The Southeast's Water Footprint and LCA: An Application using Multiregional IO Technology

DM Lambert[1]*, Di Sheng[2], L He-Lambert[1], RJ Menard[1], BC English[1], CD Clark[1]

1. Dept. of Agricultural & Resource Economics, University of Tennessee Institute of Agriculture, Knoxville, TN
2. Dept. of Agricultural & Resource Economics, Colorado State University, Fort Collins, CO

*Corresponding: dlamber1@utk.edu

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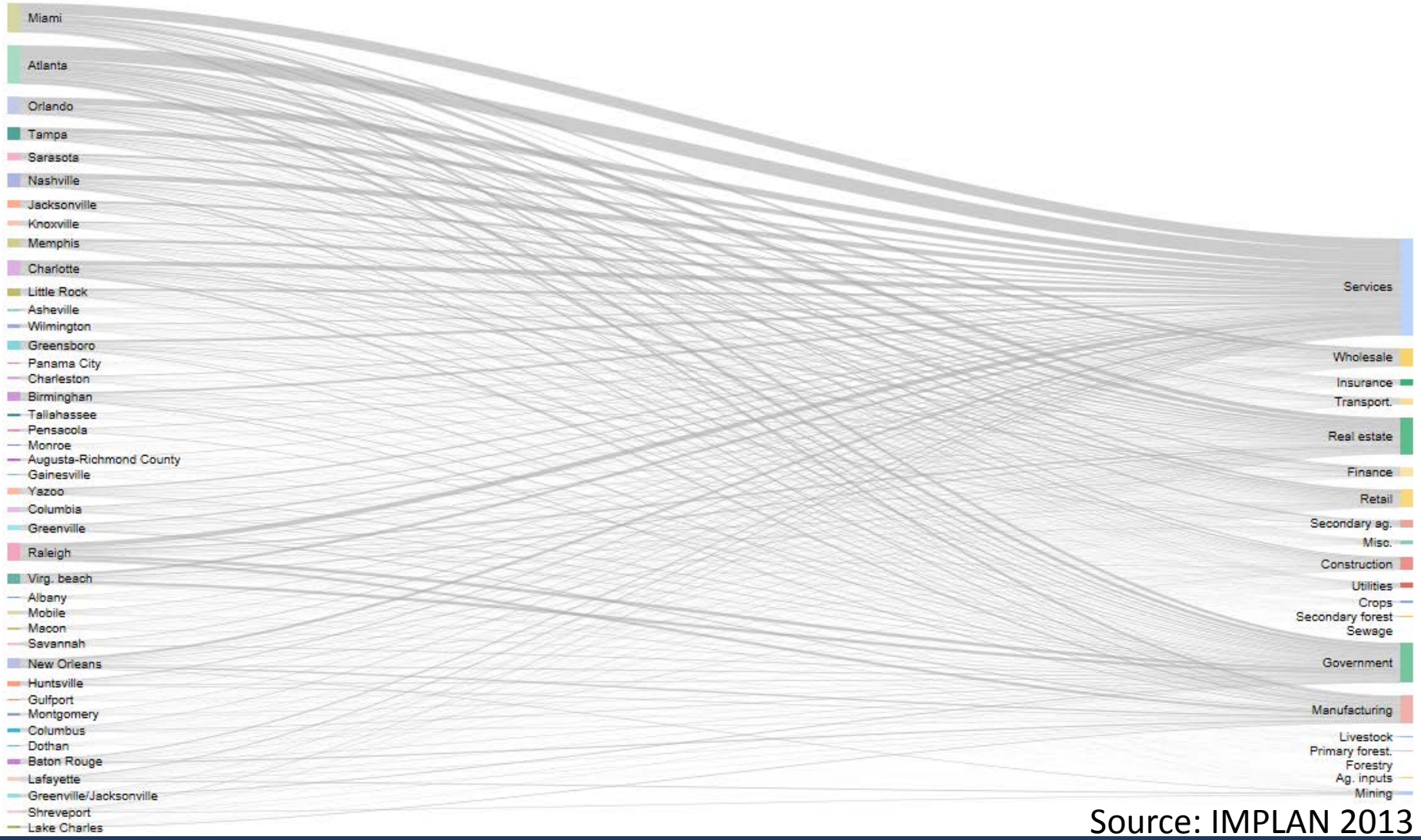
Support

USDA-NIFA, Water for Agriculture Challenge Area

Project title: "*Increasing the Resilience of Agricultural Production in the Tennessee and Cumberland River Basins through More Efficient Water Resource Use*"

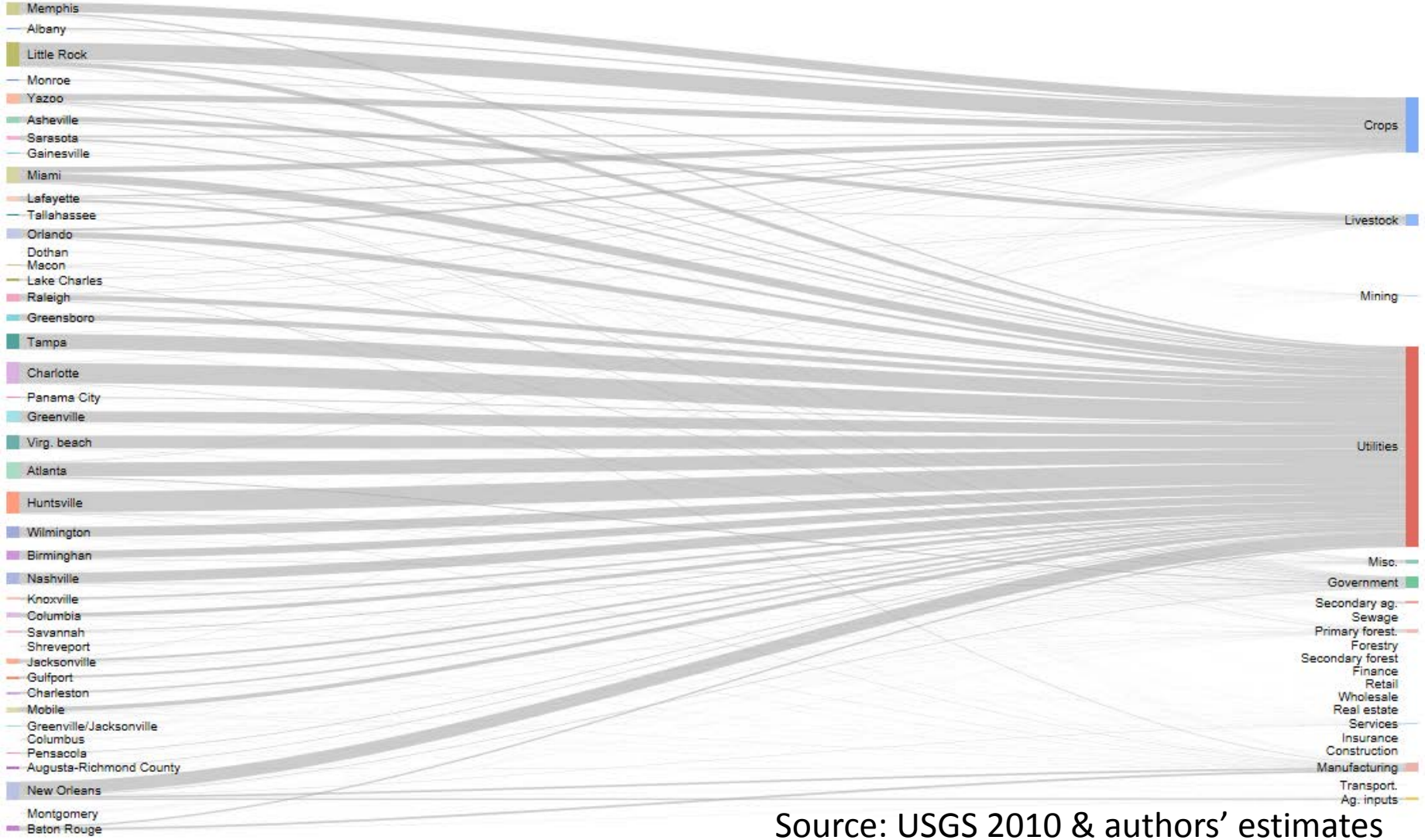
United States Department of Agriculture
National Institute of Food and Agriculture

