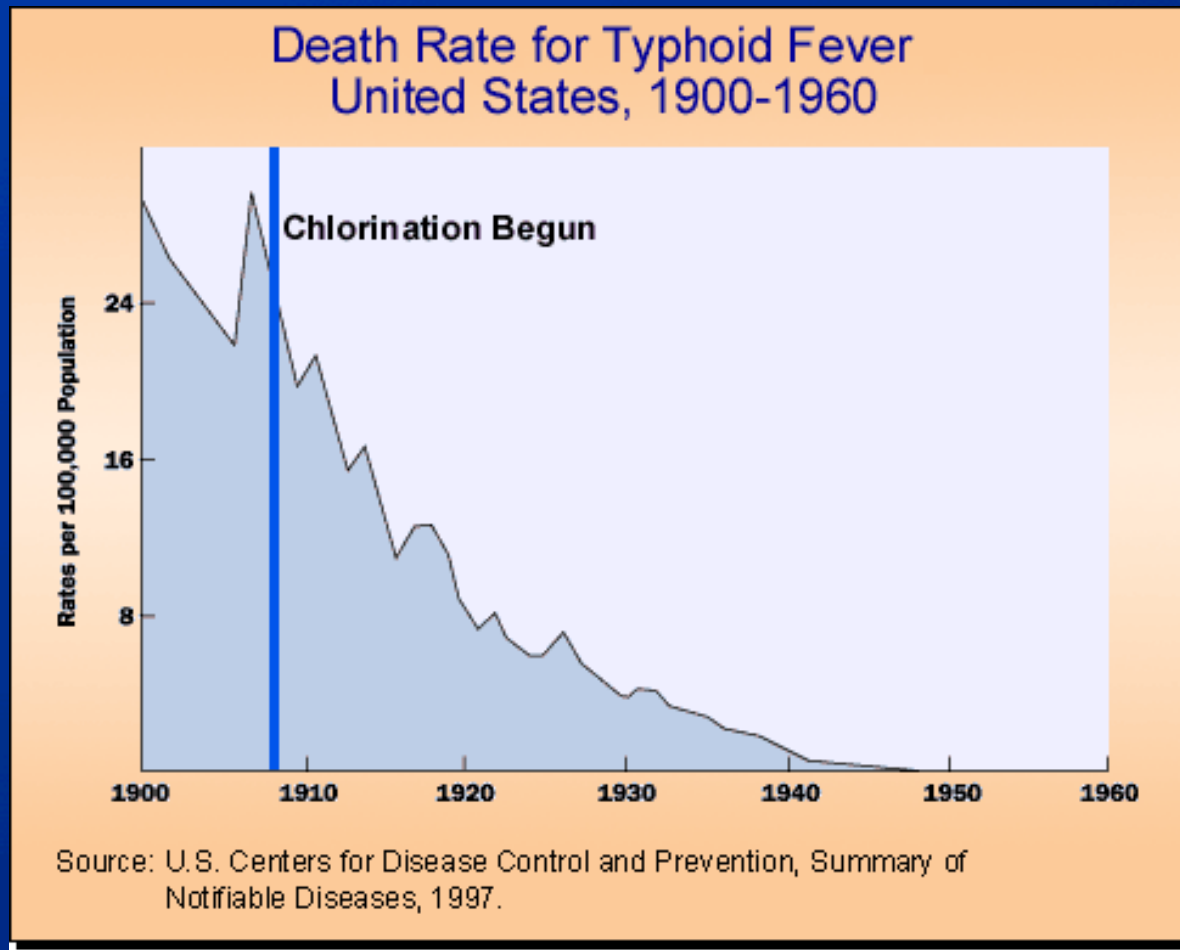# Water and Sewer Service Disparities in North Carolina

Public Health Implications

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Gillings School of Global Public Health
University of North Carolina at Chapel Hill

November 7, 2014

Water and Sanitation Service Led to 20th Century Public Health Gains

Death Rate for Typhoid Fever
United States, 1900-1960

Chlorination Begun

Source: U.S. Centers for Disease Control and Prevention, Summary of Notifiable Diseases, 1997.

Some Communities Were Left Behind

New York Times, 2005:

"Golf has made Moore County rich. . . .

But as developers rush to provide 'resort quality' amenities in the newest subdivisions, some neighborhoods have been left behind—without sewers, police service, garbage pickup, or . . . piped water."
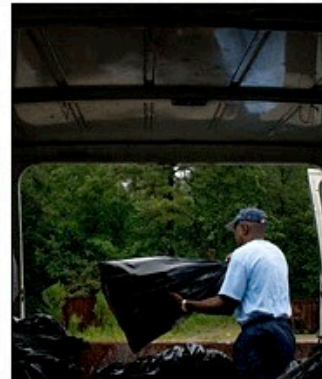
In County Made Rich by Golf, Some Enclaves Are Left Behind

By SHAILA DEWAN
Published: June 7, 2005

PINEHURST, N.C., June 2- Golf has made Moore County rich. There are spas, country clubs and new $2 million homes. The United States Open, to be held later this month on the most famous of the county's 43 golf courses, is expected to bring $124 million to the state.

⊞ Enlarge This Image

John Loomis for The New York Times

Maurice B. Holland Sr. empties his trash at the dump. More Photos >

But as developers rush to provide "resort quality" amenities in the newest subdivisions, some neighborhoods have been left behind - without sewers, police service, garbage pickup or even, in some cases, piped water.

These enclaves, Jackson Hamlet, Midway and Waynor Road, are virtually all black. They butt up against, or are even completely surrounded by, affluent towns that are mostly white: Pinehurst, Aberdeen and Southern Pines.

The 500 residents of these unincorporated enclaves are close enough to point out sewer lines that run past their properties en route to new developments, or to watch garbage trucks trundle past without stopping.

