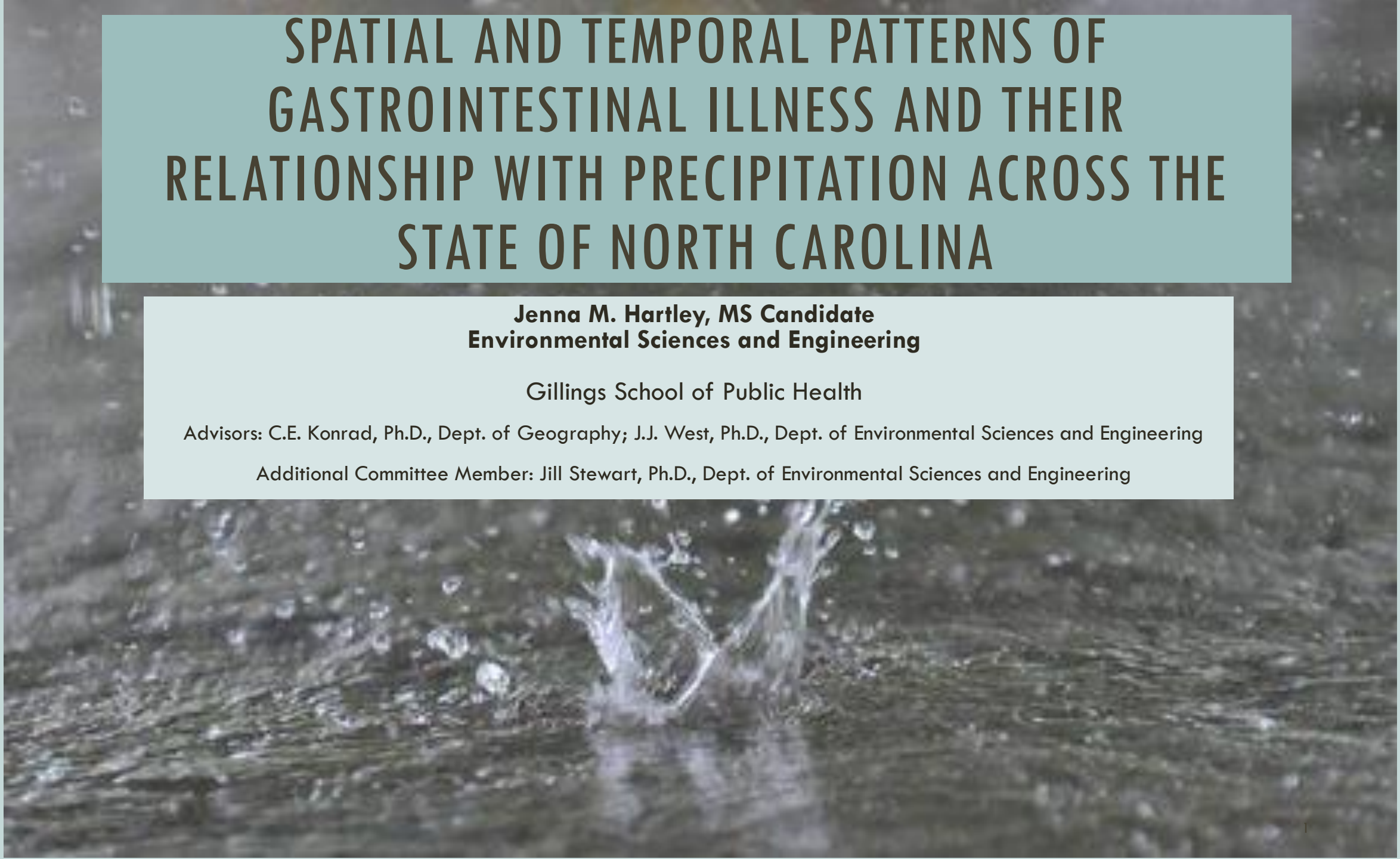


SPATIAL AND TEMPORAL PATTERNS OF GASTROINTESTINAL ILLNESS AND THEIR RELATIONSHIP WITH PRECIPITATION ACROSS THE STATE OF NORTH CAROLINA

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)

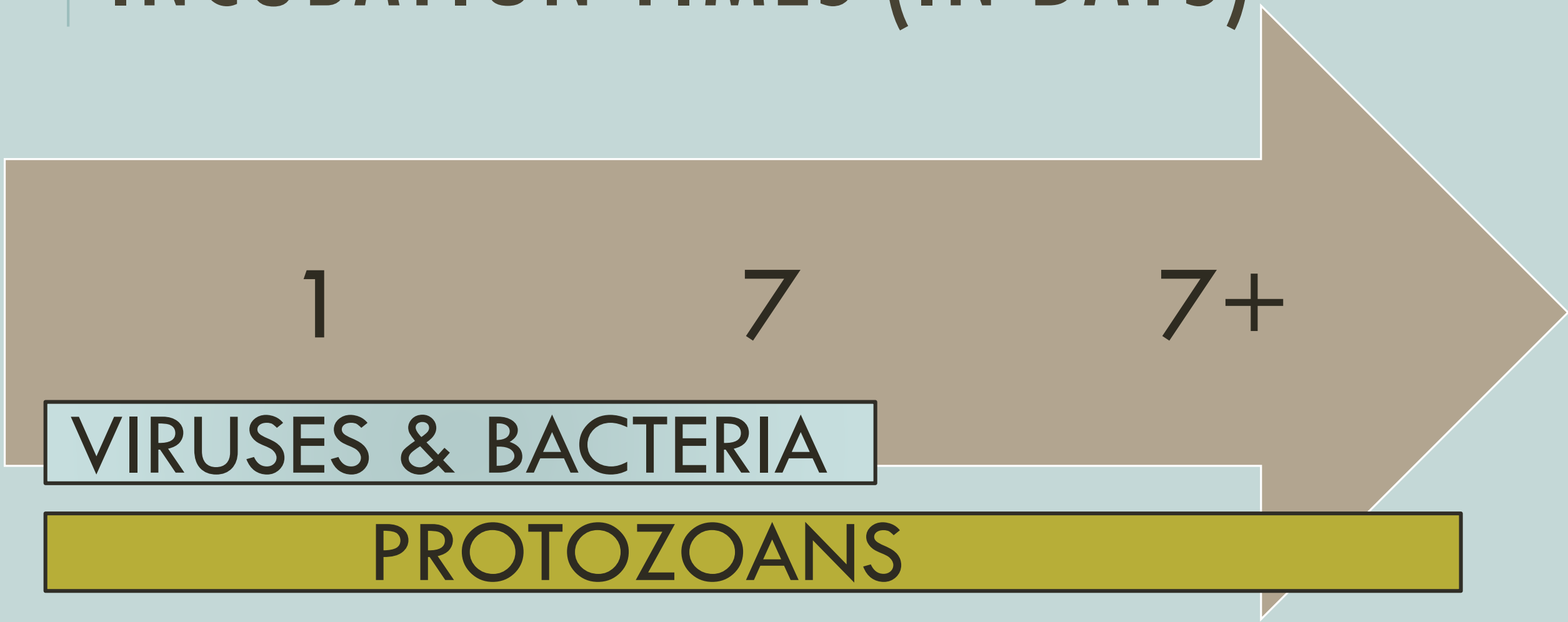
TYPES OF PATHOGENS THAT CAN BE FOUND IN CONTAMINATED WATER

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

Protozoans/Parasites: *Cryptosporidium, Giardia*

Viruses: rotavirus, norovirus, enterovirus, calcivirus, adenovirus

INCUBATION TIMES (IN DAYS)



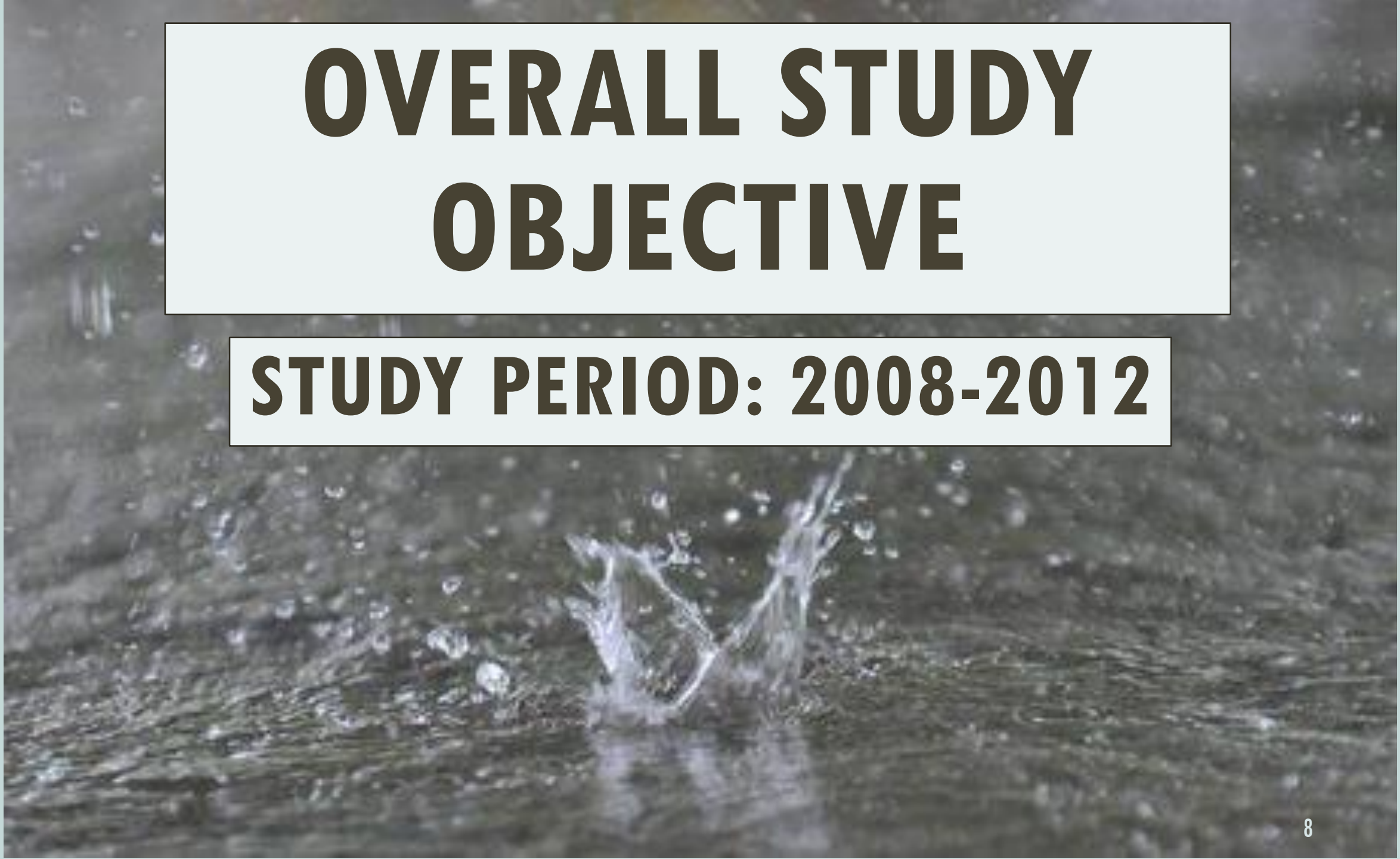
Drayna et al., 2010

HEAVY RAINFALL AND AGI

John A. Anderson, Shutterstock

John A. Anderson, Shutterstock

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

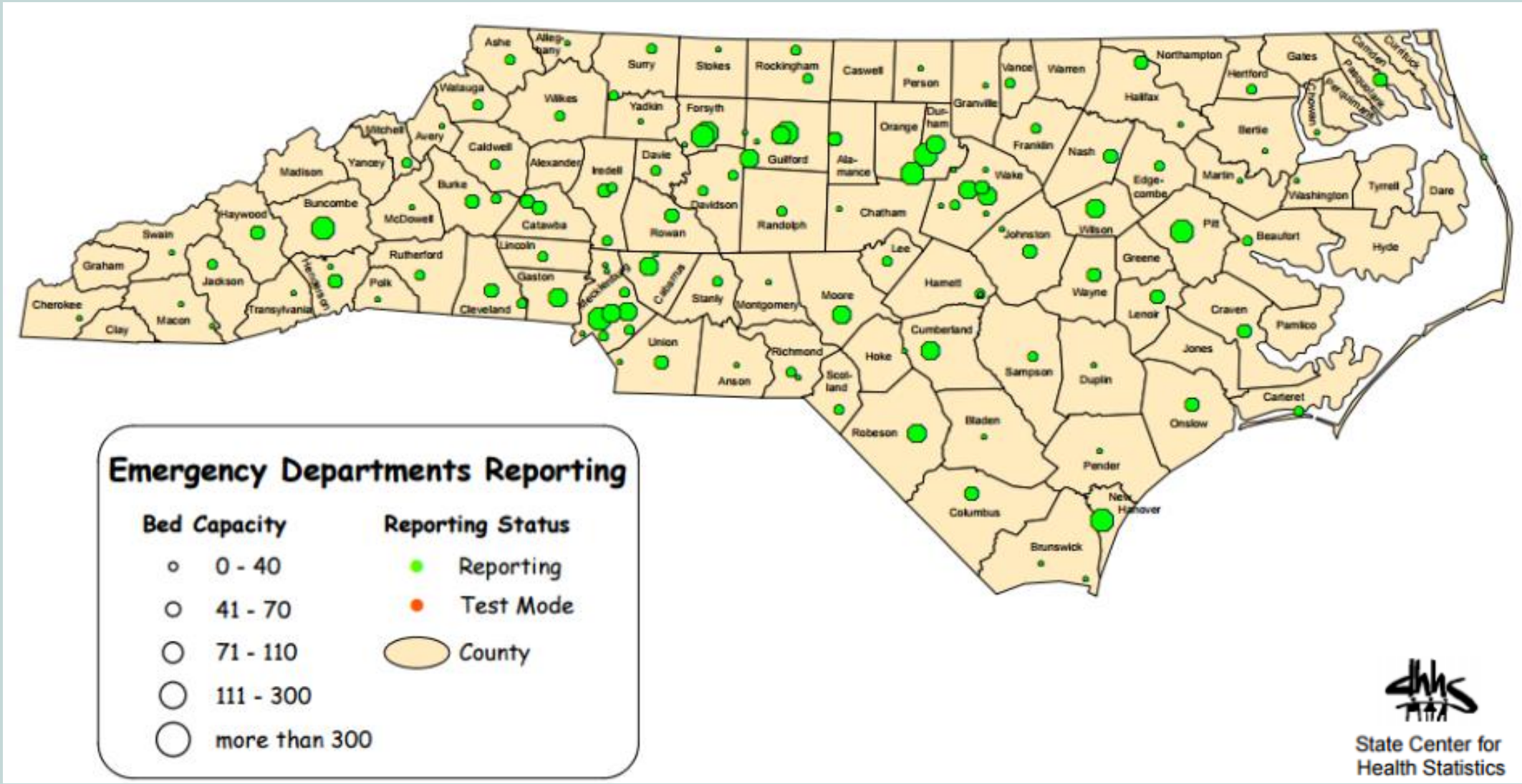
HEALTH DATA: NC DETECT

METHODS

HEALTH DATA: NC DETECT

Emergency Departments Reporting to NC DETECT by General Bed Capacity

(as of Nov. 2014, 122 ED's reporting)



