

Mapping Uncertainty for Decision Support

Stephanie Deitrick

School of Geographical Sciences, Decision Center for a Desert City
Arizona State University, Tempe, AZ

Uncertainty in Geographic Information

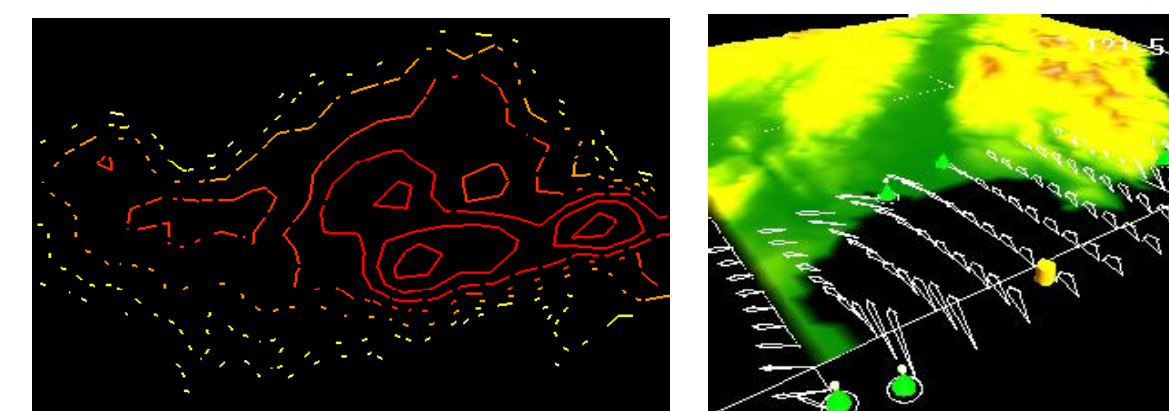
- Geographic data are often analyzed and presented for use in making decisions, often under considerable time constraints
 - Information often represented visually
 - Information presented to decision makers, through both visualization and other methods, contains uncertainty
- Techniques that make cartography effective - abstraction, generalization, selection - add an additional level of uncertainty
- Maps may imply an authoritativeness to the data that is unwarranted, making data appear more certain than they are

Forms of Uncertainty

- Data Quality: degree to which dataset fulfills or conforms to requirements
- Lineage: history of data, including sources, processing, transformations
- Completeness: extent to which data are comprehensive
- Accuracy (positional, attribute and temporal): closeness of measured values or observations or estimates to the true value
- Precision: conformity of repeated measurements to the reported value
- Fitness for Use: suitability of data for use and user
- Error: difference between a measured or reported value and the true value, encompassing both precision and accuracy
- Ambiguity: doubt in classification, differing perceptions
- Vagueness: poor definition of an object or class

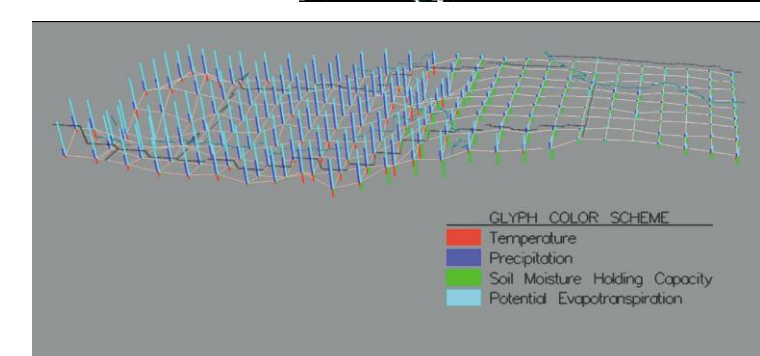
Why are uncertainty representations not found in practical application?

