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An analysis of probability of area techniques for missing persons in Yosemite National Park

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A B S T R A C T

Study of wilderness search and rescue (WiSAR) incidents suggests a dependency on demographics as well as physical geography in relation to decisions made before/after becoming lost and subsequent locations in which subjects are found. Thus an understanding of the complex relationship between demographics and physical geography could enhance the responders' ability to locate the subject in a timely manner. Various global datasets have been organized to provide general distance and feature based geostatistical methods for describing this relationship. However, there is some question as to the applicability of these generalized datasets to local incidents that are dominated by a specific physical geography. This study consists of two primary objectives related to the allocation of geographic probability intended to manage the overall size of the search area. The first objective considers the applicability of a global dataset of lost person incidents to a localized environment with limited geographic diversity. This is followed by a comparison between a commonly used Euclidean distance statistic and an alternative travel-cost model that accounts for the influence of anthropogenic and landscape features on subject mobility and travel time. In both instances, lost person incident data from years 2000 to 2010 for Yosemite National Park is used and compared to a large pool of internationally compiled cases consisting of similar subject profiles.

Introduction

Wilderness search and rescue (WiSAR) consists of four basic processes that are defined as: Locate, Access, Stabilize and Transport. Each of these elements presents a unique geographic problem which provides a novel and largely unexplored testing ground for the spatial sciences. Of these elements, "Locating" the lost subject(s) can often prove particularly challenging as a result of the potential interaction between time and geography as defined by Winter and Yin (2010). Stated more succinctly, in order to find a lost subject the responder must overlap the subject in both time and space. This issue is further exacerbated by the often disproportionately limited number of responders for the large geographical area that is defined as the search area. The need to search such large areas often times contributes to the delay in locating the lost subject and subsequently impacts their chances of survival. In fact, if missing subject is not found within the first 51-h of a search, the chances of surviving decline significantly (Adams et al., 2007).

Several options are available to the responder for improving their response capability including: 1) increasing the number of responders available to search, 2) enhancing the available responders' Probability of Detection (POD – likelihood of detecting the subject if they were present) or 3) reducing the size of the search area through improved assignment of geographic Probability of Area (POA – likelihood of the search being present in a subregion within the search area) (Cooper, Frost, & Robe, 2003). Limitations on personnel and capabilities forces attention on to methods that can be used to better define POA.

Demographics and the environment have a strong influence on where lost persons are ultimately found, and the decision that are made by the subject(s) both before and after becoming lost. The demographics, or category, of a lost subject includes the activity in which they were involved in prior to becoming lost, their age and their medical condition particularly as it relates to their cognitive ability. These factors greatly influence the relationship between the lost subject and their environment. For example, individuals characterized as "Hikers" are more prone to rely on linear features such as roads and trails for travel. These individuals often become lost as

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a result of active or passive decisions made in relation to these travel aides (ie decision to leave the travel aide for some purpose or confusion along the feature). And when lost these individuals tend to focus locating some form of linear feature to assist with re-orientation (Koester, 2008; Syrotuck, 2000). Both before and after becoming lost, individuals are forced to make decisions based on their immediate environment. This would suggest that geographical knowledge of the search area could enhance responders' ability to located lost persons or at least more accurately assign POA to regions within the search area.

To assist the responder in better understanding complex interactions between subject and environment, several global datasets have been compiled that span a variety of subject categories (Hill, 1999; Koester, 2008; Syrotuck, 2000). Currently the largest of these datasets, consisting of over 50,000 incidents from around the world is the International Search and Rescue Database (ISRID - Koester, 2008). ISRID contains forty-one different subject categories with sub-divisions based on Bailey's terrestrial eco-region domains (Bailey & Ropes, 1998 – Fig. 1) and population density of the location of the Initial Planning Point (IPP). The IPP is typically defined as either the Point Last Seen (PLS) or the Last Known Point (LKP) (Ferguson, 2008; Theodore, 2009). Utilizing the categorized datasets within ISRID basic geostatistical analyses were performed to consider such parameters as distance from IPP to Find Location (Euclidean Distance – ring model), geographical description of the find location, difference in elevation between the IPP and Find Location and distance from nearest linear feature (road, trail, drainage) to Find Location. Additionally post-search interviews of search subjects were conducted to obtain an estimate of the time the subject was mobile and how far the subject had deviated from their intended destination. Cumulative information was used by Koester to develop a generic lost person behavioral profile based on subject category (Koester, 2008).

As the ISRID database is composed of world-wide incident data, there is some concern as to its accuracy for local incidents that occur within an area with limited geographic diversity. This study provides a comparison of search incident data for the "Hiker" category from ISRID ($n = 568$) and Yosemite National Park for years 2000–2010 ($n = 130$). The ring model (Euclidean Distance from IPP) is often used to assist in assigning probability to regions within the search area. This metric provides an easy to use format for comparing the global and local datasets. Additionally, comparisons are made between the ring model and a mobility (cost-distance) model that accounts for the influence of terrain, vegetation, travel

Fig. 1. Bailey Eco-Region Domains used in classifying the search area within the International Search and Rescue Database (Bailey & Ropes, 1998; Koester, 2008).