DISEASE OUTCOMES IN THIS STUDY THAT ARE ASSOCIATED WITH CONTAMINATED WATER

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ICD-9 Codes utilized:

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ICD-9 Codes utilized:

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

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- **787.91 (Diarrhea, Not otherwise Specified)**

"GASTROINTESTINAL ILLNESS"

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

METHODS

METEOROLOGICAL DATA: NC DETECT CLIMATE-HEALTH TOOLBOX

NC DETECT Tool

HEALTH

Enter your ICD-9 Codes

- Primary Diagnostic Codes Only
- **-OR-**
- Primary and Secondary Diagnostic Codes
- **-OR-**
- Primary Diagnostic Code 1: 1.00-9.00, 558.9, 787.9

Operator Between Diagnostic 1 and 2-11

- OR
- AND

Secondary Diagnostic Codes 2-11

Select your date range:

Start Month / Day: January 01

End Month / Day: December 31

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

- [ ] 2007
- [x] 2008
- [x] 2009
- [x] 2010
- [x] 2011
- [x] 2012
- [ ] 2013

Pull records for the following counties or ZCTAs

- Counties: Alamance, Alexander, Alleghany, Anson, Ashe
- ZCTAs: 23322, 23323, 23434, 23437, 23438

CLIMATE

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

- [ ] Average Temperature
- [ ] Maximum Temperature
- [ ] Minimum Temperature
- [x] Precipitation
- [ ] Maximum Heat Index
- [ ] Minimum Wind Chill

Select antecedent weather periods:

- [ ] Precipitation Sums:
  - Day of ERV
  - Day Before ERV through Day of ERV
  - Day Before ERV
  - 3 Days Before ERV through Day of ERV
  - 6 Days Before ERV through Day of ERV
- [ ] Temperature Departures From Normal:
  - Day of ERV
  - 3 Days Before ERV through Day of ERV
  - 6 Days Before ERV through Day of ERV
  - 13 Days Before ERV through Day of ERV
  - 20 Days Before ERV through Day of ERV

Choose which station networks to include in the data retrieval:

- [x] ASOS
- [x] AWOS
- [x] ECONet
- [x] RAWS

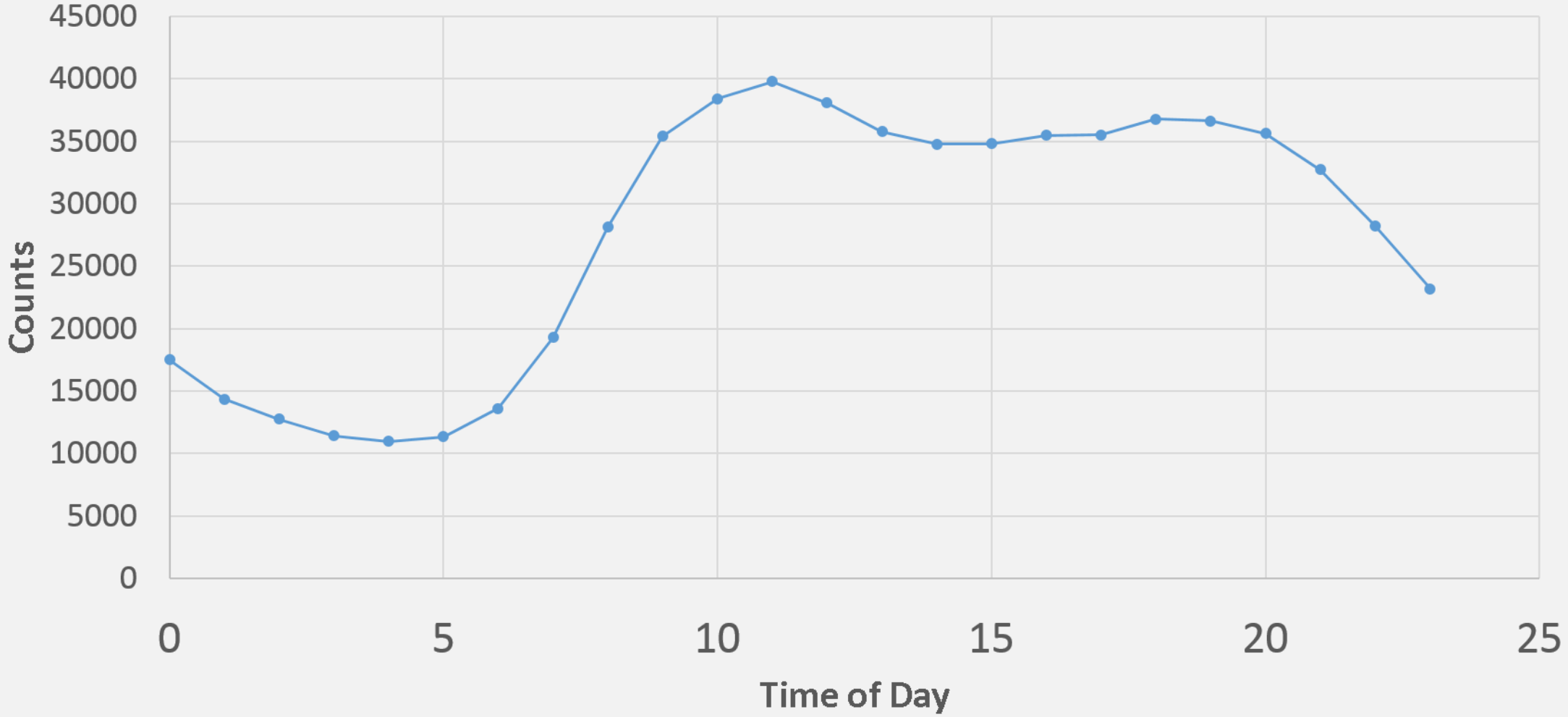
RETRIEVE DATA

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**



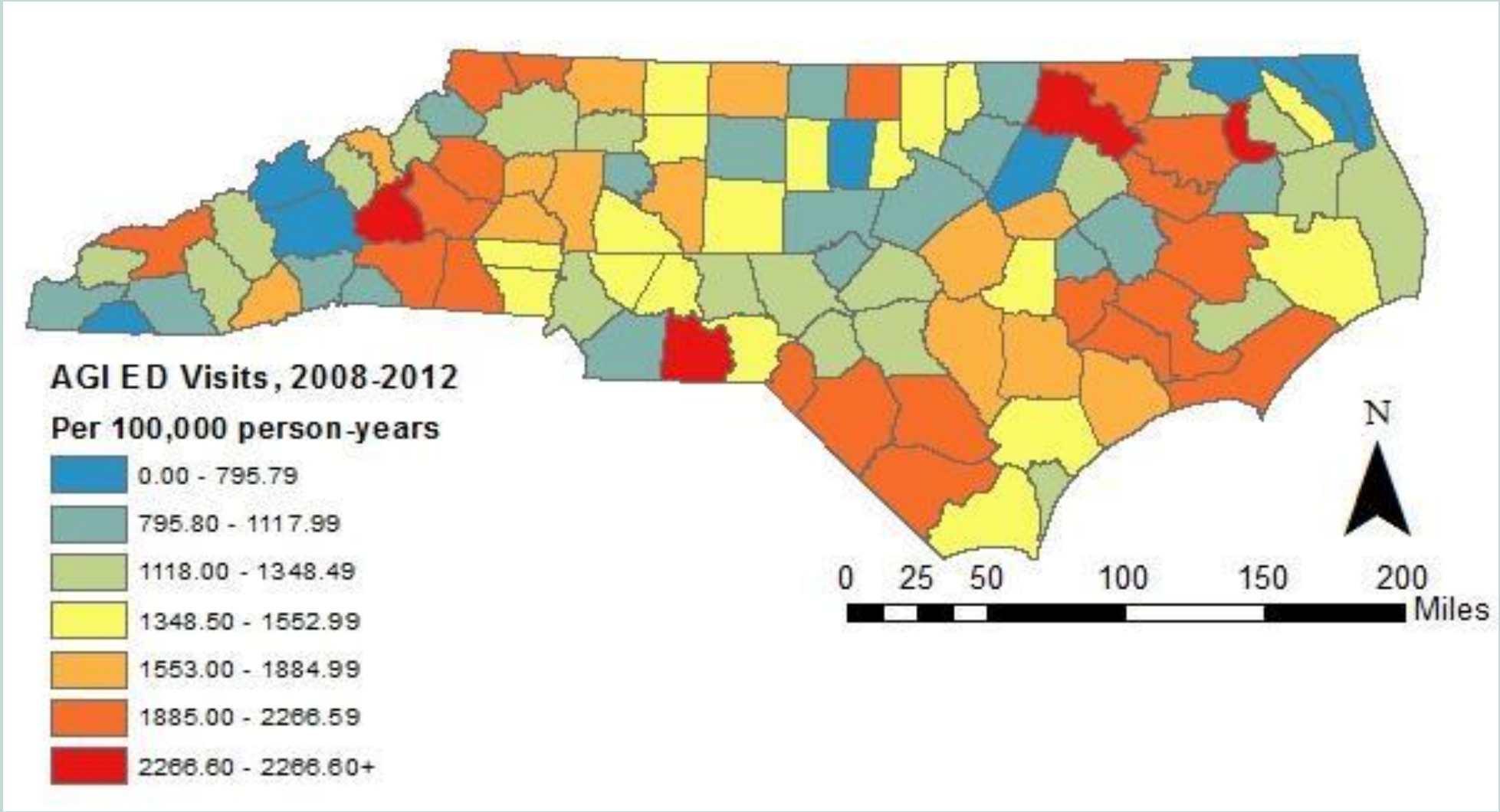
TOTAL COUNTS OF AGI IN NORTH CAROLINA FROM 2008-2012 BY **MONTH**