Some Unserved Communities Border Municipal Utility Pipes

Moore County (Pinehurst) example:

Irregular city boundaries exclude

minority communities

Source: Cedar Grove Institute for Sustainable Communities

Map 1. Southern Moore County Political Boundaries, City Services, and Race
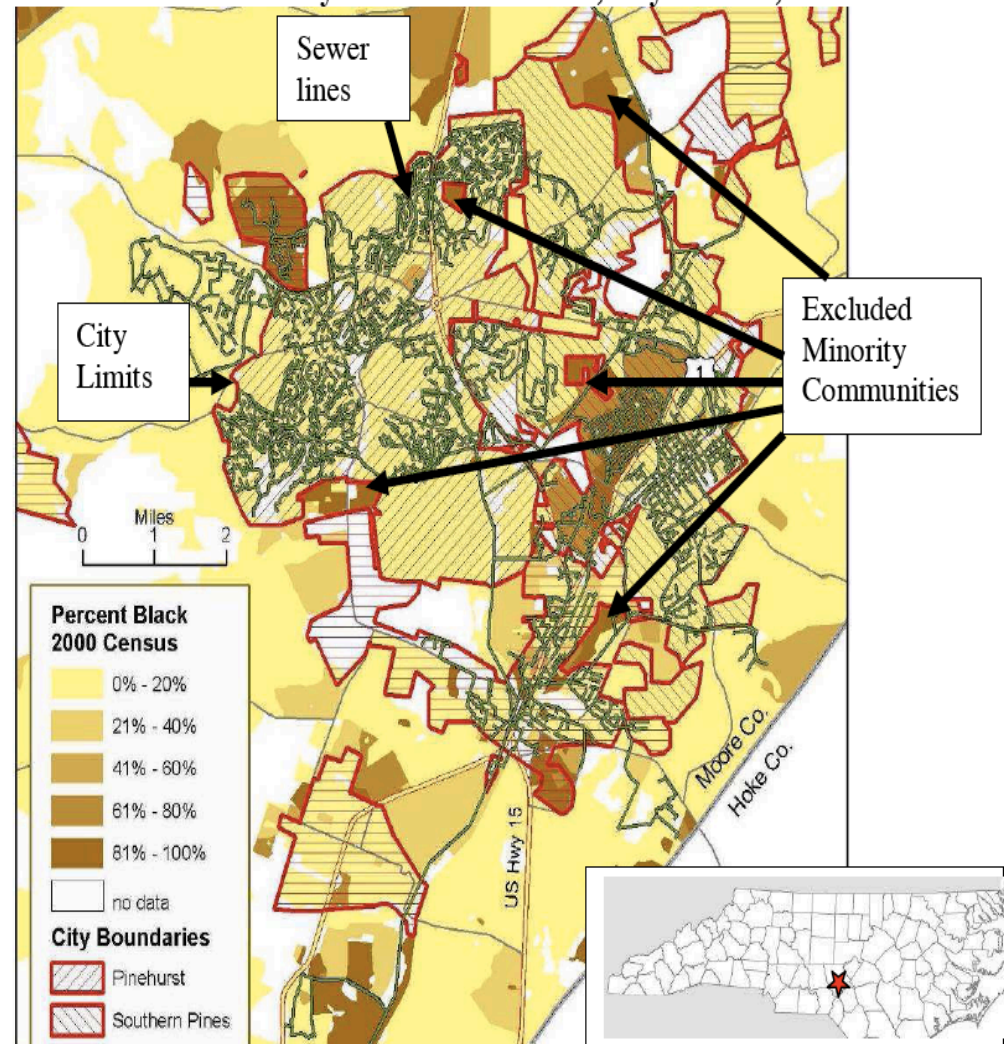
Magnitude of Service Disparities Problem Is Unknown

- **Survey asked all 100 NC county health directors to quantify service disparities.**

  - **Only 39 responded.**

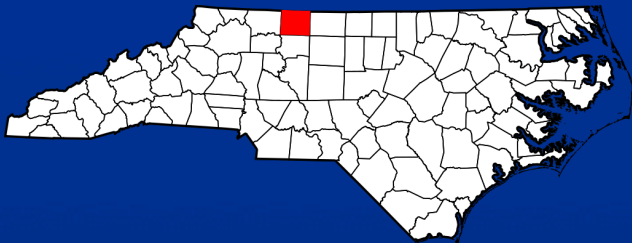 - **Provided qualitative rather than quantitative descriptions.**

Example Survey Responses

Pitt County

"**Homes with privies, straight-pipes, failing drain fields, or incomplete plumbing.**

Severely limited soils with high water table."

Stokes County

"**Clusters of homes with insufficient or failing septic systems.**

Residences with cistern, spring, or no piped water to home.

Clusters of homes with no available space remaining to install a replacement septic system or replacement well."

Long-Term Objectives

- **Assess extent of water and sewer service disparities in North Carolina.**

- **Characterize health benefits of extending water and sewer services.**

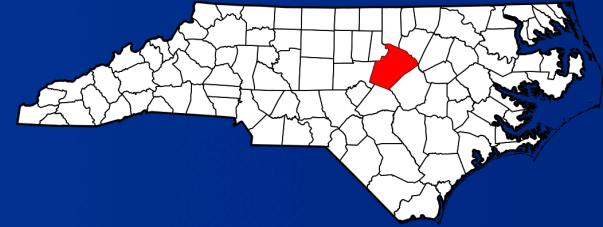- **Identify factors influencing decisions to extend or not extend services.**

Focus on "Extraterritorial Jurisdictions" (ETJs)
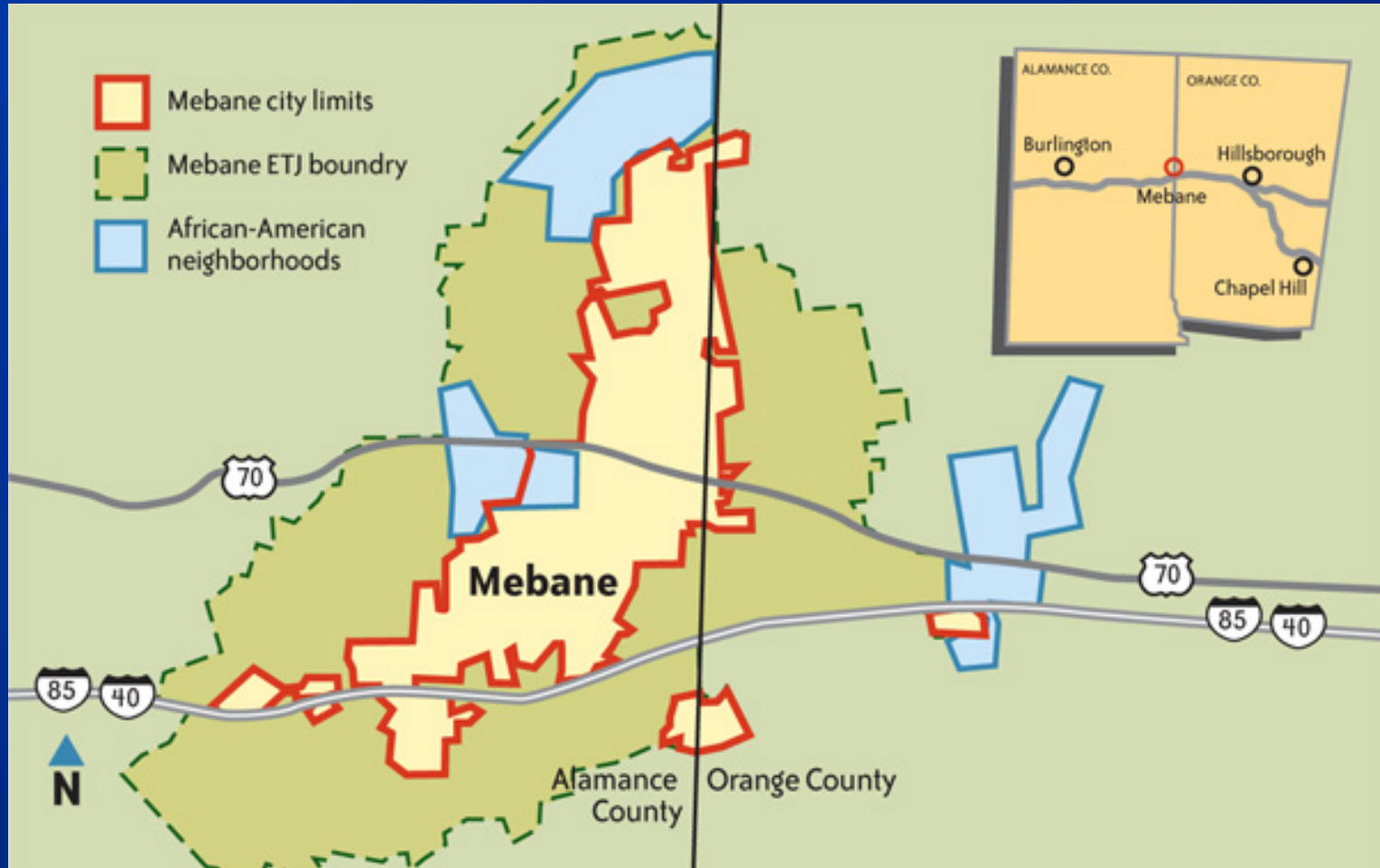
SOURCE: J.P. Trostle, *Indie Week*, May 25, 2011

