

# SPATIAL AND TEMPORAL PATTERNS OF GASTROINTESTINAL ILLNESS AND THEIR RELATIONSHIP WITH PRECIPITATION ACROSS THE STATE OF NORTH CAROLINA

**Jenna M. Hartley, MS Candidate**  
**Environmental Sciences and Engineering**

Gillings School of Public Health

Advisors: C.E. Konrad, Ph.D., Dept. of Geography; J.J. West, Ph.D., Dept. of Environmental Sciences and Engineering

Additional Committee Member: Jill Stewart, Ph.D., Dept. of Environmental Sciences and Engineering

# WATERBORNE DISEASES BY THE NUMBERS

**900,  
000**

**U.S. cases per year** (Rose et al. 2000)

**900**

**U.S. deaths per year** (Rose et al. 2000)

**100**

Total types of pathogenic bacteria, viruses, and protozoa that can be found in contaminated flood water (Patz 2008)

# TYPES OF PATHOGENS THAT CAN BE FOUND IN CONTAMINATED WATER

Bacteria: *Vibrio sp.*, *Campylobacter sp.*, *Salmonella sp.*, and *Echerichia coli sp.*

Protozoans/Parasites:  
*Cryptosporidium*, *Giardia*

Viruses: rotavirus, norovirus, enterovirus, calicivirus, adenovirus

# INCUBATION TIMES (IN DAYS)

1

7

7+

VIRUSES & BACTERIA

PROTOZOANS

# HEAVY RAINFALL AND AGI











**Heavy rainfall and flooding were the mostly commonly reported events preceding an outbreak.** (Cann, K.F., 2013; Curriero et al., 2001)

# **OVERALL STUDY OBJECTIVE**

**STUDY PERIOD: 2008-2012**



# **METHODS:**

**HEALTH DATA  
DEMOGRAPHIC DATA  
METEOROLOGICAL DATA**

# METHODS

## HEALTH DATA: NC DETECT



# METHODS

## HEALTH DATA: NC DETECT



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### RSS Feeds

Morbidity and Mortality Weekly Report (MMWR)

- QuickStats: Percentage of Residential Care Communities\* Using Electronic Health Records,†§ by Number of Beds — National Study of Long-Term Care Providers, United States, 2014
- Notifiable Diseases and Mortality Tables
- Announcement: Recommendation Regarding Cardiovascular Disease Prevention and Control from the Community Preventive Services Task Force
- Errata: Vol. 64, No. 17
- Errata: Vol. 64, No. 18

HealthMap Global Disease Alerts

- PRO/EDR> Chikungunya (31): Americas, Africa
- PRO/AH/EDR> Undiagnosed diseases, livestock - South Sudan: (UN) RFI
- PRO/AH/EDR> Anthrax - UK: (England) bovine
- PRO/AH/EDR> West Nile virus - Europe (09): France, human, equine
- PRO/AH/EDR> Rift Valley fever - Mauritania (02)

### North Carolina Disease Event Tracking and Epidemiologic Collection Tool

The North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT) is North Carolina's statewide syndromic surveillance system. NC DETECT was created by the North Carolina Division of Public Health (NC DPH) in 2004 in collaboration with the Carolina Center for Health Informatics (CCHI) in the UNC Department of Emergency Medicine to address the need for early event detection and timely public health surveillance in North Carolina using a variety of secondary data sources. Authorized users are currently able to view data from emergency departments, the Carolinas Poison Center, and the Pre-hospital Medical Information System (PreMIS), as well as pilot data from select urgent care centers.

NC DETECT is designed, developed and maintained by CCHI staff with funding by the NC DPH. New functionality is added regularly based on end user feedback.

Please send questions to [ncdetect@listserv.med.unc.edu](mailto:ncdetect@listserv.med.unc.edu).

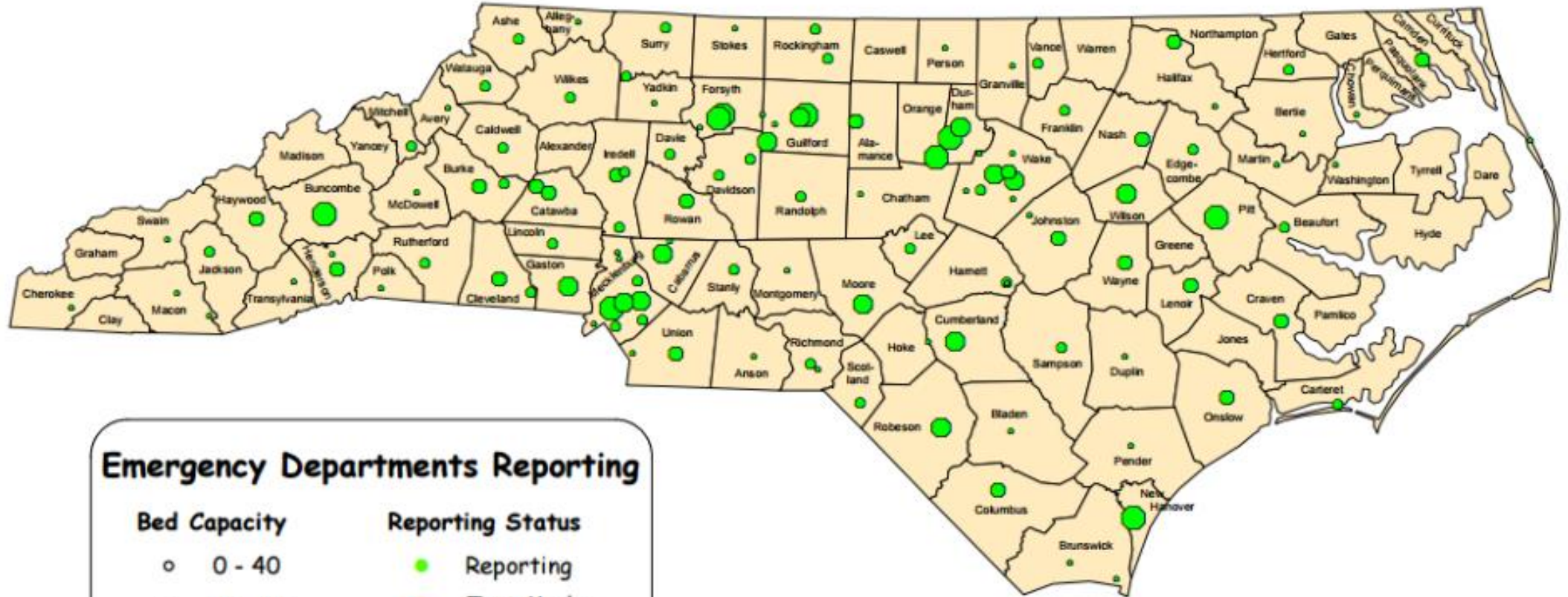
### Monthly Spotlight

The graph below shows the number of ED visits for opioid overdoses from 2008 - 2014. Authorized users can also view various overdose-related reports for their jurisdictions in NC DETECT. For more information and/or training, please contact us at [ncdetect@listserv.med.unc.edu](mailto:ncdetect@listserv.med.unc.edu).

### What's New

- Fact Sheet on ED Visits for Stroke
- Fact Sheet on ED Visits for Falls - All Ages (UPDATED)
- Fact Sheet on ED Visits for Falls - Children (UPDATED)
- Fact Sheet on ED Visits for Falls - Older Adults (UPDATED)
- Fact Sheet on ED Visits for Firearm-related Injuries, 2010-2012
- Fact Sheet on ED Visits with a Mental Health Disorder Diagnosis Code in 2012
- Fact Sheet on ED Visits with a Mental Health Disorder Diagnosis Code - School Age Children in 2012

# Emergency Departments Reporting to NC DETECT by General Bed Capacity (as of Nov. 2014, 122 ED's reporting)



**Emergency Departments Reporting**

Bed Capacity	Reporting Status
○ 0 - 40	● Reporting
○ 41 - 70	● Test Mode
○ 71 - 110	○ County
○ 111 - 300	
○ more than 300	





**DISEASE OUTCOMES IN THIS STUDY THAT ARE  
ASSOCIATED WITH CONTAMINATED WATER**

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**ICD-9 Codes utilized:**



# DISEASE OUTCOMES IN THIS STUDY THAT ARE ASSOCIATED WITH CONTAMINATED WATER

## ICD-9 Codes utilized:

- 001-009 (intestinal infectious diseases)
  - *Examples: Cholera (001), Salmonella (003), Giardiasis (007.1), Cryptosporidiosis (007.4), Campylobacter (008.43), Norovirus (008.63), Rotavirus (008.61)*

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- **558.9 (Gastroenteritis, noninfectious, specified)**

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- 558.9 (Gastroenteritis, noninfectious, specified)
- 787.91 (Diarrhea, Not otherwise Specified)



# “GASTROINTESTINAL ILLNESS”

<b>ICD-9 CODE</b>	<b>DISEASE</b>
001-009	intestinal infectious diseases
558.9	Gastroenteritis, noninfectious, specified
787.91	Diarrhea, Not otherwise Specified

# METHODS

**METEOROLOGICAL DATA: NC  
DETECT CLIMATE-HEALTH  
TOOLBOX**

## HEALTH

### Enter your ICD-9 Codes [?](#)

Primary Diagnostic Codes Only

**-OR-**

Primary and Secondary Diagnostic Codes

**-OR-**

Primary Diagnostic Code 1

*Operator Between Diagnostic 1 and 2-11*

OR

AND

Secondary Diagnostic Codes 2-11

### Select your date range:

Start Month / Day:

End Month / Day:

### Choose over which year(s) you would like to pull data:

- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013

### Pull records for the following counties or ZCTAs

Counties:

ZCTAs:

## CLIMATE

### Select which weather parameter(s) you would like to retrieve:

- Average Temperature
- Maximum Temperature
- Minimum Temperature
- Precipitation
- Maximum Heat Index
- Minimum Wind Chill

### Select antecedent weather periods:

Precipitation Sums:

Temperature Departures From Normal:

