
# Geographies of the Missing & Lost in Yosemite National Park

Royal Geographical Society - Annual International Conference 2019 (London, UK)

**Paul Doherty & Jared Doke, NAPSG Foundation** August 28, 2019

## Introduction

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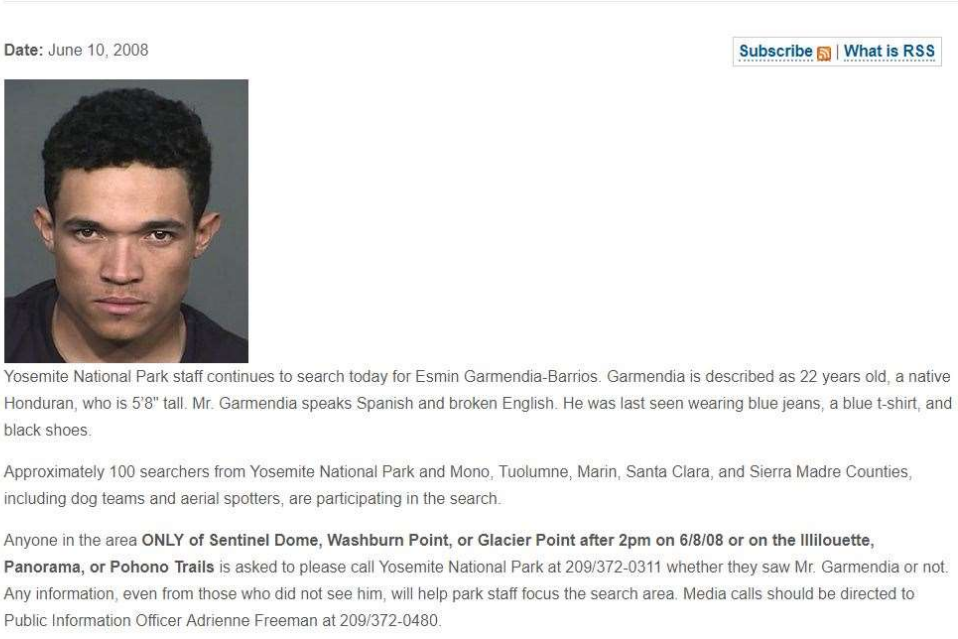
As you d rescue in Yosemite National Park with maps, photos and narrative.

First, a story about how our geography adventure in Yosemite began.



**Date:** June 10, 2008

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Yosemite National Park staff continues to search today for Esmin Garmendia-Barrios. Garmendia is described as 22 years old, a native Honduran, who is 5'8" tall. Mr. Garmendia speaks Spanish and broken English. He was last seen wearing blue jeans, a blue t-shirt, and black shoes.

Approximately 100 searchers from Yosemite National Park and Mono, Tuolumne, Marin, Santa Clara, and Sierra Madre Counties, including dog teams and aerial spotters, are participating in the search.

Anyone in the area **ONLY of Sentinel Dome, Washburn Point, or Glacier Point after 2pm on 6/8/08 or on the Illilouette, Panorama, or Pohono Trails** is asked to please call Yosemite National Park at 209/372-0311 whether they saw Mr. Garmendia or not. Any information, even from those who did not see him, will help park staff focus the search area. Media calls should be directed to Public Information Officer Adrienne Freeman at 209/372-0480.

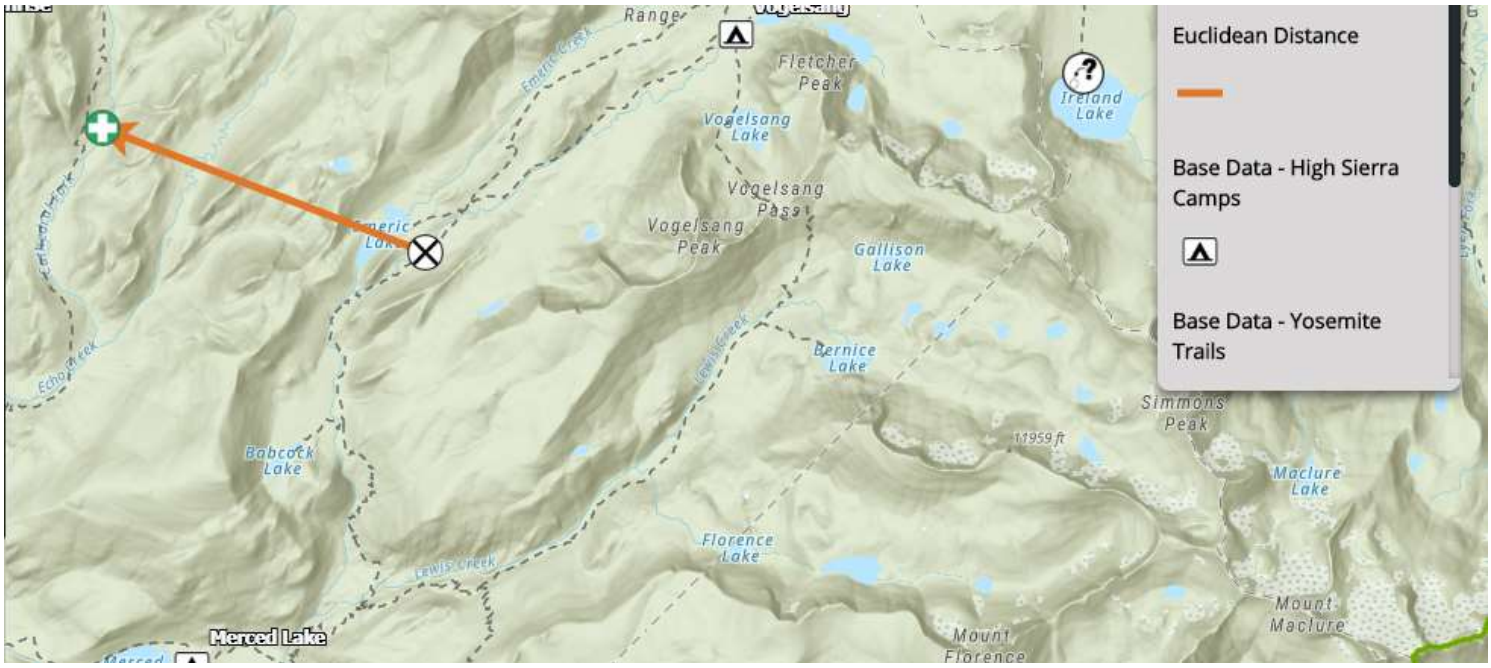
Missing person flyer for a search operation in 2008.