SPATIAL PATTERNS

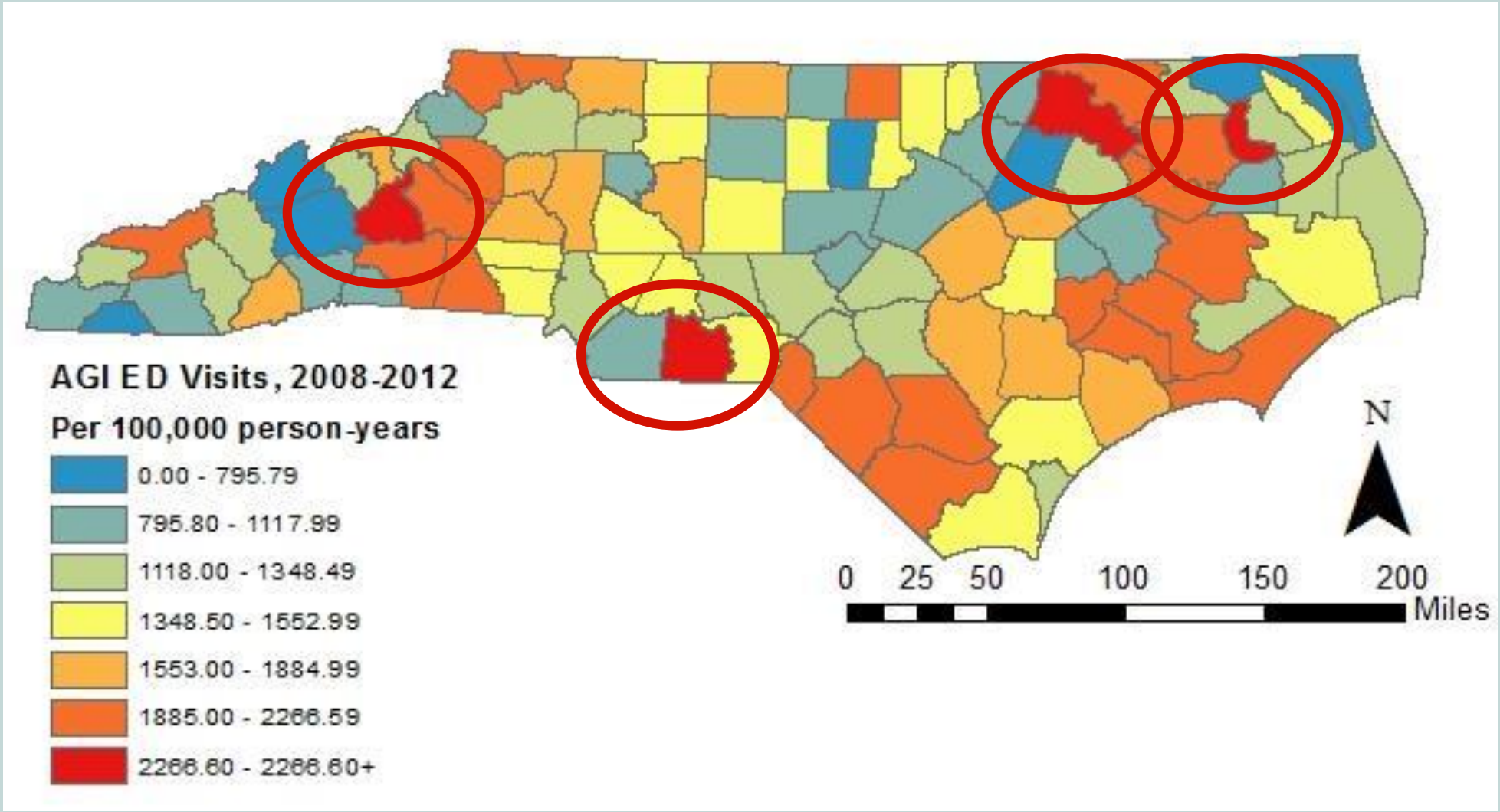
SPATIAL PATTERNS

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

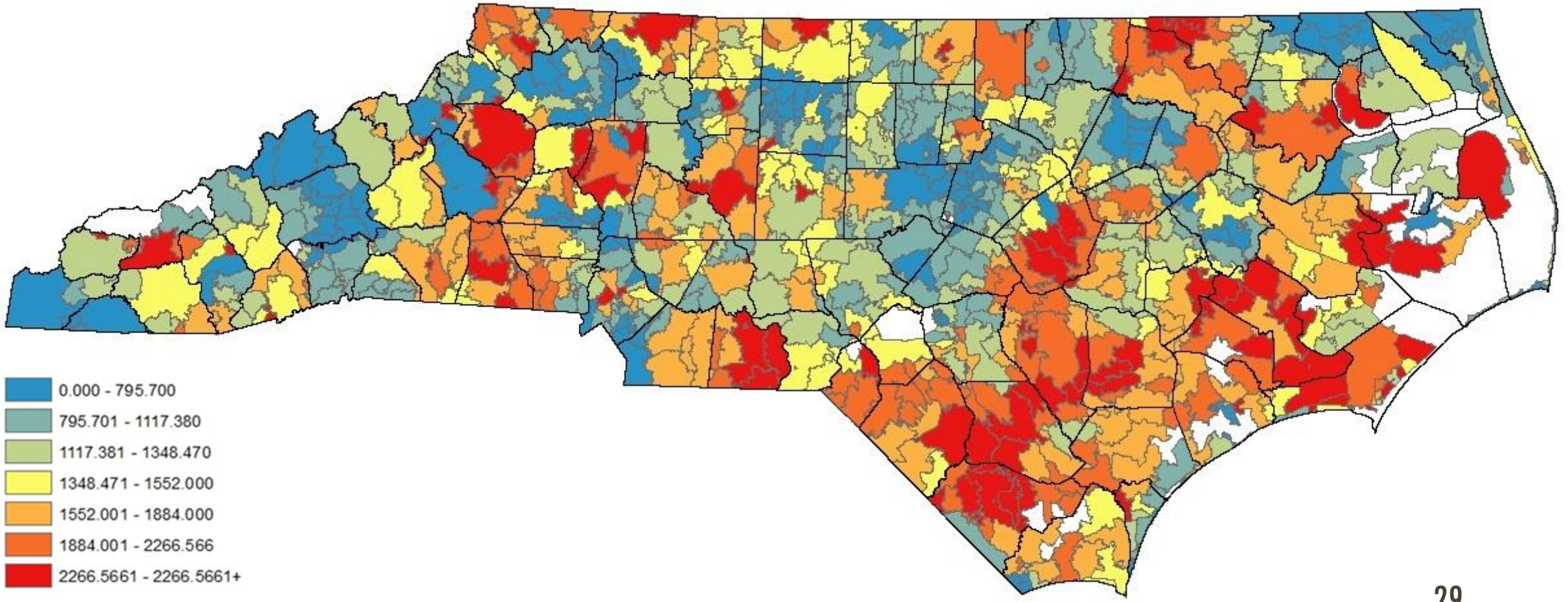
INCIDENCE OF AGI IN NORTH CAROLINA FROM 2008-2012 PER 100,000 PERSON-YEARS



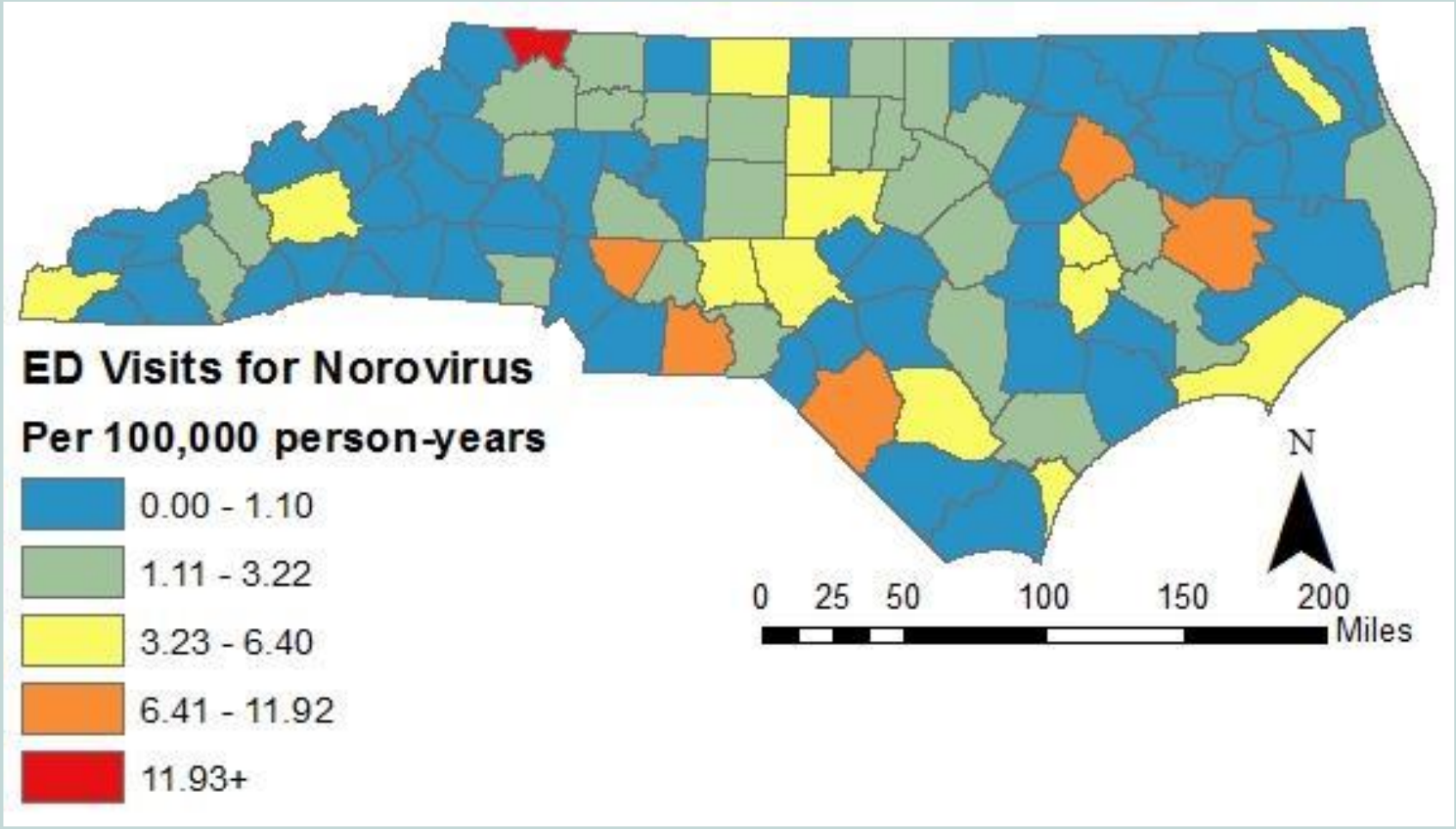
INCIDENCE OF AGI IN NORTH CAROLINA FROM 2008-2012 PER 100,000 PERSON-YEARS



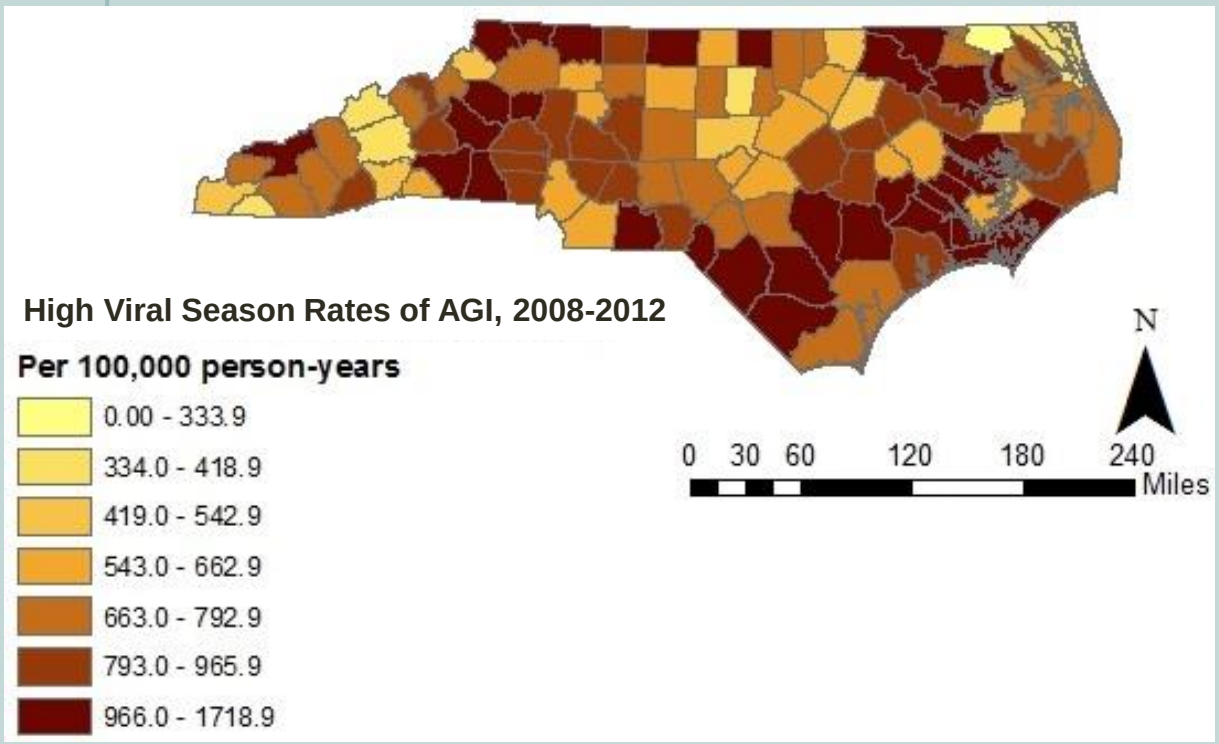
INCIDENCE OF AGI IN NORTH CAROLINA FROM 2008-2012 PER 100,000 PERSON-YEARS