The Southeast's Economy: Total Value Added ($)



Source: IMPLAN 2013

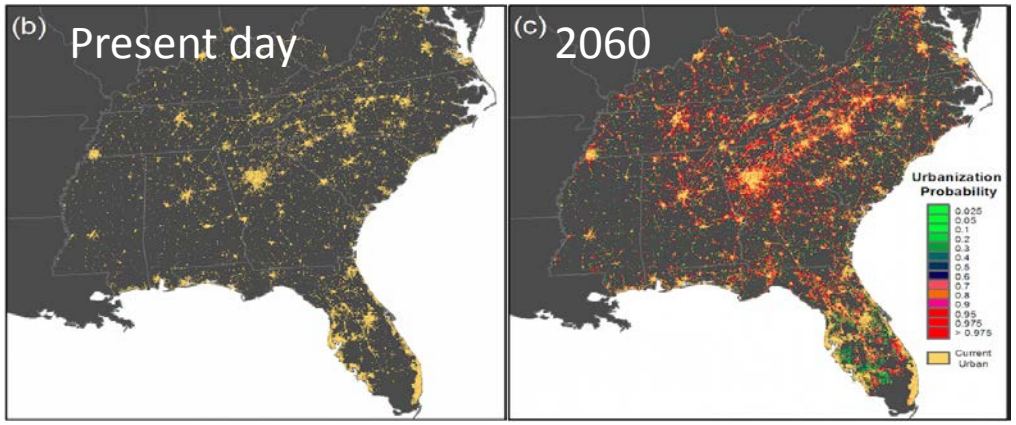
The Southeast's Use of Water Across Economic Sectors (gallons)



Source: USGS 2010 & authors' estimates

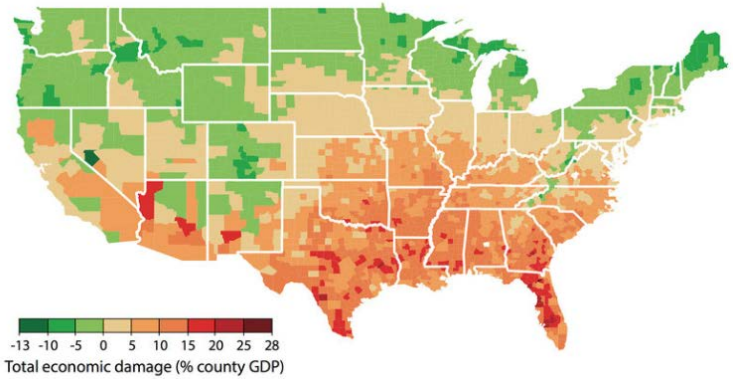
Challenge drivers?

Increased demand for land & water?



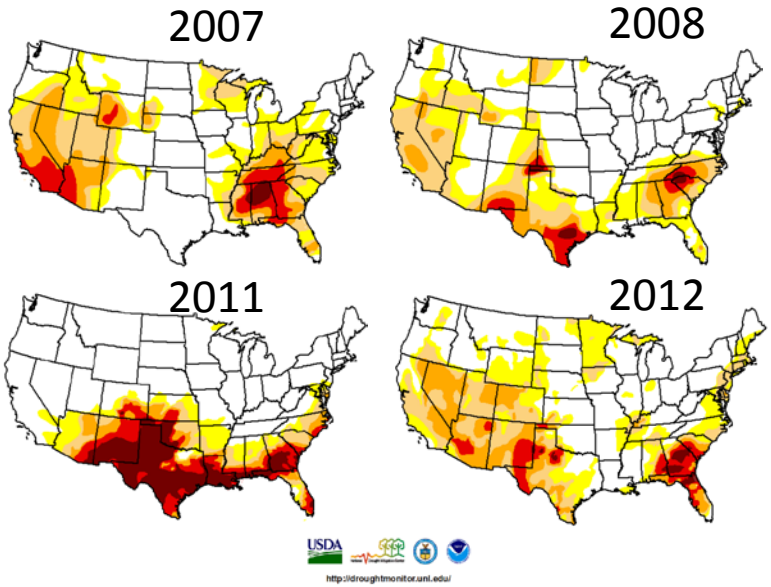
Source: Terando et al., 2014.

Warmer Seas, Bigger Storms?

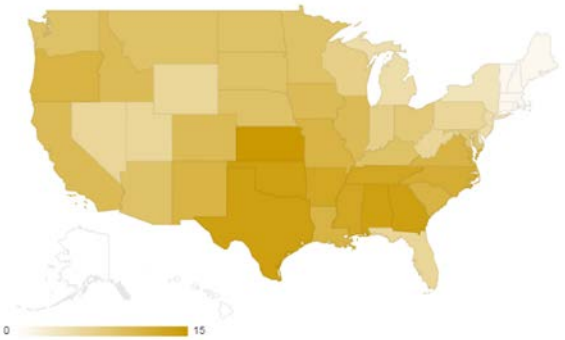


https://www.npr.org/sections/thetwo-way/2017/06/29/534896130/mapping-the-potential-economic-effects-of-climate-change

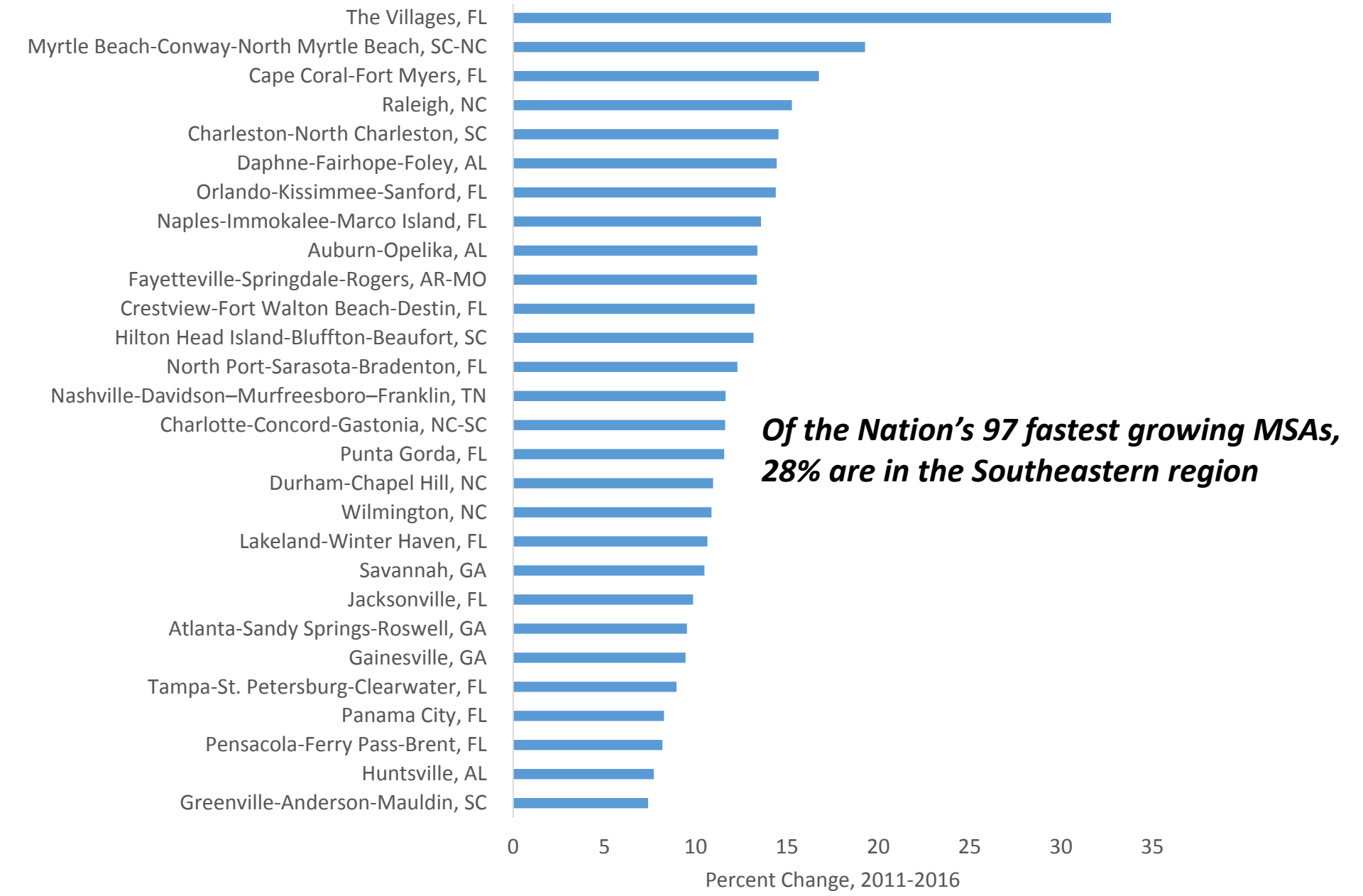
More Frequent Drought?



