The Social Impact of Infrastructure Destruction: Social Order, Sociotechnical Systems, and Layered Indicators

Benjamin Sims

Statistical Sciences Group

Los Alamos National Laboratory

Infrastructure and Sociology

- Sociologists generally don't talk about infrastructure
- My background is in Science and Technology Studies (STS), which takes the view that technology is a key sociological topic
- Infrastructure, in particular, plays such an active role in structuring modern societies that it would be a major oversight for social scientists to ignore it
- A key STS point about infrastructure is that it is the principal interface between the social and natural worlds, managing flow of energy and resources
- For this reason, infrastructure is a key topic in social studies of disasters, because a natural disaster by definition breaks down the relationship between social world and nature

Overview

- Better capturing the social response to infrastructure disruption is the key to understanding where resources need to be committed following disasters, and should be a key concern for policy-makers
- Adding a social response element can considerably enhance the predictive value of infrastructure simulation and modeling efforts
- Provides a conceptual overview of several existing frameworks for understanding the social response to infrastructure disruption
  - Social order
  - Sociotechnical systems
  - Layered indicators
- Moves from a more theoretical social science perspective to more concrete analysis approaches
- A starting point, not a set of conclusions

The New Orleans Police Department and Hurricane Katrina: Infrastructure and Social Order

Katrina's impact on infrastructure in New Orleans

- Infrastructure disabled August 29 (landfall):
  - Power
  - Telephones (land and cellular)
  - Some radio towers used by emergency response agencies

- Infrastructure disabled August 30:
  - Levees and floodwalls, and with them:
  - Sewers
  - Running water
  - Roads
  - Homes
  - Hospitals
  - Backup generators for most remaining radio towers used by emergency response agencies
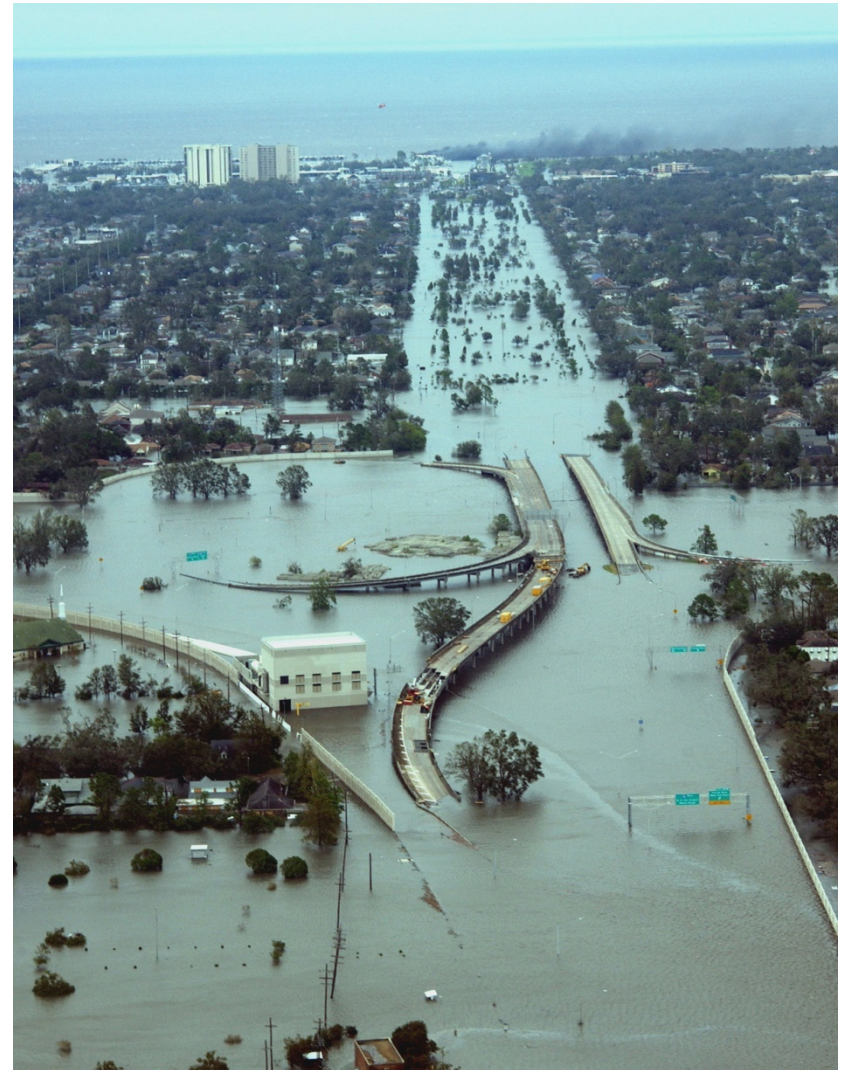
Impact of Infrastructure Failures on NOPD

- Loss of facilities: headquarters, crime lab, evidence room, armory, jail, many police stations
  - Led to shortage of supplies: food, ammunition
- Loss of mobility: roads impassable, police vehicles stranded, lack of gasoline
- Loss of communications: radios, phones
- Loss of police officers' homes (required to live in NO)
  - Food, shelter, clothing
- These factors led to a breakdown of social order for NOPD and New Orleans generally