Progress Report (Today's Talk)
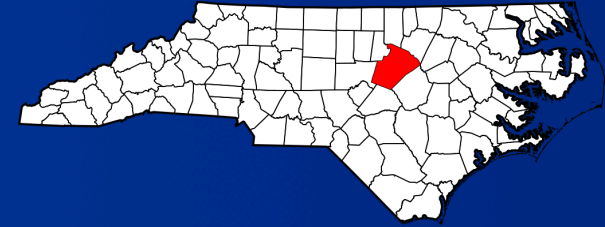
1. **Extent of disparities:**

    – **Mapping affected communities in Wake County**

Progress Report (Today's Talk)

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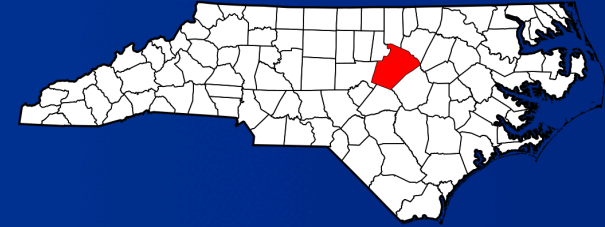
2. **Health risks and benefits:**
   - **Private well testing in Wake County**
   - **State-wide private well health risk analysis**

Progress Report (Today's Talk)

1. **Extent of disparities:**
   – **Mapping affected communities in Wake County**

2. **Health risks and benefits:**
   – **Private well testing in Wake County**
   – **State-wide private well health risk analysis**

3. **Factors influencing decisions**
   – **Case studies in three communities**
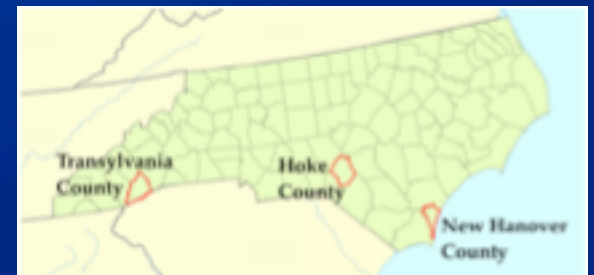
Project 1: Map Affected Communities In Wake County

Questions:

1. **Where are underserved communities in Wake County extraterritorial jurisdictions located?**

2. **Is race a significant factor in predicting water and sewer access in Wake County extraterritorial jurisdictions?**

Data Sources

Two data sources:

1. County-level tax parcel data

2. State-wide U.S. Census data

    – **Water and sewer service data not available after 1990**
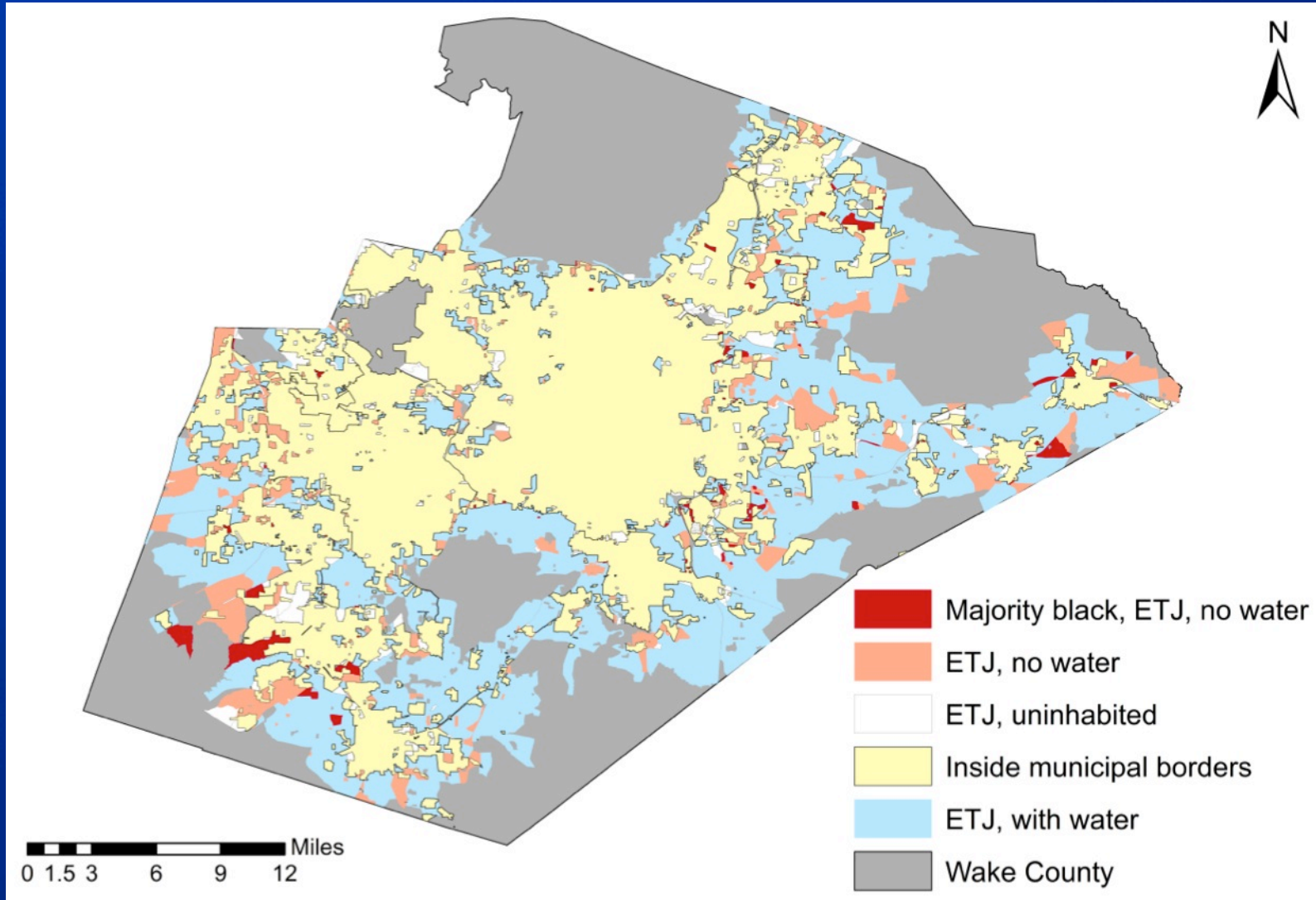
Analysis Method: Logistic Regression

