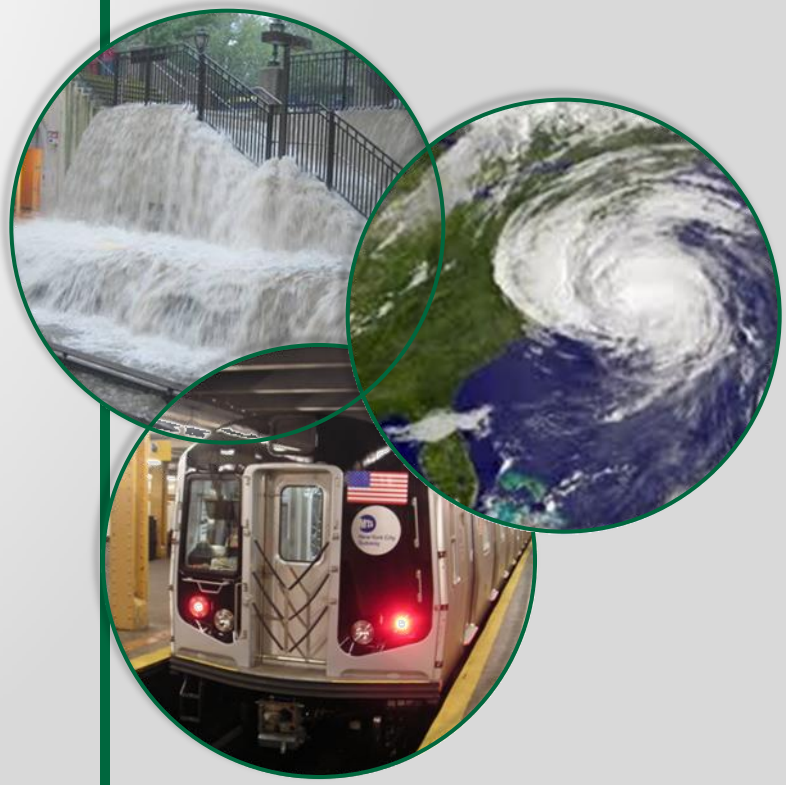
Climate Change Science Institute
AT OAK RIDGE NATIONAL LABORATORY

# Demographic Projections in Climate Change IAV Research



**Workshop on Scenarios of U.S. Demographic Change**
**June 23-24, 2014**


**Benjamin L. Preston**
**Deputy Director**
**Climate Change Science Institute**
**Oak Ridge National Laboratory**



**Acknowledgments:** Megan Maloney, Esther Parish, ORNL


U.S. DEPARTMENT OF ENERGY

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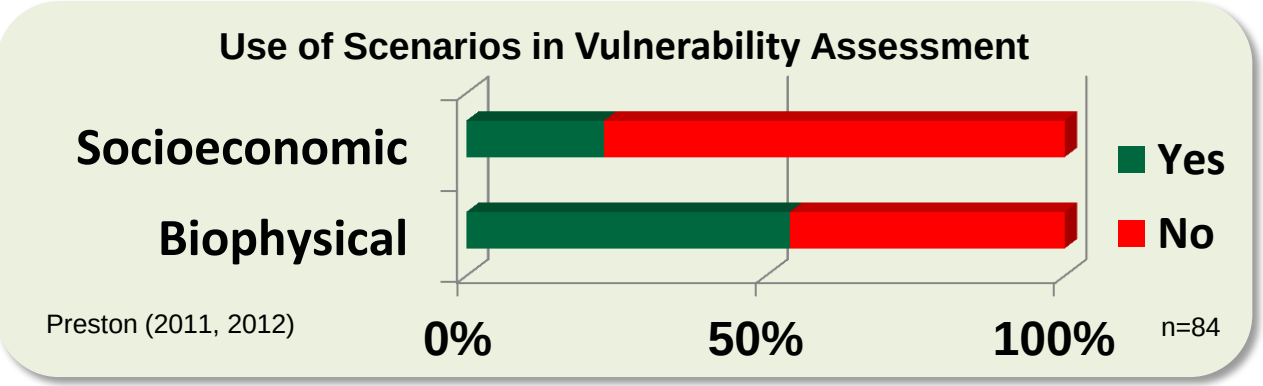
# Outline

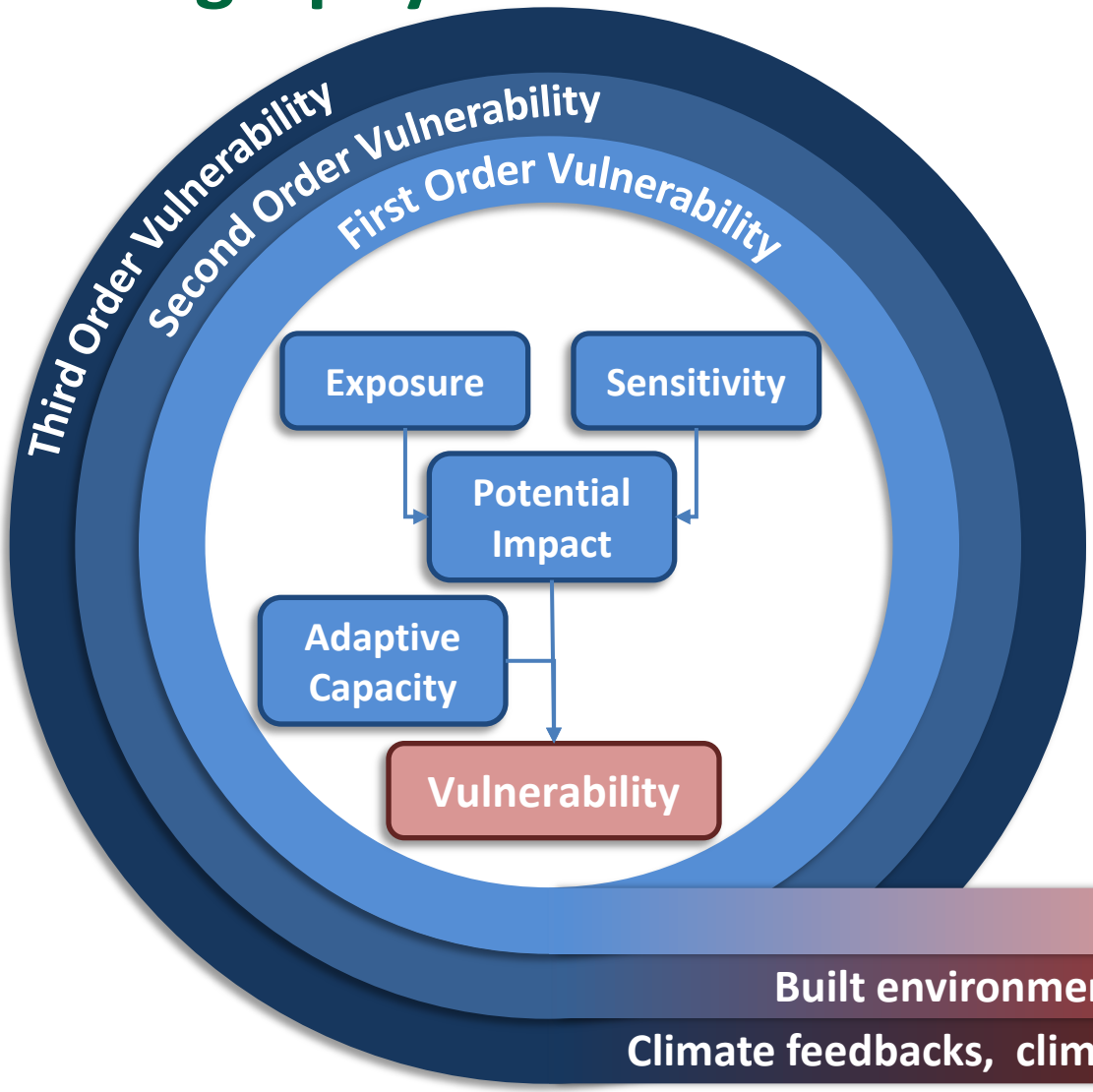
- Demography & impacts, adaptation, and vulnerability
- Examples of demographic information in IAV studies
- Cross-cutting considerations for demographic scenarios
- Conclusions: Scenario design criteria