Social Order

- Key concept in classic Durkheimian tradition in sociology and anthropology; elaborated by Mary Douglas (anthropologist)
  - A culture's systems for categorizing things in the world and its ways of organizing society are interdependent
  - Applies to modern as well as "primitive" societies

Four Elements of Social Order

- *Categories:* classes of things (e.g. species), social roles (e.g. police officer) – WHAT
- *Norms:* behavioral norms (e.g. for a police officer), rules about category separation (e.g. drinking water vs. sewage) – WHY
- *Practices:* rewards or sanctions related to norms (e.g. shunning), methods of category separation (e.g. bathing, separation of sewage from drinking water systems) – HOW
- *Durable structures:* systems that stabilize practices over time (e.g. sewage and wastewater treatment infrastructure, the legal system) – HOW across time and space

Infrastructure and Social Order

- Infrastructure is a type of durable structure
  - Built to enable and reinforce existing categories, norms, and practices
  - Creates its own practices, norms, and categories
  - Creates uniformity of practices, norms, and categories across time and space, characteristic of modernity
  - So infrastructure is key to social order in modern societies
- Three major breakdowns in infrastructure/social order for NOPD
  - Boundaries of the human body
  - Spatiotemporal routines
  - Moral order of police work

Boundaries of the Human Body

Boundaries of the Human Body

- Mary Douglas: pollution (ritual and cleanliness) = "matter out of place" – when norms of separation of categories are violated

- Infrastructure (levee) failure broke down barriers between streets and water, and potable water and sewage infrastructures, creating polluted environment

- Police had to work in direct contact with polluted environment, could not easily manage human waste, could not bathe

- Became bodies became "polluted" as well: inability to separate self from contamination; blisters, rashes, fungal infections

Boundaries of the Human Body - Impact

- Mary Douglas: body serves as metaphor for social order
  - in this case, bodily pollution probably enhanced sense of collapse of social order
- Threatened police identity

  In the car where he sleeps, he has hung three starched, white uniform shirts wrapped in plastic. He's been wearing a ratty, gray T-shirt for several days. "I'm not going to wear those starched shirts in this filth," he explained. "I'm saving them." (*The Washington Post*, September 12, 2005.)

- Cited as contributing to collapse of morale:

  If I put you out on the street and made you get into gun battles all day with no place to urinate and no place to defecate, I don't think you would be too happy either. (Police Superintendent Compass)

Spatiotemporal Routines

- Police infrastructure (facilities) destroyed provided space for coordination of police work and shared sense of identity and purpose; parking lot command posts a poor substitute

- Infrastructure failure (levees) submerged streets and landmarks, making navigation difficult

- Destruction of homes, absence of families disrupted usual home/work schedules, put officers on work footing continuously

Spatiotemporal Routines - Impacts

- Spatial disorientation – landmarks missing, need to take alternate routes, create sense of confusion
- Temporal disorientation (examples from media accounts):

  > This is the same kind of stress I experienced in war … there is no way to tell what day of the week it is … time just stopped on August 29th and it has been one long, continuous day ever since. (*Law and Order Magazine*, October 2005)

  > It disturbs me that I don't know where I slept for the first few days … it reached a point when we didn't know what day it was. (*The Times-Picayune*, December 18, 2005)

  > "I know what day it is. Every day is the same day; it's the day after the hurricane." (*The Washington Post*, December 7, 2005)

- Breakdown of practices for managing time and space of police work actually threatened officers' perceptions of those categories

Moral Order of Police Work

- Destruction/inaccessibility of police infrastructure (stations and jails) made it impossible for officers to remove criminals from the streets

- Sense of being outgunned by criminals who were no longer intimidated by the police

- Need to procure food and other supplies with normal supply chains; difficult to draw line between legitimate commandeering of resources and illegal acts (e.g. Cadillacs)

- Inability to help victims of the storm due to disruption of infrastructure for mobility, communications, and health care

Moral Order of Police Work - Example

He was helping at the convention center one night when a man came up to him carrying his baby in a filthy blanket. "The baby's lips were blue," he remembered. He hadn't eaten in days, and his mother was unable to breast-feed because she was ill. [He] didn't know what to do. There was no hospital, no paramedics to call. He rushed the father and baby into his car, and began speeding west, away from the water. He stopped in St. Charles parish and called an emergency medical service crew, which picked up the child. He found out later that the baby did not survive. "I never thought in my wildest fears that this could happen – that a baby could starve like that in America. I have to think God has a reason," he said. A few days later, after the National Guard arrived, [the officer] saw a huge pallet of baby formula at the police headquarters and was in agony all over again. (*The Washington Post*, September 12, 2005)

Moral Order of Police Work - Consequences

- Collapse of morale and commitment to police force
- Of 1400 officers, in aftermath of storm
  - 228 left posts without permission
  - 91 resigned
  - 2 committed suicide

    "Look, man, I stayed that whole week […] no electricity, no radio communications. I hadn't heard from my wife and kids. . . . I finally decided this, this job . . ." He sighed, looking for words to describe the thanklessness of being a New Orleans cop. "I decided that my family was more important." (Dan Baum, *The New Yorker*, January 9, 2006)

Moral Order of Police Work - Consequences

- Overwhelming sense of failure at individual and departmental level
  - Chief Eddie Compass resigned – "I've done my share"
  - Police officer who stayed for the duration:

