" or "dress right," with each member only maintaining spacing with the single teammate in the direction of that anchor line, effectively halving the attentional effort to maintain the line.

The head, belt, boots method offers another potential benefit, stemming from other search-relevant measurements. *W* values have a roughly linear relationship with Rd (Koester et al. 2004 and 2014) in a method similar to the Northumberland rain dance. This relationship, which relates the distance at which one can spot an object when its location is known (Rd) with the distance at which it is likely to be detected when a searcher does not know where to look for it (*W*), makes intuitive sense. But it was not predicted by search theory and needed to be demonstrated empirically (Koester et al. 2014).

Given that the distance for spotting a known object has a relatively simple relationship to its *W*, does it follow that the distance for seeing a neighboring searcher's head, belt, or boots is also proportional to *W*? And if so, does that mean that spacing searchers at head, belt, or boots distances produces a consistent POD across different environments? In this report, we measure head, belt, and boots distances for two locations — State Game Lands Number 203 in Wexford, Pennsylvania, USA, and Snake Hill Wildlife Management Area, Morgantown, West Virginia, USA — and, using *W* values previously measured for the former (Chiacchia and Houlahan 2010 and 2023) and newly measured for the latter, compare the predicted POD values for spacing searchers at either the head, belt, or boots distances for two search objects in summer and winter.

Methods

We conducted the human visual sweep width exercise in the Snake Hill Wildlife Management Area in the manner of Koester RJ et al., 2004, with modifications previously described (Chiacchia and Houlahan 2010), using the IDEA Microsoft Excel worksheet provided by R. Koester and N. Guerra to automatically generate a randomized plan for a sweep-width course that followed extant trails. We calibrated the course with Rd values obtained at one random location, 17S PD 00646 85942 (US National Grid). Note we had randomized a second location for Rd determination as well, at 17S PD 00254 86576, but upon arriving at that location discovered it was a vertical drop that would not have been safe to perform the measurements in. Rather than move a randomized location, we elected to rely on the values obtained only at the former coordinates.

The course that we chose was above and intentionally avoided an elevation of roughly 550 to 600 m, where the rhododendron (aptly named *Rhododendron maximum*) grows as a solid mass and profoundly impedes both movement and visibility. While sweep width values for this environment would be interesting, the values would clearly be low enough, and movement through the environment difficult enough, to make grid search impractical. Moreover, a course that included both heavy rhododendron and more open woods would in effect be two sweep width courses, necessitating separate analysis of the two environments and splitting of data, leading to weaker statistical comparisons. Our course as laid out between an elevation of 600 and 650 m (See Fig. 1) therefore had a mix of open largely deciduous woods, woods with heavy undergrowth including greenbrier, and some patchy but not continuous rhododendron, and is more representative of areas in which we would task traditional grid searchers.

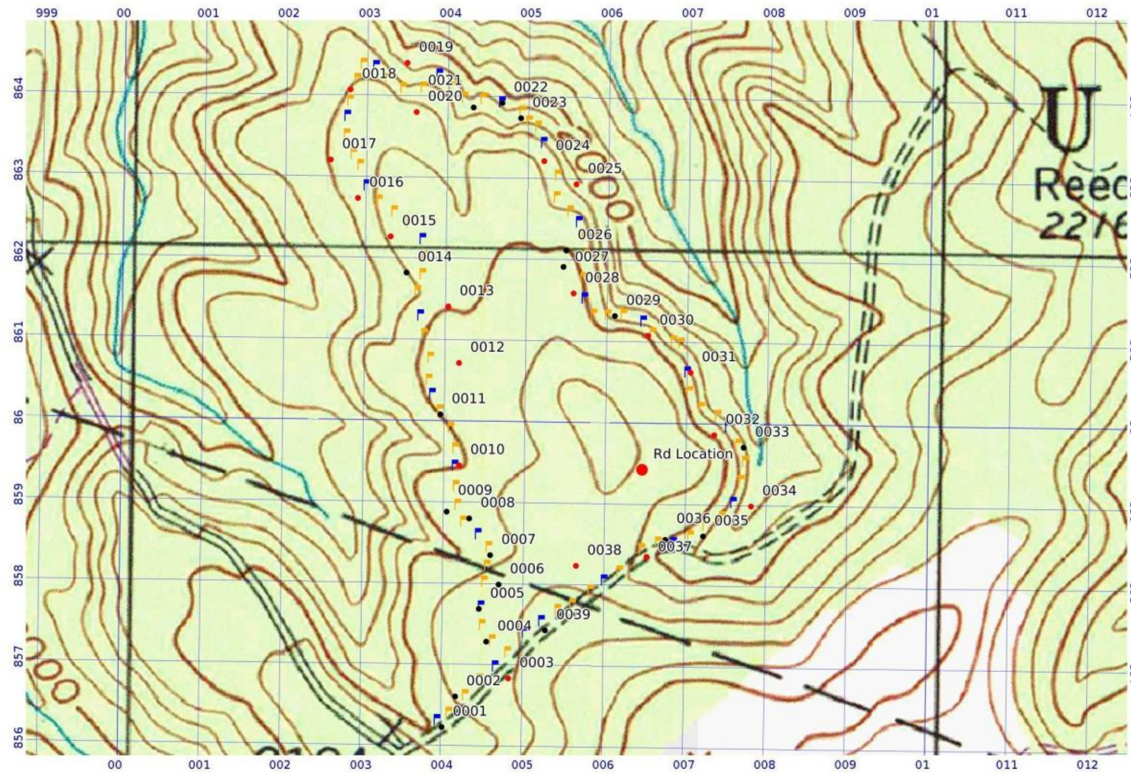
We placed the following search objects in the positions generated by the IDEA worksheet, using the methods of Koester et al. 2004:

- 19 high-visibility adult mannequins: white Tyvek suits, stuffed with packing boxes to give them roughly the same cross-section as a prone human, wearing blaze orange safety vests. One of these randomized placements lay at a lateral distance that was not visible from the course due to thick vegetation. We therefore counted the original placement as “virtual” (Koester et al. 2004), scoring it as an automatic miss for each searcher, and placed the physical mannequin at a shorter lateral distance just visible from the course. This resulted in a total of 20 detection opportunities (DOs) for these search objects.
- 20 low-visibility adult mannequins: the same Tyvek suits, spray-painted olive drab. Two of the randomized placements were not visible from the course and were treated as above, resulting in a total of 22 detection opportunities, with two of them automatic misses.

The resulting course was 2,225 m long, beginning at 17S PD 00392 85624 and ending at 17S PD 00500 85733 (See Fig. 1). The first search object, a low-vis mannequin, was randomized to a position 9 m down-trail from the beginning of the course; the last, a high-vis mannequin, at 2,208 m. Locations of course flags and mannequins were recorded with either an Alpha 200i or a GPSMAP 66st GPS receiver (Garmin International, Olathe, KS, USA).

Fourteen searchers blinded to mannequin placement walked the course beginning at 09:32 EDT on Sept. 14, 2024, and ending at 18:10 the same day. Data loggers helped them stay on the flagged course and recorded sightings or suspected sightings of clues (false sightings were also recorded but by design did not affect the results). This produced a total of 280 detection opportunities (DOs, hits or misses) for the high-vis mannequins and 308 for the low-vis.

Figure 1. Snake Hill WMA Sweep Width Course. Blue flags, unlabeled, represent start, finish, and 100 m marks along the course length; orange flags, 25 m marks. Low-vis mannequins, black dots, are labeled with their clue numbers, as are high-vis mannequins, red dots. These are the actual locations of the mannequins; virtual placements are not shown. Location for the Rd determination is marked with a large red dot. Note trails are not shown, for clarity. Image generated with SARTopo (CalTopo LLC, Truckee CA, USA).



For each search object and as previously described (Chiacchia and Houlahan 2023), we generated a curve that related PODs observed, cumulated from the marked course each searcher followed outward to C_{50} (coverage, where C = *W*/L, with L = lateral distance from the detector's path). By plotting the PODs against C_{50}, the coverage assuming *W* = 50 m, we obtained the true value of *W* from a least-square fit to POD versus C_{50} using the "random search model" equation:

5. $POD = 1 - e^{-(C_{50} W/50m)}$

As part of the Snake Hill exercise and following up on the earlier exercises at SGL 203, we conducted a "heads, belts, boots" measurement at the same locations as used to measure Rd values to calibrate each course (Koester et al. 2004, Koester et al. 2014). Four searchers carried out these measurements, requiring two evolutions per location to carry out measurements from each of the eight semi-cardinal compass directions. These measurements were carried out on Sept. 3, 2023 (SGL 203 summer), Dec. 31, 2023 (SGL 203 winter), and Sept. 12, 2024 (Snake Hill summer).

To accomplish this, we adapted the Rd method of placing the desired search object (in this case, the low- and high-vis mannequins) on the randomized spot(s) in each search area. This process is similar to the "Northumberland rain dance" described above. Each searcher moved back and forth to measure three distances in addition to Rd. "Head" was represented by the distance between each pair of searchers opposite each other (N vs. S, SW vs. NE, etc.) when each could just see the other's head above the vegetation or terrain. “Belt” was when each searcher could see each other’s belt area just above the vegetation or terrain. “Boots” was the most difficult to achieve consistently, with each searcher gauging when the opposite searcher’s boots were just visible. As with the Rd values, these distances were measured with the laser rangefinder (sometimes requiring multiple measurements, with propagated errors, when intervening vegetation did not obscure the target but did interfere with the laser beam) when more than the 10 m lower limit of the rangefinder, and a tape measure when less than 10 m.

For the least-square fits and ANOVA analyses, we employed GraphPad Prism version 5.00 for Windows (GraphPad Software, San Diego, CA, USA, www.graphpad.com) to perform statistical testing. Data are expressed as mean±standard deviation (SD), except where noted below as ±propagated measurement errors. Propagation was performed using the Ludwig Maximilian University of Munich online calculator (Wienand J, http://www.julianibus.de/, last accessed Oct. 6, 2024). All tests were two-tailed, with $P<0.05$ set as the threshold for statistical significance.

Results

Rd and Head, Belt, Boots Distance Determination

Using the low- and high-vis mannequins, we determined the Rd and head, belt, boots distances as cited in Methods. The heights of the four searchers involved were 1.75 m, 1.73 m, 1.7 m, and 1.57 m (mean 1.69±0.08 m).

Mean Rd values at the Snake Hill WMA site were 21.6±5.9 m for the low-vis mannequin and 24.0±7.8 m for the high-vis. These new figures compare with 15.7±3.9 m previously measured for the low-vis mannequin at State Game Lands 203 in the summer and 34±11 m in the winter, and 27.9±8.0 m summer and 50±21 m winter for the high-vis (Fig. 2, also Chiacchia and Houlahan 2010).

We determined the head, belt, boots distances at the same locations previously used for the Rd values for SGL 203 (Chiacchia and Houlahan 2010) and the new Rd location at Snake Hill (Methods). They can be seen in Fig. 2 and Table 1. An ANOVA of the data was significant ($P<0.0001$), with the head vs. head, belt vs. belt, and boots vs. boots differences not significant between SGL 203 and Snake Hill in the summer. The significance of the other comparisons varied (Table 2), but note that the head versus belt distances were often not significantly different in the same area and season.

The standard deviation represents the variance of the head, belt, boots distances as the terrain and vegetation in a given locale and season varies. Because of this, this value does not represent the error in these distances experienced by grid searchers if they are adjusting their spacing to maintain head, belt, or boots distance. To get a sense of the other end of this spectrum — namely, perfect adjustments to keep spacing at head, belt, boots distances — we also calculated the error in these values using the limitations of the tools used to measure them (±0.5 m for the laser rangefinder, ±0.01 m for the tape measure used for distances <10 m) and propagated those errors in the averaging process. These are also shown in Table 1.