*It is June 9th, 2008 and I am called in to assist with mapping for a missing person search operation in Yosemite National Park.*

*I had just finished my S-341 Wildland Fire GIS (geographic information systems) training so I could support mapping on wildland fire incidents.*

*So I asked...*

*"Where is your standard operating procedure for Search and Rescue GIS and standard incident geodatabase?"*




Case Studies

To best illustrate the geography of search and rescue please click on the "Case Studies" button to open an interactive Story Map.

> Problem: Until recently - how were most incident locations collected?

Using locality descriptions and *occasionally* map coordinates.

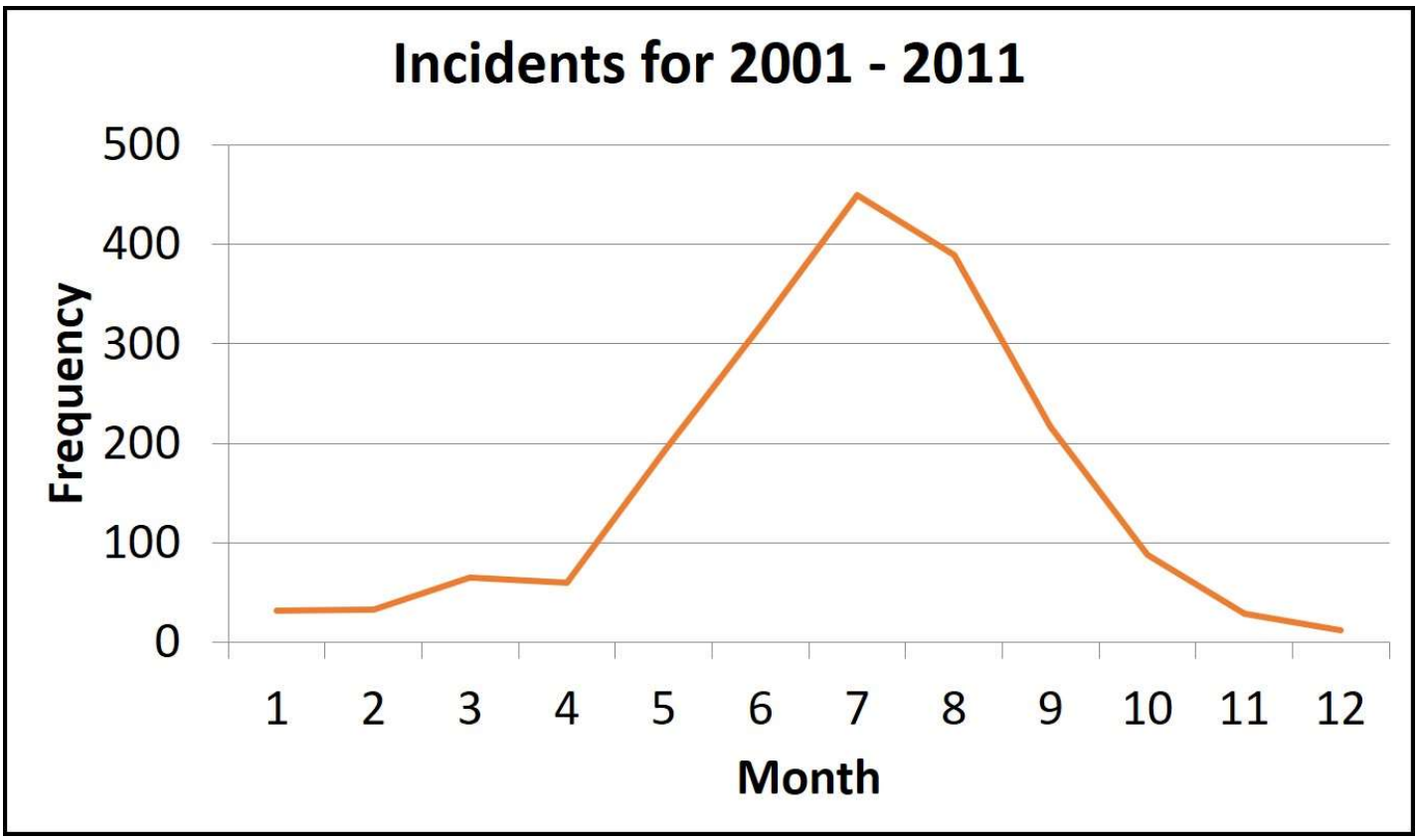
**Why is this a problem?**

SAR is an inherently spatial challenge...but if we do not use a spatially explicit process during data collection, we cannot answer key "where" questions related to search, rescue, and prevention.

Thanks Jared.

Jared was a Yosemite Search and Rescue intern and M.S. Student at University of Kansas, Lawrence.

In Yosemite National Park, Jared Doke and I began mapping incidents (manually) and immediately learned a lot about the *where, why, and when* of search and rescue in Yosemite National Park.