  "Today, it finally hit me," he said softly. "I woke up and thought, there's nothing here for me. Not at work. Not at home. What did we accomplish? Nothing. We took such an ass-whipping. We didn't stop the flooding. We didn't stop the looting. The whole city got destroyed. We lost." (Dan Baum, *The New Yorker*, January 9, 2006)

Social Order Framework: Advantages and Disadvantages

- Advantages
  - Provides a useful framework for "thick description" and qualitative understanding of social impacts of disaster
  - Connects infrastructure issues and disaster responses to rich body of social theory
  - Enables exploration of moral/emotional response to disaster
- Disadvantages
  - Presents a largely static view of social order
  - Does not provide clear understanding of how individuals and organizations can be resilient despite erosion of social order – NOPD case is an exception
  - Entirely qualitative perspective is not readily compatible with simulation and modeling approaches and is of limited policy relevance

Disaster Resilience:
A Sociotechnical Systems View

Resilience

- Increasingly popular perspective in disaster impact and recovery research

- Interdisciplinary origins: engineering, ecology, psychology

- Resistance vs. Resilience (Norris et al. 2007 – psychologists)
  - *Resistance* occurs when a system is able to withstand the impact of a stressor with no internal change
  - *Resilience* occurs when a stressor causes internal change to a system such that the system must adapt to regain functionality

- A disaster can be defined as a stressor that overwhelms the resistance capacity of a system

Stress as Resource Loss

- Hobfoll's Conservation of Resources (COR) theory is a dominant view of stress in psychology and disaster research (Hobfoll 1989 - psychologist)

  - Basic tenet: "people strive to retain, protect, and build resources and … what is threatening to them is the potential or actual loss of these valued resources."

  - Definition of stress: "A reaction to the environment in which there is

    a) The threat of a net loss of resources
    b) The net loss of resources, or
    c) A lack of resource gain following the investment of resources."

Resources

- Examples of resources from study by Hobfoll (1993)
  - Personal transportation
  - Adequate clothing
  - Time with loved ones
  - Necessary tools for work
  - Housing that suits my needs
  - Adequate income
  - Status/seniority at work
  - Feeling valuable to others
  - Sense of commitment

- Many of these resources can be directly linked to key infrastructure and social systems:
  - Transportation systems
  - Work organizations
  - Communication technology
  - Community services

Extending COR Theory

- The COR perspective can be adapted to apply to physical as well as mental stress
  - Resources such as food, medicine, water
- Can also be adapted to different types of sociotechnical systems in addition to individuals
  - For both physical and social/behavioral systems, stress occurs when resources are lost
  - For social/behavioral systems (self-aware) a perceived threat of loss of resources is also stressful
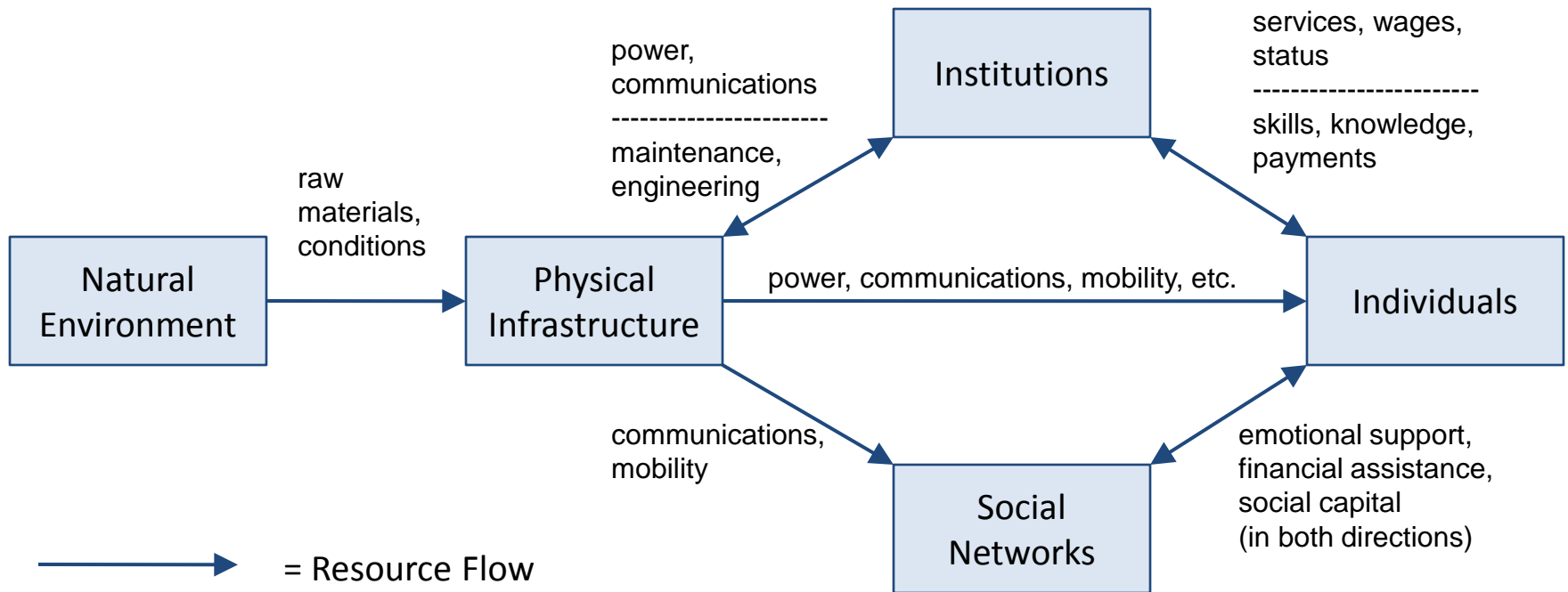
Characteristics of Resilient Systems