### Choose which station networks to include in the data retrieval:

- ASOS
- AWOS
- ECONet
- RAWS

**RETRIEVE DATA**



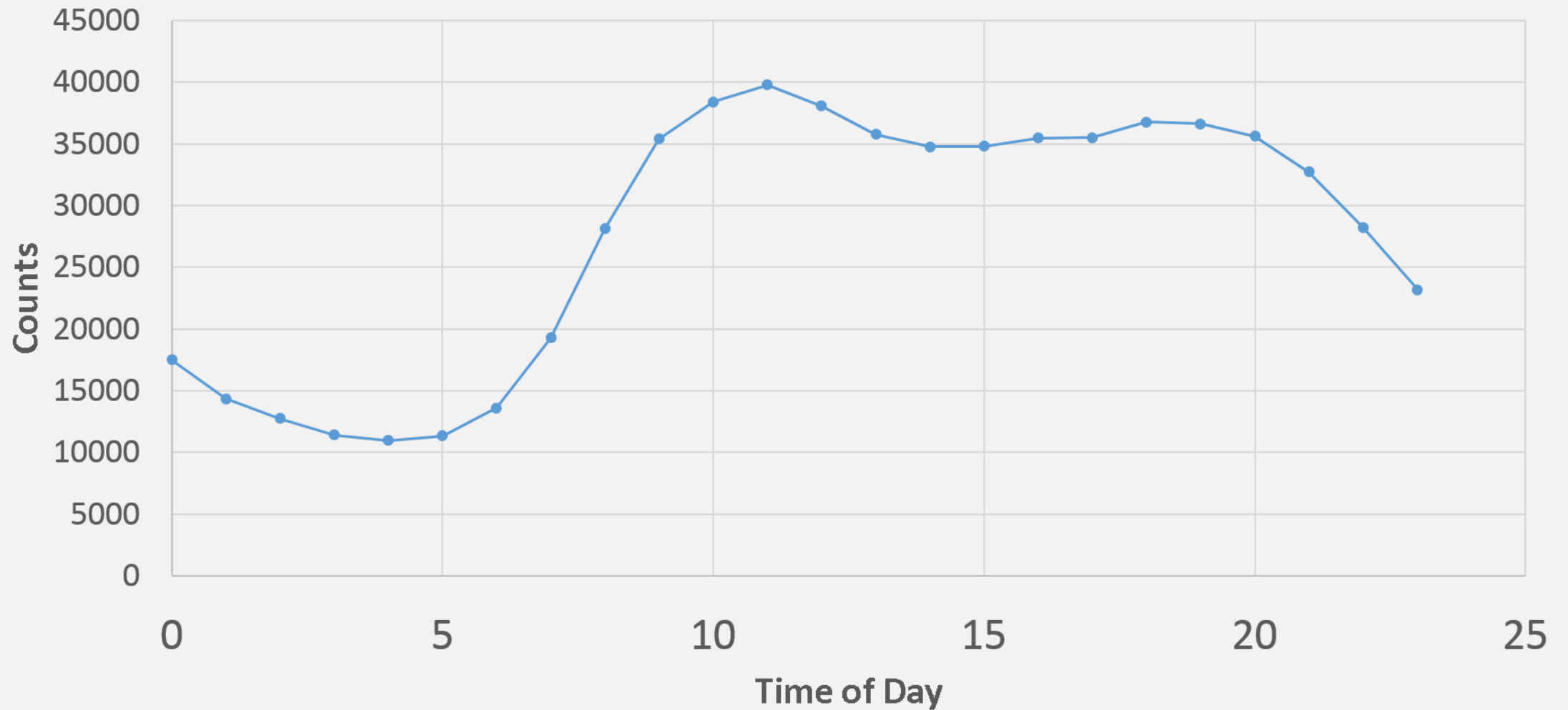
# RESULTS

- TEMPORAL PATTERNS
- SPATIAL PATTERNS
- DEMOGRAPHIC PATTERNS
- PRECIPITATION PATTERNS

# TEMPORAL PATTERNS



# TOTAL COUNTS OF AGI IN NORTH CAROLINA FROM 2008-2012 BY **HOUR OF DAY**





# TOTAL COUNTS OF AGI IN NORTH CAROLINA FROM 2008-2012 BY MONTH



# SPATIAL PATTERNS

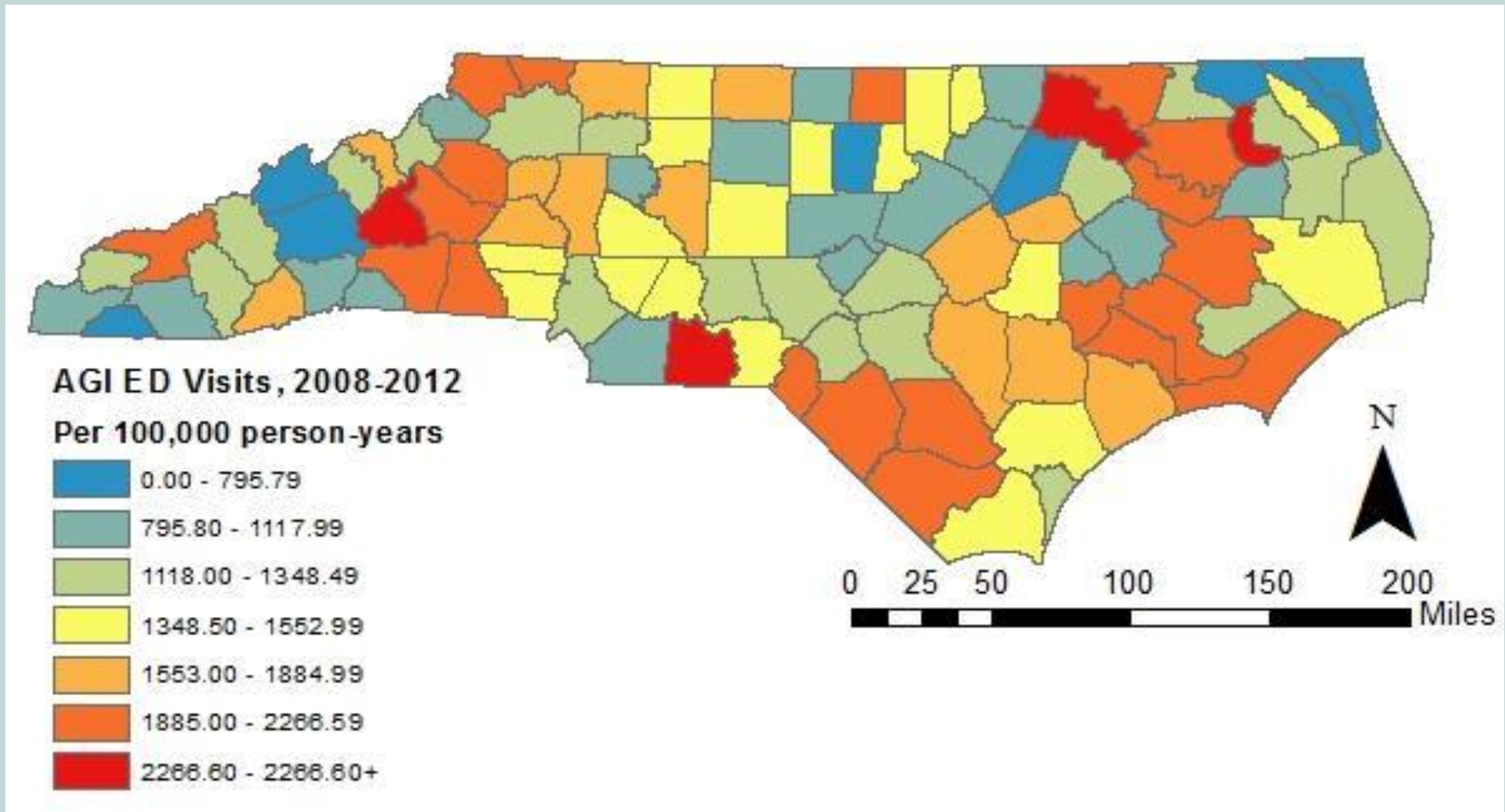


# SPATIAL PATTERNS

- COUNTY-LEVEL
- ZIP-CODE LEVEL
- NOROVIRUS
- “HIGH VIRAL” VS. “LOW VIRAL” SEASON

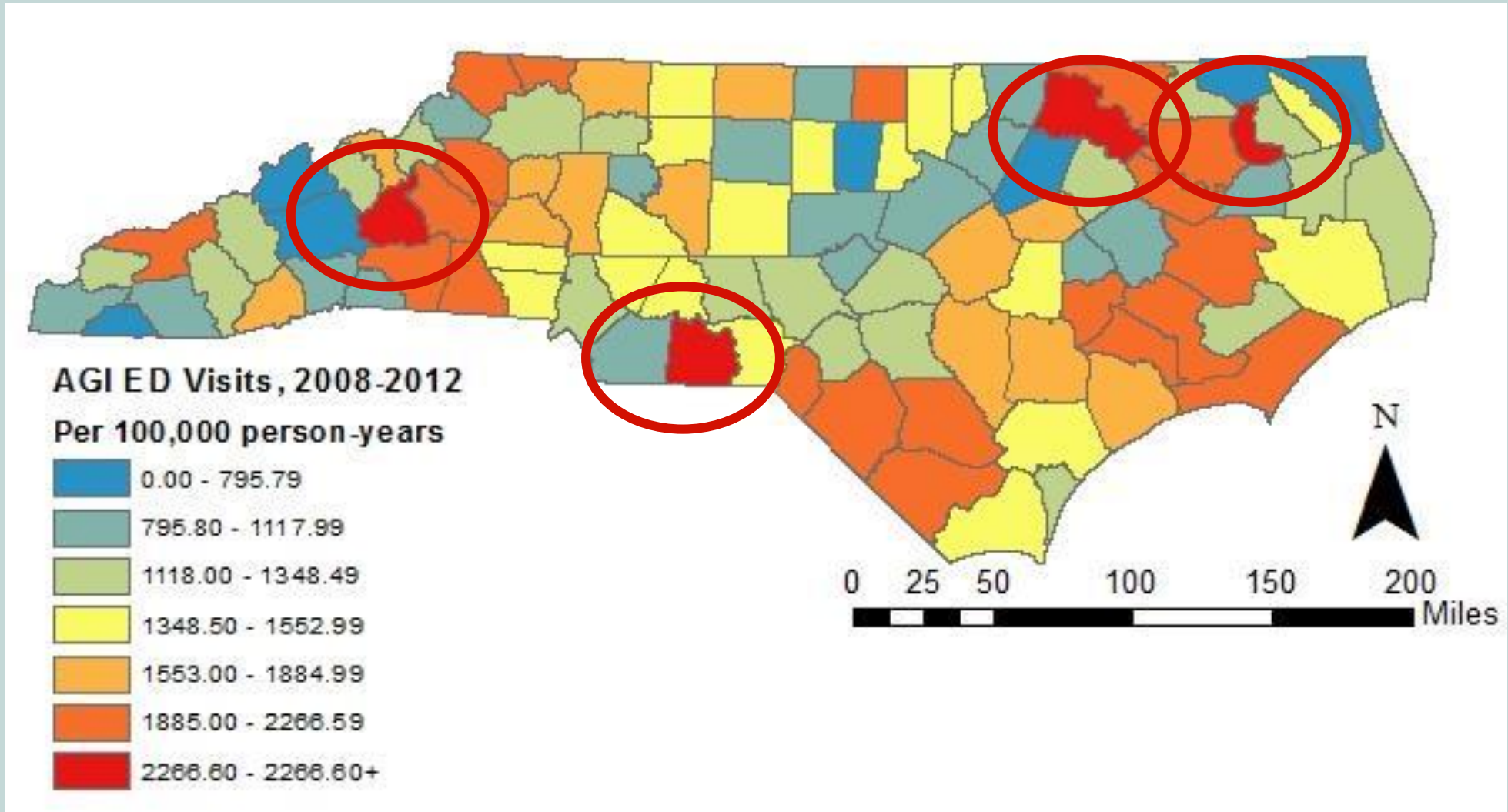


