Air Pollution and Environmental Justice Modeling: The Case of North Carolina's Concentrated Animal Feeding Operations (CAFOs) Hog Industry

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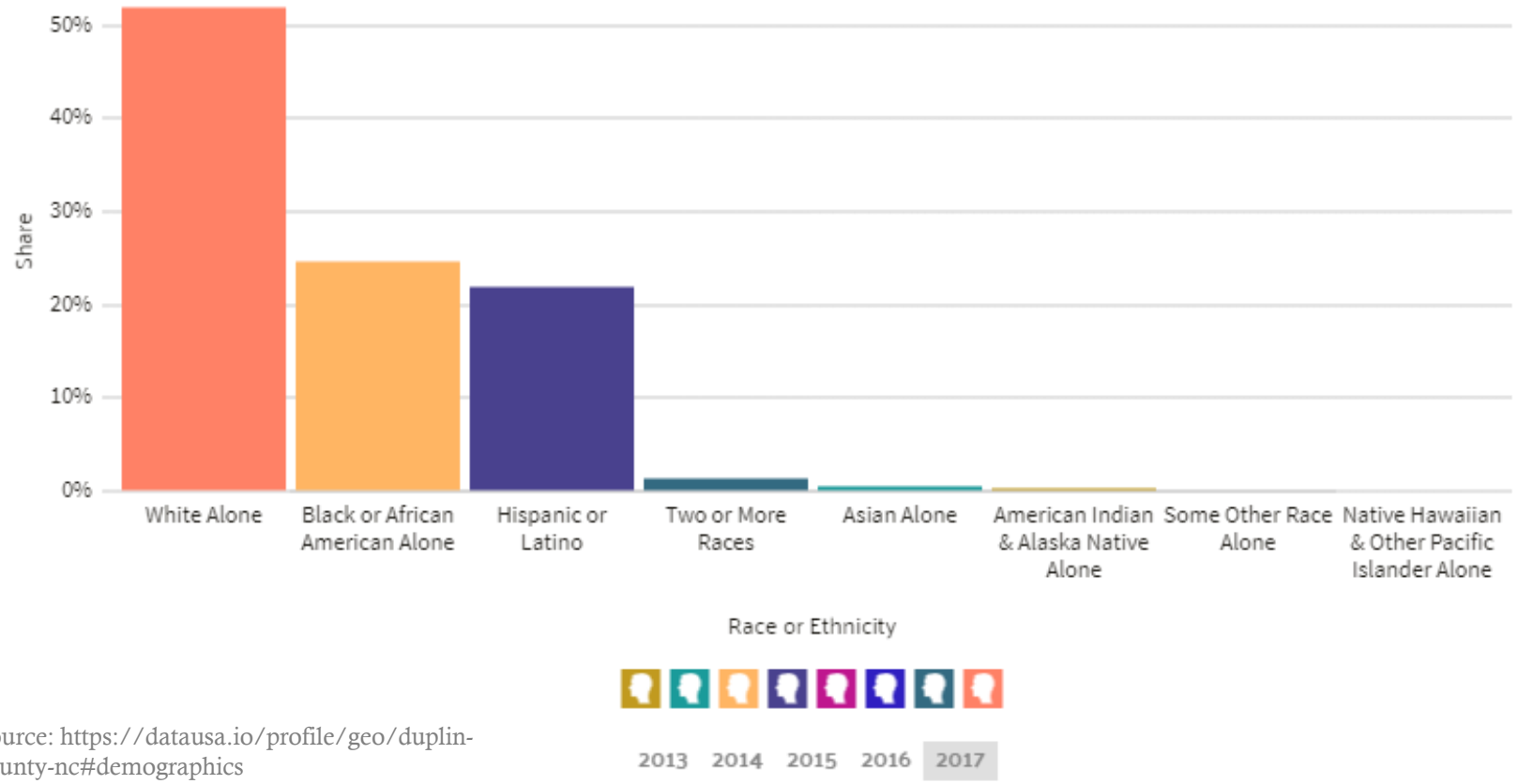
Brief History of North Carolina Swine

