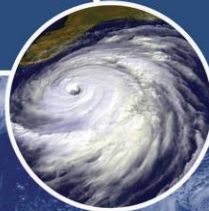




» Wildfire



» Hurricane



» Tropical Cyclone

» Tsunami



» Flooding

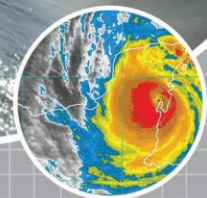


» Earthquake



» Pandemic Influenza

Fostering Disaster - Resilient Communities



MEASURING VULNERABILITY

Christina Finch
International Training Workshop
National Science and Technology Center for Disaster Reduction
May 4-8, 2009

Hazards, Vulnerability & Risk

» Hazard

- Physical Event or Process
- Natural Hazard – Flood, Earthquake
- Technological – Nuclear Explosion
- Probability of Occurrence
- Characteristics: Magnitude, Intensity, Frequency, Duration, Time of Onset

» Disaster

- *“Hazards only become disasters when people’s lives and livelihoods are swept away.”* – UN Secretary-General Kofi Annan

Hazards, Vulnerability & Risk

» Vulnerability

- Potential for Harm
- Likelihood that an individual or group will be exposed to and adversely affected by a hazard
- *“The conditions determined by physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard.” - UNDP*

Hazards, Vulnerability & Risk

» Risk

- Probability of Loss (Likelihood, Frequency)
- Expected Losses (Deaths, Economic Damages)

» Risk Assessment

- Probability of Natural Hazard and Degree of Danger
- *Function of Hazard, Exposure, Vulnerability and Coping Capacity*

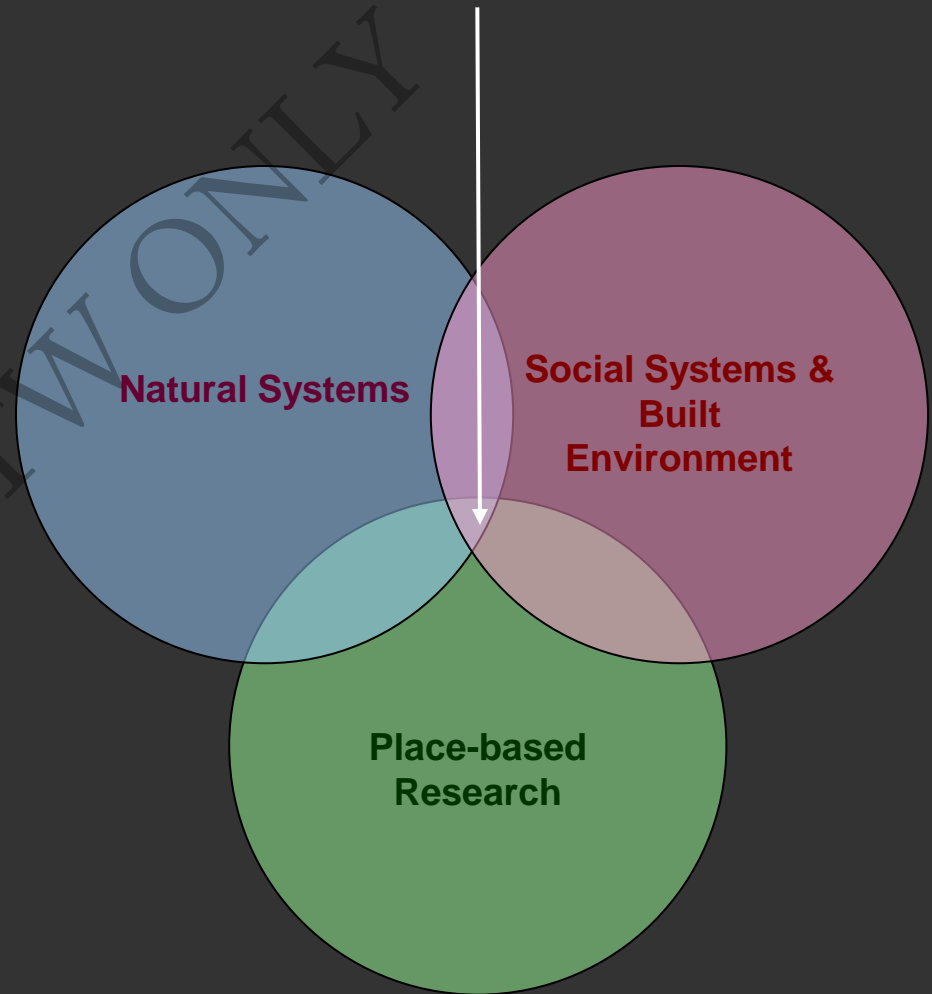
» Risk Reduction

Vulnerability Science

- » What makes people and places vulnerable to environmental threats from natural, technological, and human-induced hazards?
 - What circumstances place people and localities at risk?
 - What enhances or reduces the ability to respond to environmental threats?
- » Development of methods and metrics for analyzing societal vulnerability and resilience to environmental hazards and extreme events

Importance of Spatial Perspective

- » Interaction of Natural Systems, Social Systems, and Built Environment
- » Place-Based Research



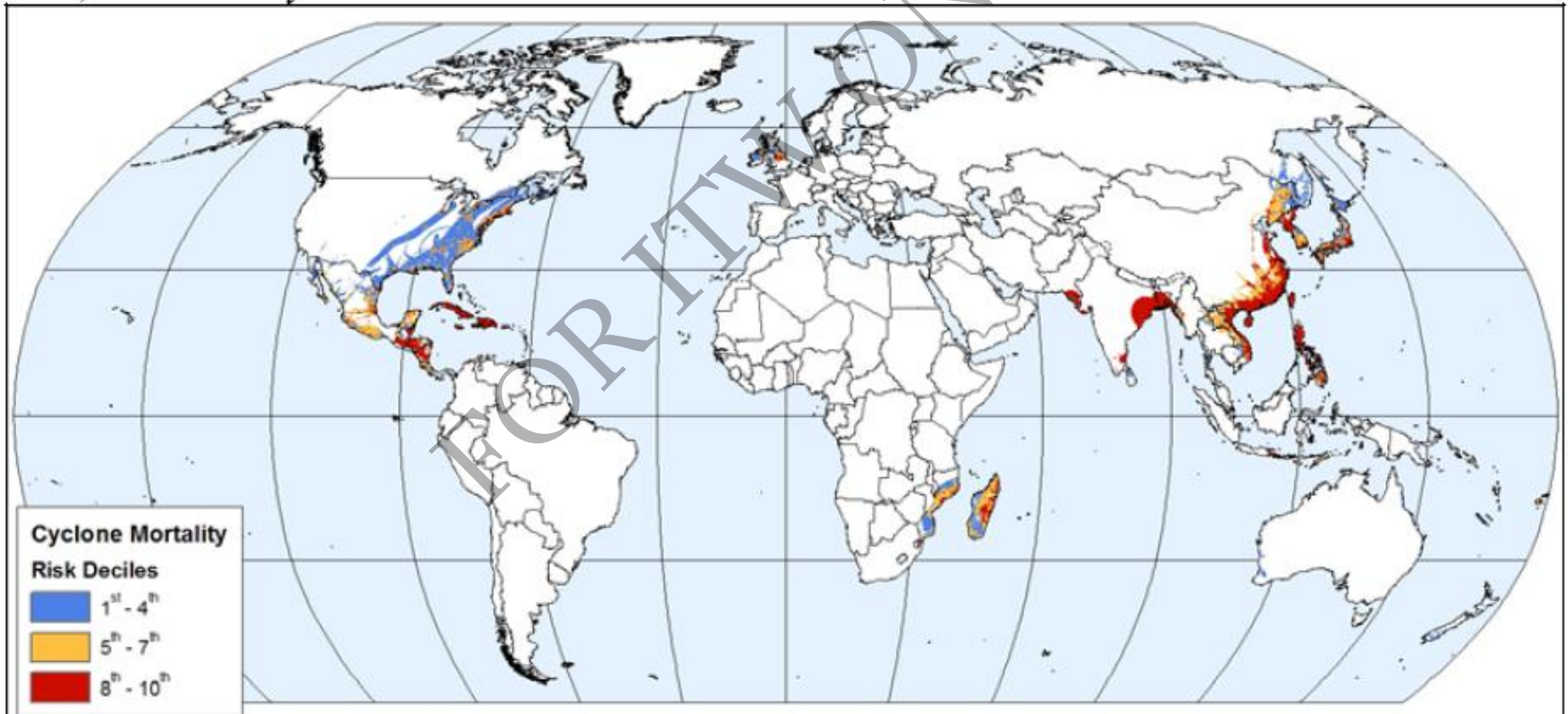
Outline

- » Global Risk & Vulnerability Assessments
 - Global Hotspots (Columbia University, World Bank)
 - Disaster Risk Index (UNDP/UNEP-GRID)
- » Social Vulnerability Index – SoVI (Cutter, Boruff and Shirley 2000)
 - U.S. County
 - Spatial Patterns and Temporal Trends
 - Case Study: New Orleans, Louisiana

