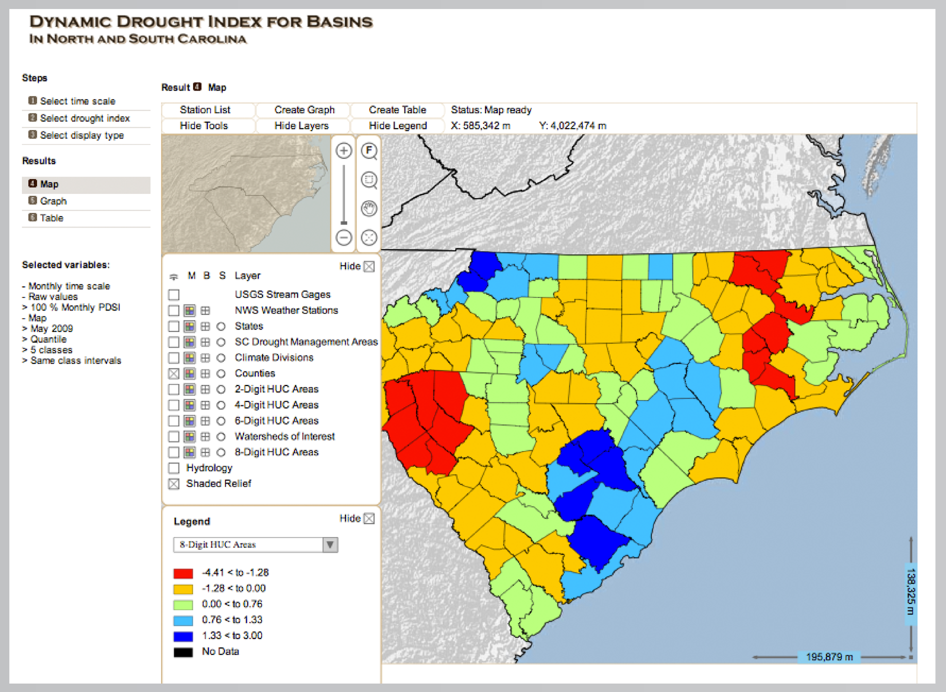
Communicating the Certainty of Drought Data

Abstract

Individuals participating in various forms of water management seek information to guide their learning, understanding, and decision-making. Web based decision support tools provide useful information through the mapping of rainfall, temperature, and drought indices. However, they often fail to provide any measure of the presented data's reliability. Decision support systems (DSS) put water managers in contact with data of varying degrees of reliability, as uncertainty is unavoidable and inherent in information.

DSSs increasingly communicate through information visuals such as maps. When viewing a map, it is often assumed that all the information presented is truthful and accurate. This is never quite the case, however, as maps are just simplified representations of reality. Cartography faces the challenge of communicating uncertainty because of its impacts and implications on decision making. The uncertainty behind water related data and our knowledge of it has important implications on conclusions that are made, and can negatively affect decision-making. Thus, it is vital that water managers have a complete understanding of the data they receive.