- Shift from traditional farms to CAFOs
- Passage of legislation in the 1970s- Murphy's laws
- North Carolina went from 15th to 2nd (after Iowa) in hog production between the mid-1980s and mid-1990s
- Today, North Carolina hog herd around 9-10 million animals
- By 1997, 95% of hog farms located in the eastern counties of the coastal plain

Duplin Race/Ethnicity (2017)



The following bar chart shows the 8 races and ethnicities represented in Duplin County, NC as a share of the total population

Source: https://datausa.io/profile/geo/duplin-county-nc#demographics

The Problems

Significant Emissions of Ammonia, Hydrogen Sulfide, and Volatile Organic Compounds

- Formation of PM

- Health effect and premature death from PM

Exposure to pollutants

- Adverse Health Effects: ability to cause respiratory ailments and eye irritation

-Lower Quality of Life: odor detection, psychological effects (tension, depression, anger, fatigue)

- Public spaces- parks, schools, roads

The Problems

Disruption of local economy

- agricultural operations often remove a higher percentage of funds from rural communities unlike when this industry is dominated by privately owned operations

-Decrease of property values

A Clustering of rural communities

- Low income/ Minority

People of color and the poor living in rural communities having to bear the potential burden of dealing with socio-economic, environmental, or health related effects of swine waste externalities

Methods

We use the Human Exposure Model (HEM-3) to estimate ambient concentrations of ammonia and hydrogen sulfide, human exposures, and health risks from CAFOs within Duplin County.

We combine this with EJ Census (2010) demographic data (block groups) to investigate whether exposures to these pollutants differ by race/ethnicity, age, income, linguistic isolation, and education attainment.

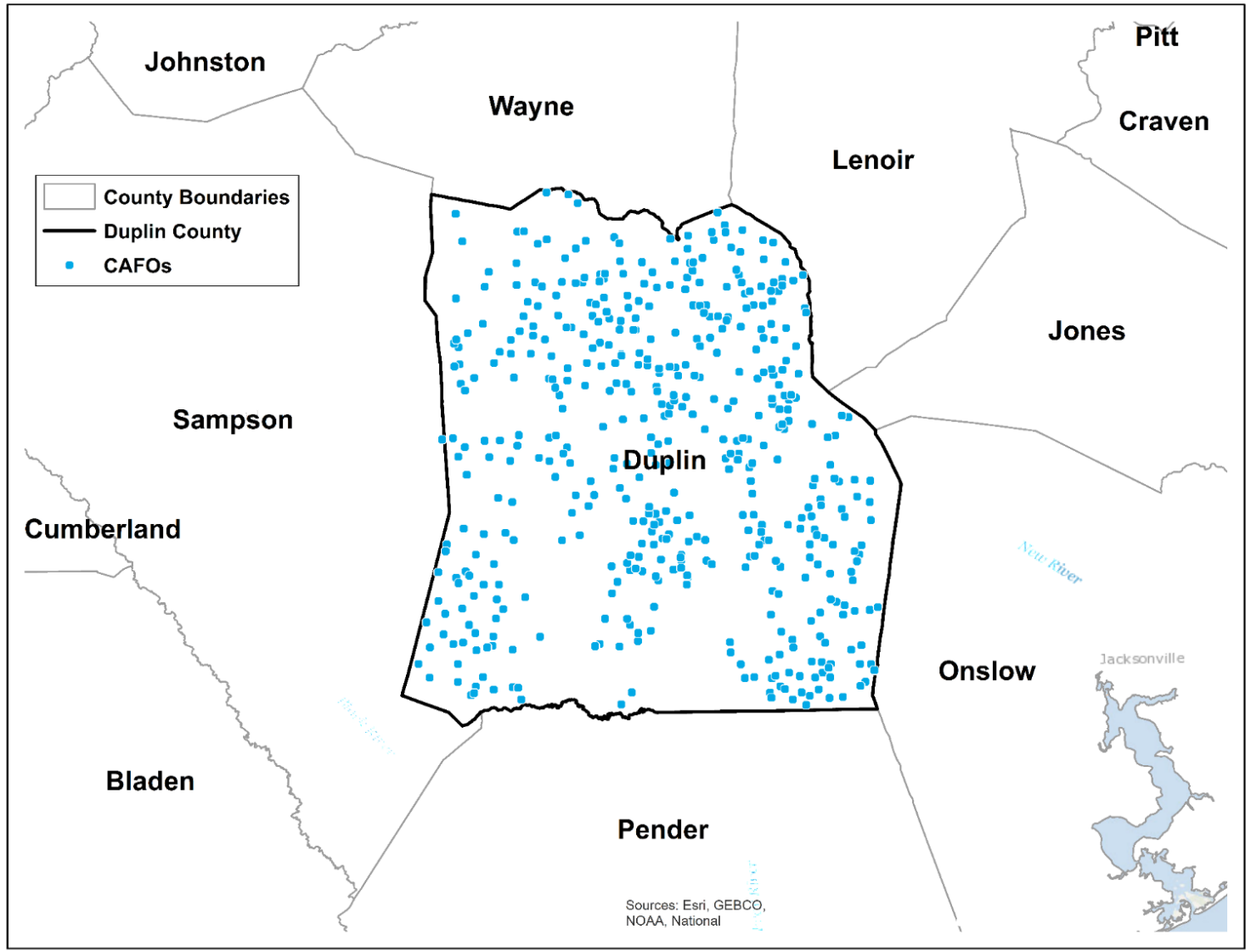
Contributions:

- Smaller study area to show local effects at census block level in Duplin County

- Use modeled pollutant concentrations in the air as a measure of population exposure

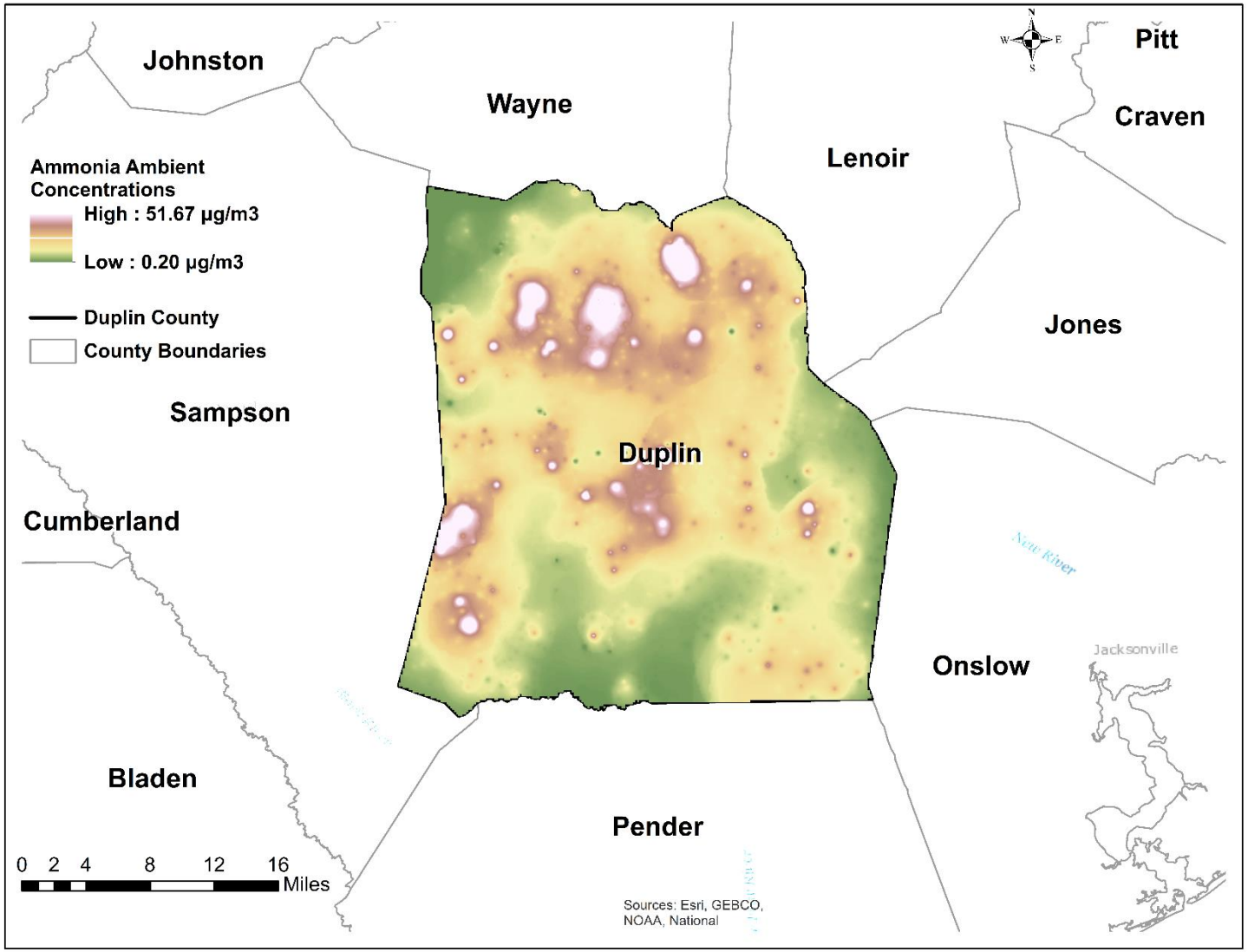
- Looks at multiple pollutants: Ammonia, Hydrogen Sulfide, and VOCs