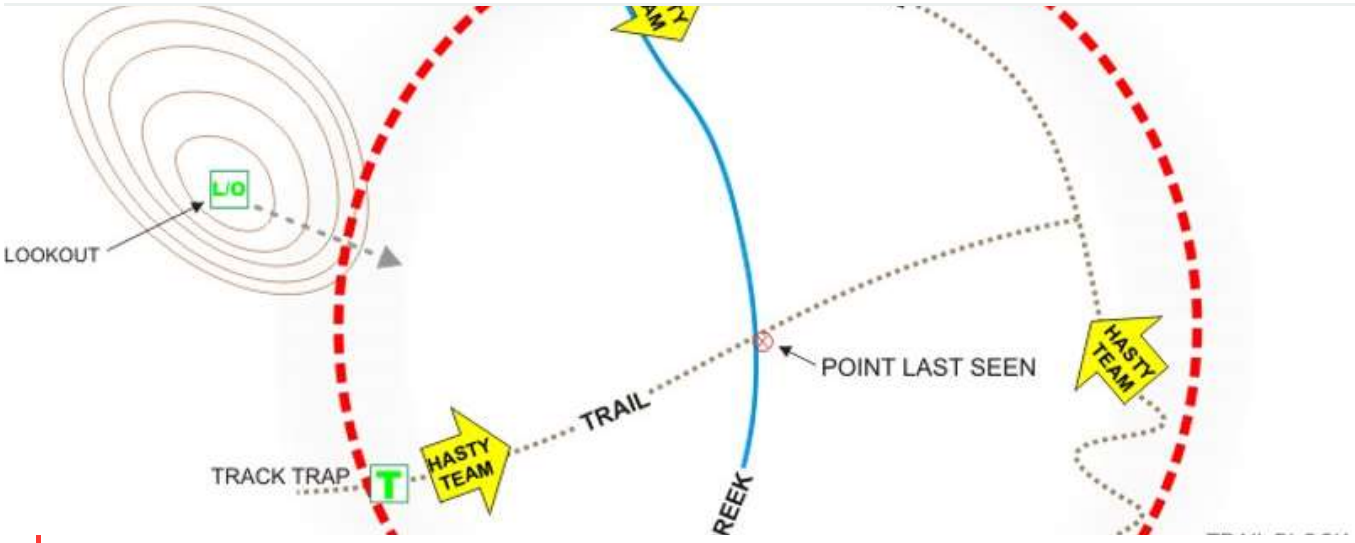

Dissertation Defense Video

> Jared also got to go outside and save lives as well!

Actual photos of Jared's 5.10 Guide Tennies after assisting on many carry-outs, a few technical rescues, and even a helicopter operation.

## Research: Missing Person Outcomes in Yosemite National Park

In the next section, Jared Doke will take you through our research and present the key findings from our work on missing person incidents.




## Hypotheses

1. If landscape and terrain affects human movement then local search outcomes will differ from global datasets.
2. If humans move across the landscape with a constrained speed based on the terrain, then we can model the limits of their movement based on terrain factors.

For more details see Doherty et al. 2013 in *Applied Geography*

## Put the incidents on a map.

For the historic data from 2001 - 2010, +2,000 incidents were georeferenced using methods described in the journal article below, 130 of which were search incidents.

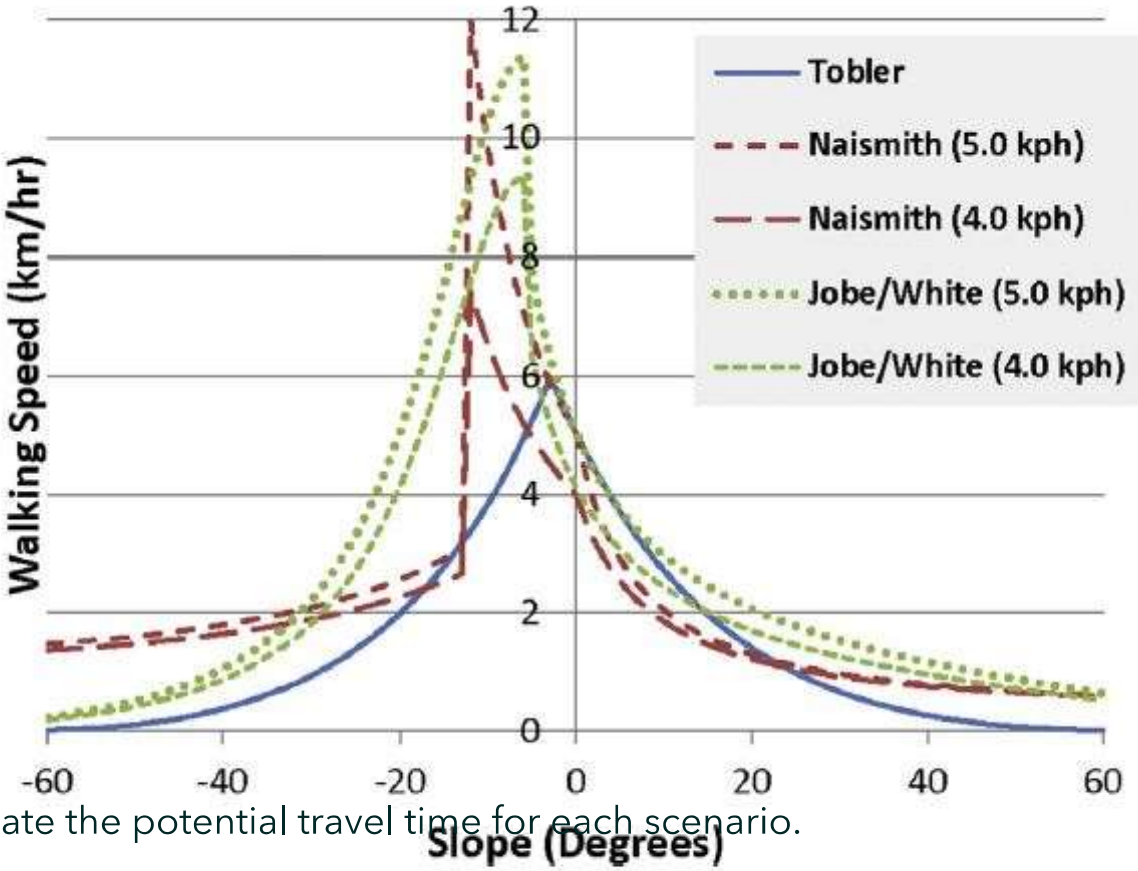
The map to the right shows locations of the Initial Planning Point (place where missing persons were last seen or know to be) and the location they were found - marked with a plus + sign.

## Calculate spatial statistics.

Incident Database, we generated statistics for euclidean distance from the initial planning point to the point found (as the crow flies) for 130 search incidents in Yosemite National Park.

> Create a cost surface model to calculate impedance.

We created a cost surface model (how long does it take to cross each cell, in each direction) based on landscape variables.




Cost-dist ıvel
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details o

> Calculate the potential travel time for each scenario.

**Fig. 5.** Comparison of the various slope speed based functions for human foot travel at preferred walking speeds.

A Cost Surface for all of Yosemite National Park was generated and used to produce Path Distance surfaces from the IPP of all 130 missing Hiker incidents with isochrones representing distance traveled in a specified amount of time.

Subject mobility was determined by sampling the Path Distance surface isochrones at the Find location providing an estimate for the minimum amount of time (Tmin) for the subject

IMPORTANT: The model is not intended to take into account the fact that a person may wander, stay in one place, leave an area and return, or any impact from weather but rather it is an empirical model based on physical limitations imposed by terrain and environmental features.