# INCIDENCE OF AGI IN NORTH CAROLINA FROM 2008-2012 PER 100,000 PERSON-YEARS

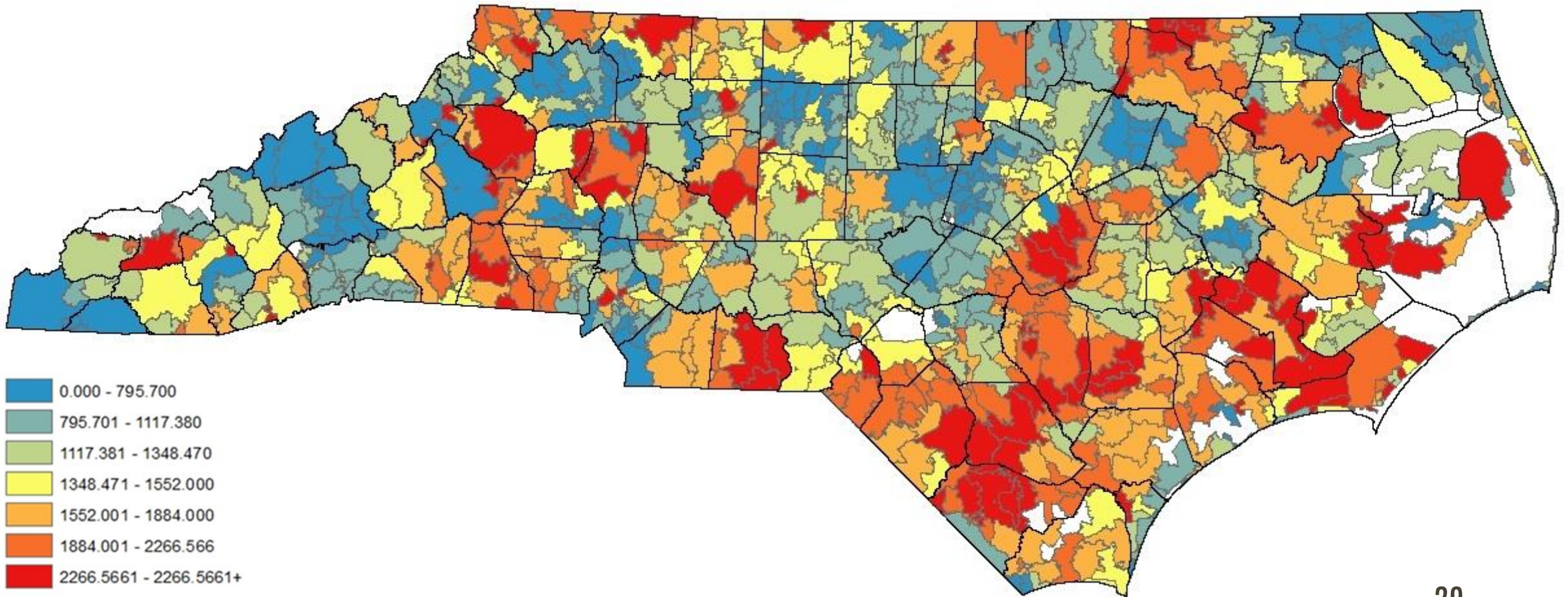




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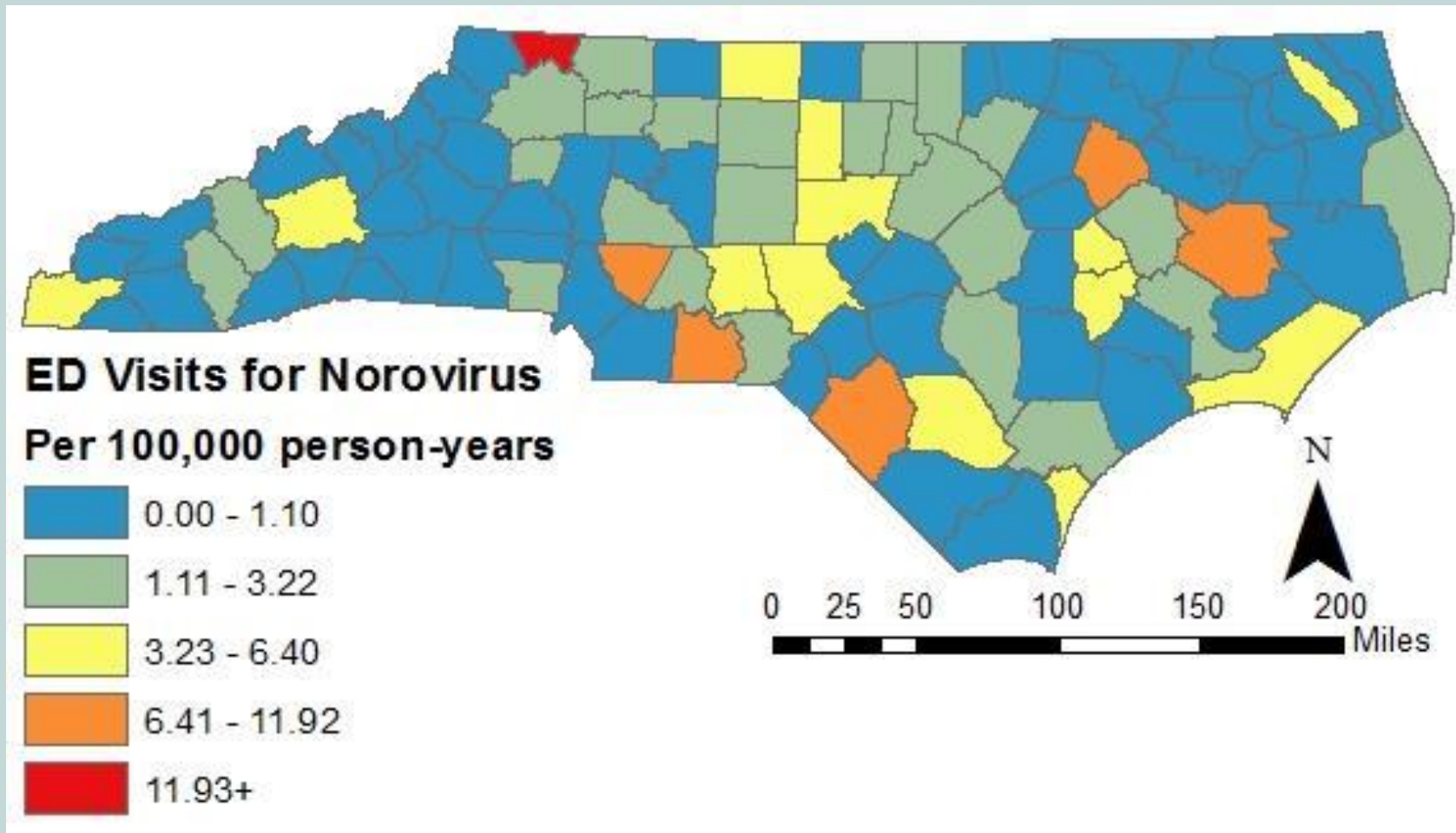


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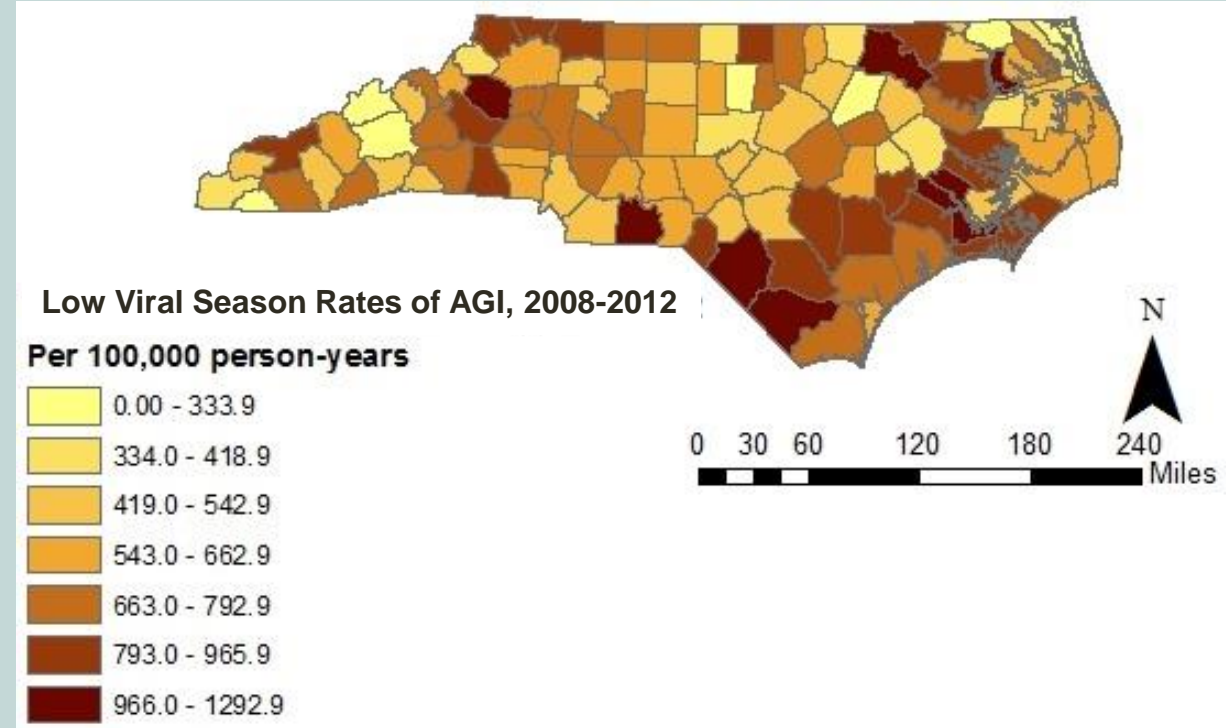
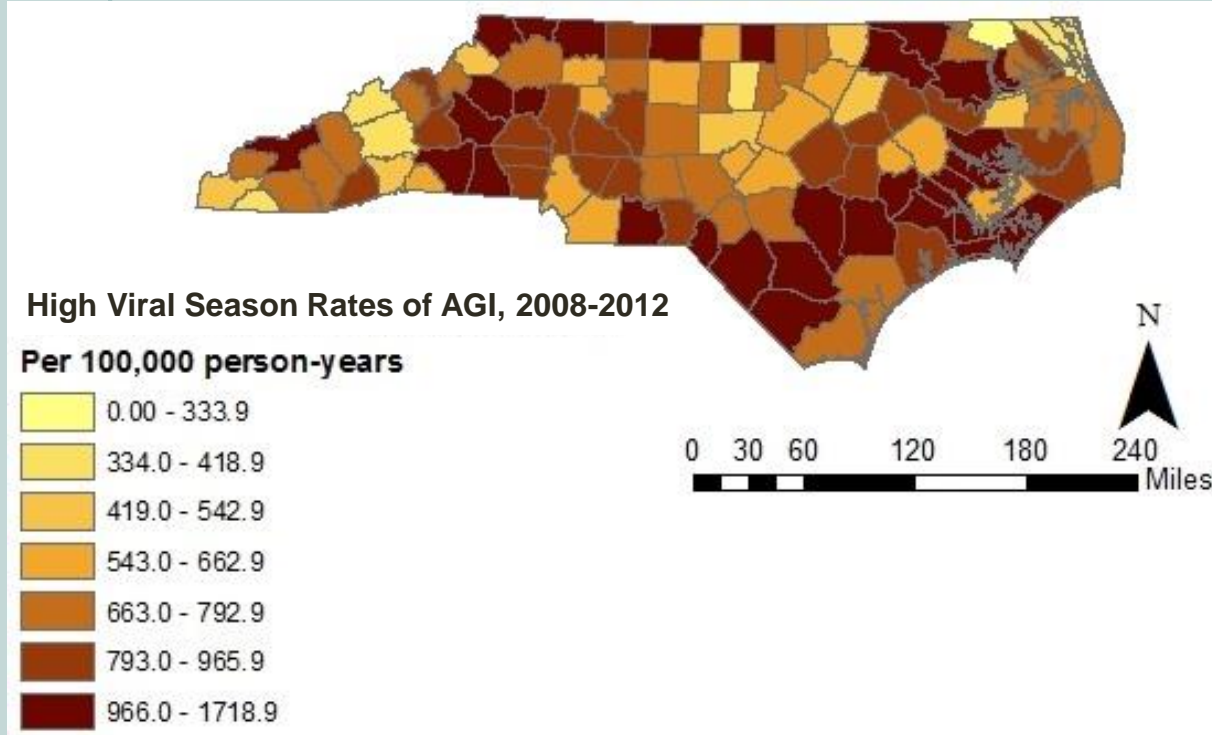




# INCIDENCE OF NOROVIRUS ACROSS THE STATE OF NORTH CAROLINA FROM 2008-2012 PER 100,000 PERSON-YEARS



# HIGH-VIRAL VS. LOW-VIRAL SEASON MAPS





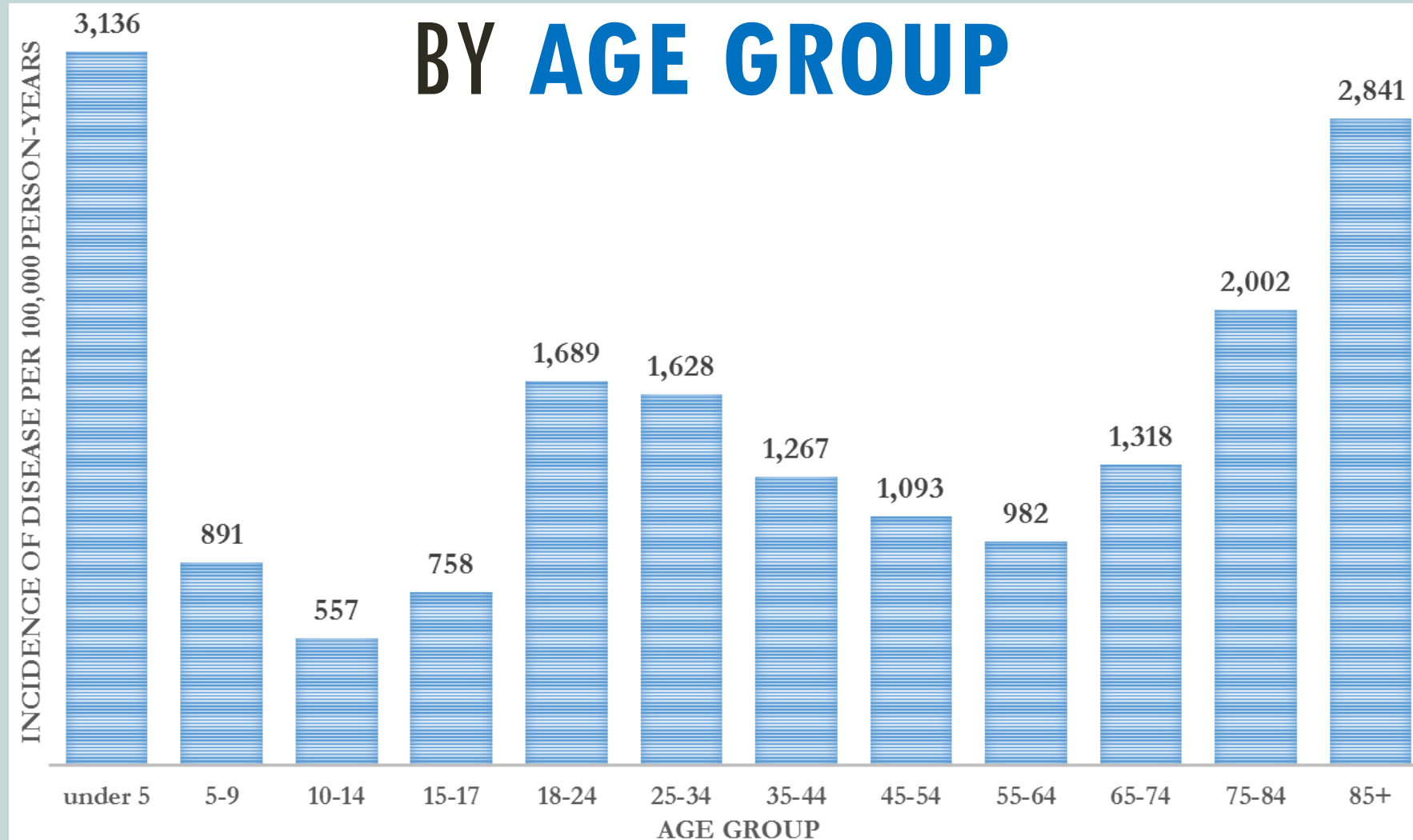
# DEMOGRAPHIC PATTERNS:

- AGE
- SEX
- SOCIOECONOMIC STATUS
- POPULATION DENSITY
- RURAL VS. URBAN COUNTIES
- DRINKING WATER SOURCE
- HEALTH INSURANCE STATUS

