



# Lost Person Behavior – The Science of Search and Rescue



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Robert Köster





# What is Lost Person Behavior?

- A book or app
- Results of a large database (ISRID)
- Development of individual behavior profile
- Development of general subject category
- A set of Statistics, circles on a map
- Behaviors of lost people
- Scenario Analysis



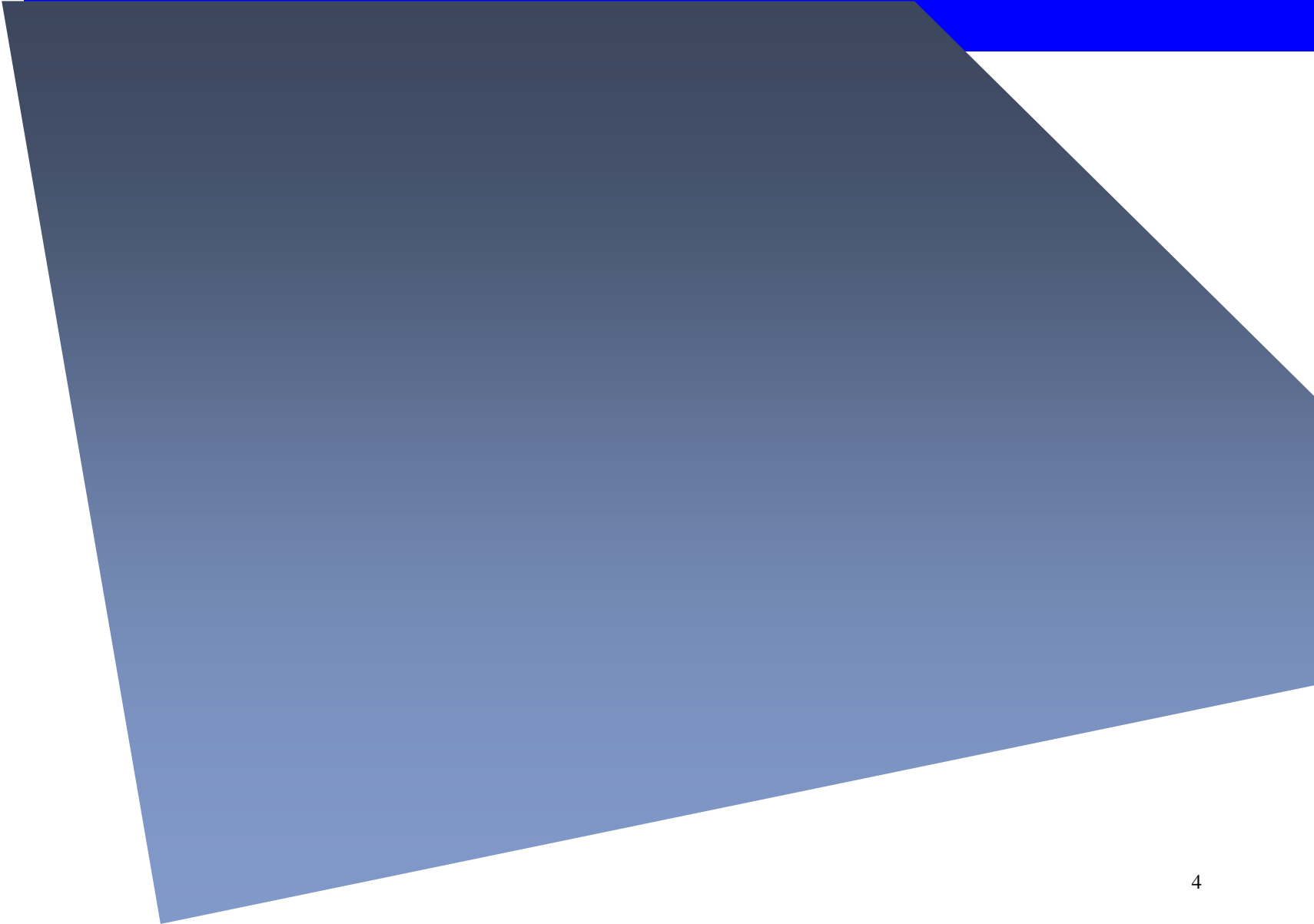
# Missing vs Lost

## Missing Person

- Abductions
  - Trafficking
  - Stranger
  - Family
  - Honor
- Asylum-seeking
- Runaways
- Throwaways
- Forced Marriage
- Mental health

## Lost Person (outdoors)

- Avalanche
- Criminal
- Despondent
- Drowning
- Investigative
- Lost
- Medical
- Overdue
- Stranded
- Trauma





# Where are my keys!

- Investigation
  - Determine PLS
  - Determine where should be
  - Retrace steps using memory
- Hasty search those locations
- Scenario Analysis
- ISRLKD
- Hasty search – Investigation + Stats
- Saturation Searches