Cost of Drought



1980-2017 Billion-Dollar Drought Disasters (CPI-Adjusted)
NOAA, 2017 April 6th



Of the Nation's 97 fastest growing MSAs, 28% are in the Southeastern region

Challenges for our region (and our research challenge…)

- How do we plan for scarcity in abundance?
- What are the urban/rural tradeoffs, allocation and management (water use, social & political dimensions)?
- Are there regional leadership opportunities in innovation (institutional roles, policy, technology transfer and adoption)?
- What are tipping-points (commodity/resource markets, production mix – local, global drivers)?

- Requires understanding resource stock/economic flow dependencies…
- How much water do we use to meet industry and consumer requirements?

Objectives

- Estimate quantity of water required to meet changes in final demand for goods produced and traded in the Southeastern US
- Quantify the southeastern US state's water use with an Environmental Input-Output Life Cycle Analysis (EIO-LCA)

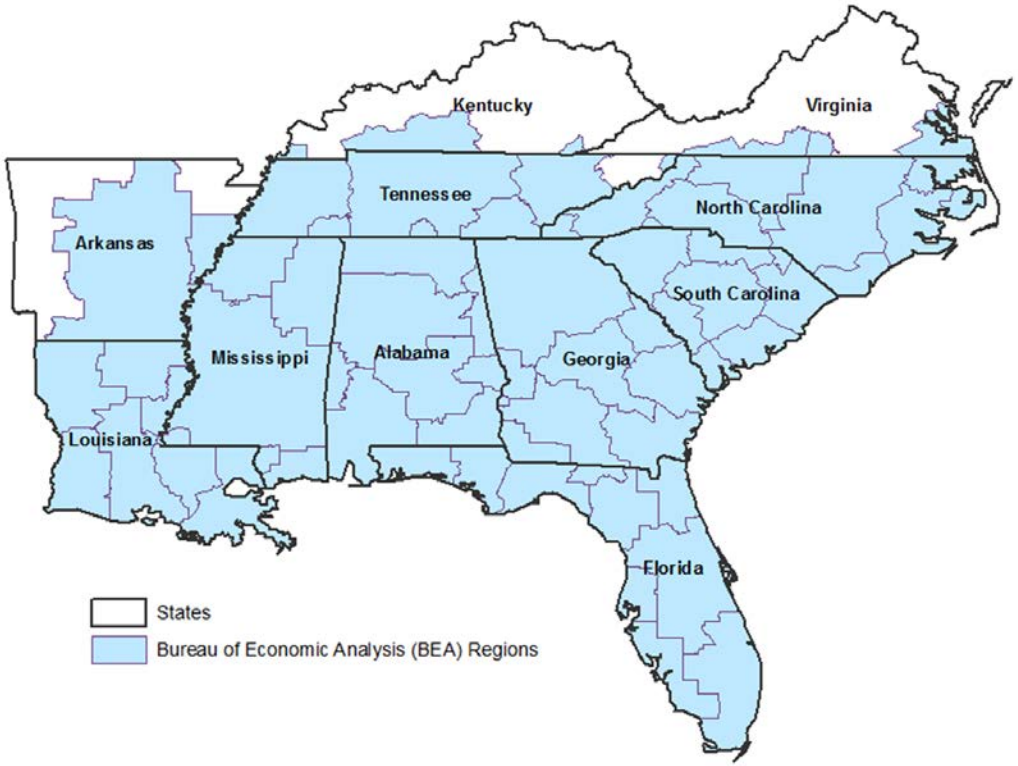
Inter-industry economic transactions

Multi-regional economic transactions

What is "trade-off"?, or $\left(\frac{Water\ used\ to\ make\ a\ good}{Change\ in\ demand\ for\ a\ good}\right)$

Scope

- Southeastern U.S.
- 11 states
- 43 BEA regions
- 763 counties

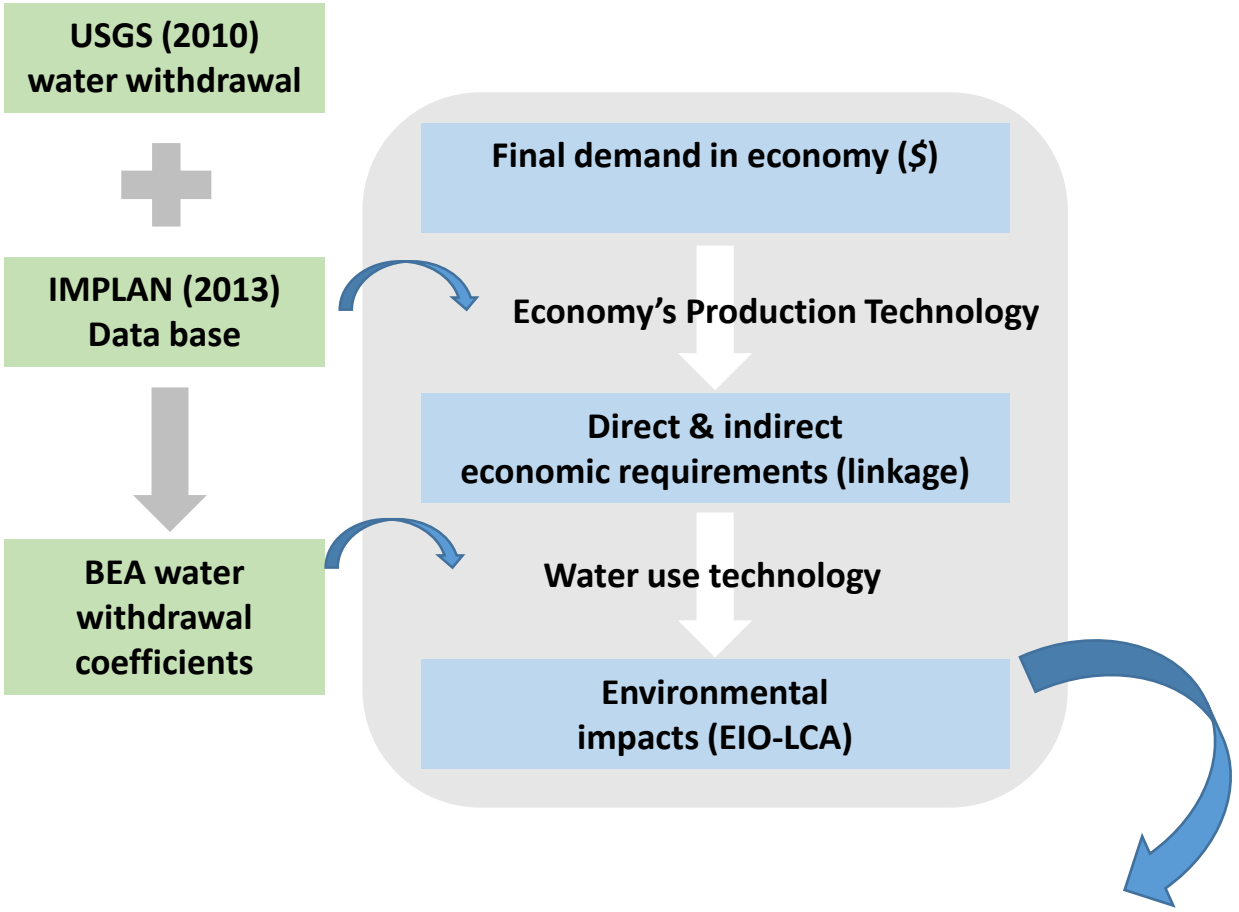


Data

- 536 IMPLAN sectors (MIG, 2013)
- USGS 2010 water withdrawal (county level)
- USDA-ARS 1976 plant water requirement coefficients
- Carnegie-Mellon non-agricultural water use coefficients
- BEA shapes, *xy*-centroids (ESRI ArcGIS)