Figure 2: Head, Belt, Boots Distances (±SD)

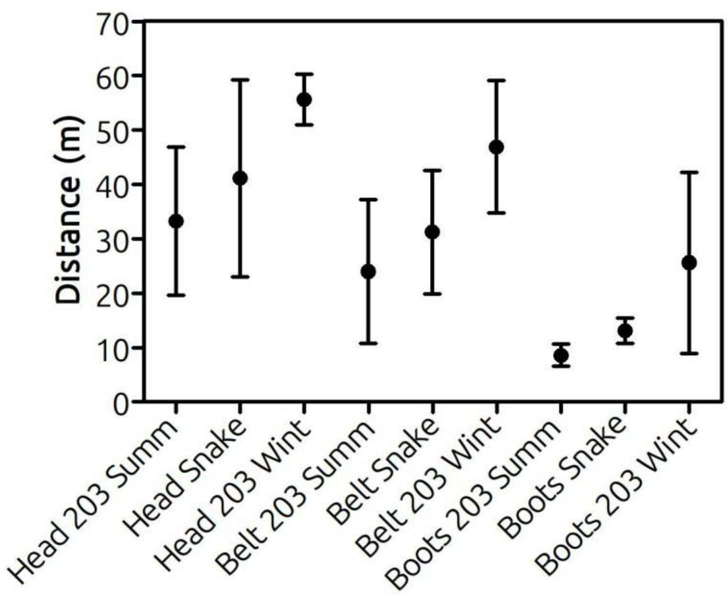


Table 1: Head, Belt, Boots Distances ± Standard Deviation vs. Propagated Error

Value	*Mean, m*	*SD*	*Propagated error*
Head Summer SGL 203	33.27	14	0.18
Belt Summer SGL 203	24.00	13	0.17
Boots Summer SGL 203	8.63	2.0	0.11
Head Winter SGL 203	55.63	4.7	0.25
Belt Winter SGL 203	46.88	12	0.23
Boots Winter SGL 203	25.63	17	0.18
Head Summer Snake Hill	41.13	18	0.35
Belt Summer Snake Hill	31.25	11	0.31
Boots Summer Snake Hill	13.13	2.3	0.25

Table 2: Tukey's Multiple Comparison Test, Head, Belt, Boots Values at SGL 203 and Snake Hill

Comparison	*Mean Diff.*	*q*	*P-value*
Head Summ vs Belt Summ	9.275	2.23	>0.05
Head Summ vs Boots Summ	24.65	5.927	<0.01
Head Summ vs Head Wint	-22.35	5.374	<0.05
Head Summ vs Belt Wint	-13.6	3.27	>0.05
Head Summ vs Boots Wint	7.65	1.839	>0.05
Head Summ vs Head Snake	-7.85	1.541	>0.05
Head Summ vs Belt Snake	2.025	0.3975	>0.05
Head Summ vs Boots Snake	20.15	3.956	>0.05
Belt Summ vs Boots Summ	15.38	3.697	>0.05
Belt Summ vs Head Wint	-31.63	7.604	<0.001
Belt Summ vs Belt Wint	-22.88	5.5	<0.01
Belt Summ vs Boots Wint	-1.625	0.3907	>0.05
Belt Summ vs Head Snake	-17.13	3.362	>0.05
Belt Summ vs Belt Snake	-7.25	1.423	>0.05
Belt Summ vs Boots Snake	10.88	2.135	>0.05
Boots Summ vs Head Wint	-47	11.3	<0.001
Boots Summ vs Belt Wint	-38.25	9.197	<0.001
Boots Summ vs Boots Wint	-17	4.087	>0.05
Boots Summ vs Head Snake	-32.5	6.38	<0.01

Comparison	*Mean Diff.*	*q*	*P-value*
Boots Summ vs Belt Snake	-22.63	4.442	>0.05
Boots Summ vs Boots Snake	-4.5	0.8834	>0.05
Head Wint vs Belt Wint	8.75	2.104	>0.05
Head Wint vs Boots Wint	30	7.213	<0.001
Head Wint vs Head Snake	14.5	2.847	>0.05
Head Wint vs Belt Snake	24.38	4.785	<0.05
Head Wint vs Boots Snake	42.5	8.343	<0.001
Belt Wint vs Boots Wint	21.25	5.109	<0.05
Belt Wint vs Head Snake	5.75	1.129	>0.05
Belt Wint vs Belt Snake	15.63	3.067	>0.05
Belt Wint vs Boots Snake	33.75	6.626	<0.001
Boots Wint vs Head Snake	-15.5	3.043	>0.05
Boots Wint vs Belt Snake	-5.625	1.104	>0.05
Boots Wint vs Boots Snake	12.5	2.454	>0.05
Head Snake vs Belt Snake	9.875	1.679	>0.05
Head Snake vs Boots Snake	28	4.76	<0.05
Belt Snake vs Boots Snake	18.13	3.081	>0.05

***W* Values for the Snake Hill WMA Exercise**

Fourteen searchers completed the Snake Hill effective sweep width exercise, with 20 real and 2 virtual DOs each on the low-visibility mannequins, and 19 real and 1 virtual DOs on the high-vis, for a total of 308 DOs for the low-vis and 280 for the high-vis. The resulting crossover-graph-based *W* values calculated by the IDEA spreadsheet were 22 m for the low-vis and 56 m for the high-vis mannequin. These compare with the *W* values predicted by the Rd measurements, 24 m and 43 m, respectively (Koester et al. 2014).

We also calculated the *W* values for the summer Snake Hill exercise using the POD-curve-based method previously described (Chiacchia and Houlahan, 2023), thus gaining parameters that could be used for statistical comparisons. These were 25.2±5.4 m for the low-vis and 68±23 m for the high-vis (Figs. 3a and b). The R-square for the fits were 0.7504 for the low-vis and 0.2941 for the high-vis mannequins; an F-test comparison of the two curves revealed a significant difference between the *W* values (P<0.0001).

The *W* values for Snake Hill compare with values of 22.5±1.9 m for the low-vis at SGL 203 in the summer (two exercises, averaged) and 53.5±8.9 m for the high-vis mannequin in the summer (Chiacchia and Houlahan, 2023).

Figure 3a: POD Curves for Determining W *Values at Snake Hill Exercise*

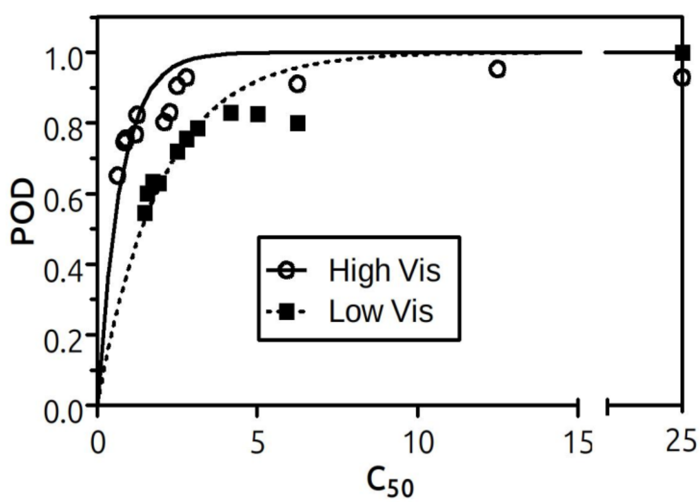
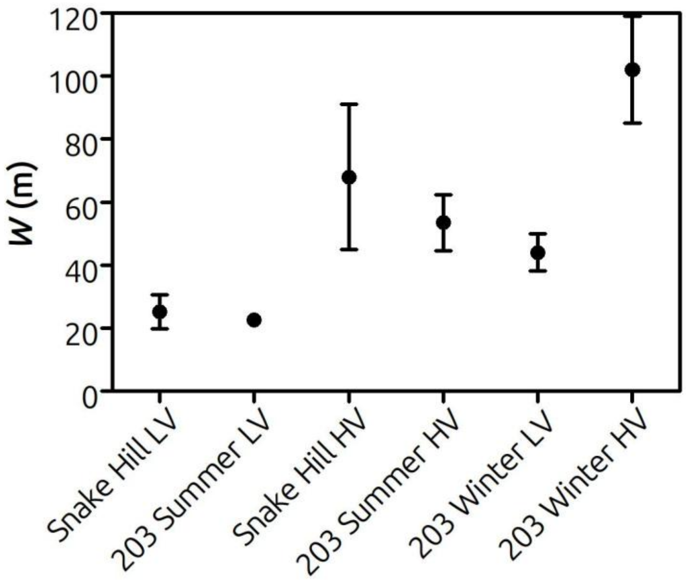


Figure 3b: W *Values for Snake Hill Exercise versus SGL 203*



A one-way ANOVA of these data, including the winter values at SGL 203 in that report (44.1±5.9 m low-vis, 102±17 m high-vis), was significant ($P<0.0001$). The post-test differences between the low-vis mannequins at Snake Hill and SGL 203 in summer as well as the high-vis at Snake Hill and SGL 203 in summer, however, were not significant. More post-test comparisons can be found in Table 3.

Table 3: Tukey's Multiple Comparison, W *Values at SGL 203 and Snake Hill*

Comparison	*Mean Diff.*	*q*	*P-value*
Snake Hill LV vs 203 Summer LV	7.7	3.043	>0.05
Snake Hill LV vs Snake Hill HV	-42.8	14.16	<0.001
Snake Hill LV vs 203 Summer HV	-28.8	9.103	<0.001
Snake Hill LV vs 203 Winter LV	-18.9	5.399	<0.05
Snake Hill LV vs 203 Winter HV	-76.4	24.15	<0.001
203 Summer LV vs Snake Hill HV	-50.5	20.6	<0.001
203 Summer LV vs 203 Summer HV	-36.5	13.91	<0.001
203 Summer LV vs 203 Winter LV	-26.6	8.804	<0.01
203 Summer LV vs 203 Winter HV	-84.1	32.06	<0.001
Snake Hill HV vs 203 Summer HV	14	4.516	>0.05
Snake Hill HV vs 203 Winter LV	23.9	6.94	<0.01
Snake Hill HV vs 203 Winter HV	-33.6	10.84	<0.001
203 Summer HV vs 203 Winter LV	9.9	2.774	>0.05
203 Summer HV vs 203 Winter HV	-47.6	14.7	<0.001
203 Winter LV vs 203 Winter HV	-57.5	16.11	<0.001

POD Values for Head, Belt, Boots Distances

Given the head, belt, or boots spacing for a grid team, the POD value for that team making one pass through a search segment, and assuming a non-overlapping pattern, the POD value can be approximated as:

6. $POD = 1 - e^{-(W/G)}$

Where G again is the spacing between individual searchers in the line (Koopman 1980, NASAR 2018, Chiacchia and Houlahan, 2023).

In this case, *W* was derived from the field sweep width experiments, and G from measuring Head, Belt, and Boot distances. We calculated the POD predicted for each of the two search objects at Snake Hill in the summer and SGL 203 in the summer and winter, propagating the errors assuming either the propagation-error-based or SD-based uncertainties described above. These values are shown in Fig. 4 and Table 4.