## Results

**Hypothesis 1 -** If landscape and terrain affects human movement then local search outcomes will differ from global datasets.

### Supported.

We saw significant differences in the 50%, 75%, and 95% percentile ring, but no difference in the 25% ring. In the real world, this means using the International data, we may overestimate search the probable search area in Yosemite.

Why is there a difference? Likely because the steep terrain in Yosemite National Park presents a great impedance to travelers, especially once off trail.

## Results

**Hypothesis 2 -** If humans move across the landscape with a constrained speed based on the terrain, then we can model the limits of their movement based on terrain factors.

### Supported.

Analysis of the Yosemite data suggests 50% of hikers should be found in the 1 hour travel time from the IPP.

In the real-world, this would suggest that search areas should be prioritized close to the

If we generate the model shown to the right for each new incident, we would expect 50% of hikers would be found in the "green area" if there is no evidence to suggest otherwise.

> Conclusions

1. Agencies should collect spatially explicit search and rescue incident data and use geospatial tools for decision support.
2. Both the euclidean distance / statistical approach and cross country mobility models are useful for search planning. We cannot actually predict where people will be, but we can prioritize limited resources.
3. Unexpected conclusion: Watersheds are a readily available dataset that provide terrain-based functional planning areas (see Doke Master Thesis and Sava et al 2015).

## Additional Research

> Rescue - Can we use terrain and other factors to model where helicopters can and cannot land in Yosemite National Park?

# Yosemite National Park

Article *in* The Professional Geographer · January 2012

DOI: 10.1080/00330124.2012.697857

Doherty et al 2012

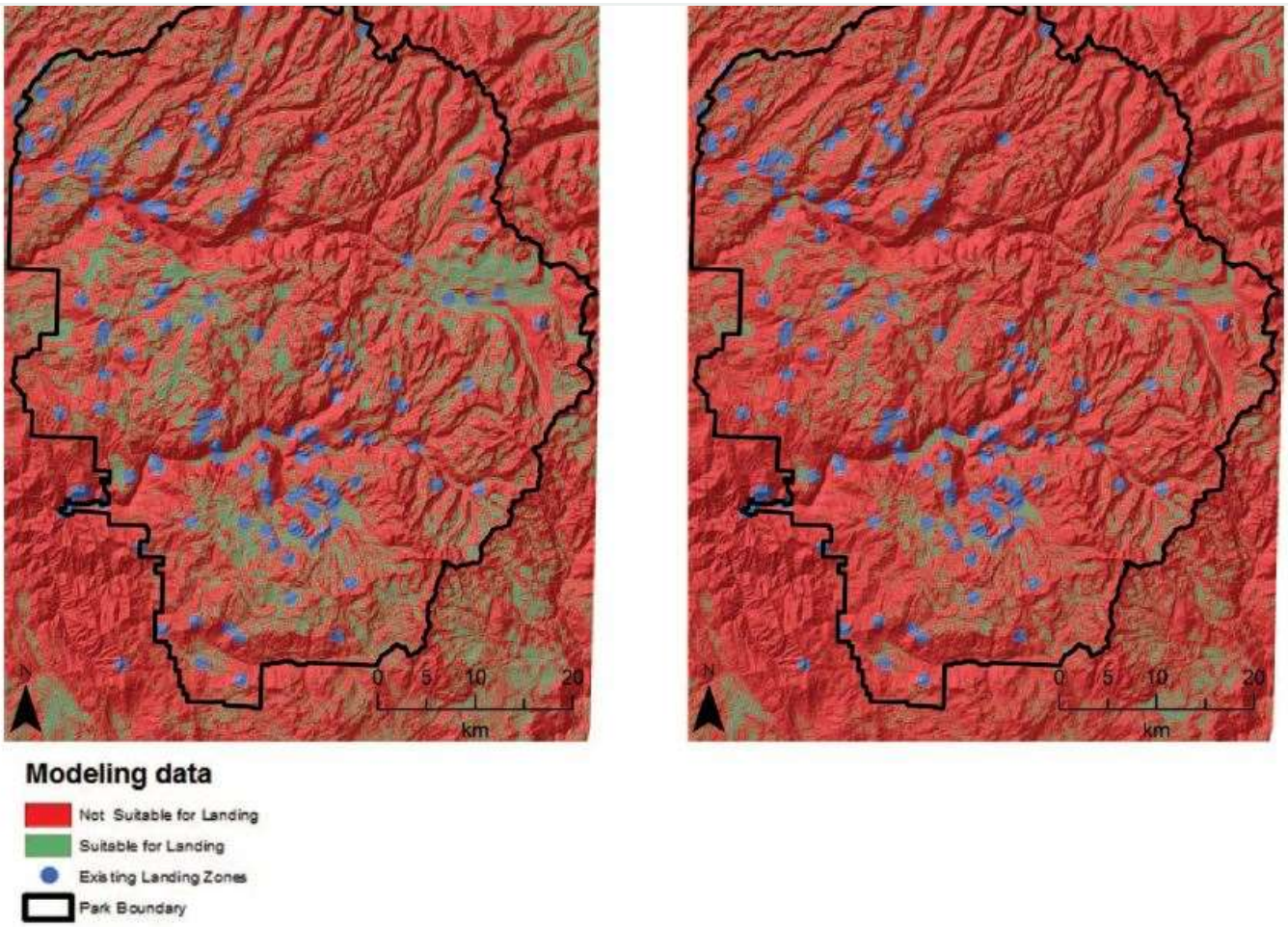


**Figure 3** *A comparison of helicopter landing suitability binary results for (A) an expert model and (B) Maxent in and near Yosemite National Park (black line indicates park boundary). Green indicates suitable and red indicates not suitable pixels. Blue circles represent preexisting helicopter landing locations (N = 140). Overall agreement between the two models is 90.2 percent (N = 53,776,590 pixels). (Color figure available online.)*

> Prevention - Can we use locations of past incidents and relevant base data to predict where and when incidents will occur in the future?