Global Natural Disaster Risk Hotspots

» Tropical Cyclones Based on Mortality

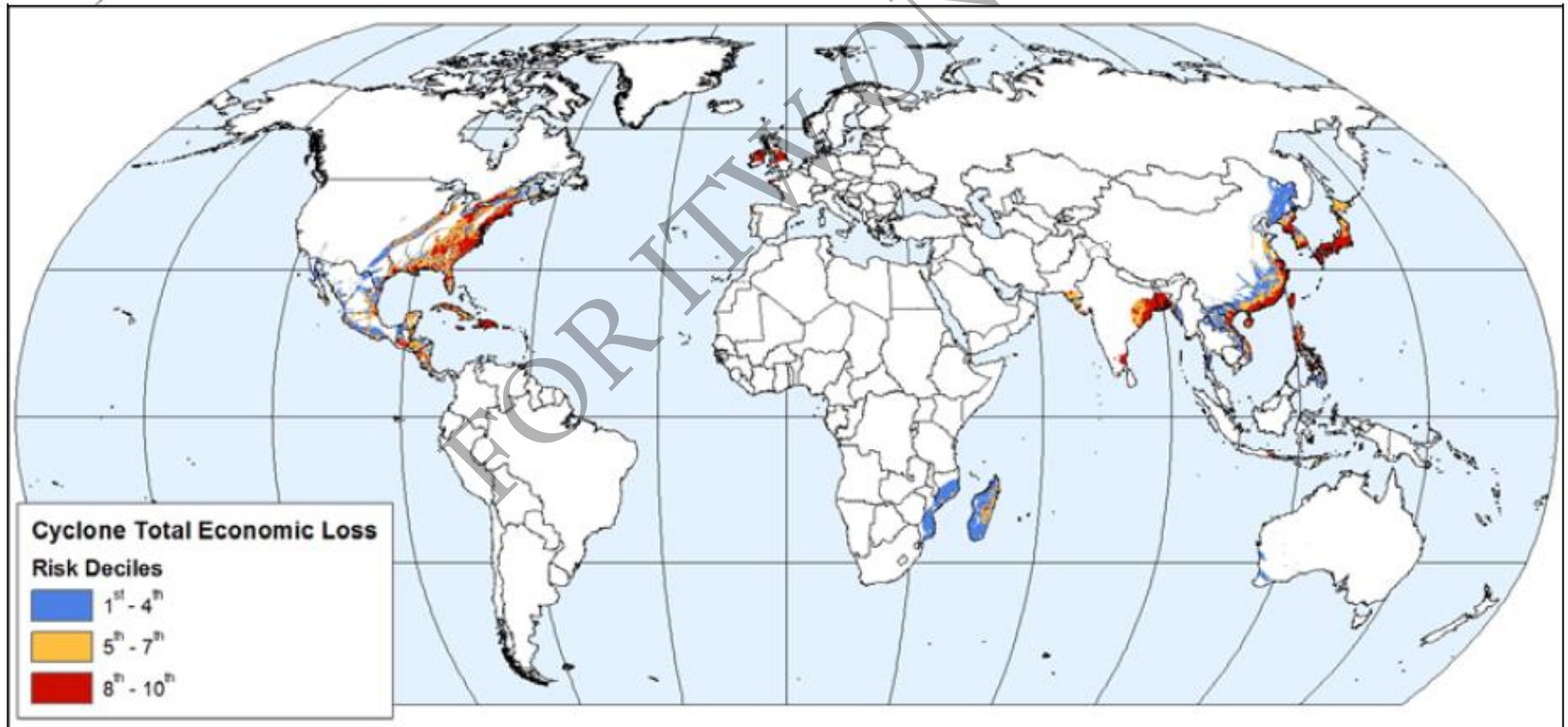
a) *Mortality*



Global Natural Disaster Risk Hotspots

» Tropical Cyclones Based on Economic Losses

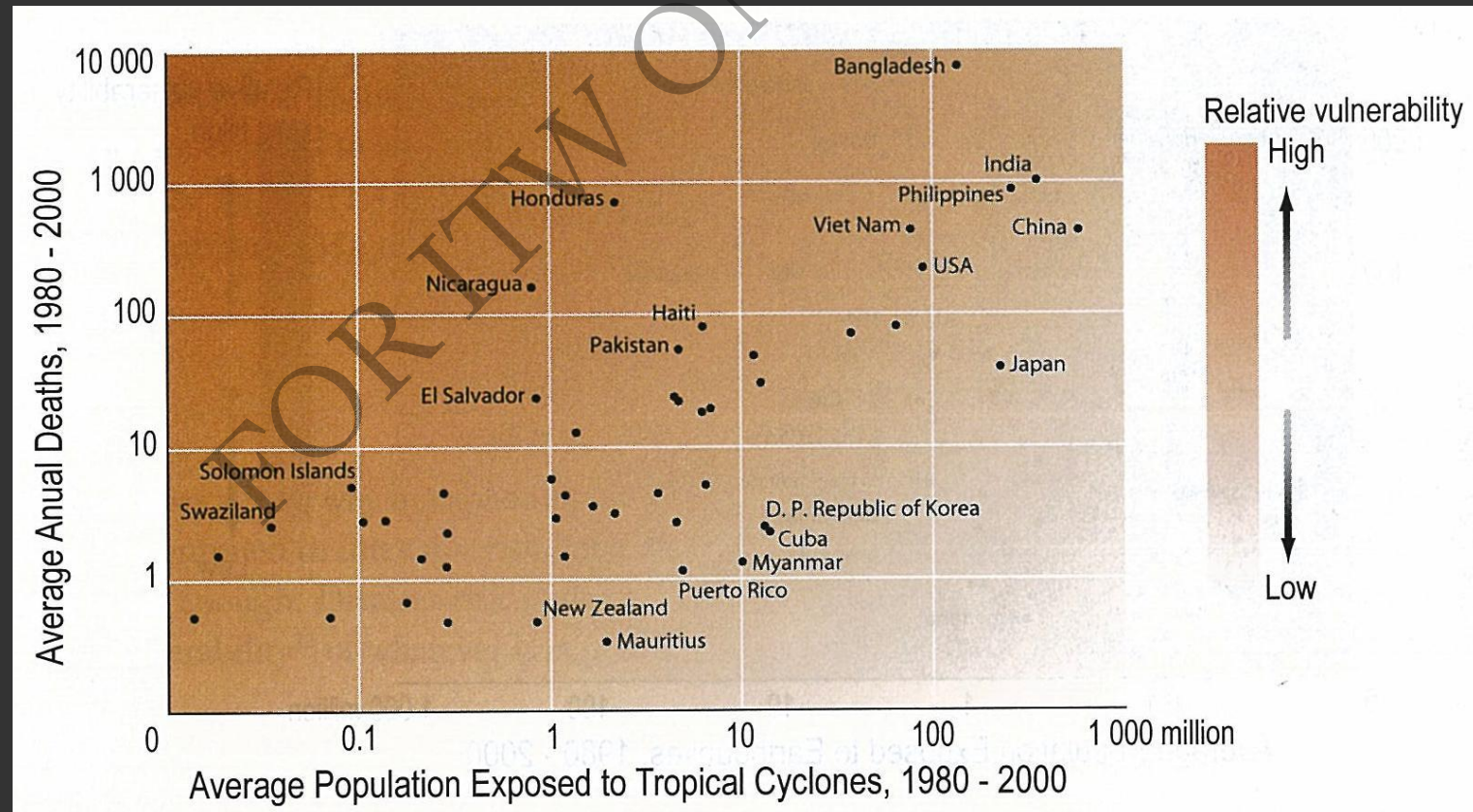
b) Total economic loss



Disaster Risk Index

- » Index Based on Mortality
- » “Vulnerability is perceived as the concept that explains why people with the same level of physical exposure can be more or less at risk.”
- » Similar Exposure – Different Human Impacts
 - Least Developed Countries
 - 11% of Physical Exposure
 - 53% of Casualties
 - Most Developed Countries
 - 15% Physical Exposure
 - 1.8% of Casualties

Disaster Risk Index: Tropical Cyclones



Social Vulnerability

- » Characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard

Characteristics of Social Vulnerability

Special Needs Populations

- » Difficult to identify (infirm, transient) let alone measure; invariably left out of recovery efforts; often invisible in communities



Age (Elderly and Children)

- » Affect mobility out of harm's way; need special care; more susceptible to harm



Socioeconomic Status (Rich, Poor)

- » Ability to absorb losses and recover (insurance, social safety nets), but more material goods to lose



Race and Ethnicity (Non-white, Non-Anglo)

- » Impose language and cultural barriers; affect access to post-disaster recovery funding; tend to occupy high hazard zones



Gender (Women)

- » gender-specific employment, lower wages, care-giving role



Social Vulnerability Index (SoVI)

