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Committed Vulnerability to Climate Variability and Change

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OAK RIDGE NATIONAL LABORATORY
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The inertia of global change poses significant challenges for risk management

- 'Committed warming'
  - Thermal inertia of the Earth system will contribute to additional global climate change regardless of future emissions trajectories
    - Wetherland et al. (2001); Friedlingstein and Solomon (2005) Wigley et al. (2005); Hare and Meinshausen (2006); Armour and Rose (2011)
- 'Committed vulnerability'
  - Trajectories of demographic change and economic development are likely to drive growth in social and ecological vulnerability to climate
  - Rates of change with respect to vulnerability are likely to be greater than those for climate
    - Chagnon et al. (2000); Chagnon (2003); Pielke and Sarewitz (2005); Pielke (2007); Pielke et al. (2008); Diffenbaugh et al. (2009); Baldassarre et al. (2011); Bouwer (2011)

Rates of socioeconomic change can help inform understanding of adaptation demand

- Literature indicates that global costs of adaptation will largely be associated with managing climate extremes
  - Development, maintenance, replacement of built environment
    - Stern (2006); UNFCCC (2008); Parry et al. (2009)
- The geographic distribution of adaptation costs must therefore be associated with future demographic change and economic growth
- By examining the rates of socioeconomic change at the local level, one can infer changes in adaptation demand

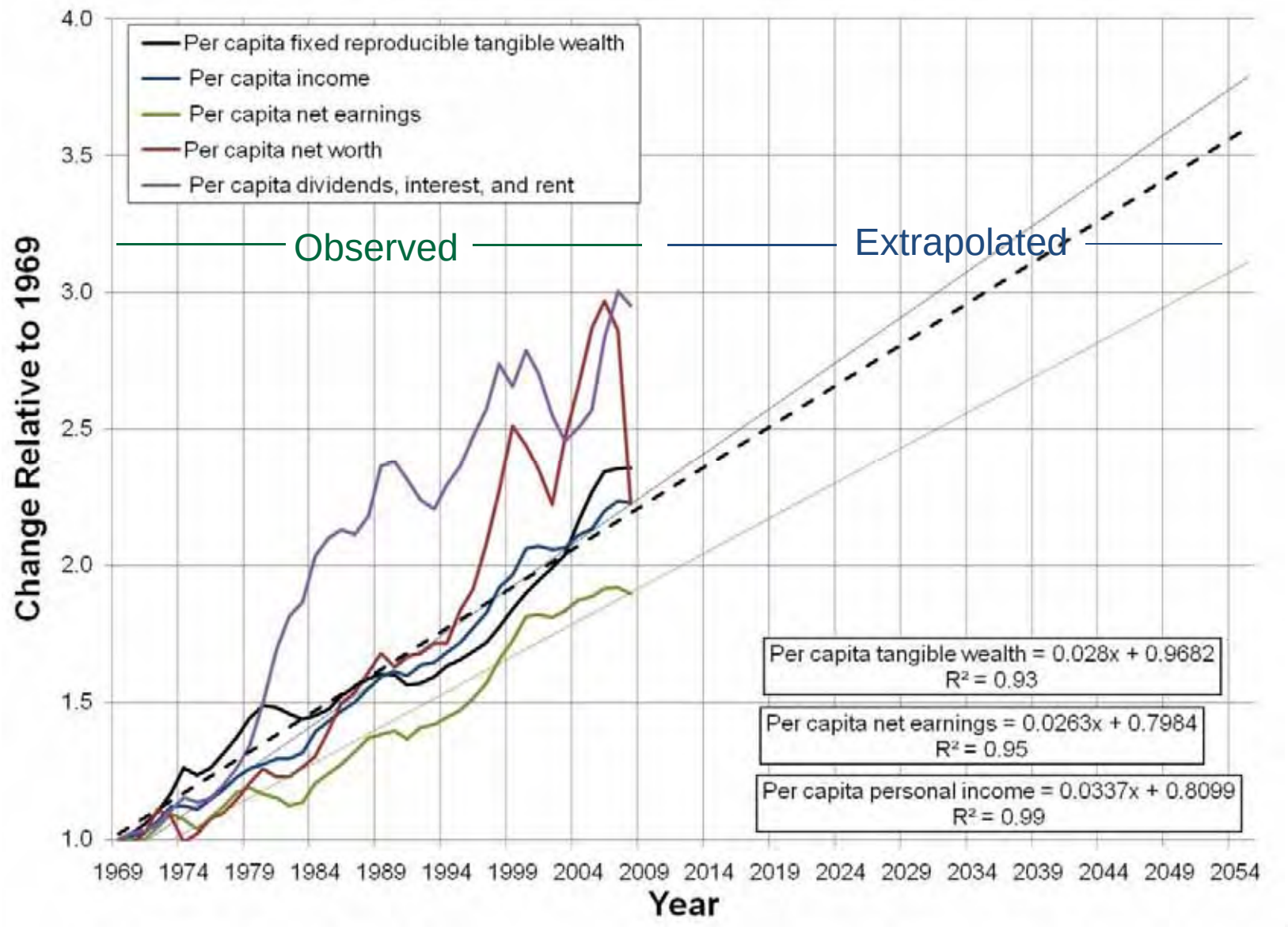
Reproducing historical socioeconomic exposure (1960-2009)

- Potential socioeconomic exposure (PSE) of local populations to extreme events:

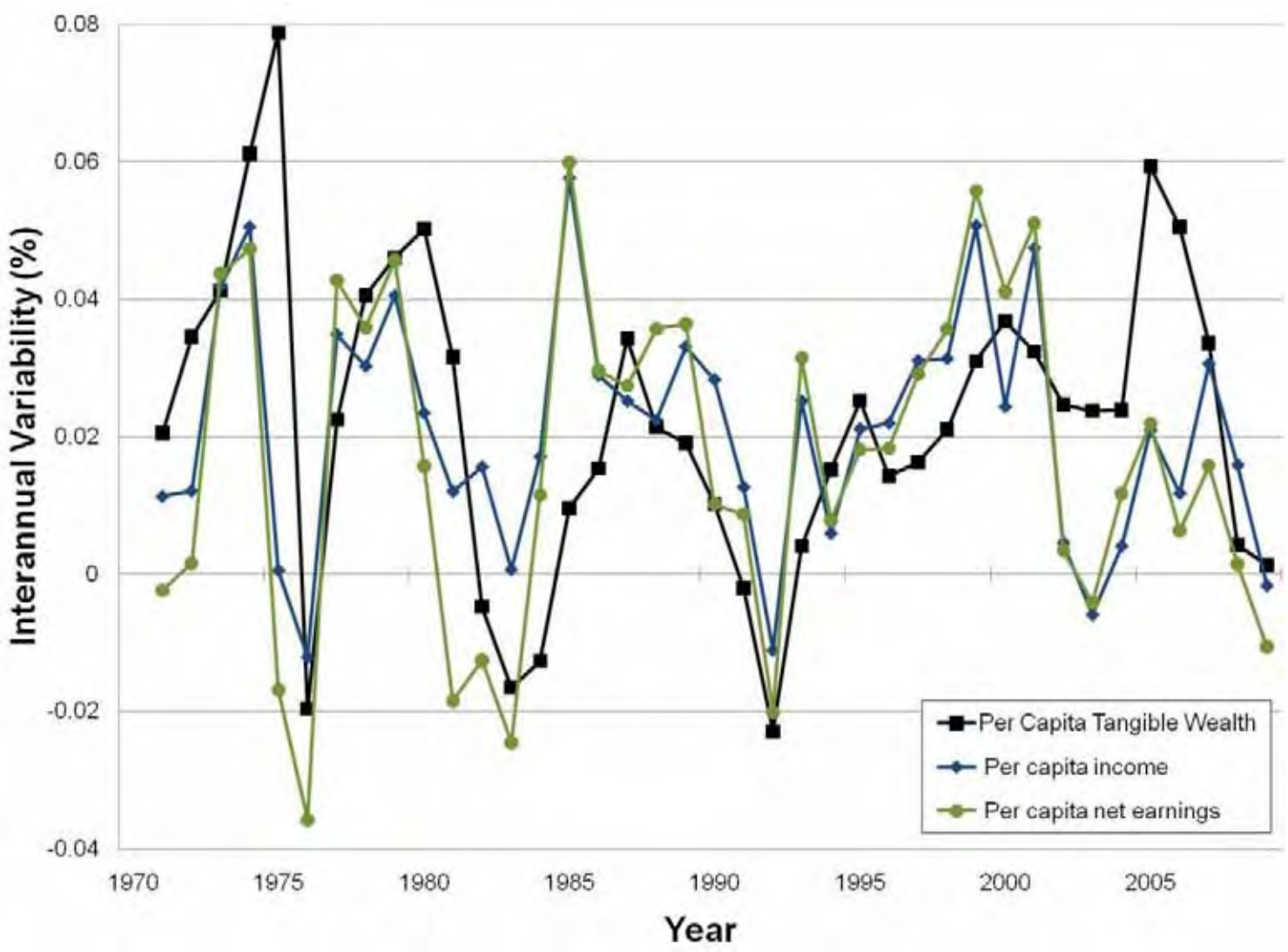
  PSE = County population size X County per capita wealth