# Why demography matters

- **Demography is a key source of uncertainty regarding the fate of human and natural systems**
  - High temporal variability
  - High spatial variability
  - High levels of inertia and path dependence
  - Difficult to constrain projections due to stochastic events
- **Yet, the IAV community has done a poor job of accounting for demographic change**



# Demography & climate vulnerability




**Demography & Scale**

**Global**

- *Demography as a driving force*

- *Demography as a determinant of vulnerability*

**Local**

**Human health & safety**

**Built environment, land use, consumption**

**Climate feedbacks, climate variability and change**

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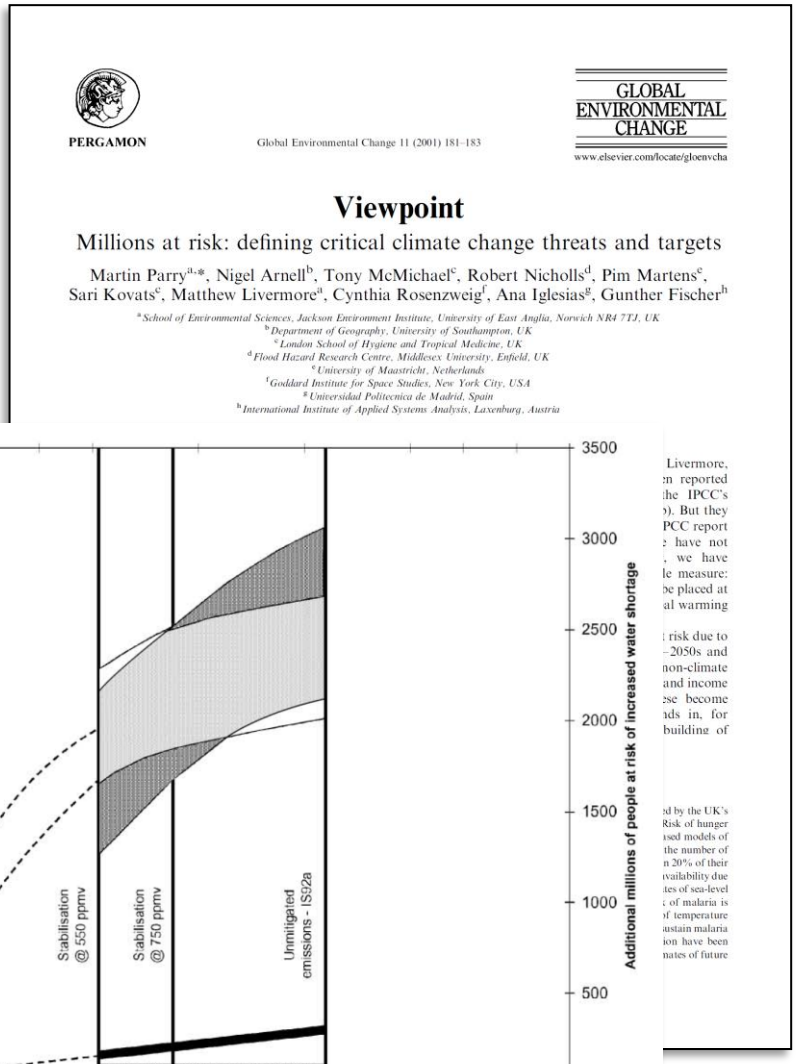
# 1º Vulnerability: *global population exposure*

- **"Millions at risk" (circa 1999) provided global estimates of population exposure to climate change**
  - Compared the distribution of projected climate hazards with population scenarios
  - Numerous studies have followed
- **However, climate-related hazards and demography are highly heterogeneous (spatially and temporally)**
  - Need to understand climate/demography/vulnerability interactions at more refined spatial scales
  - Need scenarios that reflect different aspects of demography



PERGAMON

Global Environmental Change 11 (2001) 181–183

GLOBAL ENVIRONMENTAL CHANGE

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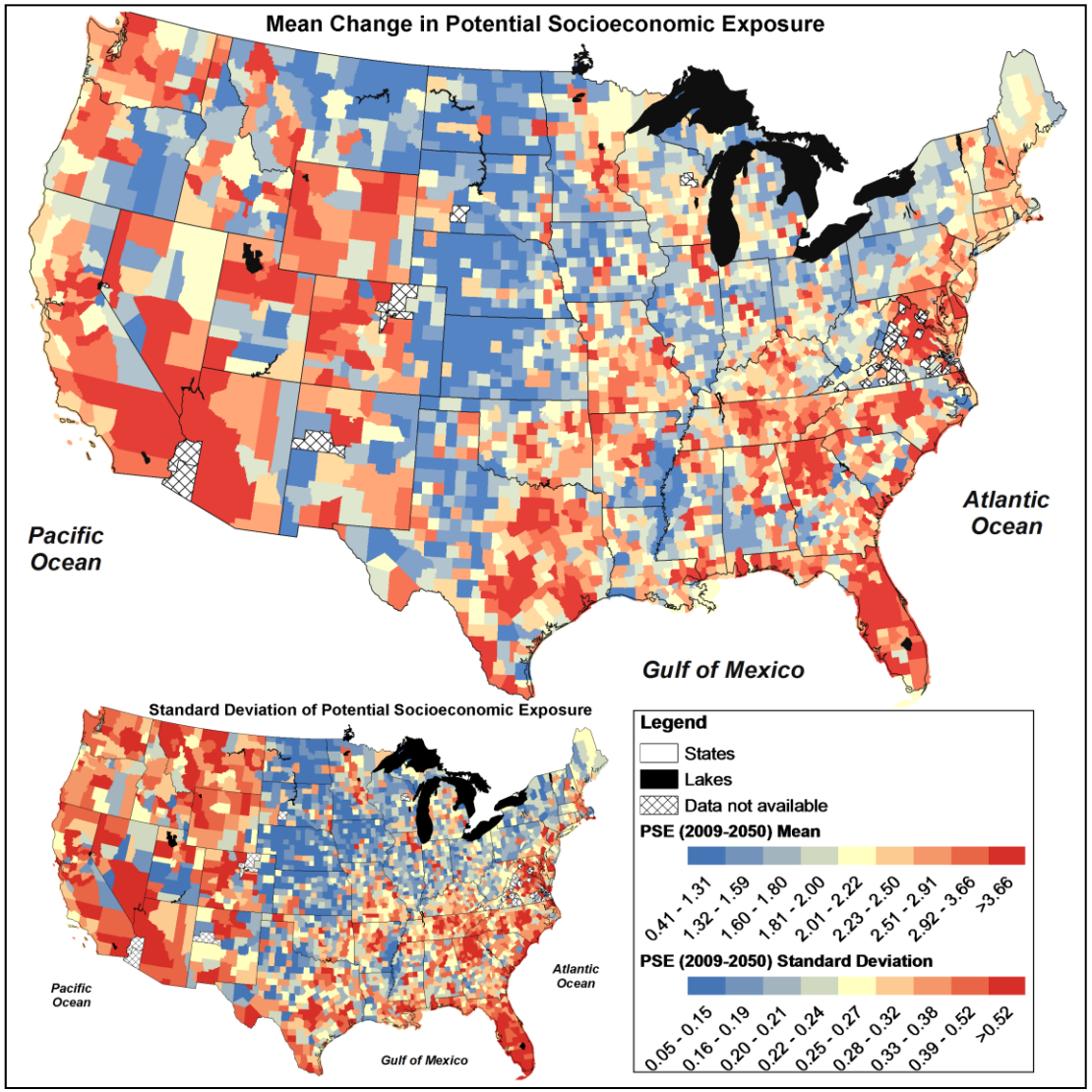
**Viewpoint**