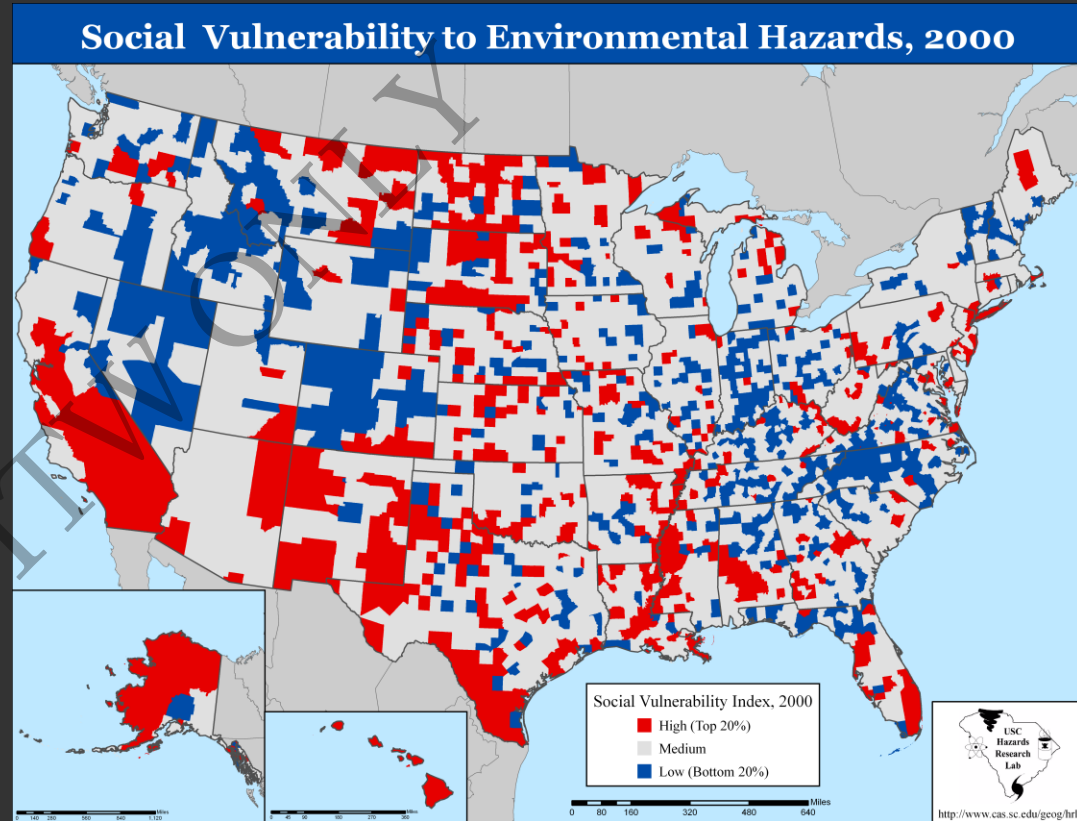
- » Identify Vulnerable Populations
- » Replicate Methodology for Different Time Periods
- » Assess Spatial Patterns and Changes
- » Highlight Temporal Trends
- » Project Future Vulnerability
- » Scale Methodology for Different Levels of Geography

SoVI

- » Socioeconomic Status
(Income, Political Power, Prestige)
- » Gender
- » Race and Ethnicity
- » Age
- » Commercial and Industrial Development
- » Employment Loss
- » Rural/Urban
- » Residential Property
- » Infrastructure and Lifelines
- » Renters
- » Occupation
- » Family Structure
- » Education
- » Population Growth
- » Health Status
- » Medical Services
- » Social Dependence
- » Special-needs Population

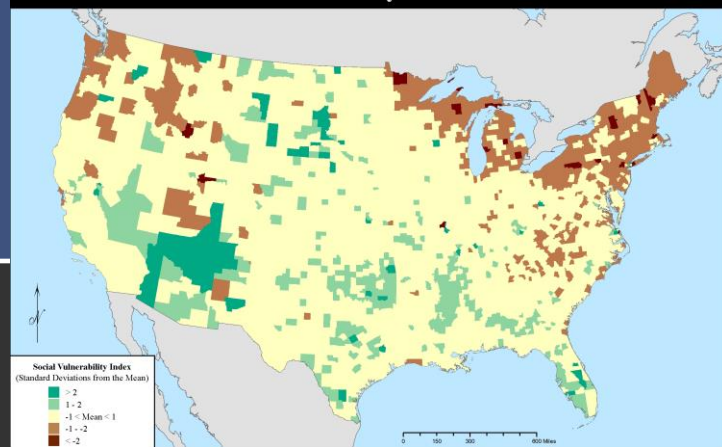
Social Vulnerability Index (SoVI)

- » Relative Index
- » County Level
- » United States
- » Decade - 2000
- » Data Reduction
- » 42 Socioeconomic Variables

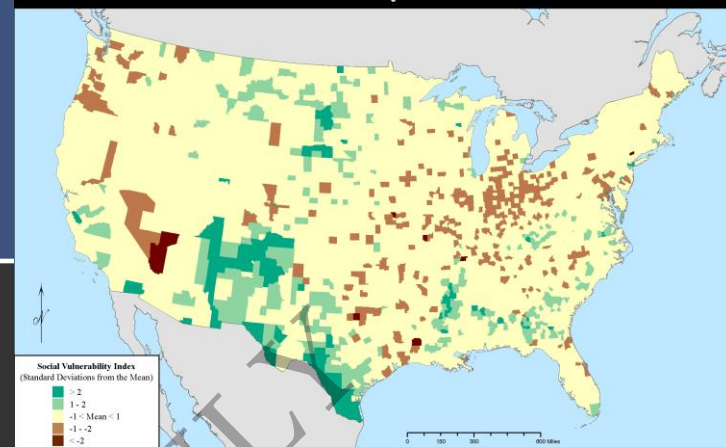


Cutter, S.L., B.J. Boruff, and W.L. Shirley. 2003. "Social Vulnerability to Environmental Hazards." *Social Sciences Quarterly*. 84(2): 242-261.

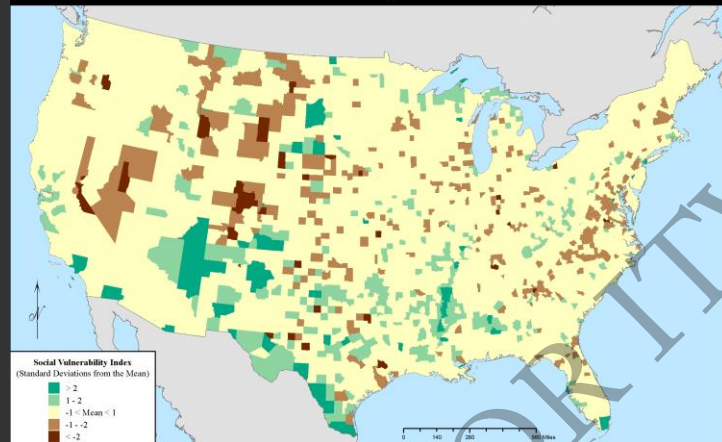
Social Vulnerability Index in 1960



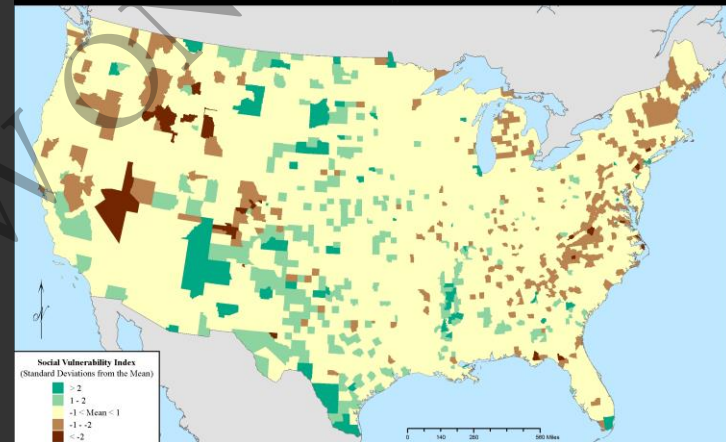
Social Vulnerability Index in 1970



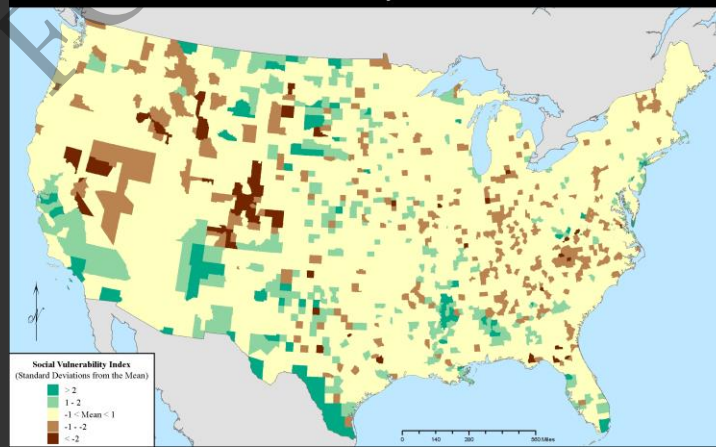
Social Vulnerability Index in 1980



Social Vulnerability Index in 1990



Social Vulnerability Index in 2000



High Social Vulnerability Regional Trends

- » Lower Mississippi River
- » Texas-Mexico Border
- » North Central US/Great Plains

Low Social Vulnerability Regional Trends

- » Northwest
- » Nevada
- » Colorado

25 Most Vulnerable Counties

1960	1970	1980	1990	2000
New York, NY	New York, NY	New York, NY	New York, NY	New York , NY
Shannon, SD	San Francisco, CA	Yellowstone National Park, MT	San Francisco, CA	Roanoke City, VA
Monroe, WI	Bronx, NY	San Francisco, CA	Washington, DC	Bronx , NY
Todd, SD	Kings, NY	Shannon, SD	Bronx, NY	Webb , TX
Duval, TX	Suffolk, MA	Todd, SD	Kings, NY	Northampton , VA
Jackson, SD	Washington, DC	Kings, NY	Suffolk, MA	Shannon , SD
Apache, AZ	Maverick, TX	Apache, AZ	Shannon, SD	San Francisco , CA
Athens, OH	Queens, NY	Bronx, NY	Benton, WA	Kings , NY
Navajo, AZ	Starr, TX	Starr, TX	Todd, SD	Starr , TX
San Juan, UT	Zavala, TX	Maverick, TX	St. Louis City, MO	Todd , SD
McKinley, NM	Philadelphia, PA	Buffalo, SD	Buffalo, SD	Maverick , TX
Buffalo, SD	Kenedy, TX	Hudson, NJ	Apache, AZ	McKinley , NM
Adams, WA	Webb, TX	Queens, NY	Hudson, NJ	Zavala , TX
Monroe, IL	Dimmit, TX	Falls Church, VA	Baltimore, MD	Buffalo , SD
Rolette, ND	St. Louis City, MO	Suffolk, MA	Philadelphia, PA	Issaquena , MS
Ormsby, NV	Jim Hogg, TX	Menominee, WI	Queens, NY	Clifton Forge City, VA
Dewey, SD	Willacy, TX	Sioux, ND	Sioux, ND	Queens , NY
Sioux, ND	Hudson, NJ	McKinley, NM	McKinley, NM	Hudson , NJ
Brown, NE	Zapata, TX	Rolette, ND	Platte, NE	Brooks , TX
Alpine, CA	Hidalgo, TX	Webb, TX	Webb, TX	Wilcox , AL
Mohave, AZ	Denver, CO	St. Louis City, MO	Big Stone, MN	Cameron , TX
Coryell, TX	Shannon, SD	Dewey, SD	Menominee, WI	Presidio , TX
Coconino, AZ	Santa Cruz, AZ	Corson, SD	Arlington, VA	Apache , AZ
Kings, NY	Presidio, TX	Val Verde, TX	Dewey, SD	Sioux , ND
Stanley, SD	Cameron, TX	Emporia, VA	East Carroll LA	Dimmit , TX