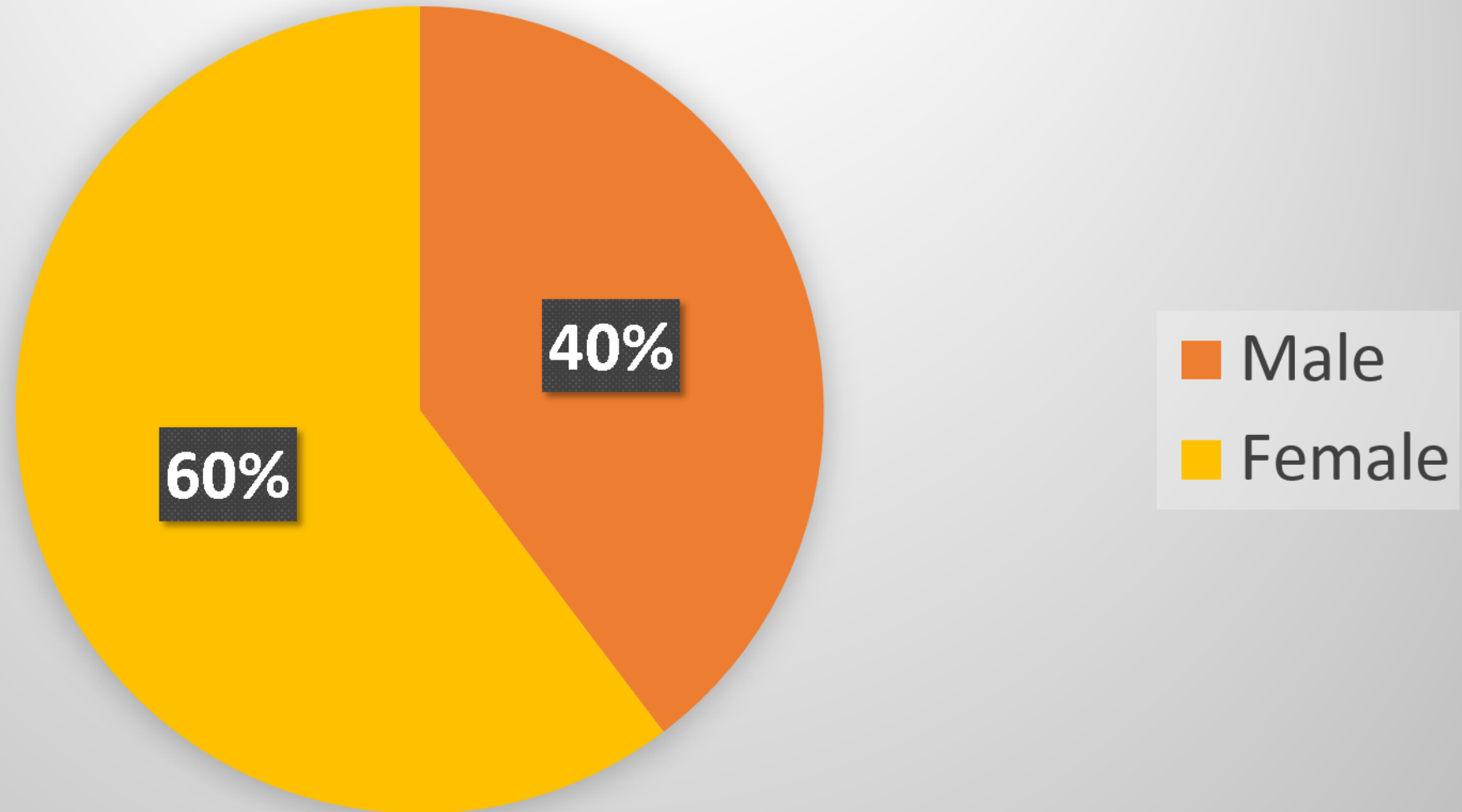
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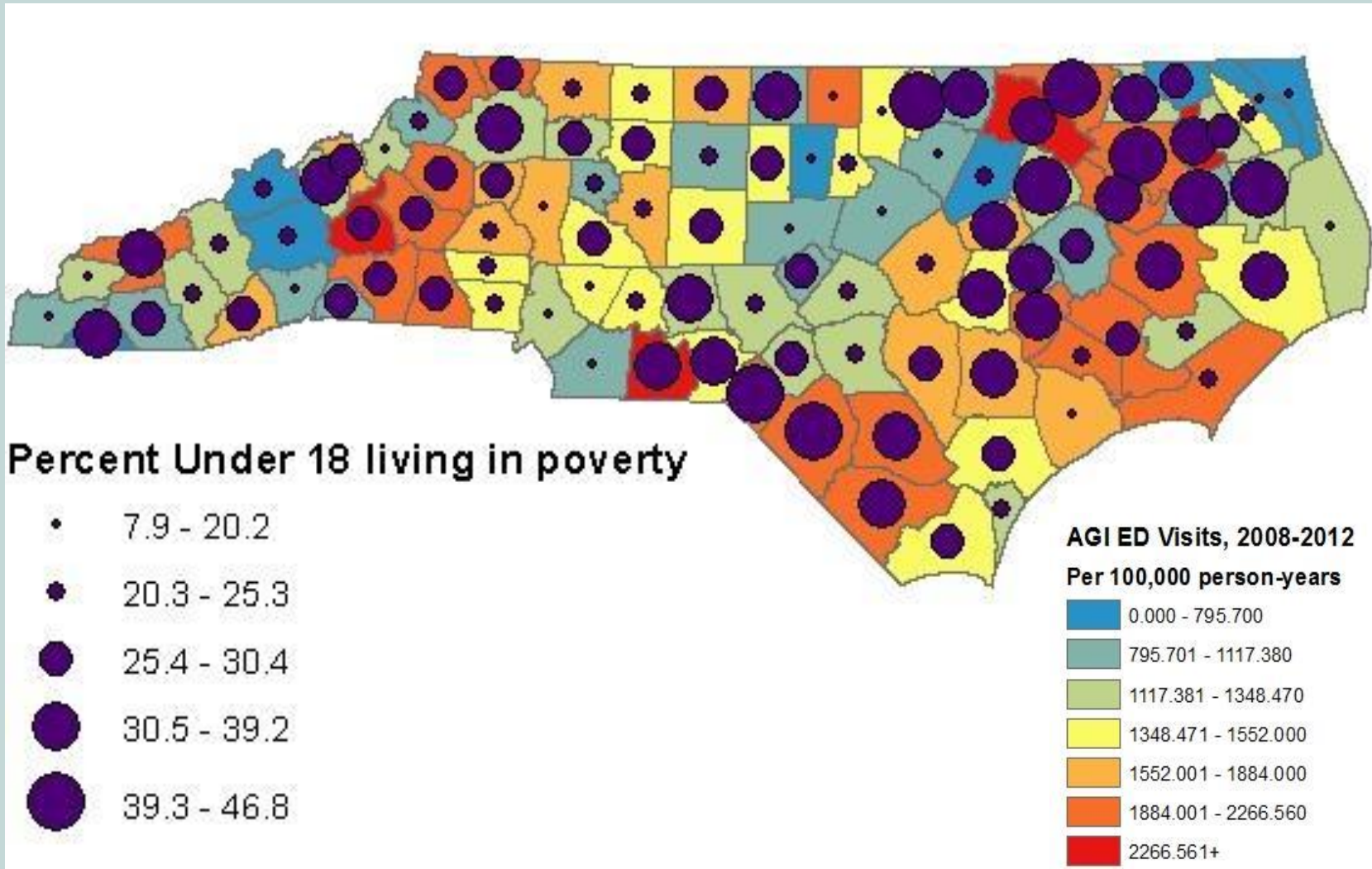


# RATIO OF AGI IN NORTH CAROLINA FROM 2008-2012 BY **SEX**

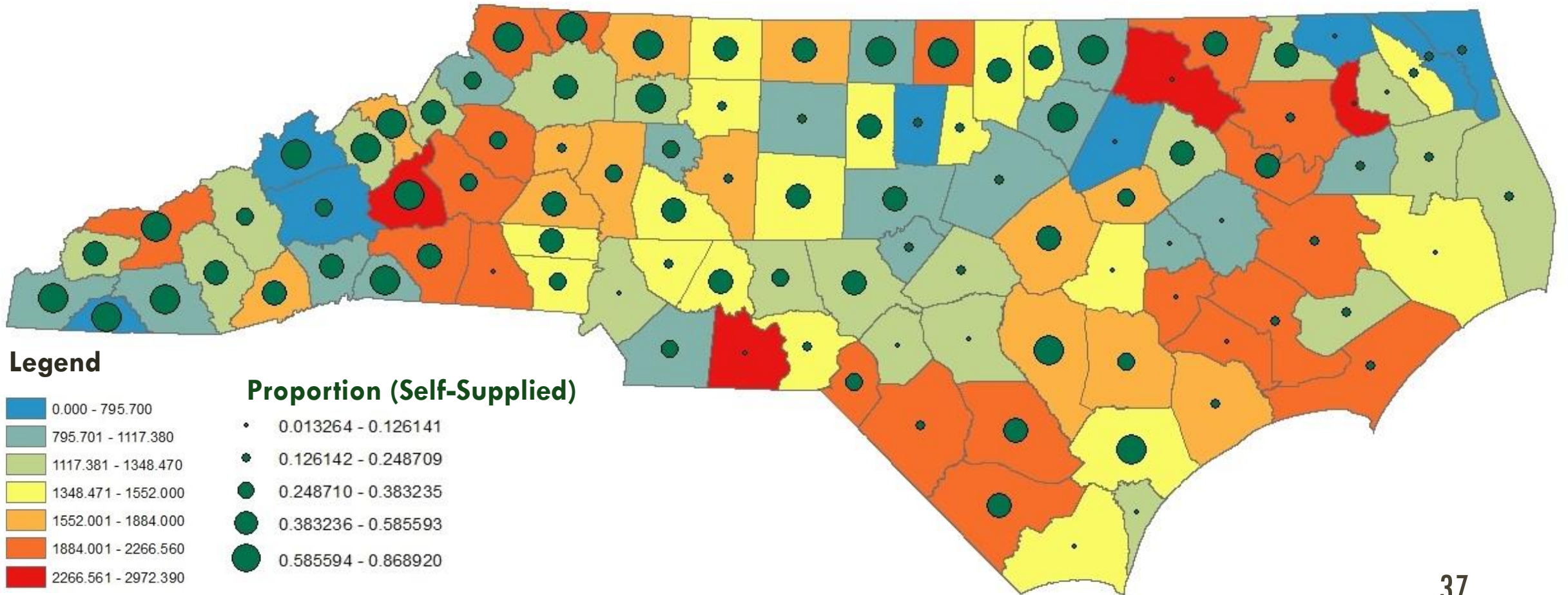




# INCIDENCE OF AGI IN NORTH CAROLINA FROM 2008-2012 PER 100,000 PERSON-YEARS AS SHOWN WITH % OF POPULATION UNDER 18 LIVING IN POVERTY

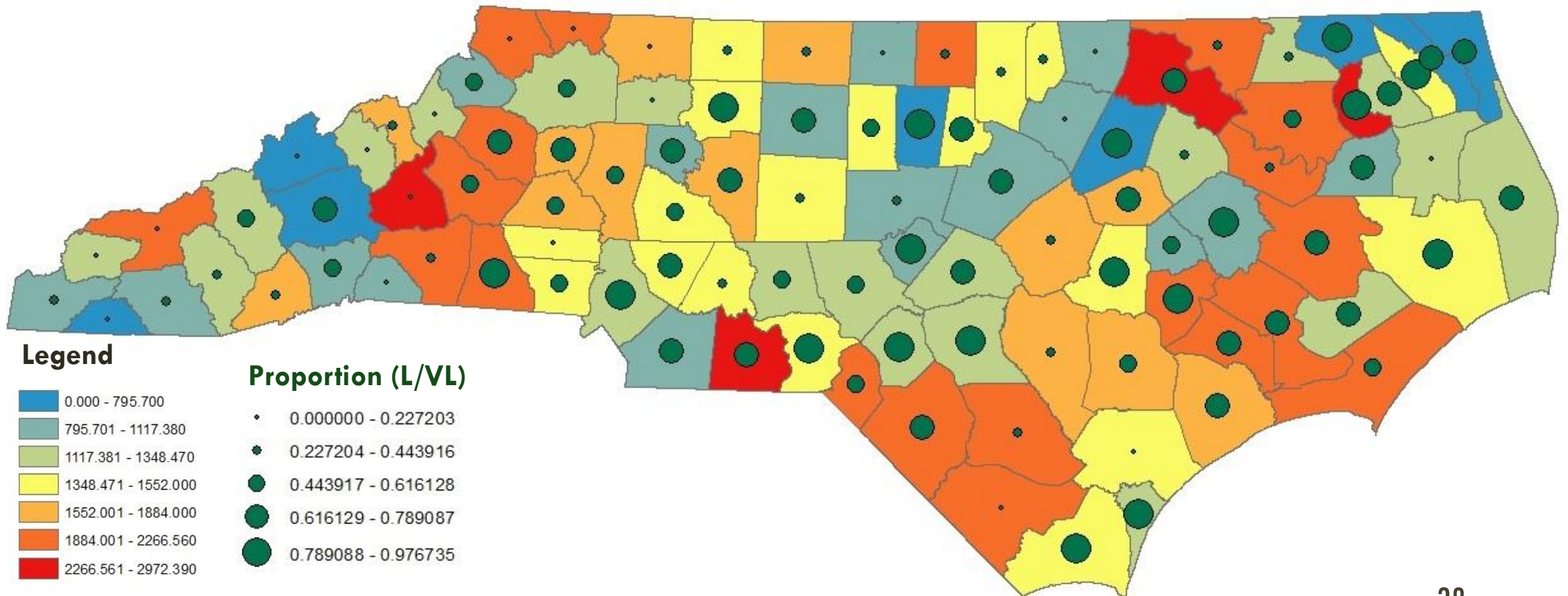


# INCIDENCE OF AGI BY COUNTY IN 100,000 PERSON-YEARS AND THE PROPORTION OF THE COUNTY WITH SELF-SUPPLIED DRINKING WATER (2005)