- Estimates health impacts from pollutant concentrations



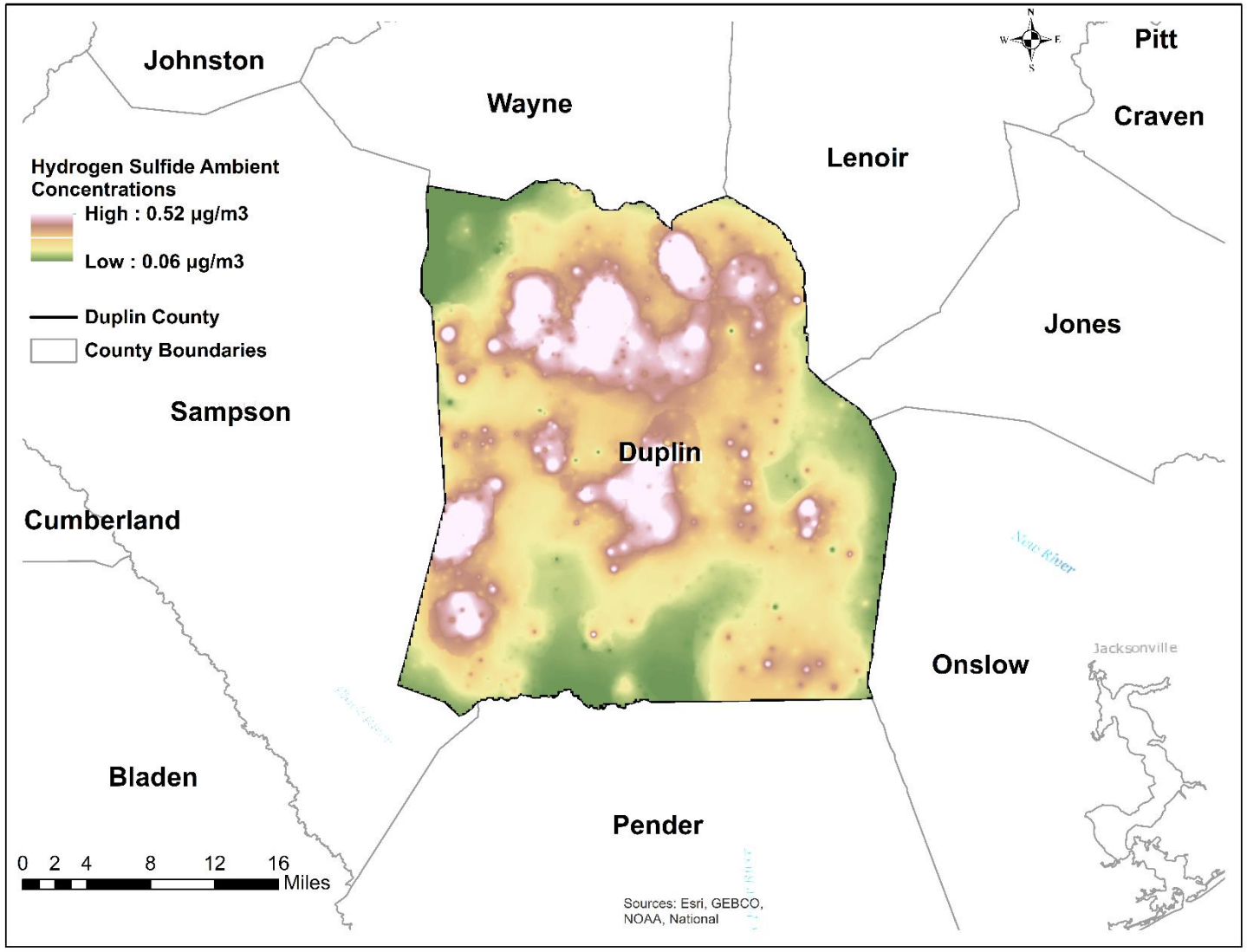
- Modeled 483 facilities in our simulation
- Results due to CAFOs within Duplin County solely
- Dimensions: volume sources. 100 meters squared, 1.8 meters, vertically, and 1-meter initial release height
- Location: latitude and longitude (NCDEQ) (centered)
- Ammonia EF: 12.76 kg NH3 /yr/animal (EPA NEIv2 2014)
- Hydrogen Sulfide EF: 0.127 kg H_2S/yr/animal