Occurrence Frequency of Most Vulnerable Counties

2 Decades	3 Decades	4 Decades	5 Decades
Cameron, TX ←	Dewey, SD ←	Apache, AZ ←	Kings, NY ←
Dimmit, TX ←	Maverick, TX ←	Bronx, NY ←	New York, NY ←
Menominee, WI ←	St. Louis City, MO ←	Buffalo, SD ←	Shannon, SD ←
Philadelphia, PA ←	Starr, TX ←	Hudson, NJ ←	
Presidio, TX ←	Suffolk, MA ←	McKinley, NM ←	
Rolette, ND ←		Queens, NY ←	
Washington, DC ←		San Francisco, CA ←	
Zavala, TX ←		Sioux, ND ←	
		Todd, SD ←	
		Webb, TX ←	

Main Themes

Development - Urban

Race/Ethnicity – Native American

Race/Socioeconomic Status – Lack of Education, Poverty, Diversity

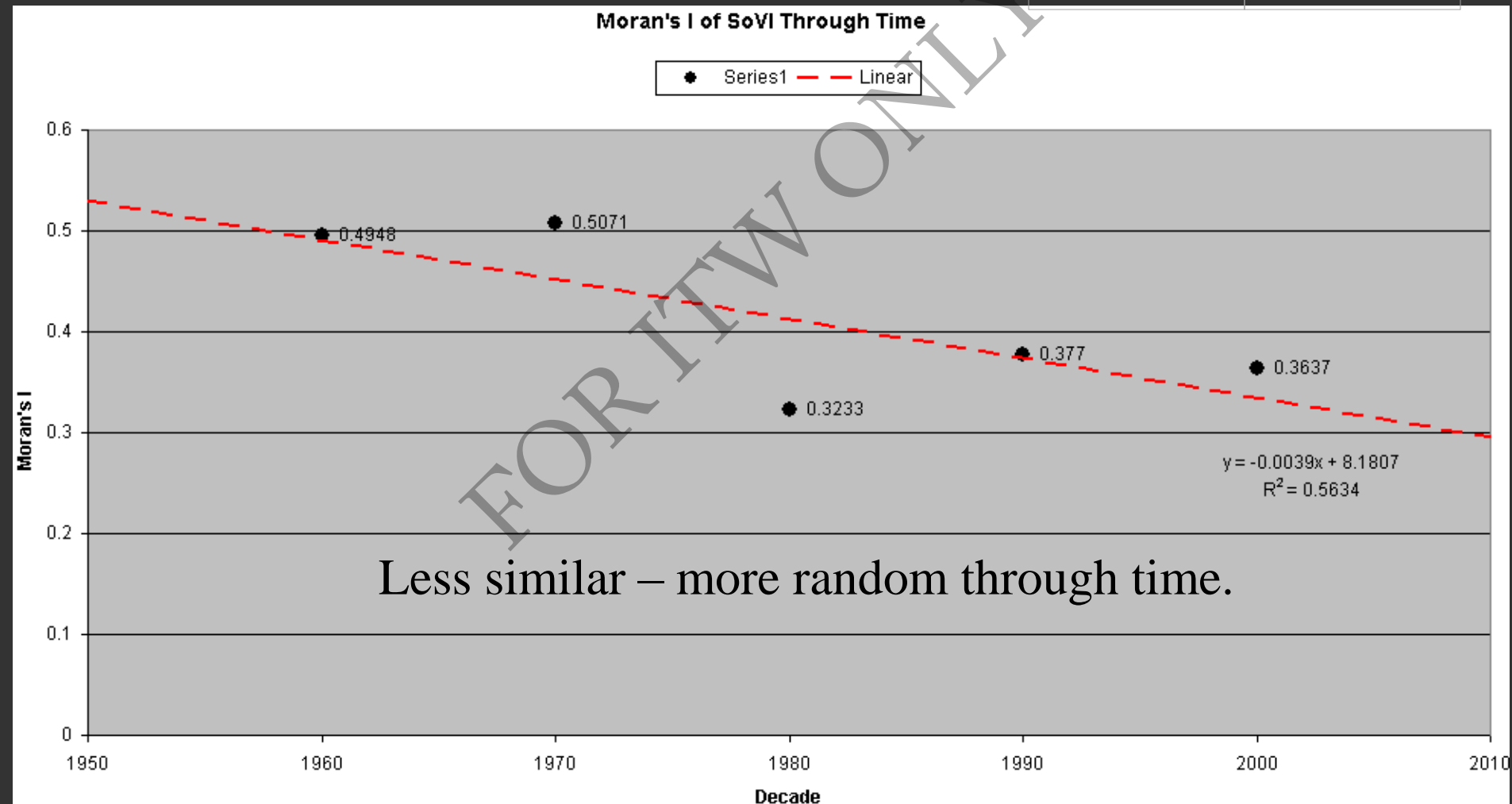
Spatial Variations and Patterns

- » Measures of Spatial Autocorrelation
 - Global Moran's I
 - Measure of Association - Similar/Dissimilar
 - Similar (+1), Random (0), Dissimilar (-1)
 - Local Moran's I (LISA)
 - Influence of Local Neighbors
 - Identify Significant Clusters of Similar Values
 - *High-High* and *Low-Low*

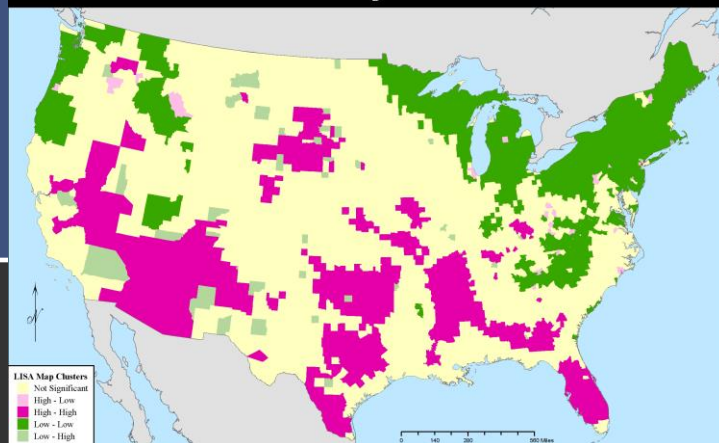
Global Moran's I

There was significant positive spatial autocorrelation in all decades.

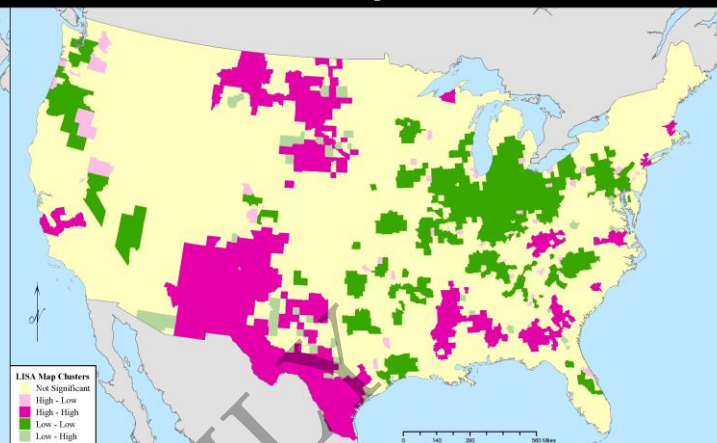
Decade	Moran's I
1960	0.4948
1970	0.5071
1980	0.3233
1990	0.377
2000	0.3637