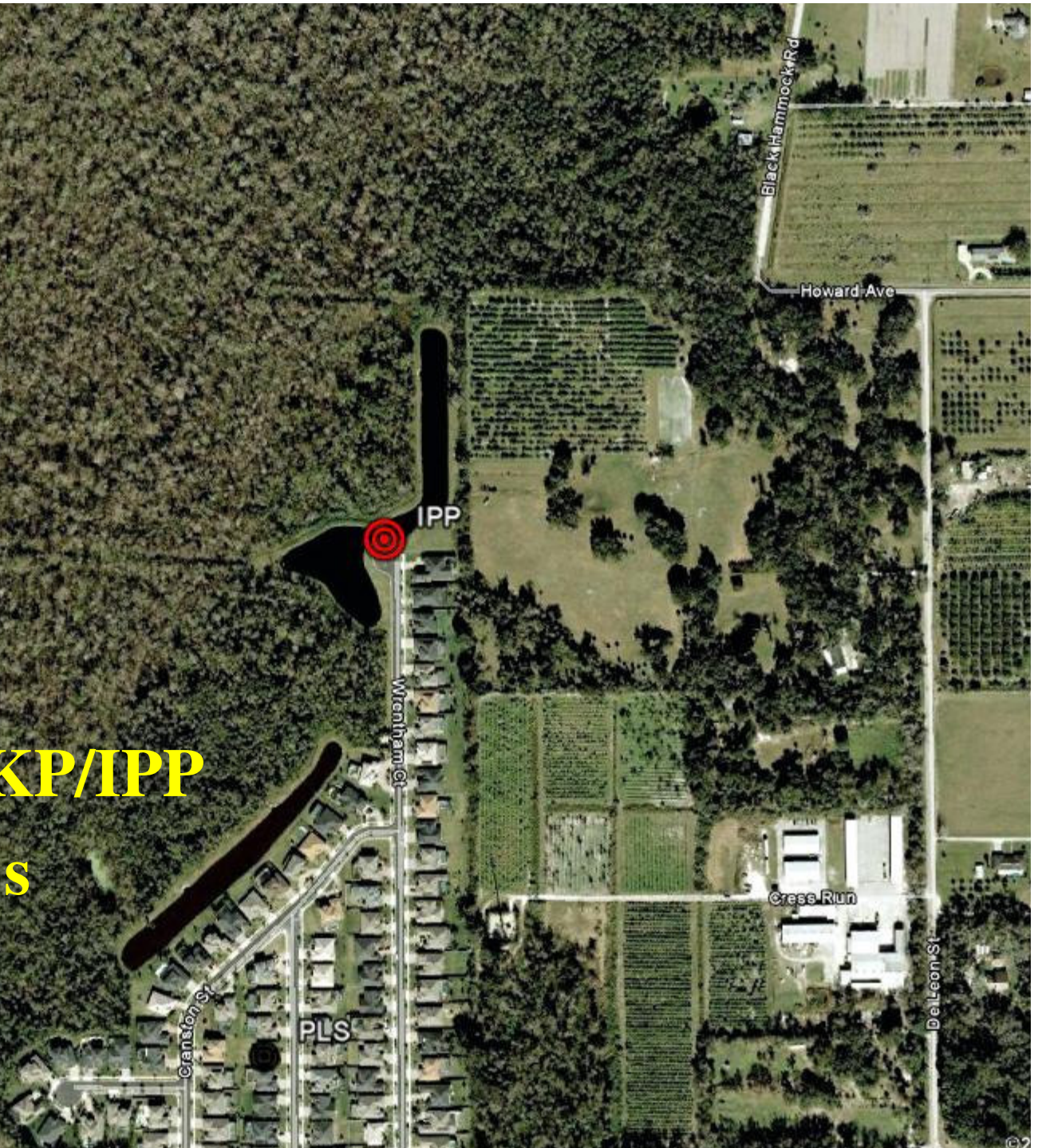


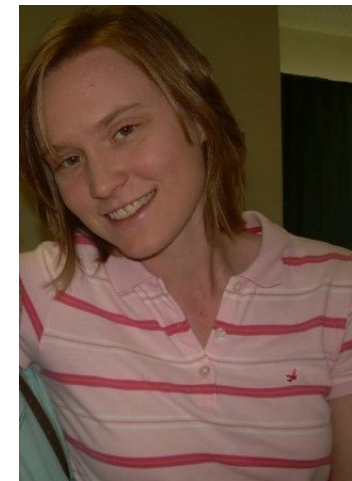
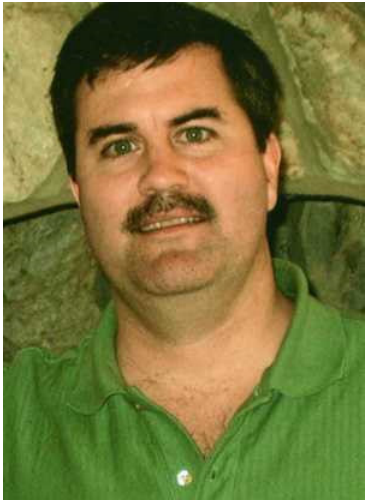
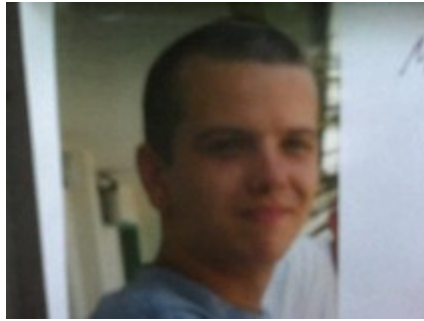
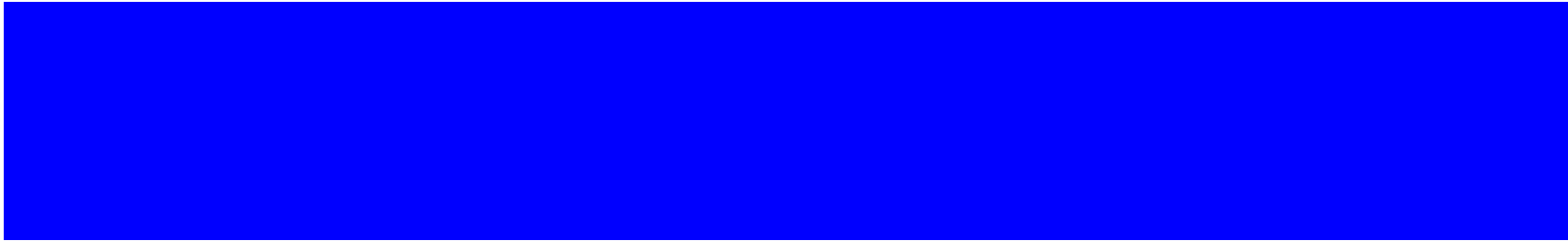
# Approaches to POA

- Subject Matter Expert
- Stochastic
- Agent Based Modeling
  - ✓ SAROPS
  - ✓ LandSAR
  - ✓ Many others but not ready for prime time
- Ensemble



- Age 11
- Bike at LKP/IPP
- Asperger's



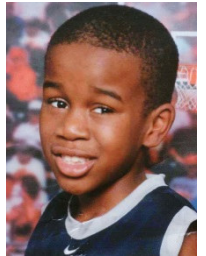






# Collection of Incidents

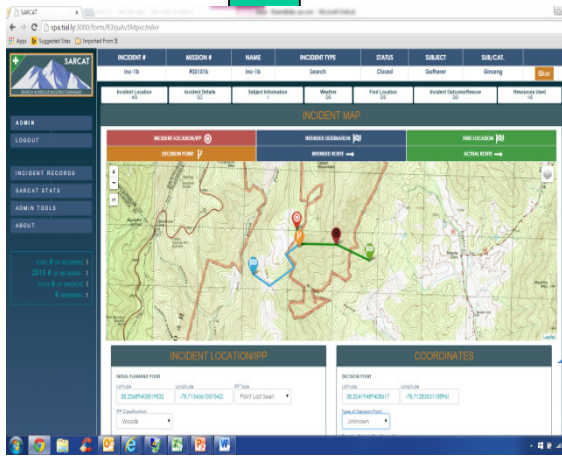
1	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
	Data Source	Key#	Mission #	Incident Date	City	County	EcoRegion Domain	EcoRegion Division	Population Density	Terrain	Incident Type	Subject Category	Subject Sub-Category	Scenario	Subject Activity	Age	Sex	Number Lost	
739	NZ	NZ-1504	06302817	5/9/2004	Wellington	Wellington	Temperate	230	Wilderness		Search	Autistic	Child	Lost	Walkaway	6	M		
740	NZ	NZ-1573	07152938	7/15/2005	Hson Bays	Tasman	Temperate	230	Urban	Flat	Search	Autistic	Child	Lost	Walkaway	7	F	1	
741	NZ	NZ-1585	07202962	8/5/2003	Wellington	Wellington	Temperate	230	Urban	Hilly	Search	Autistic	Autistic		Lost	Walkaway	15	M	1
742	NZ	NZ-1756	08253089	8/24/2005	Wellington	Wellington	Temperate	230	Wilderness	Hilly	Search	Autistic			Lost	Walkaway	18	M	1
743	NZ	NZ-1786	09243162	8/26/2005	Waitakere	Waitakere	Temperate	230	Rural	Flat	Search	Autistic	Youth		Lost	Walkaway	13	M	1
744	NZ	NZ-2053	01263679	1/23/2006	North City	Central	Temperate	230	Urban	Flat	Search	Autistic	Child		Lost	Walkaway	8	M	1
745	UK	UK-0200	9875		MRC		Temperate	M240	Wilderness	bountainous	Search	Autistic			Lost	Walkaway		M	
746	UK	UK-0215	9922		MRC		Temperate	M240	Wilderness	bountainous	Search	Autistic			Lost	Walkaway		M	
747	UK	UK-0286	10373		MRC		Temperate	M240	Wilderness	bountainous	Search	Autistic	Child		Lost	Walkaway	4	M	
748	UK	UK-0535	12565		MRC		Temperate	240	Urban	Flat	Search	Autistic	Child		Lost	Walkaway	10	M	
749	UK	UK-0611	-42		ALSAR		Temperate	240	Urban	Flat	Search	Autistic			Lost	Walkaway		M	
750	US-AZ	US-AZ0125	223	#####		PIMA	Dry	320	Suburban	Flat	Search	Autistic	Youth		Lost	Walkaway	13	M	1
751	US-AZ	US-AZ0142	244	12/7/2005		PIMA	Dry	320	Suburban	Flat	Search	Autistic	Child		Lost	Walkaway	10	M	
752	US-CAc	US-CAc0011	99011	2/25/1999		Contra Costa	Temperate	M260		Mountainous	Search	Autistic			Walkaway				
753	US-CAc	US-CAc0130	01-010	3/6/2001		Contra Costa	Temperate	M260		Mountainous	Search	Autistic			Walkaway		21		
754	US-CO	US-CO0571	571	3/18/1996	RA RIVER	CHULETA	Dry	M330	Wilderness	bountainous	Search	Autistic	Child	Medical	Wandering				
755	US-ID	US-ID0215	4	5/1/2005		Jerome	Dry	340		Hilly	Search	Autistic						1	
756	US-ME	US-ME0096	B17-91-04	12/6/2003	Woolwich	Sagadahoc	Temperate	210		Hilly	Search	Autistic	Child				6	M	1
757	US-NM	US-NM0804	00-06-07	10/9/2000		6	Dry	M310	Wilderness	bountainous	Search	Autistic			Lost	Hiking		M	2
758	US-OR	US-OR3020	000-1743	7/27/2000		Benton	temperate	m240		mountainous	Search	Autistic	Youth				16	M	
759	US-OR	US-OR3168	000-2176	9/11/2000		Wasco	temperate	m240		mountainous	Search	Autistic	Child				8	M	
760	US-OR	US-OR3226	000-2366	10/1/2000		Wasco	temperate	m240		mountainous	Search	Autistic	Child				8	M	
761	US-OR	US-OR4954	002-1623	7/4/2002		Clackamas	temperate	m240		mountainous	Search	Autistic	Child				6	M	
762	US-OR	US-OR5665	003-0364	2/14/2003		Clackamas	temperate	m240		mountainous	Search	Autistic	Child				6	M	
763	US-OR	US-OR6076	003-1947	9/2/2003		Yamhill	temperate	m240		mountainous	Search	Autistic	Child				10	M	
764	US-OR	US-OR6371	004-0117	1/14/2004		Clackamas	temperate	m240		mountainous	Search	Autistic	Youth				15	M	
765	US-OR	US-OR6684	004-1307	6/19/2004		Clackamas	temperate	m240		mountainous	Search	Autistic	Youth				13	M	
766	US-OR	US-OR7511	06-0953TP	4/6/2006		Jackson	temperate	m260		mountainous	Search	Autistic	child		Walkaway		4		1
767	US-PA	US-PA0566	Logantree	10/18/200	4														
768	US-PL	US-PL0055	56	5/22/2002	hesapeake	VA	Temperate	230	urban	Flat	Search	Autistic			Walkaway		47	M	1
769	US-PL	US-PL0076	77	#####	hesapeake	VA	Temperate	230	urban	Flat	Search	Autistic	Child		Walkaway		11	M	1
770	US-PL	US-PL0189	190	6/4/2005	Blacksburg	VA	Temperate	m220	Suburban	Hilly	Search	Autistic	Child		Walkaway		10	F	1
771	US-PL	US-PL0249	250	5/23/2005	Norfolk	VA	Temperate	230	urban	Flat	Search	Autistic			Walkaway		22	M	1
772	US-PL	US-PL0250	251	4/15/2005	Norfolk	VA	Temperate	230	urban	Flat	Search	Autistic			Walkaway		22	M	1
773	US-PL	US-PL0251	252	2/1/2005	Norfolk	VA	Temperate	230	urban	Flat	Search	Autistic			Walkaway		22	M	1
774	US-PL	US-PL0286	287	6/14/2005	alamazoo	MI	Temperate	220	Rural	Hilly	Search	Autistic	Child		Walkaway		7	M	1
775	US-PL	US-PL0289	290	5/11/2004	Roanoke	VA	Temperate	m220	urban	Hilly	Search	Autistic	Child		Walkaway		10	M	1
776	US-PL	US-PL0314	315	5/17/2005	King	WA		240	Suburban	Hilly	Search	Autistic	Youth		Walkaway		13		1
777	US-VA	US-VA0156	02-051	5/1/2002		Pittsylvania	Temperate	230	Rural	Hilly	Search	Autistic			Walkaway		28	M	1
778	US-VA	US-VA0235	03-144	9/9/2003		Clarke	Temperate	M220	Rural	bountainous	Search	Autistic			Walkaway		36	M	1
779	US-VA	US-VA0961	98-115	9/11/1998		Warren	Temperate	M220	Rural	bountainous	Search	Autistic			Walkaway		26	M	1
780	US-VA	US-VA1190	VA-986	9/9/2003		Clarke	Temperate	M220	Rural	bountainous	Search	Autistic			Walkaway		36	M	1
781	US-WA	US-WA0396	03-2139	8/25/2003		skagit	Temperate	m240	Urban	Flat	Search	Autistic	Child	Wandering			8	M	1