# Space-time analyses for forecasting future incident occurrence: a case study from Yosemite National Park using the presence and background learning algorithm

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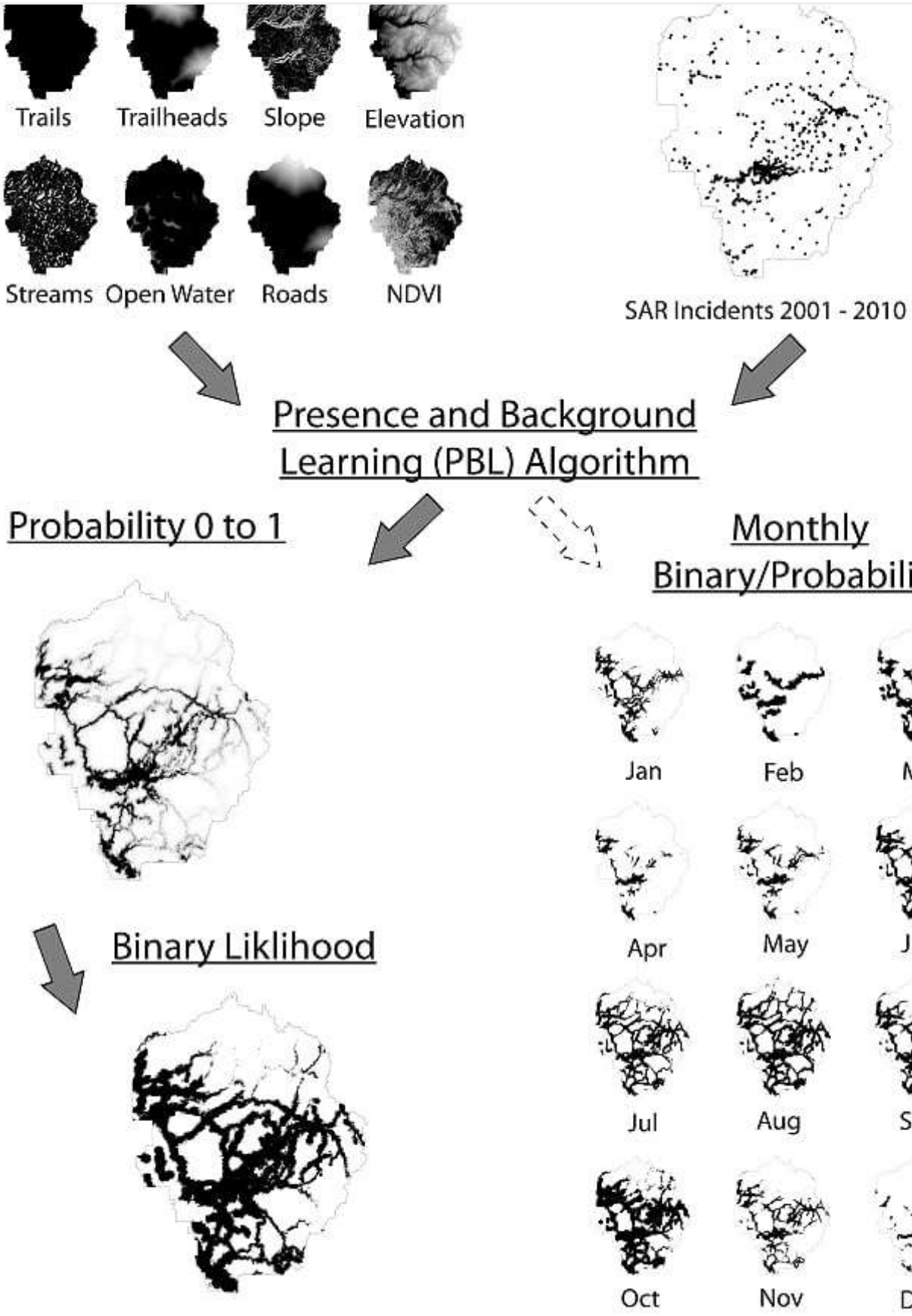
(*Received 19 March 2013; accepted 21 January 2014*)

Doherty et al. 2014


Trails
Trailheads
Slope
Elevation
Streams
Open Water
Roads
NDVI
SAR Incidents 2001 - 2010
Presence and Background Learning (PBL) Algorithm
Probability 0 to 1
Monthly Binary/Probability
Binary Liklihood
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

discuss how to solve some practical problems in the real-world.

What is SARGIS? - Our Story

A photo from our SARGIS10 Workshop in 2018.

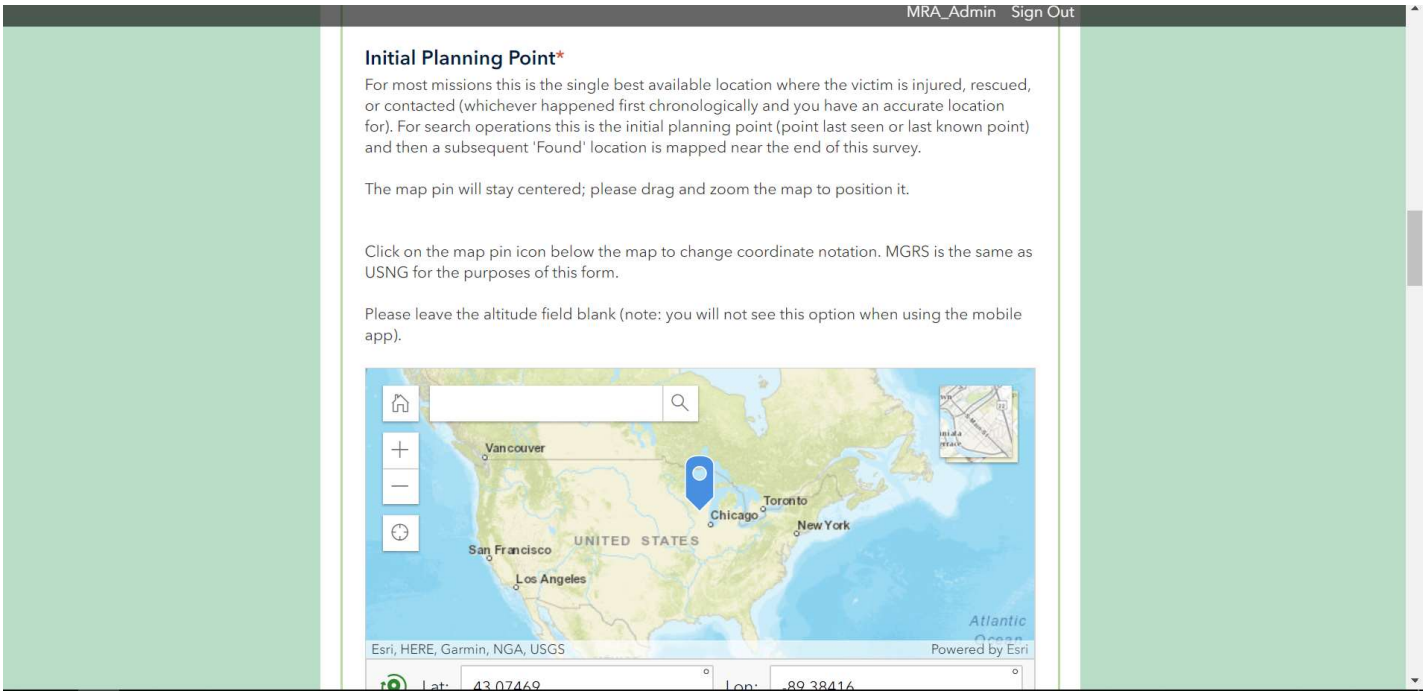
As a result of this community, many "life-saving maps" have been made (and microbreweries visited). Below are some of the most recent outcomes.