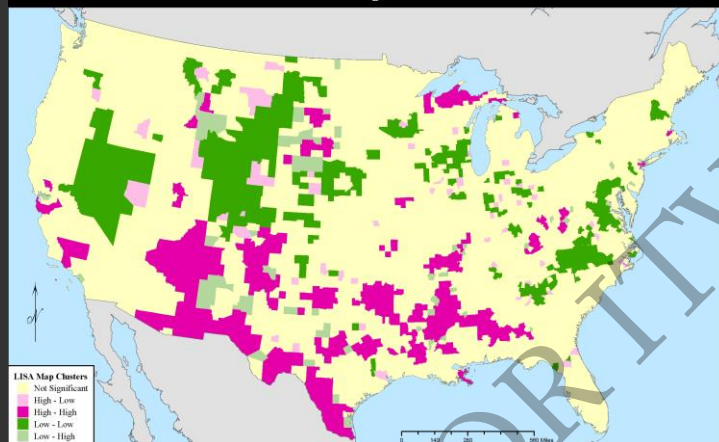
LISA Cluster Map of 1960 SoVI



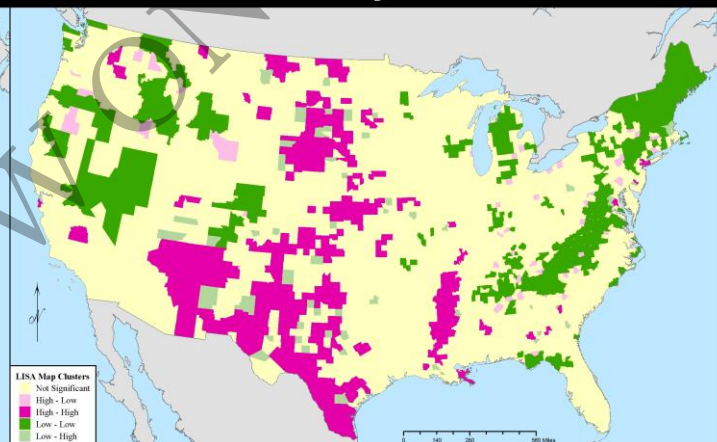
LISA Cluster Map of 1970 SoVI



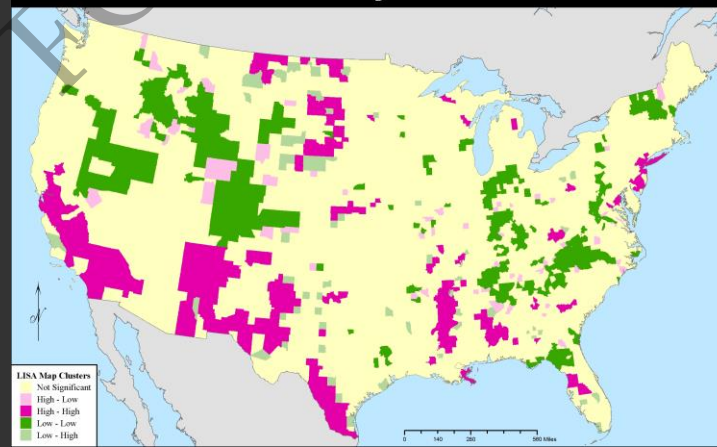
LISA Cluster Map of 1980 SoVI



LISA Cluster Map of 1990 SoVI



LISA Cluster Map of 2000 SoVI



High-High
517
Low-Low
636

High-High
355
Low-Low
597

High-High
293
Low-Low
344

High-High
344
Low-Low
448

High-High
239
Low-Low
342

Spatial Pattern and Variations

- » Significant Positive Spatial Autocorrelation for ALL Decades (Moran's I)
- » Number of Counties with Significantly Similar Neighbors Decreased Through Time
- » **Spatial Pattern is More Random and Less Similar Through Time**

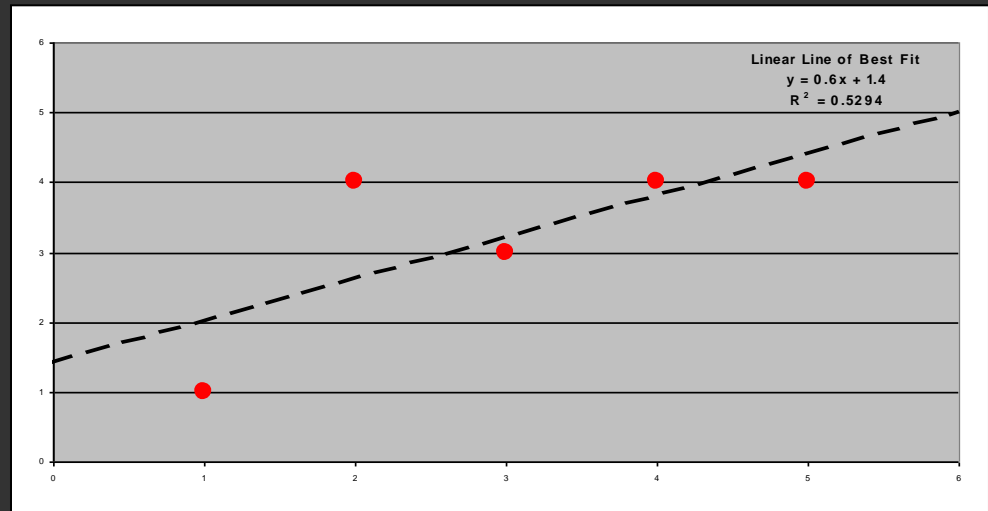
Temporal Trends

» Linear Regression for Each County

- Line of Best Fit
 - Slope (Direction of Trend)
 - R^2 (Strength of the Trend)
 - F-Statistic (Level of Significance)

» Identify Counties with Significant Trends in SoVI

- Predict 2010 SoVI Based on Linear Trend through Time

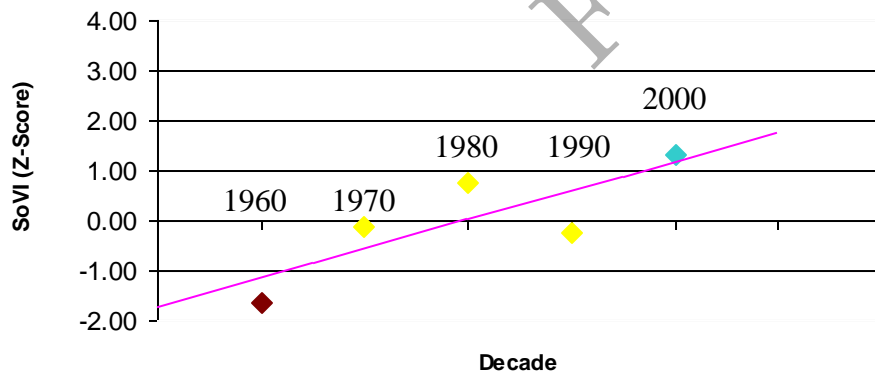


Significant Increase in Social Vulnerability

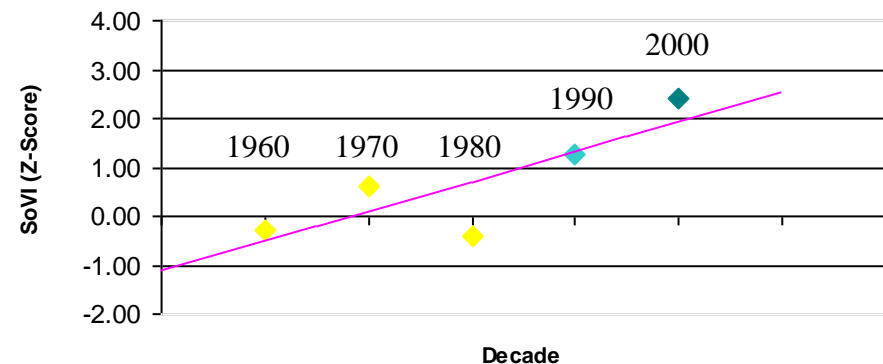
» 46 Counties
» 25 Counties Shown in Table

COUNTY	ZSOVI_1960	ZSOVI_1970	ZSOVI_1980	ZSOVI_1990	ZSOVI_2000	SLOPE	R_SQUARED
Roanoke city, VA	-0.38	1.15	1.83	1.58	6.41	1.40	0.75
Northampton, VA	-0.26	2.02	1.01	1.50	4.95	0.99	0.66
Beaver, PA	-1.89	-0.69	0.08	1.54	1.59	0.92	0.95
Clifton Forge city, VA	0.26	0.22	2.89	2.38	3.62	0.89	0.81
McIntosh, ND	-0.43	1.79	0.30	2.23	2.95	0.72	0.66
Box Butte, NE	0.55	-0.03	1.60	2.46	2.85	0.71	0.84
Delaware, PA	-1.87	-0.29	0.66	0.56	1.23	0.71	0.85
Wyandotte, KS	-0.56	-0.52	1.82	2.10	1.65	0.70	0.71
Bergen, NJ	-1.95	0.52	-0.25	0.34	1.56	0.68	0.70
San Mateo, CA	-1.30	-0.07	1.60	0.24	1.82	0.65	0.65
Salem, NJ	-1.46	-0.93	-0.11	0.58	0.97	0.64	0.99
Jefferson, OH	-1.35	-0.76	0.70	0.42	1.23	0.63	0.88
Brooke, WV	-1.86	-0.73	-0.19	-0.23	1.02	0.63	0.91
Moore, TX	-0.57	-0.39	0.43	0.89	1.92	0.63	0.96
Towner, ND	-0.76	0.25	-0.33	0.89	2.02	0.62	0.81
Norton city, VA	-0.10	0.01	2.07	2.04	1.95	0.61	0.73
Divide, ND	-0.29	0.59	-0.42	1.28	2.41	0.61	0.67
Mahoning, OH	-1.64	-0.27	0.74	0.57	0.99	0.61	0.81
Middlesex, NJ	-1.55	-0.18	-0.39	-0.19	1.47	0.60	0.78
Hancock, WV	-1.81	-0.65	0.07	0.19	0.78	0.60	0.92
Boyd, KY	-0.98	-1.71	0.67	0.65	0.81	0.59	0.66
DuPage, IL	-1.68	-0.90	-0.71	0.13	0.72	0.58	0.98
Barnstable, MA	-1.63	-0.10	0.75	-0.23	1.32	0.58	0.66
St. Louis, MO	-2.17	-0.87	-0.22	-0.24	0.39	0.58	0.87
Orange, CA	-0.33	-0.28	-0.28	0.65	2.07	0.57	0.76