Millions at risk: defining critical climate change threats and targets

Martin Parry[a,*], Nigel Arnell[b], Tony McMichael[c], Robert Nicholls[d], Pim Martens[e], Sari Kovats[c], Matthew Livermore[a], Cynthia Rosenzweig[f], Ana Iglesias[g], Gunther Fischer[h]

[a] School of Environmental Sciences, Jackson Environment Institute, University of East Anglia, Norwich NR4 7TJ, UK
[b] Department of Geography, University of Southampton, UK
[c] London School of Hygiene and Tropical Medicine, UK
[d] Flood Hazard Research Centre, Middlesex University, Enfield, UK
[e] University of Maastricht, Netherlands
[f] Goddard Institute for Space Studies, New York City, USA
[g] Universidad Politecnica de Madrid, Spain
[h] International Institute of Applied Systems Analysis, Laxenburg, Austria

# 1º Vulnerability: *U.S. county population exposure*

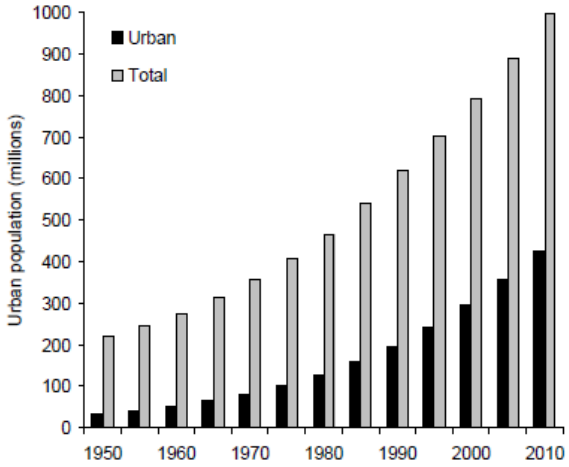


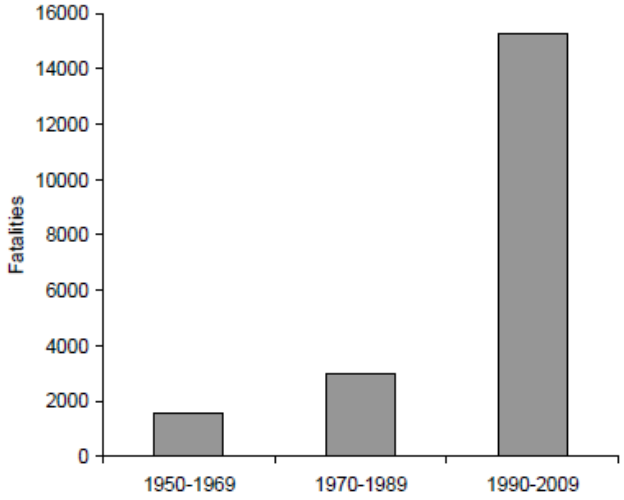

Preston (2013)

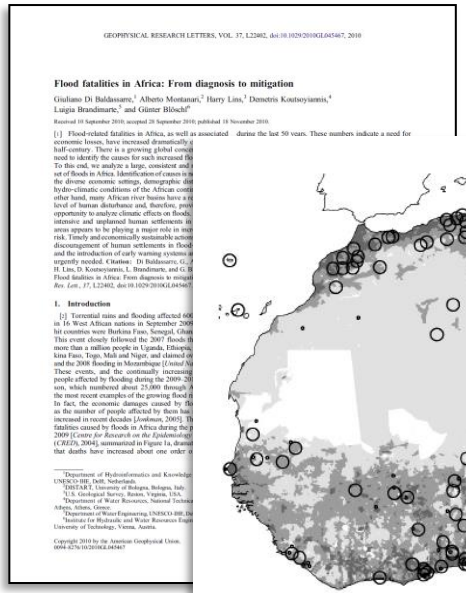
- ***"Potential socioeconomic exposure"*** **(PSE) reflects the demographic contribution to societal exposure by 2050**
- **Net societal exposure for CONUS increases by a factor of 3-4**
- **Large deviations from the national trajectory are seen at the local level**
  - Southeast urbanization
  - Coastal areas
  - Rural south

# 1º Vulnerability: *urbanization/migration & exposure*

- **Increasing population growth coupled to migration/urbanization is driving increases in flood fatalities**





GEOPHYSICAL RESEARCH LETTERS, VOL. 37, L22402, doi:10.1029/2010GL045467, 2010

**Flood fatalities in Africa: From diagnosis to mitigation**

Giuliano Di Baldassarre,[1] Alberto Montanari,[2] Harry Lins,[3] Demetris Koutsoyiannis,[4] Luigia Brandimarte,[1] and Günter Blöschl[5]

Received 10 September 2010; accepted 20 September 2010; published 18 November 2010.

[1] Flood-related fatalities in Africa, as well as associated during the last 50 years. These numbers indicate a need for economic losses, have increased dramatically half-century. There is a growing global consc need to identify the causes for such increased flo To this end, we analyze a large, consistent and set of floods in Africa. Identification of causes is n the diverse economic settings, demographic dyn hydro-climatic conditions of the African conti other hand, many African river basins have a re level of human disturbance and, therefore, prov opportunity to analyze climatic effects on floods. intensive and unplanned human settlements in areas appears to be playing a major role in incr risk. Timely and economically sustainable action discouragement of human settlements in flood and the introduction of early warning systems a urgently needed. **Citation:** Di Baldassarre, G., H. Lins, D. Koutsoyiannis, L. Brandimarte, and G. B Flood fatalities in Africa: From diagnosis to mitigation, *Geophys. Res. Lett.*, *37*, L22402, doi:10.1029/2010GL045467.