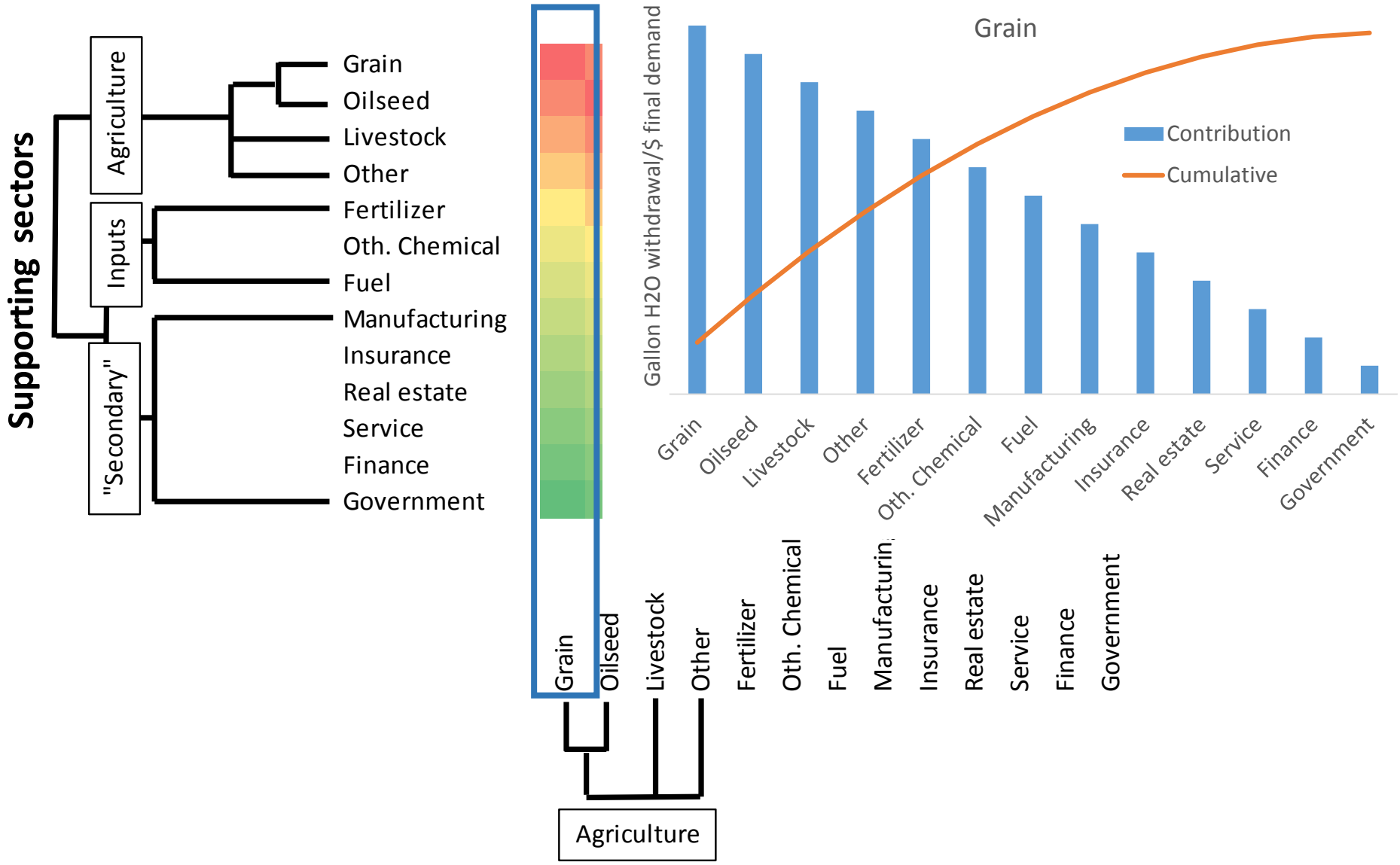
Environmental Input-Output/Life Cycle Analysis

Leontief (1970); Henry and Bowen (1981); Blackhurst et al. (2010); Matthews et al. (2015)



$$Multipler = \left(\frac{Gallons\ of\ water\ used\ to\ make\ a\ good}{1\$\ increase\ in\ demand\ for\ a\ good}\right)$$

EIO-LCA Concept

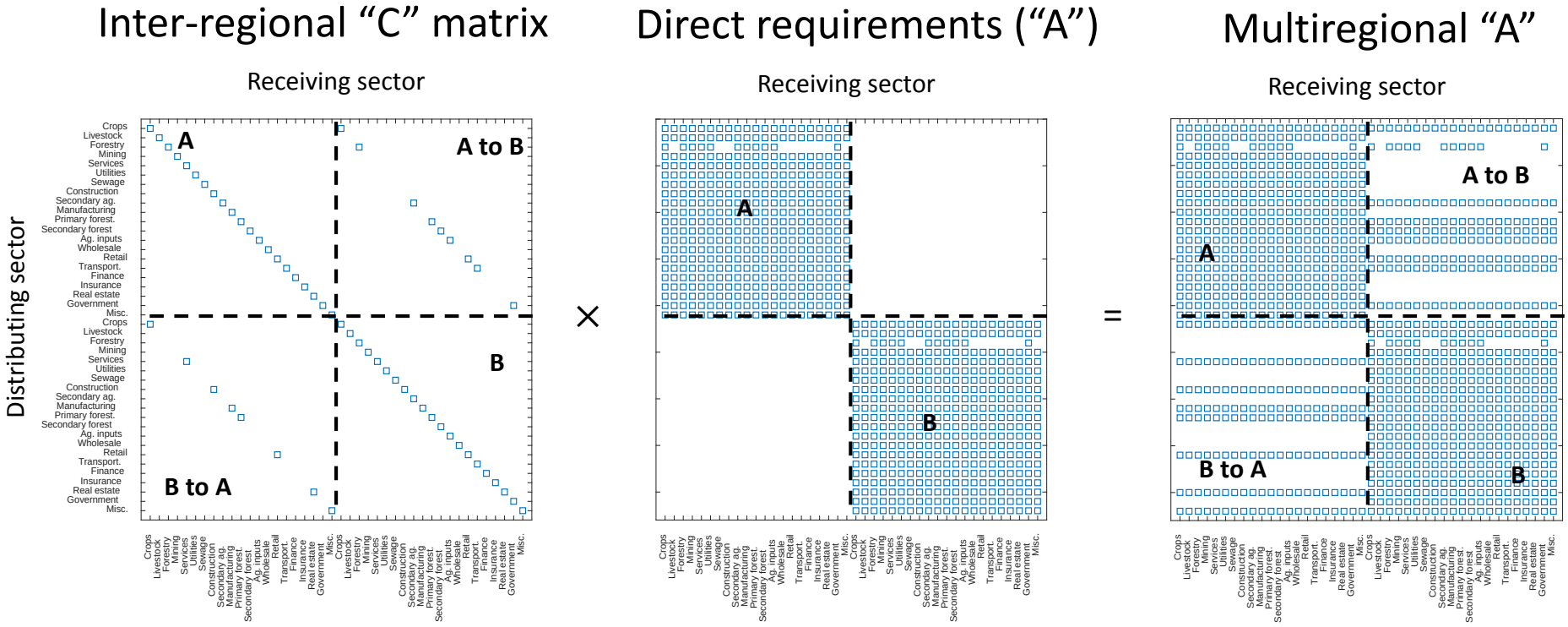


The “usual” EIO-LCA…

- Have not modeled inter-regional transactions (to the best of our knowledge)
- We model inter-regional transactions: **demand pull** in one region → **changes in water use** in another region
- Multi-Regional Input-Output (MRIO) model (Metzler, 1950; Hewings, Okuyama, Sonis, 2001)
- Potential scenarios for virtual water “trading” (?)