Barnstable County, MA



Divide County, ND

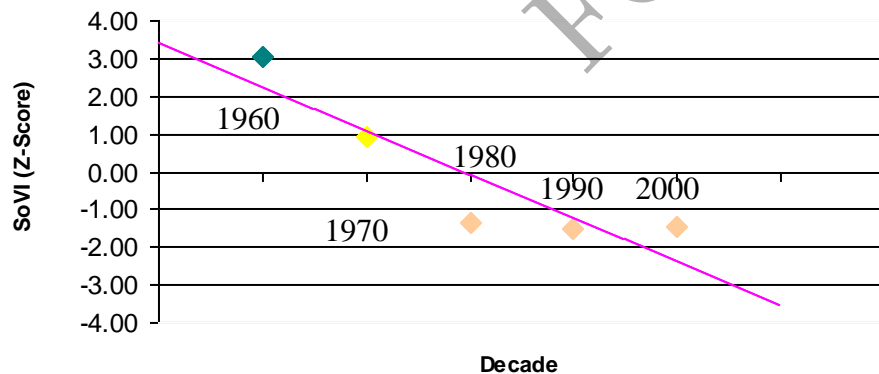


Significant Decrease in Social Vulnerability

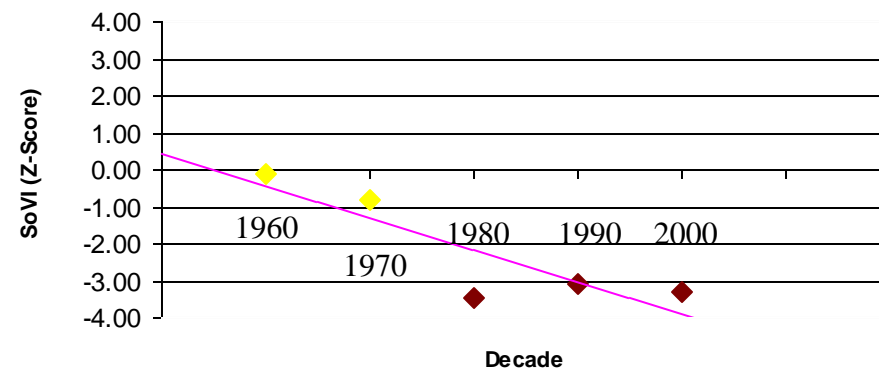
» 40
Counties
» 25
Counties
Shown in
Table

COUNTY	ZSOVI_1960	ZSOVI_1970	ZSOVI_1980	ZSOVI_1990	ZSOVI_2000	SLOPE	R_SQUARED
San Miguel, CO	0.80	0.38	-1.41	-2.77	-3.72	-1.22	0.97
Alpine, CA	3.07	0.95	-1.34	-1.50	-1.46	-1.15	0.80
Daggett, UT	1.98	2.22	-0.11	-0.70	-2.18	-1.12	0.91
Stanley, SD	2.95	0.14	-0.75	-0.71	-2.23	-1.12	0.86
King, TX	0.50	1.05	-2.33	-1.53	-3.30	-1.02	0.75
Pitkin, CO	-0.13	-0.80	-3.48	-3.07	-3.29	-0.86	0.75
Mono, CA	1.15	-0.69	-2.06	-0.93	-2.98	-0.85	0.74
Lafayette, FL	0.04	0.81	-0.74	-2.36	-2.61	-0.85	0.81
Gilpin, CO	0.15	-0.73	-2.31	-2.61	-3.04	-0.83	0.93
Roberts, TX	0.52	-0.19	-1.15	-1.49	-2.85	-0.80	0.97
Union, FL	1.08	-1.01	-1.46	-1.20	-2.71	-0.78	0.81
Brown, IL	0.25	0.07	-0.02	-1.35	-2.83	-0.76	0.84
Grand, CO	-0.30	-0.36	-2.67	-1.85	-3.23	-0.73	0.76
Liberty, FL	-0.22	0.24	-0.24	-2.61	-2.41	-0.72	0.72
Teton, WY	-1.08	-0.18	-2.44	-2.50	-3.52	-0.72	0.75
Echols, GA	-0.15	1.15	-0.64	-1.00	-2.51	-0.69	0.67
Bandera, TX	0.77	-0.05	-0.23	-1.56	-1.88	-0.68	0.95
Pershing, NV	0.46	0.71	-0.35	-0.66	-2.23	-0.68	0.85
Grant, NE	1.46	0.39	-0.48	-0.46	-1.41	-0.66	0.93
James City, VA	0.21	-0.24	-1.39	-1.97	-2.22	-0.66	0.95
Blaine, ID	-0.14	-0.14	-1.93	-2.32	-2.28	-0.65	0.82
Granville, NC	0.78	0.56	-0.91	-0.73	-1.78	-0.64	0.90
Carroll, MS	1.20	1.37	0.07	-0.09	-1.19	-0.62	0.89
Lafayette, MS	1.19	-0.64	0.14	-0.93	-1.76	-0.62	0.77
Baldwin, GA	1.49	-0.02	0.26	-0.35	-1.41	-0.61	0.85

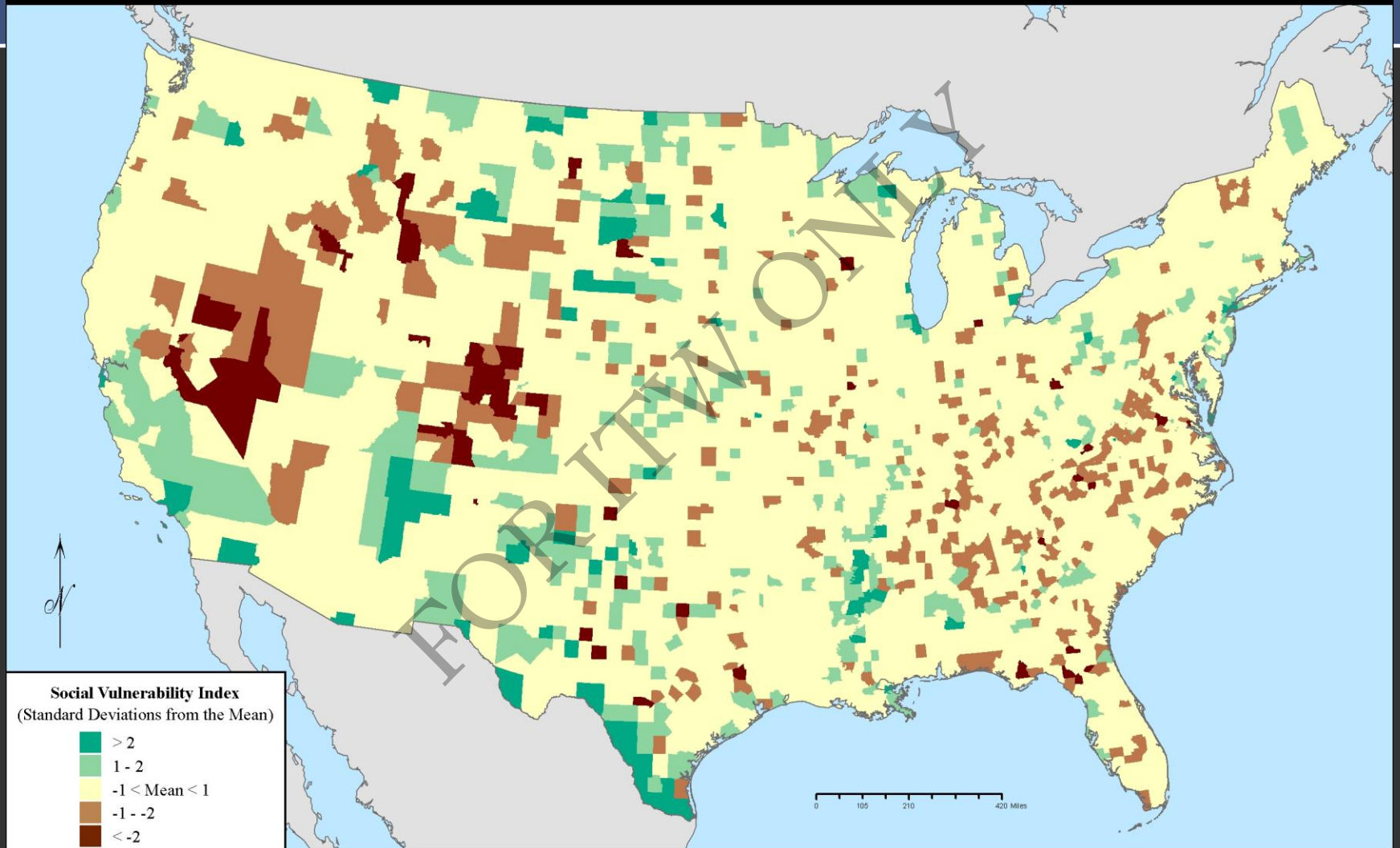
Alpine County, CA



Pitkin County, CO



Projected Social Vulnerability Index in 2010



Temporal Trends

- » Identified Significant Changes in Social Vulnerability
- » Increasing Vulnerability
 - Depopulation
 - Development
- » Decreasing Vulnerability
 - Increasing Wealth
- » SoVI in 2010
 - Significant Positive Spatial Autocorrelation
 - Moran's I Supports Decreasing Trend
 - Decrease also Apparent in LISA Clusters

Benefits and Impacts

- » Identification of socially vulnerable counties and regions, and their associated socio-economic characteristics is **beneficial for mitigation planning, immediate response and long-term recovery.**
- » The spatial pattern of social vulnerability is becoming more dispersed and less clustered in similar geographic regions, and therefore **more counties will need to plan for a broad spectrum of social vulnerability characteristics.**

Benefits and Impacts

- » Many counties in the United States are experiencing significant increases or decreases in social vulnerability; these counties should have **more emphasis on current mitigation plans**, as their demographics and resilience to environmental hazards have changed.
- » The projected future of social vulnerability in 2010 **identifies priority areas** that should be addressed in the present to increase the resilience of those communities.