- Resilience of a system can be viewed in terms of 4 Rs (Bruneau et al. 2003 – earthquake engineers and social scientists)
  - *Robustness:* ability to withstand a level of stress without degradation (= resistance, as defined previously)
  - *Redundancy:* existence of substitutable elements in a system
  - *Rapidity:* capacity to mobilize resources quickly
  - *Resourcefulness:* capacity to identify problems, improvise solutions, and identify appropriate resources
- These apply to both technological and socioeconomic systems (probably could be extended to individuals as well)
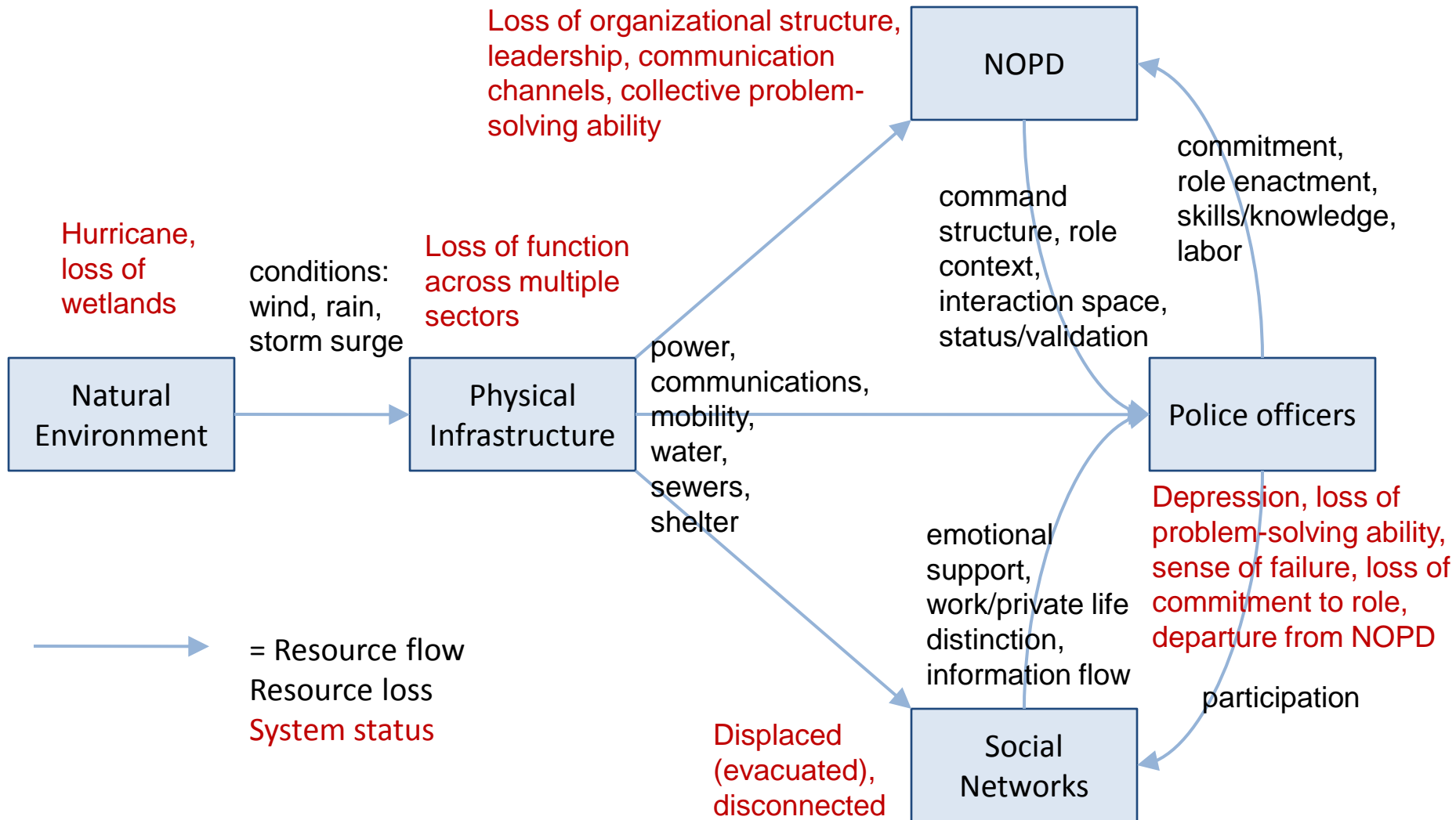
Elements of a Sociotechnical Systems View of Resilience

- Stressor characteristics (Norris et al. 2008):
  - Severity: degree of resource loss
  - Duration: duration of resource loss
  - Surprise: whether a particular resource loss has been anticipated
- System resilience factors (4 Rs)
- Flow of resources between entities
  - Physical infrastructure
  - Social institutions (organizations, standardized social systems)
  - Social networks (connections between individuals)
  - Individuals