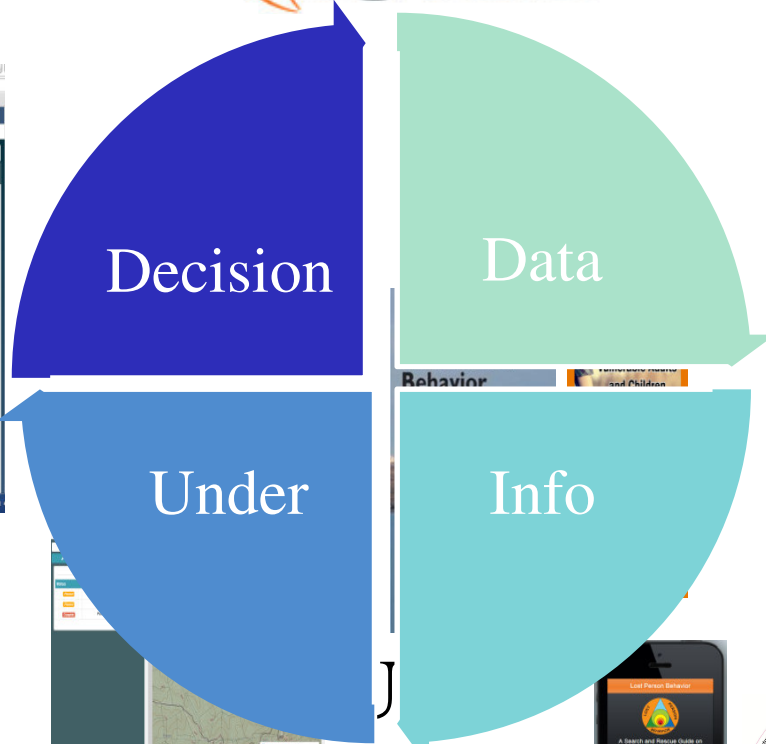
**Some of this work was supported  
with funding from the Science and  
Technology Directorate of the  
United States Department of  
Homeland Security**