Hurricane Katrina

- » August 23, 2005
- » **Damage:** \$81 billion total; \$40.6 billion in insured losses
- » **Deaths:** 1,833
 - LA: 1,577, MS: 238, FL: 14, GA: 2, AL: 2
- » **Storm Surge**
 - Mississippi: 17-28 ft
 - Louisiana: 5-15ft
 - Alabama: 8-15ft
- » **Evacuees:** 1.2 million people



Mississippi

Pass Christian, MS



Long Beach, MS



Highway I-90 Bridge
Biloxi, MS



Gulfport, MS

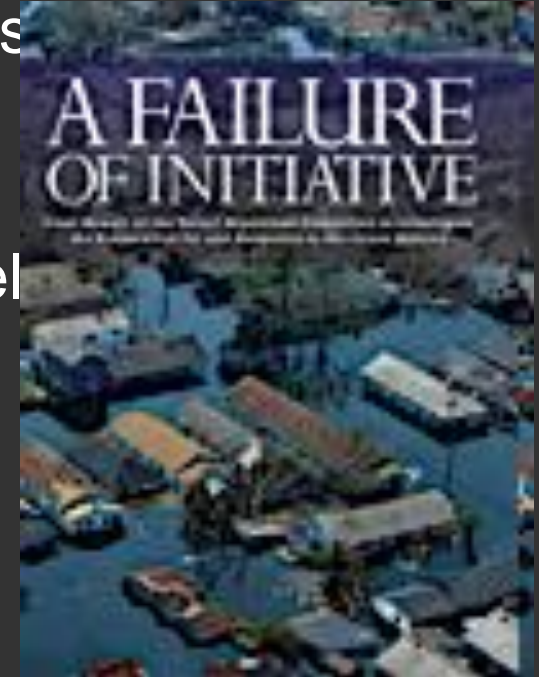


New Orleans, Louisiana



A Failure of Initiative

- » Imagination and initiative – in other words leadership – require good information. And a coordinated process for sharing it. And a willingness to use information – however imperfect or incomplete – to fuel action.
- » A national emergency management system that relies on state and local governments to identify needs and request resources is adequate for most disasters, a catastrophic disaster like Katrina can and did overwhelm most aspects of the system.
- » Response plans at all levels of government lacked flexibility and adaptability.



SoVI for New Orleans, LA

» Methods

- Orleans Parish, LA
- Tract Level (181)
- 31 Variables

» Results

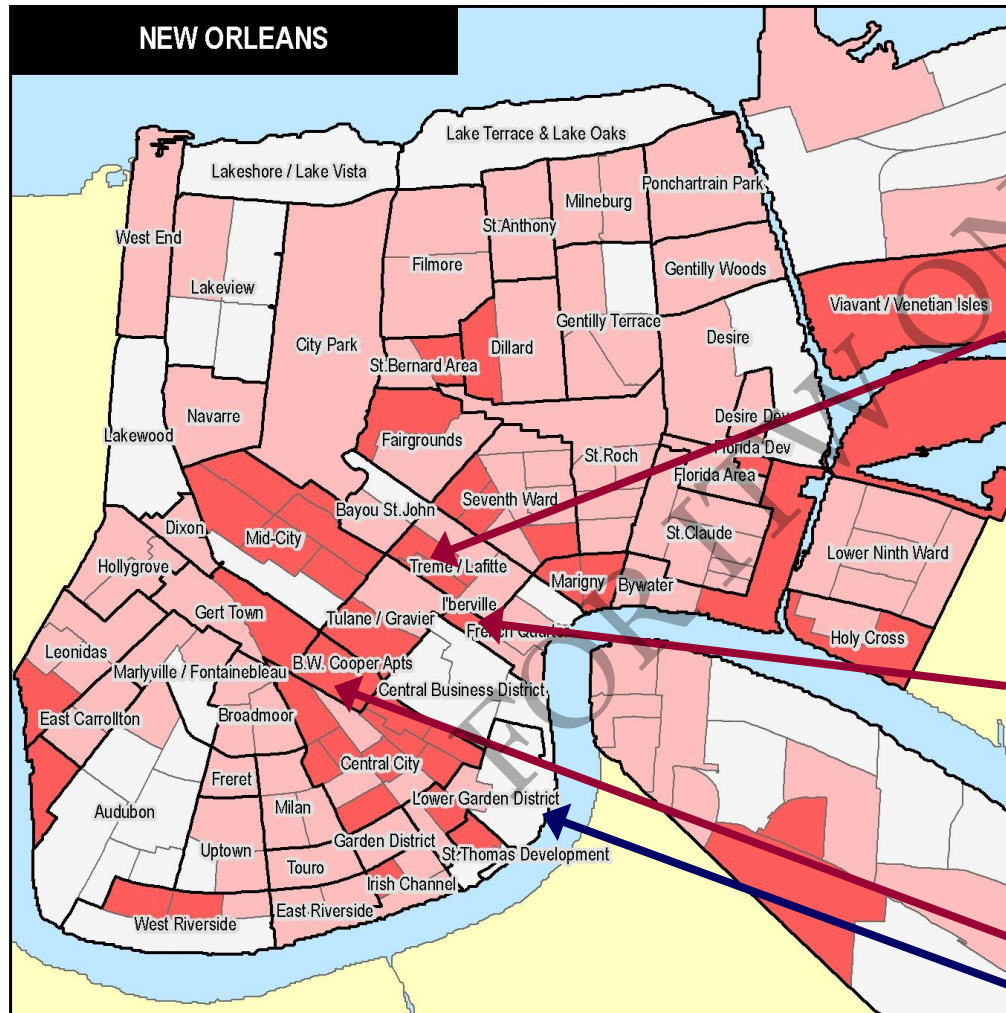
- Explained 76.57% of the Variance
- 8 Components

» Dominant Variables

- Socioeconomic Status
- Age and Gender
- Poverty and Unemployment

Neighborhood Disparities

Social Vulnerability



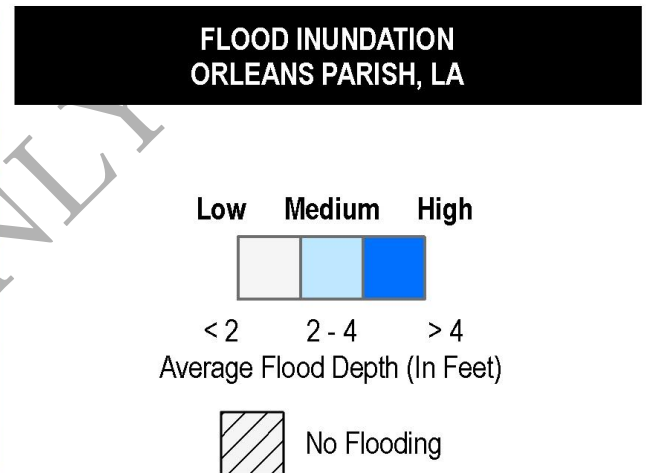
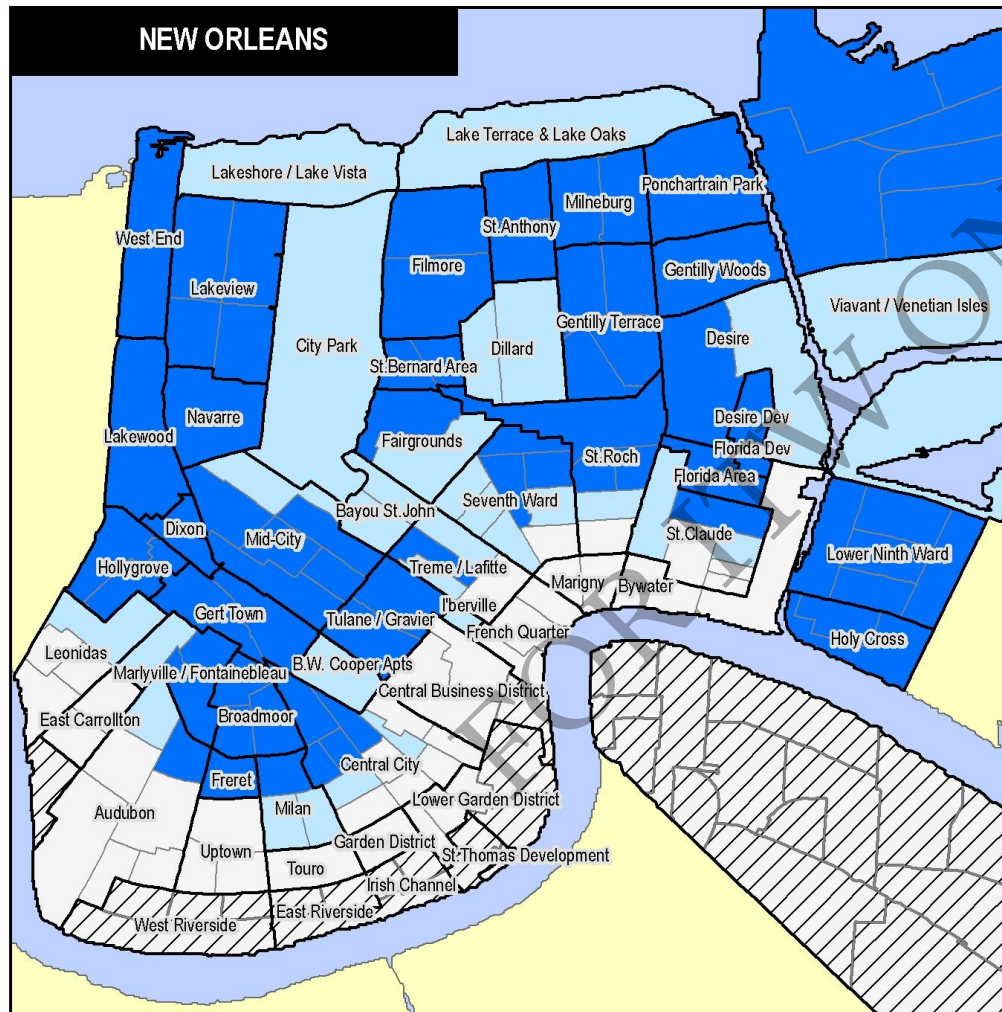
**SOCIAL VULNERABILITY INDEX
ORLEANS PARISH, LA**