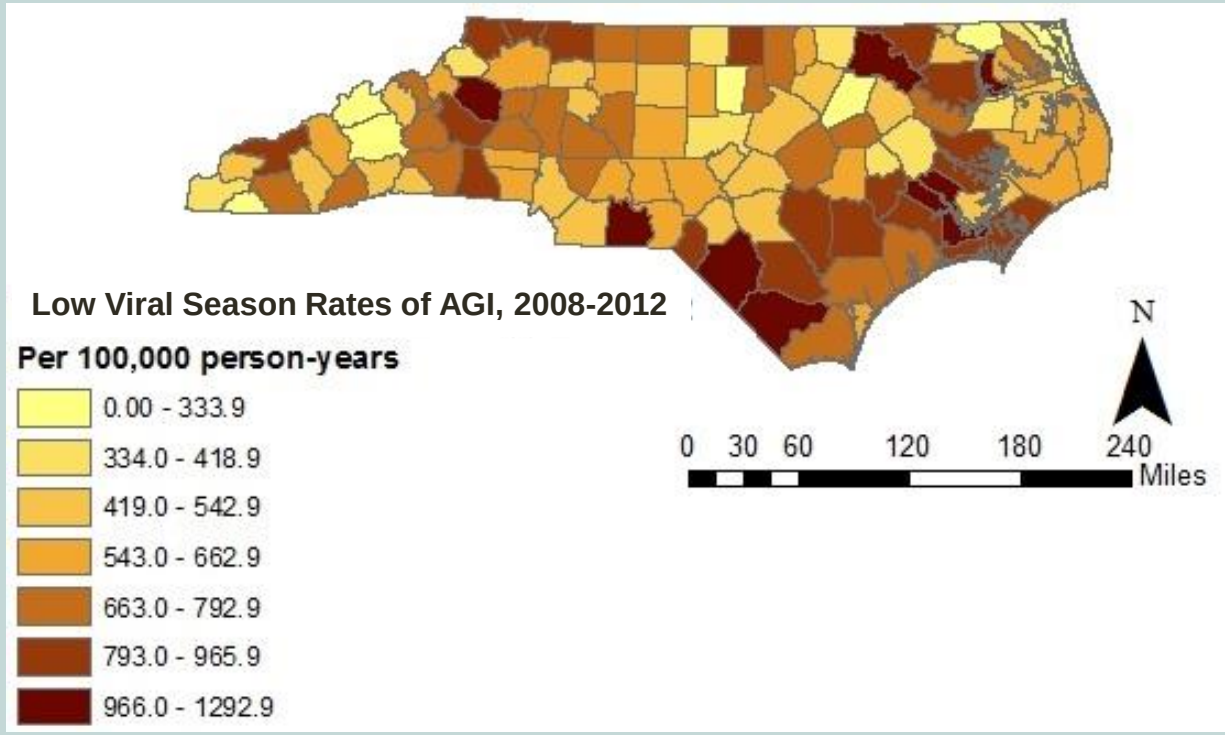


INCIDENCE OF NOROVIRUS ACROSS THE STATE OF NORTH CAROLINA FROM 2008-2012 PER 100,000 PERSON-YEARS



HIGH-VIRAL VS. LOW-VIRAL SEASON MAPS





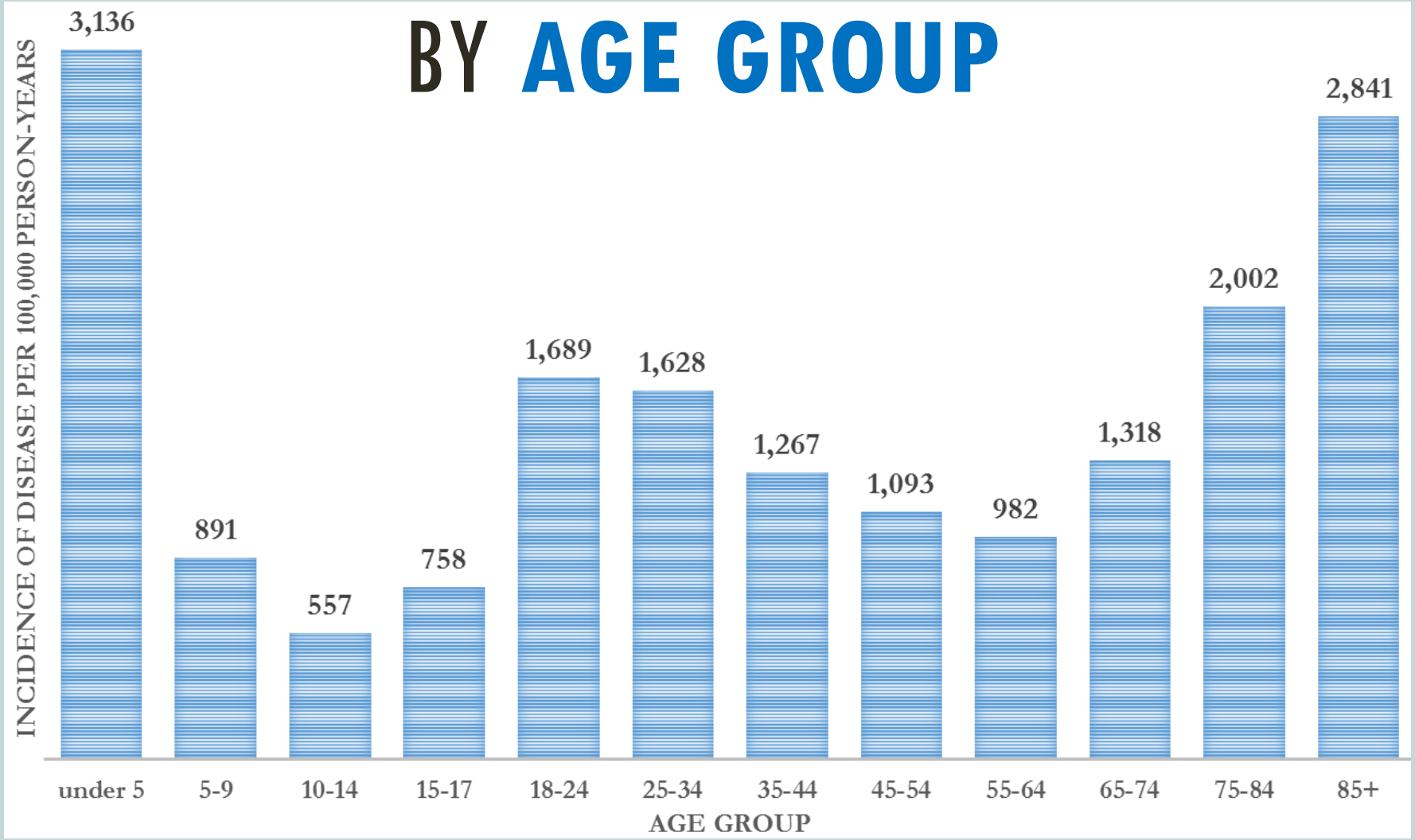
DEMOGRAPHIC PATTERNS:

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

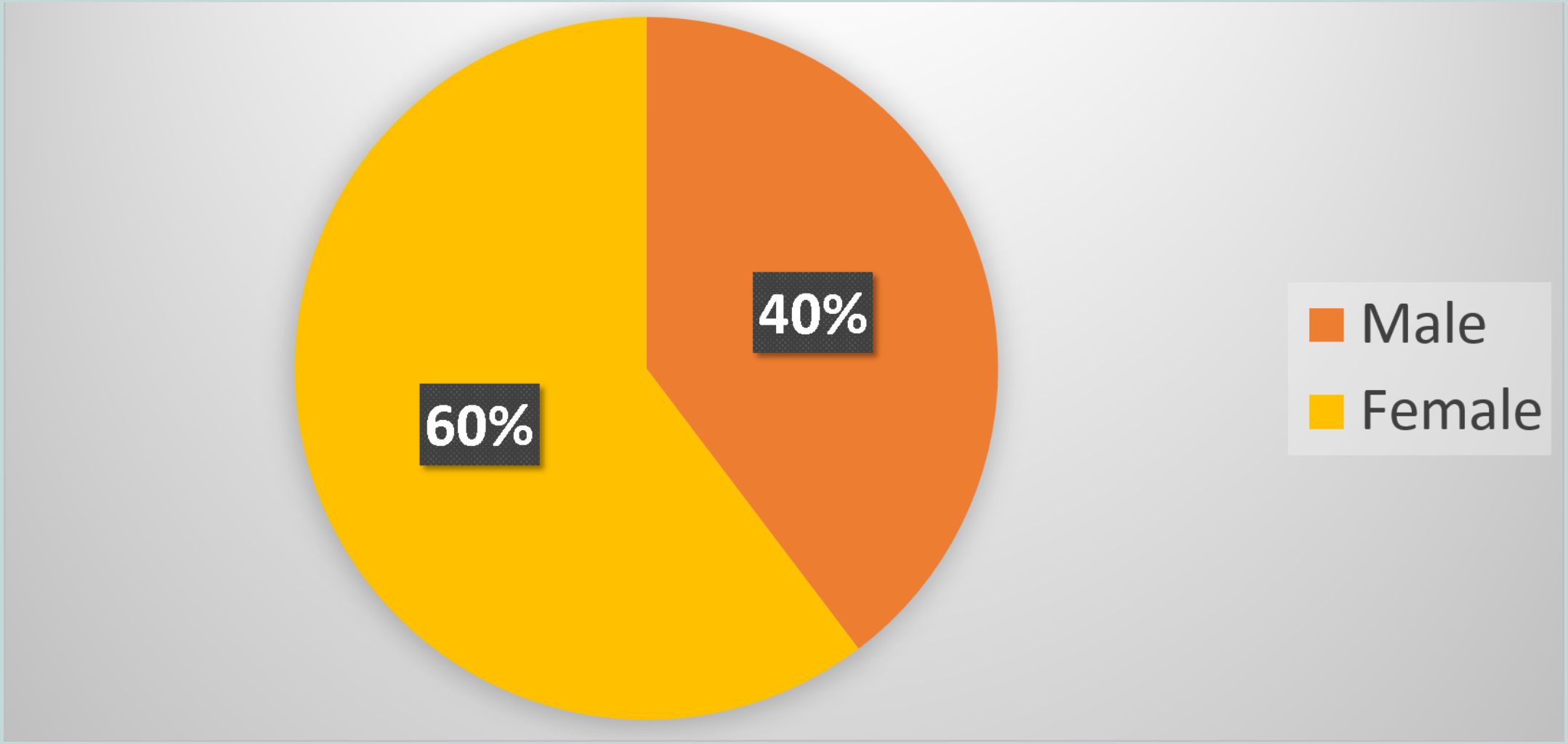
DEMOGRAPHIC PATTERNS:

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

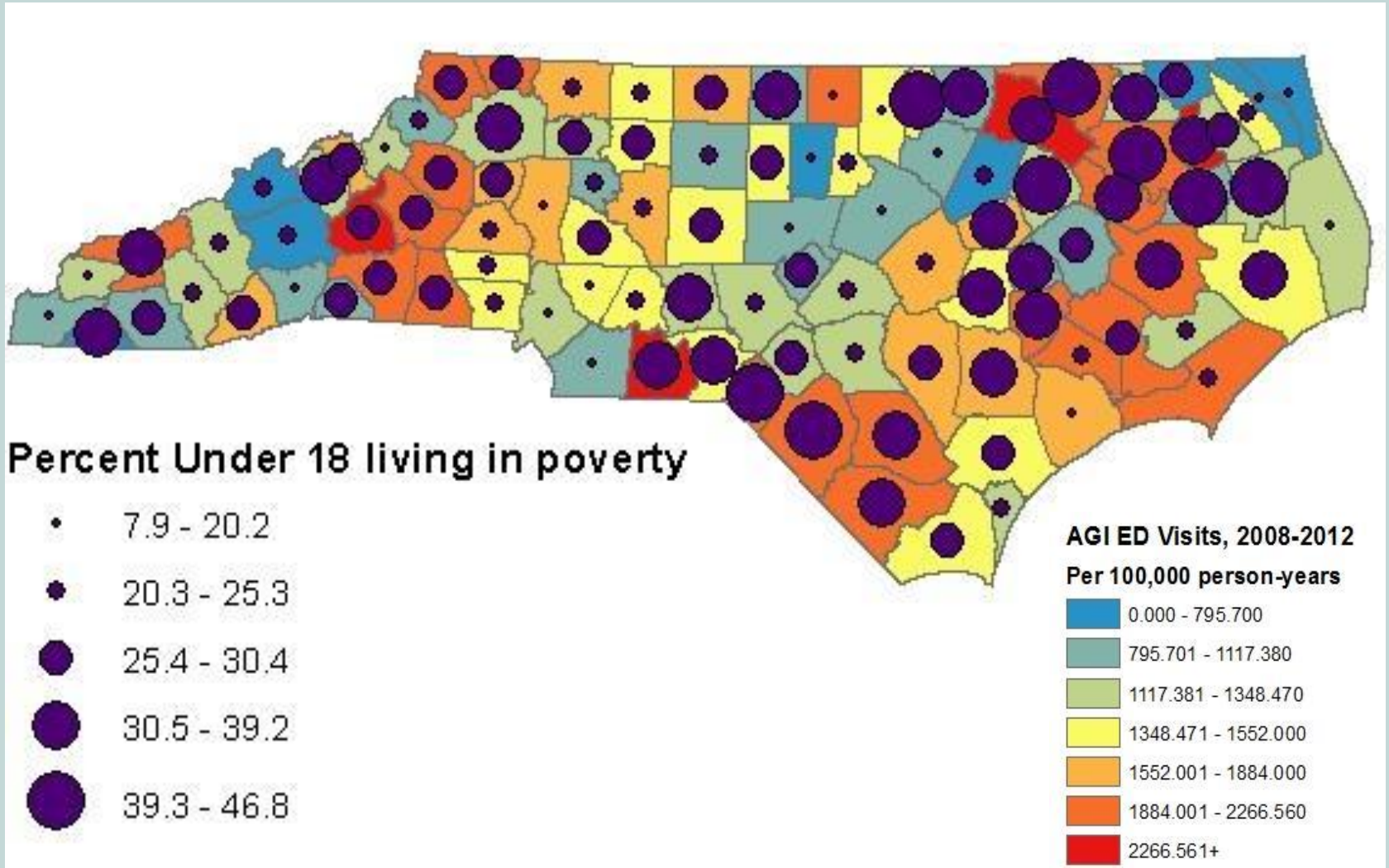
INCIDENCE OF AGI IN NORTH CAROLINA FROM 2008-2012 PER 100,000 PERSON-YEARS BY AGE GROUP