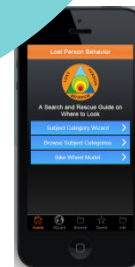
# Lost Person Locator Project



SARCAT



Products

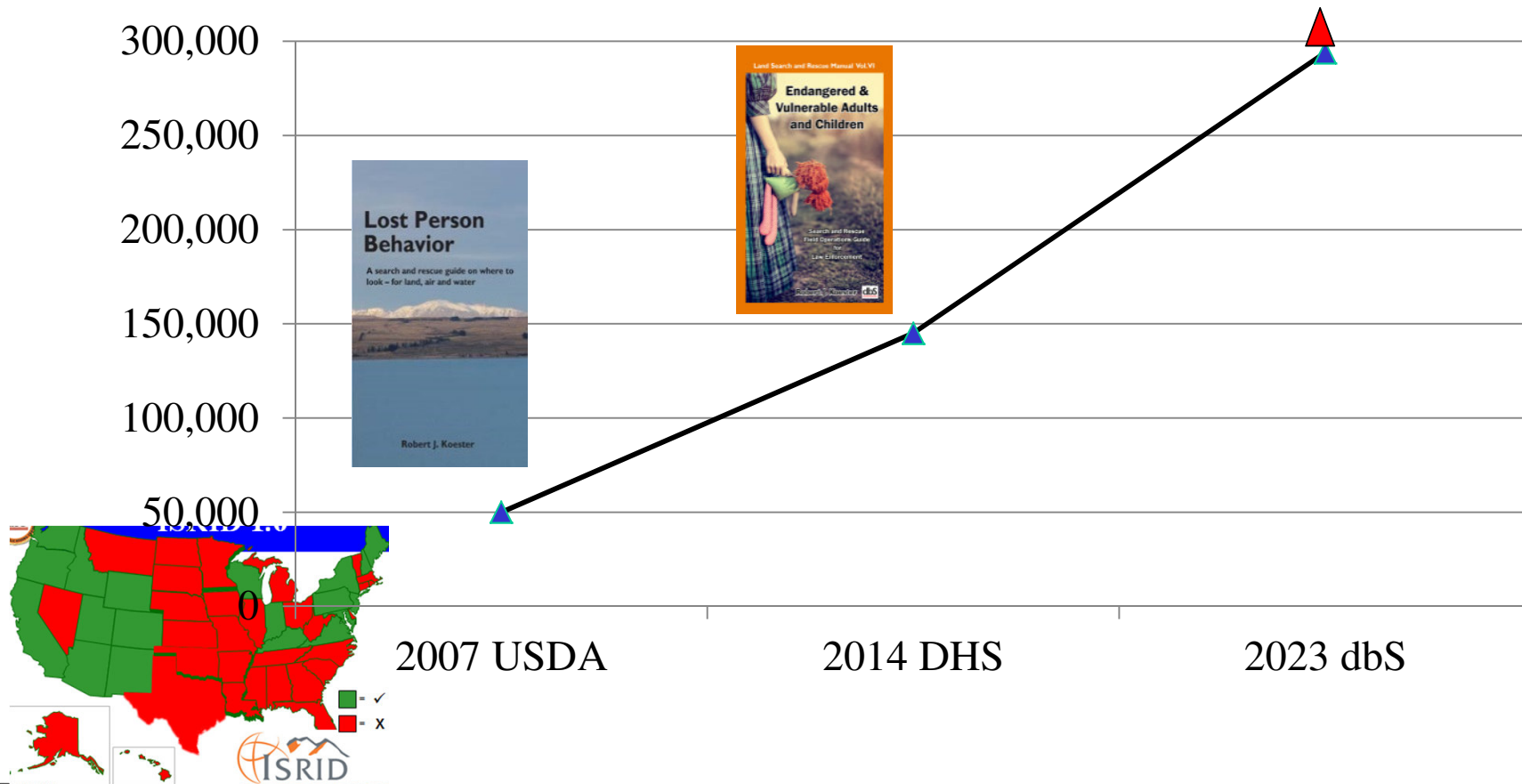


Summary  
Statistics



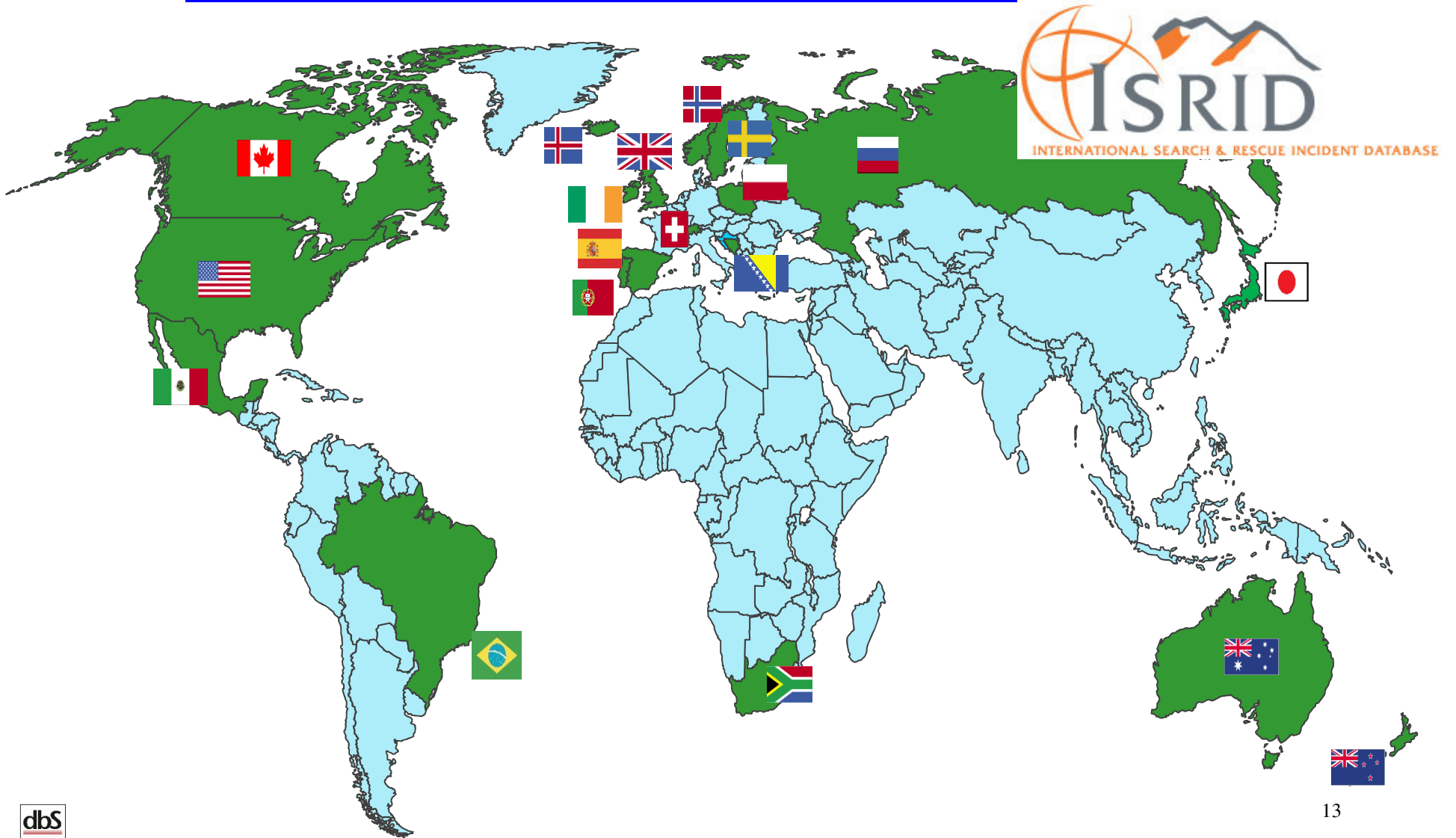
# 2. ISRID 1-3

## # of Incidents in ISRID



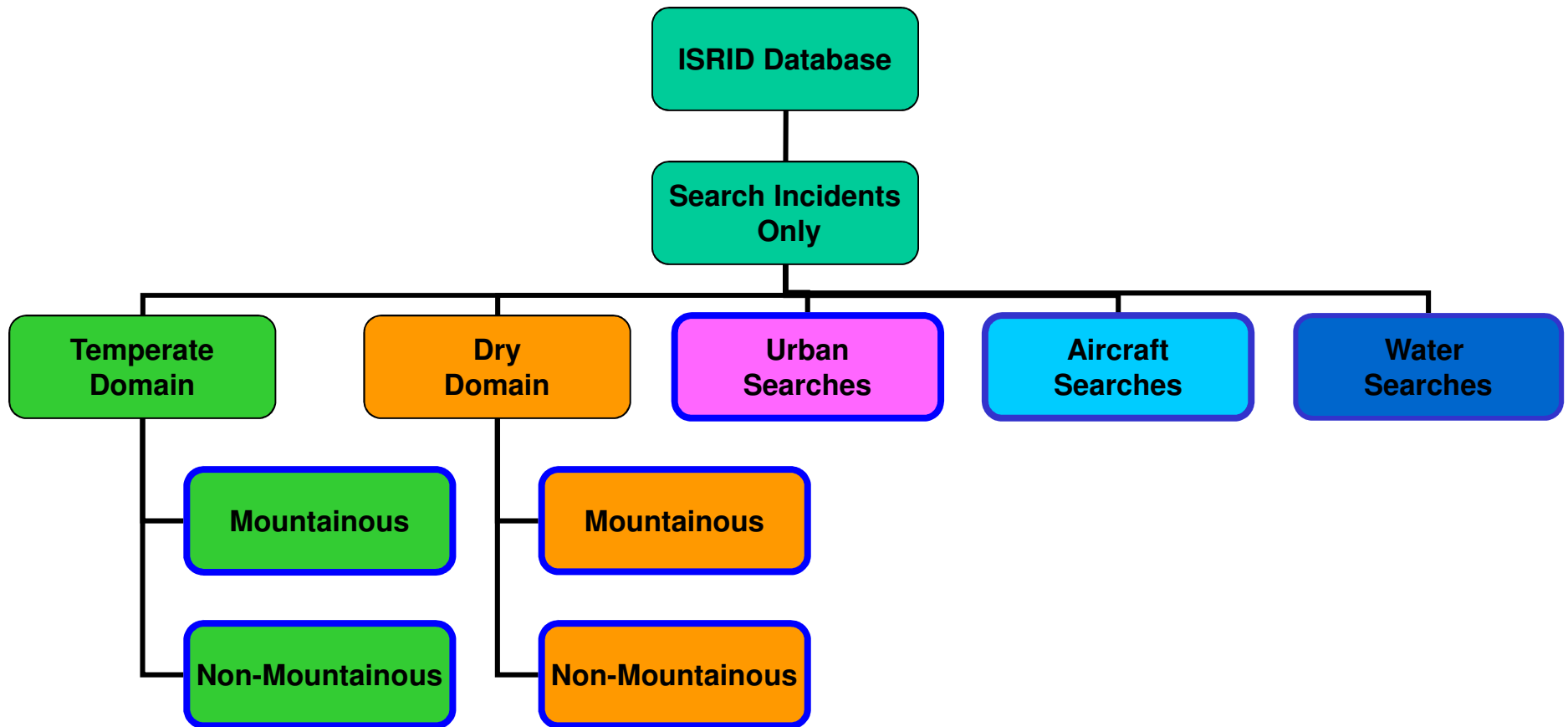


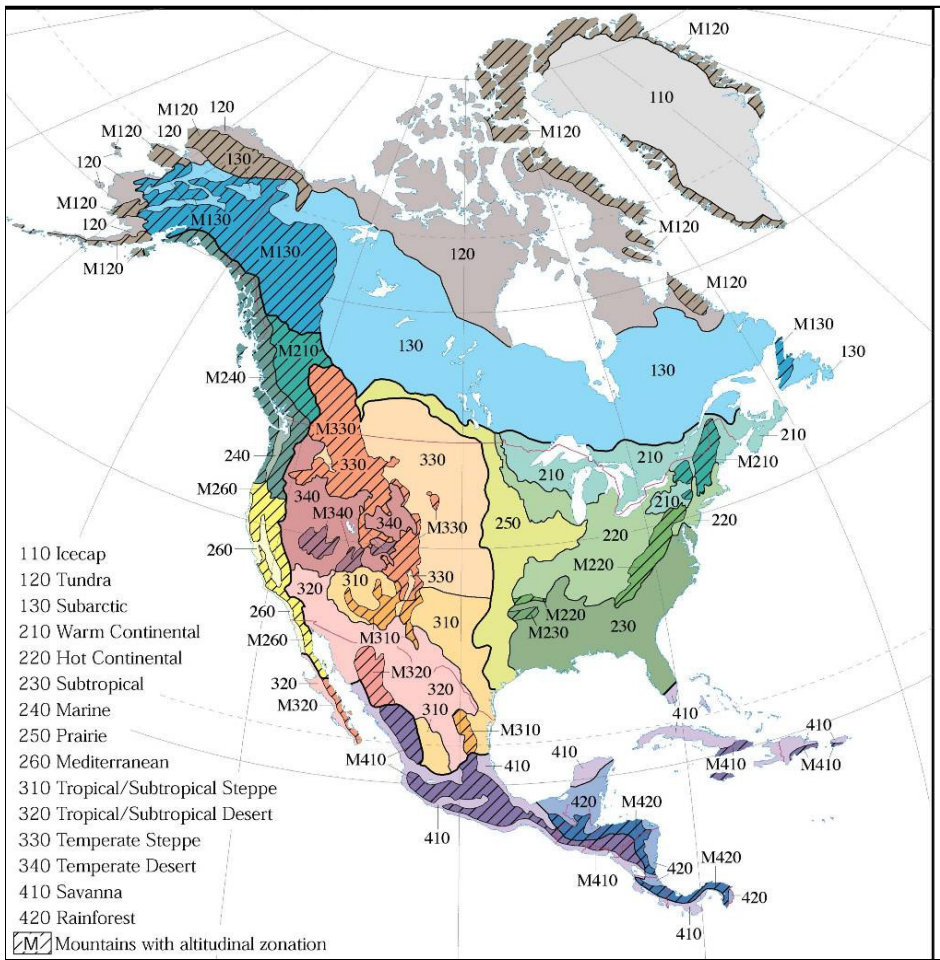
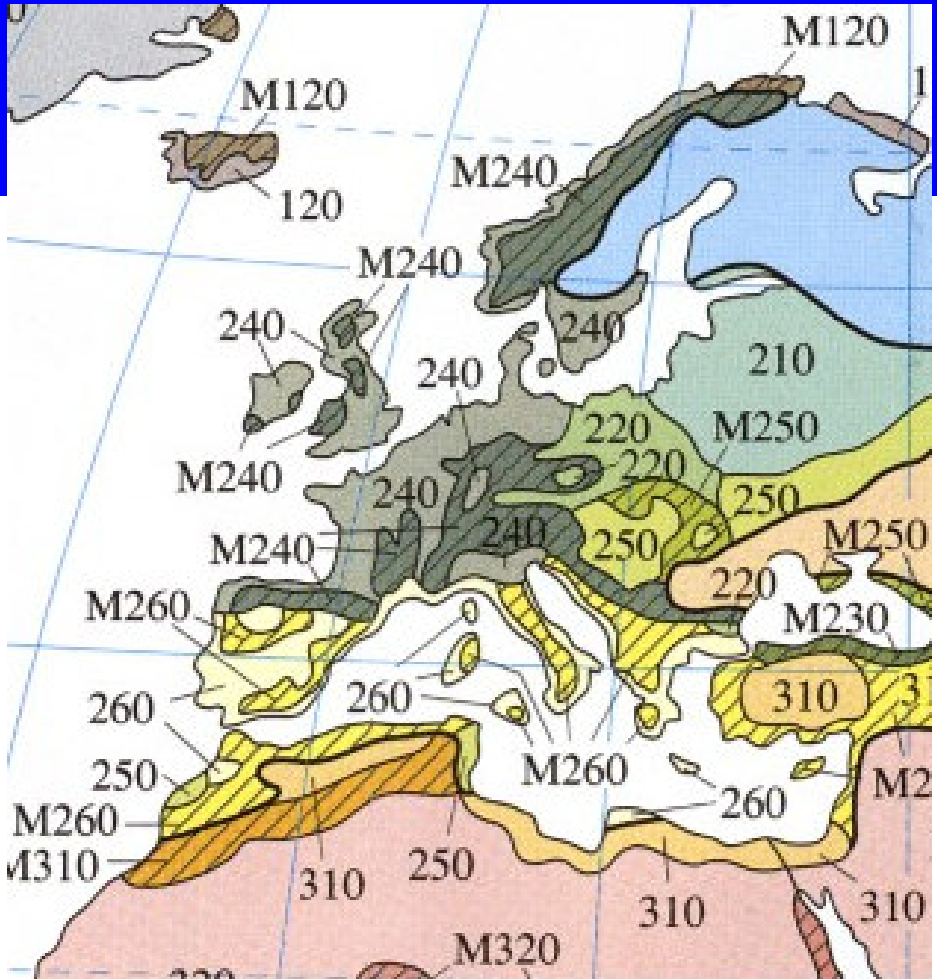
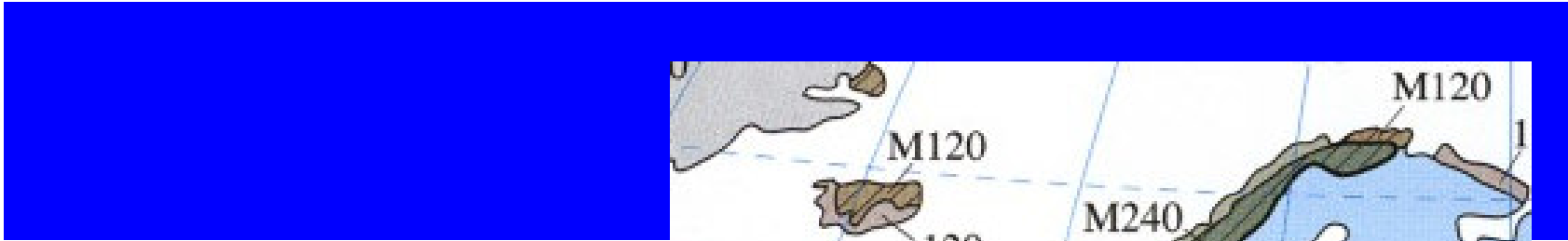
# Country Contributors