Sociotechnical Systems View of Resilience

NOPD: Resource Loss and System Degradation

Loss of organizational structure, leadership, communication channels, collective problem-solving ability

NOPD

commitment, role enactment, skills/knowledge, labor

command structure, role context, interaction space, status/validation

Hurricane, loss of wetlands

conditions: wind, rain, storm surge

Loss of function across multiple sectors

Natural Environment

Physical Infrastructure

power, communications, mobility, water, sewers, shelter

Police officers

Depression, loss of problem-solving ability, sense of failure, loss of commitment to role, departure from NOPD

emotional support, work/private life distinction, information flow

participation

= Resource flow
Resource loss
System status

Displaced (evacuated), disconnected

Social Networks

Resilience in the NOPD: 4 Rs

- *Robustness/Resistance:* None
  - Severity of stressors quickly overwhelmed almost all normal organizational routines, pushing NOPD into resilience mode
- *Redundancy:* Insufficient
  - Some redundancy existed (e.g. radios/cell phones, cars/boats) but in most cases substitutable resources were also lost
- *Rapidity:* Low-moderate
  - Police department was able to reorganize some functions and acquire minimally adequate resources within hours-days
- *Resourcefulness:* Moderate
  - Numerous instances of improvisation: establishing command centers in parking lots, wiring car batteries to pumps to obtain gasoline from underground storage tanks, organizing boat rescues, but largely limited to immediate survival

Sociotechnical Systems Framework: Advantages and Disadvantages

- Advantages
  - More dynamic view of system interactions that lead to resilience (or lack of resilience)
  - Specification (simplification) of causal links in terms of resource flow
  - These features make it a potentially useful framework for modeling and simulation approaches to explore resilience

- Disadvantages
  - "Thinner" description of cultural phenomena
  - Less connected to traditions of social theory
  - Difficult to quantify some elements of resilience (e.g. resourcefulness) and some resources (e.g. emotional support)

Layered Indicators

Indicators

- Some researchers have worked to develop simple indexes of disaster vulnerability based on readily available data

- This approach avoids having to address the complexities of resilience directly, but provides an indication of how resilience might come into play

- Example: Social Vulnerability Index (Cutter et al. 2003 - geographers)

Social Vulnerability Index (SoVI)

- Begins with list of demographic variables that have been associated in the literature with worse disaster outcomes (SoVI variant focusing on social variables)

Civilian labor force participation	Percentage of female participation in civilian labor force
Average family income	
Median dollar value of owner occupied housing units	Percentage of female-headed households
Median gross rent ($) for renter-occupied housing units	Percentage of Native American population (American Indian, Eskimo, or Aleut)
Percentage of population who are immigrants	Percentage of population under 5 years
Percentage of institutionalized elderly population	Percentage of population 65 years or older
Average number of people per household	Percentage of living in poverty
Percentage of employed in primary industry: farming, fishing, mining, forestry	Percentage of renter occupied housing units
	Percentage of rural farm population
Percentage of Asian or Pacific Islander	Percentage of Hispanic persons
Percentage of black population	Percentage employed in transportation, communications, and other public utilities
Percentage of the civilian labor force unemployed	
Percentage of population over 25 years old with less than 12 years of education	Percentage of the population living in urban areas
	Percentage employed in service occupations
Percentage of females	Percentage of households that receive Social Security benefits

# Social Vulnerability Index (SoVI)

- Uses principal component analysis to group these variables into factors that best cover the variability between geographic units in the selected area

- As a result, how the index is calculated varies depending on the geographic area selected and the granularity of the units within that area (e.g. census tracts in a state vs. counties in a region)

- At Los Alamos, we have begun to incorporate the Social Vulnerability Index into reports for NISAC

Southern California SoVI

- Done for NISAC Southern California earthquake study
- Done for 8 county area, by census tract
- Factors derived from principal component analysis
- Analyst has to determine the sign of each factor based on the known relevance of its dominant variables to vulnerability

Factor Rank and Name	Contributions of Dominant Variables		Correlation with Social Vulnerability
1. Income and Housing	-0.86	Median household income	Positive
	+0.84	Renter occupied units	
	+0.76	Female-headed households	
	-0.75	Median rent	
	+0.74	Poverty rate	
2. Work , Households and Education	+0.87	Ave. Household Size	Positive
	-0.80	Female workforce participation	
	+0.76	Hispanic/Latino population	
	+0.75	Pop. with < 12 yrs. Education	
	-0.74	Civilian labor force participation	
3. Age	+0.90	Pop. 65 years and older	Absolute value
	+0.88	Receiving Social Security	
	-0.30	Pop. under 5 years	
4. Rural and Urban	+0.82	Rural farm population	Absolute value
	-0.78	Urban population	
	+0.59	Employment in farming, fishing, mining and forestry	
5. Race and Employment	+0.82	Employment in utilities	Positive
	+0.69	African American population	
	-0.35	Median housing value	
6. Gender and Work	+0.91	Female population	Absolute value
	+0.34	Civilian labor force participation	
	+0.32	Female-headed households	
7. Immigration and Race	+0.87	Asian/Pacific Islander pop.	Positive
	+0.50	Immigrant population	
8. Race, Housing and Age	-0.54	Native American population	Absolute value
	+0.47	Median housing value	
	+0.45	Institutionalized elderly pop.	