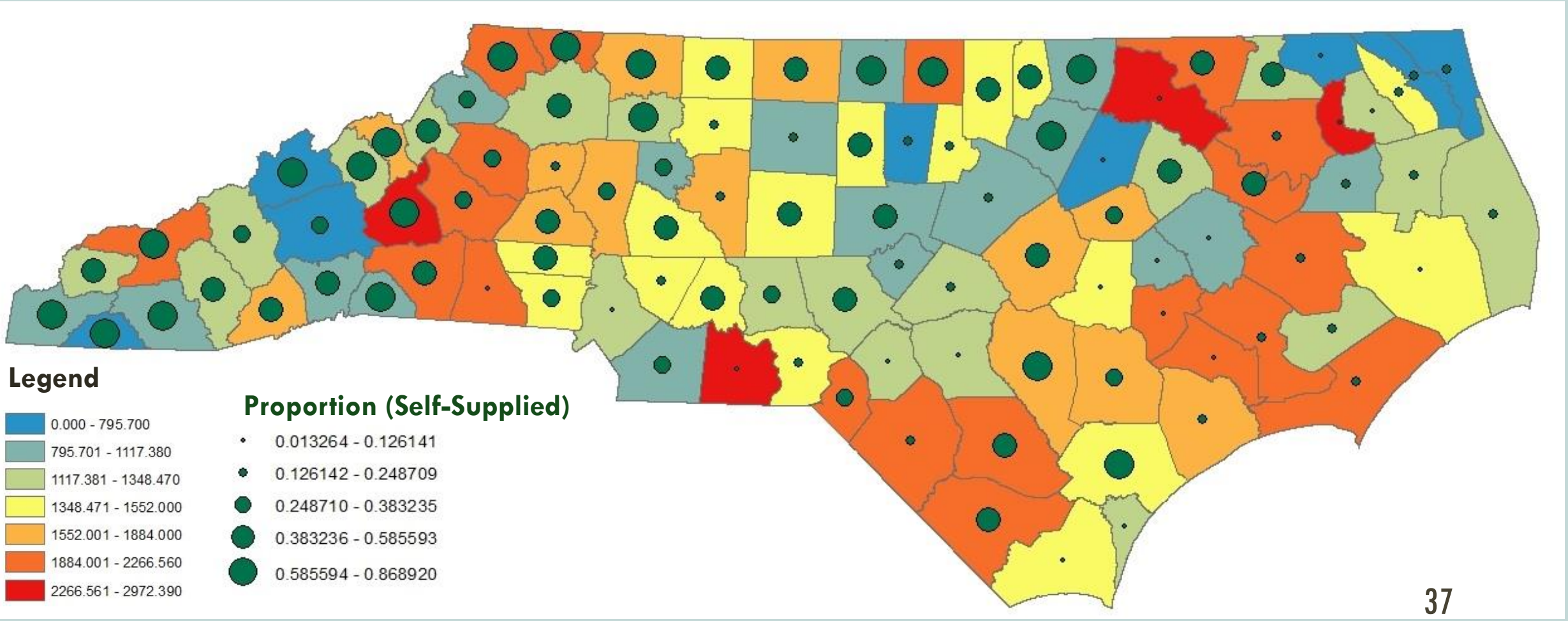
RATIO OF AGI IN NORTH CAROLINA FROM 2008-2012 BY SEX



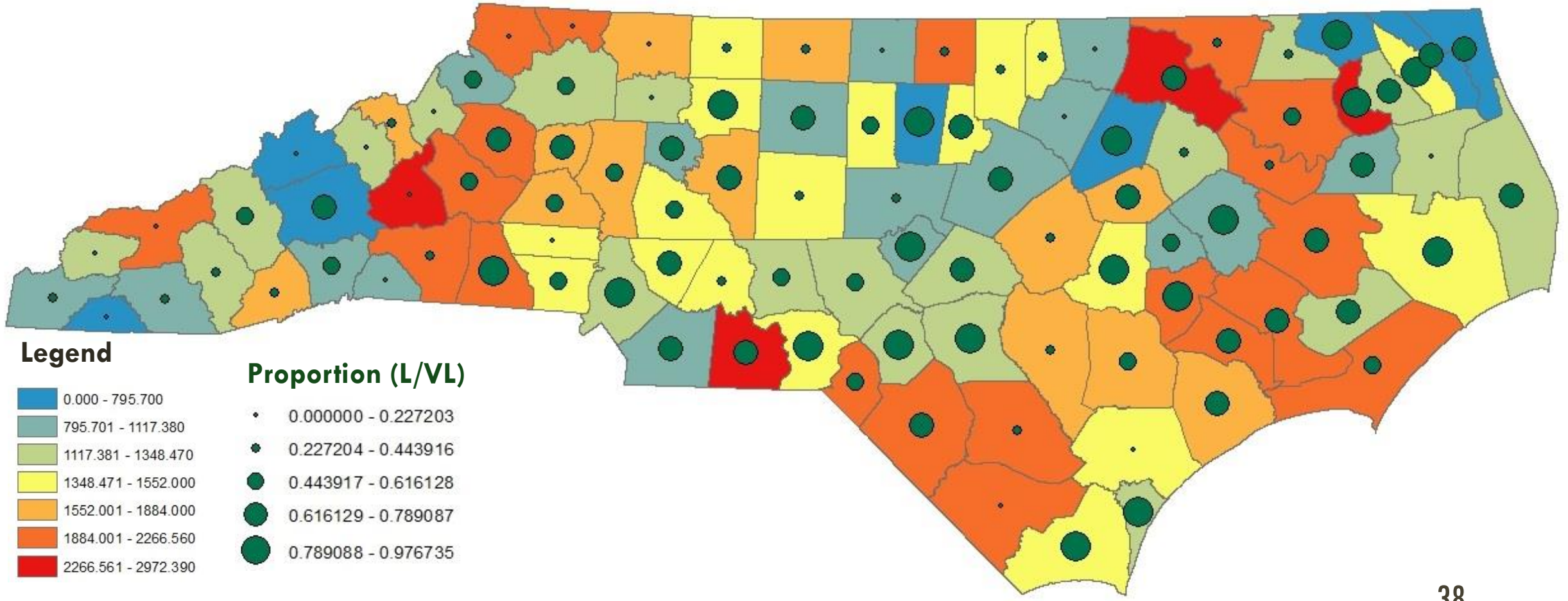
INCIDENCE OF AGI IN NORTH CAROLINA FROM 2008-2012 PER 100,000 PERSON-YEARS AS SHOWN WITH % OF POPULATION UNDER 18 LIVING IN POVERTY



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

LARGE CORRELATION MATRIX, ALL DATA

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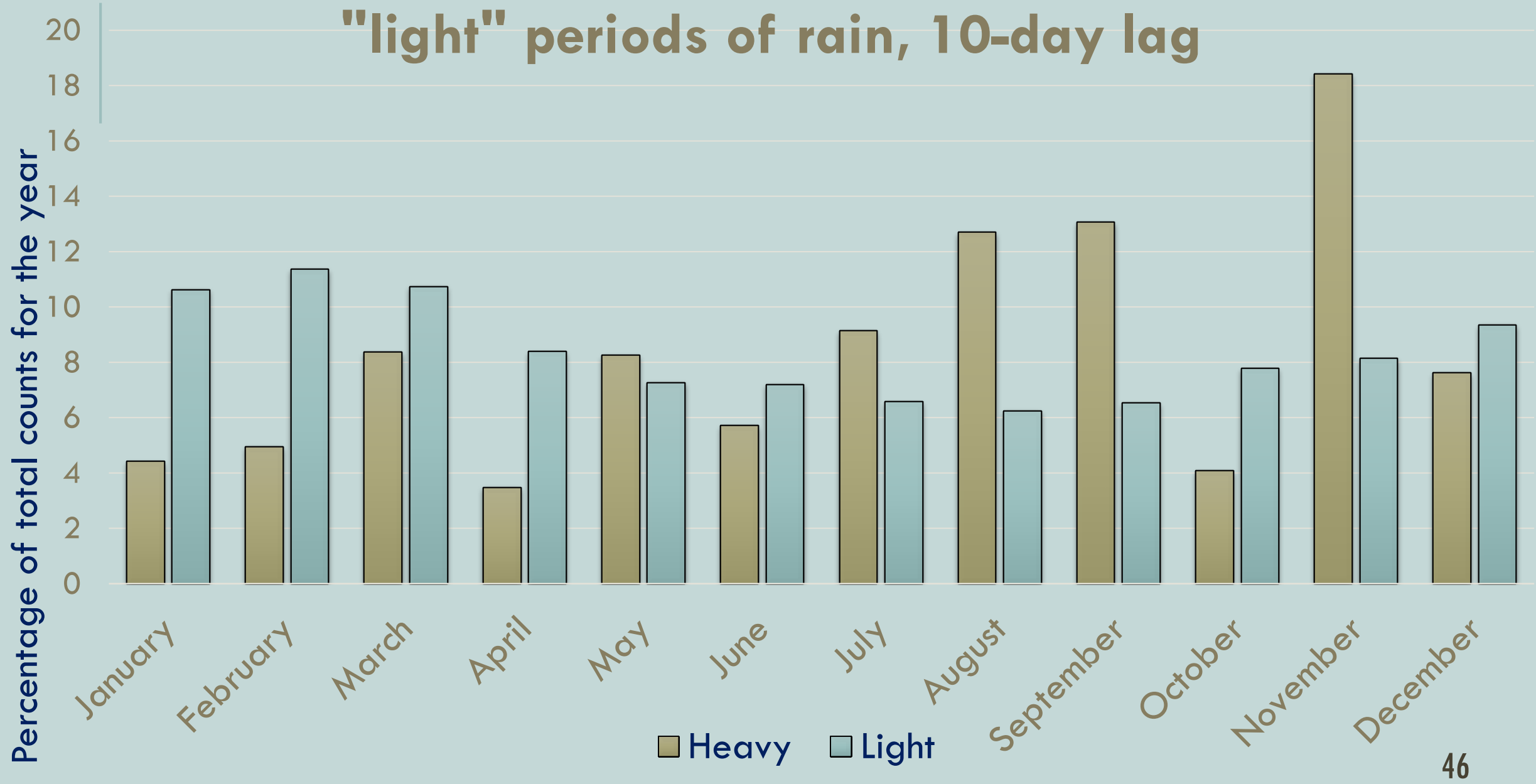
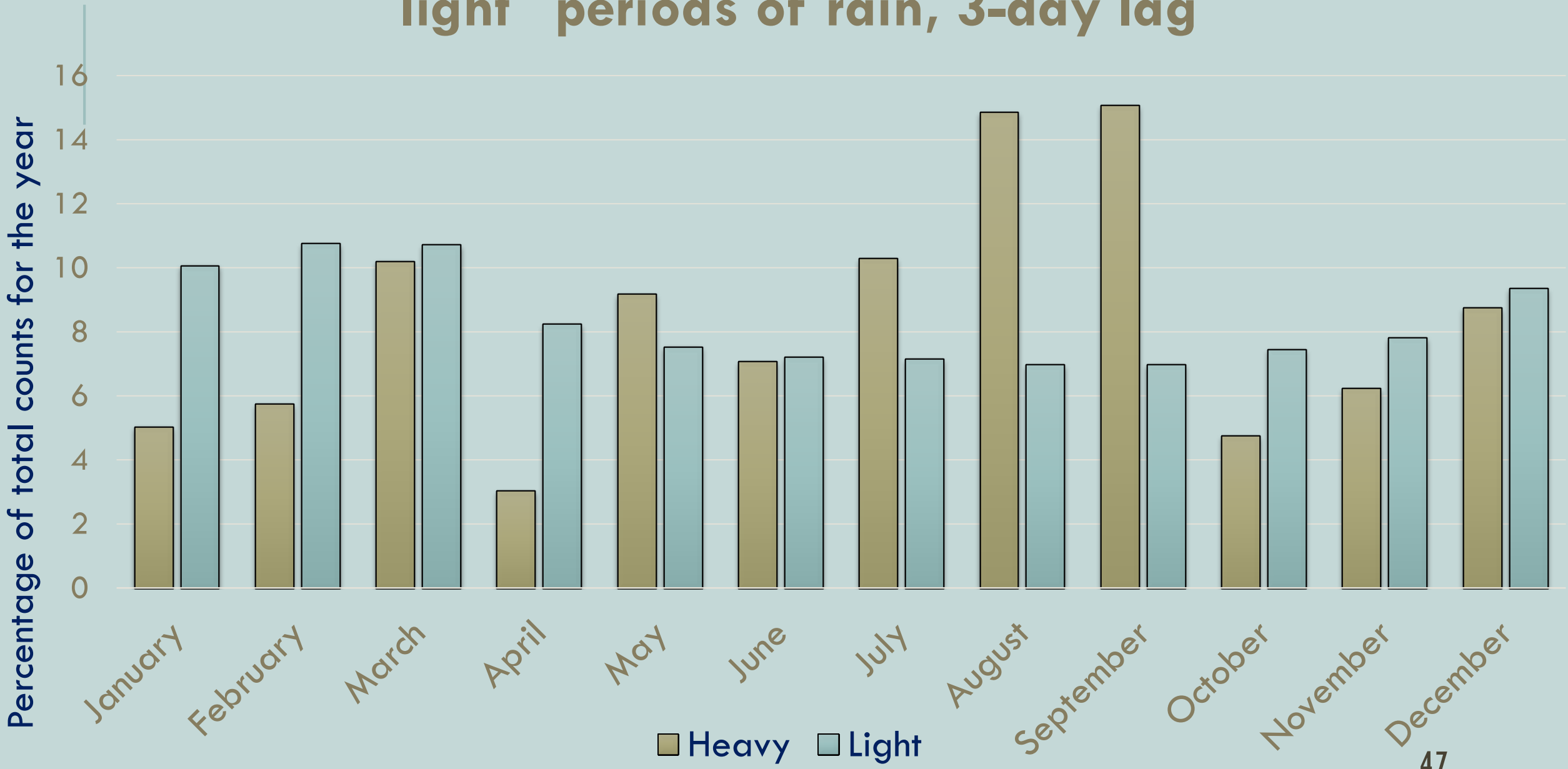
PRECIPITATION PATTERNS