# Reporting System







# Need for more data

- 75 Subject categories
  - 15 Ecoregion divisions
  - 2 terrains
  - 4 population densities
  - 9 age brackets
  - 5 group types
  - 4 seasons
  - 3 light conditions
- 4.9 Million combinations  
X  
= 30 cases





# Current Categories

- **Abduction (735/92)**
- **Aircraft (1551)**
- **Angler (1016)**
- **ATV (995)**
- **Autistic (124)**
- **Camper (727)**
- **Caver (254)**
- **Child (1594)\* +**
- **Climber (1984) +**
- **Dementia (1051)**
- **Despondent (962)**
- **Gatherer (213)**
- **Hiker (3837)\***
- **Horseback (105)**
- **Hunter (2230)\***
- **Mental Illness (180)**
- **Intellectual Disability (MR) (263)**
- **Mountain Biker (343)**
- **Other (BASE, Extreme, Motorcycle)+**
- **Runner (30)**
- **Skier – Alpine (225)**
- **Skier – Nordic (125)**
- **Snowboarder (81)**
- **Snowmobiler (548)**
- **Snowshoer (22)**
- **Substance Intoxication (68)**
- **Urban Entrapment**
- **Vehicle (Vehicle, 4wd, Left)+ 757**
- **Water (Boats, non powered, PIW+) 777**
- **Worker (191)**



Subject Categories	Sub
<b>Abduction</b>	Vehicle
	No Vehicle
	<b>Clandestine graves</b>
Aircraft	<b>Mass Graves</b>
	<b>Jet</b>
	<b>Helicopter</b>
	<b>Propeller</b>
Angler	
ATV	
ASD	<b>Adult</b>
	<b>Children</b>
<b>Avalanche</b>	
BASE Jumper	<b>Non-winged suit</b>
	<b>Winged Suit</b>
<b>Beacons</b>	<b>406 (PLB/ELT/EPIRB)</b>
	<b>SEND</b>
	<b>Phone/Wi-Fi</b>
	<b>Bluetooth</b>

<b>Brain Injury</b>	
Car Camper	
Caver	<b>Cave Diver</b>
	<b>some training</b>
	<b>no training</b>
	<b>technical caver</b>
<b>Cell Phone Forensics</b>	
Child 1-3	<b>Child 1</b>
	<b>Child 2</b>
	<b>Child 3</b>
Child 4-6	
Child 7-9	
Child 10-12	
Child Adolescent 13-15	No stats just trends
Climber	Sports
	Mountaineer
Dementia	
Despondent	
<b>Extreme Sports</b>	
Gatherer	
Hikers	<b>Day</b>
	<b>Backpackers?</b>
Horseback Riders	
<b>Human Remains</b>	

Hunter	
Intellectual Disability	
Mental Illness	
Motorcycle	
Mountain Biker	
Other	<b>Parachutist</b>
	<b>Vision Quest</b>
Runner	
Skier-Alpine	
Skier-Nordic	
Snowboarder	
Snowmobiler	
Snowshoer	
Substance intoxication	
Urban Entrapment	
Vehicle	Vehicle
	Four-wheel drive
	Abandoned Vehicle
Water Related	Powered Boats
	non-powered
	Lakes Ponds, Reservoirs
	River & Streams
	Flood Water
	<b>Bridge jumpers</b>
	<b>Scuba Divers</b>
<b>Wide Area Search</b>	<b>Floods</b>
	<b>Fire</b>
	<b>Tornado?</b>
	<b>Mud?</b>
Worker	
<b>Scenarios</b>	<b>Evading</b>
	<b>Investigative</b>
	<b>Medical</b>
	<b>Overdue</b>
	<b>Stranded</b>
	<b>Trauma</b>
<b>Fugitive (wilderness)??</b>	
<b>Runaway?</b>	<b>into the woods</b>



# Subject Category Hierarchy

## 1. External Forces

Abduction, Aircraft, Entrapment, Water

## 2. Wheels

Horseback

ATV, Motorcycle, Vehicle, Mountain Bike

## 3. Cognitive

Substance Intoxication,  
medical, head injury

Autism, Dementia, Despondent, Mental Illness, Intellectual  
disability

## 4. Age (if Child)

1-3, 4-6, 7-9, 10-12, 13-15

## 5. Activity

Angler, Hunter, Gatherer, Hiker\*, etc.



# Statistical Tables

## Dementia (Alzheimer's)

	Distance (horizontal) from the IPP (miles)				
	Temperate		Dry		Urban
	Mtn.	Flat	Mtn.	Flat	
<b>n</b>	<b>95</b>	<b>175</b>	<b>14</b>	<b>15</b>	<b>336</b>
25%	0.2	0.2	0.6	0.3	0.2
50%	0.5	0.6	1.2	1.0	0.7
75%	1.2	1.5	1.9	2.2	2.0
95%	5.1	7.9	3.8	7.3	7.8

	Distance (horizontal) from the IPP (kilometers)				
	Temperate		Dry		Urban
	Mtn.	Flat	Mtn.	Flat	
<b>n</b>	<b>95</b>	<b>175</b>	<b>14</b>	<b>15</b>	<b>336</b>
25%	0.3	0.3	1.0	0.5	0.3
50%	0.8	1.0	1.9	1.6	1.1
75%	1.9	2.4	3.1	3.6	3.2
95%	8.3	12.8	6.1	11.8	12.6

	Elevation (vertical) Change from IPP (feet)						
		Temperate			Dry		
		Uphill	Down	Same	Uphill	Down	Same
<b>%</b>	<b>19%</b>	<b>42%</b>	<b>39%</b>	<b>50%</b>	<b>38%</b>	<b>13%</b>	
25%							
50%	75	60		317	187		
75%							
95%							

	Mobility (hours)	
	Temperate	Dry
	<b>n</b>	<b>42</b>
25%	0	
50%	0.25	4.5
75%	3.8	
95%	18	

	Dispersion Angle (degrees)
	Temperate
	<b>n</b>
25%	11
50%	23
75%	66
95%	70

## Dementia (Alzheimer's)

	Find Location (%)		
	Temp	Dry	Urban
	<b>n</b>	<b>207</b>	<b>7</b>
Structure	20%	29%	35%
Road	18%	14%	36%
Linear	9%		9%
Drainage	9%	14%	4%
Water	7%	14%	6%
Brush	6%		1%
Scrub			
Woods	17%		3%
Field	14%	29%	6%
Rock			

Scenario (%)	
<b>n</b>	<b>1050</b>
Avalanche	
Criminal	
Despondent	
Evading	
Investigative	2%
Lost	96%
Medical	
Drowning	
Overdue	1%
Stranded	
Trauma	

	Survivability	
	Wilderness	Urban
Uninjured	73%	80%
Injured	17%	14%
Fatality	8%	6%
No Trace	2%	5%
<b>Survivability</b>	<b>Alive</b>	<b>n</b>
<24 hours	95%	736
>24 hours	77%	79
>48 hours	60%	30
>72 hours	60%	20
>96 hours	46%	13