# INCIDENCE OF AGI BY COUNTY IN 100,000 PERSON-YEARS AND THE PROPORTION OF THE COUNTY ON MEDIUM, LARGE AND VERY LARGE COMMUNITY PIPED SYSTEMS (2010)



# CORRELATIONS



# LARGE CORRELATION MATRIX, ALL DATA

	Disease Rates	Population Density	Avg. Household Size	% under 18 in poverty	% 18-64 in poverty	% 65+ in poverty	Percent Minority	High Viral Rates	Low Viral Rates	Self-supplied DW	VS/S DW	L/VL DW	% no health insurance	% no or public health insurance	% with health insurance
Disease Rates	1.00														
Population Density	-0.14	1.00													
Avg. Household Size	0.02	0.03	1.00												
% under 18 in poverty	*0.40	-0.32	0.06	1.00											
% 18-64 in poverty	*0.24	-0.25	-0.11	*0.71	1.00										
% 65+ in poverty	*0.30	-0.40	*0.22	*0.68	*0.54	1.00									
Percent Minority	*0.22	0.04	*0.39	*0.61	*0.40	*0.53	1.00								
High Viral Rates	*0.96	-0.16	0.00	*0.42	*0.26	*0.33	*0.26	1.00							
Low Viral Rates	*0.96	-0.13	0.00	*0.36	*0.23	*0.26	*0.20	*0.97	1.00						
Self-supplied DW	-0.06	-0.32	-0.17	0.01	0.02	0.06	-0.38	-0.09	-0.07	1.00					
VS/S DW	0.04	-0.31	-0.24	*0.25	*0.22	*0.34	0.05	0.07	0.01	0.10	1.00				
L/VL DW	0.03	*0.41	*0.25	-0.12	-0.11	-0.20	*0.30	0.05	0.06	-0.89	-0.54	1.00			
% no health insurance	*0.23	-0.18	-0.16	*0.40	*0.38	*0.33	0.02	*0.27	*0.24	*0.21	*0.30	-0.31	1.00		
% no or public health insurance	*0.35	-0.51	-0.18	*0.73	*0.53	*0.55	*0.23	*0.38	*0.35	*0.29	*0.30	-0.38	*0.63	1.00	
% with health insurance	-0.21	*0.24	0.03	-0.40	-0.29	-0.43	-0.25	-0.26	-0.20	0.04	-0.49	0.18	-0.64	-0.37	1.00

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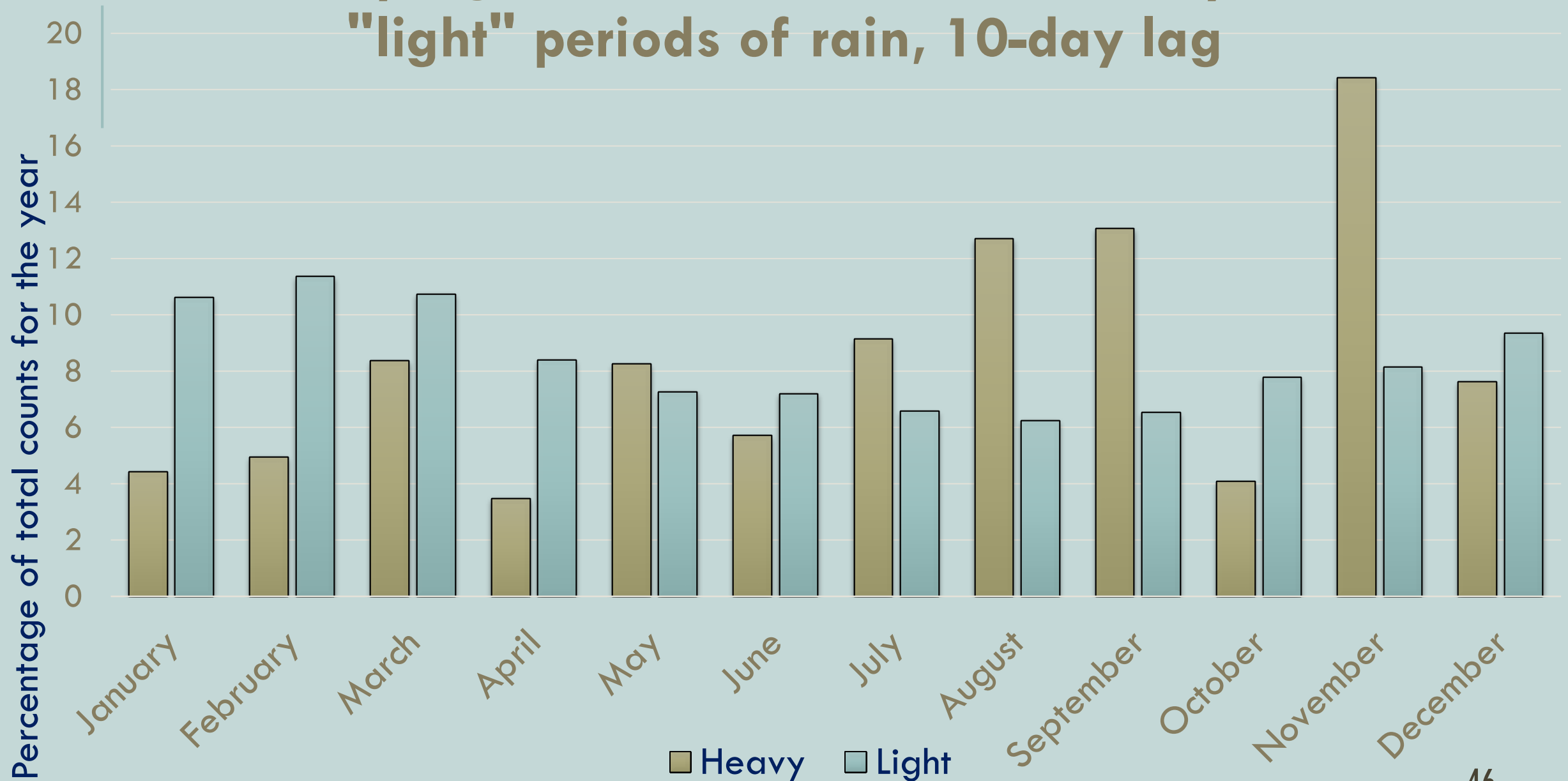
# PRECIPITATION PATTERNS



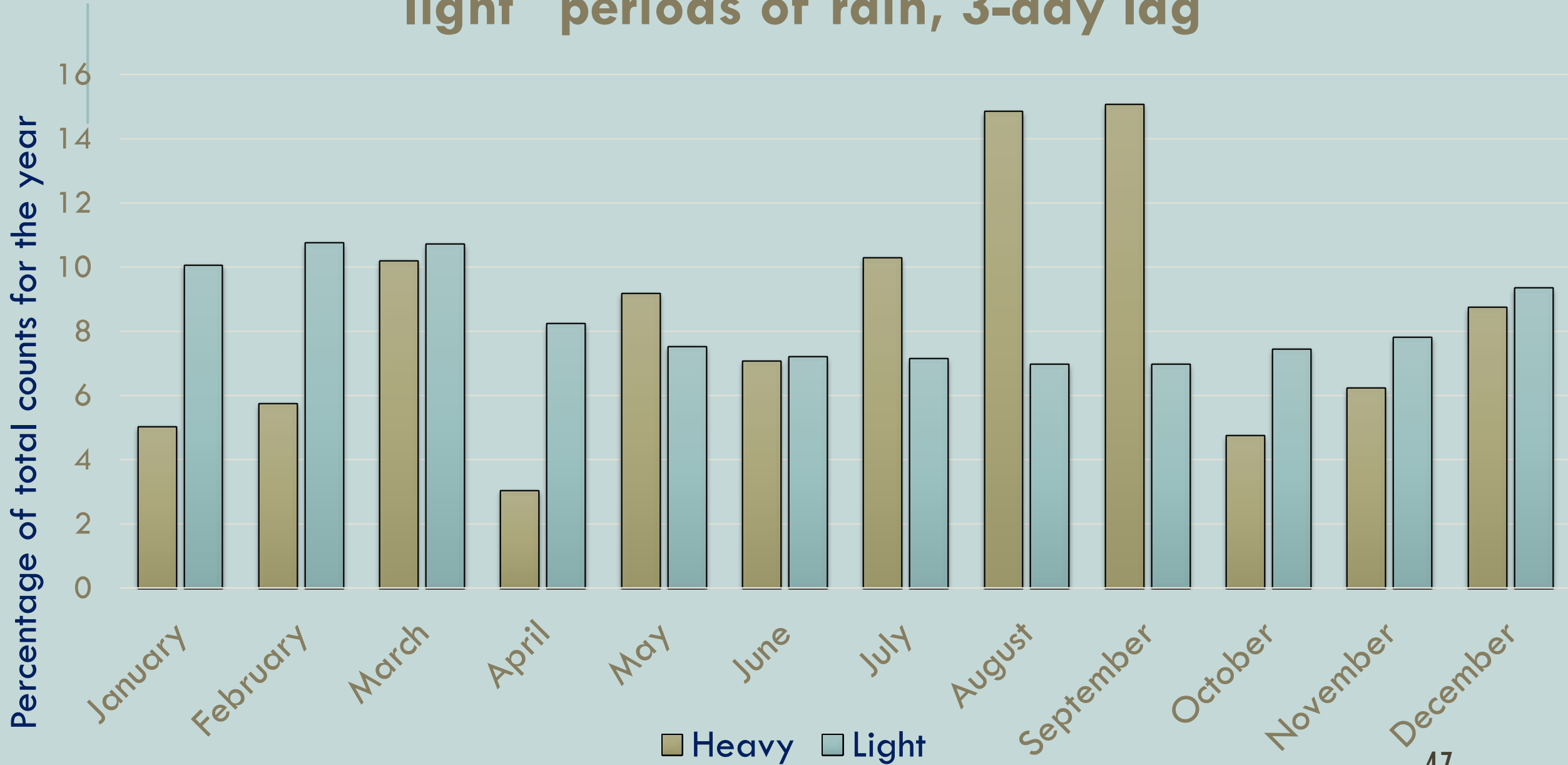
# TOTAL COUNTS OF AGI IN NORTH CAROLINA FROM 2008-2012 BY MONTH