Ammonia Ambient Concentrations



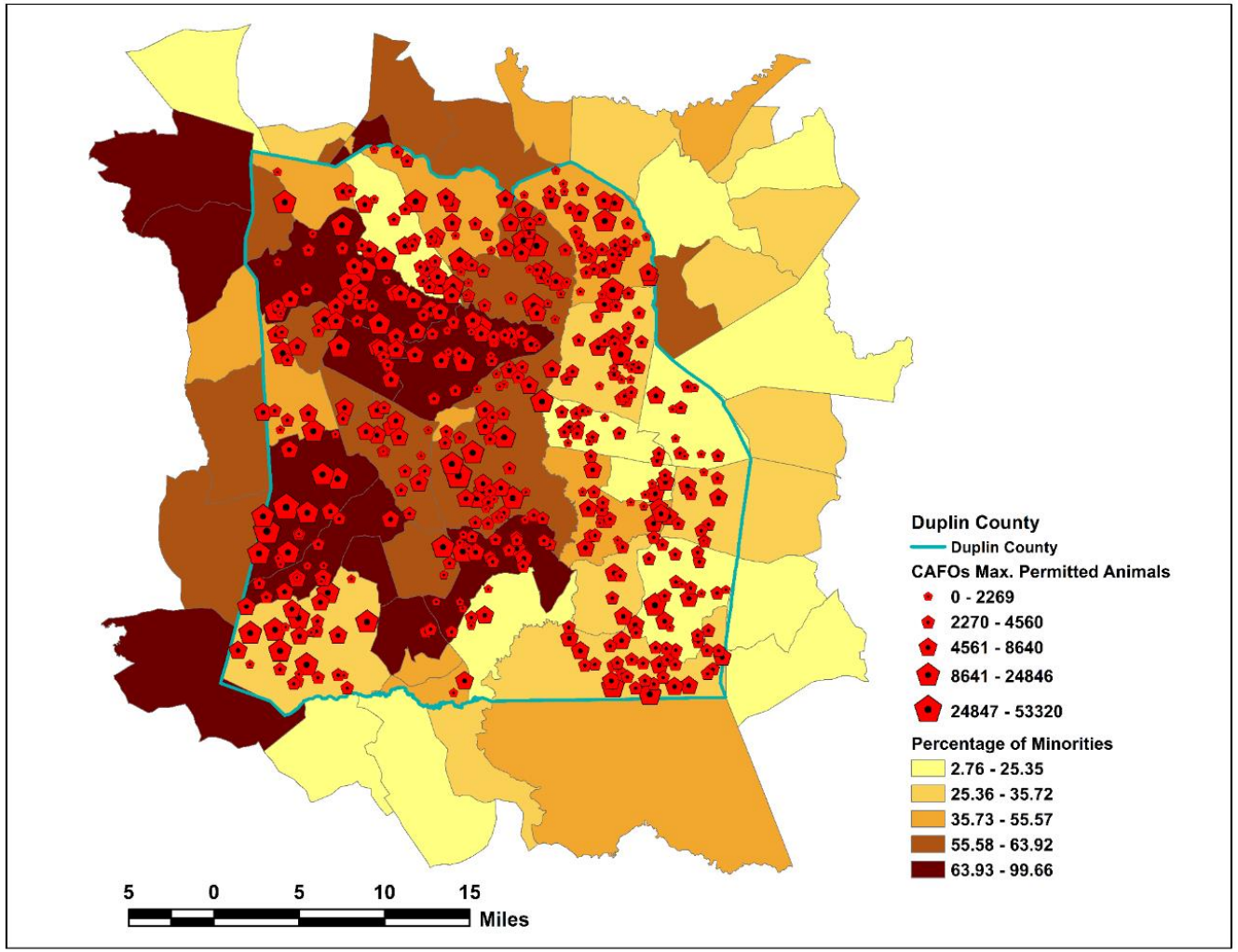
Ammonia
Max: 51.67 µg NH_3/m3
Average: 6.05 µg NH_3/m3