Southern California SoVI Map

Social Vulnerability Category

- 1
- 2
- 3
- 4
- 5

Miles
0 10 20 40 60 80
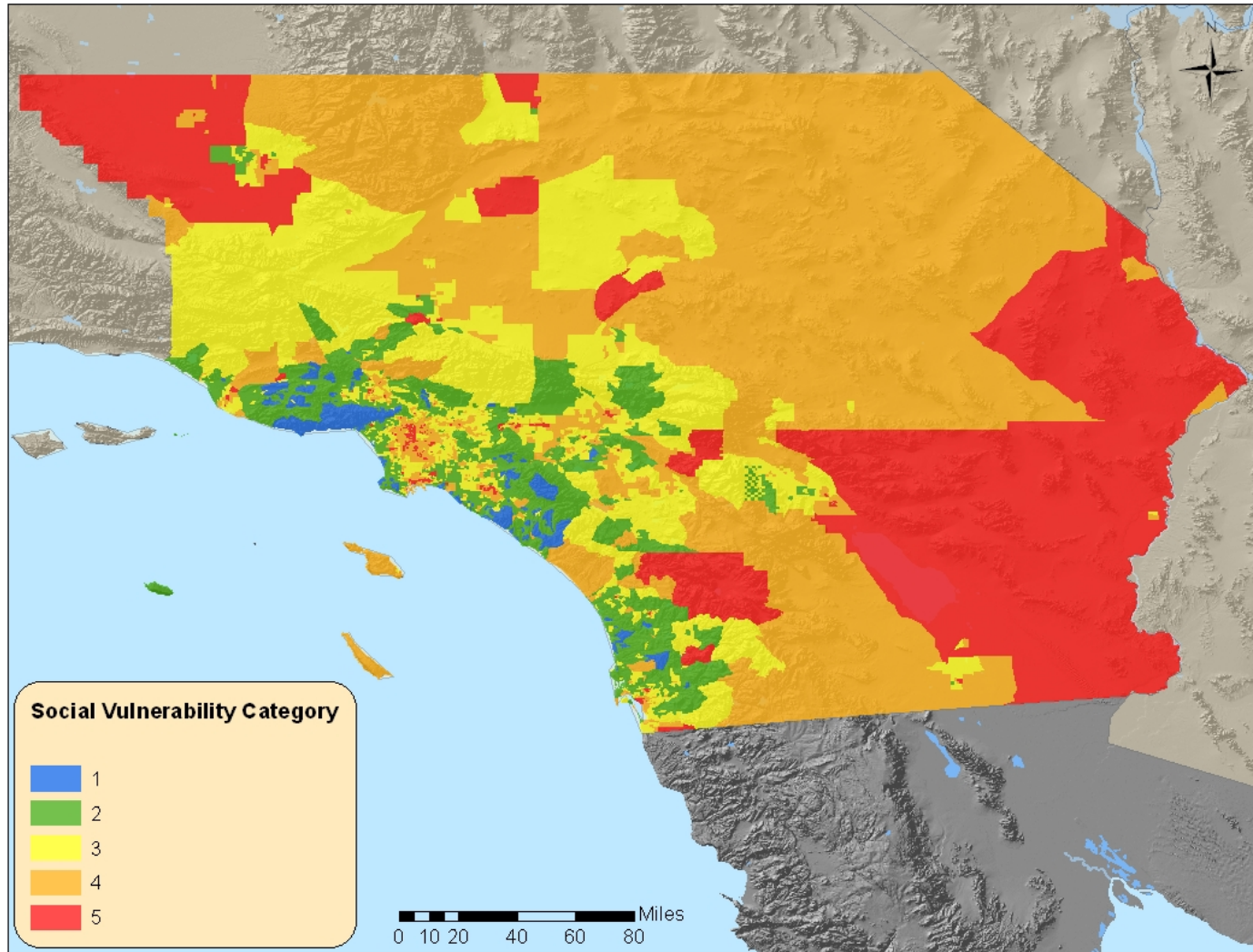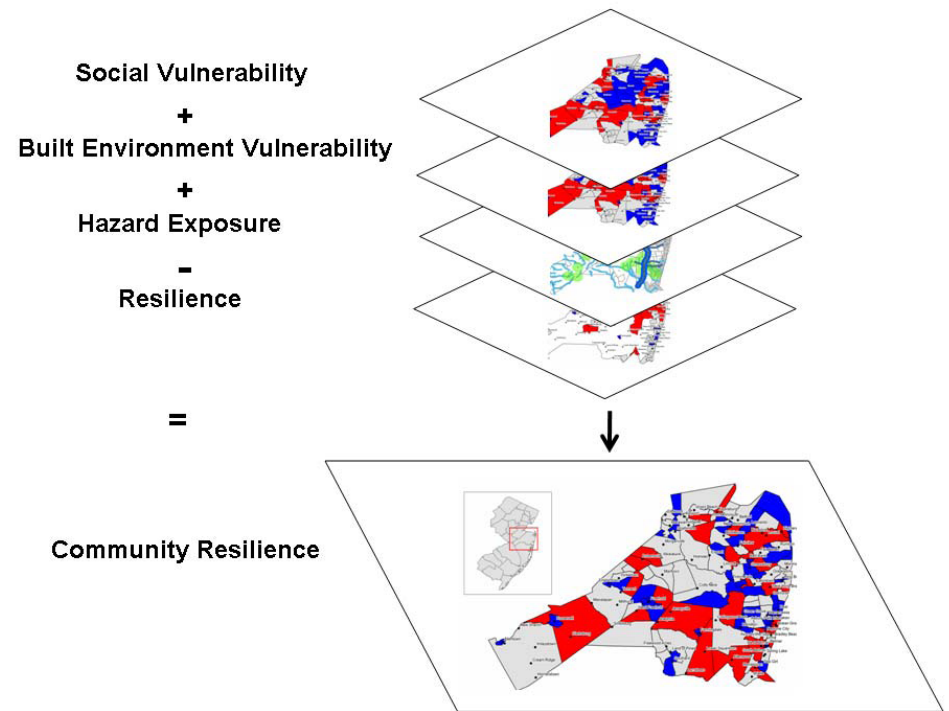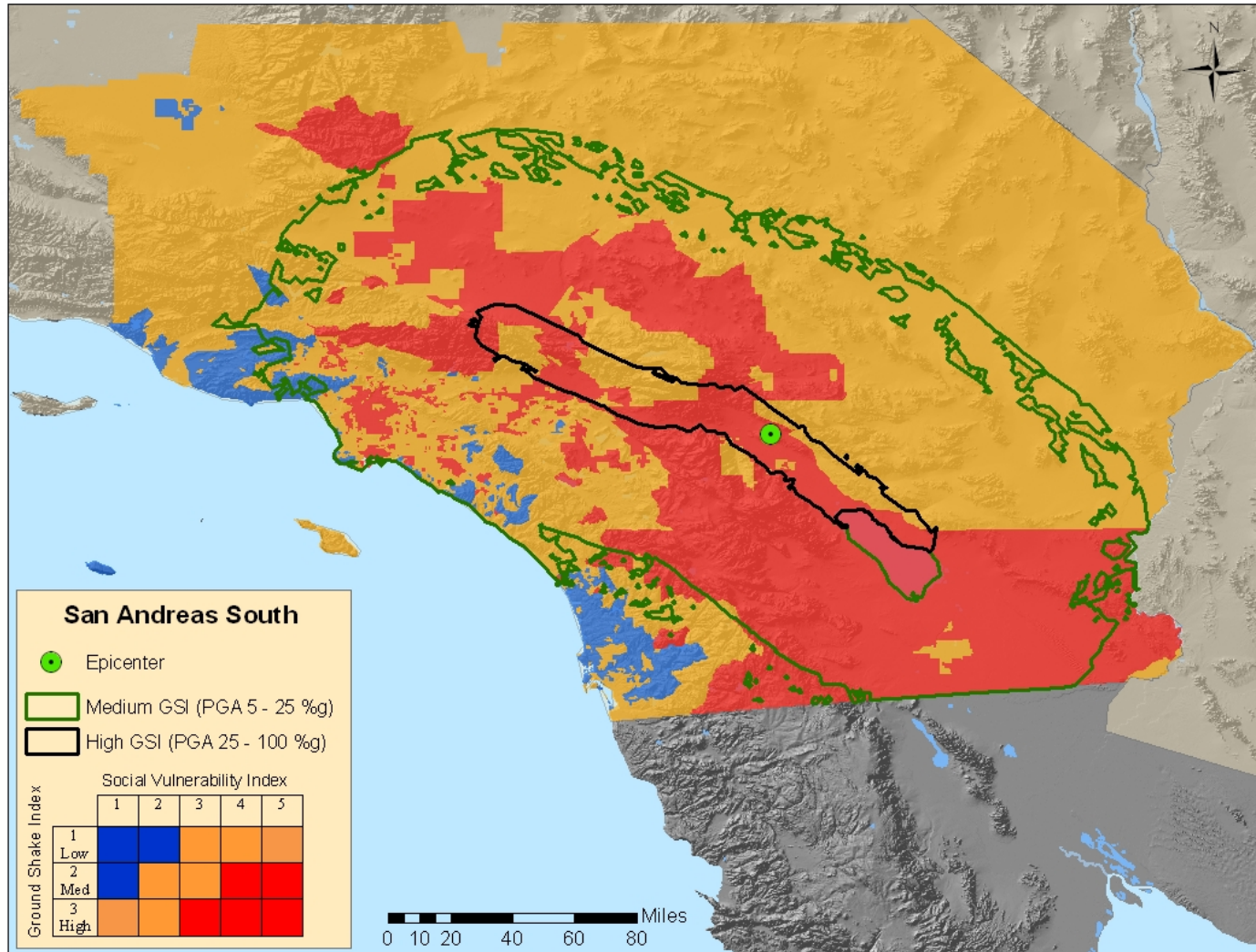
Map: Rachel Hixson