MRIO Model*

Matrix structure of Inter-regional "A": two sector/two region example



* Miller & Blair, 2009; Hewings, Okuyama, Sonis, 2001

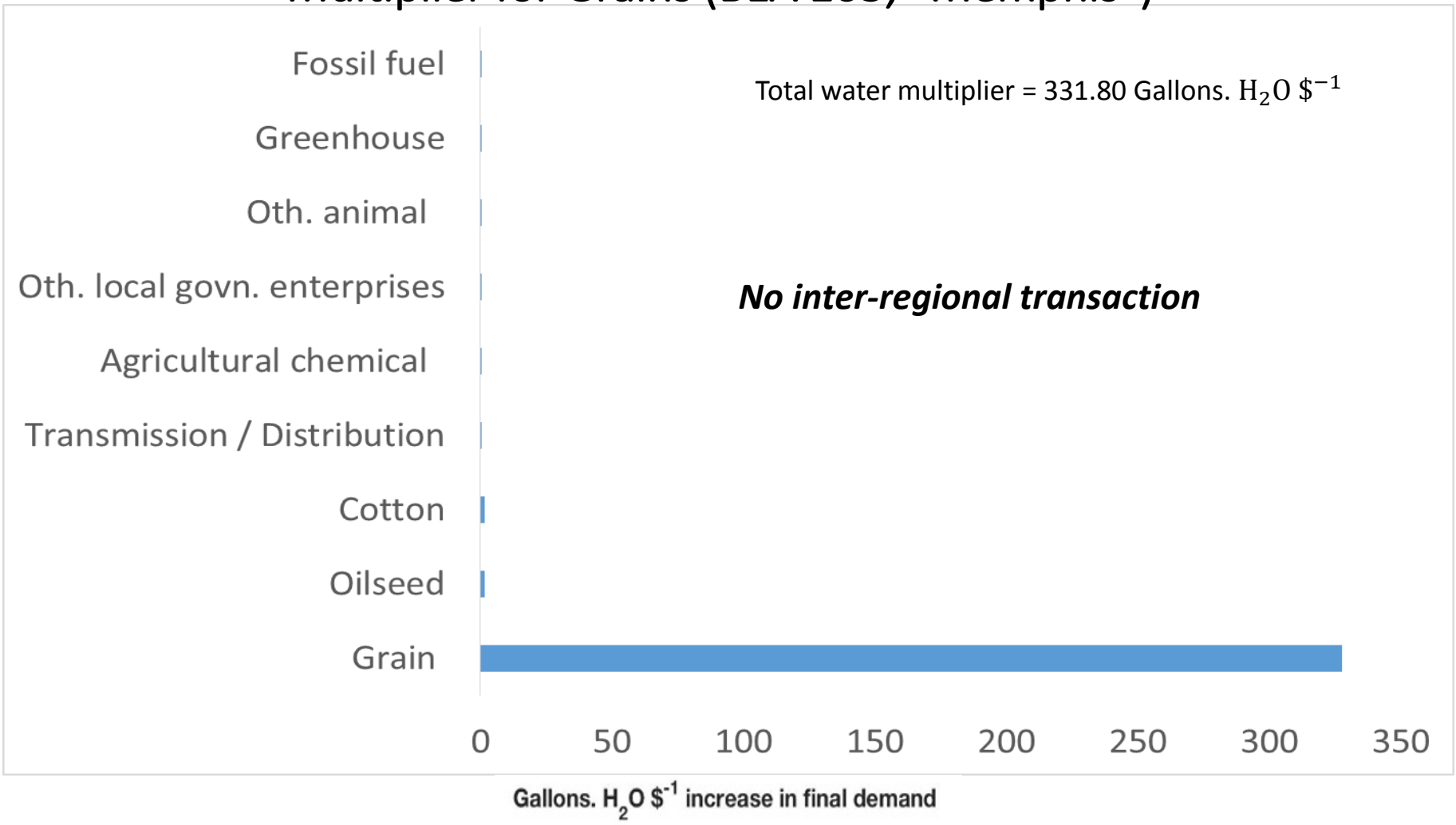
Working example

- 536 economic sectors
- 43 BEAs