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



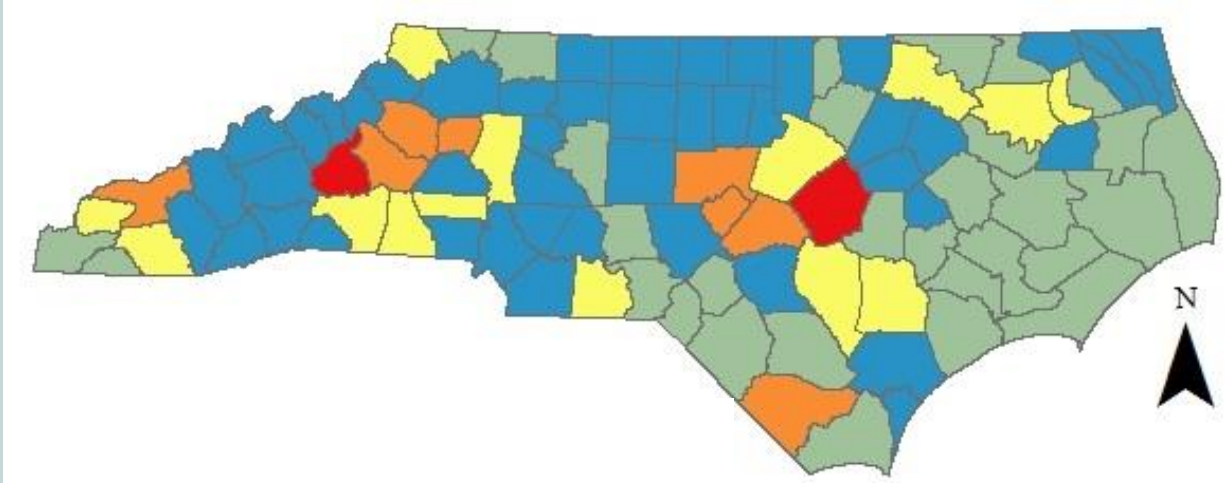
Monthly signal for ED visits after "heavy" and "light" periods of rain, 3-day lag



PRECIPITATION PATTERNS, 3-DAY LAG

3-day lag, "light" precipitation

3-day lag, "heavy" precipitation



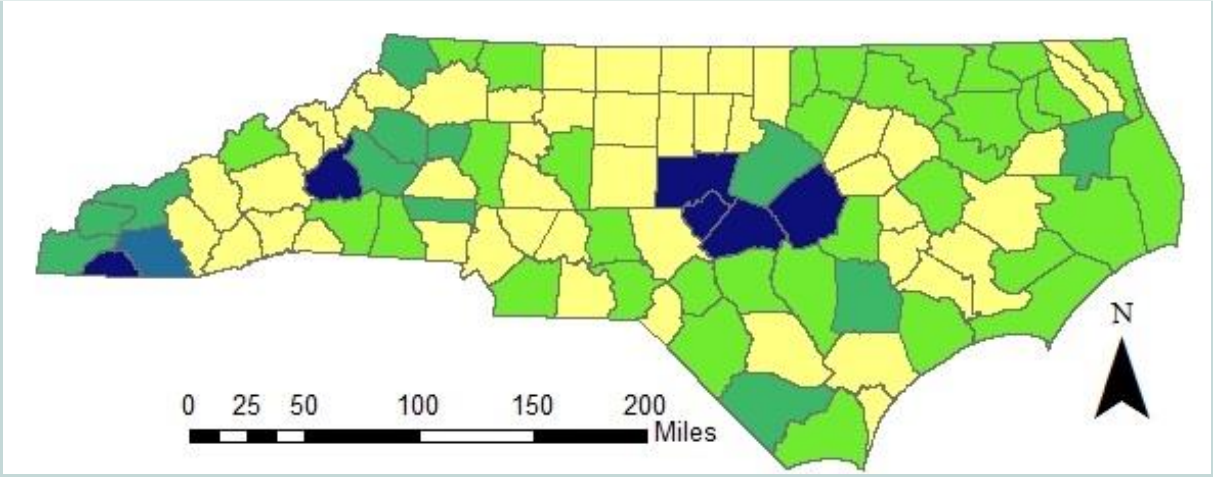
Average number of admissions per day per 100,000 person-years

- 1.11 - 3.89
- 3.90 - 6.99
- 7.00 - 11.49
- 11.50 - 20.27
- 20.28 - 31.10

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

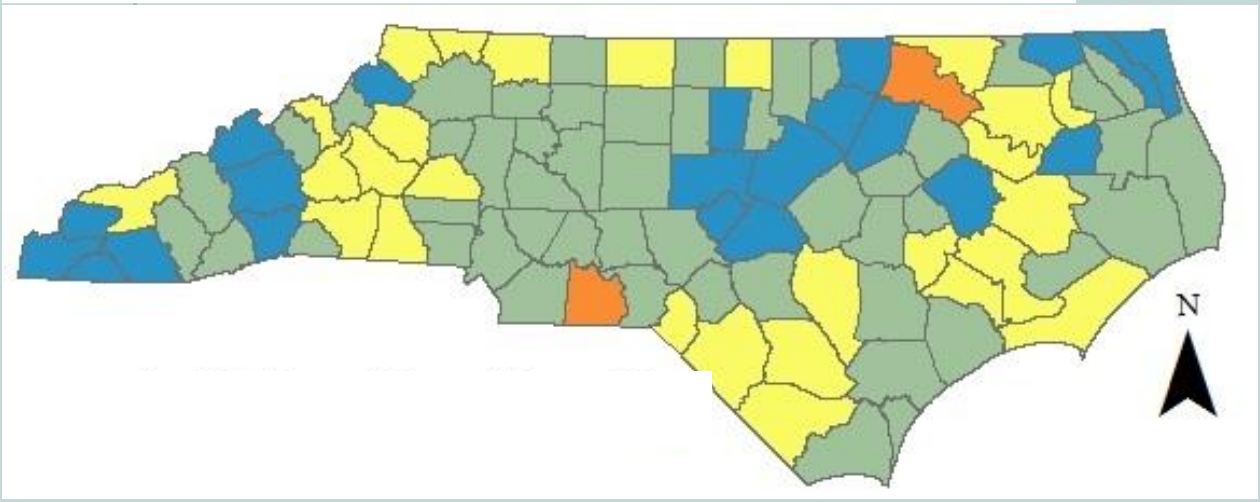
Proportional difference values in the two rates

- 0.21 - 0.99
- 1.00 - 1.99
- 2.00 - 2.99
- 3.00 - 3.99
- 4.00 - 6.71

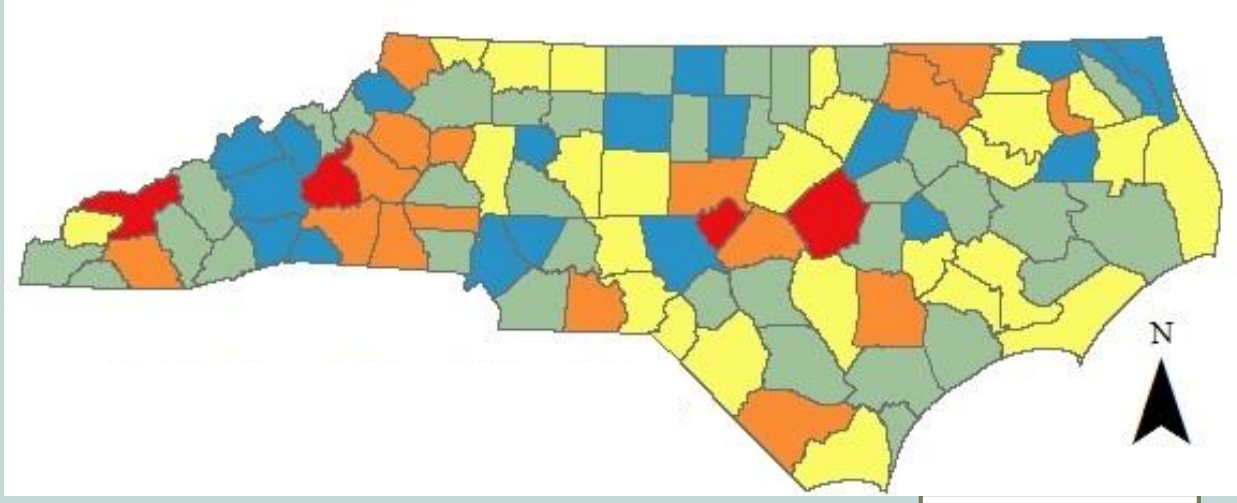


PRECIPITATION PATTERNS, 10-DAY LAG

10-day lag, "light" precipitation



10-day lag, "heavy" precipitation



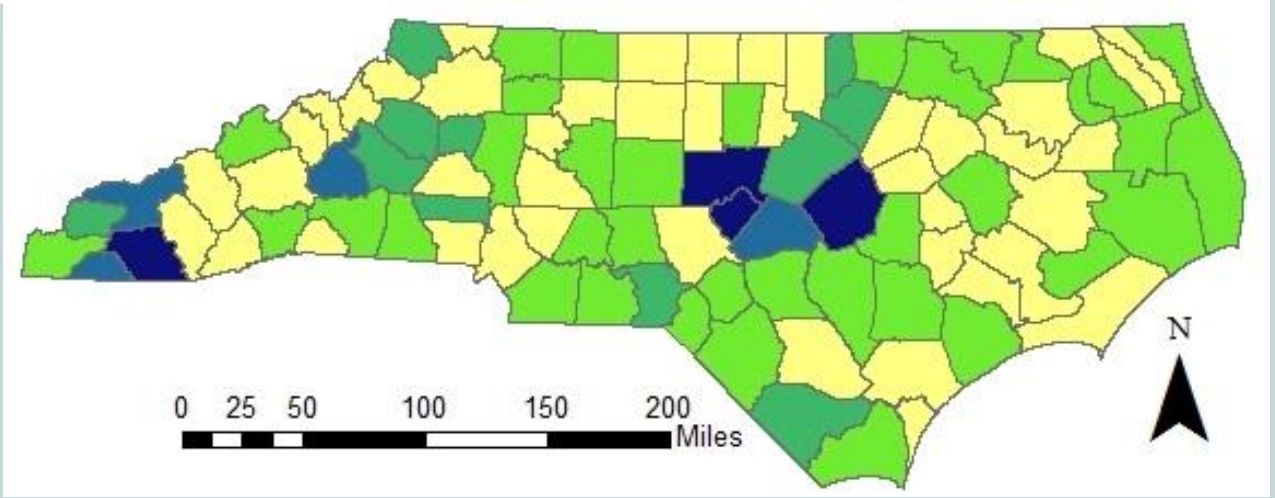
Average number of admissions per day per 100,000 person-years

- 1.10 - 2.82
- 2.83 - 4.64
- 4.65 - 7.68
- 7.69 - 13.87
- 13.88 - 21.05

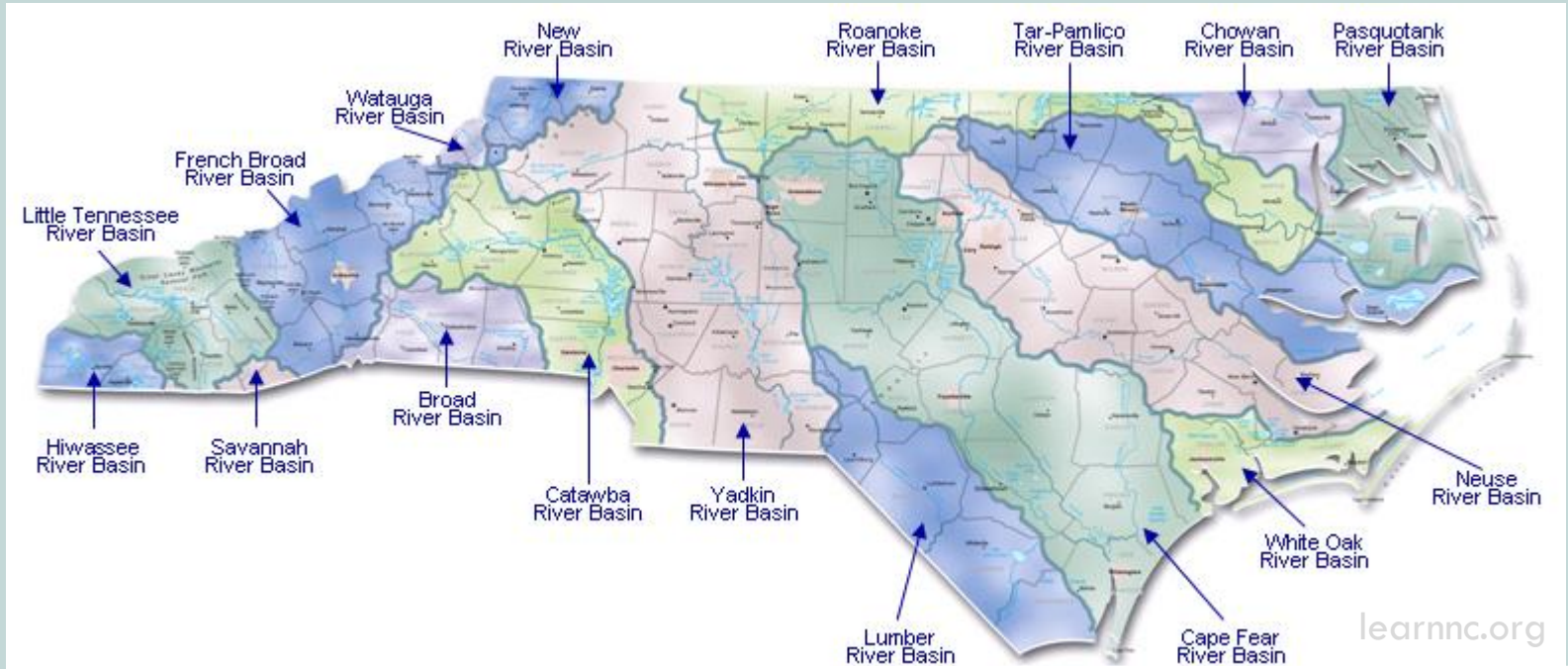
10-day lag, proportional difference: "heavy" divided by "light"