What factors predict "odds" of water service in a random census block in an extraterritorial jurisdiction?

$$\text{Odds} = \frac{P(\text{no water service})}{P(\text{water service})}$$

Analyze significance of explanatory factors with "logistic regression:"

$$Ln(\text{Odds}) = \beta_0 + \beta_1 \times \%Black + \beta_2 \times Income$$

Results: Tax Data Reveal Unserved Wake County Areas

Legend:
- Majority black, ETJ, no water
- ETJ, no water
- ETJ, uninhabited
- Inside municipal borders
- ETJ, with water
- Wake County

Miles
0 1.5 3   6   9   12

-15-

Close-Up Views Reveal "Donut Holes" Lacking Water Service

Descriptive Data Suggest Race Is Associated with Water Access
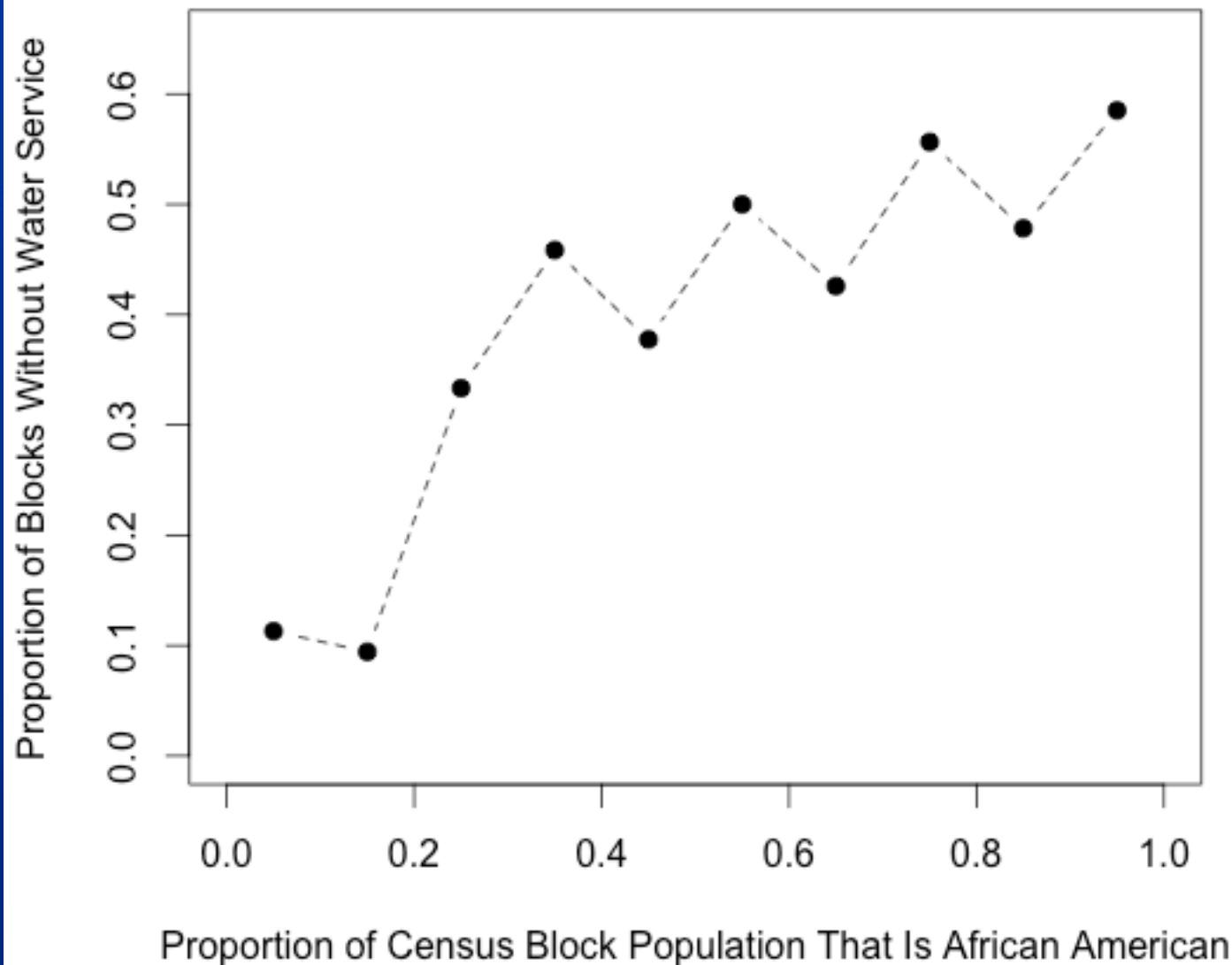
Logistic Regression Shows Race Is Significantly Associated with Water Access

Variable	Coefficient	*p* Value
Intercept	-0.57	0.0001
%Black	0.36	0.05
Income	6.1×10^{-7}	0.72

Income is NOT a significant predictor of water service access.

Interpretation: Every 10% increase in Black population increases odds of being without water service by exp(0.1*0.36)=1.037 (3.7% increase).

Project 2: Benefits of Extending Municipal Services

What are the benefits of extending municipal water service to under-served areas?

- **State-wide analysis using existing data**

- **(Wake County well sampling in ETJs)**

E.M. Johnson water treatment plant, Raleigh. Photo: Hazen & Sawyer

State-Wide Analysis

Overall approach: "Population intervention model"

Seeks to answer the question: "What if exposure to a risk factor were modified in some portion of the population?"