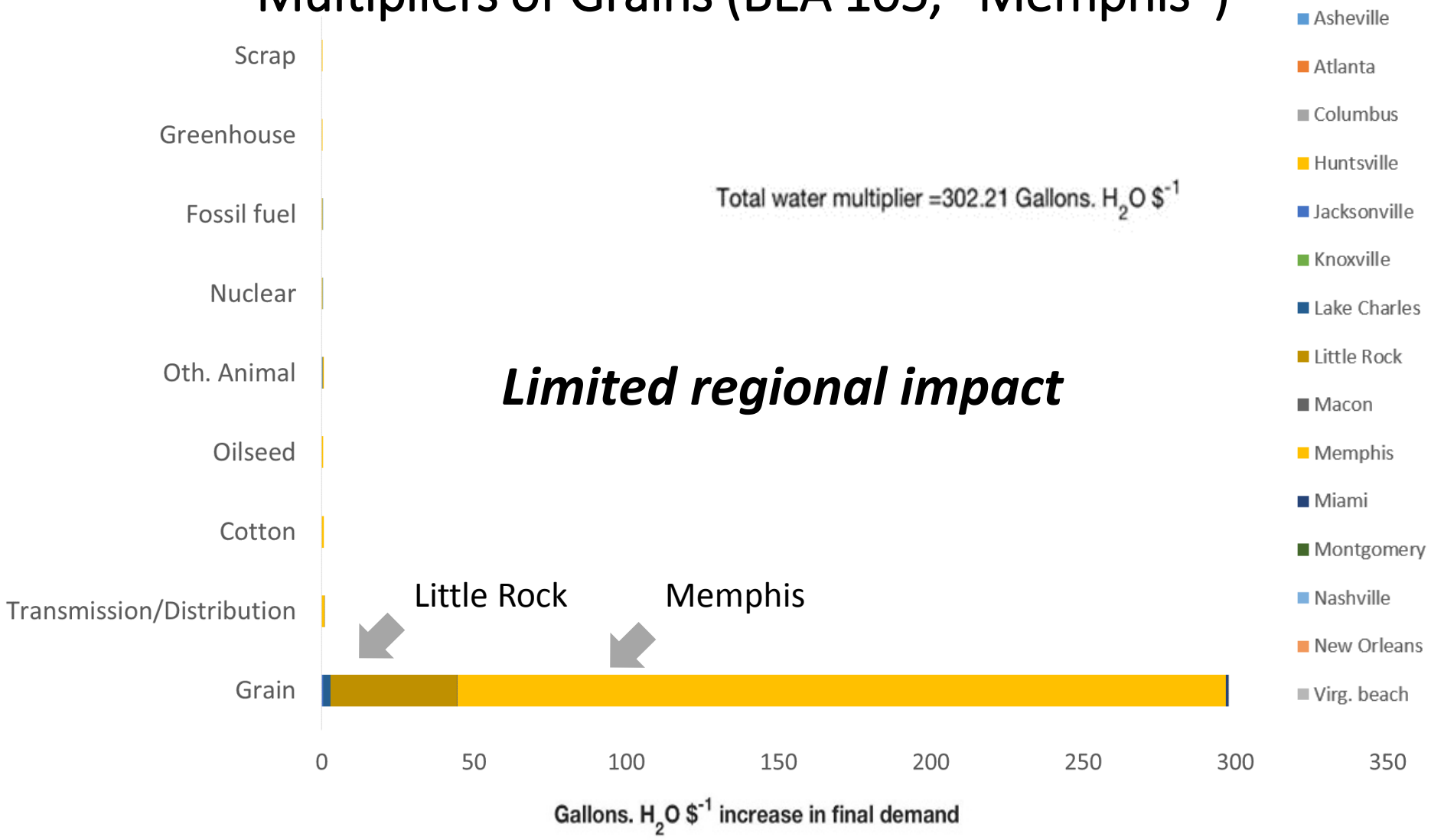
Focus on

- Memphis: Grains & Oilseed
- Atlanta: Poultry

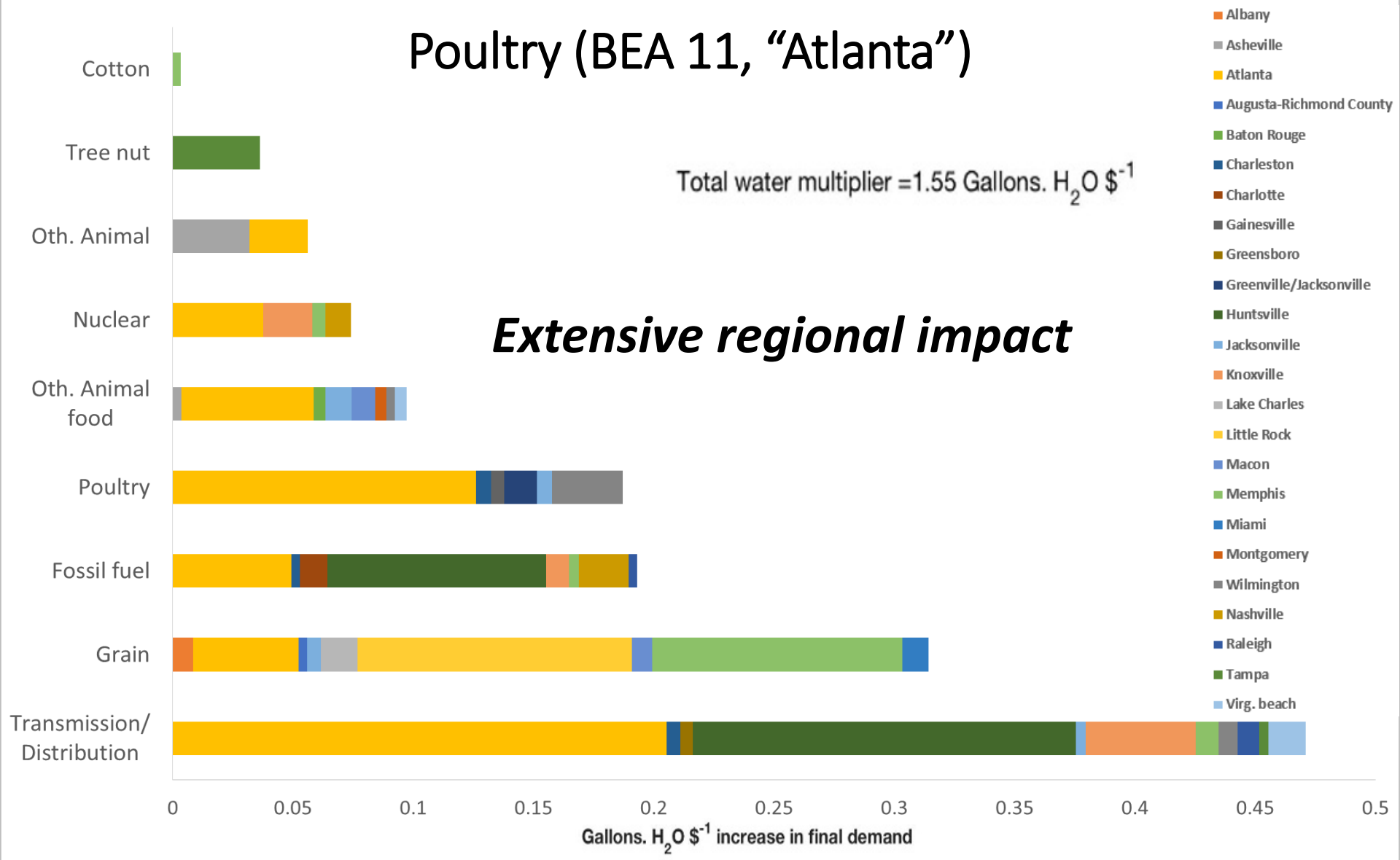
Multiplier for Grains (BEA 105, “Memphis”)



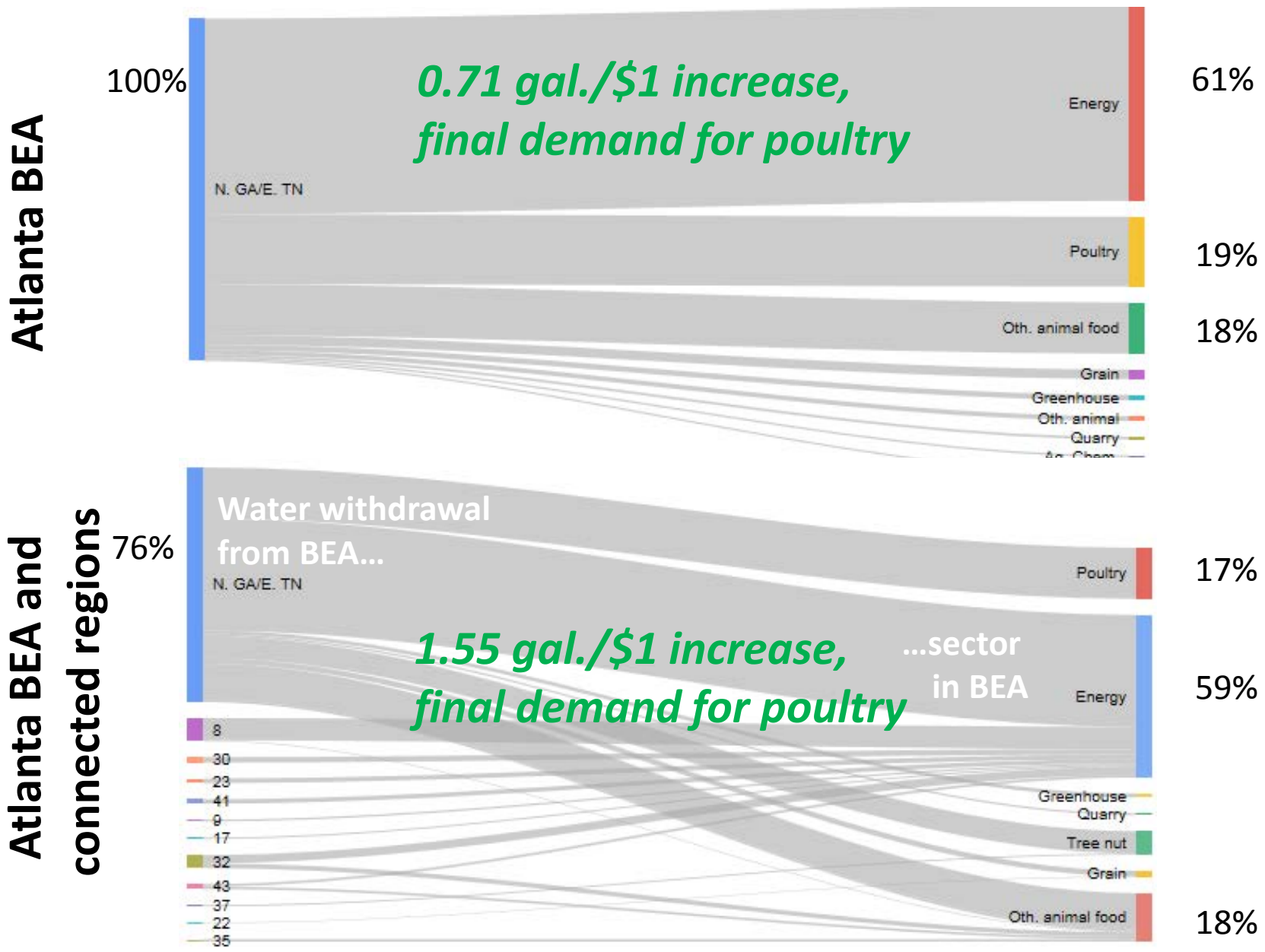
Multipliers of Grains (BEA 105, “Memphis”)