# Monthly signal for ED visits after "heavy" and "light" periods of rain, 10-day lag



# Monthly signal for ED visits after "heavy" and "light" periods of rain, 3-day lag



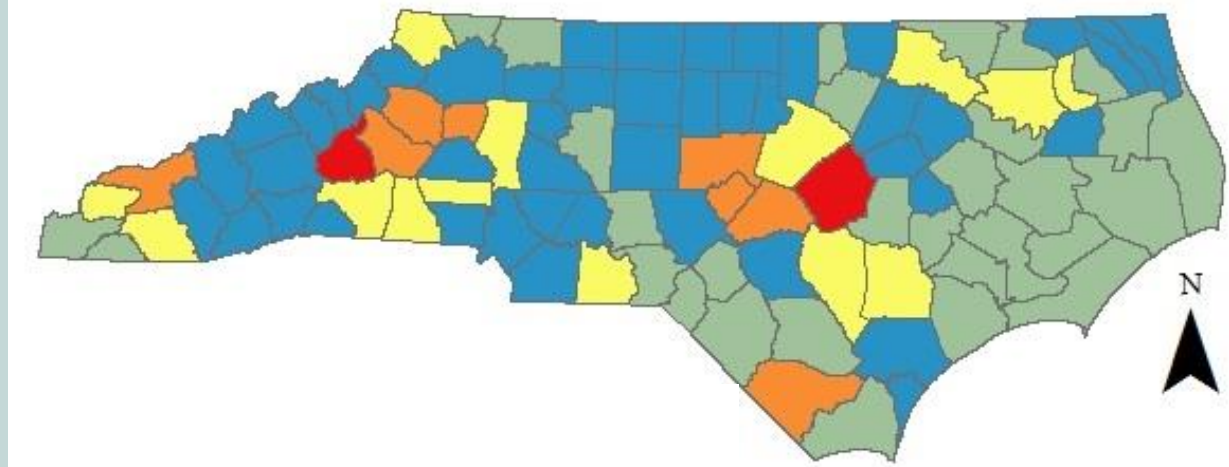


# PRECIPITATION PATTERNS, 3-DAY LAG

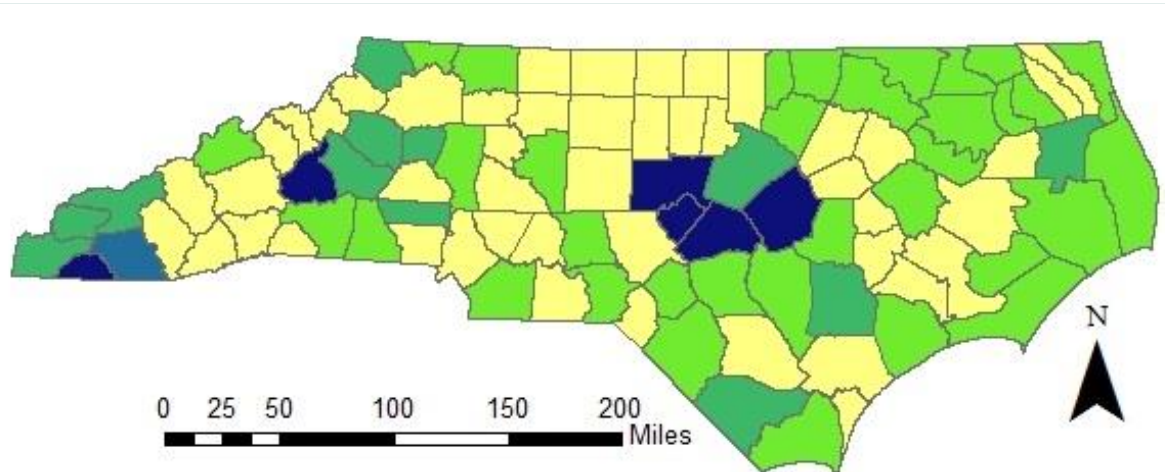
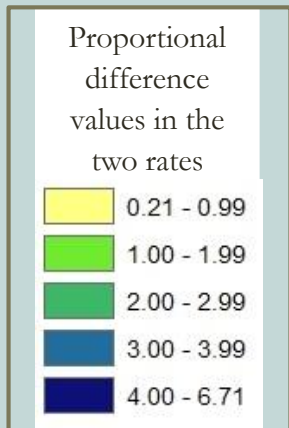
3-day lag, “light” precipitation



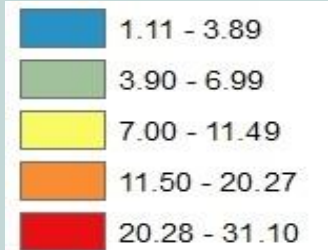
3-day lag, “heavy” precipitation



3-day lag, proportional difference: “heavy” divided by “light”

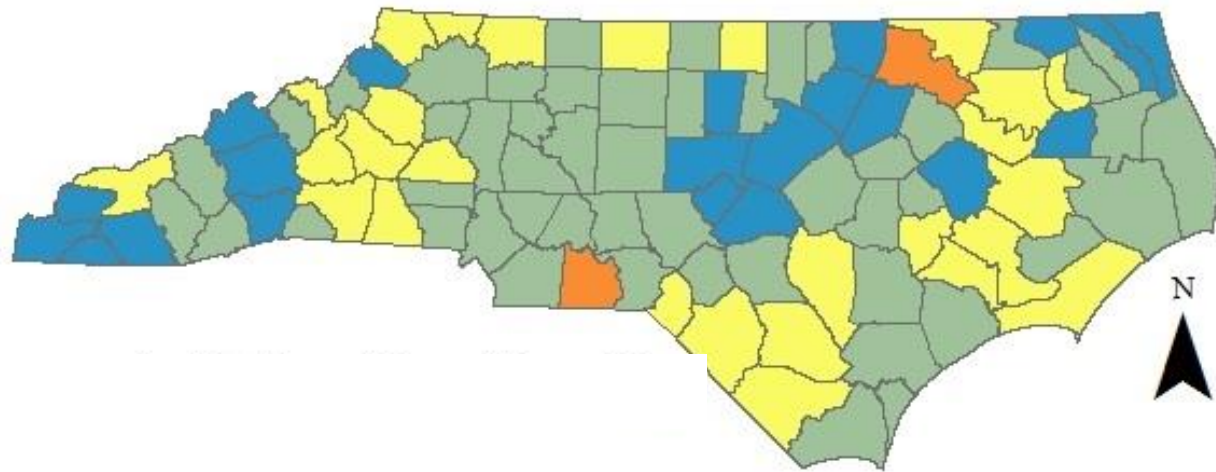


Average number of admissions per day per 100,000 person-years

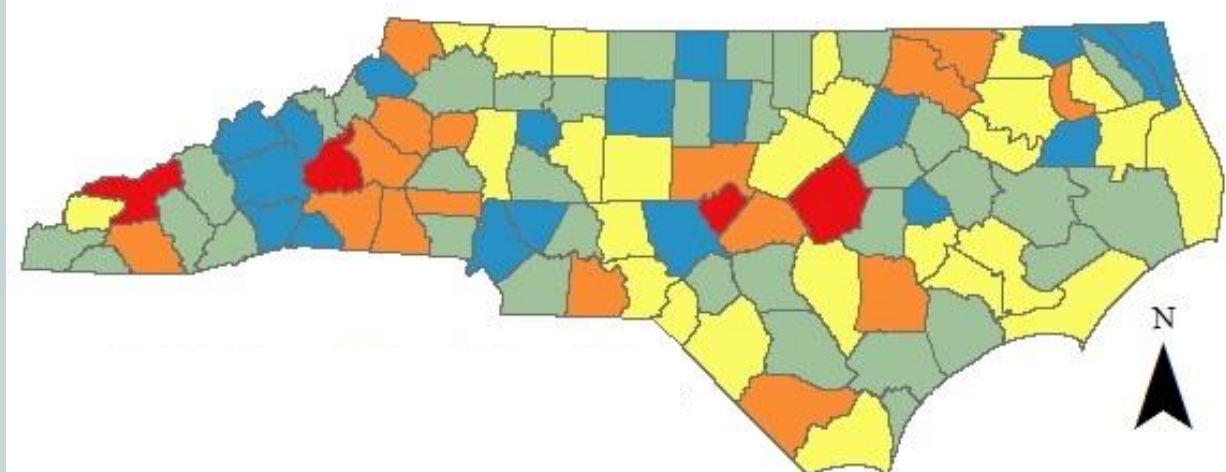


# PRECIPITATION PATTERNS, 10-DAY LAG

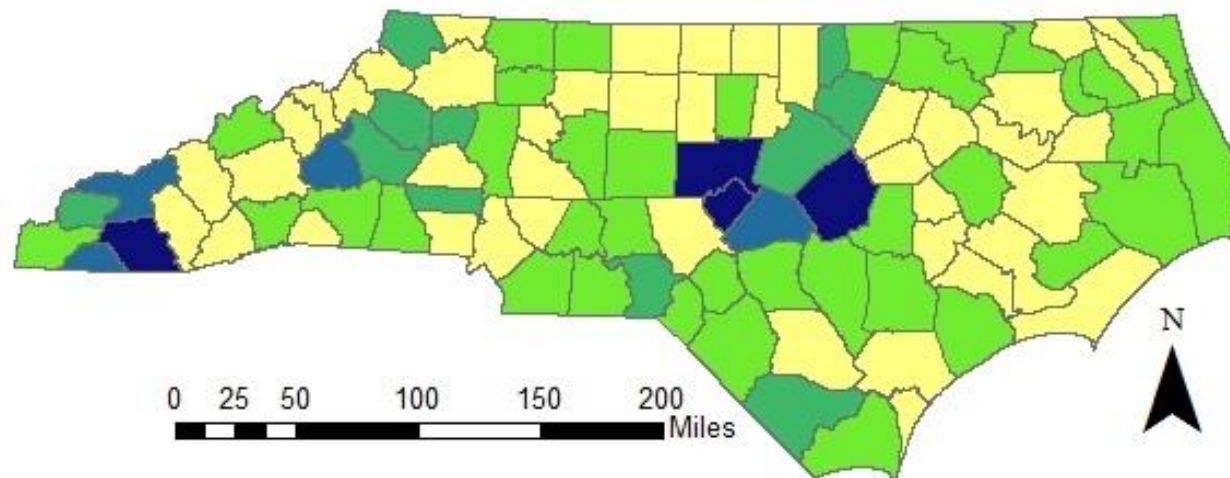
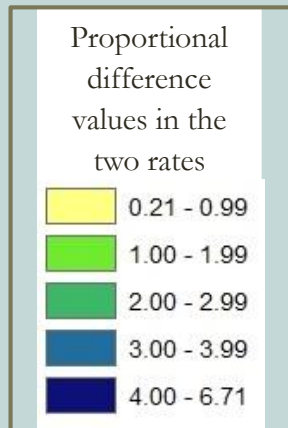
10-day lag, “light” precipitation



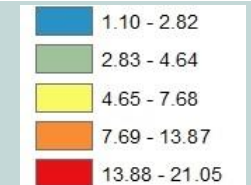
10-day lag, “heavy” precipitation



10-day lag, proportional difference: “heavy” divided by “light”