**1. Introduction**

[2] Torrential rains and flooding affected 60 in 16 West African nations in September 2009 hit countries were Burkina Faso, Senegal, Ghan This event closely followed the 2007 floods th more than a million people in Uganda, Ethiopia, kina Faso, Togo, Mali and Niger, and claimed ov and the 2008 flooding in Mozambique [*United Na* These events, and the continually increasing people affected by flooding during the 2009–20 son, which numbered about 25,000 through 2 the most recent examples of the growing flood h To fact, the economic damages caused by flo as the number of people affected by them has increased in recent decades [*Jonkman*, 2005]. Th fatalities caused by floods in Africa during the p 2009 [*Centre for Research on the Epidemiology* (CRED), 2004], summarized in Figure 1a, drama that deaths have increased about one order o

[1]Department of Hydroinformatics and Knowledge UNESCO-IHE, Delft, Netherlands.
[2]DIISTART, University of Bologna, Bologna, Italy.
[3]U.S. Geological Survey, Reston, Virginia, USA.
[4]Department of Water Resources, National Technical Athens, Athens, Greece.
[5]Department of Water Engineering, UNESCO-IHE, Del
[6]Institute for Hydraulic and Water Resources Engin University of Technology, Vienna, Austria.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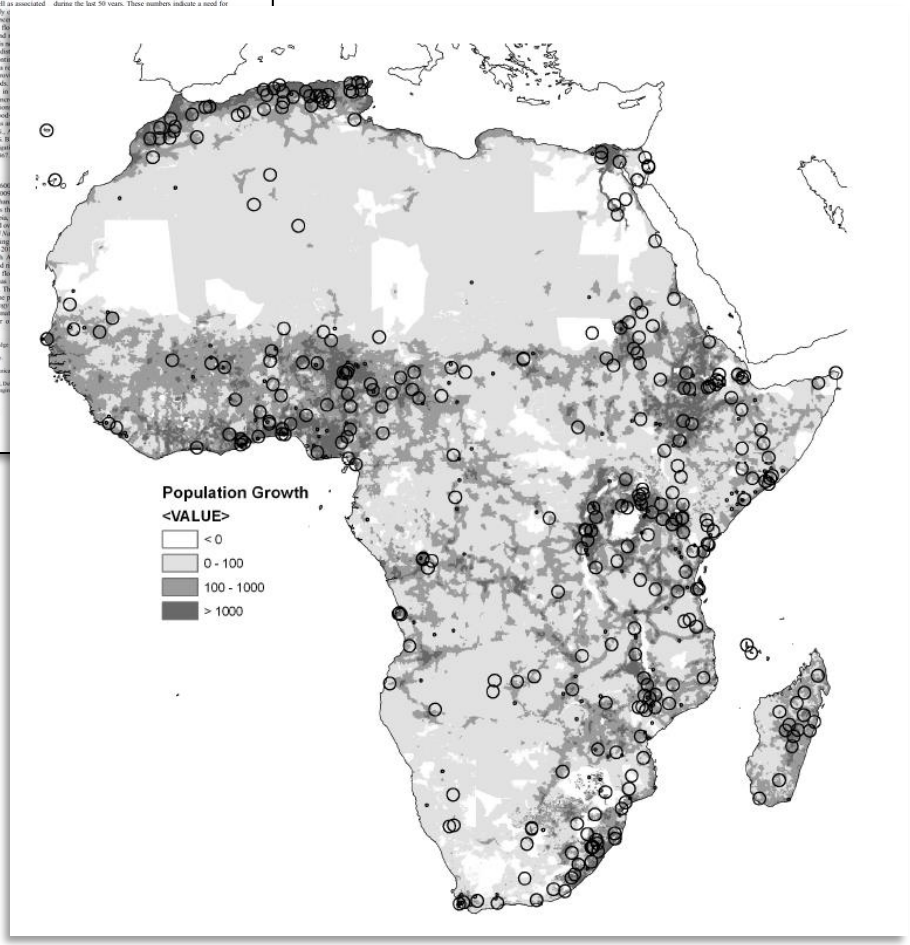
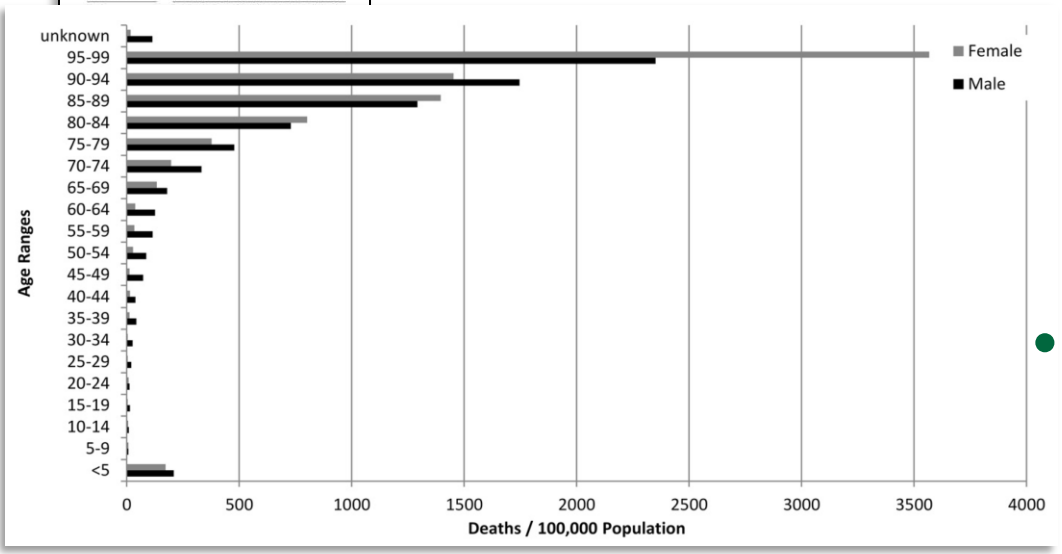
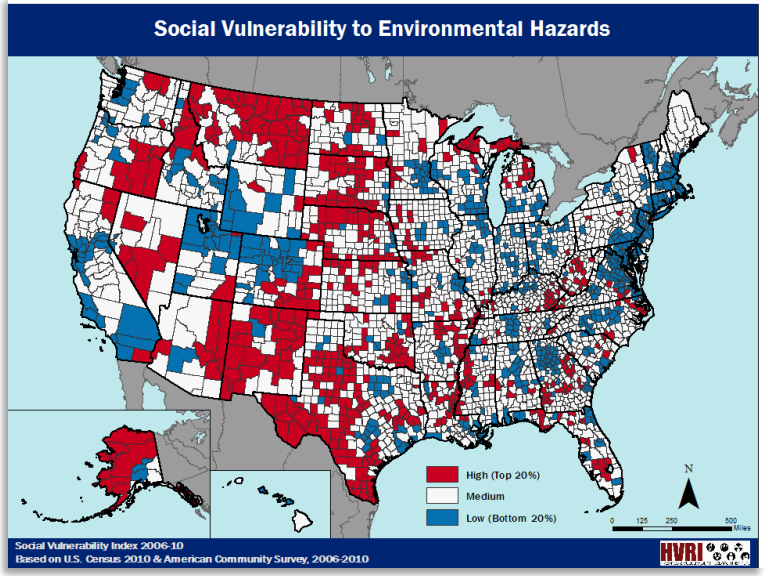


# 1º Vulnerability: *sensitivity & adaptive capacity*

- **Age & gender are key factors influencing human vulnerability to extreme events**
  - Physiological sensitivity
  - Coping mechanisms
  - Perceptions of risk (e.g., Wolf et al., 2010)


- **Spatial heterogeneity of social vulnerability (SoVI) is influenced by demographic variables**