Figure 4: POD Values for Head, Belt, Boots Distances, Propagation-Error (black) and SD (gray) Uncertainties at State Game Lands 203 in summer and winter, and Snake Hill WMA in summer

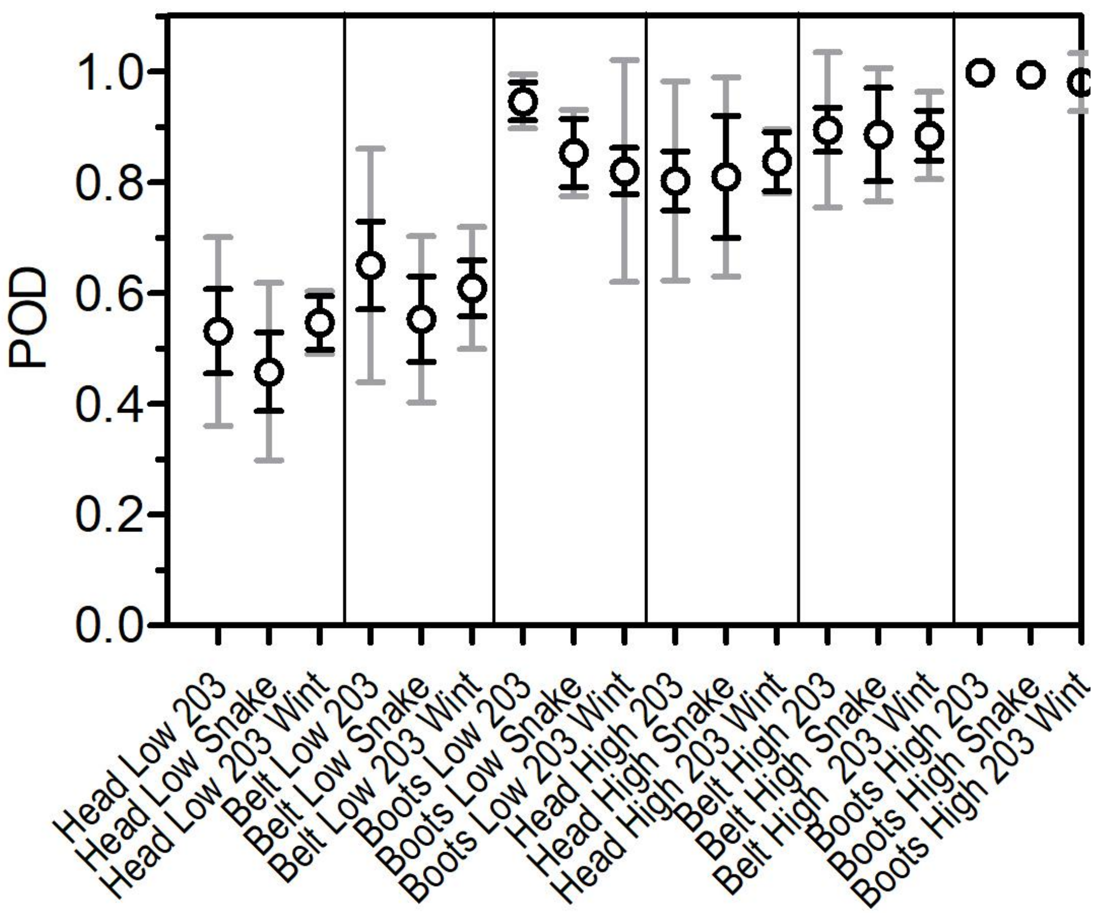


Table 4: POD Values with Propagation-Error-Based versus SD-Based Uncertainties

Search Object/Exercise	*POD*	*Propagated Error*	*SD*
Head Low 203	0.531	0.076	0.17
Head Low Snake	0.458	0.071	0.16
Head Low 203 Wint	0.547	0.048	0.057
Belt Low 203	0.650	0.079	0.21
Belt Low Snake	0.553	0.077	0.15
Belt Low 203 Wint	0.609	0.050	0.11
Boots Low 203	0.946	0.034	0.049
Boots Low Snake	0.853	0.061	0.078
Boots Low 203 Wint	0.820	0.042	0.20
Head High 203	0.803	0.053	0.18
Head High Snake	0.81	0.11	0.18
Head High 203 Wint	0.837	0.053	0.058
Belt High 203	0.895	0.040	0.14
Belt High Snake	0.886	0.084	0.12
Belt High 203 Wint	0.884	0.045	0.079
Boots High 203	0.9981	0.0020	0.0034
Boots High Snake	0.994	0.010	0.011
Boots High 203 Wint	0.981	0.014	0.052

It is not valid to use ANOVA on probabilities. However, we employed a logit transformation:

7. y = ln(POD/(1-POD))

to convert the PODs to normalized y values that could be analyzed. Using the lower, propagated-error uncertainties, a two-way ANOVA of the resulting logit values (unweighted means analysis due to the different sample sizes and the need to use values calculated from the POD-curve fit rather than repeated measurements) was significant for the column factor (P<0.0001), namely the difference between the different locations and seasons given the same spacing. The row factor was, not surprisingly, also significant (P<0.0001) — in other words, choosing head, belt, or boots spacing changes the POD. There was also a significant interaction between these two factors (P<0.0001).

Using a Bonferroni post-test to compare summer vs. winter at SGL 203, only the (transformed) POD values for the boots distances differed significantly (for each mannequin P<0.001, Table 5a). Comparing summer at SGL 203 vs. summer at Snake Hill, again only the PODs obtained at the boots distances were significantly different (for each mannequin P<0.05, Table 5b). The transformed PODs for summer at Snake Hill were not significantly different than for winter at SGL 203, except for the high-vis mannequin at boots distance (P<0.05, Table 5c). The POD values for the head or belt distances were, by this measure, unaffected by the changes in location or season (Tables 5a through c). Note, in any case, that the POD differences themselves within each spacing was almost always less than 10% — the one exception being at the boots distance in summer vs. winter at SGL 203 of 13% (see Table 4).

Table 5a: Bonferroni Post-Test of Logit Transformed PODs, Summer SGL 203 versus Summer Snake Hill

Row Factor	*Difference*	*t*	*P-value*
Low Man Head	-0.2926	0.8218	>0.05
Low Man Belt	-0.4062	1.141	>0.05
Low Man Boots	-1.105	3.104	<0.05
High Man Head	0.04729	0.1329	>0.05
High Man Belt	-0.0881	0.2475	>0.05
High Man Boots	-1.149	3.228	<0.05

Table 5b: Bonferroni Post-Test of Logit Transformed PODs, Summer SGL 203 versus Winter SGL 203

Row Factor	*Difference*	*t*	*P-value*
Low Man Head	0.06271	0.2158	>0.05
Low Man Belt	-0.1767	0.608	>0.05
Low Man Boots	-1.345	4.626	<0.001
High Man Head	0.2352	0.8093	>0.05
High Man Belt	-0.1074	0.3697	>0.05
High Man Boots	-2.338	8.044	<0.001

Table 5c: Bonferroni Post-Test of Logit Transformed PODs, Summer Snake Hill versus Winter SGL 203

Row Factor	*Difference*	*t*	*P-value*
Low Man Head	-0.3553	0.9980	>0.05
Low Man Belt	-0.2295	0.6448	>0.05
Low Man Boots	0.2396	0.6731	>0.05
High Man Head	-0.1879	0.5279	>0.05
High Man Belt	0.01934	0.05434	>0.05
High Man Boots	1.189	3.340	<0.05

Discussion

The results reported above suggest some interesting and operationally useful relationships between sight lines (represented by head, belt, boots values), the practical ability of humans to search visually in the Appalachian woods (represented by *W*), and the resulting PODs. At the simplest level, as previously reported for Pennsylvania and Ohio (Chiacchia and Scelza, 2023), the subjectively similar environment of Snake Hill WMA in the Appalachian Mountains in West Virginia and State Game Lands Number 203 on the Allegheny Plateau in Pennsylvania provide similar effective sweep width values for a given search object and season. (The vegetation in the two locations is somewhat different, the terrain almost indistinguishable.)

More provocatively, the three comparisons here (one location in summer and winter; two locations in summer; and different locations, one in summer and one in winter) suggest that the differences seen between the distances necessary for keeping sight of a neighboring searcher's head and belt (at least) and *W* values in effect cancel out in the final PODs obtained. In other words, for example, searchers spread at belt distance in an "open grid" line obtain the same PODs for a given search object (say the low-vis mannequin, standing in for a human in low-vis color clothing) regardless of location or season. This lack of statistically significant difference held despite applying the much smaller uncertainties of the propagated errors rather than SD values.

Even the statistically significant differences seen for the PODs at boots distance are unlikely to be operationally significant. The largest such difference is only 13%, comfortably less than the roughly 25% or more variation in POD seen when searchers attempting to maintain set spacing were simulated and measured (Perkins 2018) or the 25% or more errors seen when team leaders estimate POD (Koester et al. 2004). More to the point, the difference between any of the PODs measured for each distance with their mean values is well under 10% — a POD difference unlikely to drive a search effort.

Of course, we have only demonstrated the above in two subjectively similar, relatively close-by locations. It remains to be seen whether this relationship will hold in very different environments, such that "head, belt, boots" provides consistent PODs. Another caveat to the current results is that searcher height is a major affector of *W* for visual search (Koester, 2004). Given the small number of searchers involved in these exercises, particularly the heads, belts, boots measurements, we simply do not have the statistical power necessary to investigate this factor. Given the height of our searchers for the head, belt, boots measurements (1.69±0.08 m) and the average height in the United States of 1.63 m for women and 1.75 m for men (World Population Review, 2025), and the fact that our heights were not significantly different from either (one sample t-test, P=0.251 and 0.220, respectively), we can say that these results are likely to be typical assuming searchers are neither significantly taller nor shorter than the general population.

Digging deeper operationally, these three spacing options are not created equal. The head distance is not particularly practical. While it covers more ground, it's not much farther than the belt distance. Worse, when keeping neighboring searchers' heads just in sight, we run the risk of losing sight of them entirely. This, as stated in the Introduction, creates a situation in which we have become unaware of how big the gap has become, and we risk losing operational cohesion for the grid team.

The boots distance suffers from a different issue. As we said above in most searches, our imperative is to balance speed with thoroughness. Boots achieves thoroughness at the expense of placing searchers so close together that they will not cover much area very quickly; PODs will be high, but again we risk lingering in an area that does not contain the subject. We also found that, in practice, boots distance was difficult to define as exactly as the others, which may have contributed to the fact that this distance was the only one to show a significant P-value for the same search object between the seasons and locations.

The belt distance may represent exactly the kind of speed/thoroughness balance we desire. From our results we would expect it to produce a POD of 55-65% for prone subjects in low-visibility clothing and a little under 90% for subjects in high-vis. These are quite serviceable PODs, particularly when this spacing allows a six-member grid team to sweep a roughly 120 to 240 m front for each pass through an area, depending on season. Should these consistent PODs prove to result in a wider variety of environments, our recommendation would be for belts to be the standard spacing for open grid teams.

Crucially, the head, belt, boots method provides objective advantages compared with virtually all the other methods for spacing searchers (specifically, "keeping in sight," rain dance, Rd spacing, and specific spacing based on known *W*). Specifically, it provides a demonstrably more accurate POD (particularly compared with "in sight" and rain dance) and requires less divided attention from searchers (compared with rain dance, Rd, and specific spacing) than the other methods. Divided attention is of particular concern in translating performance of searchers in exercises to that in the field in real deployments.

A word should be given for the so-called "purposeful wandering" technique (NASAR 2018). Intended to improve searchers' performance, it consists of having searchers wander within a given envelope (most often defined by Rd) to search under, behind, and among vegetation, rocks, and terrain. It undoubtedly increases POD, but perhaps not by improving *W*, as is often assumed. Note purposeful wandering differs from the dynamic distancing in heads, belts, boots as it does not involve a well-defined target and can open up spaces between searchers in a way that heads, belts, boots does not.