Layered Indicators

- Cutter et al. suggest a geographic layering approach to assessing community resilience
- NISAC models + HAZUS already cover built environment and hazard exposure for specific cases
- Social vulnerability tool has been implemented
- Resilience metrics need further development

Social Vulnerability
+
Built Environment Vulnerability
+
Hazard Exposure
-
Resilience

=

Community Resilience
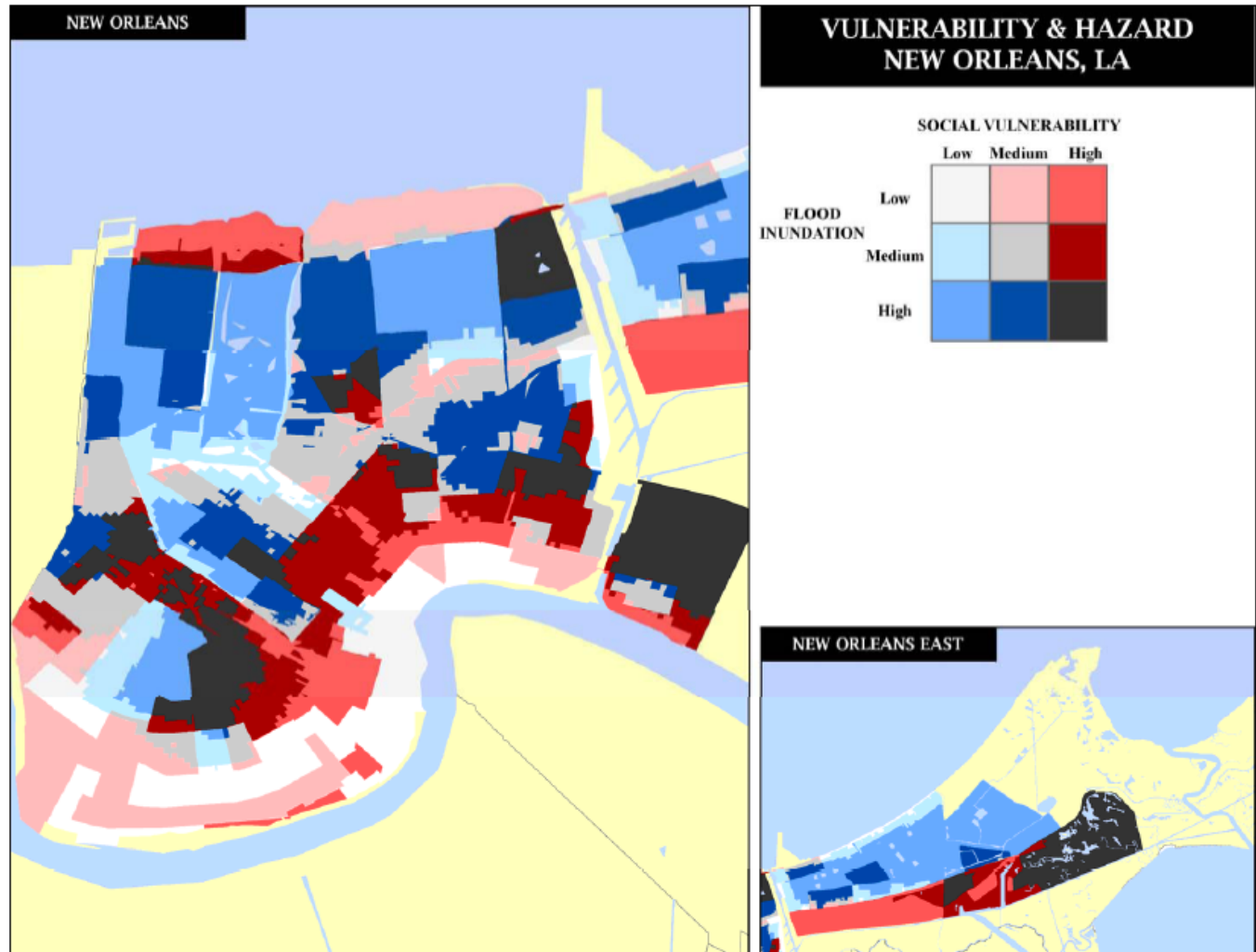
Cutter et al. (2008)

Layered Indicators: SoVI + Ground Accel.

Map: Rachel Hixson

Layered Indicators: New Orleans

- Tate (2007); student of Cutter

Layered Indicators: Advantages and Disadvantages

- Advantages
  - Readily implemented right now, or in the near future, with currently available data
  - Integrates and summarizes potential disaster impacts in a way that is accessible to policy makers and the general public
- Disadvantages
  - SoVI as current implemented assigns weights to different factors somewhat arbitrarily – needs an expert judgment component
  - Largely static approach, glosses over some interesting/relevant complexities in resilience
  - Focuses on spatial distribution of impacts rather than processes

Implementing Layered Indicators

- A key step in further developing a layered indicators approach in NISAC is to develop an Infrastructure Disruption Index

- This index would incorporate output from NISAC models and HAZUS to capture likely infrastructure and built environment impacts across multiple sectors

- Would provide integrative, easily understood way of presenting NISAC analysis results

- Work would focus on capturing expert judgment for weighting impacts of different infrastructure systems, and on reconciling output formats across multiple models

A Larger Research Agenda

- The resilience/sociotechnical systems framework is a useful starting point for modeling and simulation investigations of social response to disaster
  - Dynamic theoretical model
  - Focus on resource flow
  - Attends to feedback between infrastructure, organizations, and individuals
- Ultimately, investment in social science research (case studies, ethnographic work, demographic studies) is key to credibility of all of these approaches

Conclusion

- Social response to disasters is an area where the national labs can make a significant impact
  - Modeling and simulation resources in place
  - Ability to overcome disciplinary barriers between modeling and simulation, engineering, and social science communities
  - Could significantly enhance the value of modeling and simulation products for emergency responders and disaster planners