Poultry (BEA 11, “Atlanta”)

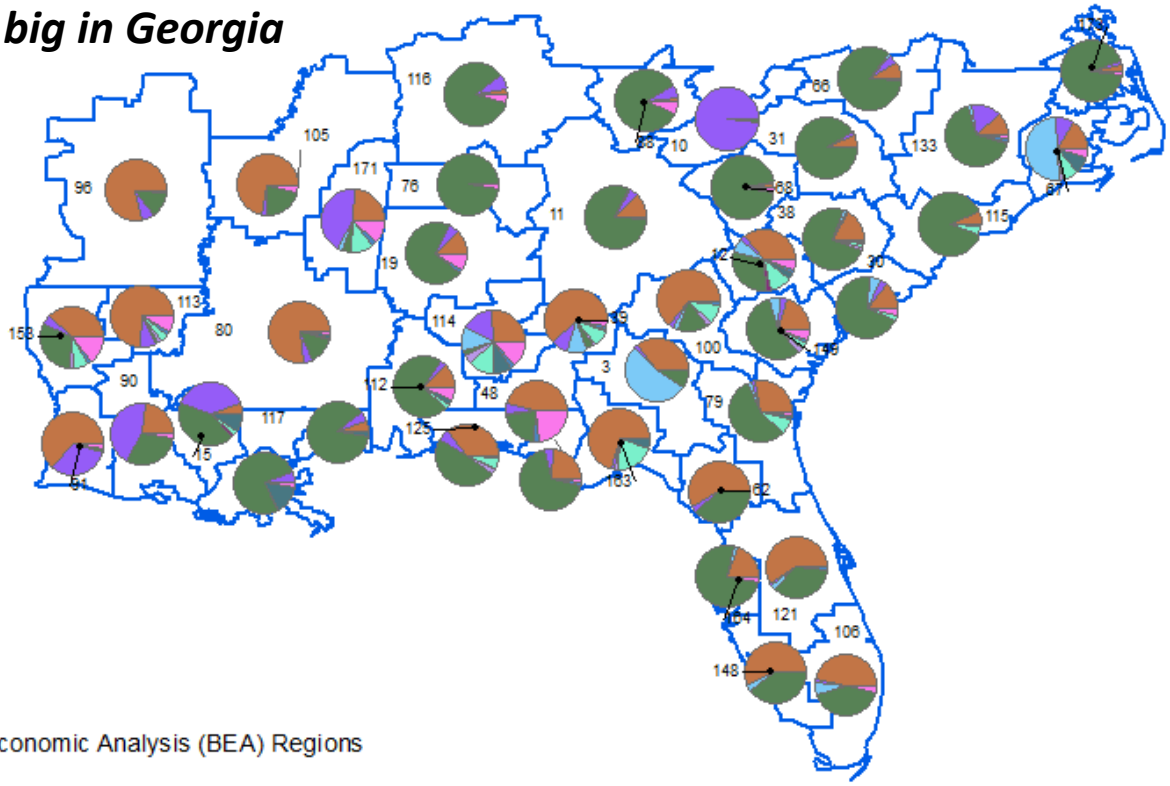


A different perspective for the poultry sector…

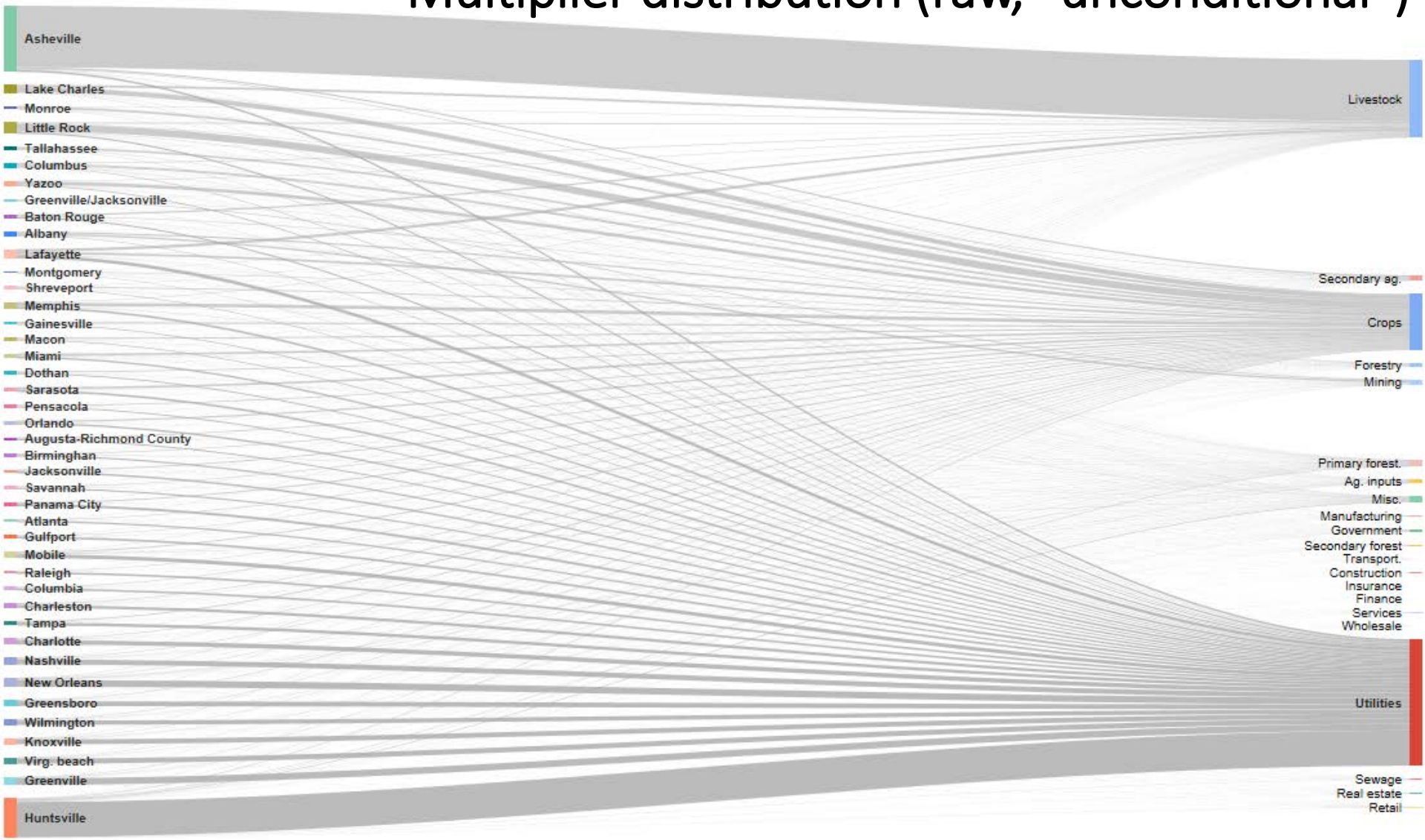


Geographic distribution of multipliers
(gal. H2O/1$ increase in value asdded; aggregated, 21 sectors)