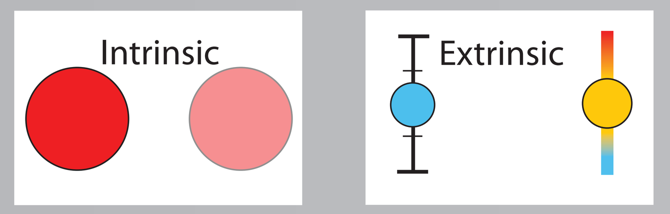
Above: An example of a DSS

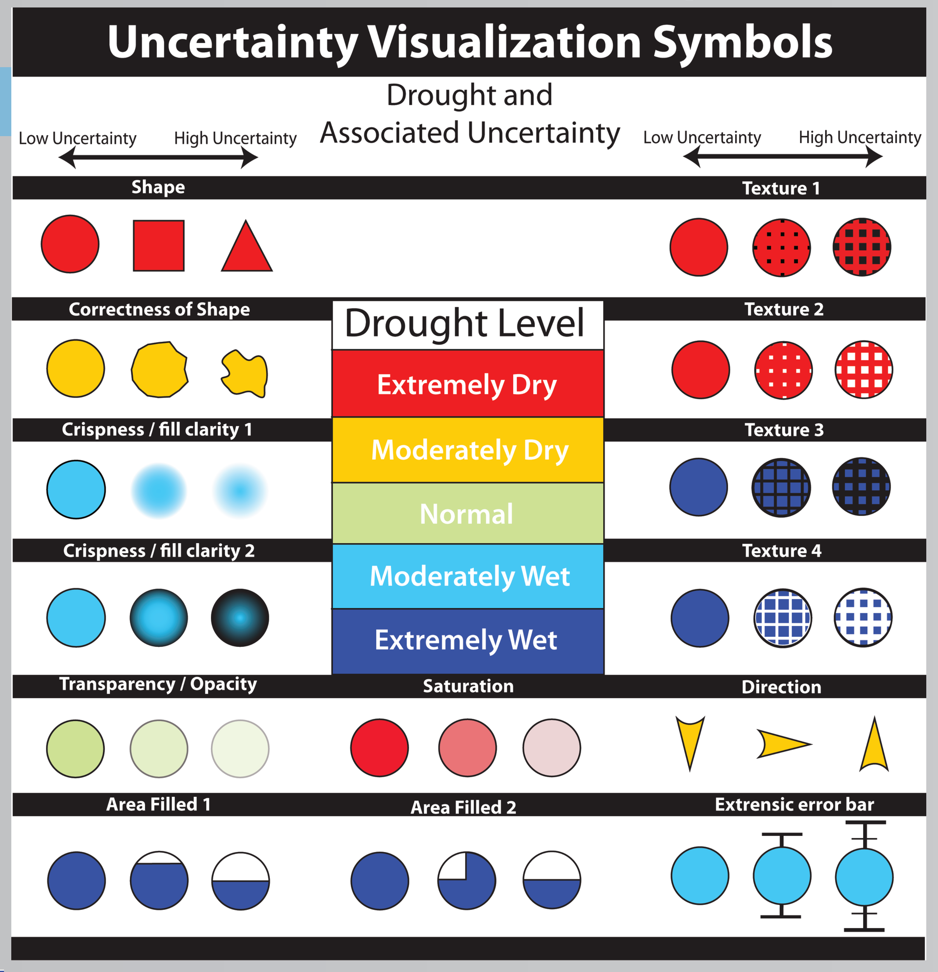
What Work is Being Conducted Studying Data Certainty Communication?

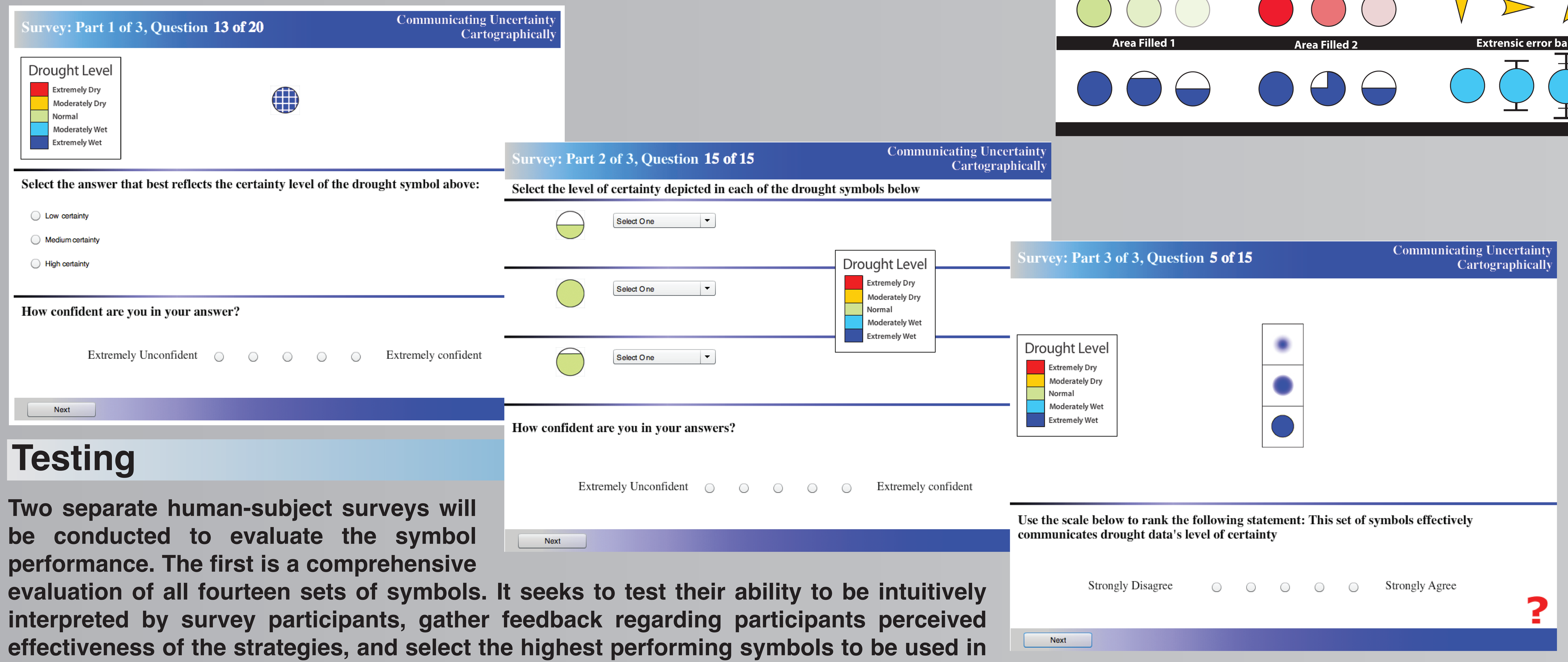
Currently, there is no clear conclusion as to how data quality should be depicted, and this has been recognized as an important challenge to the visualization field (Wittenbrink et al. 1996). There have been numerous suggestions, but there has been little testing of these proposed methods to determine which are the most effective (MacEachren 1997). In order to address this need, fourteen sets of point symbols have been designed that aim to communicate a data value as well as its corresponding degree of certainty. These symbols were developed based upon ideas posed in the cartographic literature from the authors MacEachren, Schweizer and Goodchild, Leitner and Buttenfield, Drecki, Wittenbrink, Pang, and Lodha, Deitrick and Edsall, and Cliburn et al..