Clearly, by increasing searchers' paths walked through the area, it causes them to linger, which will increase POD. But we cannot move toward a spot without moving away from another spot. This is critical, as searchers in practice tend to use purposeful wandering to look in places that are otherwise difficult to see into, not necessarily places in which the subject is more likely to *be*. This is a problem if there is a mismatch between the two. Equating them may be valid for an evasive subject, but if the subject is not trying to hide, purposeful wandering could cause us to miss subjects who are *not* in difficult places.

Purposeful wandering may also subvert search planning's intentions for a given search task. As the POA values used to determine where to task teams are based on statistical behavior, they can never be more than an estimate and may be quite inaccurate for a given, if outlying, search subject. Thus, as described above we must aim for a "Goldilocks" level of search that is neither too thorough nor too fast, to avoid lingering in empty areas or missing a subject in the area being searched, respectively. By increasing linger, purposeful wandering tends to push all search efforts toward high thoroughness, low speed, when we need to balance the two.

Finally, purposeful wandering takes the problem of maintaining searcher spacing at arbitrary distances and scrambles it. With searchers wandering, the theoretical Rd envelope is in practice impossible to maintain, as searchers must both memorize a target distance *and* the deviation from that distance produced by wandering. With all the above taken into consideration, the authors would not recommend the use of purposeful wandering at all in human visual grid search.

At the National Association for Search and Rescue annual conference in San Diego in 2005, one of us (KBC) had the opportunity to see Robert Koester present his and his colleagues' initial findings (Koester et al. 2004) on how to measure effective sweep width in the ground-search environment. The method clearly offered a means to achieving objective PODs in the field; but it was not received well by all attendees. Some were dismayed by the observation (since replicated, including by us) that SAR training and experience do not seem to improve the sweep widths achieved by searchers. These attendees' accusation at the time was that the work was devaluing trained searchers and their necessity to a successful search effort.

Even at the time, the author realized that there is much that trained, professional searchers, paid or volunteer, offer searches beyond placing eyes on targets. These include navigation, field team leadership, incident management, communications, and many other factors needed to make searches more successful. Nonetheless, effective sweep width findings do suggest that untrained local volunteers are as useful at the *seeing* part as trained searchers, particularly when led by the latter. Combined with the worsening sparsity of volunteers for public safety organizations, the results suggested a new paradigm in which we train SAR responders not to be *searchers*, but to be search *leaders*. To some extent, this paradigm has been adopted.

The current findings add a potentially important nuance. The rather large SD-based uncertainties seen in Fig. 4 above represent the inconsistency we would see in POD if we spaced our searchers at a given distance and had them walk in perfectly straight lines through the area, regardless of changes in terrain or vegetation. The considerably smaller propagated errors, on the other hand, represent our searchers spacing themselves at that distance and then using their neighbors' heads, belts, or boots to adjust to changes in terrain or vegetation perfectly, so that those target points of anatomy remain just visible.

Clearly, all the training in the world will not allow searchers to adjust their spacing with such perfection. But arguably this represents a training *target*. More importantly, we would expect trained searchers to differ from emergent volunteers by achieving spacing consistency *closer* to that target. Part of the value of search training may be about moving from the inconsistency of the SD errors toward the tighter propagated errors, and may offer a way in which trained searchers are more *consistent* at searching than emergent volunteers, in addition to offering the other SAR skillsets.

Limitations of the Current Study

The limits previously discussed (Chiacchia and Houlahan 2023) of using mannequins to stand in for prone humans, while probably not a major factor, still apply. More significant is the question of whether adding additional members to a search team over a single searcher, which is what we measured here, will truly increase the team's effective sweep width in an additive manner. This question merits future study.

This report compared the PODs expected from heads, belt, and boots spacing in one location in two seasons, and two locations in the same season. As cited above, this is a small sampling and will need to be replicated, particularly in different environments that are less similar.

Possibly the most speculative element to this report is the use of propagated measurement errors rather than standard deviations in ANOVA tests. While our reasons for doing so are, we believe, valid and described above, it may affect the accuracy of the P-values derived. However, again as outlined above, the standard deviations of the head, belt, boots distances are unlikely to represent the variance in POD of a team adjusting their spacing to maintain a given target distance. Moreover, because these SDs are so much larger than the propagated errors, the stated aim of our report — to determine whether the PODs at a given distance are *not* significantly affected by locale or season — would have been trivial using the larger SDs. We used the propagated errors as a more rigorous test of these similarities.

Another issue, with the two-way ANOVA in the transformed POD comparison, was the significant interaction P-value. Interaction makes significance in the column or row factors difficult to interpret; in this case, the significant differences between the boots POD values, while the differences between the heads and belts PODs were not significant, are interesting but not likely to be operationally significant due to the reasons offered above. Also contributing to the difficulty of interpreting this result precisely was the unweighted means analysis necessitated by different sample sizes re. the head, belt, boots measurements as well as deriving uncertainty parameters from a fit instead of multiple measurements.

Finally, our discussion of the meanings of the propagated versus SD variances, while we believe to be justified, is somewhat speculative. Measurement of the actual variance in POD performance versus training level of searchers (bearing in mind that we do not expect the PODs themselves to be significantly different based on SAR experience, Koester et al. 2004, Chiacchia and Houlahan 2010) will be necessary to assess this prediction.

Conclusions

A key lost-person search method is the “grid team,” a line of searchers moving abreast through the woods. The optimum spacing for such searchers is not clear, however. We have determined the spacing necessary for searchers to see their immediate neighbors’ head, belt, or boots at sites in West Virginia in the summer and in Pennsylvania in the summer and winter. An analysis of the probabilities of detection expected from previously or newly measured effective sweep width values in those locations for each of these spacings suggests that each spacing offers a consistent and useful POD for a given search object that does not appear to be affected by location or season by an operationally significant amount.

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Abbreviations

Rd: Radius of detection, the mean distance at which an observer cued to the location of an object can detect it when moving toward it.

C: Coverage, the ratio of effective sweep width times the path length of a detector within an area to its size.

C_{50}: Coverage assuming an effective sweep width of 50 m.

DO: Detection opportunity, a detection or miss of a search object at a right angle (lateral) to the detector’s path.

POA: Probability of area, the estimated probability that a search object is contained within a given area.

POD: Probability of detection, the probability that a given detector will detect a given search object within an area under certain environmental conditions, assuming that object is in the area.

POS: Probability of success, the probability that a given search effort will detect a search object within a given area being searched (a “segment”). Equal to POA X POD.

W: Effective sweep width, a distance-denominated term defining the envelope within which a given detector’s number of misses on a search object equals the number of detections outside, under specific environmental conditions.

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Probability Modelling for Optimization of Evidence Searches

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Abstract

Evidence searches (seeking human remains or objects related to criminal cases) have characteristics that differ from searches for lost persons. Often, evidence searches are focused on relatively small areas and seek hard-to-detect objects that may have been initially concealed by criminal behavior and subsequently scattered by animal activity or environmental changes. Because of these characteristics, the success rate for evidence searches can be quite low.

For that reason, it is imperative to focus search efforts in areas that have the highest likelihood of containing sought-after evidence. Traditional application of search theory involves mapping planning regions, which are assigned Probability of Area (POA) and Probability Density (Pden) values via a consensus process. Search segments mapped within planning regions inherit their POA and Pden from their parent planning regions.

We describe an application of search theory concepts aimed at optimizing the success of evidence searches. The approach consists of: Mapping search segments of uniform size; identifying Evidence Probability Factors (EPFs) based on terrain analysis, historical criminal behavior, and animal behavior; assigning relative values to EPFs via a proportional consensus process, and then representing EPFs on a map to develop a probability mosaic which provides POA and Pden for each search segment.

KEY WORDS: *Search theory, search planning, probability modelling, human remains, evidence search.*

Introduction

Evidence Search Challenges

Human remains may be deposited in natural environments as a consequence of routine activities (lost hikers), via historical actions (Native American burials), via abnormal behavior (suicide), or via criminal behavior (abduction and murder). Finding human remains in criminal cases has always been of vital importance, both for law enforcement and for families of the victims (DiBiase, 2023). Moreover, the recent advent of new DNA identification technology (Bukyya et al, 2021) and genealogical matching techniques (Kling et al, 2021) has dramatically improved the ability to identify victims, and made it even more crucial to recover human remains.

For many reasons, however; finding human remains in wilderness or rural areas can be exceptionally difficult. Criminals may purposefully conceal bodies by burial or in bodies of water (Congram, 2013; Nethery, 2002). Animals may degrade or disarticulate remains and distribute them over great distances (Sincerbox & DiGangi, 2018). Foliage and fallen leaves may cover and conceal scattered bones (which can take on the same color as the surrounding environment), and weather and natural terrain changes may distribute remains. In addition, searching for aged evidence (e.g., scattered bones, fragments, or bits of clothing) is extremely time and resource intensive. Law enforcement personnel (often aided by search and rescue volunteers) seldom have the capacity to thoroughly search large areas for potential evidence. Because of these factors, the success rate for many evidence searches can be quite low.

The remains of murder victims in natural environments are acted upon first by criminals, and then often acted upon by animal scavengers. In this paper, we describe how search theory concepts can be systematically integrated with knowledge of past patterns of criminal behavior and with understanding of natural animal behavior to optimize searches for human remains. Such a planning synthesis can be readily adopted by law enforcement agencies and used to focus searching in areas of higher probability, thereby increasing the likelihood of finding and recovering human remains.

Applying Search Theory to Evidence Searches

A primary strategy for improving the success rate of evidence searches is to focus efforts in areas that have the highest likelihood of containing sought-after evidence. Traditional application of search theory involves developing and quantifying an initial model of probability in the search area, followed by systematically assessing how search sorties reduce that probability in segments that have been traversed by search teams (Cooper et al., 2003; Frost, 2000). In this paper, we describe an application of search theory concepts aimed at combining subject matter expert input with probability modelling to optimize the success of evidence searches. Some of our approach is analogous to how search theory is applied to maritime searches (Department of Homeland Security, 2011). As shown in Figure 1, our methodology can be summarized in three phases:

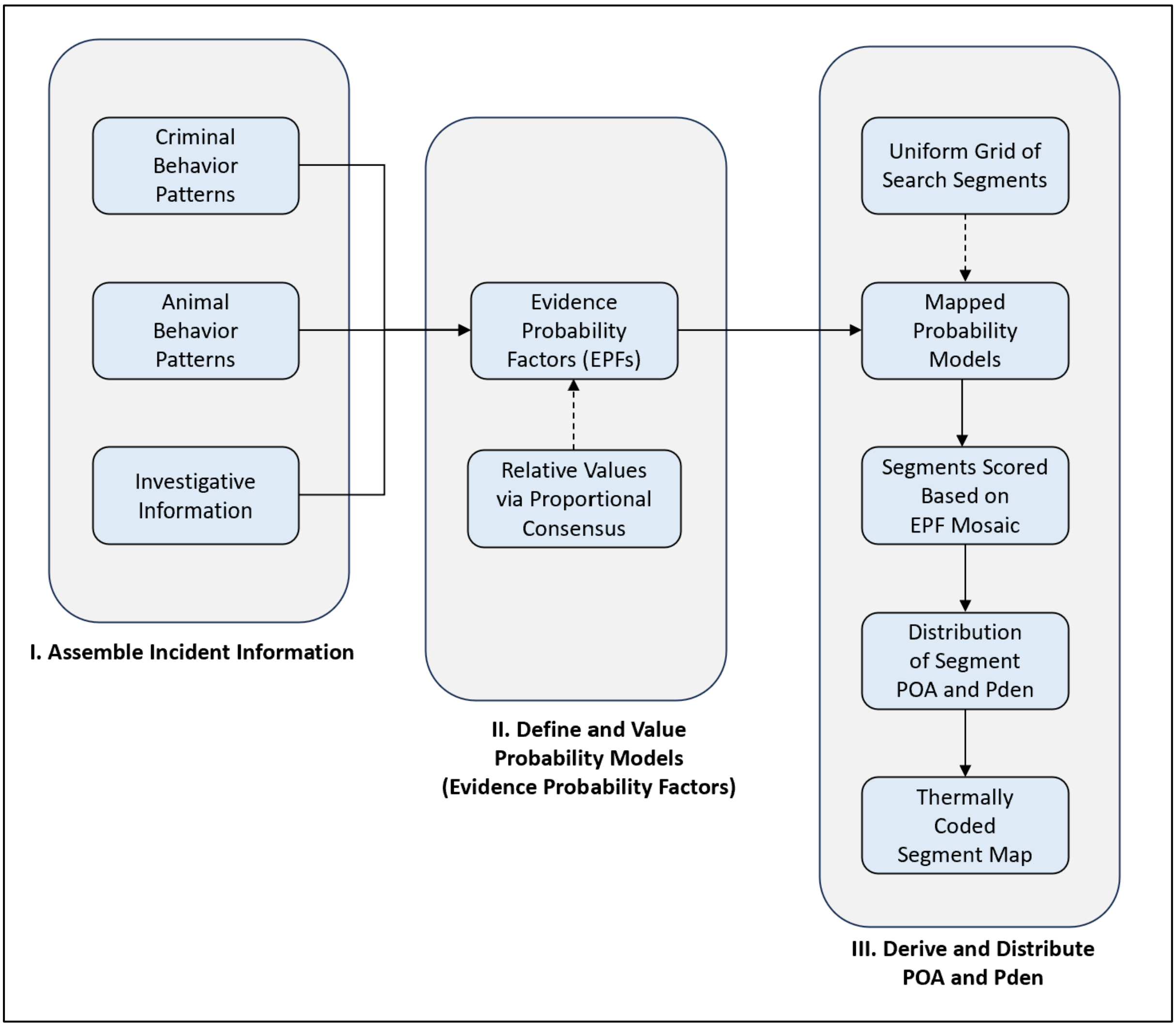


Figure 1: Overview of Evidence Probability Factor Methodology

I. Assembling Incident Information: We begin by assembling as much investigative information as is available. Ideally, this will include (a) key facts from the incident case file, and (b) information about the search area derived from terrain analysis, and (c) any previously found clues or remains.

II. Defining and Valuing Probability Models: This incident-specific information, combined with known patterns of criminal and animal behavior, serves as the basis for a curated set of probability models. These Evidence Probability Factors (EPFs) can be based on historical data or on subjective assumptions. Each EPF is assigned a relative value (based on a proportional consensus process) and then represented on the search planning map.

III. Deriving and Distributing Segment POA and Pden: Once all EPFs are mapped, an overlay of a uniform grid of search segments is applied to the map. Each search segment inherits a cumulative score, based on the underlying EPF models that it contains. These cumulative scores are normalized to derive Probability of Area (POA) and Probability Density (Pden) for each search segment. The quantitative POA/Pden values can be conveniently represented as a thermally-shaded probability mosaic.

Methods

Translating Criminal and Animal Behavior into Evidence Probability Factors

The remains of murder victims in natural environments are acted upon first by criminals and then may be acted upon secondarily by animal scavengers. A body of literature exists about how criminal behavior (Congram, 2013; Killiam, 2004; Koester, 2016; Manhein et al., 2006,) and animal behavior (Beck et al., 2014; Berezowski, MacGregor, Ellis, et al. 2023; Gleason, 2008; Haglund & Sorg, 1997; Moraitis & Spiliopoulou 2010; Rossmo, 2025; Sincerbox & DiGangi 2018) interact with terrain features to influence the location of human remains. For example, criminals will often seek road pull-outs to discard bodies. Animals may move remains along their natural travel paths. This literature can be used to characterize conceptual probability models, as shown by the examples in Tables 1 and 2 below. The goal of our approach is to objectively distribute POA to grid segments based on systematic consideration of these factors.

Conceptual Model	**Influence of Criminal Behavior of H. sapiens on Location Probability**
Distance	Probability generally increases in proximity to a road or pull-out.
Slope	Probability is generally higher on downhill side of a road or pull-out.
Vegetation Cover	Probability is generally higher in wooded areas (providing seclusion).
Structures	Probability generally decreases near inhabited buildings or houses.
Investigative	Detectives may suspect burn piles on a rural property.

Table 1: Examples of General Probability Concepts for Criminal Behavior.

Conceptual Model	Influence of Animal Activity on Location Probability
Distance	Probability may increase with proximity to other found remains.
Terrain	Probability may reflect movement along animal trails, along fence lines, along draws, on ridge lines, or around shorelines.
Vegetation Cover	Wooded areas have higher probability than open areas.
Structures	Probability generally decreases near inhabited buildings, houses, roads, or any human activity

Table 2: Examples of General Probability Concepts for Animal Behavior.

These general probability concepts can be translated into quantified probability models, a step that can be based on objective data or based on informed consensus[1] judgement. In our approach, quantified probability models are used in two ways: (1) They guide how areas of higher probability are represented on the map, and (2) they inform how Evidence Probability Factors are assigned relative values via a proportional consensus process. Two examples are illustrated in Table 3 below.

General Probability Concept	Mapped Evidence Probability Factor	Basis for Quantification
Criminal Behavior: Probability generally increases in proximity to a road.	100-yard "high probability buffer" mapped along roads in the search area.	Objective data showing that 89% of historical finds were located within 100 yards of a road (Koester, 2016).
Animal Behavior: Probability may reflect movement along game trails or fence lines.	20-yard "high probability buffer" mapped along game trails and fence lines in the search area.	Estimation based on field observations and forensic taphonomy studies (Sincerbox & DiGangi, 2018).

Table 3: Examples of Quantified Probability Models

Using Evidence Probability Factors to Derive Segment POA

Koester (Koester, 2025) describes four main approaches to determining POA: (1) algorithmic modelling of agent behavior (often used for maritime searches), (2) consensus input from subject matter experts, (3) statistical models (e.g., based on historical data incident data), and more recently, (4) use of artificial intelligence methods. As described below, our method combines the consensus-based and statistical modelling approaches.

[1] There are a number of consensus processes (e.g., Mattson Consensus, Scenario Weighting, Proportional Consensus) used during search planning. In this paper, we use the term "consensus" as a general reference to these processes, and we use "proportional consensus" to refer to the specific consensus method used in our approach.

For each incident, a curated list of Evidence Probability Factors (EPFs) is created, based on input from detectives, investigators, and search planners. This list may include factors based on historical criminal behavior, geographic profiling (Berezowski et al, 2022), patterns of animal behavior, incident-specific clues or information, and local terrain characteristics. A sample table of EPFs is shown in Table 4.

Evidence Probability Factor	**Relative Score**
Search grid contains a road pull-out area.	
Search grid contains a road pull-out above a downhill slope.	
Search grid contains an area where garbage has been discarded in the past.	
Search grid contains areas within 100 yards of road or trail.	
Search grid contains areas within 20 yards of a located animal/game trail.	
Search grid contains a secluded spur road.	
Search grid contains a logging path or trail that provides access into woods.	
Search grid contains a burn pile.	
Search grid contains a wooded area that can be easily accessed.	
Search grid is within 100 meters of IPP or found clues.	
Search grid is between 100-200 meters from IPP or found clues.	
Search grid contains an area or soils where it is easy to dig.	

Table 4: Example Table of Evidence Probability Factors

Evidence Probability Factor lists may start as generic, but then are customized for each incident depending upon:

- The nature of the incident. For example, in a wide area search for a clandestine grave, proximity to secluded roads and pull-outs would be important. For a narrow area search of a single rural property, factors such as proximity to burn piles, wooded areas, or swamps would be added to the list.

- The presence of clues or evidence. If the location of previously-found evidence (e.g., a partial human skull) is known, then proximity to this evidence would be an important factor. The Evidence Probability Factor list should also contain a factor for items found during the search. This would allow for prompt re-assessment of area probabilities.

- The search terrain. If a segment was partially wooded, (a feature that might provide seclusion), then that terrain characteristic would be a useful EPF. In contrast, if the entire search area is wooded, that would not be a useful discriminating factor and could be eliminated from an EPF list.

Once the list of evidence probability factors is compiled, the next step is to assign a relative value to each EPF. For this scoring, we use a Proportional Consensus process (Frost & Cooper, 2014). This has several advantages:

- The process combines the judgement of investigative experts and search analysts.
- The process derives EPF scores that reflect their relative importance for a specific incident.
- The process instructions are easy to follow (even for non-SAR personnel).
- The process allows for independent, non-biased ratings.

In our approach, all of the proportional consensus participant's scores for each EPF are simply summed to provide a value for each EPF.

After the Evidence Probability Factor list is finalized and scored, each factor is then represented as an object on the planning map. Examples of such objects are shown in Figure 2, and include:

- Distance radii (dotted yellow lines) from clues or important locations.
- 100-yard buffers (red lines) along roads.
- Polygons (orange lines) outlining high probability areas (e.g., denser brush).

Figure 2 can also be used to illustrate an important analytical technique, particularly for evidence searches related to crimes committed many years ago. The aerial image in Figure 2 is an historical image from Google Earth, dated as close as possible to the year when the crime occurred. This allowed mapping of wooded areas (orange polygons) based on the tree coverage of that past date, even though current-day tree coverage is much more uniform.