Hydrogen Sulfide Ambient Concentrations



Hydrogen Sulfide
Max: 0.52 µg H_2S/m3
Average: 0.06 µg H_2S/m3

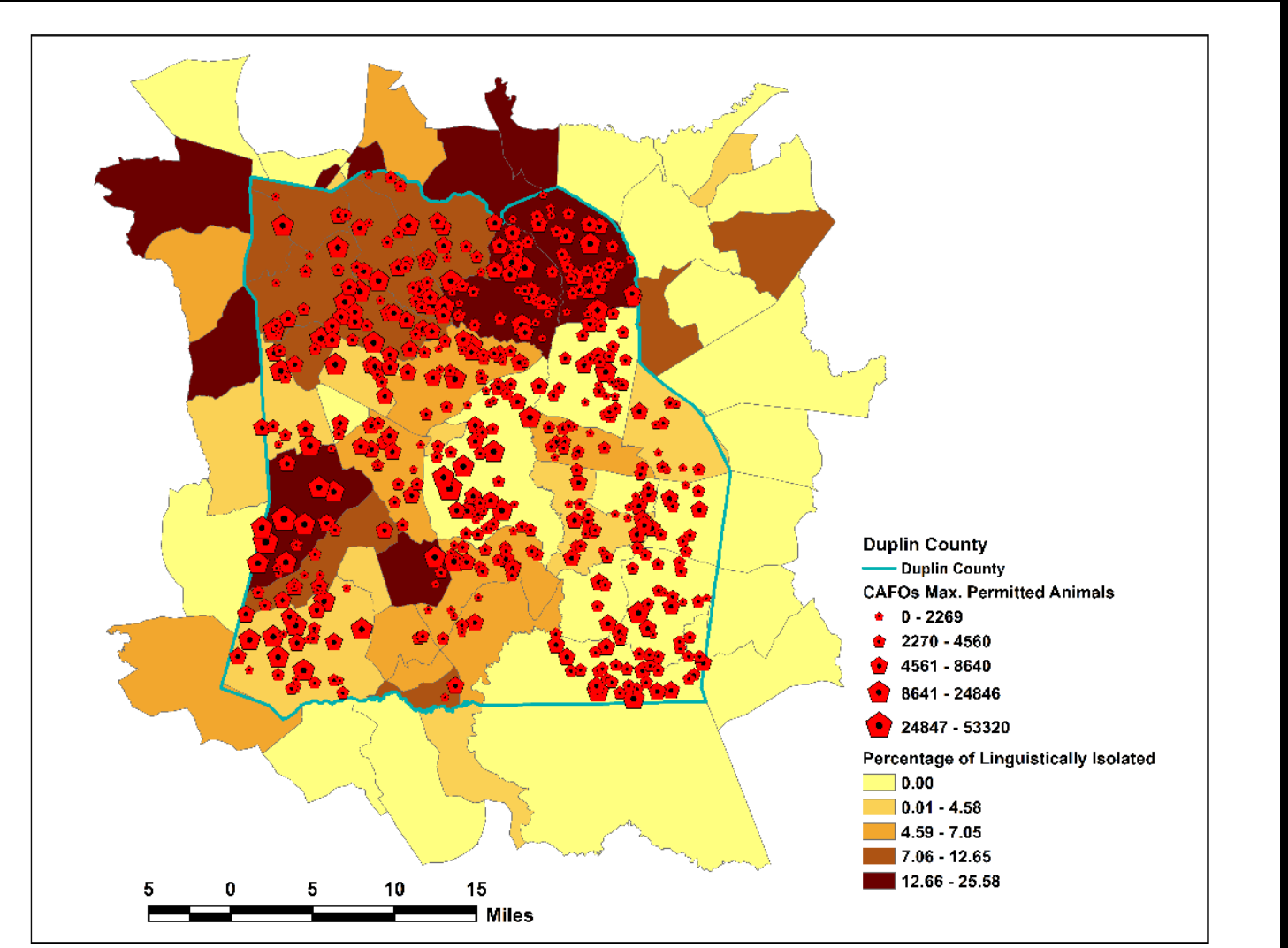
Choropleths Maps - Minorities



Choropleth maps – uses shading patterns