Visualization Methods

Visualization methods can be divided into two categories: intrinsic and extrinsic. Intrinsic visualization methods rely on alteration to the existing objects appearance, while extrinsic techniques add additional detail surrounding the symbol in order to represent uncertainty.







Testing

Two separate human-subject surveys will be conducted to evaluate the symbol performance. The first is a comprehensive evaluation of all fourteen sets of symbols. It seeks to test their ability to be intuitively interpreted by survey participants, gather feedback regarding participants perceived effectiveness of the strategies, and select the highest performing symbols to be used in the second study. The second survey will place the most successful symbol sets from study one in a mapped setting to re-evaluate their performance as well as participants perceptions of their effectiveness. Generating results from a testing environment similar to what decision-makers actually experience is important (Hope and Hunter 2007).

Pictured Above: The First Survey

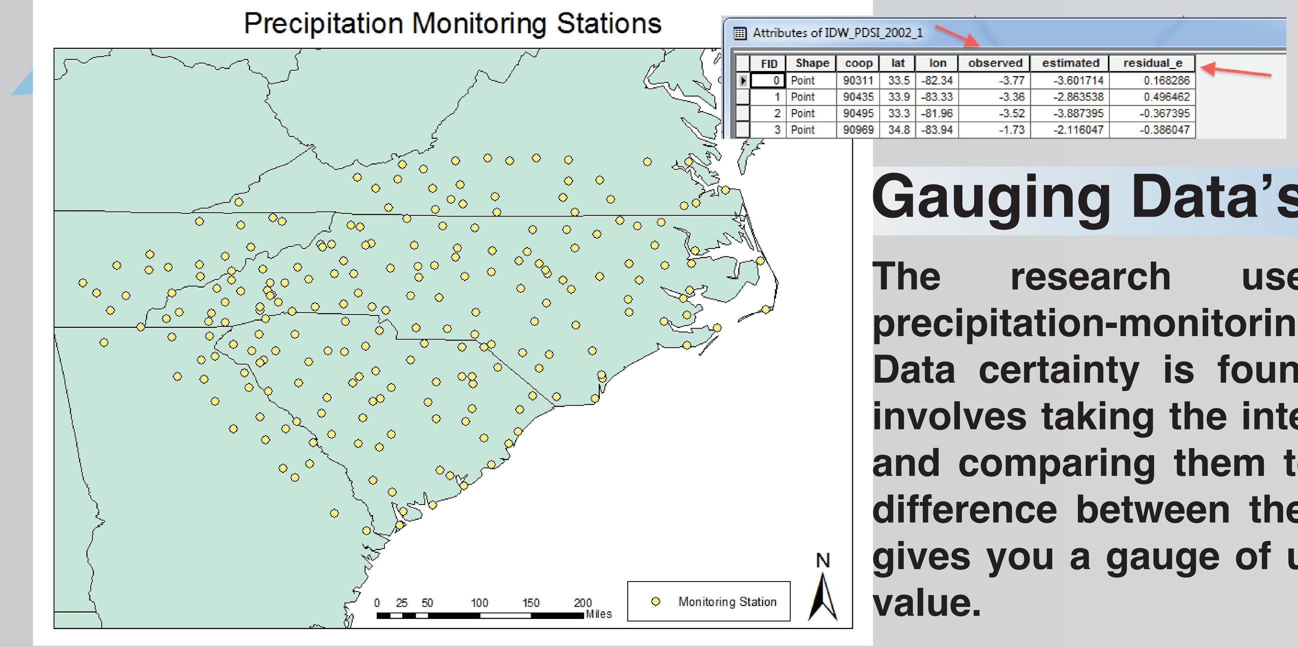
The first two questions test interpretation. The last tests individual preference.

What is Uncertainty?