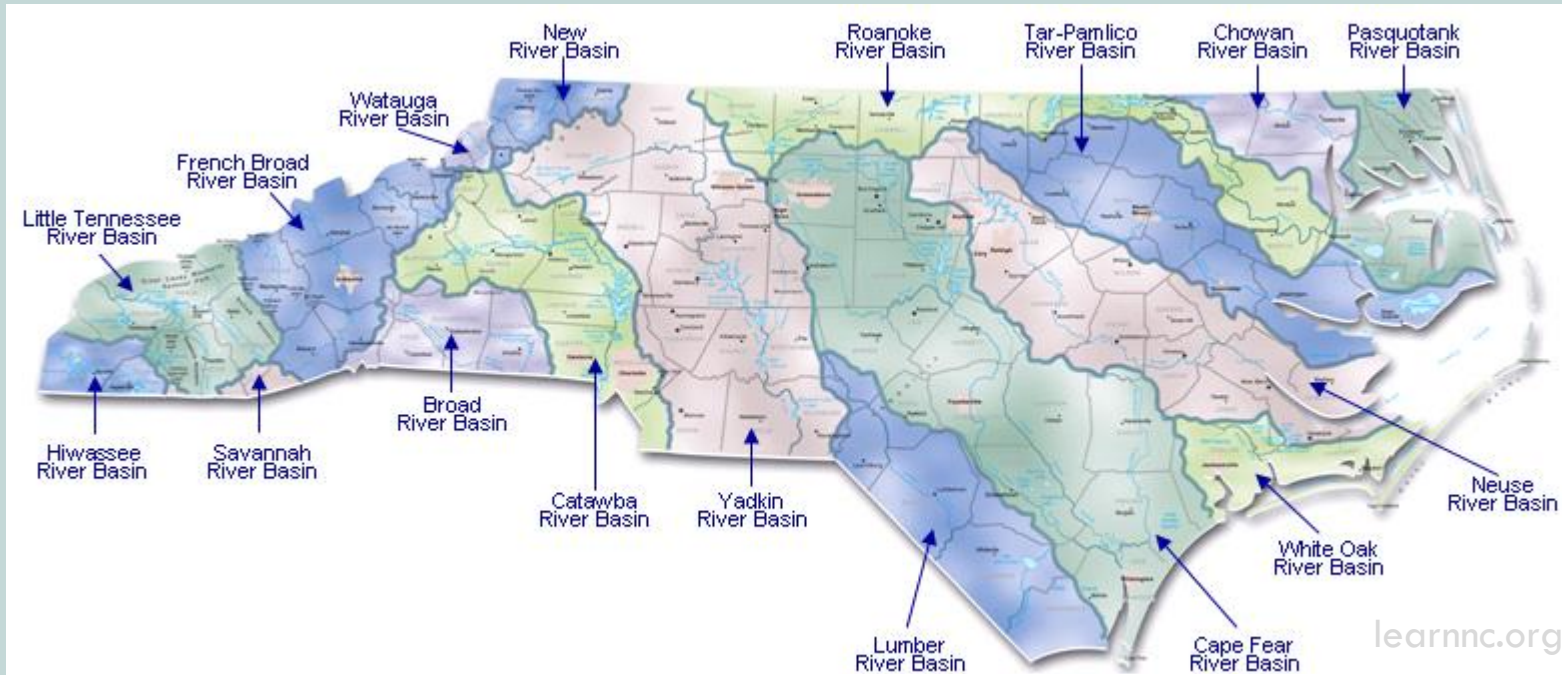


Average number of admissions per day per 100,000 person-years

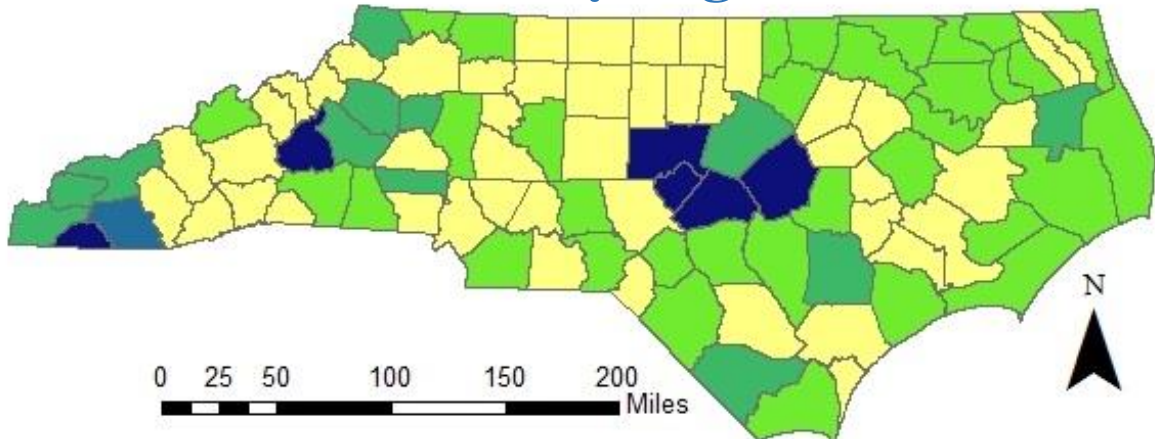




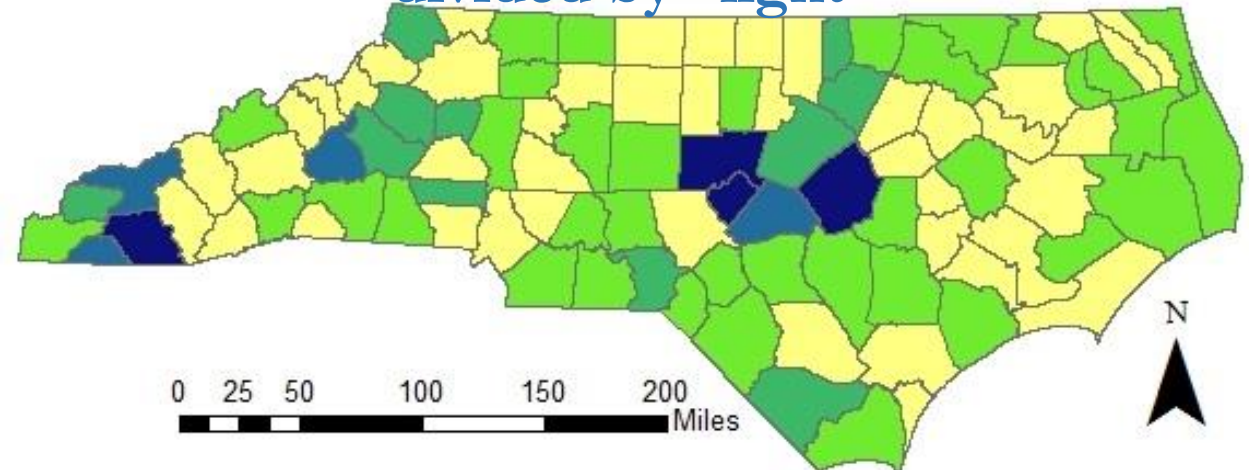
# NORTH CAROLINA RIVER BASINS



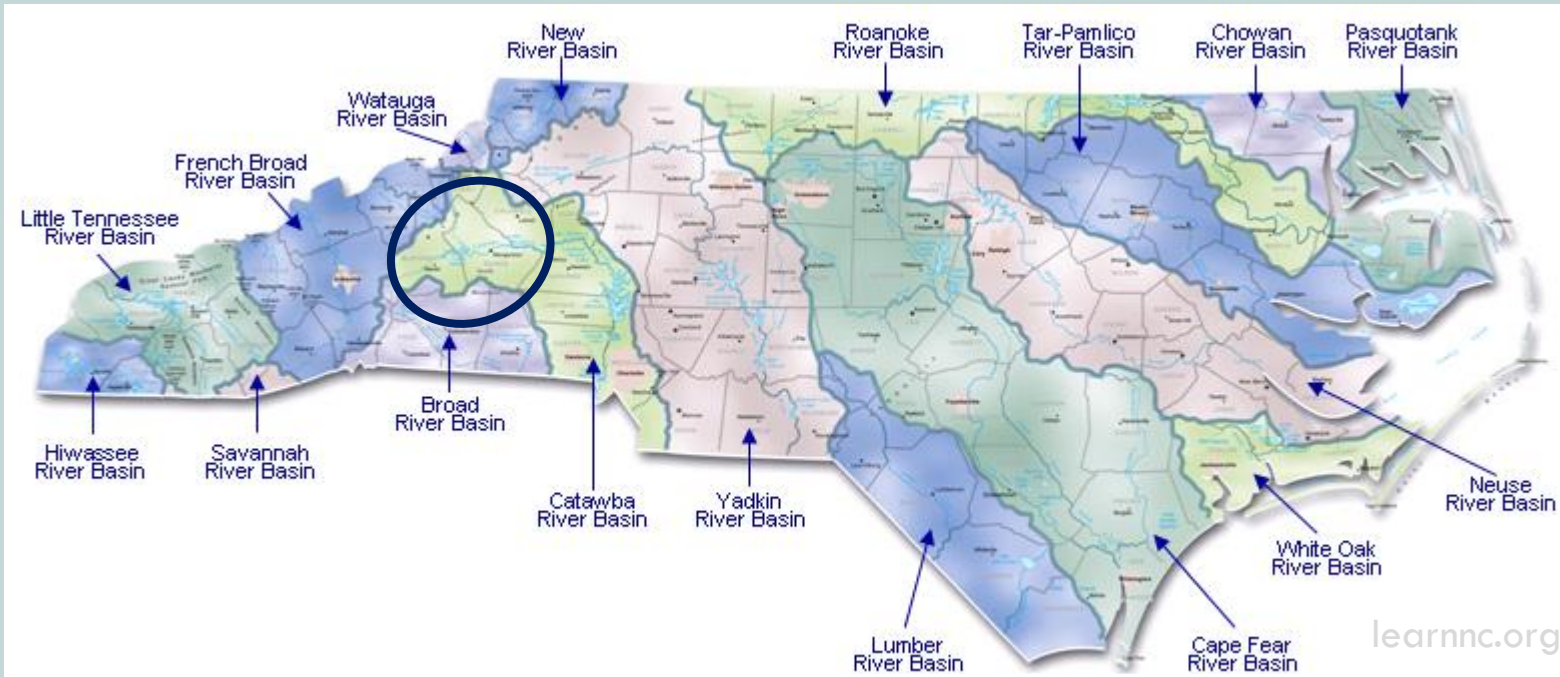
3-day lag, proportional difference: “heavy”  
divided by “light”



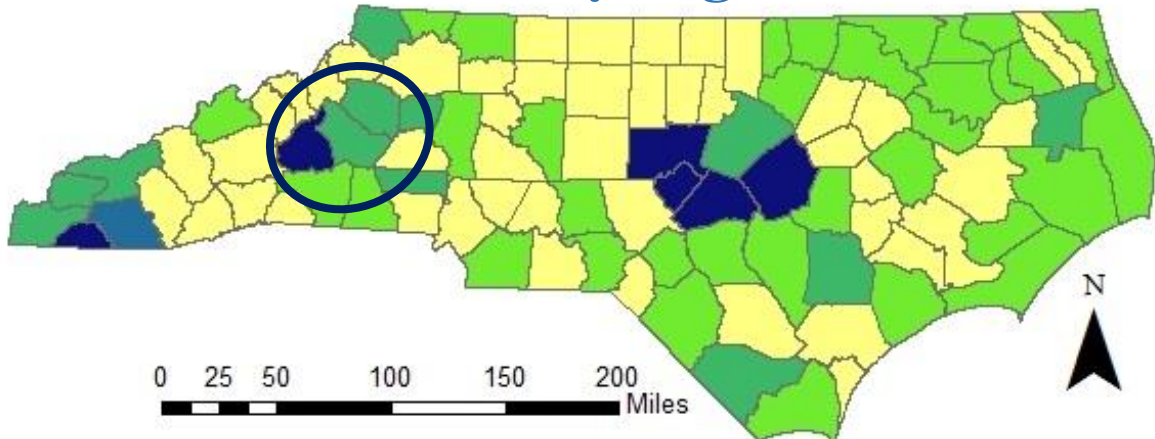
10-day lag, proportional difference: “heavy”  
divided by “light”



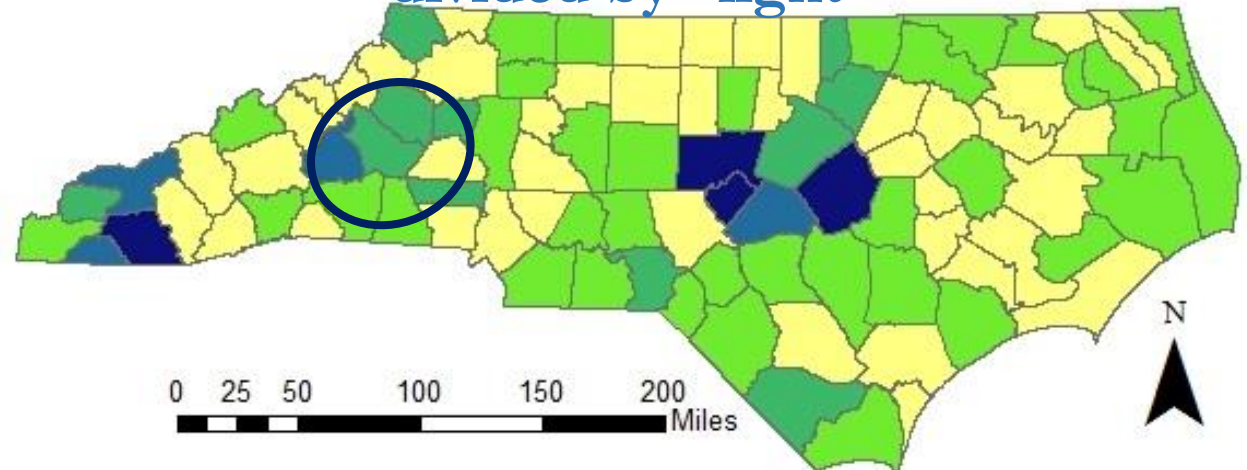
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3-day lag, proportional difference: “heavy”  
divided by “light”

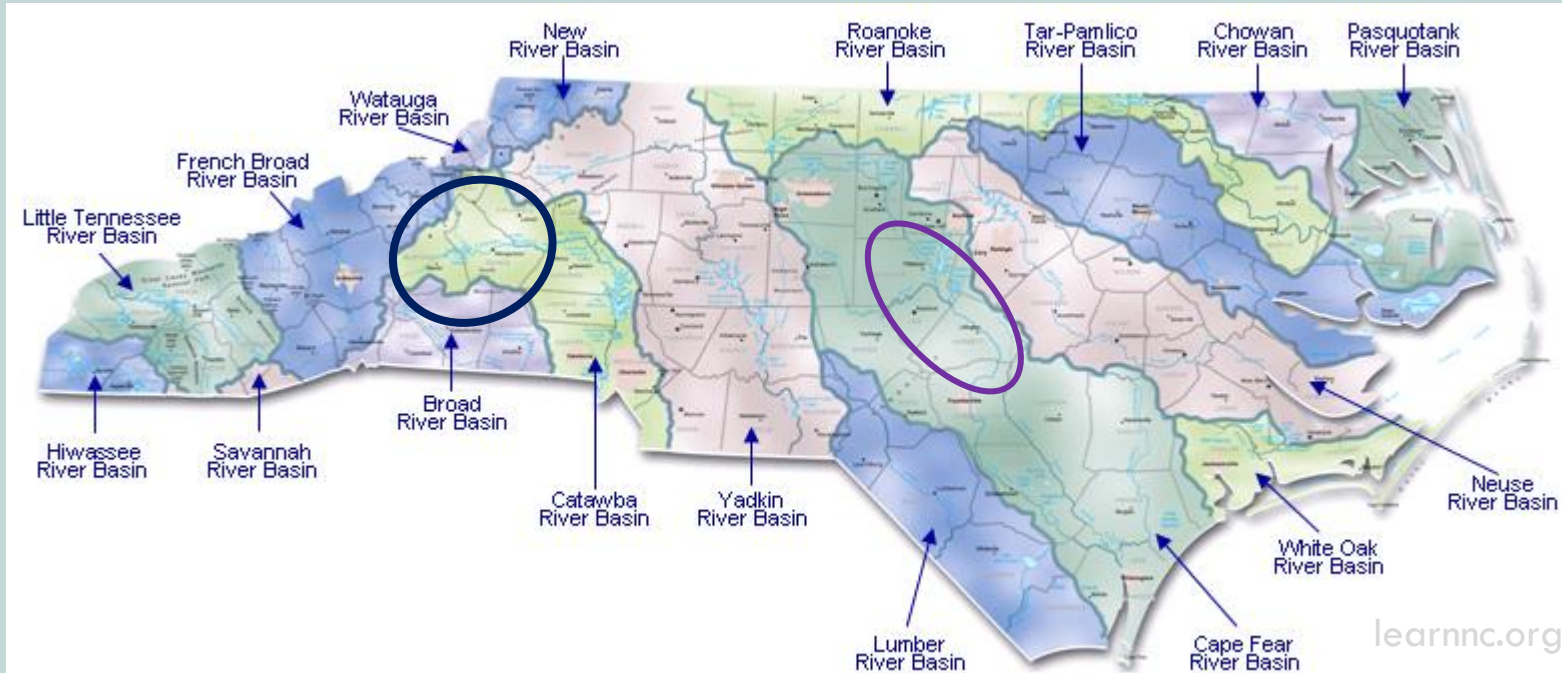


10-day lag, proportional difference: “heavy”  
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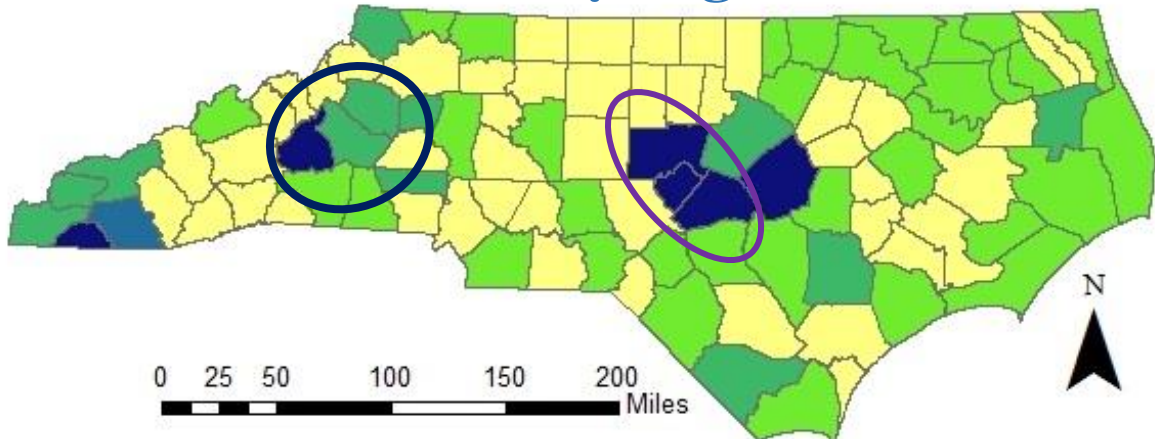