Track Offset (meters)	
<b>n</b>	<b>110</b>
25%	4
50%	15
75%	71
Max Zone	307

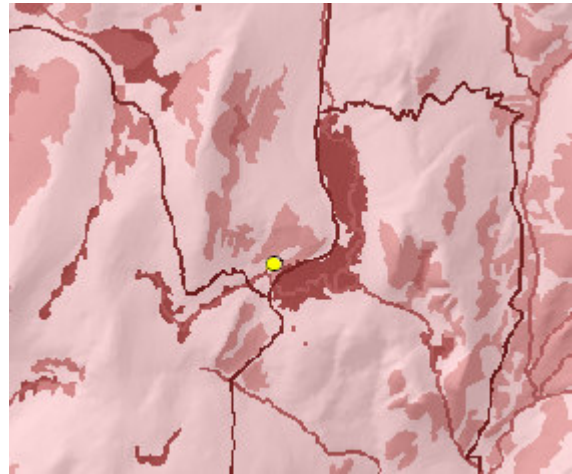
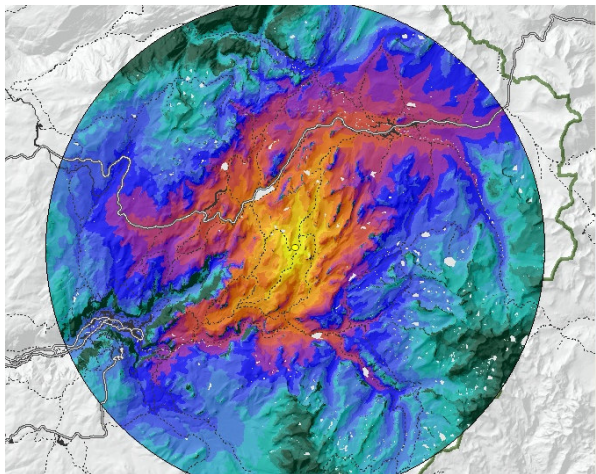
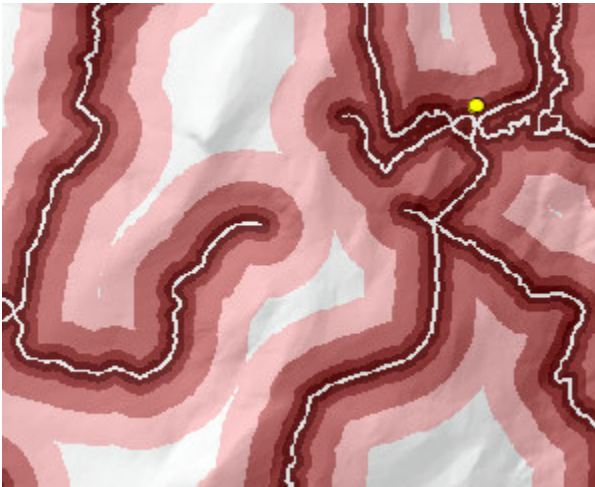
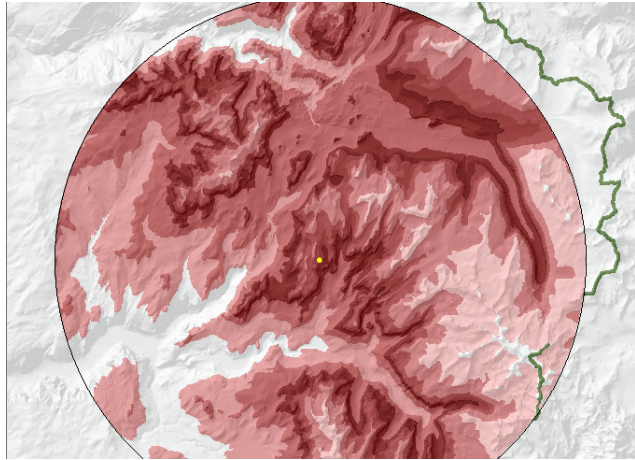
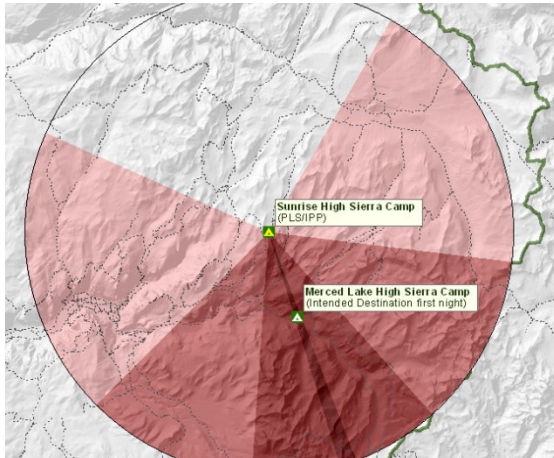
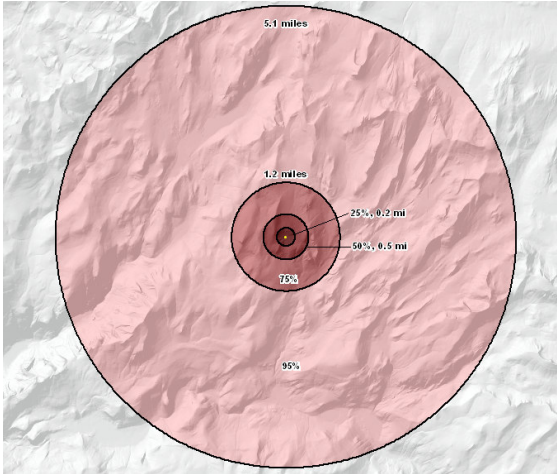
**Lost Person Behavior**

A search and rescue guide on where to look – for land, air and water

Robert J. Koester



# Different Models for POA



- **Probabilistic Thinking:** *81-yo with moderate dementia, high BP, heart disease, arthritis, overweight. Wandered 3x before, found in facility. Currently a degree above freezing and sun just set. Wearing a dress with light sweater. Does not know area.*

**What is the most likely location?**

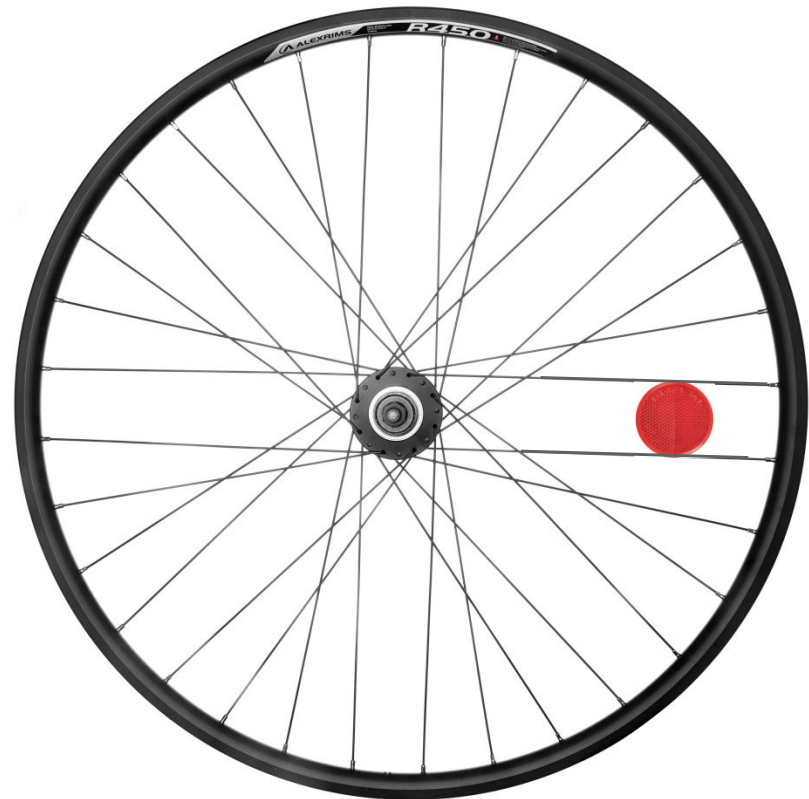
**What are the probabilities?**

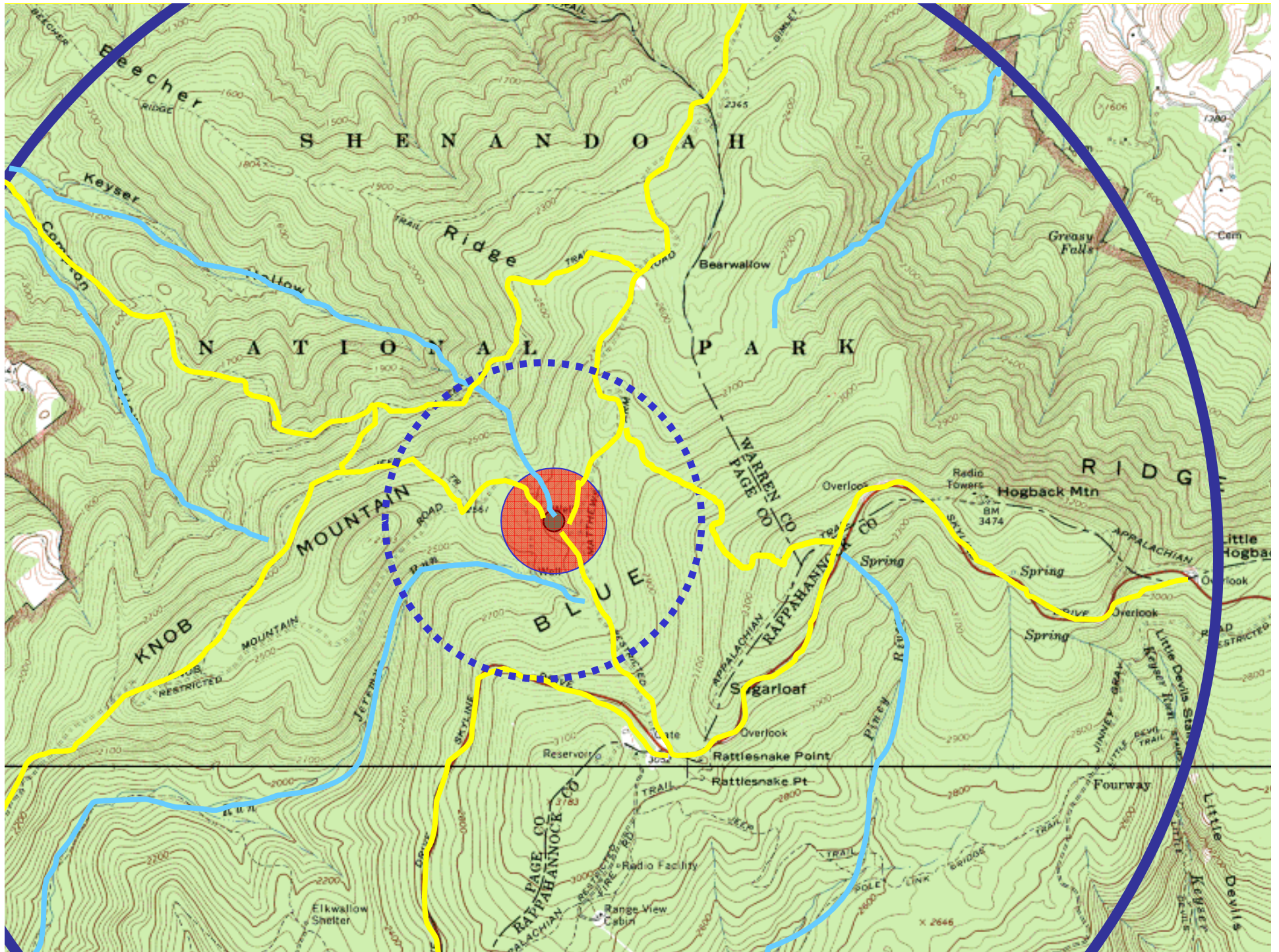
- 25% and 50% rings shown
- 9% within 100 meters
- 50% within 15 m of linear feature
- 25% in facility
- 10% near creek
- 96% lost