Proportional difference values in the two rates

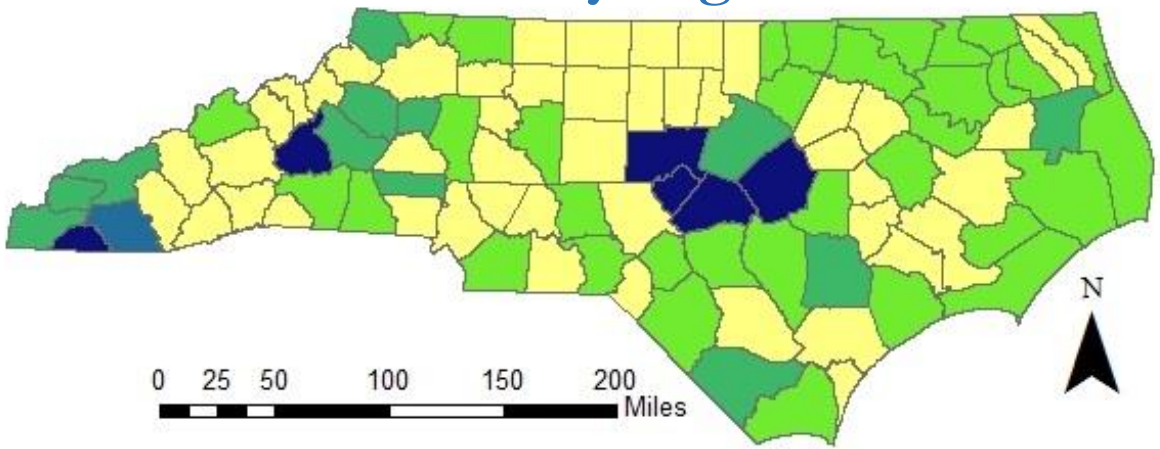
- 0.21 - 0.99
- 1.00 - 1.99
- 2.00 - 2.99
- 3.00 - 3.99
- 4.00 - 6.71



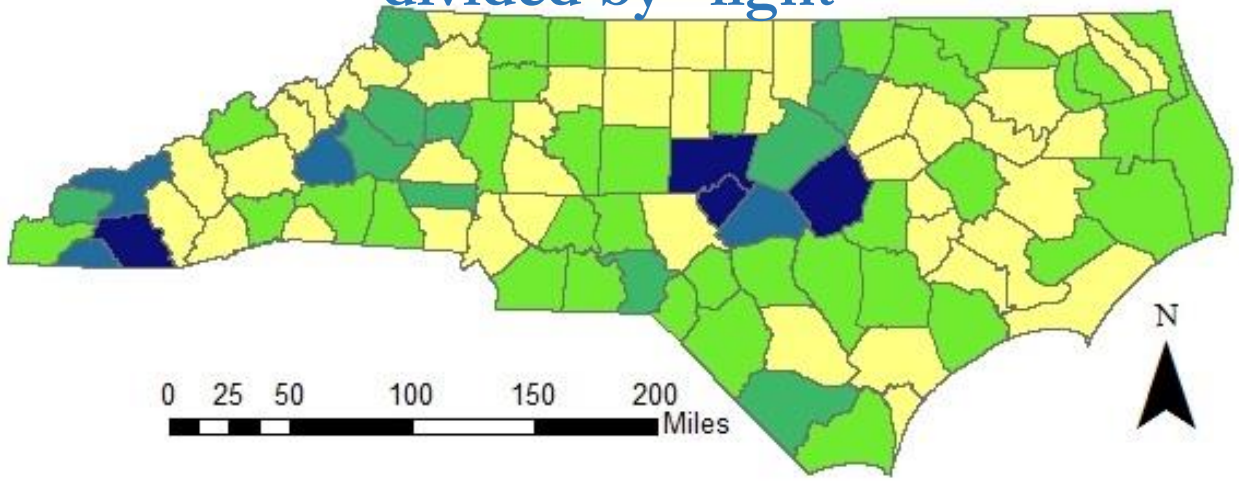
NORTH CAROLINA RIVER BASINS



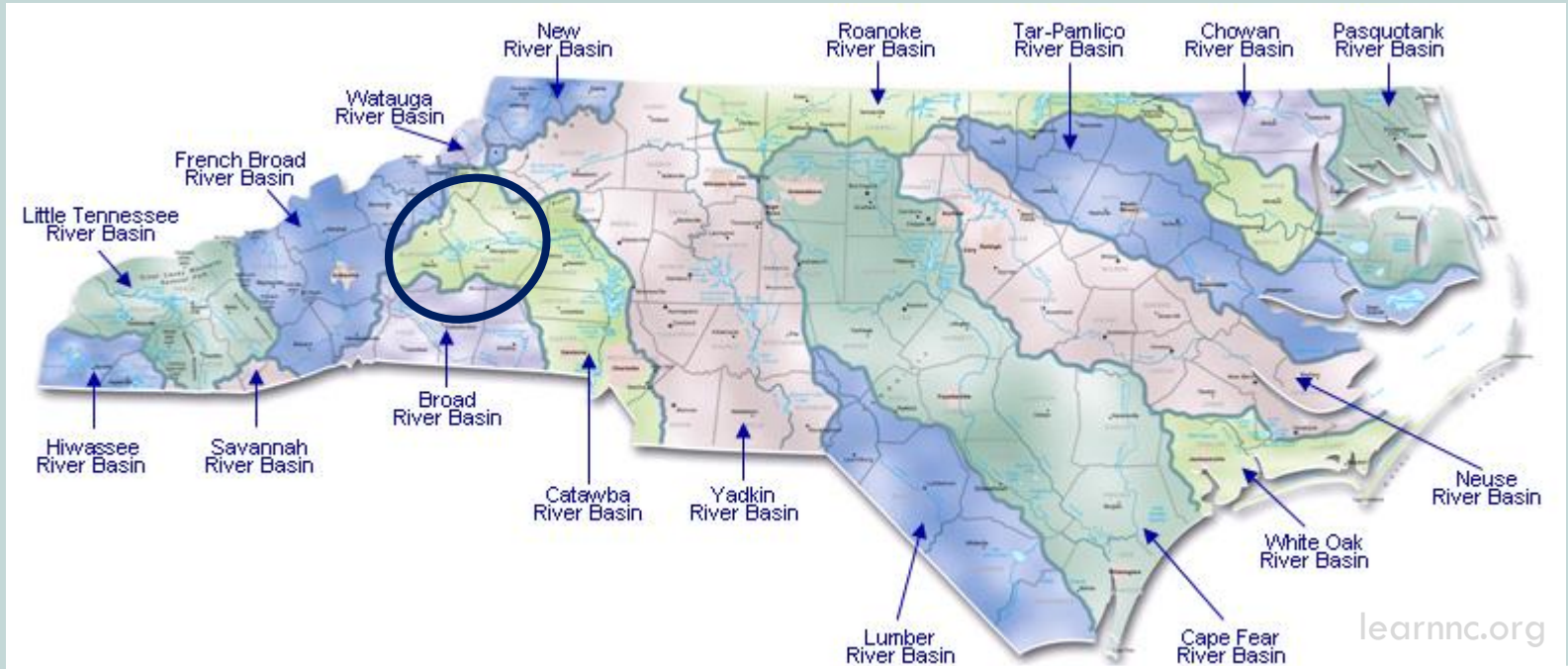
3-day lag, proportional difference: "heavy" divided by "light"



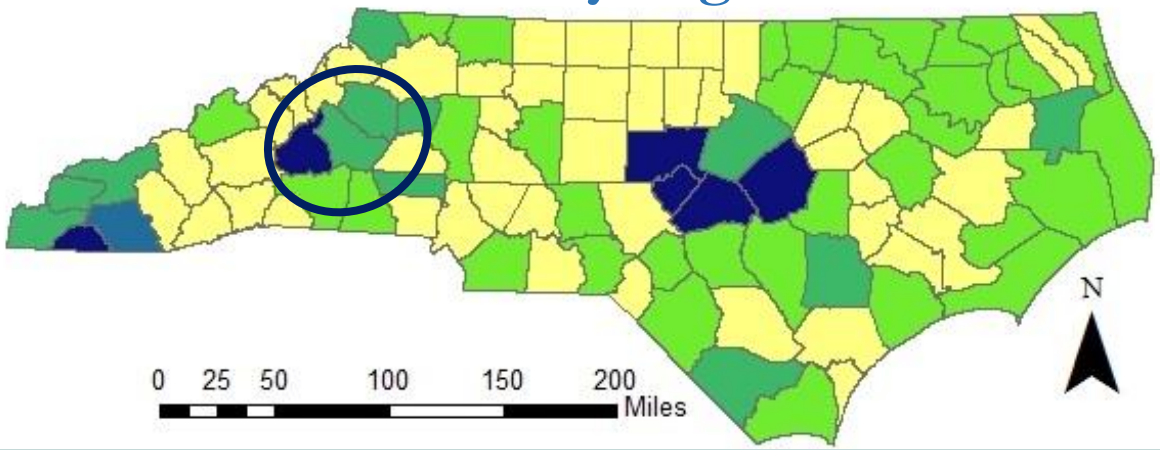
10-day lag, proportional difference: "heavy" divided by "light"