  - County population size (U.S. Census Bureau)
    - 1960-1980: Linear interpolation of decadal census
    - 1980-2009: Decadal census, interstitial annual population estimates
  - County per capita wealth (U.S. Bureau of Economic Analysis)
    - No direct county-level measures of wealth (e.g., fixed reproducible tangible wealth)
    - Evaluated a range of economic indicators to identify proxy metrics that scale with wealth at the national level
    - Indicators inflation-adjusted to 2008$

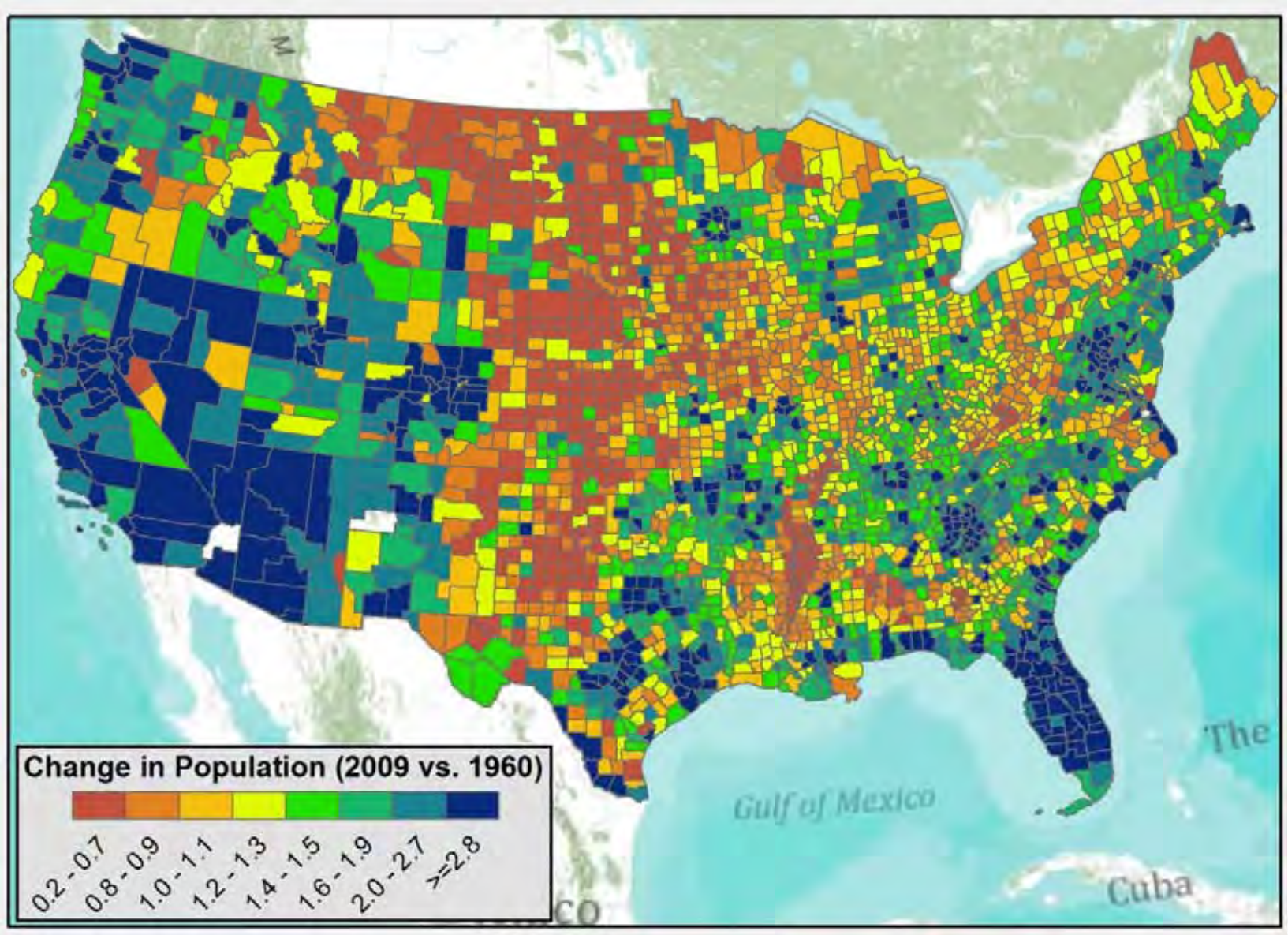
Evaluating wealth proxies



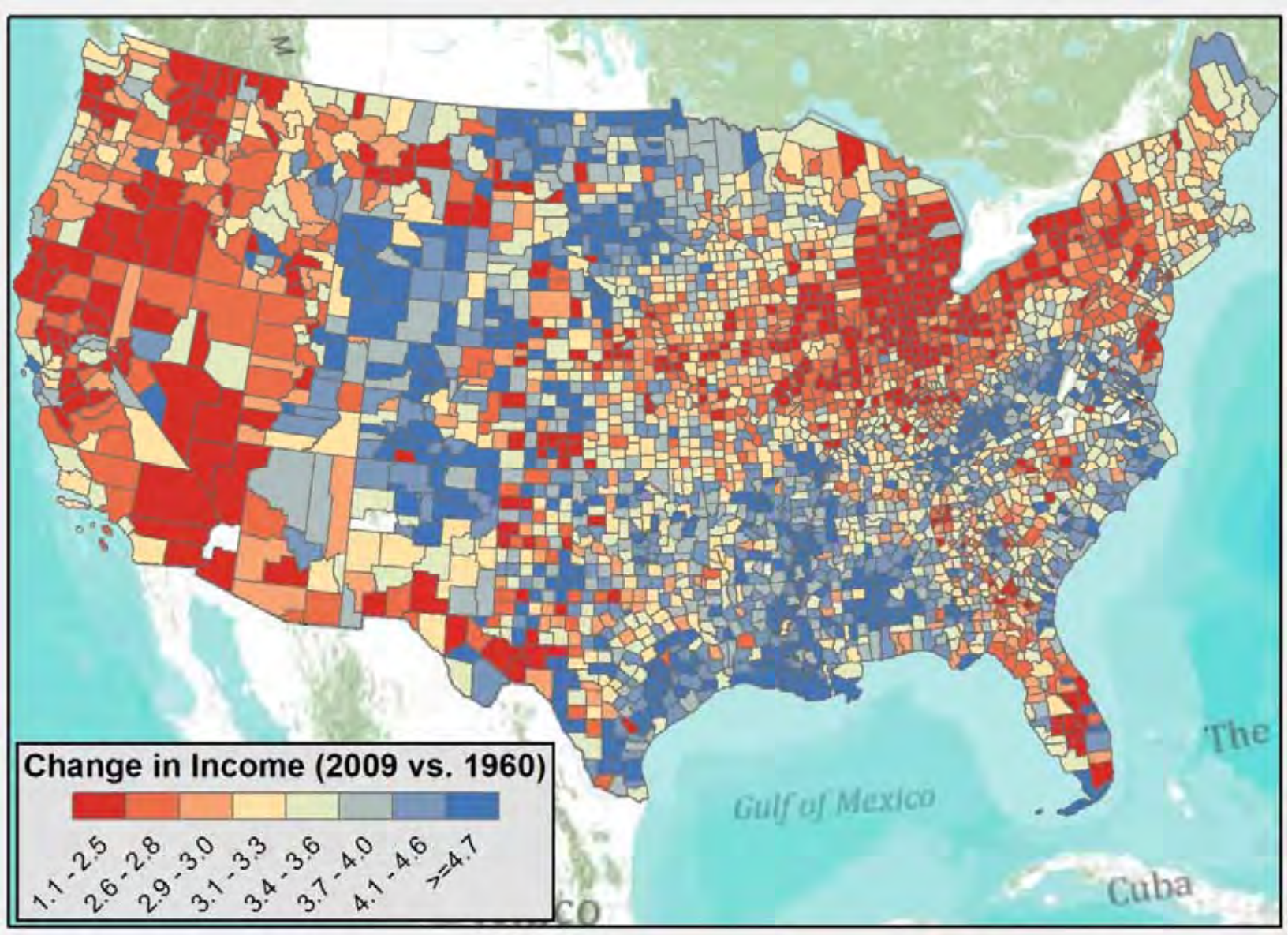
Variability of economic indicators



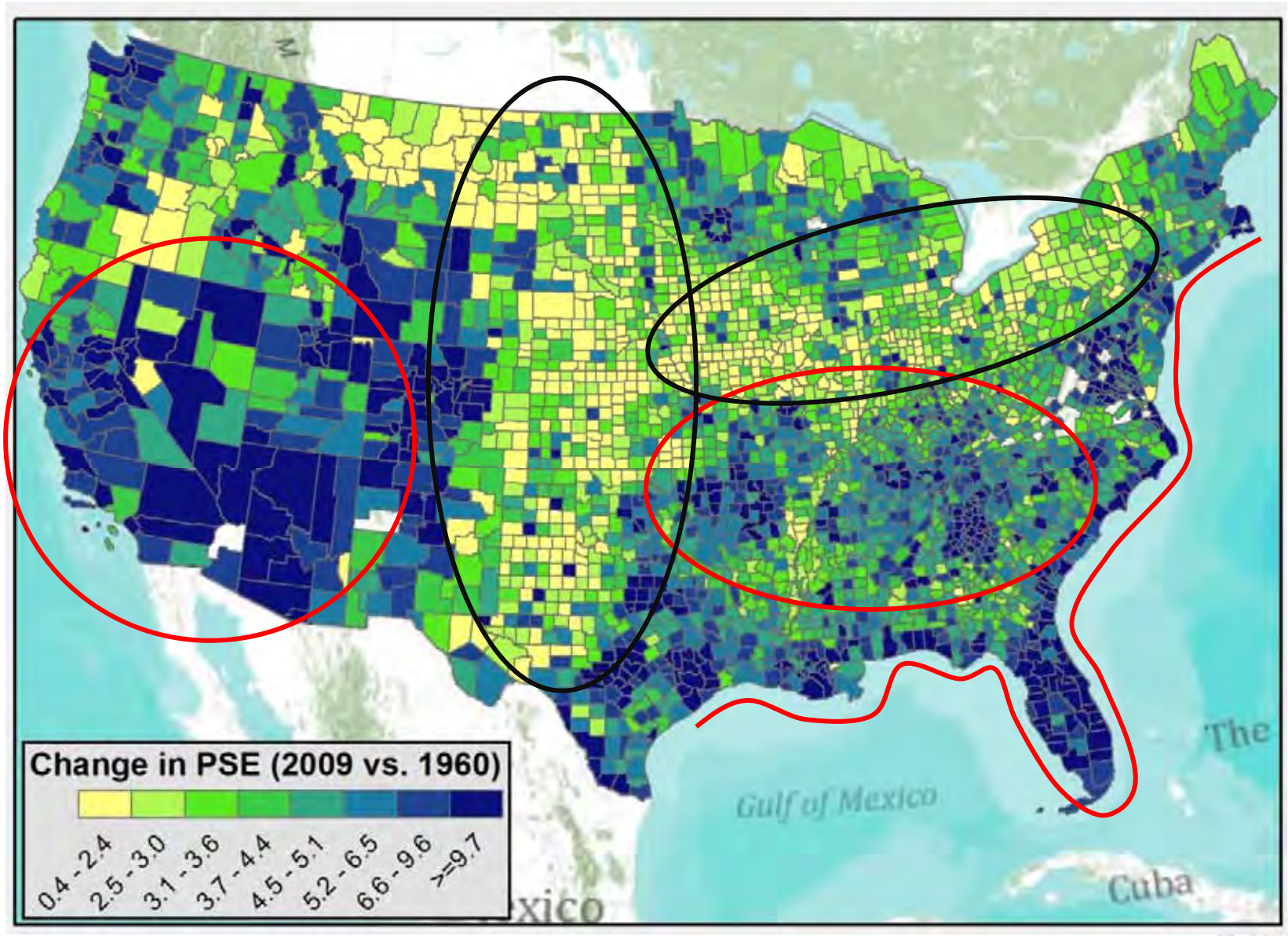
Relative change in population (1960-2009)



Relative change in income(1960-2009)



Relative change in PSE (1960-2009)



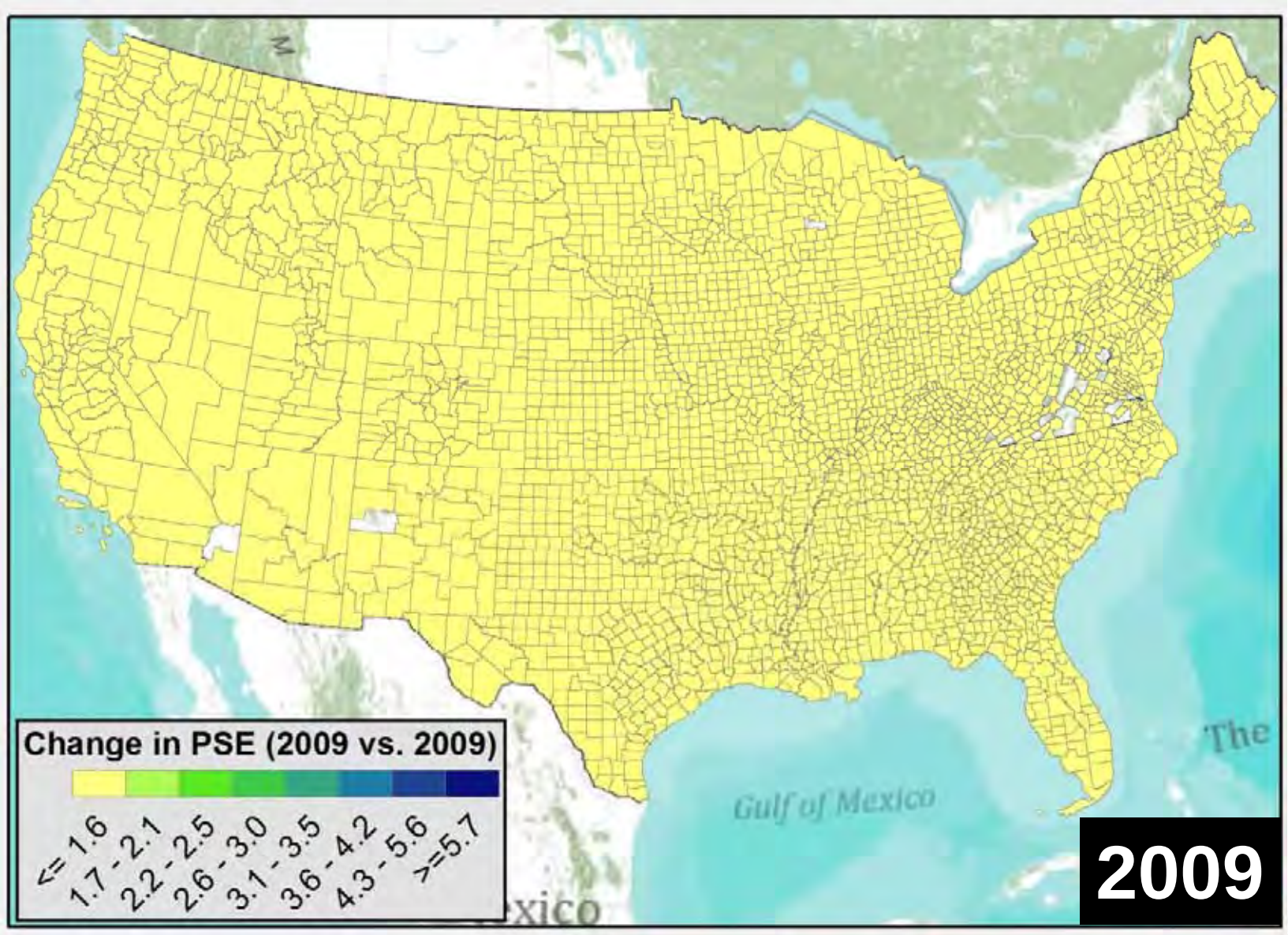
Future socioeconomic exposure (2009-2054)