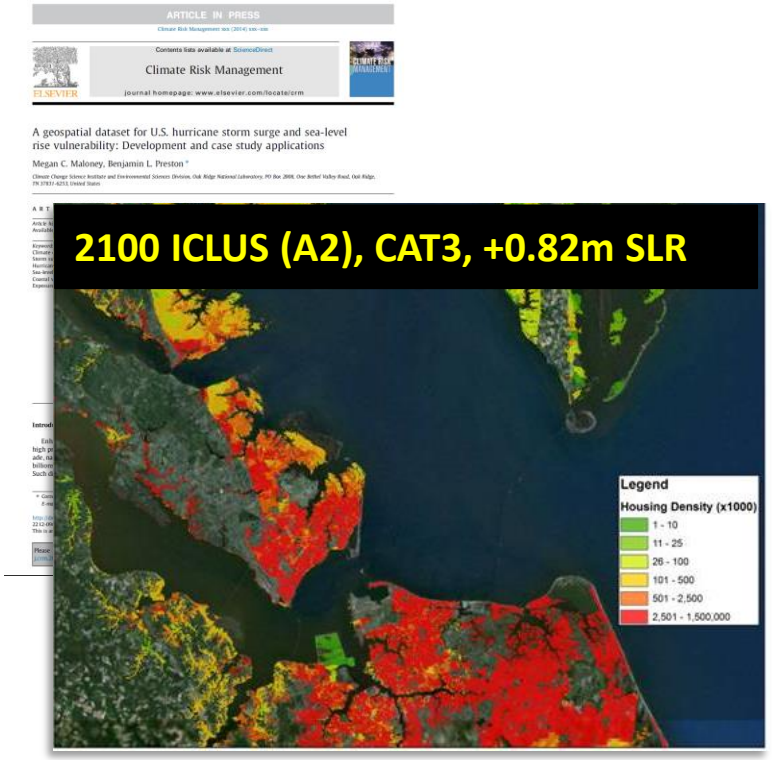



72% of variance explained by **race**, **ethnicity**, class, wealth, special needs, and service industry employment

- **SoVIs are often used to represent sensitivity & adaptive capacity of communities**
  - But prognostic indices are lacking

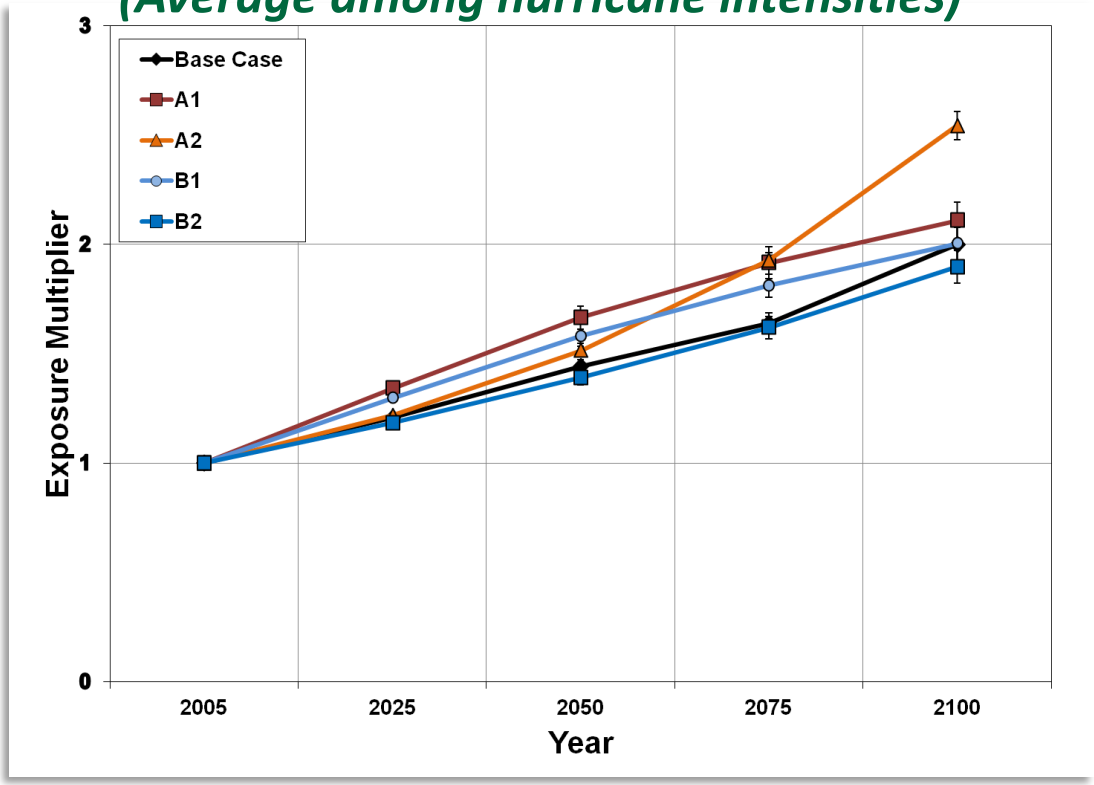
# 2º Vulnerability: *coastal housing exposure*

- **Development is a significant driver of vulnerability to coastal hazards**



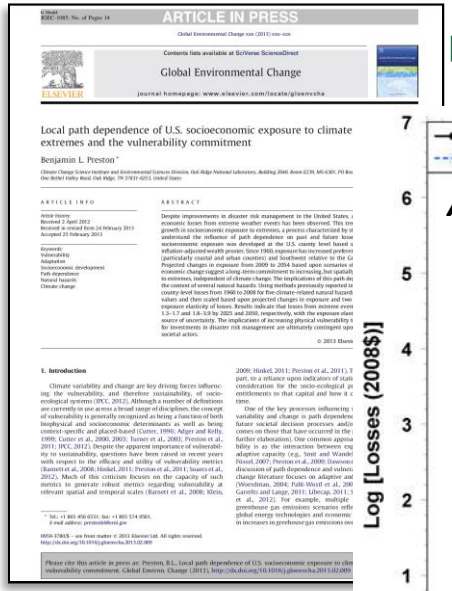

**Hampton Roads Housing Exposure**

## Projected Trend in Housing Exposure *(Average among hurricane intensities)*




**By 2050:** ~50% increase in exposure
**By 2100:** ~100-150% increase in exposure

# 2º Vulnerability: *economic losses from extremes*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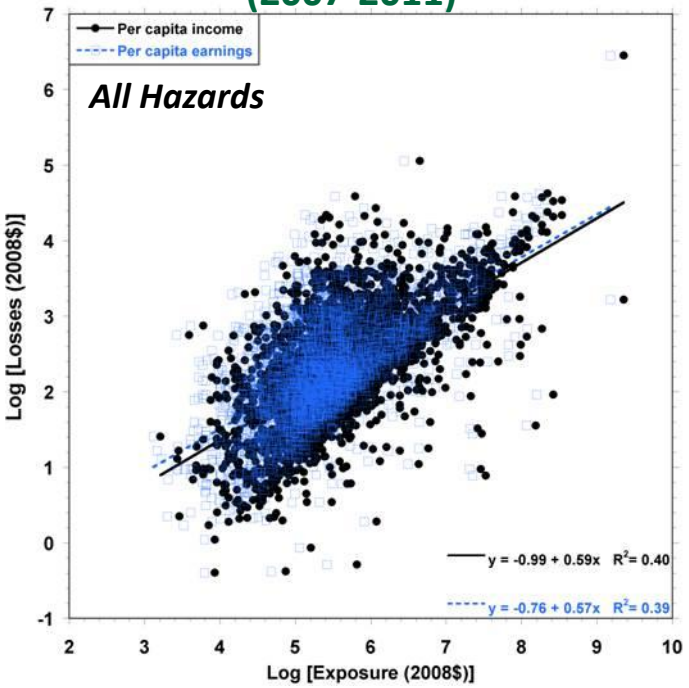
Global Environmental Change