Uncertainty Visualization



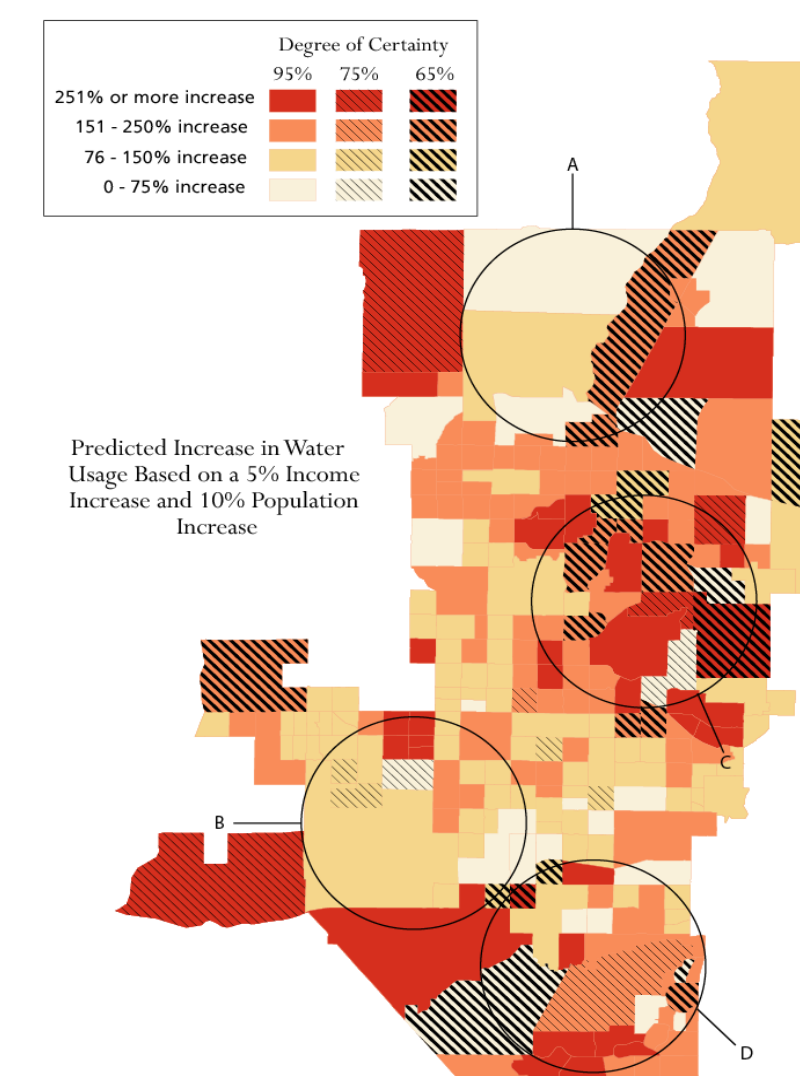
Pang 2001

Cliburn et al 2002



- Decision makers may be unaware of uncertainty in data or introduced in the production process
- Uncertainty visualization to make users aware of presence of uncertainty and its characteristics (type, spatial distribution, degree, etc)
- Representations are often explicit and "objective"

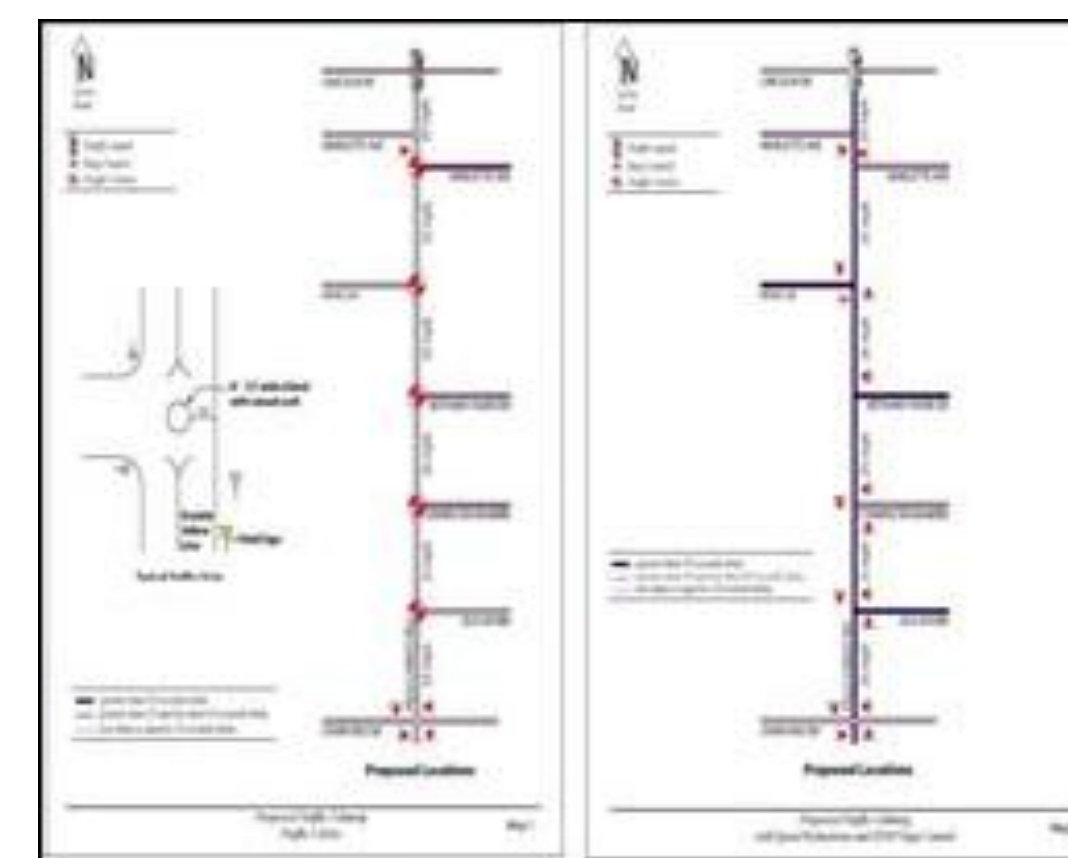
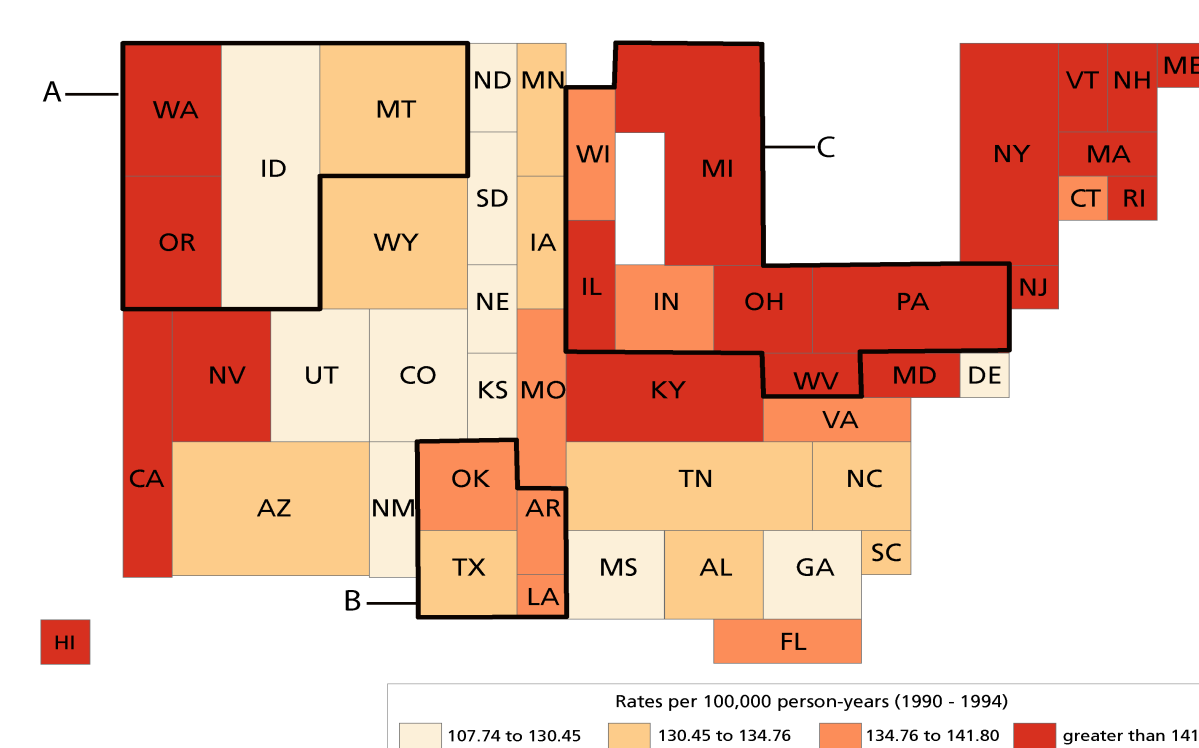
Influence of Uncertainty Visualization and Decision Making: User Studies