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Backyard Wells　　　　**Municipal Water Service**

State-Wide Analysis

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Backyard Wells   **Municipal Water Service**

Regression Establishes Link Between Health Outcome and Exposure

Regression equation for population intervention model:

$$Y_{i,j} = \beta_0 + \beta_1 C_{CWS_{i,j}} + \beta_2 E_{CWS_{i,j}} + \beta_3 C_{DWS_i} + \text{other factors}$$

Acute gastrointestinal illness (AGI) cases in county *i*, month *j*

Coliform bacteria in community water systems

Coliform bacteria in private wells

Regression Establishes Link Between Health Outcome and Exposure

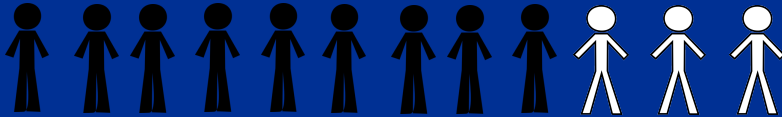**Regression equation for population intervention model:**

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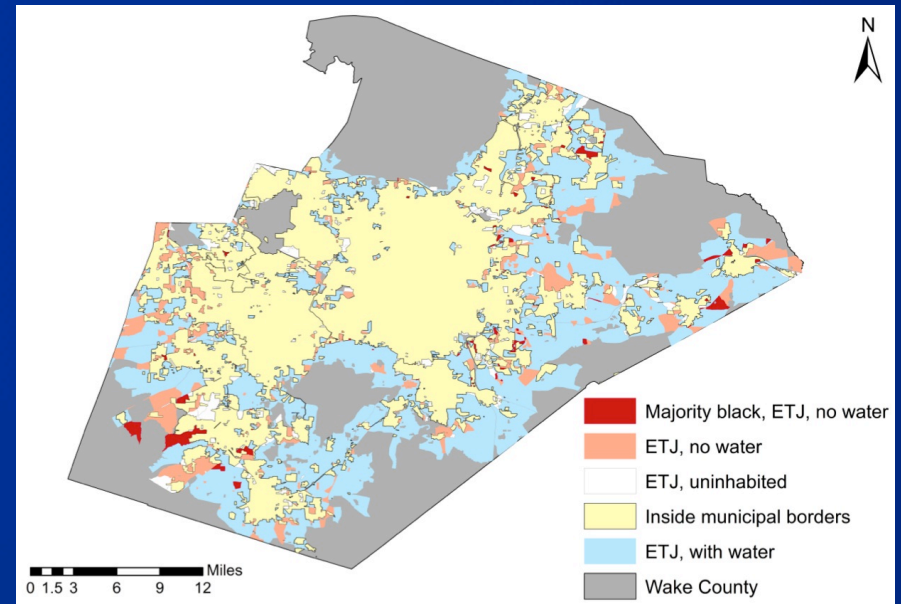
Data Sources

Health Outcome Data

- **Emergency department visits for acute gastrointestinal illness (AGI) in all NC emergency departments (n=122)**
  - **2007-2013**

Water Quality Data

- **Community water systems: Reported compliance samples for the total coliform rule**
  - **2006-2013**

- **Domestic wells: Private well permit program coliform sampling results**
  - **2009-2013**

Wake County Water Quality Analysis

- **Sampling in 100 homes selected at random from "red" blocks**

- **Testing for indicators of fecal contamination:**
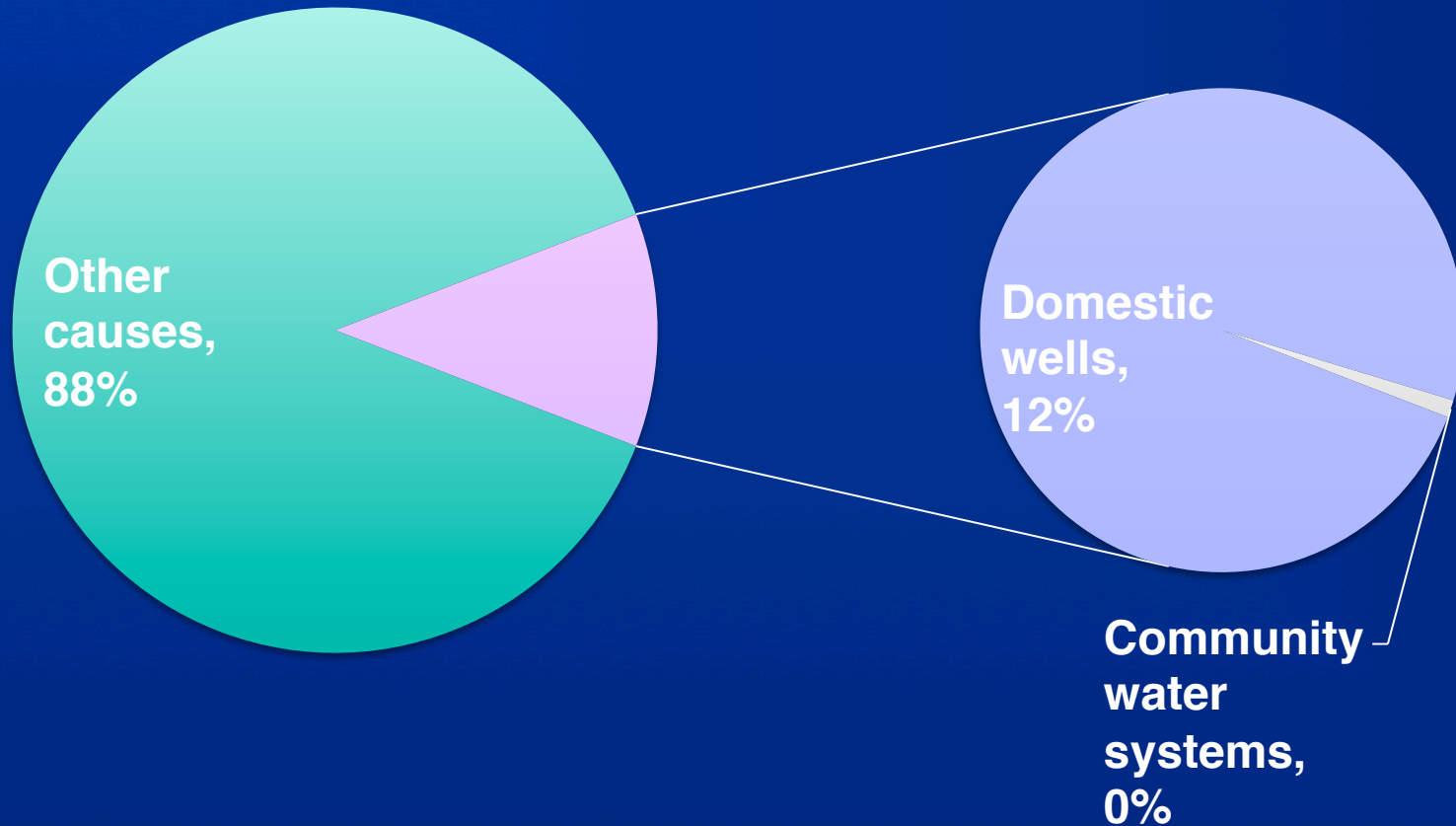 - **Total coliform bacteria**
  - **E. coli**
  - **Enterococci**