- County per capita wealth
  - Application of different growth rate scenarios to 2009 baseline wealth proxies
  - Scenarios based upon interannual rates of change from 1969-2008

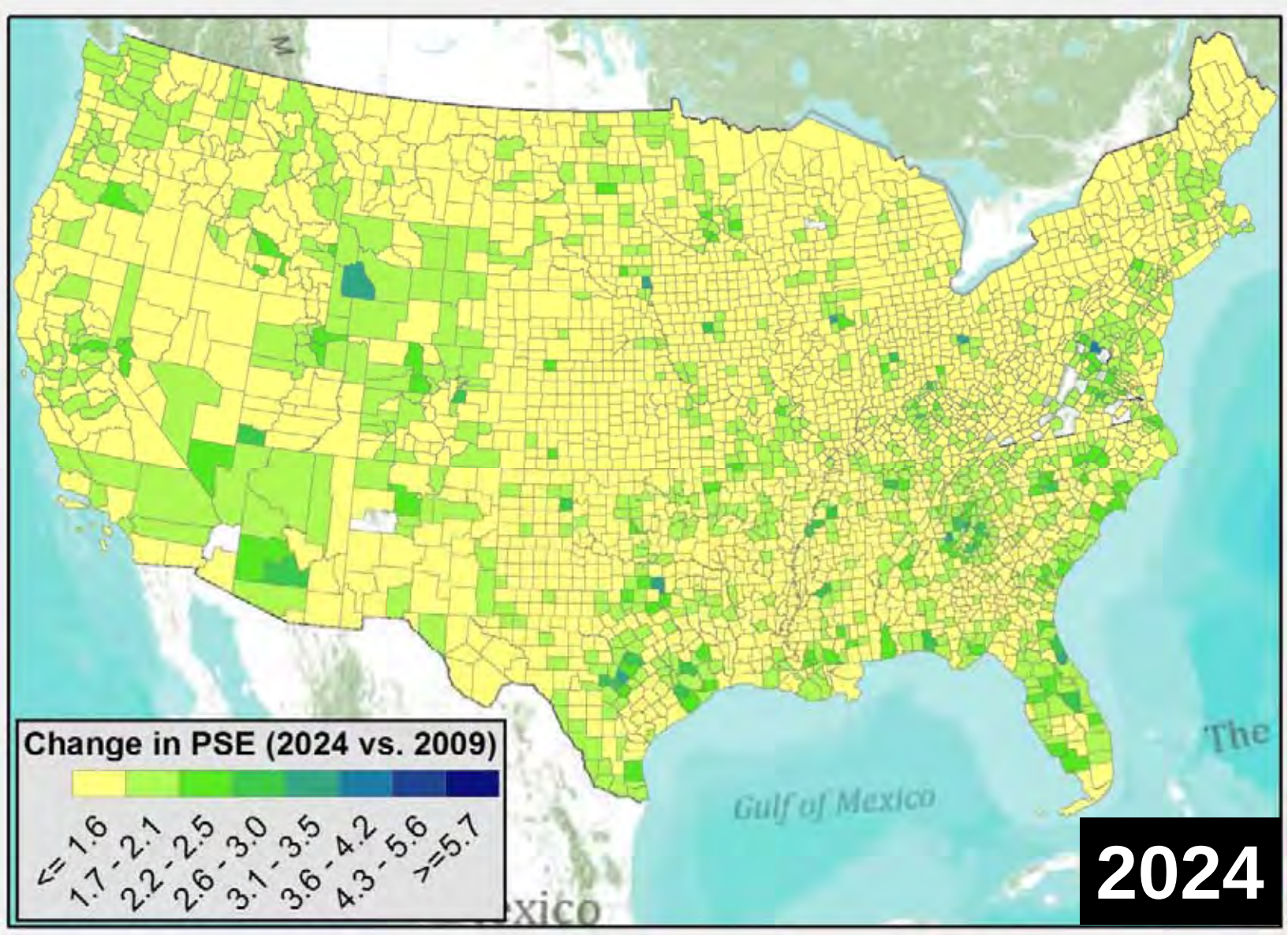
Scenario	County-Specific	National Mean
Low (40th)	S_1	S_4
Mid (50th)	S_2	S_5
High (60th)	S_3	S_6

- County population size
  - Component-cohort model
    - 2009 baseline year
    - Birth, deaths, domestic migration, international migration
    - 5-year time steps, annualized via linear interpolation

Future potential socioeconomic exposure



Future potential socioeconomic exposure



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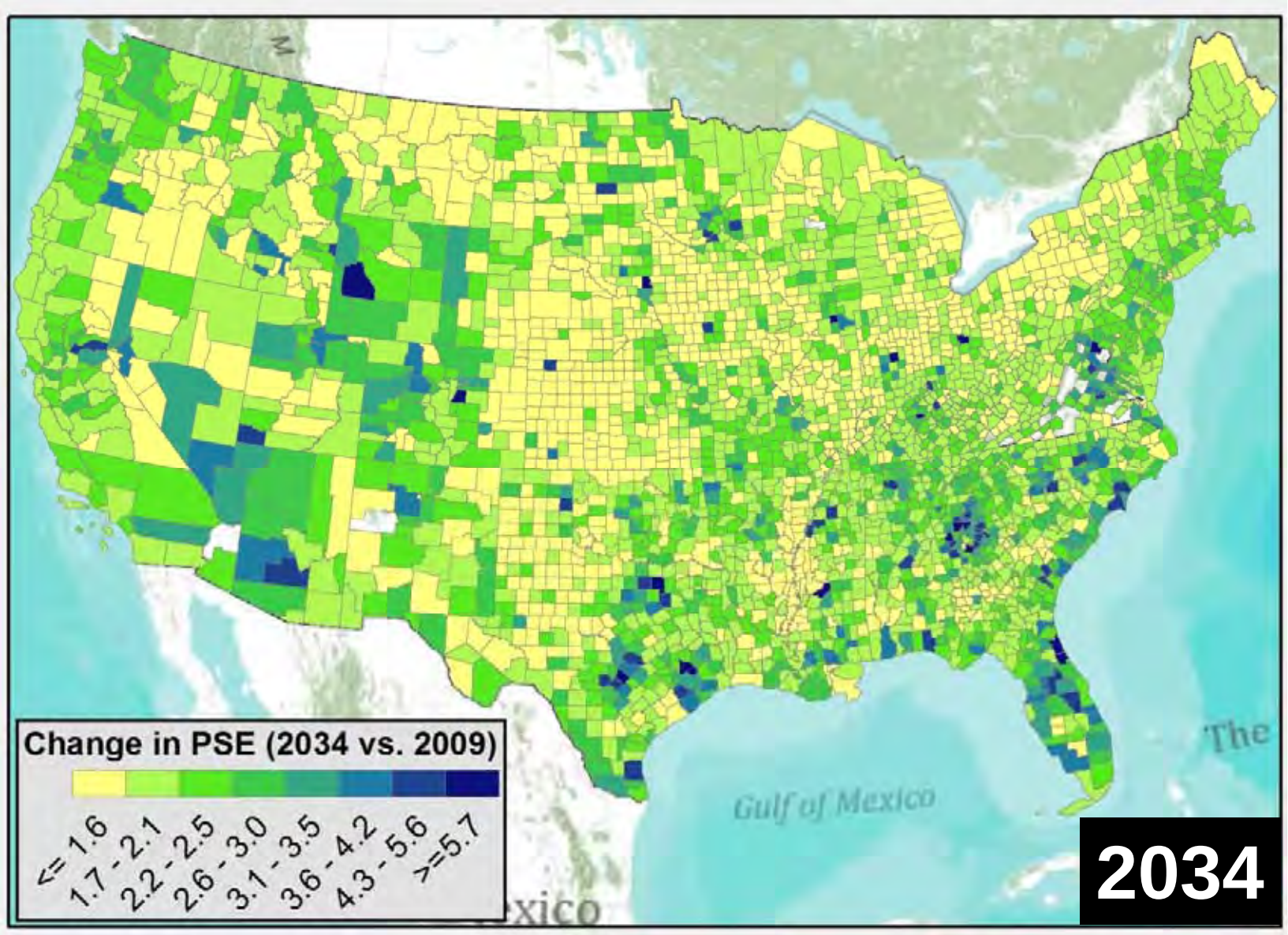