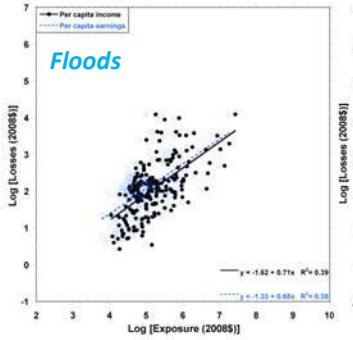
Local path dependence of U.S. socioeconomic exposure to climate extremes and the vulnerability commitment

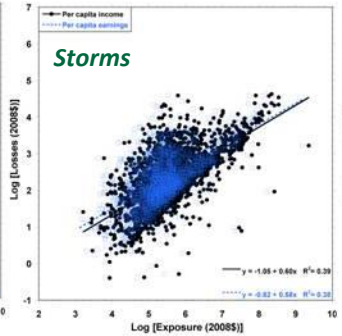
Benjamin L. Preston

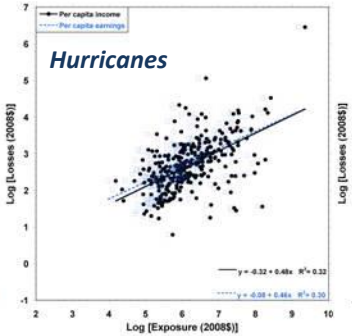
## Losses vs. Economic Exposure (2007-2011)

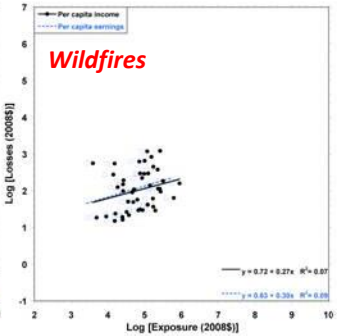



- Analysis of five years of county level preliminary damage estimates from FEMA
- Reported losses increase significantly with increases in development density (i.e., population and wealth)
- This enables one to relate changes in demography to the economic impacts of climate hazards



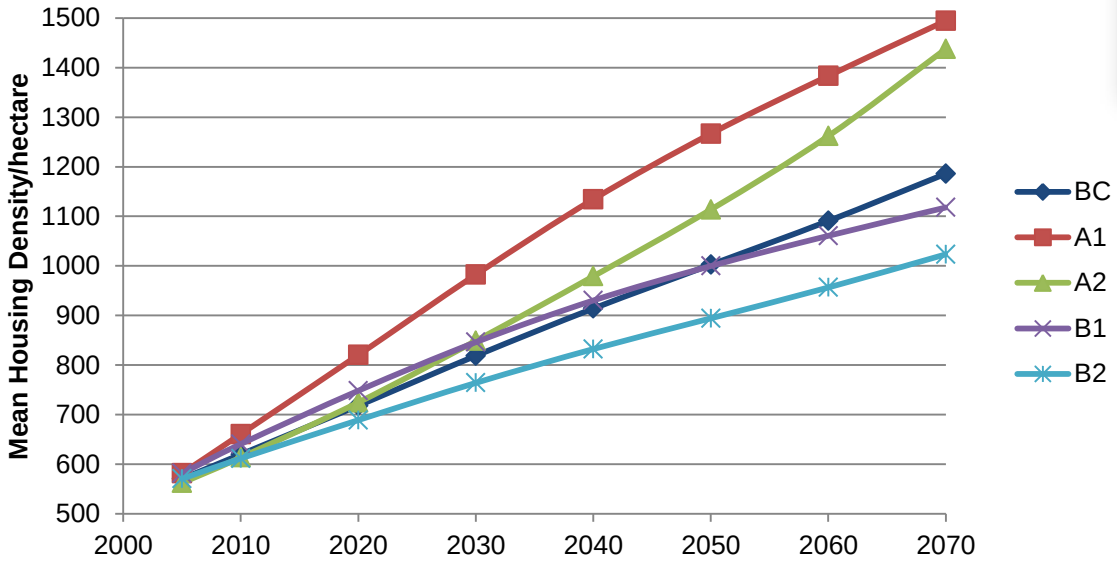



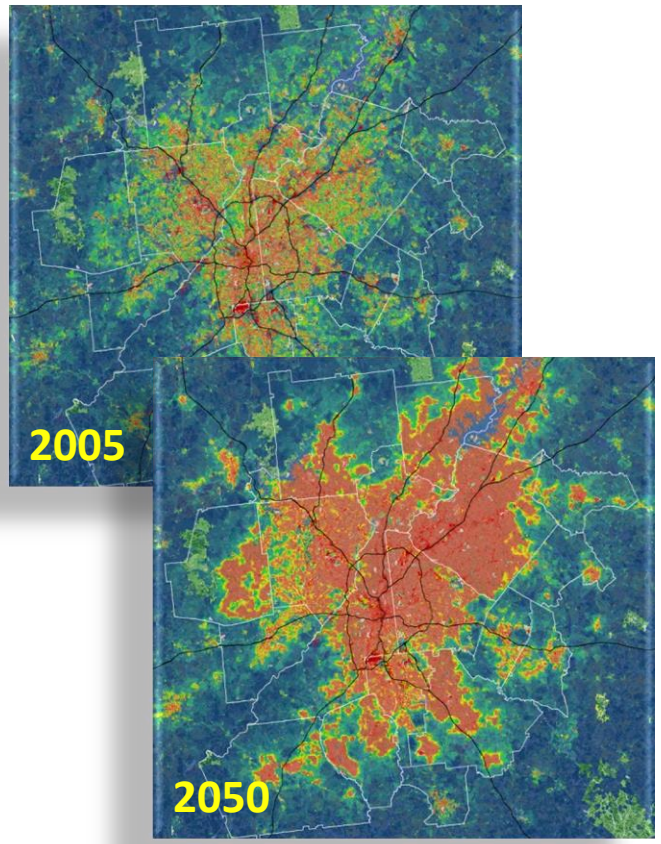
# 3º Vulnerability: *urbanization & climate feedbacks*

- **U.S. urban areas are growing rapidly**
  - Urban land area projected to grow from 3.1% (2000) to 8.1% (2050)
  - This will drive large changes in the built environment
- **Urbanization has climate feedbacks**
  - Urban heat islands
  - Impacts on extreme rainfall events