Legend:
- Majority black, ETJ, no water
- ETJ, no water
- ETJ, uninhabited
- Inside municipal borders
- ETJ, with water
- Wake County

Miles: 0 1.5 3 6 9 12

State-Wide Analysis Results
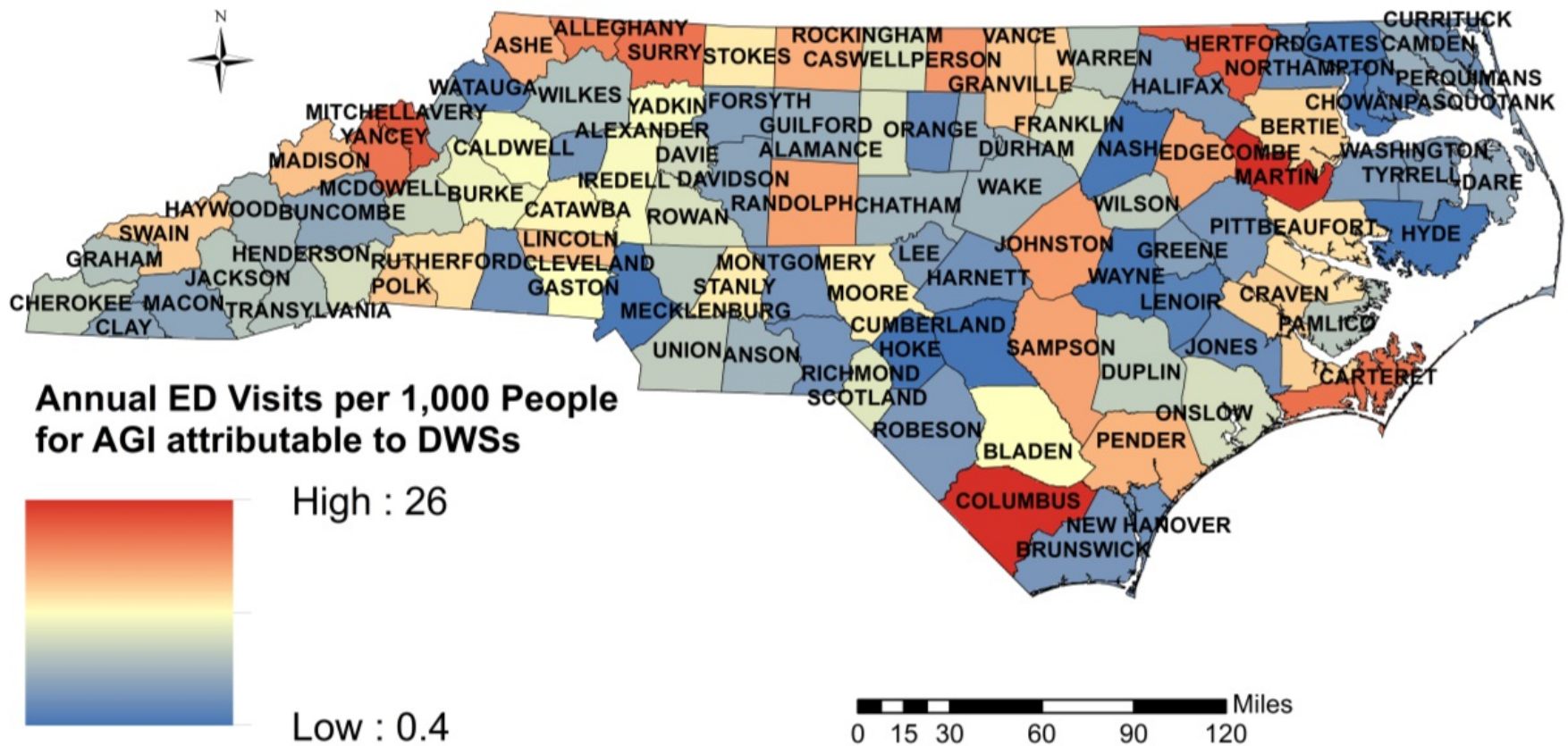
Variable	Beta
Total coliforms in community water systems	0.0000671**
E. coli in community systems	0.000163*
Private well contamination	**0.0044****
Population	0.0012**
Poverty	0.0077**

Microbial contamination of private wells is significantly associated with emergency department visits for AGI