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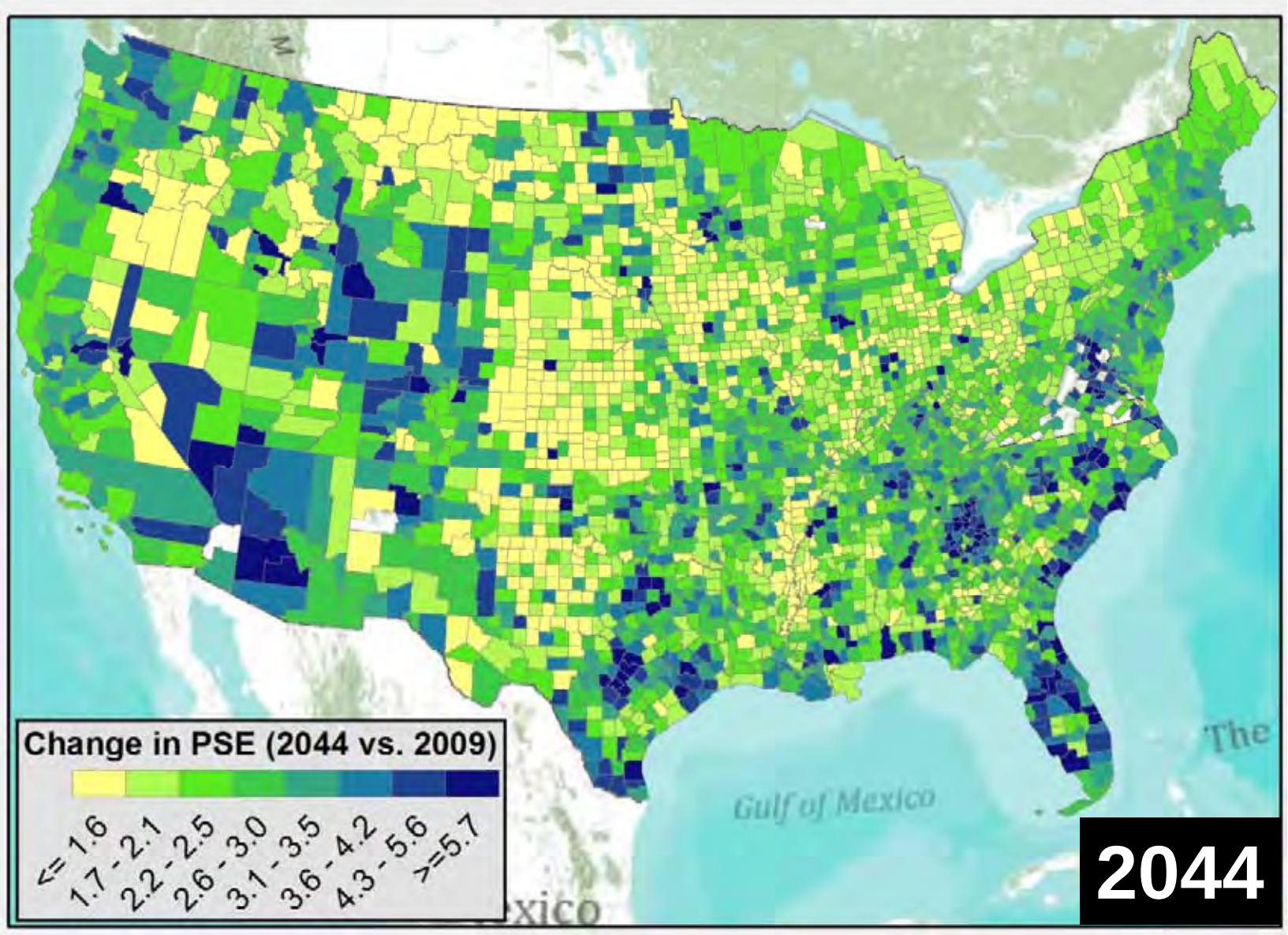