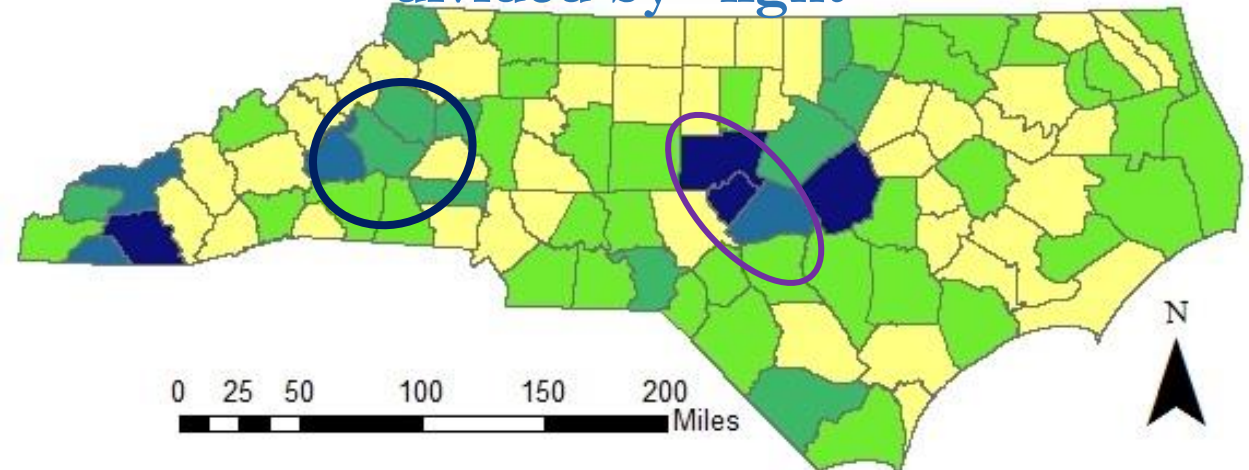
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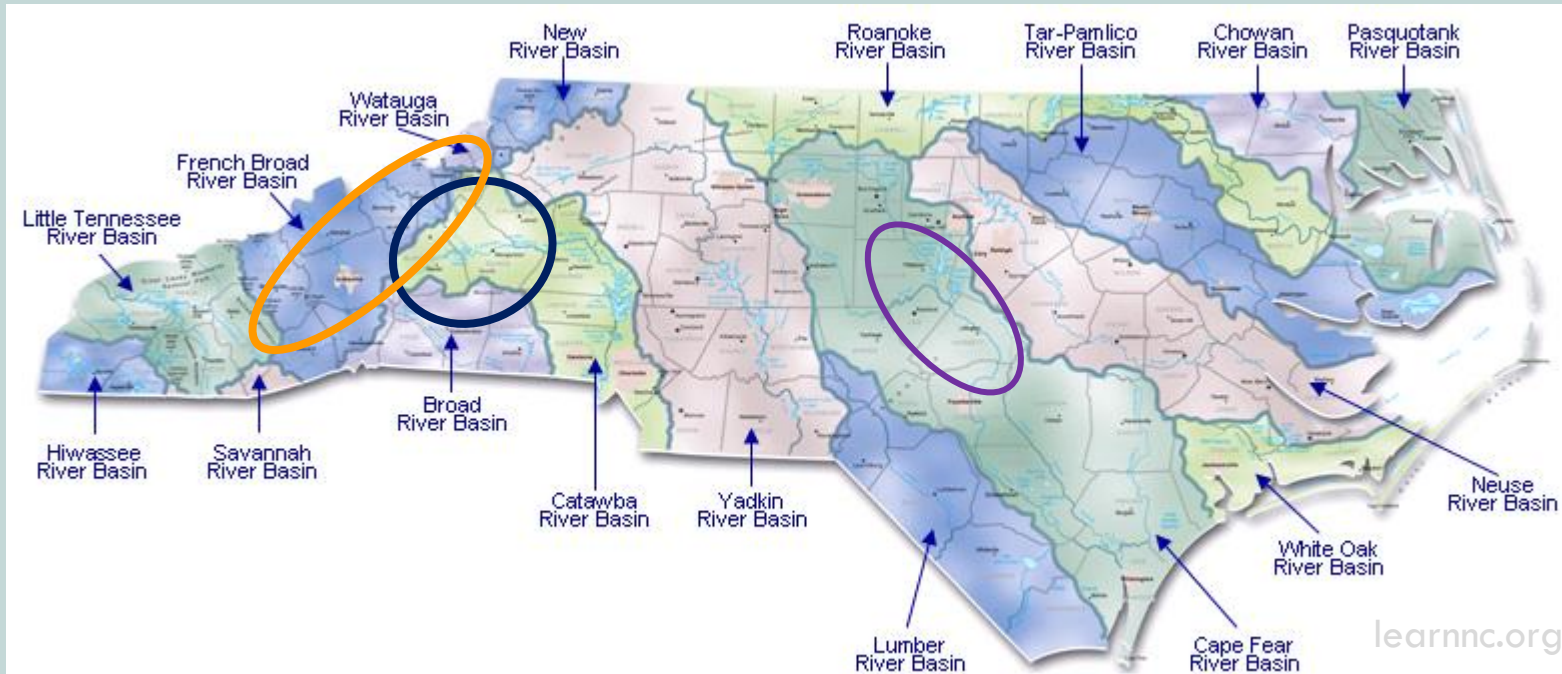
3-day lag, proportional difference: “heavy”  
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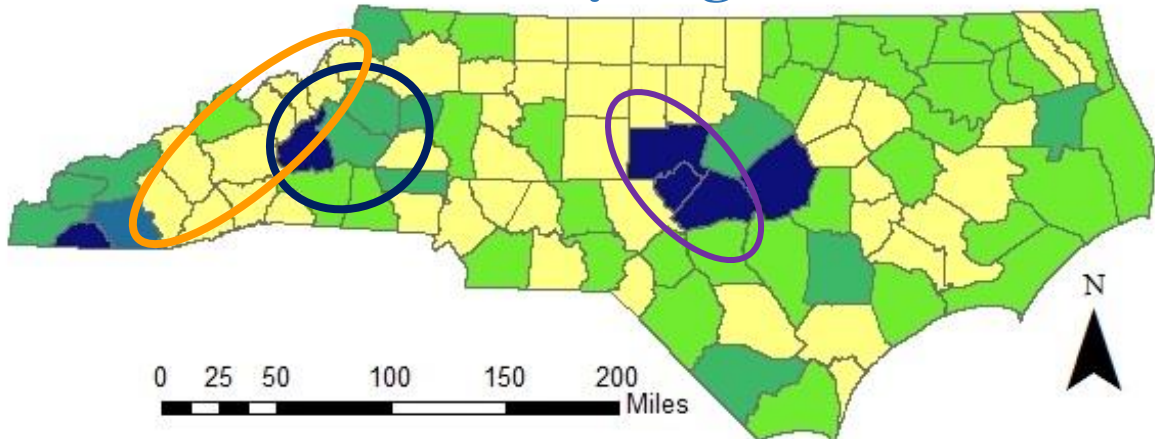
10-day lag, proportional difference: “heavy”  
divided by “light”



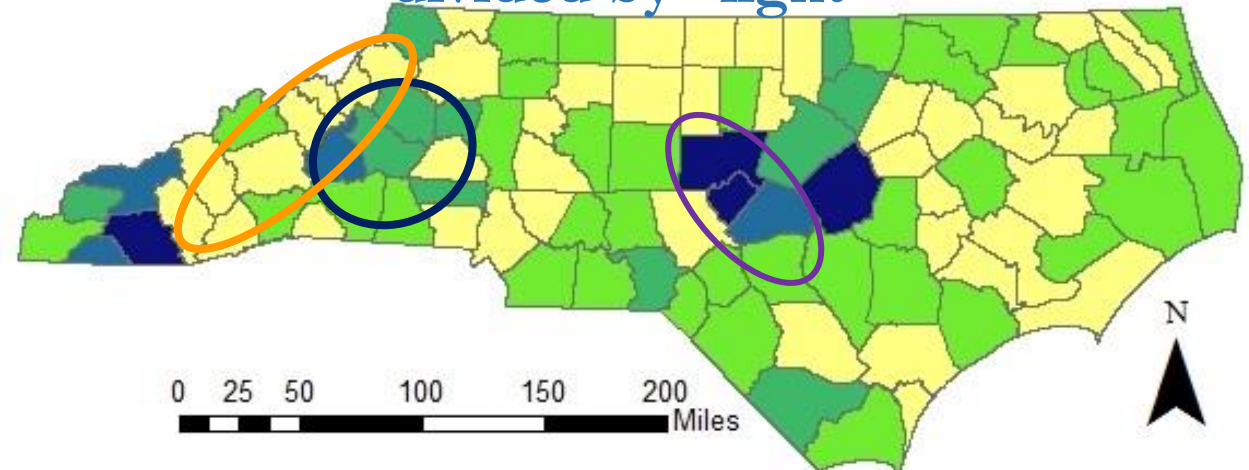
# NORTH CAROLINA RIVER BASINS



3-day lag, proportional difference: “heavy”  
divided by “light”



10-day lag, proportional difference: “heavy”  
divided by “light”





# CONCLUSIONS

1. RELATIONSHIPS WITH GASTROINTESTINAL ILLNESS ARE VERY COMPLEX
2. THERE ARE SIGNIFICANT ASSOCIATIONS WITH POVERTY AND POVERTY ELEMENTS
3. THERE IS SIGNIFICANT CLUSTERING IN PROPORTIONS OF DISEASE AFTER “HEAVY” RAIN
4. THERE ARE OTHERWISE UNIQUE SPATIAL POCKETS OF HIGH RATES OF DISEASE IN NC AFTER “HEAVY” RAIN

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# **STUDY LIMITATIONS**

- 1. ED DATA LIMITATIONS**
- 2. LAG PERIODS**
- 3. WEATHER STATION LOCATION**

# **FUTURE WORK**

- 1. AGRICULTURE**
- 2. ANALYSES OF WATER QUALITY**
- 3. ANALYSES AT ZIP CODE LEVEL**
- 4. DRAINAGE BASINS AND WATERSHEDS**
- 5. DIFFERENT LAG PERIODS AND THRESHOLD DEFINITIONS**
- 6. CLUSTERS OF DISEASE OCCURRENCE**



# MANY THANKS!

- ADVISOR: C.E. KONRAD, PHD, UNC-CH DEPT. OF GEOGRAPHY
- ADVISOR: J.J. WEST, PHD, UNC-CH ENVIRONMENTAL SCIENCES AND ENGINEERING, GILLINGS SCHOOL OF PUBLIC HEALTH
- MENTOR: MAGGIE SUGG, PHD, APP. STATE DEPT. OF GEOGRAPHY
- GRADUATE STUDENT MENTOR: KRISTEN DOWNS, UNC-CH ENVIRONMENTAL SCIENCES AND ENGINEERING
- NC DETECT: ANNA WALLER
- CLIMATE-HEALTH TOOLBOX: ASHLEY HIATT, NORTH CAROLINA STATE CLIMATE OFFICE, RALEIGH, NC
- SERCC STAFF: WILLIAM G. SCHMITZ, JORDAN MCLEOD
- KEITH HARTLEY