## US Search and Rescue Organizations

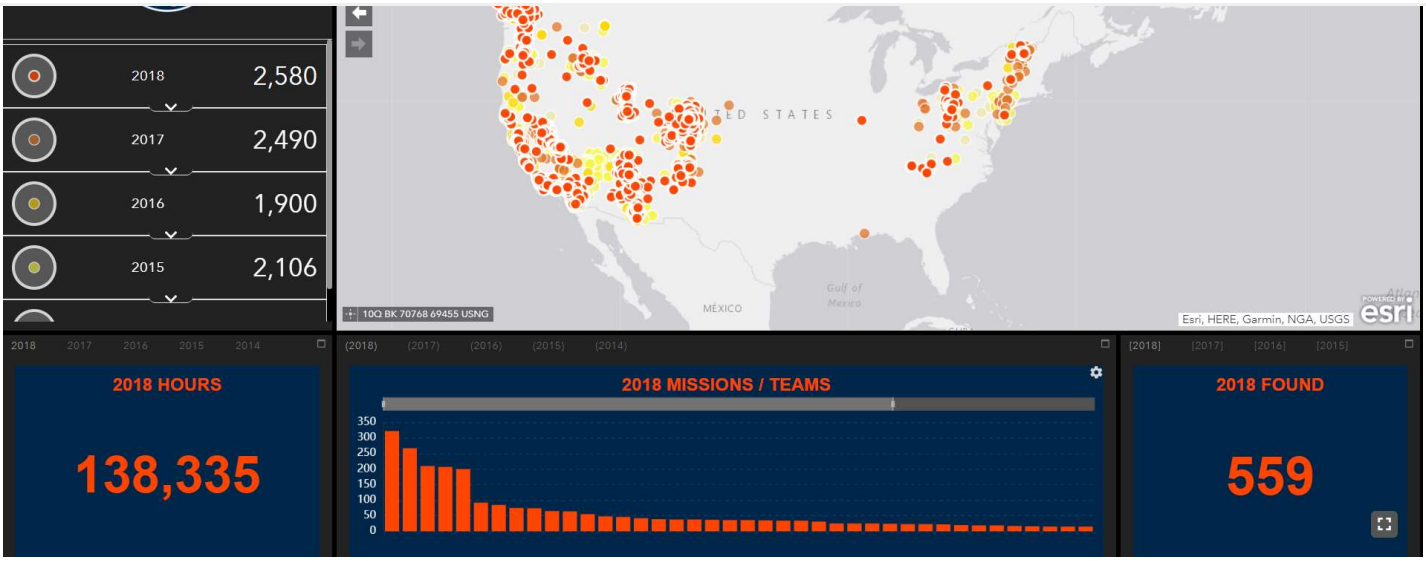
The following organization are all now using spatially explicit mission incident data collection for enhanced situational awareness and spatial analysis. This will ultimately

## Wildland Search and Rescue

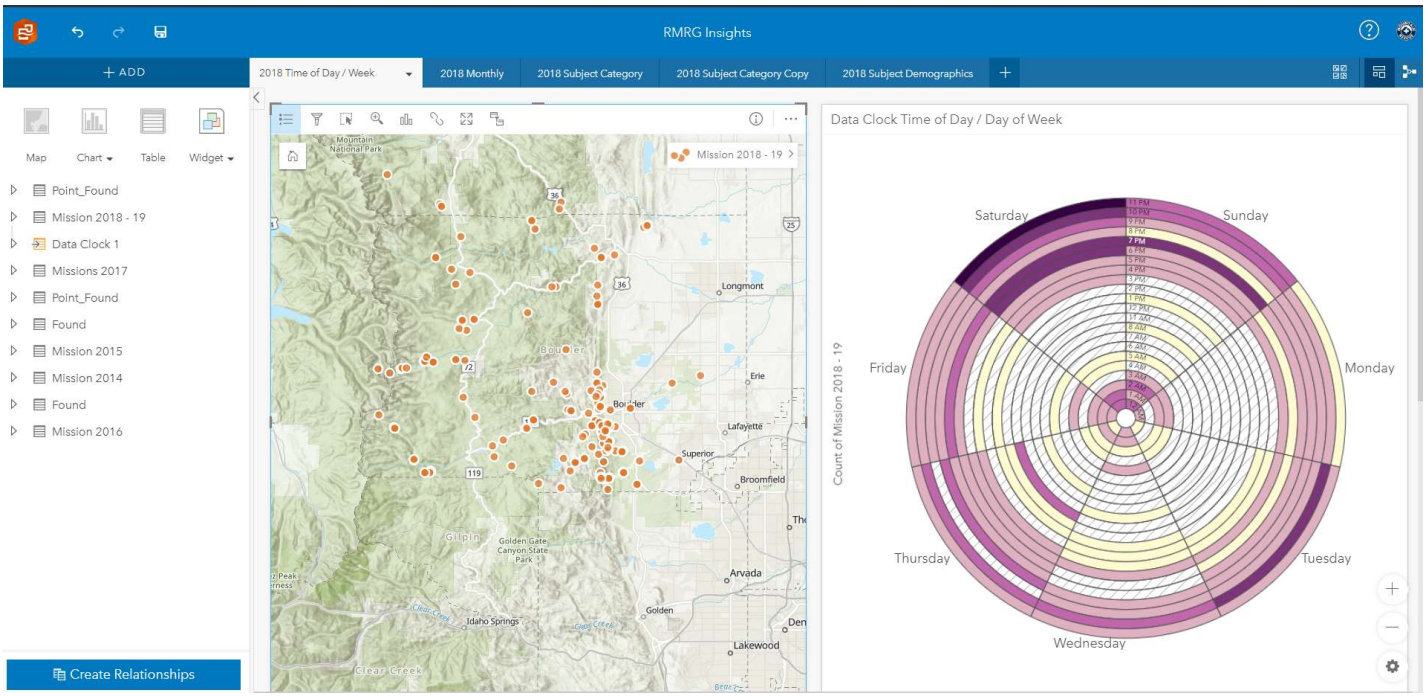
Mountain Rescue Association (example), US National Park Service (example) & California Office of Emergency Services have adopted a spatially explicit data collection system for missions.