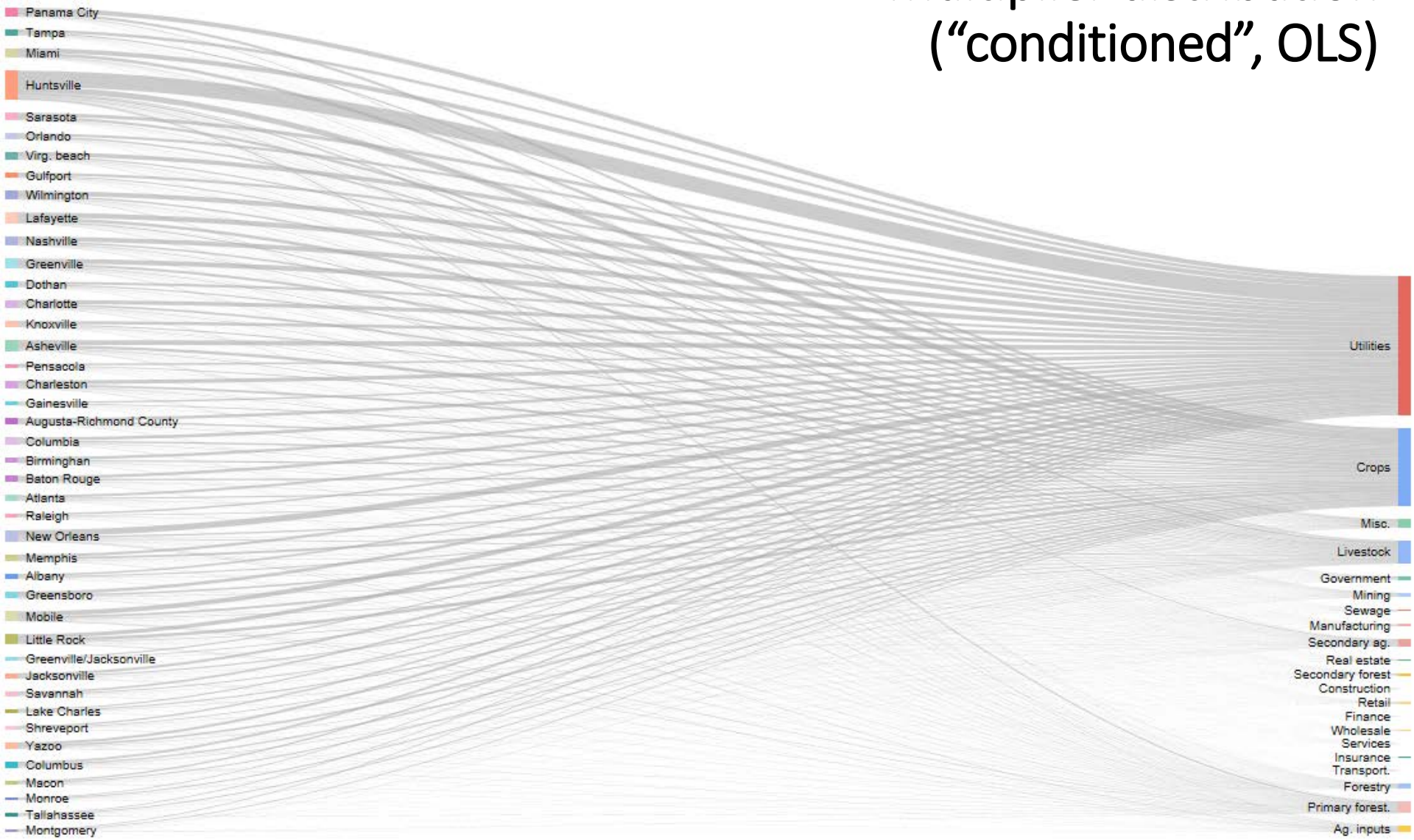
Utilities a driver in urban areas
Rural; Crops, Livestock, Forestry
Asheville, Livestock (huge trout farm! – lesson on outliers)
Forest multiplier big in Georgia



Multiplier distribution (raw, “unconditional”)



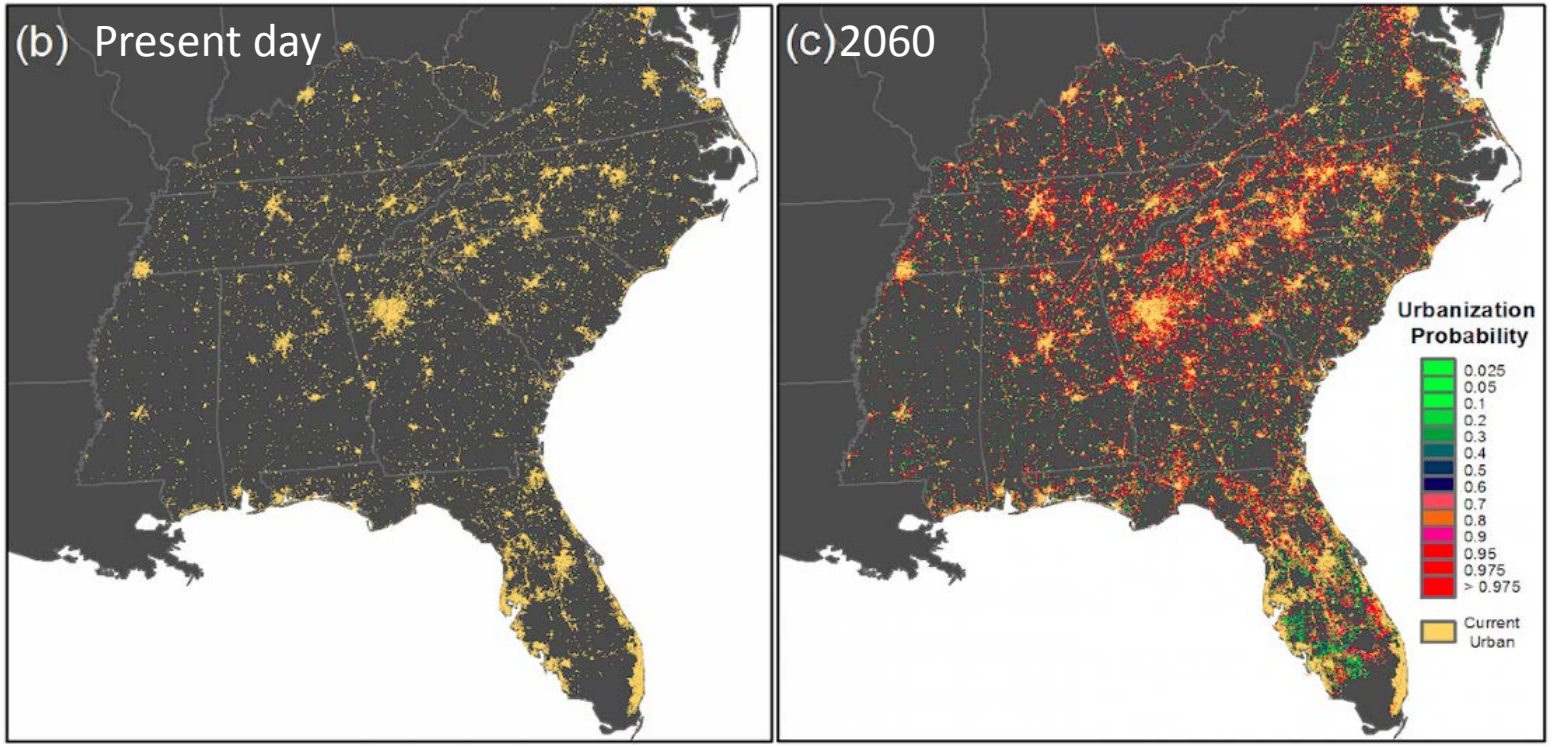
Multiplier distribution ("conditioned", OLS)



Conclusions & directions

- Multiregional IO approach to EIO-LCA analysis of water makes intuitive sense
  - Method examines resource multipliers as function of inter-sectoral linkages, but also
    - Interregional water withdrawal
    - MREIO-LCA accounts for mismatch between state, county, or BEA boundaries and a region's hydrology
    - Model inter-regional water flow as "virtual transactions" (opportunities for "virtual trading"?)
- Limitation – really, a descriptive analysis, a profile (no policy conclusions, but offers supporting information)
- Next steps: MRIO-LP (→ H_2O marginal prices, "industry demand curves")
  - Policy scenarios, "disaster scenarios" (e.g., cause water shortage in Atlanta BEA – what happens to TIO in supporting regions?)

Challenge driver



Source: Terando et al., 2014.