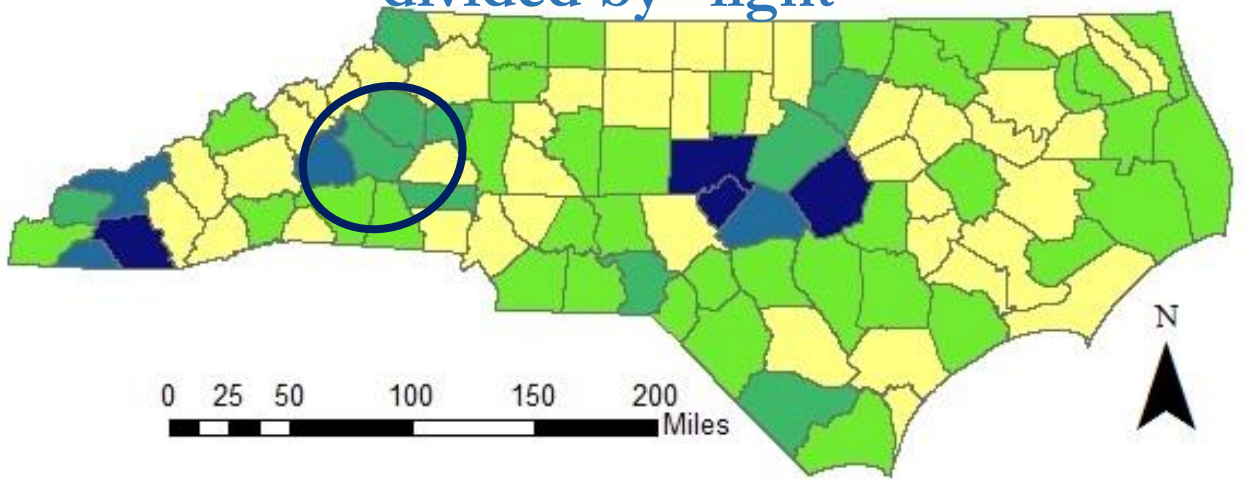
NORTH CAROLINA RIVER BASINS



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



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



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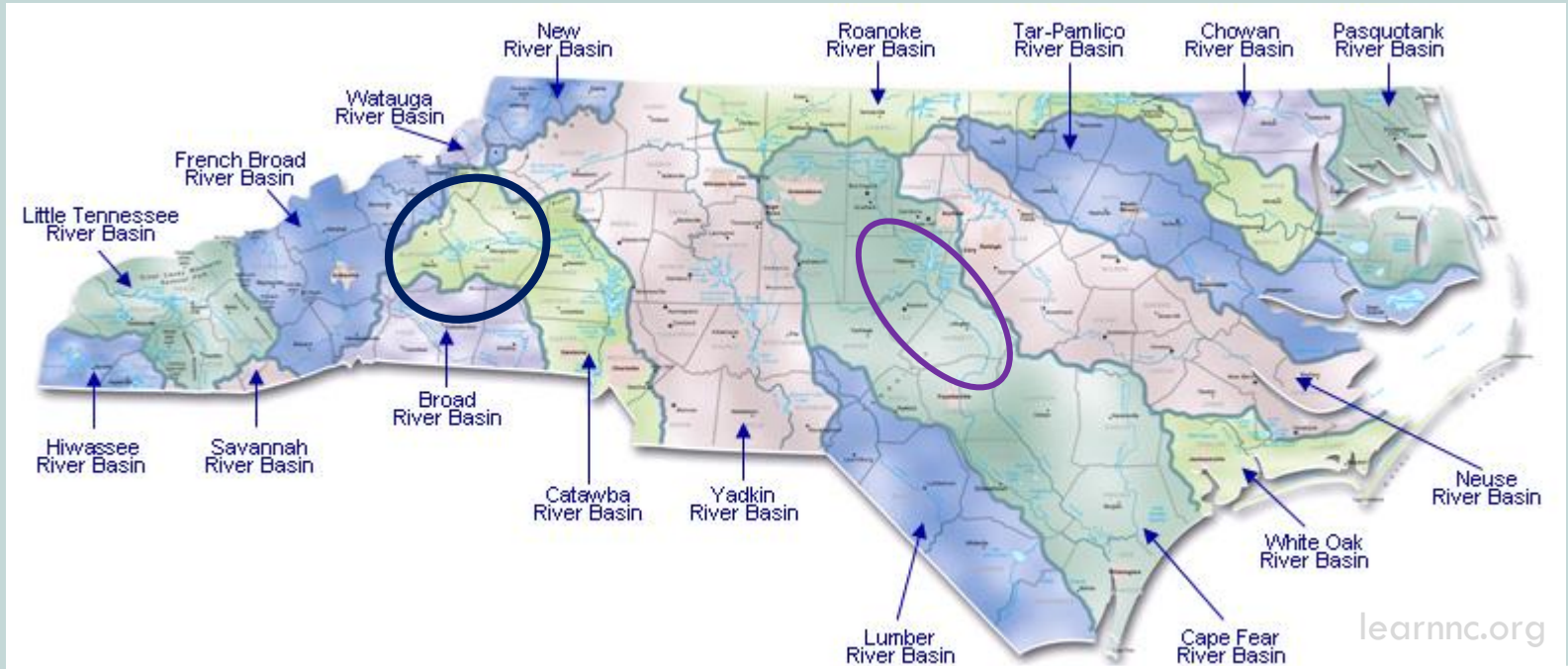

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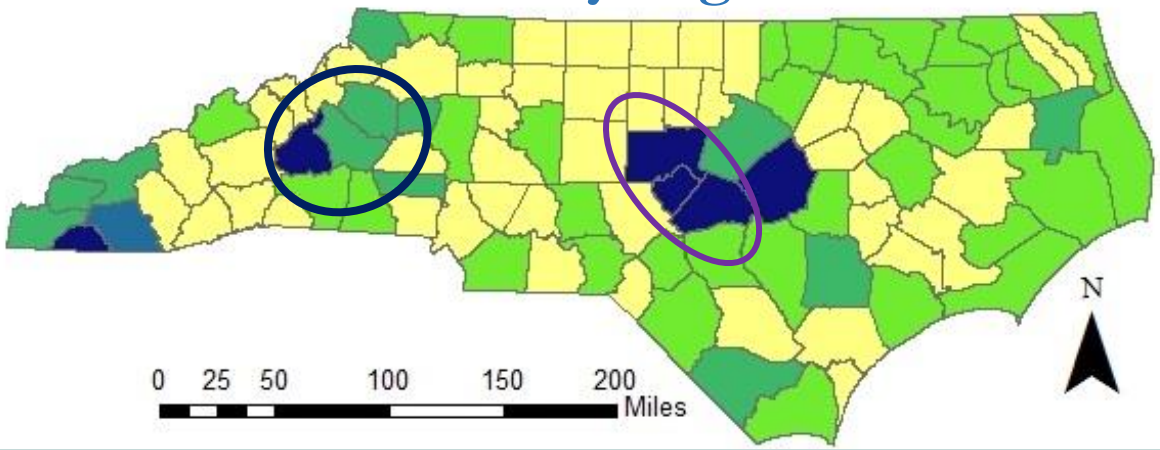
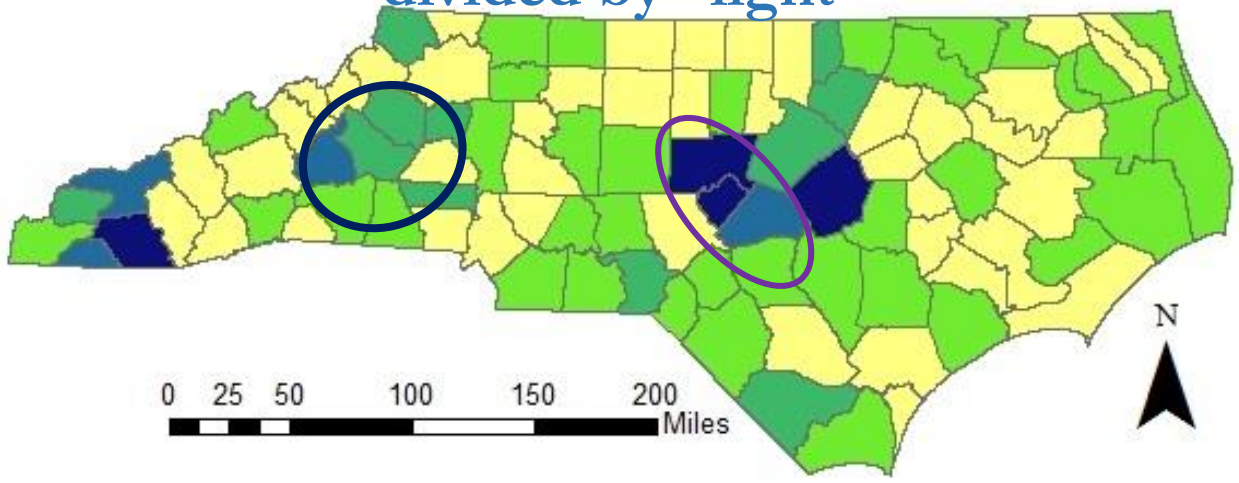
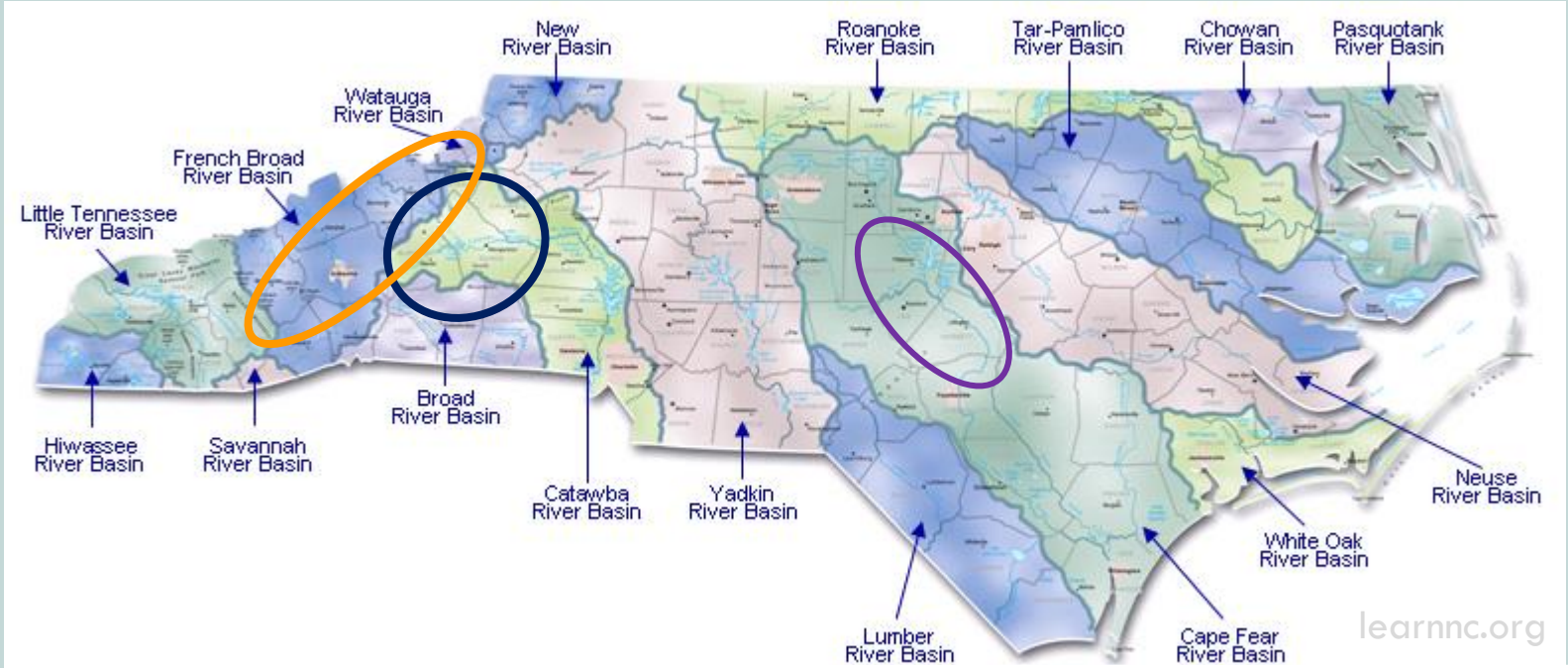


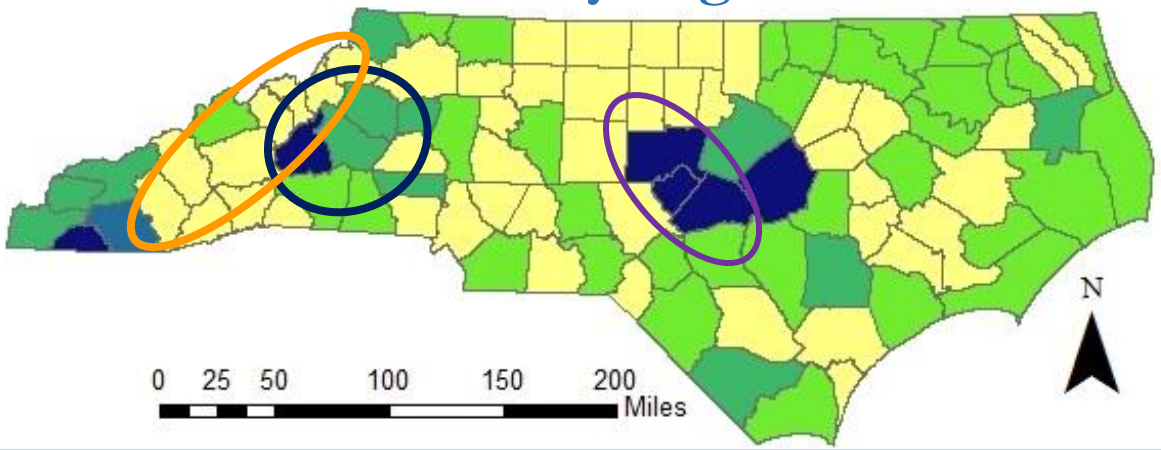
10-day lag, proportional difference: "heavy" divided by "light"



NORTH CAROLINA RIVER BASINS



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



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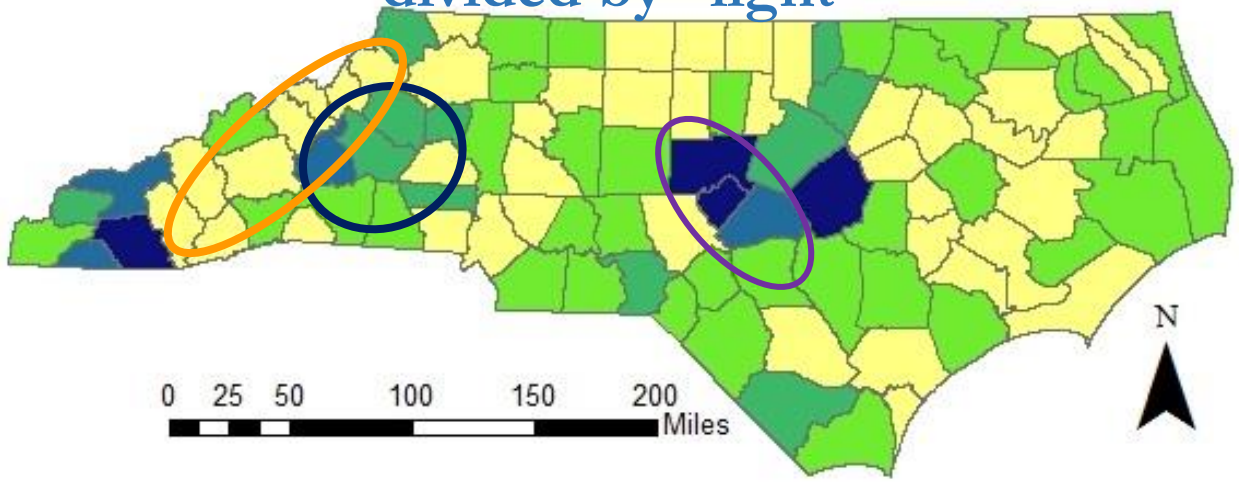

CONCLUSIONS

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!

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