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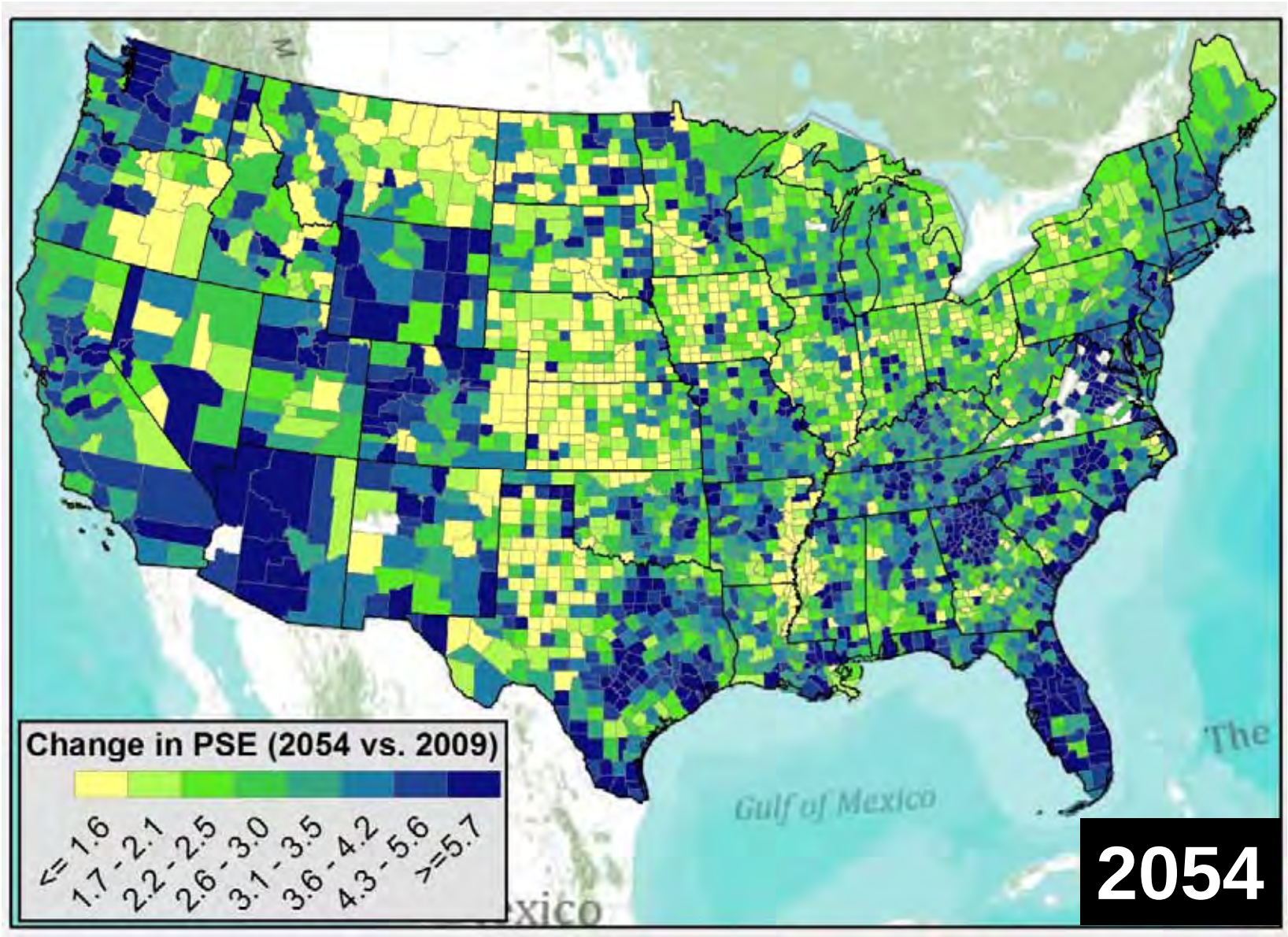
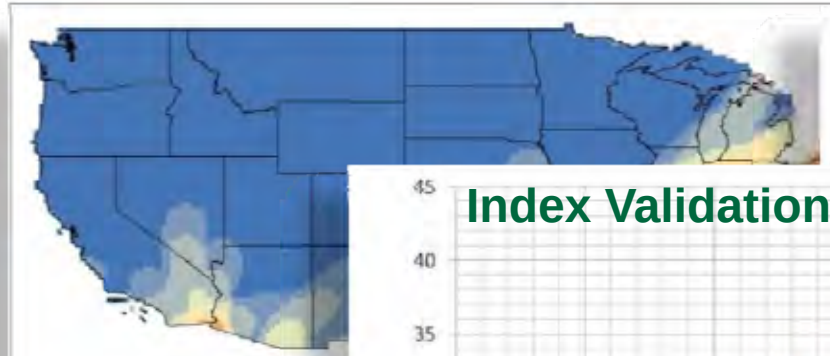


Using PSE to explore adaptation demand

- Socioeconomic inertia results in a 'vulnerability commitment', which is spatially heterogeneous
- Areas experiencing greater relative increases in PSE are likely to have greater changes in adaptation demand
  - Anticipatory: Climate-resilient development
  - Reactive: Response, recovery, repair in the wake of events
- PSE also has implications for informing the geography of adaptive capacity
  - Low rates of PSE growth=outmigration and/or economic stagnation
  - High rates of PSE growth=rapid economic development
- There are likely to be trade-offs between exposure and adaptive capacity

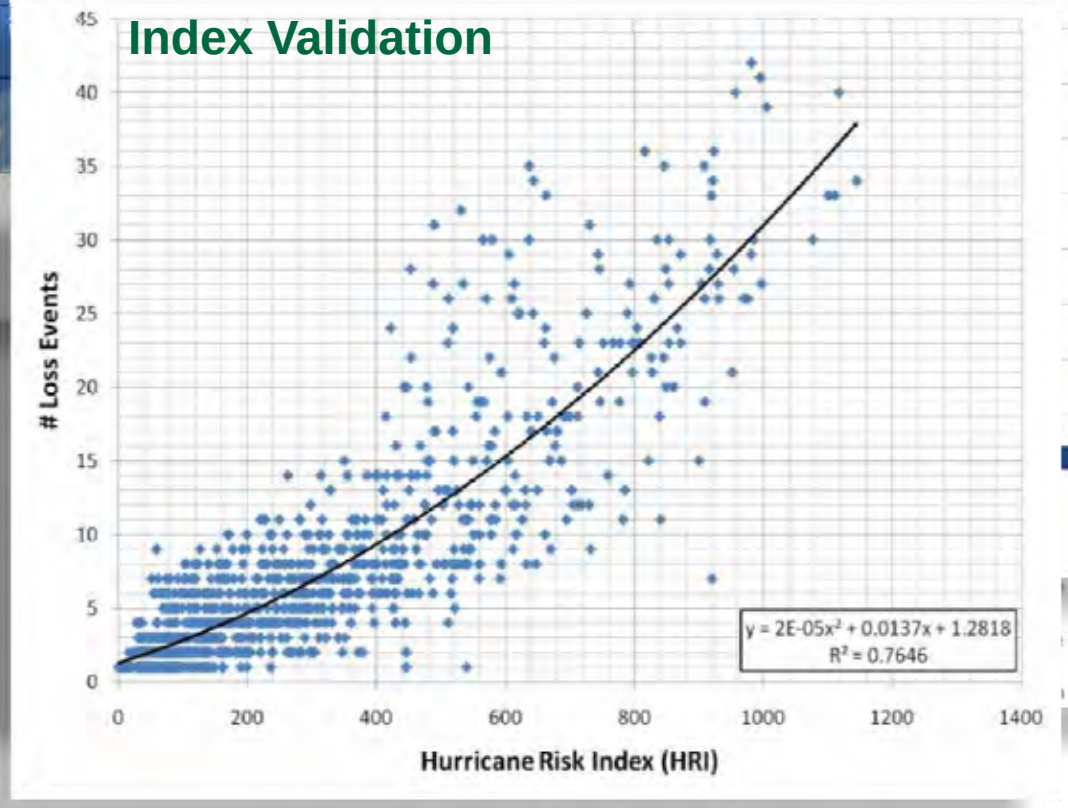
Population has grown disproportionately in counties exposed to tropical cyclones

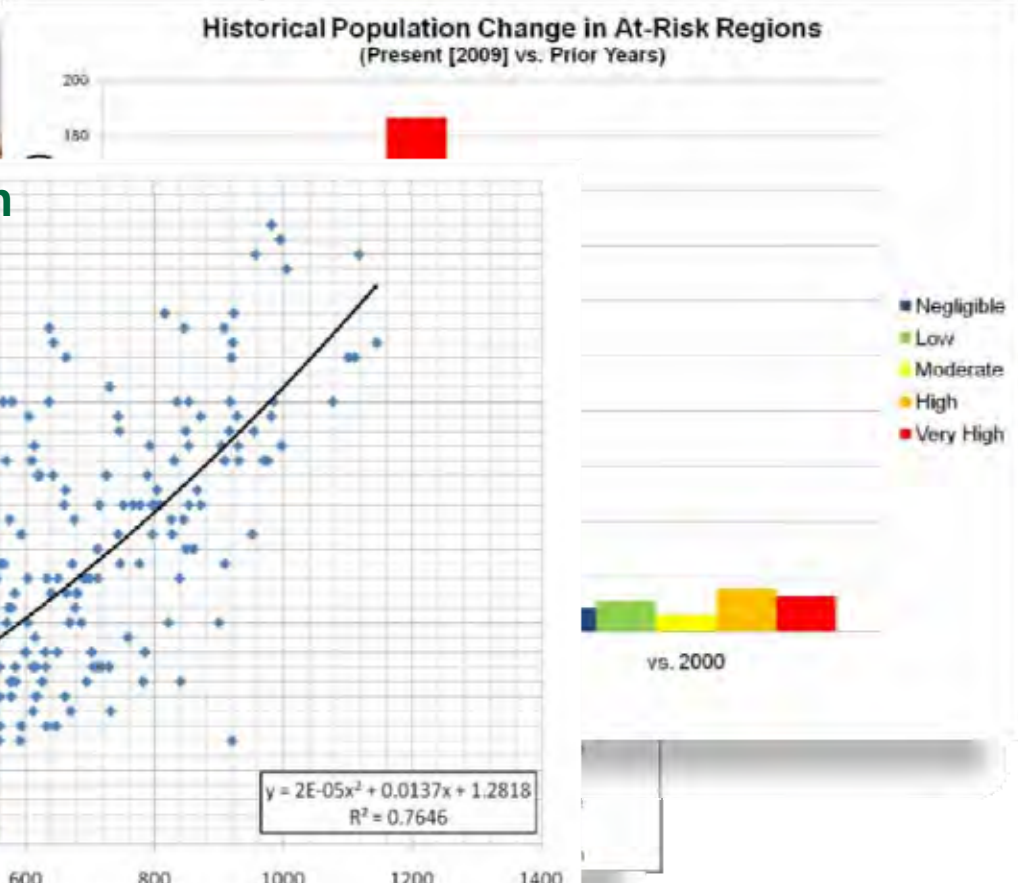
- The regional distribution of tropical cyclone exposure is geographically heterogeneous