The MRA uses Survey123 for Mission Data Collection, it is an easy to use form, with a built-in map to validate their entries. This saves time and produces valuable insights for decision making.




The MRA uses interactive maps for engagement with the donors and for educating the public.



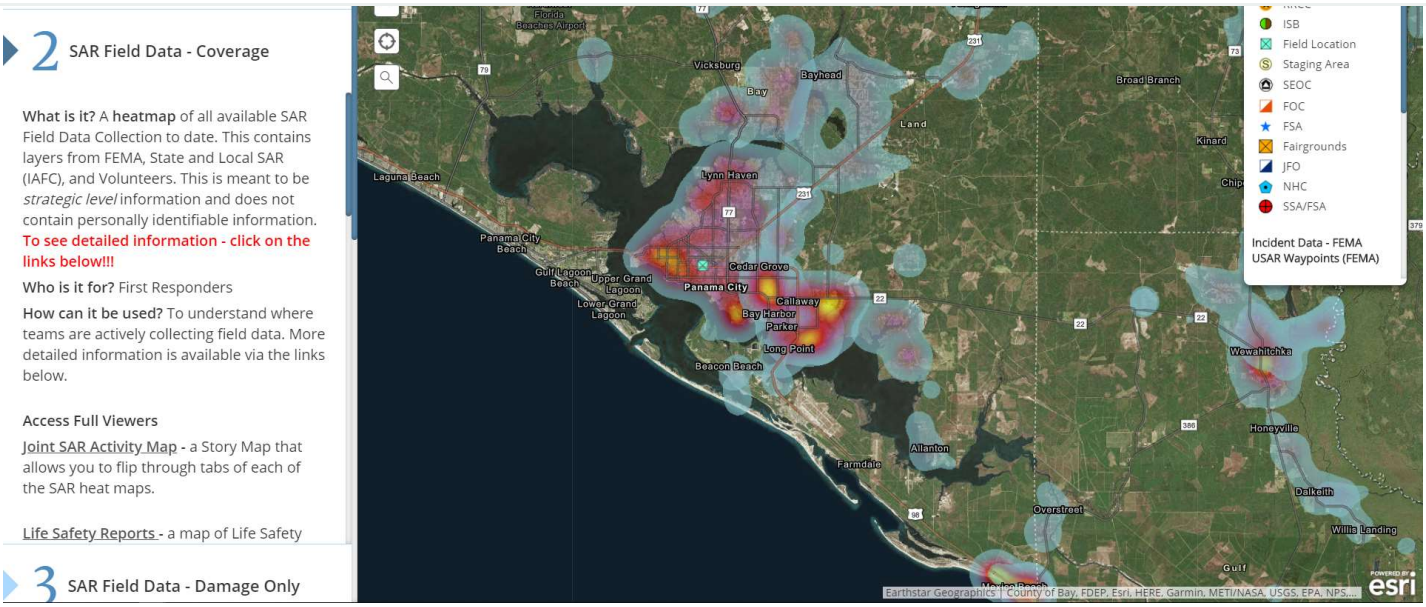

By collecting spatially explicit data, MRA teams can explore the spatio-temporal aspects of their response to better prepare for each season.

## Urban Search and Rescue (Disaster Response)

collecting spatially explicit field data during disaster response.


The NAPSG SAR Working Group developed a standard data collection form to geoenable first responders in disasters.

This provides situational awareness with real-time location intelligence and reduces duplication of effort during response & recovery.




## New Zealand

In New Zealand, students from Youth Search and Rescue (YSAR) are learning how to use and create geospatial tools for SAR and emergency management.

YSAR
YOUTH SEARCH AND RESCUE

https://ysar.org.nz/training-program/


During a search and rescue (SAR) operation, officials don't have time to wait until a GIS specialist is on scene. They need maps immediately. Preconfigured and ready-to-use GIS tools must be available to SAR teams before an incident occurs.

In this lesson, you'll create a web map to prepare data for search operations. Your map will contain static base data showing regional boundaries and key features, as well as editable layers that can be changed as an incident develops. Then, you'll use the map to create a web app that even non-GIS professionals can use. Finally, you'll use the app to track a fictional SAR mission.

## Lesson plan

| | | |
|---|---|---|
| Create a map | Create and configure a web map with base and incident data. | 30 minutes |
| Create an app | Create and configure a web app with tools to support search operations. | 1 hour 15 minutes |
| Map a search operation | Use the app to map a fictitious search and rescue operation as it happens. | 1 hour 15 minutes |

### Builds skills in

Creating Apps | Get Started | Sharing and Collaboration

### Focus industry

Public Safety

### Requirements

Publisher or Administrator role in an ArcGIS organization (get a free trial) or ArcGIS Enterprise