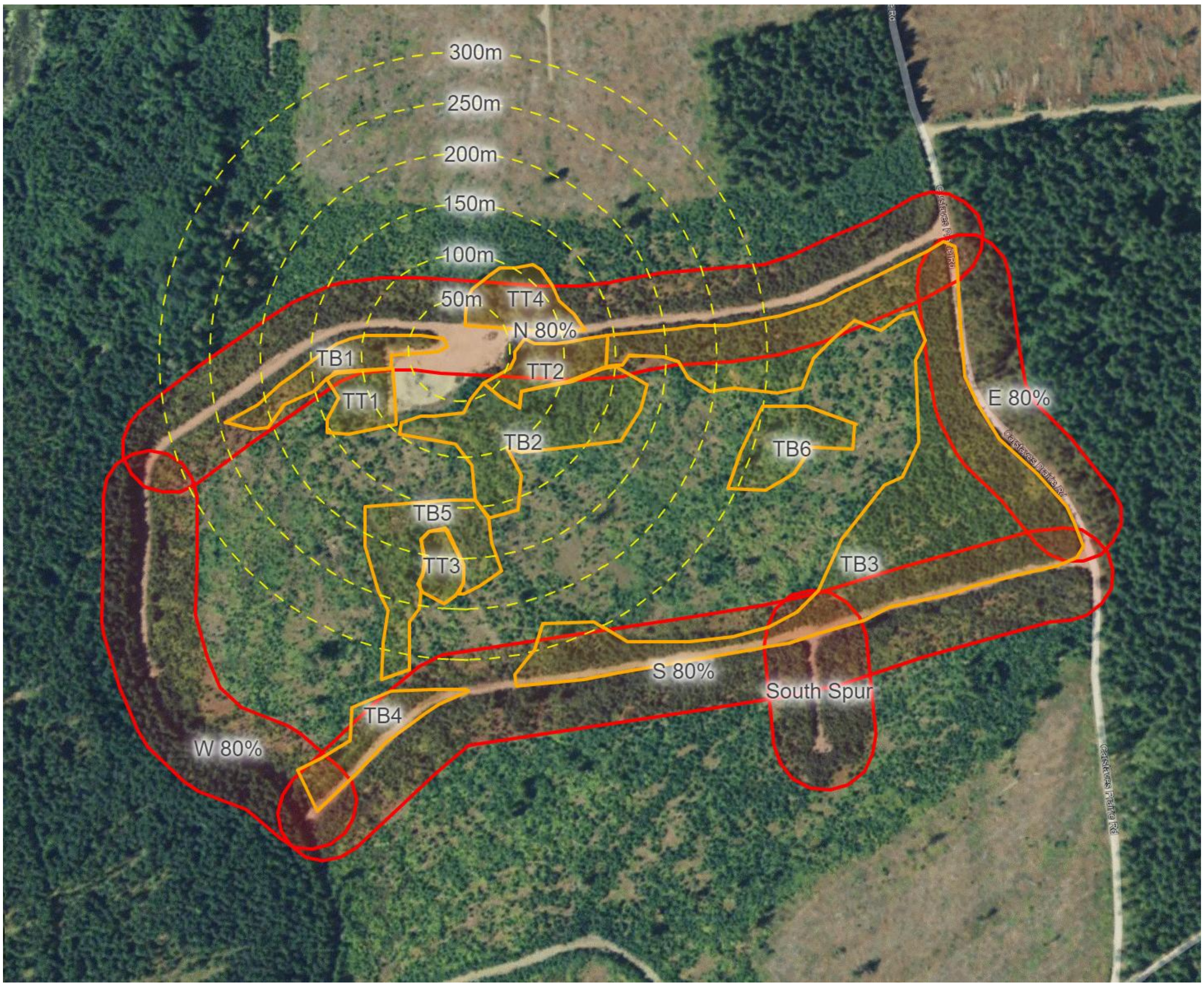


Figure 2: Example of Mapped High Probability Zones

Uniform Search Segments

Wilderness search terrain frequently includes drainages, ridges, and trails which can have significant effects on subject travel and on subject find locations (Jacobs, 2016). In contrast, most evidence searches focus on smaller areas with relatively low geospatial variability. The main factors influencing probability in evidence searches are criminal behavior, animal behavior, localized foliage differences, and previously found evidence.

Traditional search theory approach begins with mapping planning regions, which are assigned Probability of Area (POA) values via a consensus process (Hill, 2011). For land searches, planning regions are typically mapped with irregular shapes and sizes that reflect interaction between search scenarios and the search area terrain (Stoffel, 2006). Within planning regions, search segments are typically sized for feasible search coverage during a single operational period, and mapped with boundaries that correspond to features that teams on the ground can easily recognize (Stoffel, 2006).

For our methodology, we have adopted the practice of mapping a grid of uniform-size segments similar to that used for maritime searches. This approach is feasible for relatively small search areas (typical of evidence searches), and eliminates Pden artifacts due to wide variations in region or segment size.

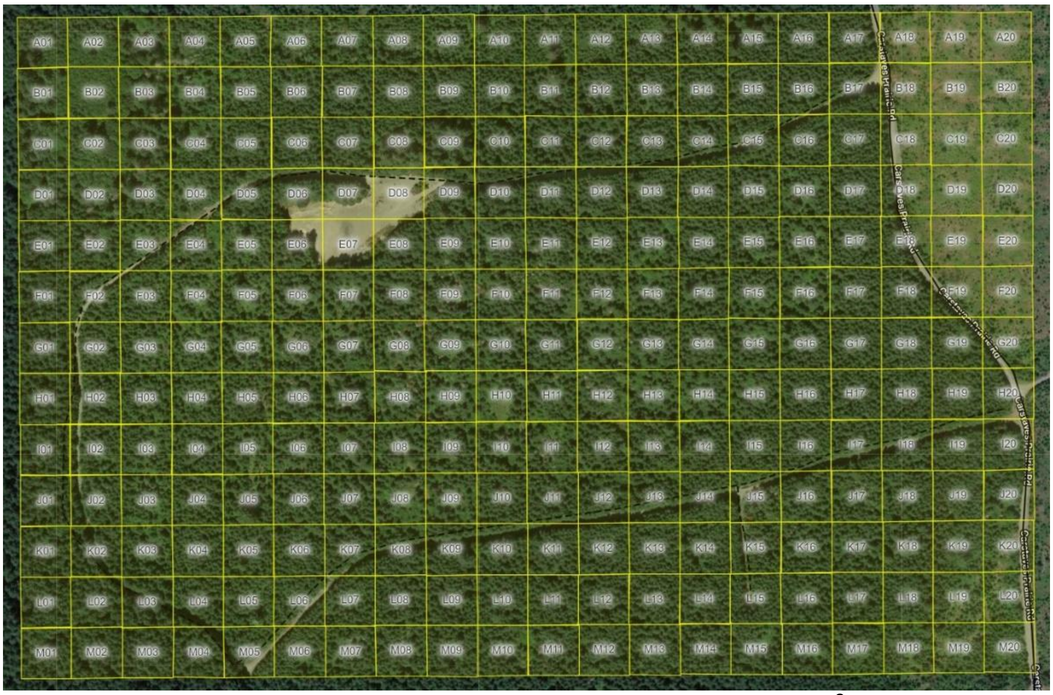


Figure 3: A 13 x 20 Grid of Uniform Segments[2].

Figure 3 shows a uniform grid of segments mapped over a 260-acre forested area that is to be searched for evidence in a homicide case. In the example shown, each grid segment is a 50-meter square, with an area of approximately 0.62 acres (about 0.25 hectares). While the size and number of grid segments can be varied depending upon the area and circumstances of each search incident, we have found 50-meter squares to be a suitable size for careful searching by both ground and K9 resources.

In traditional application of search theory to land searches, search segments inherit their POA and Pden from their parent planning regions. Segment POA is distributed in proportion to relative segment size, and segment Pden is uniform throughout a planning region (Hill, 2011). In the methodology that we describe, planning regions are not used, and segment POA is derived via a proportional consensus scoring process that takes into account criminal behavior and animal (scavenging) behavior. Because all search segments have the same size, Pden is simply POA divided by a constant segment area.

[2] Note: For confidentiality reasons, none of the maps presented show actual evidence search areas.

Once Evidence Probability Factors are represented on the map, each segment in the grid can be scored. We use a spreadsheet for this scoring process. If an advanced GIS application is available, this can be done programmatically. However, even in the absence of a GIS, segment scoring is quite feasible, particularly if the task can be distributed to multiple planners.

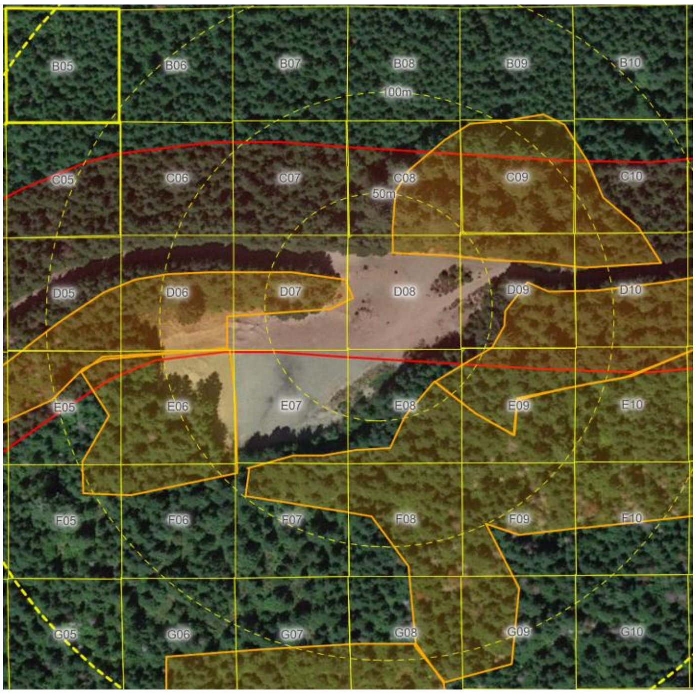


Figure 4: Uniform Grid with Underlying Mapped EPFs

Figure 4 can be used to illustrate how visual scoring of a search segment (in this example C08) is conducted by following simple rules: (a) Is C08 within the 50-meter range ring? Yes: Add appropriate score. (b) Is any portion of C08 within a road buffer (red polygon)? Yes: Add appropriate score. (c) Is any portion of C08 within a wooded area (orange polygon)? Yes, Add appropriate score.

As shown in Figure 5 (see Column B "SUM"), once every segment has been evaluated for every Evidence Probability Factor, each segment will have a cumulative score. This cumulative score is normalized (see Column C "POA") to yield a Probability of Area (POA) for each segment, thereby distributing 100% of probability across all of the search segments.

Figure 5 also illustrates two other features of the segment scoring process.

- Columns E through N show how segments accumulate scores for each applicable Evidence Probability Factor (indicated by blue shading). For example, the highest ranked segment (E09), was within 50 meters of primary evidence (designated as the IPP), was within 50 meters of a spur road, contained a wooded area, and was within 10 meters of a faint trail, and therefore accumulated points for each of these factors.

- Column C (POA) shows the cumulative score for Segment E09 normalized into a Probability of Area and color-coded for mapping.

The end-products of EPF-based scoring are:

1) Quantitative POA values as shown in Figure 5 Column C. These can be used to guide prioritization of search assignments, and in subsequent POD calculations.
2) A mapped thermal probability mosaic, as shown in Figure 6. Such “heat maps” or “choropleth maps” can be effective aids to visual interpretation of data sets (Tufte, 1990). In this context, our methodology shares some similarities with the RAG (Red Amber Green) approach (Donnelly, and Harrison, 2013; Ruffell and McKinley, 2017; Somma et al., 2018) in which multiple factors are systematically assessed to derive color-coded mapping of prioritization for locating clandestine graves.

A	B	C	D	E	F	G	H	I	J	K	L	M	N
	SUM	EPF Factor -->		0-50 m from IPP	50-100m from IPP	100-150m from IPP	150-200m from IPP	Dump Site	50m near minor road	10 m near stream or	Wooded Area	Depression or pit	Faint Trail
Grid Segment	102665	POA	Rank	451	296	225	138	301	381	207	257	241	252
E09	1340	1.31	2	451					381		257		252
D07	1340	1.31	2	451					381		257		252
D09	1340	1.31	2	451					381		257		252
E07	1340	1.31	2	451					381		257		252
C08	1340	1.31	2	451					381		257		252
C07	1185	1.15	7		296				381		257		252
C09	1185	1.15	7		296				381		257		252
D11	1114	1.08	9			225			381		257		252
E08	1114	1.08	9			225			381		257		252
E10	1088	1.06	11	451					381		257		
C10	1088	1.06	11	451					381		257		
E06	1084	1.06	13	451					381				252
D10	1084	1.06	13	451					381				252
D08	939	0.91	15					301	381		257		
D12	939	0.91	15					301	381		257		
C12	939	0.91	15					301	381		257		
D06	939	0.91	15					301	381		257		
E05	939	0.91	15					301	381		257		
D05	939	0.91	15					301	381		257		
C06	939	0.91	15					301	381		257		
C05	939	0.91	15					301	381		257		
F09	939	0.91	15					301	381		257		
F08	934	0.91	24		296				381		257		
E11	929	0.90	25		296				381				252
E04	929	0.90	25		296				381				252
D04	929	0.90	25		296				381				252

Figure 5: Example of Segment Scoring Spreadsheet (simplified for clarity)

Figure 6: Example of a Uniform Grid Thermal POA Mosaic (Red = High, Orange = Med-High, Yellow = Medium, Green = Med-Low, Blue = Low, Violet = Very Low)

Discussion

The use of a uniform grid to array search area probability is not a novel approach; it is a standard component of maritime search methodology. As shown in Figure 7 below, our approach differs in that where maritime searches employ agent-based modelling to derive POA (Grewe & Griva, 2024), we combine multiple probability models based on Evidence Probability Factors.