# Bicycle Wheel Model

- Axle (IPP)
- Hub/Gears (immediate area search)
- Rim (Containment)
- Spokes (Travel routes)
- Reflectors (high POA)









# Phases to Becoming Lost

- IPP
- Departure from IPP
- Error at Decision Point
- Movement based upon terrain analysis
- Foggy feeling of maybe something not OK
- Realization of Lost
- Self Rescue strategy



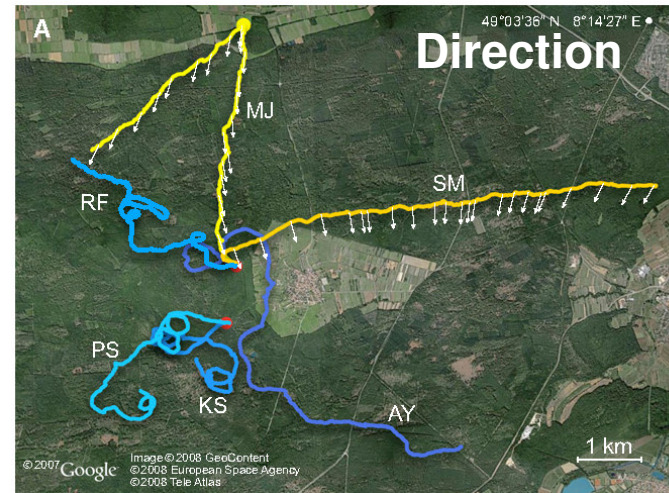
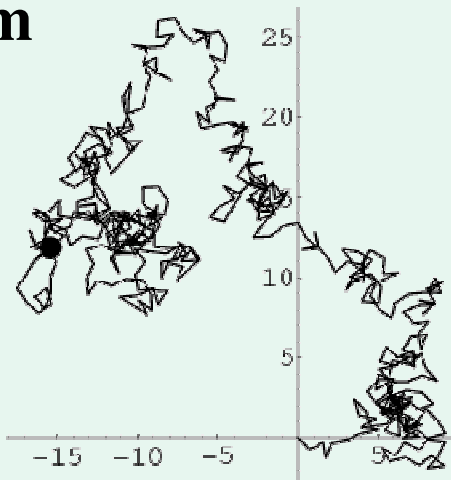
# Experience of Lost

System	Freeze, Fight or Flight	Panic Attack
Heart	↗ Heart rate	↗ Heart rate, palpitations, Chest pain or discomfort
Circulation	↗ Blood - vessels to muscles ↘ Blood – vessels to digestion	Trembling or shaking Nausea or abdominal distress
Lungs	↗ Respiratory rate	Shortness of breath, smothering, feeling of choking
Liver	↗ Glycogen to glucose	
Skin	Pale or flushed, sweating	
Eyes	↗ Pupil size	↗ Pupil size, blurred vision
Mind	↗ Focus on threat ↘ hearing, tunnel vision	Derealization, depersonalization, fear of losing control, fear of dying.

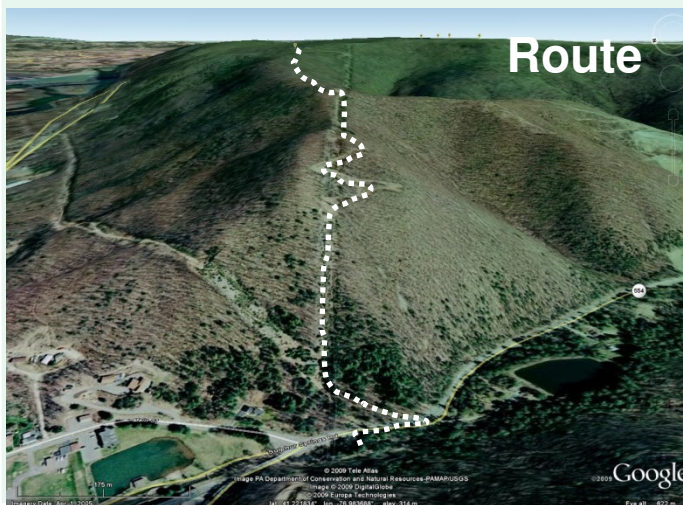
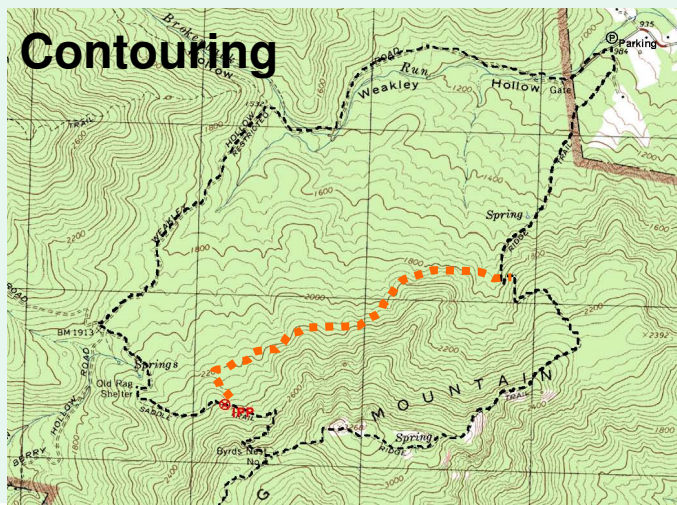


# Lost Person Strategies

## Random



## Contouring



## Others

- Backtracking
- Landmark
- Folk Wisdom
- View +
- Cell Phone
- Beacon
- Staying Put

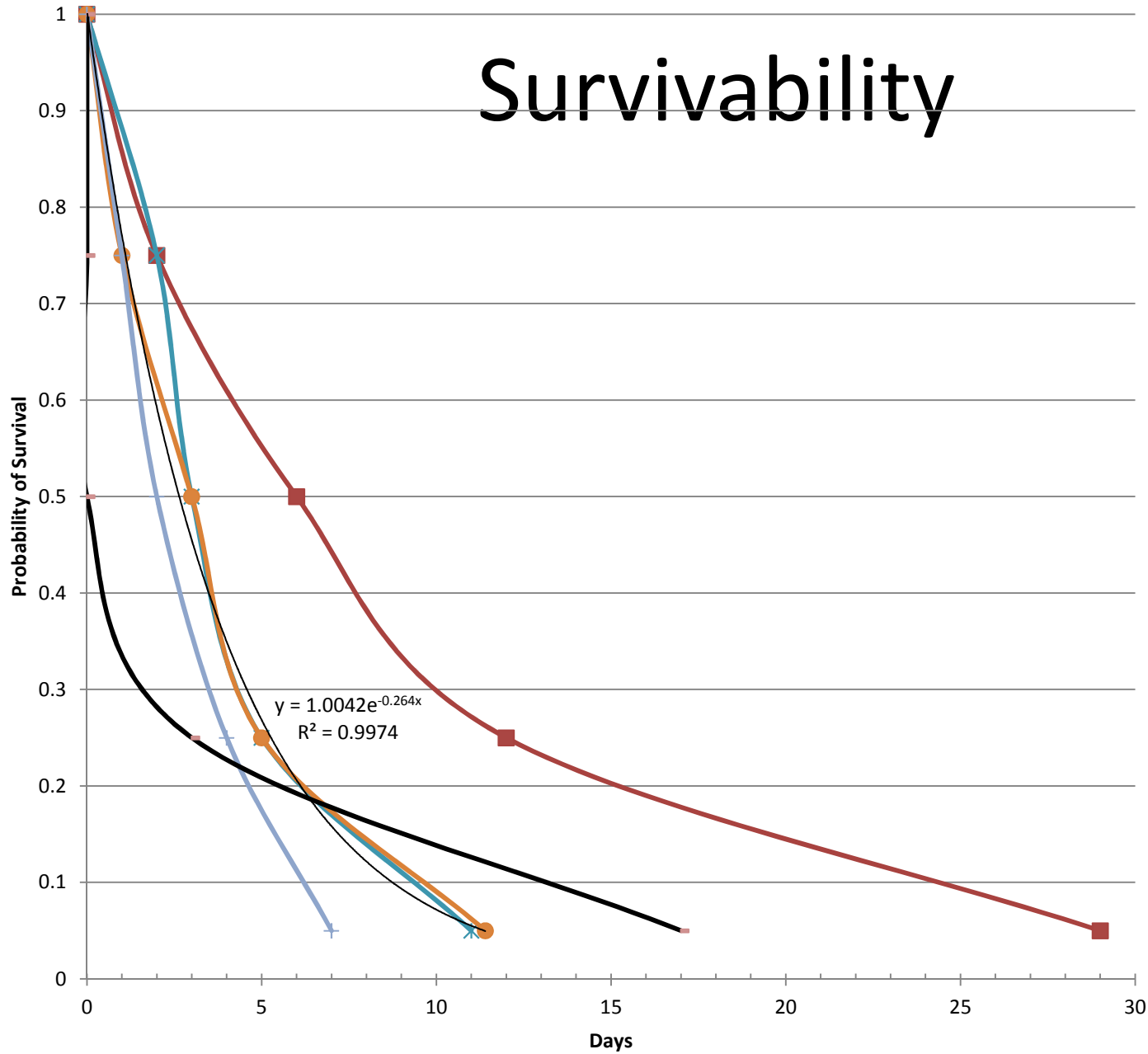


# Scenario Analysis

1. Gather information about the subject including timelines
2. Look at scenario statistics, determine which search scenarios are possible
3. Determine which search scenario are more probable
4. Determine how each search scenario might impact task planning