Hazard Index
1960-2008

Preston (2011)

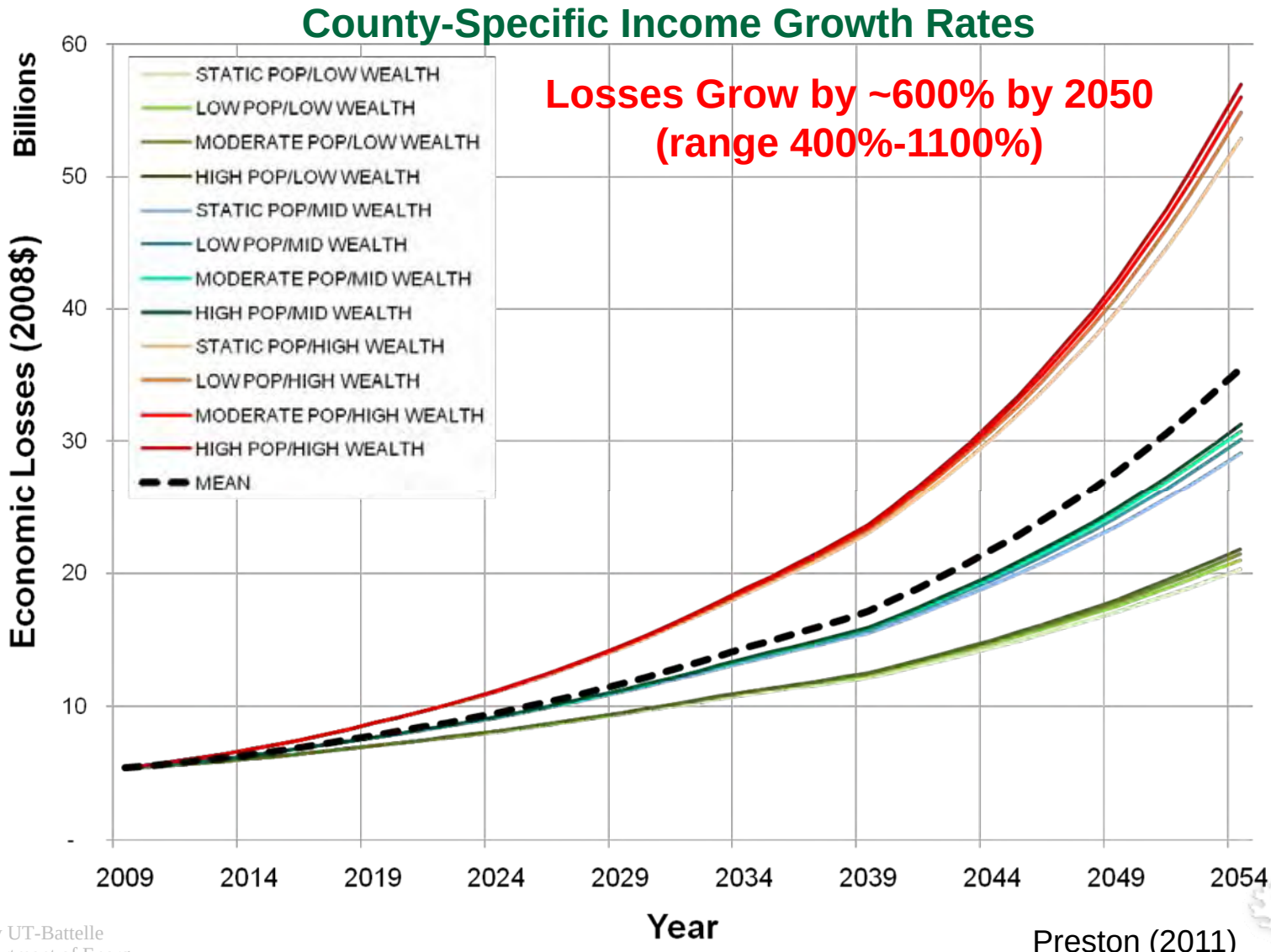




Applying PSE to project changes in economic losses from tropical cyclones

- Changes in PSE, like natural hazards, are heterogeneously distributed across the nation
  - Use local metrics of PSE to estimate changes in future economic losses from natural hazards
- Data Source: Spatial Hazards Events and Loss Database (SHELDUS)
  - Extracted county estimates of tropical cyclone losses (1960-2008)
  - Adjusted loss data to 2008$
  - Normalized losses in each year to 2009 population and income
  - Annualized losses were calculated for each county
  - Annual projections of PSE were applied to annualized loss estimates to project changes in economic losses

Future increases in PSE in coastal regions contributes to a commitment to future losses



Preston (2011)