**Metropolitan Atlanta Housing Density**




**Metro Atlanta Housing Density**




ICLUS v1.3 (A2); 2006 USGS NLCD

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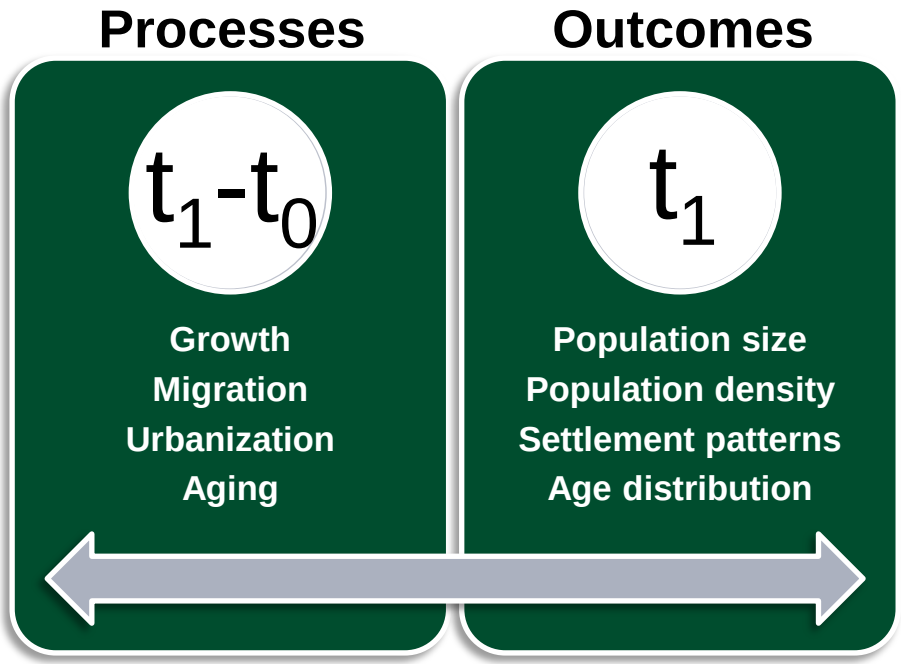
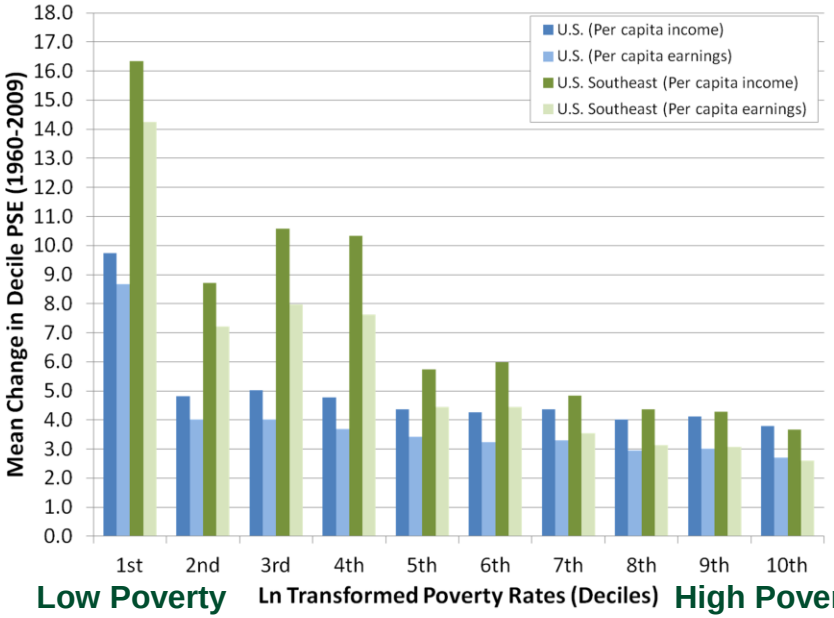
# Demography as process and outcome




- **Information on demographic outcomes for a given time period is useful**
- **But, so is information on the processes that generated those outcomes**

## 2009 County Poverty Rates vs. Demographic Change (1960-2009)

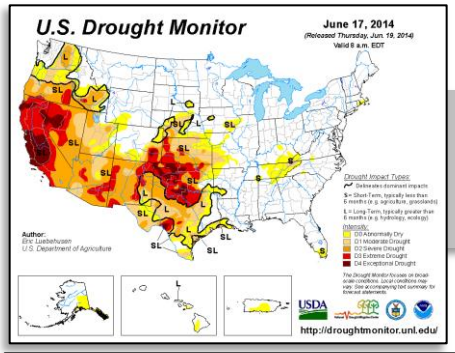



- **U.S. county poverty rates in 2009 were linked to demographic change in the preceding 50 years**
  - Counties with the lowest poverty rates experienced higher rates of demographic change

# Scale & scaleability

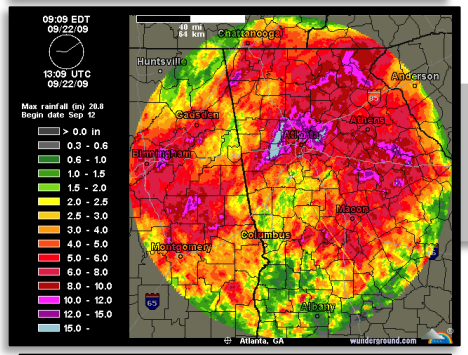
- **We need demographic information at the scale at which impacts and vulnerability occur**

Drought



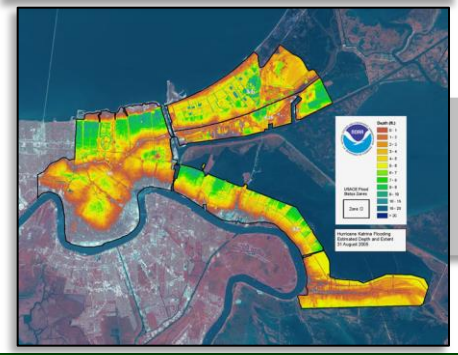

**State to county**

Storms



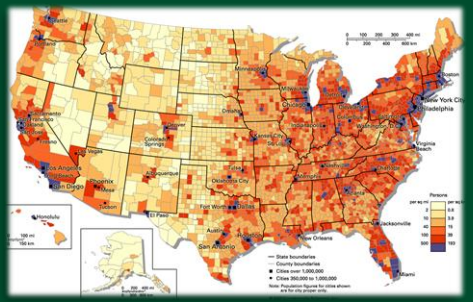

**County to census block**

Flooding



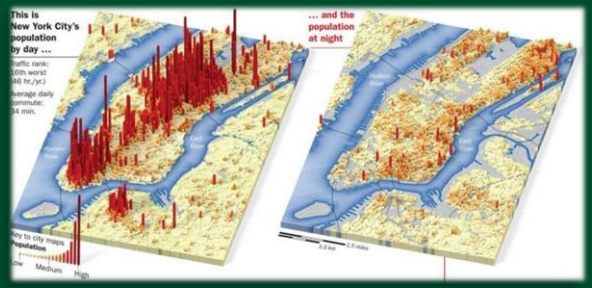
**Census block to property**

## Scenario Scalability



Downscaling

Upscaling



# Top down or bottom up?

- **Choice of scenario approach should be consistent with research approach**

## Top Down Scenarios

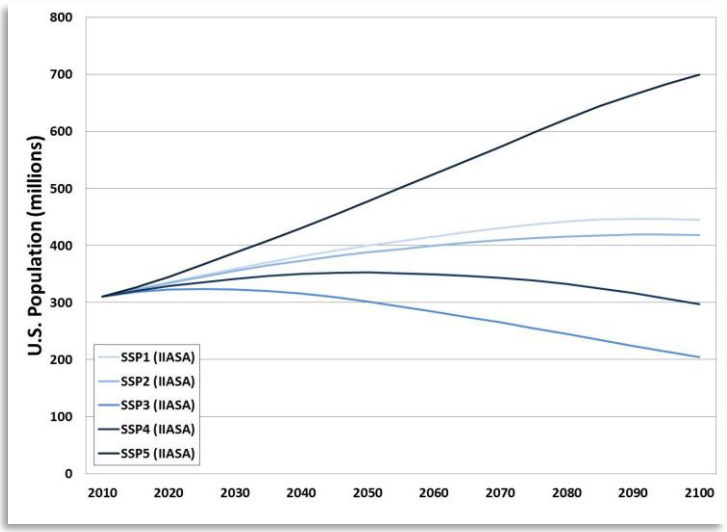
- **Applications**
  - Integrated assessment modeling
  - National scale IAV research/assessment
- **Development Tools**
  - Demographic models
  - Statistical downscaling
- **Examples**
  - SRES (CIESIN), SSPs, MEA, UN, World Bank