or symbols to represent statistical data on predetermined geographic areas (i.e. countries).

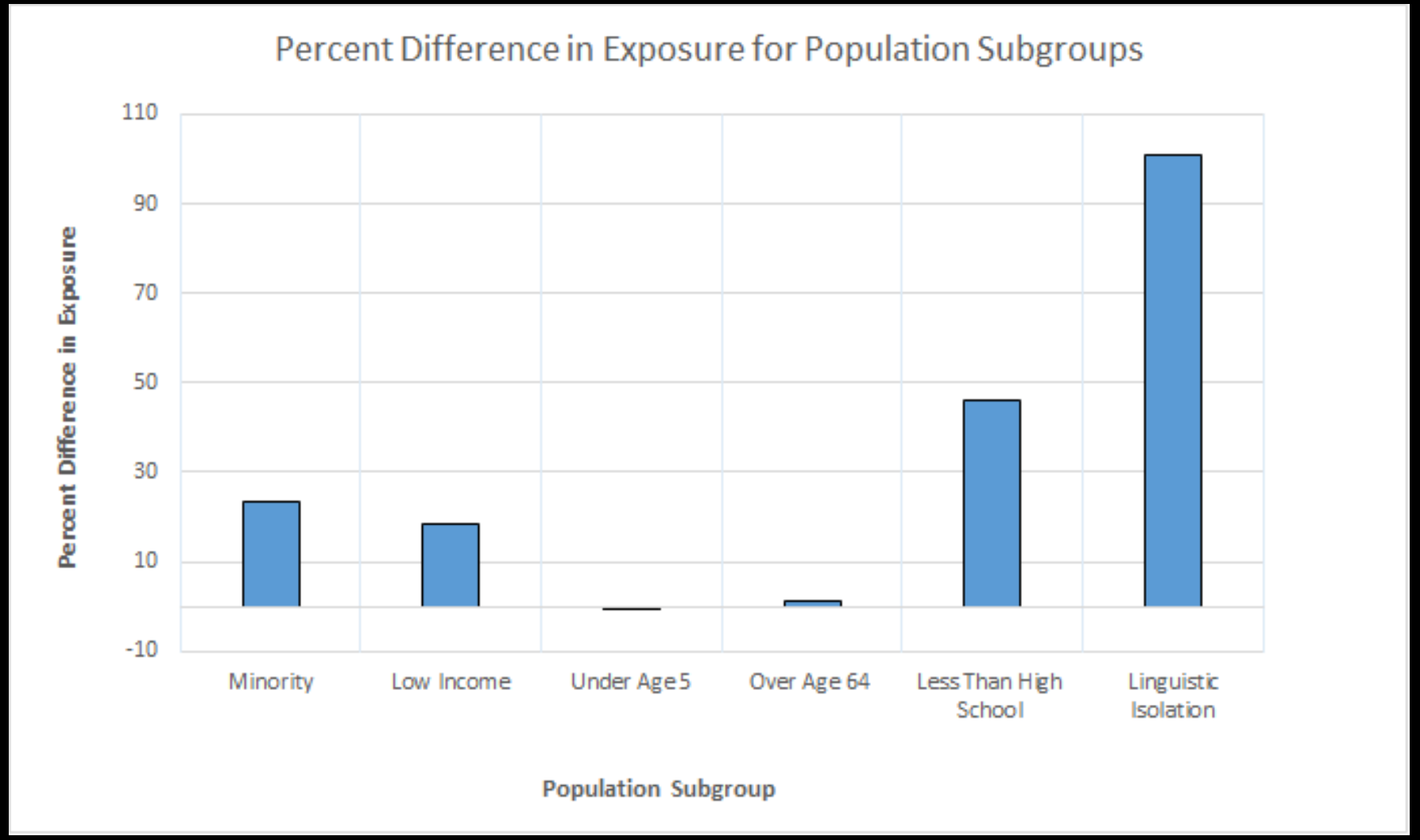
- represent variability of CAFO inventory and vulnerable pop across Duplin County.