- **Black-box scenario analysis introduced**
- **Scenario worksheet introduced**

# Survivability

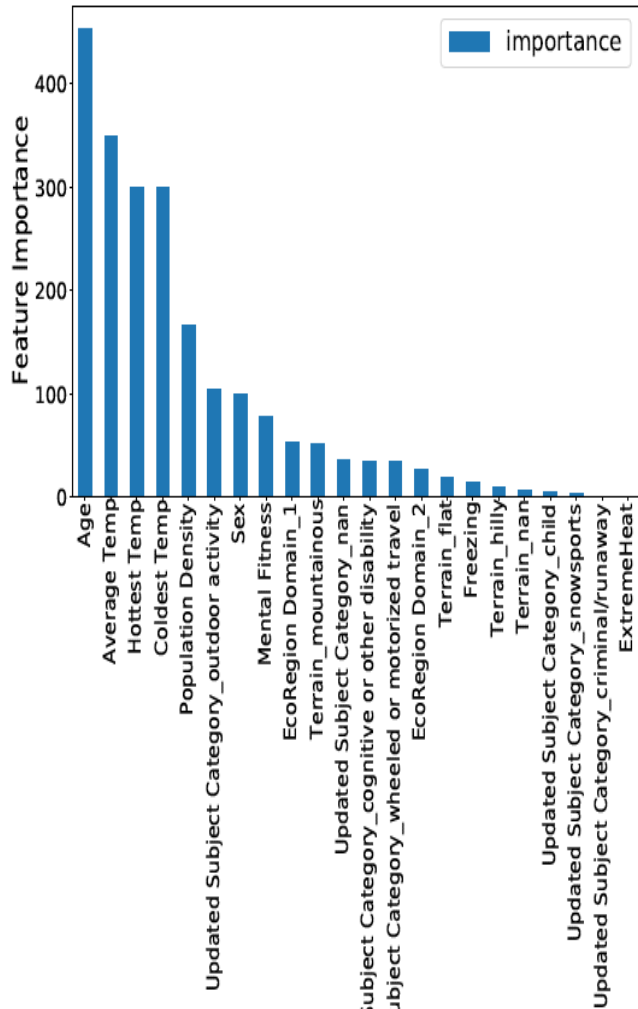


- Hunter
- \* Child 10-12
- Dementia
- + Autistic
- Aircraft
- Expon. (Dementia)

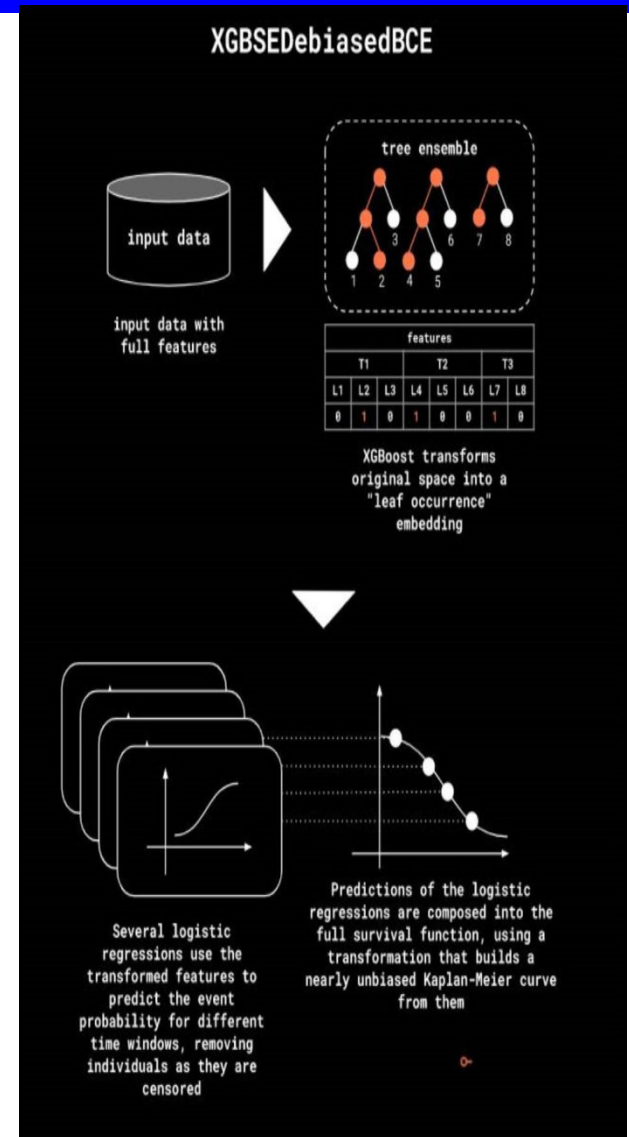
	Days	Hours
n	132	132
25%	0.16	4
50%	0.375	9
75%	2.46	59
88%	7	168
93%	14	336
95%	21	504



# Survivability Factors

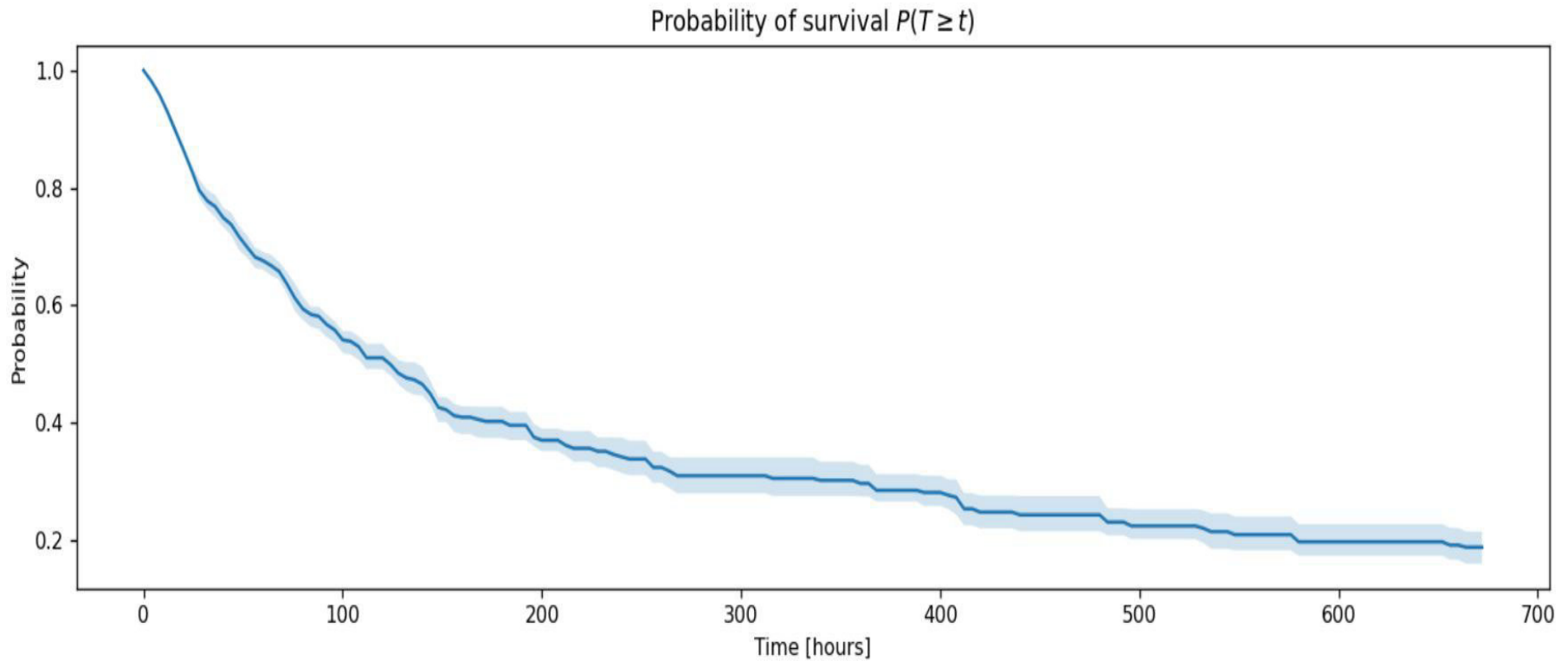


**Age**  
**Average Temp**  
**Hottest Temp**  
**Coldest Temp**  
**Wilderness vs Urban**  
**Subject Category**  
**Gender**  
**Mental Fitness**  
**Ecoregion**  
**Terrain**





# Overall P Survivability vs Time



**100 hours equals 4 days 4 hours**

# The Future of SAR

- As long as Murphy, batteries die, or people do silly things – SAR will be needed
- Better Data
- Better Models
- Better Decisions
- Better Results
- Acknowledgments
  - DHS S&T D14PC00153
  - USDA 2004-02667
  - 5 data entry, 32 reviewers, 63 data contributors





# Thank – You

## Questions? Got Data?

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