"Uncertainty is a dynamic state in which there is a perception of being unable to assign probabilities for outcomes" (Penrod, 2001). Simply put, it's when you lack a complete understanding and background information on a topic making it difficult to make informed decisions and judge outcomes.

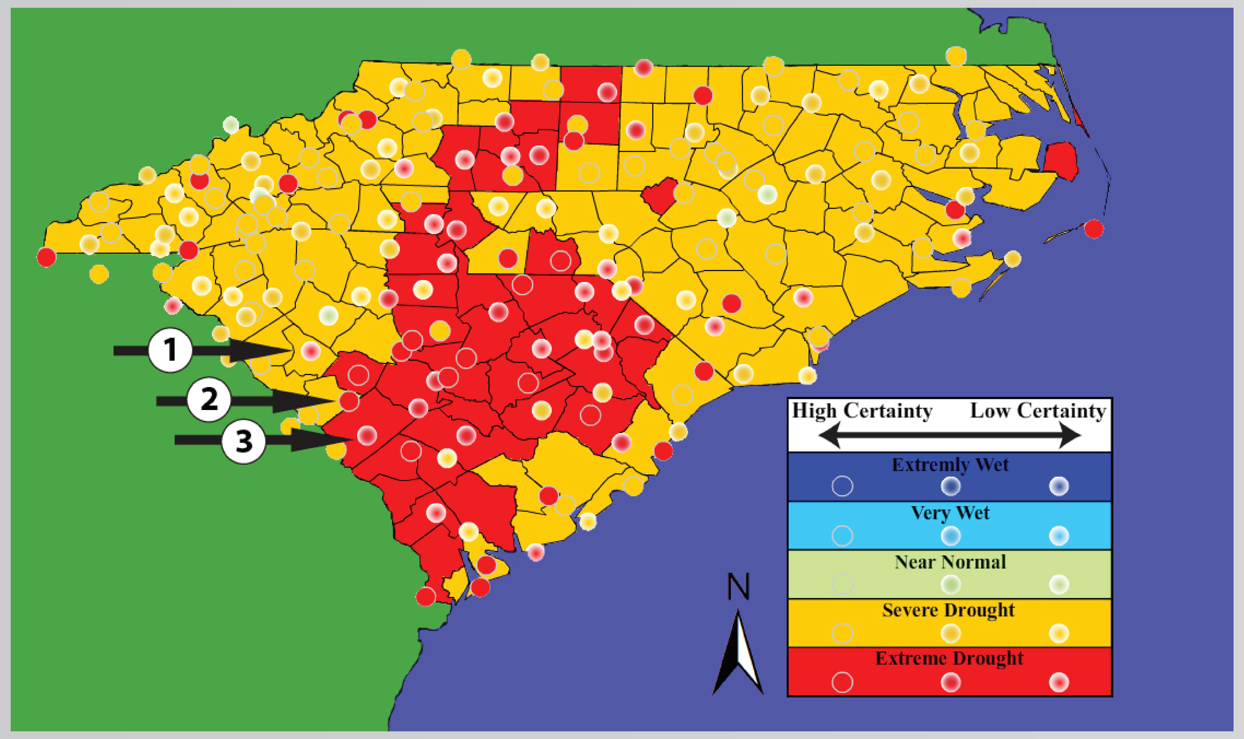
How Does Uncertainty Arise in Data?

Uncertainty in data comes from many different sources (Wittenbrink et al., 1996). As data is collected, examined, and displayed, the errors and uncertainties in the data compound. First, data that is being analyzed varies in reliability. This may be due to human error such as incorrectly measuring a phenomenon, or due to instrument error if a certain tool is not working correctly (Wittenbrink et al., 1996). Data is often manipulated introducing error. Examples of this are interpolation and extrapolation. These two methods produce results that are not completely accurate.



Gauging Data's Certainty

The research uses PDSI data from 224 precipitation-monitoring stations across the Carolinas. Data certainty is found through cross-validation. This involves taking the interpolated PDSI values (predicted), and comparing them to the observed PDSI values. The difference between the observed and predicted values, gives you a gauge of uncertainty known as the residual value.



Visualizing Data and its Certainty

The goal is to communicate the residual and observed PDSI values at the same time. Drought level is depicted through the use of color and is shown as a point at each monitoring station and as a surface. The certainty level (residual) of each monitoring station is depicted by altering a secondary characteristic of the point symbol

1 → Extreme drought with a large residual (High Uncertainty)

2 → Extreme drought with a minimal residual (Low Uncertainty)

3 → Extreme drought with a medium residual (Medium Uncertainty)

Concluding Comments

Communicating uncertainty is important, but there is limited knowledge and studies examining comprehensively the best way to map this data. The proposed effectiveness testing will provide valuable information to the uncertainty visualization community and allow for better communication with water managers using decision support tools and maps.

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