Choropleths Maps – Linguistic Isolation



Linguistically Isolated- no person 14 years old and over speaks only English, and no person 14 years old and over who speaks a language other than English speaks English "very well"

Weighted Averages



Data of Prevalence

Environmental Justice Variable	Quintiles/ Percentages	Total population	Average Concentration of NH3 (ugm3)	Average Concentration of H2S (ugm3)	Number of Allowable Hogs	Number of Block Groups	Number of CAFOs
Percentage of Linguistically Isolated	0	39,563	3.56	0.018	624,727	25	149
	0.01-4.58	13,323	4.74	0.026	193,840	10	47
	4.59-7.05	17,501	4.45	0.022	263,564	9	71
	7.06-12.7	13,653	5.66	0.028	460,002	9	87
	12.7-25.6	17,857	5.28	0.026	47,9684	10	85

Environmental Justice Variable	Quintiles/ Percentages	Total population	Average Concentration of NH3 (ugm3)	Average Concentration of H2S (ugm3)	Number of Allowable Hogs	Number of Block Groups	Number of CAFOs
Percentage of Minorities	2.76-25.6	19,629	3.58	0.018	273,867	12	75
	25.4-35.7	21,325	3.67	0.018	434,490	13	103
	35.7-55.6	21,470	4.40	0.022	368,062	13	86
	55.6-63.9	22,771	5.69	0.028	514,696	13	102
	63.9-99.7	19,124	5.39	0.027	639,405	13	113

Conclusion

Estimated Ambient Concentrations:
NH_3 Average =6.05 μg NH_3 /m3 ; Max= 51.67 μg NH_3/m3
H_2S Average= 0.06 μg H_2S/m3 ; Max = 0.52 μg H_2S/m3

Majority of Duplin CAFOs are located in areas with higher proportions of minorities and linguistically isolated.

Majority of larger CAFOs are found more in communities of low income

Above average exposures of NH_3 and H_2S for linguistically isolated communities, minorities, communities of low income, and communities with low educational attainment.

On average, areas with higher percentages of minorities, linguistically isolated people, low income, and low education are exposed to higher concentrations of ammonia and hydrogen sulfide

Conclusion

There is a collective awareness and need to address concerns regarding public health and environmental impact from the aggregation of CAFOs and environmental equity issues resulting from the disproportionality of CAFOs in vulnerable communities.

Acknowledgements

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Thank Everyone for attending my presentation