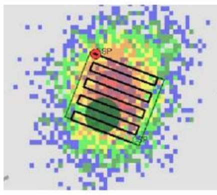
Type of Search	Probability Modeling	Quantification	Visualization
Maritime Search	Computed agent-based modeling incorporating LKP, wind, currents, etc.	• Probability of Containment • Probability Density • Probability of Detection • Residual Probability	Probability Mosaic 
Evidence Search	Evidence Probability Factors assigned values based on both objective data and expert consensus. Search segments scored based on cumulative EPFs.	• Probability of Area • Probability Density • Probability of Detection • Residual Probability	Probability Mosaic 

Figure 7: Contrasting Approaches to Quantification and Representation of POA.

Combining probability models to form an underlying probability mosaic is also not a novel approach. Koester and others (Sava, et al. 2015) have used GIS systems to develop probability mosaics for land SAR incidents. Koester has embedded this functionality (e.g., combining probability models for region POA consensus, distance from IPP, dispersion angle) into FIND software (www.findsar.com).

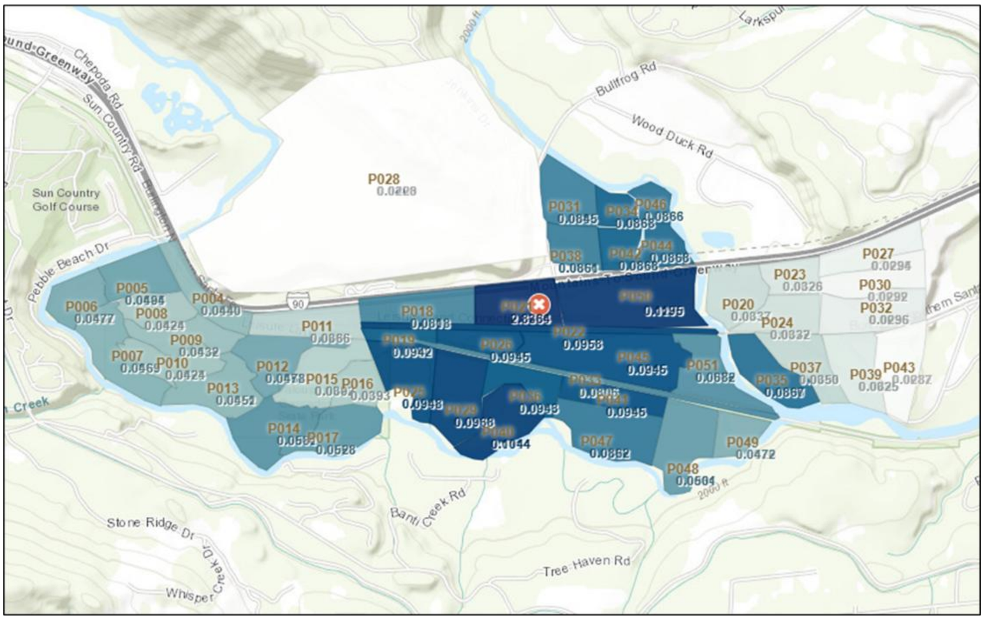


Figure 8: Pden Probability Model Produced by FIND Software.

Figure 8 above shows a Pden probability model produced by FIND software. The shading (darker colors indicate areas of higher Pden) are derived from combining probability models based on: (a) A proportional consensus of Planning Region POA; (b) Proximity to the IPP (location of an abandoned car indicated by the red "X" mark); and (c) Presumed direction of travel (based on found clues).

To date (and as our approach has evolved), we have applied components of our evidence search planning methodology to six searches of varying scale and nature, as summarized in Table 5.

Objective of the Search	Age of Evidence	Scale of the Search	Search Characteristics
Locate human remains or evidence from a child abduction/murder case.	9 years	Over 100 searchers	• Search area: 50 sq miles • Mixed forested terrain • Multiple operational periods
Locate human remains or evidence from a child abduction/murder case.	24 years	Over 60 searchers	• Search area: 32 acres • Forested terrain • Four operational periods
Locate clandestine burials or evidence from a murder case.	1-3 years	Over 50 searchers	• Search area: 150 acres • Wooded terrain • Five operational periods
Locate human remains or evidence from a child abduction/murder case.	14 years	Over 100 searchers	• Search area: 250 acres • Forested terrain • Three operational periods
Locate human remains or evidence in support of a criminal investigation.	1-3 years	Over 40 searchers	• Search area: 250 acres • Logged and wooded terrain • Two operational periods
Locate historical burial sites of American Indian children.	Over 150 years	4 K9 teams	• Search area: 50+ acres • Open grassy terrain • Two operational periods

Table 5: Our Methodology Has Been Applied to a Variety of Evidence Searches

While it would be highly desirable and valuable, a randomized control trial comparison of our EPF methodology (compared with a more standard method) would not be practical or feasible. In the future, a more formal evaluation may be possible using a methodology such as MapScore (Sava et al., 2016). While we must be circumspect with ongoing law enforcement investigations and due to cultural sensitivities, we can relate anecdotal examples of success with our approach.

An evidence search related to a child abduction and murder cold case

Mushroom hunters had located and reported a human skull found in a remote, heavily-forested area. The remains were identified as belonging to a child believed to have been abducted and murdered 15 years earlier. Terrain analysis, combined with assumptions about criminal behavior and animal behavior was used to distribute a POA model over the search area. After three operational periods, important evidence was located in a high-probability search segment.

A Human Remains Detection (HRD) K9 search for unmarked burial sites of American Indian Children

Against a background of growing national and international awareness (MMIWP Task Force 2023), and working directly with tribal representatives, we employed our EPF-based probability modelling to plan deployment of specially-trained HRD K9s in an effort to locate unmarked burials of Native American children at the site of the Fort Simcoe Indian Boarding School in Eastern Washington State. The K9s were initially deployed to high-probability areas, and in those areas, indicated with multiple "Trained Final Responses" signalling their detection of the faint odor of human remains.

Advantages

While our methodology provides no magic answers (e.g., "*Dig here and you'll find the body*,") it does offer a number of practical advantages.

(a) As shown in Table 5, this constellation of search theory concepts can be applied to incidents of different natures and scales, ranging from focused searches in small areas to wide-area searches involving a large number of searchers.

(b) Our method provides a way to incorporate the expertise of detectives, investigators, or other subject matter experts, while placing a low demand on their time. Once a list of Evidence Probability Factors is curated and valued, the downstream tasks of scoring segments and deriving segment POA are accomplished by planning staff.

(c) When criminal evidence is located and presented at trial, it can be important to provide an objective rationale for why one area was searched, and not another. Our approach provides a rationale that is objective and systematic, and moreover can be presented as based on standard search theory-based methods used for maritime searches.

(d) Planning in this approach blends input from subject matter experts with terrain analysis (via a systematic and transparent process) to yield objective values of initial POA and Pden for each search segment. When combined with capture of GPS tracks, (and estimates of sweep width) it is relatively straightforward to calculate Coverage, POD, and Residual POA after each operational period or search sortie.

(e) As shown in Figure 9 below, thermal color-coding based on our derivation of segment POA provides for easy-to-interpret visualization of initial POA/Pden (left panel) and residual POA/Pden (right panel) after searching.

(f) As alluded to above, the use of uniform search segment size allows for direct probability comparison based on POA -- although Pden can easily be calculated if prioritizing based on Probable Success Rate (Koester, Cooper, Frost, and Robe 2004) was desired.

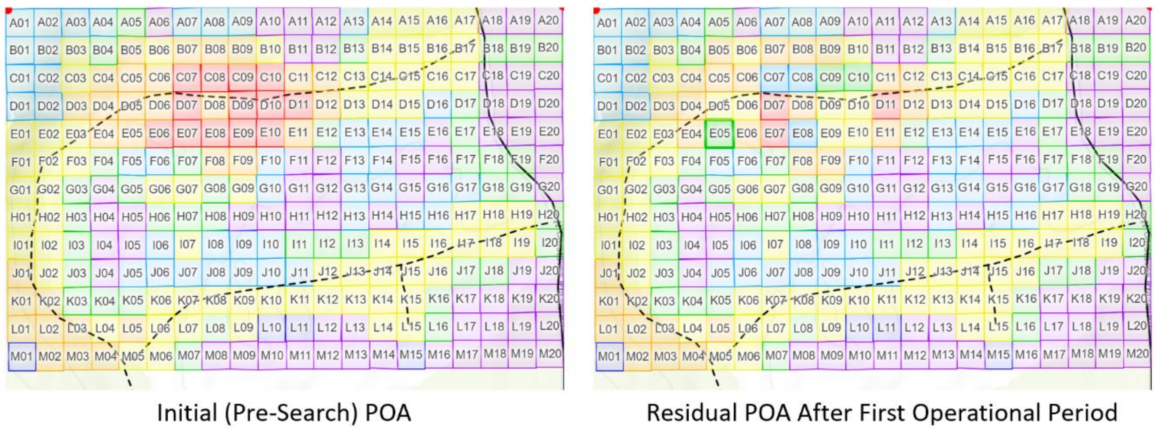


Figure 9: A Thermal Visualization of POA Before and After Searching

Limitations

(a) This method is practical with basic tools, and it is important to note that we found it feasible to develop and implement our approach with a well-designed SAR mapping program (SARTopo) and Excel spreadsheets. That being said, utilizing GIS tools would be likely to make it significantly more efficient.

Since our initial development, we have developed GIS-based tools that:

- Create a user-specified grid of uniform segments.
- Measure searcher track line length within each search segment.
- Calculate Coverage, POD, and Residual POA for each segment.
- Thermally color-code segments by Residual POA.

(b) When we first applied this approach to a search with a large number of segments, we were initially concerned when we noticed the low absolute values of POA, even for the high-ranking segments. This can be seen in Figure 5, where even the highest-ranked segments have a POA of only 1.3. Upon reflection, we realized that this was a natural result of distributing POA to a large number of segments. For comparison purposes, consider a normal wilderness search with 10 regions, each divided into 10 segments. For such a search, average region POA would be 10 and average segment POA would be 1.0.

It is the relative differences between segment POAs (not the absolute values) that are important. In Figure 5, for example, it can be seen that the average POA for Medium-High segments (orange) is about 65% of the average for the High POA (red) segments.

(c) General conceptual models of criminal and animal behavior may provide only coarse input for probability modelling. These can and should, when possible, be augmented with incident-specific information. Consider for example, modelling how far a criminal might move a body from a road in order to conceal it. While there are historical data from past cases (Koester, 2016) that can be used as a guide, if it would be important to also consider the stamina, motivation, available time, past behavior, (if that information is available) for a specific subject.

Similarly, while it is possible to model general animal scavenger behavior, if local scavengers can be identified (e.g., have there been coyotes in the area?) then modelling can be sharpened (Hagland & Sorg, 1997) to reflect the behavior of those animals (e.g., coyotes are known to move along fence lines).

Conclusions

In conclusion, we present a practical application of search theory methods for planning evidence searches. The method can be implemented using basic mapping and spreadsheet tools, and yields a systematic and objective derivation of search segment POA and Pden. The Evidence Probability Factor / Uniform Grid method is analogous to how search theory is currently applied in the maritime environment. Where the U.S. Coast Guard uses computers to model object drift and movement, we use a manual approach to blend subject matter expert input with terrain analysis to derive a probability mosaic. This uniform grid probability mosaic can be used to guide prioritization of search assignments and increase the efficiency and success of evidence searches.