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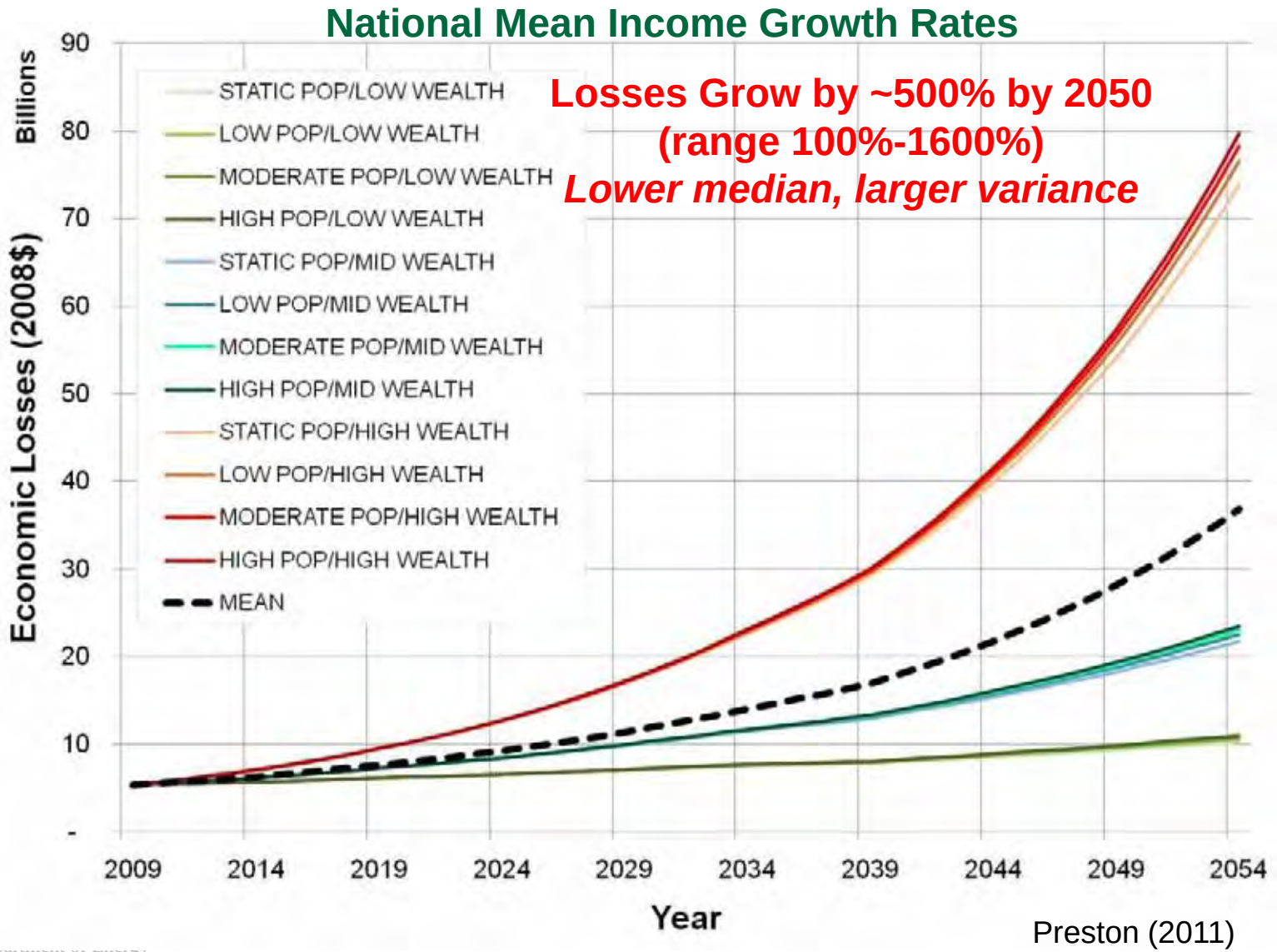
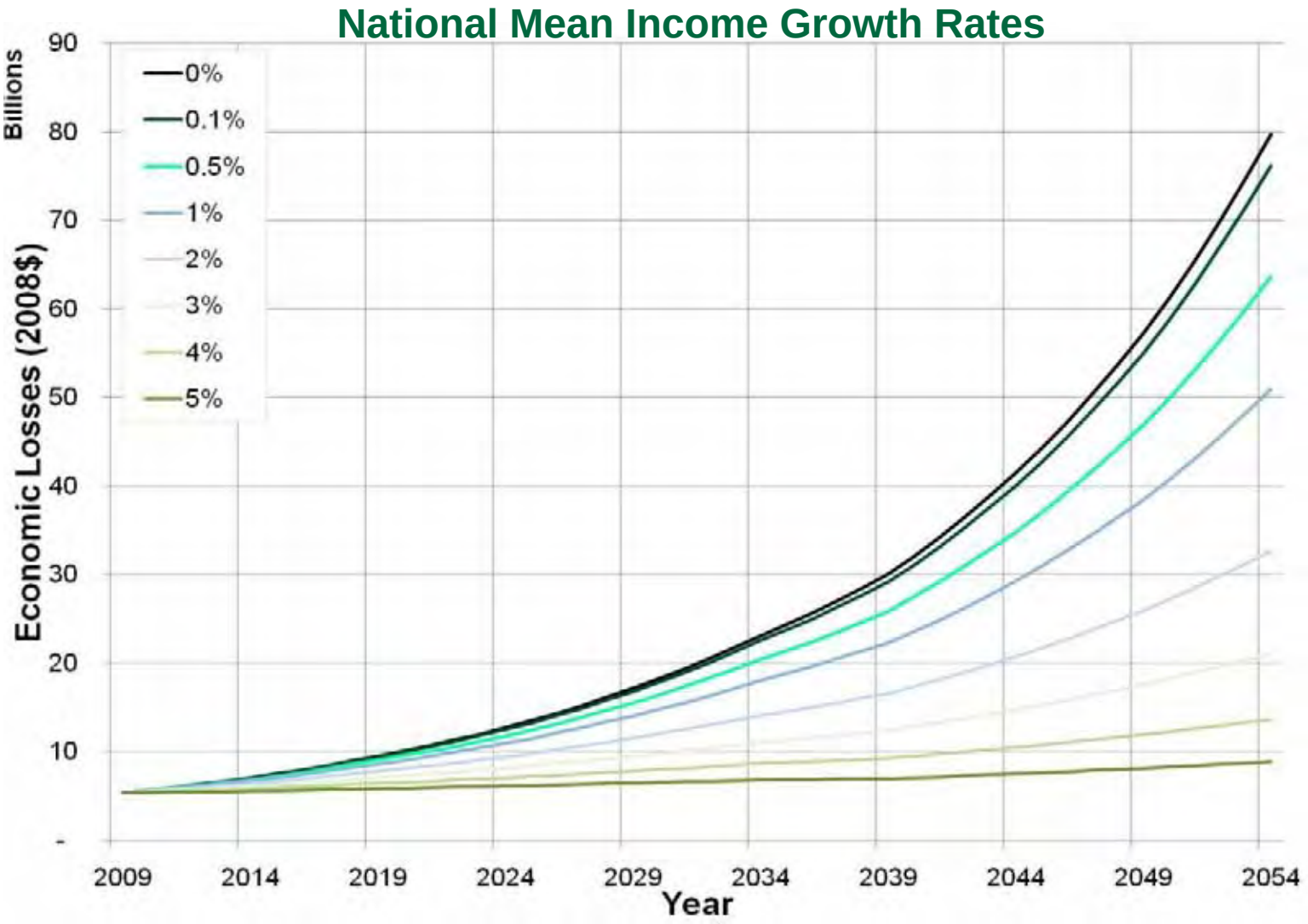


Preston (2011)

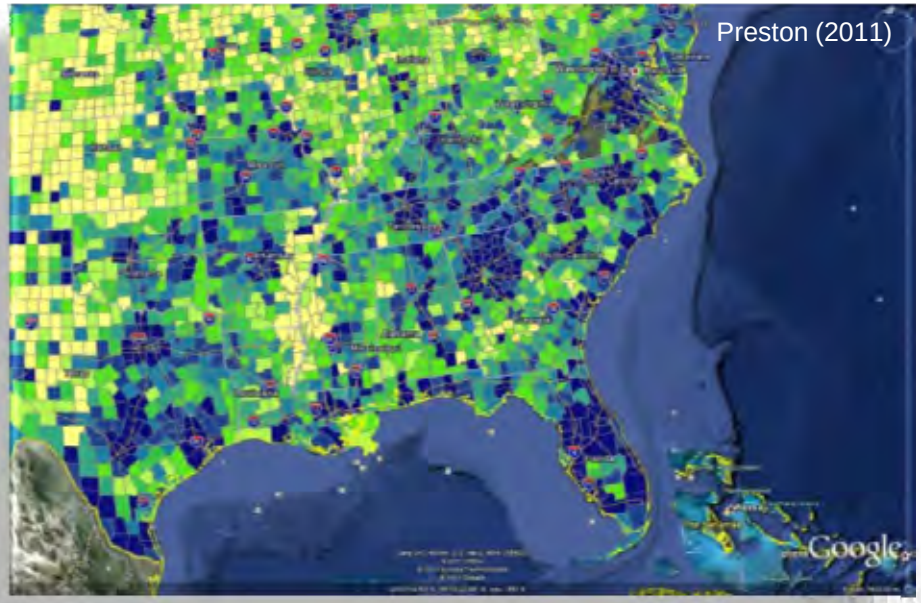
Net present value of future losses varies with assumptions about discount rates



Preston (2011)

Conclusions and next steps

- Conclusions
  - Socioeconomic exposure is a useful tool for exploring the geography of societal vulnerability to climate variability and change
  - Socioeconomic inertia will drive substantial, but geographically heterogeneous, increases in exposure and economic losses in future years
- Next steps
  - Application to other hazards
  - Downscaling of PSE
  - Visualization tools



Thank You

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Help Wanted

Integrated Assessment Modeling

1) Post-doc in uncertainty characterization in IAMs

2) Post-doc in adaptation in IAMs