Garden District

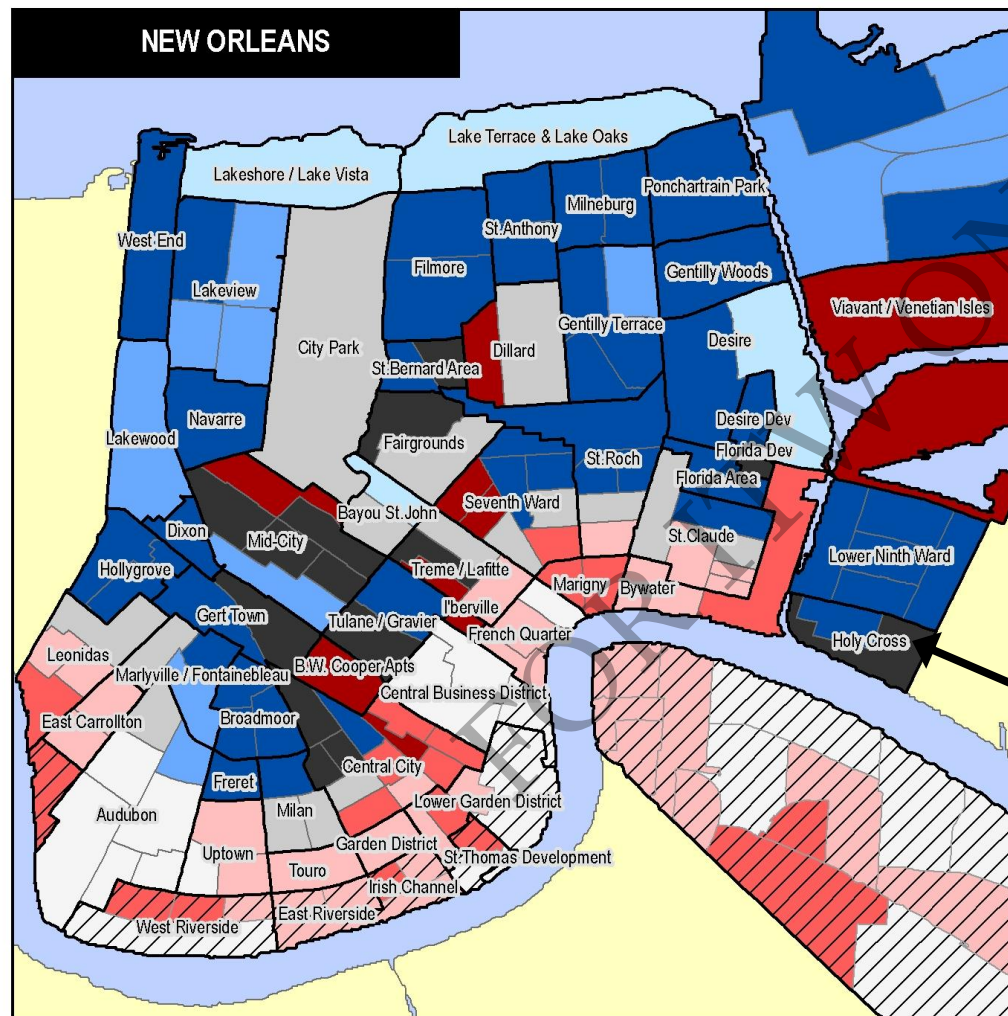
Finch, C., C. Emrich, and S. L. Cutter. 2008. Disaster Recovery in New Orleans. [Publication in Progress].

Neighborhood Disparities Hazard (Flooding)

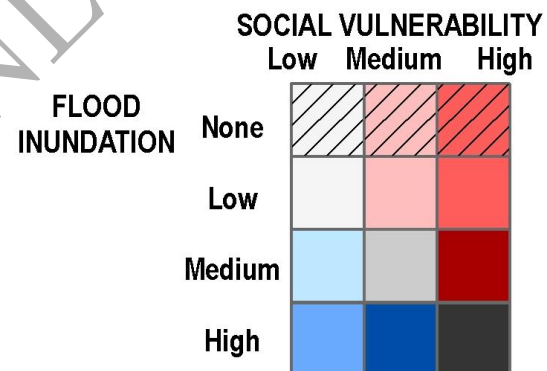


Finch, C., C. Emrich, and S. L. Cutter. 2008. Disaster Disparities and Differential Recovery in New Orleans. [Publication in Progress].

Neighborhood Disparities Uneven Impact



VULNERABILITY & HAZARD ORLEANS PARISH, LA

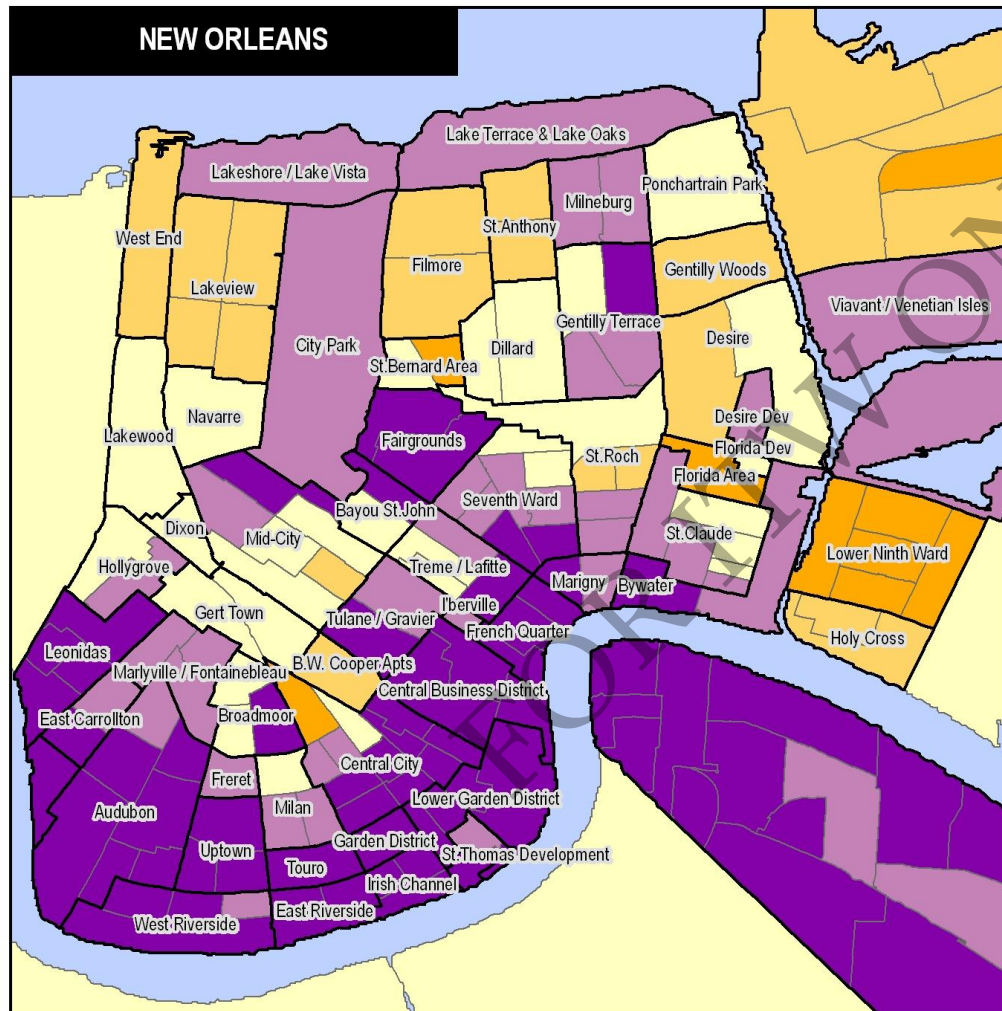


Holy Cross



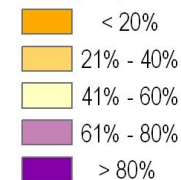
Finch, C., C. Emrich, and S. L. Cutter. 2008. Disaster Disparities and Differential Recovery in New Orleans. [Publication in Progress].

Neighborhood Disparities Uneven Recovery



**JULY 2005 - JULY 2007
ACTIVE RESIDENTIAL DELIVERIES
ORLEANS PARISH, LA**

USPS Active Residential Deliveries
Percent Returned (Compared to July 2005)



Vulnerability and Emergency Management

- » Social vulnerability influences all phases of the emergency management cycle
- » Aggregation of all social and economic characteristics
- » Identify of vulnerable areas
- » Application to different scales and areas

Prevention

Preparation

Mitigation

Response

Recovery

End-to-end Disaster Management

Thoughts and Discussion Topics

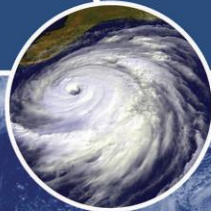
- » What is the current status of risk assessment in your country?
 - Hazard Identification
 - Vulnerability Assessment
 - Risk Assessment
 - Mitigation Planning
 - Education and Outreach
- » Risk Reduction



» Wildfire



» Hurricane



» Tropical Cyclone

» Tsunami



» Flooding



» Earthquake

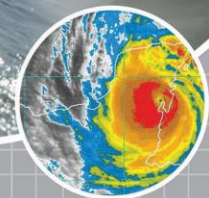


» Pandemic Influenza

Fostering Disaster - Resilient Communities



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Any Questions?

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