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Abbreviations

EPF	Evidence Probability Factor
GIS	Geographic Information System
GPS	Global Positioning System (can also refer to a handheld GPS device)
HRD	Human Remains Detection
IPP	Initial Planning Point
MMIWP	Missing and Murdered Indigenous Women and Persons
Pden	Probability Density
POA	Probability of Area
POD	Probability of Detection

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Letter To the Editor: Australian Search Urgency Assessment Form

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Abstract

The Australian Search Urgency Assessment (SUA) form is used by search coordinators as a means of determining the level of response to a Search and Rescue (SAR) incident.

A recent inquest into the death of a young snowboarder and the use of the SUA highlighted the need for this form to be regularly revisited during the search operation, particularly as the situation and circumstances change.

A regular review of the SUA during the incident would have identified the increase in urgency, and subsequent response, as the incident evolved.

KEY WORDS: *Search Urgency Assessment; Search; Resource activation; Urgency*

Background

Throughout Australia land search and rescue is a responsibility of the police in each state/territory, as outlined in Appendix B of the National Search and Rescue Manual (Whitehead. J. 2023). To ensure compliance with this responsibility each police jurisdiction has a section of trained and experienced search coordinators.

The Australian Search Urgency Assessment (SUA) form was initially developed for two purposes: to provide the SAR coordinator with a method of determining the urgency of the SAR incident, and as a driver for the allocation and deployment of SAR resources. The form has undergone several iterations since it was originally adopted by the National Search and Rescue Council in 2008 and was subsequently included in the National Search and Rescue Manual as part of appendix E (Whitehead. J. 2023)

The SUA form is primarily for land based SAR incidents. There is a marine equivalent, but in reality, any incident involving water and vessels could be considered an urgent response due to the limited survivability of people in water.

The current SUA is reproduced below. The form is self-explanatory, with the SAR Coordinator making subjective judgments of the eleven categories based on inquiries made with the missing person’s family, friends and colleagues as well as the environment and person knowledge and experience.

Each of the categories is given a score in the right hand column. The total score is added up, providing a guide to the urgency of the situation. The bottom of the form identifies that a score of between 11 and 17 requires an urgent or emergency response. A score of 11 would be the absolute worst case scenario and often relates to missing children, the elderly or those who may be in immediate danger or distress. These people require direct assistance to be located, recovered or both.

A score of 18-27 indicates a measured response, that the target lost person is not in immediate danger or distress but, nonetheless, will need assistance. Based on the scenario, that could be a first light search, a reflex search or a formal search.

A score of 28-39 suggests further evaluation and investigation. These incidents are similar to being overdue from an activity or missing a scheduled communication. The target lost people may not be lost or in need of assistance and may be adequately prepared for that eventuality. Extended communication searches and further information gathering may resolve these types of situations.

It is also very clear at the bottom of the form that if a single '1' is scored in any category it elevates the response to an emergency situation. A quick perusal of the form shows that those sub-categories associated with a score of one all have the potential to put life at risk, hence the increased urgency of the situation.

The Incident:

Kosciusko National Park is approximately 6,900km² in area and is part of the Great Dividing Range that parallels the east coast of Australia. The park straddles the New South Wales and Victorian border and represents the northern limit of the alpine area, being covered with snow for about six months each year.

A young male snowboarder had driven to a carpark in the Kosciusko National Park on a Friday evening in preparation for an early start the following morning. His intentions were to snowboard in the back country of the park and return to his car at the end of the day, Saturday. The 'back country' relates to the remote areas on the western side of the park, a significant distance from the normal ski routes and tracks to Mt Kosciusko. That particular area was basically an escarpment with a variety of chutes and valleys to ski or snowboard down. Once in that area there is no mobile telephone coverage and few other people.

The missing person (MP) was very well equipped for this activity, having good warm clothing with sufficient food and water for the day. He was experienced in the area he was going to, having been there several times before. The MP also carried an avalanche beacon and a Personal Locating Beacon (PLB) in case of emergency. Prior to entering the mobile telephone black spot, the missing person sent a message to his girlfriend. This was the last communication he had. The MP did not carry any camping equipment as he had no intention of spending the night on the snow fields, in fact he did not like camping out in any environment. The MP failed to return to his car and also failed to make any telephone calls to his mother and girlfriend alerting them to his return, which was his normal practice.

The MP was reported as a missing person on the Saturday evening. After numerous conversations with the family a SUA was completed. The original score was 29, an evaluate and investigate situation, but there was a single category score of ‘1’ because the MP was alone. It subsequently transpired during the evidence given at the Inquest that this SUA was based on the information provided by the family and girlfriend. It was agreed that a score of ‘29’ was appropriate for the activity the MP was undertaking based on the family profile. As a result of this score there was no immediate search activated and further inquiries were made during the following day, Sunday.

The Inquest:

The National Search and Rescue Manual is the single point of reference for search operations throughout Australia. This manual is not only used by Search and Rescue (SAR) Coordinators but is a reference tool regularly consulted by Coroners when investigating unusual or unnatural deaths during SAR incidents. Any amendments to the manual are reviewed to ensure they do not alter or contradict existing content before they are forwarded to the National Search and Rescue Council for adoption in September/October of each year. The updated version of the manual is then published by the Australian Maritime Safety Authority the following February.

Coronial Inquests are held to investigate the circumstances surrounding any unnatural or suspicious death in Australia. The intent of an inquest is to identify a suspect if the death was suspicious or to review legislation, policies and /or procedures relating to the activities being conducted or of any subsequent search. This Inquest was held two years after the event, and took evidence from a variety of witnesses and experts (O’Sullivan, 2024). One aspect that was spotlighted was the delay in commencing a search, and the crux of this was the SUA form.

One of the SUA form’s biggest strengths is also its biggest weakness. When initially used the form provides a snapshot of the incident from the point of view of the response. While a situation may remain the same throughout the entire incident it was highlighted during the Inquest that where the situation changes, the SUA form should be revisited and any new score acted upon. In this instance the initial score of ‘29’ was appropriate for the MP’s activity, although it could be argued that there were known hazards in the form of crags, hidden obstacles and a steep escarpment in the area the MP was snowboarding.

Because of a lack of either an emergency mobile telephone call or activation of the PLB, the false assumption was made that the MP had decided to camp out overnight. This was despite the mother and girlfriend strongly asserting that the MP never camped out as he did not like to do so. As a result, the opportunity to initiate a first light search was not followed up.

That the MP failed to return to his vehicle that day, had made no mobile telephone communication nor had he activated his PLB changed the complexion of the situation and should have prompted a review of the SUA. It was not known what had happened to the MP to cause him not to return to his car as planned, but there were a number of possible scenarios that could have occurred. The MP may have become lost and unable to return to the carpark or the MP may have had an accident, or worse, that prevented him for activating his PLB. Other scenarios were considered such as camping out, going home with someone else, or making it to another location and staying overnight. These options were put to the family who strenuously identified that they were all out of character for the MP (O'Sullivan. T. 2024).

With the situation changed it would have been opportune to revisit the SUA. At the worst case scenario, it would have identified that the MP was still alone, there were known hazards in the area with the extremely low temperatures and snow/ice, the MP was not adequately clothed for a sub-zero night out and that he did not have shelter or means of constructing it. This would have had the effect of lowering the total SUA score with multiple number '1' scores. This would become an emergent situation, requiring an immediate response.

To temper this, police are all too often faced with family members who either under or over exaggerate a missing persons ability. This has the effect of distorting the missing person profile developed by police and it is often days later that the actualities of the situation become evident. The police are therefore faced with a dilemma of either initiating an unnecessary search or not initiating search when one is needed. It is often all too easy to criticise either action.

It was not until the Sunday night when the MP still had not returned to his car that the situation was deemed urgent. The search in this incident did not actually start until the Monday morning, a further delay of 24 hours. The MP was located by helicopter just before noon. He was in a precarious section of a narrow snow and ice chute. Photographic and video evidence was recorded as a recovery was unable to be performed at that time due to the location and weather. Medical advice suggested that the MP was deceased.

The point being that SAR incidents are often fluid in nature, and as SAR coordinators continually gather information throughout the incident they should also review the SUA form, particularly when things occur that are out of character or were not anticipated and planned for by the missing person.

Conclusion:

In order to provide guidance to SAR Coordinators a recent amendment to the SAU form has been adopted by the National SAR Council. The amendment reminds coordinators to consider the entirety of the incident when making an assessment and to revisit the form at least as often as a review of search areas is undertaken.

With respect to gathering information, police are very adept at this and in criminal matters often rely on body language of a suspect to guide questioning. Within SAR this is no different. The visual and verbal clues given by family and friends can often provide a very good indication of the extent of the worry and concern being felt by the family, and therefore the response required.

Any tool, as is the SUA, is only as good as the user. Continued use of the form will increase experience and boost confidence in its use.

References

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Biography

Retired Senior Sergeant Dr Jim Whitehead APM PhD had been a police officer with the Queensland Police Service for 39 years, 34 of which he has been involved in Search and Rescue (SAR). He was the State Search and Rescue Coordinator & Training Officer being responsible for managing the SAR system in Queensland. In his time he was involved in over 15,000 SAR incidents resulting in over 24,000 lost and missing people being located. He is experienced in both the practicalities and teaching of SAR and holds numerous qualifications in the SAR field. He has taught SAR to police in all Australian States/Territories, New Zealand, Papua-New Guinea, Solomon Islands, Indonesia, Sri Lanka, Maldives and the Seychelles.

He is currently an expert witness for Coroner's Court with respect to SAR and missing people.

Appendix E-1 Search Urgency Assessment Form:

Search Urgency Assessment

Name of Incident:			**No:**
Date Completed:	**Time Completed:**	**Initials:**	**Incident Date:**

Number of subjects		
1 person	1	
2 people or 3 or more –separated	2	
3 people or more – together	3	
Age		
Very young	1	
Other	2-4	
Very Old	1	
Medical Condition		
Known illness or requires medication	2	
Suspected illness or injury	1	
Healthy	3	
Known frailty	1	
Potential vision impairment	1	
Intent		
Suicidal	1	
No known intent	3	
Absconder from facility	4	
Cognitive Capacity		
Dementia / Alzheimer's /Parkinson's	1	
Capacity of 16 year old or less	1	
Diagnosed mental illness, depression or anxiety	2	
No known capacity issues	3	
Experience profile (See notes)		
Not experienced, not familiar with area	1	
Not experienced – familiar with area	2	
Experienced – not familiar with area	3	
Experienced – familiar with area	4	
Physical Condition		
Unfit	1	
Fit	2	
Very fit	3	
Clothing profile (See notes)		
Inadequate/insufficient	1	
Adequate	2	
Very good	3	
Equipment Profile (See notes)		
Inadequate for activity/environment	1	
Questionable	2	
Adequate	3	
Very Well equipped	4	
Weather profile (See notes)		
Existing Hazardous weather	1	
Hazardous forecast (8 hours or less)	2	
Hazardous forecast (more than 8 hours)	3	
No hazardous weather forecast	4	
Terrain and Hazards profile (See notes)		
Known hazards	1	
Difficult terrain	2	
Few hazards	3	
Easy terrain, no known hazards	4	
11-17 Emergency Response 18-27 Measured response 28-39 Evaluate & Investigate		
Note: If **any individual category** above is rated as **ONE (1)**, regardless of its total – the search requires an emergency response until the contrary is proved.		
Remember: the lower the number the more urgent the response!!!		