- Generalized maps are interpreted as less certain and less reliable than detailed maps
- Altering map design may provide a method for the implicit representation of uncertainty

- Decision makers often do not want to explicitly "see" uncertainty in the data
 - Ignore/discount information
 - Interpret as flawed
- Visceral response to visual uncertainty
- Inclusion of uncertainty may result in a lowering of user confidence in their decisions
- Uncertainty representations may cause users to examine the data more closely

Cancer Mortality Rates 1990-1994
(All Cancers: White Females, All Ages)



- Consideration of the decision frame of individual decision makers may
 - Result in less mistrust of data when uncertainty is represented
 - Encourage users to attend to uncertainty in the data
- Not meeting the needs of the user may result in mistrust of the data

Affective Representation

- Uncertainty is often not objective or explicit in individual decision making
- Uncertainty often not explicitly considered (not separated from the rest of the information or alternatives)
- Decisions often influenced by emotional reactions anticipated in response to a given outcome-emotions and past experience influence decision making
- Individuals likely to recall information congruent with their current emotions - current decision evaluated based on current emotions "How do I feel about this?"
- Emotional state influences the decision making strategy most likely to be adopted:
 - Happy - heuristics, rely on prior knowledge, less attention to details at hand
 - Sad - systematic approach, little reliance on pre-existing knowledge, focus on details at hand
- Uncertainty is implicit, emotional and, often, subjective
- Affective representation to incorporate how people actually attend to uncertainty in their lives - Color, painting, music, cinema and images influence emotion and mood
- Already used to communicate uncertain information, such as climate change



What's next?

- The challenge is to incorporate affective design to influence the attention and emotion of the decision maker without attaching negative or positive value to the uncertainty or data
- Incorporate color, image and music to develop representations that reflect the inherent characteristic of uncertainty

Sources

- Cliburn, D. C., et al. 2002. Design and evaluation of a decision support system in a water balance application. *Computers & Graphics* 26 (6):931-949.
- Pang, A. 2001. Visualizing Uncertainty in Geo-spatial Data, 1-14: Computer Science and Telecommunication Board.
- <http://www.reuters.com/article/scienceNews/idUSN1235191720070712>