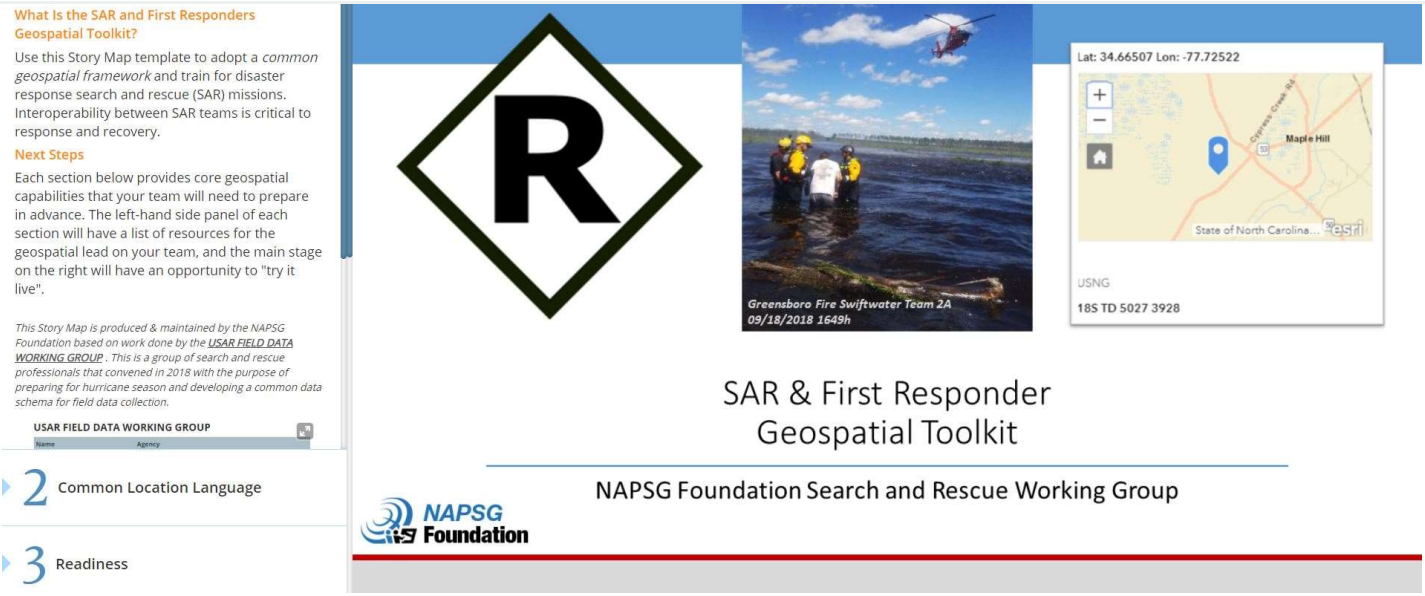
### About Alix Vezina and Paul Doherty

Alix Vezina is a GIS consultant and preventative search and rescue volunteer. Paul Doherty, PhD, is a public safety program manager for the NAPSG Foundation, university professor, and search and rescue volunteer.

During a search and rescue (SAR) operation, officials don't have time to wait until a GIS specialist is on scene. They need maps immediately. Preconfigured and ready-to-use GIS tools must be available to SAR teams before an incident occurs.

Here is a lesson that walks you through setting up layers, web maps, and apps for search and rescue.

**Start Lesson**



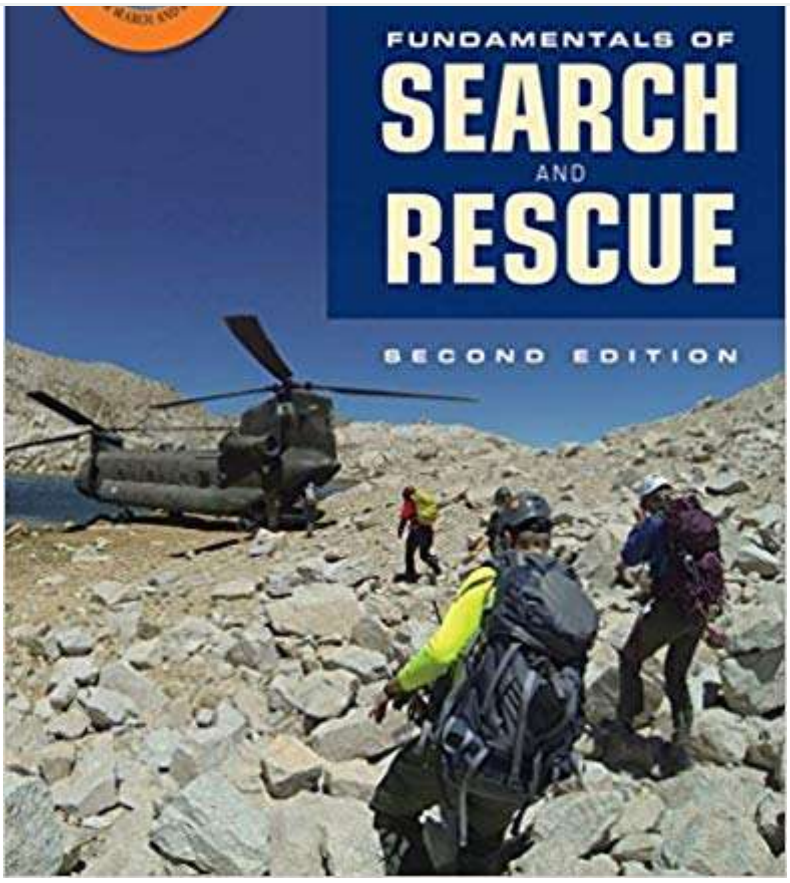

This virtual training “Geo-Enable Search & Rescue in Disasters”, provided participants the opportunity to train and gain access to a standardized suite of tools and common framework for geo-enabling Search and Rescue (SAR) missions for disaster response.

SAR and First Responder Toolkit

## Fundamentals of Search and Rescue

The 2nd Edition of "FUNSAR" includes important updates to Chapter 10 & 11 (Paul Doherty and Jared Doke co-edited) regarding the use of geospatial tools.

Buy on Amazon

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Thank you to the **Na** orting our travel to the Royal Geographi nd Rescue Community.

## Our Organizatio

www.napsgfoundation.org

Thank you for the opportunity to work with the search and rescue community (and for allowing us to travel across the Atlantic Ocean during hurricane season)!

## Our Rocket Scientist

Sorry you could not join us D

Ferguson, PhD autho *techniques for*
*missing persons in Y* en Source
(https://github.com/d e geospatial tools
for search and rescu

## The End.

## Any questions?

Access this Story Map by scanning the QR Code below with your phone's camera. Simply point your iPhone camera and open the website link when prompted.

For Android and other phones, you may need to hold the home button while scanning with the camera.

Scan this QR Code, open the Story Map, and then email it to yourself.