12% of AGI ED Visits Are Attributable to Lack of Water Service

Other causes, 88%

Domestic wells, 12%

Community water systems, 0%

Risks Vary by County

Annual ED Visits per 1,000 People for AGI attributable to DWSs
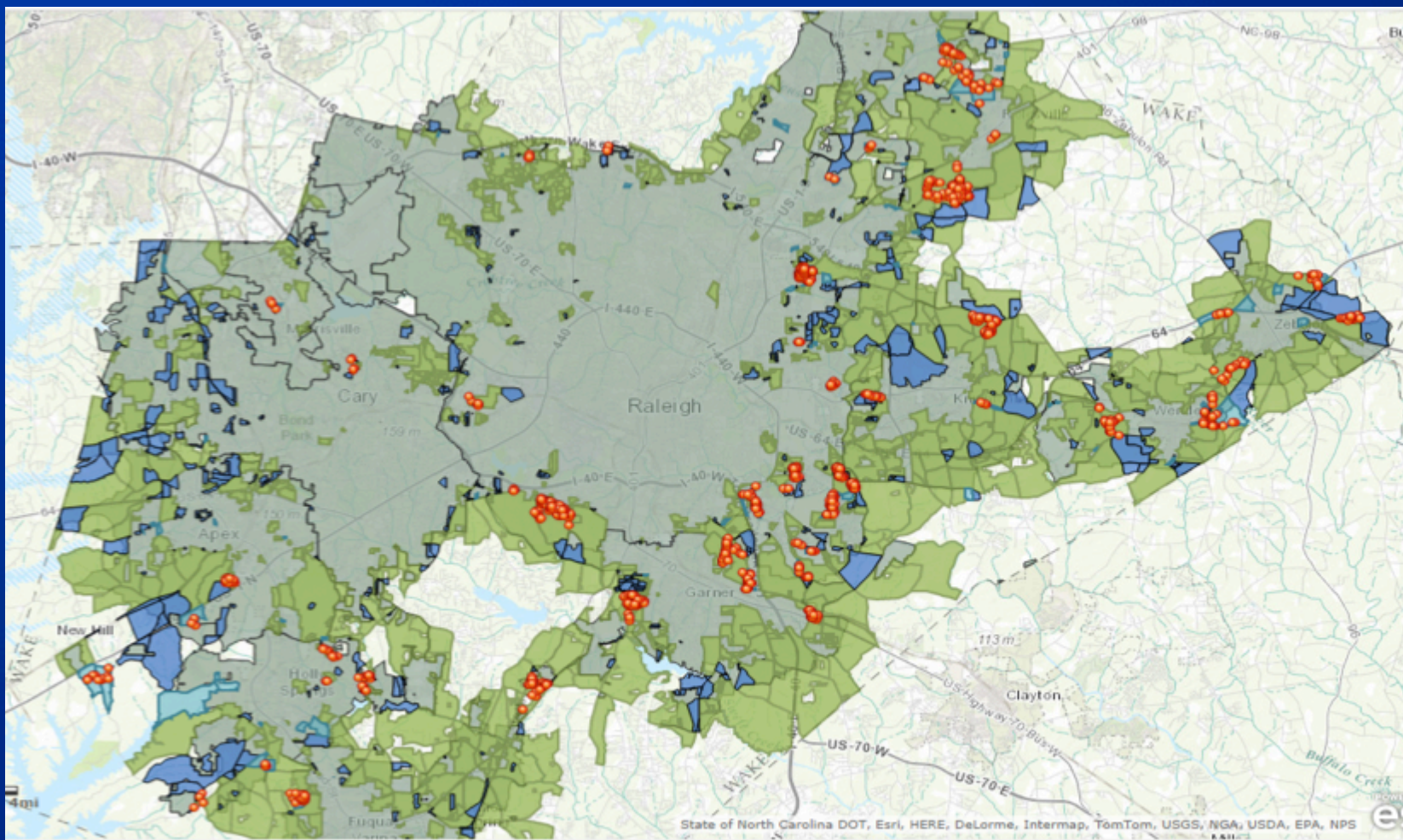
High : 26

Low : 0.4

Extending Water Service to Private Well Users Would Prevent ED Visits

- **46,700 annual ED visits attributed to private well contamination.**

- **Cost = $51 million/year.**

- **Every 10% shift in population from private to community systems is expected to decrease ED visits for AGI by 1.6%.**

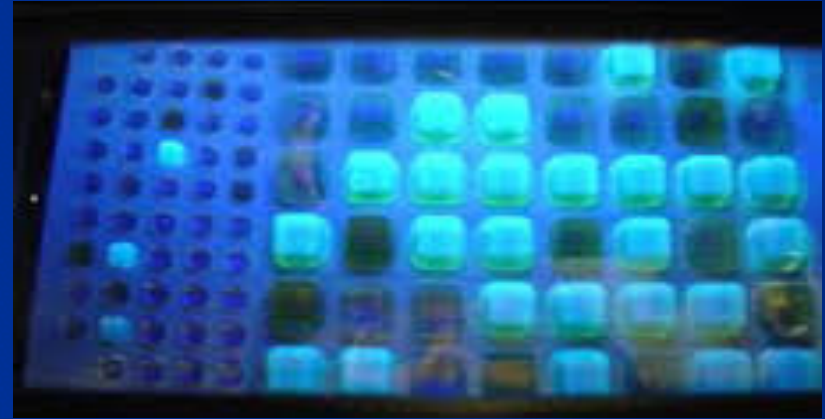# Locations of Wake County Homes Participating in Sampling

Wake County Preliminary Results

First samples: 29% positive for total coliforms (n=59)

Second samples: 39% positive (n=46)

- **Community systems in violation of Safe Drinking Water Act if more than 5% of samples are positive**