## Bottom Up Scenarios

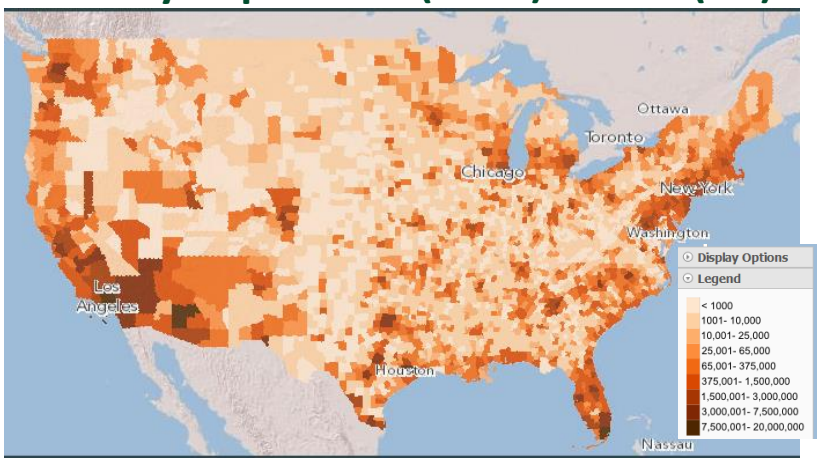
- **Applications**
  - Community-based research and assessment
  - User-driven analyses
  - Site-specific evaluations
- **Development Tools**
  - Component cohort models
  - Urban growth models
  - Gravity models
- **Examples**
  - ICLUS, LandScan

# Linking top down and bottom up

## U.S. Population: IIASA SSP Database

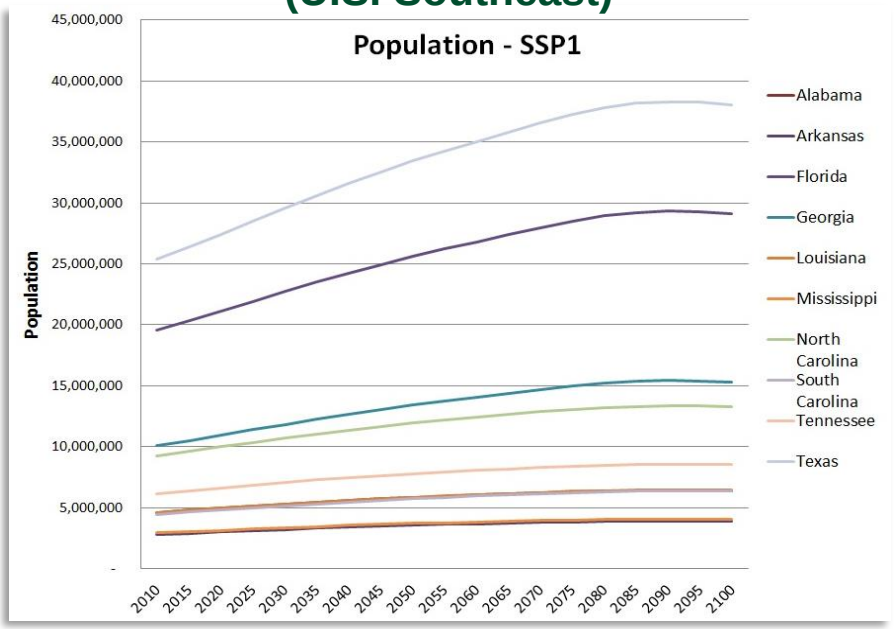



## County Population (2100): ICLUS (A2)




- Calculate county-specific scaling factors based on ICLUS scenarios
- Apply those scaling factors to national SSP population projections
- Generates ICLUS/SSP hybrid scenarios

## SSP-Constrained ICLUS Projections (U.S. Southeast)



# Conclusions: criteria for scenario design

- **Variables of interest**
  - Population (day and night?)
  - Age distribution (primarily youth, working age, and elderly)
  - Race/ethnicity
  - Gender important for specific communities
- **Scale**
  - High spatial resolution (raster or vector) but *scaleable*
    - Raster: greater flexibility for scaleability and diverse modeling applications
    - Vector: greater inherent compatibility with political boundaries
- **Time Horizon**
  - At least 2050, but likely 2100 (in 5 to 10 year time steps)
- **Uncertainty**
  - Multiple scenarios based on an existing conceptual framework (e.g., SRES, SSPs)

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# Thank You

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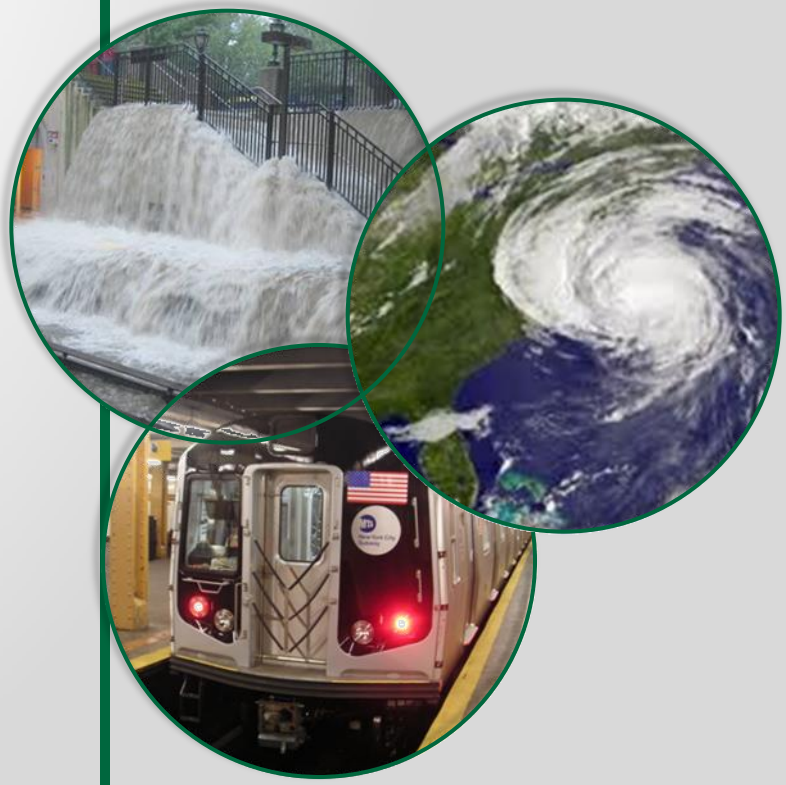

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