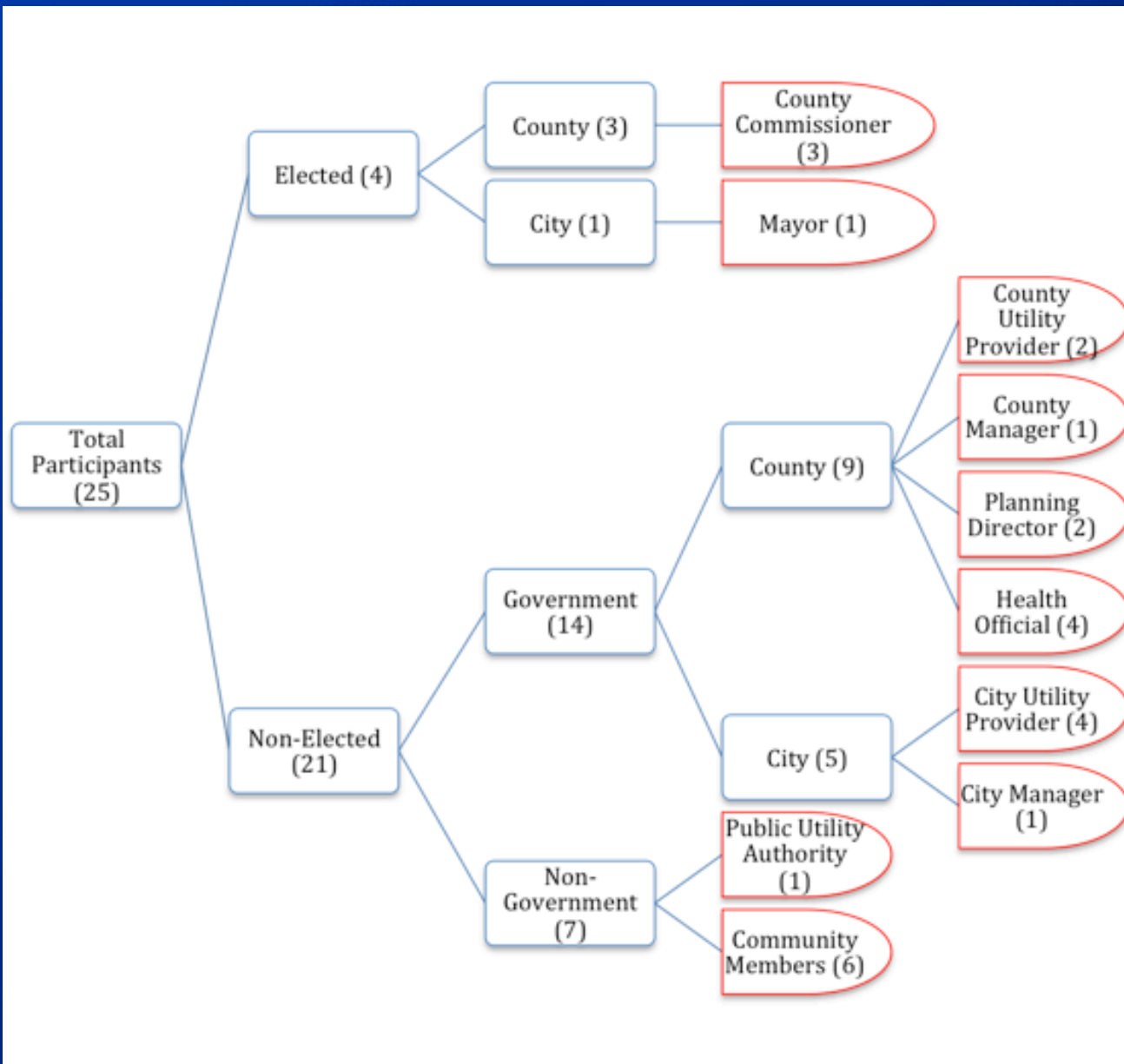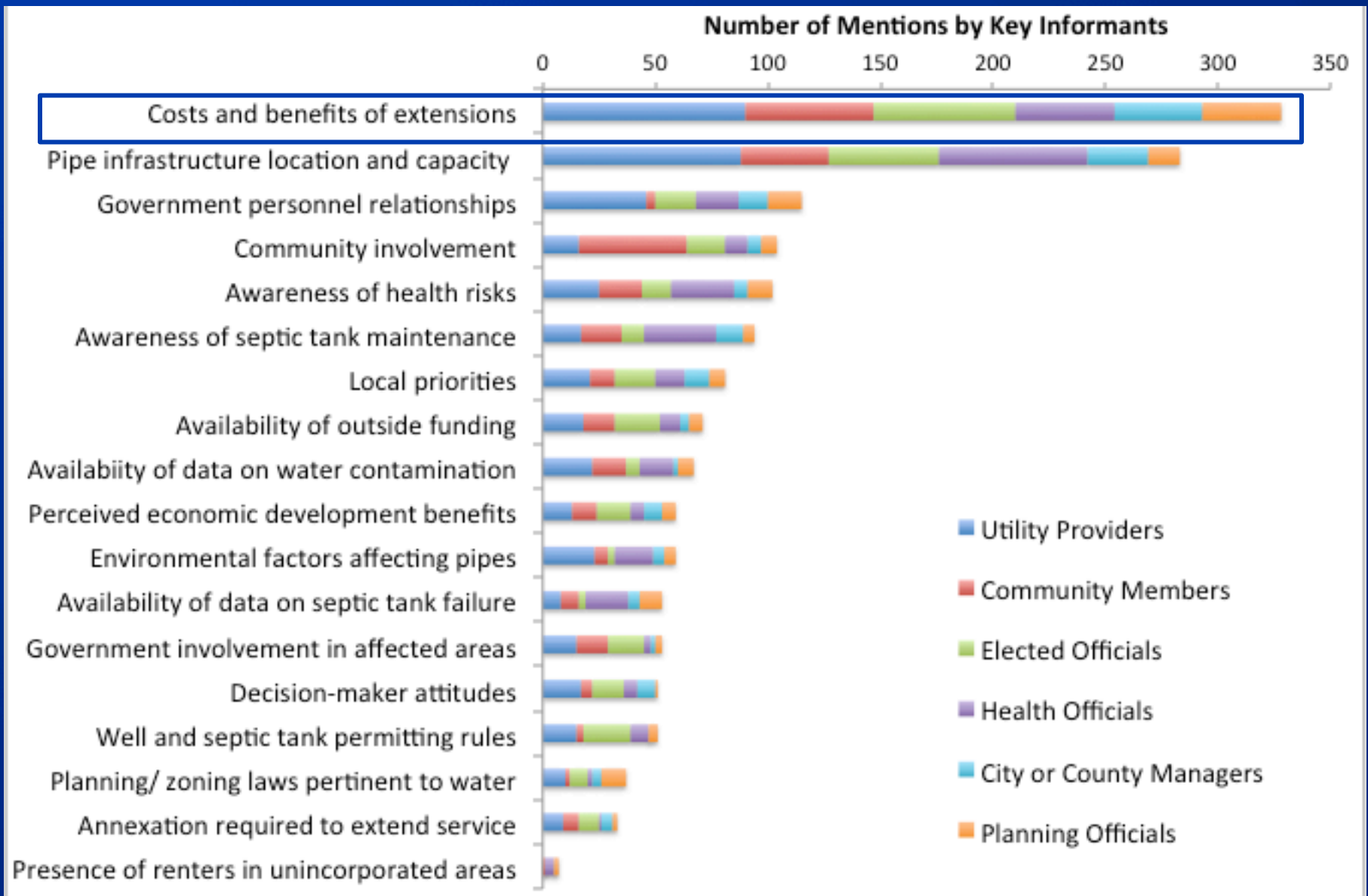# Project 3: Factors Influencing Decision to Extend Water Service

Method:

- **Key informant interviews in three communities**

- **Transcribe interviews, and code using Atlas.ti software**

- **Identify common themes**

Variety of Perspectives Sought

Results: Cost Is Key Theme

Number of Mentions by Key Informants

Costs and benefits of extensions
Pipe infrastructure location and capacity
Government personnel relationships
Community involvement
Awareness of health risks
Awareness of septic tank maintenance
Local priorities
Availability of outside funding
Availabiity of data on water contamination
Perceived economic development benefits
Environmental factors affecting pipes
Availability of data on septic tank failure
Government involvement in affected areas
Decision-maker attitudes
Well and septic tank permitting rules
Planning/ zoning laws pertinent to water
Annexation required to extend service
Presence of renters in unincorporated areas

Legend:
- Utility Providers
- Community Members
- Elected Officials
- Health Officials
- City or County Managers
- Planning Officials

Axis: 0, 50, 100, 150, 200, 250, 300, 350

Summary

- **Mapping reveals that racial disparities in water service may persist in extraterritorial jurisdictions in Wake County.**
  - Increasing black population decreases odds of water service availability in census block.

- **Water sampling suggests poor water quality in some domestic wells is associated with increased emergency department visits for AGI.**
  - Nearly 12% of emergency department visits for AGI are attributable to domestic well contamination.

- **Key informants suggest cost is key barrier to extending services.**

Acknowledgements

Thanks to my (current and former) students!

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Daniel Sebastian

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Daisy Wang

Yuyun Liang

Brenda Benevides

Yang Du

Anna Ballesiotes

Jamie Sabo

Joe Strasser

Questions?