The effects of hog farms waste on human health

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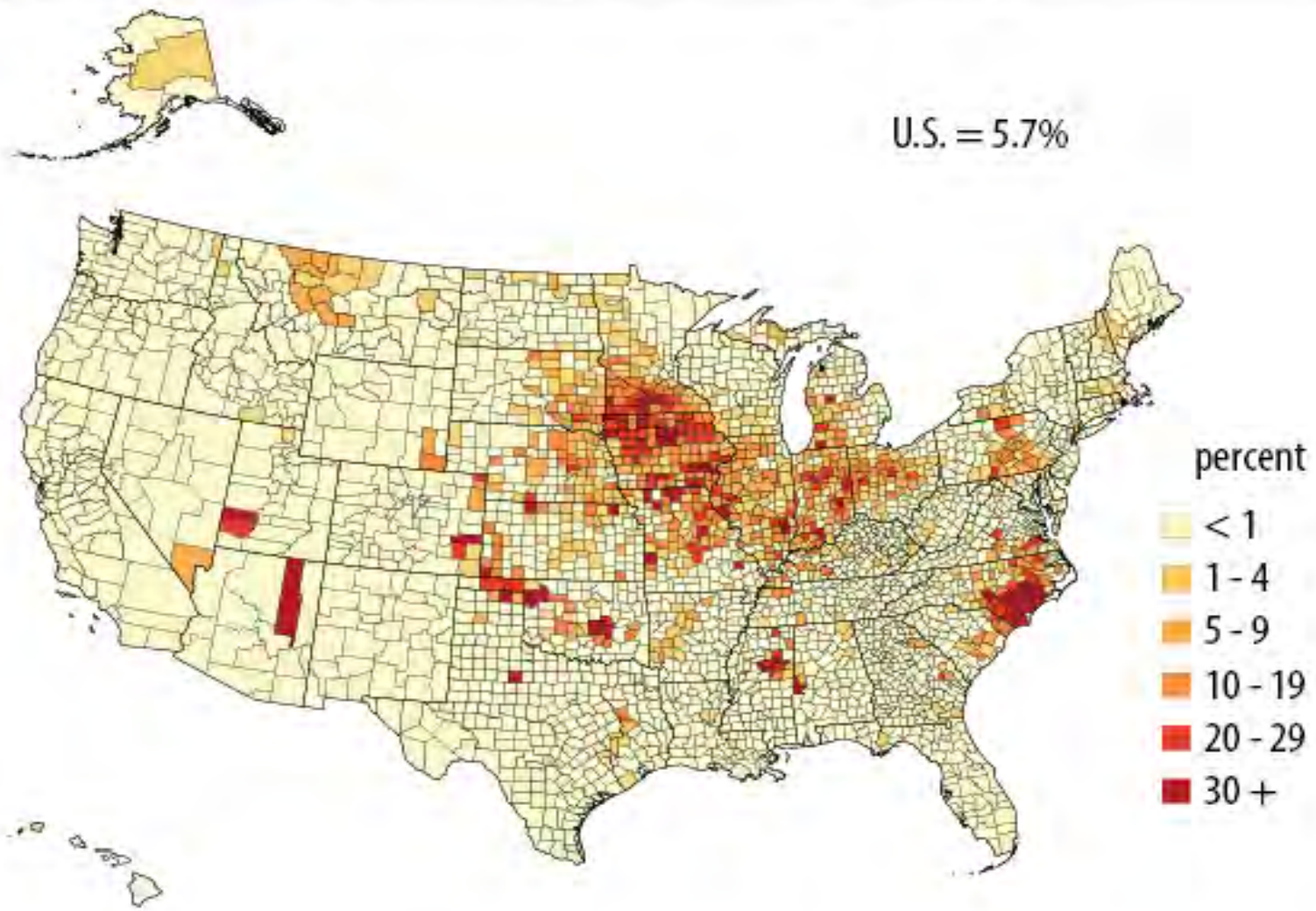
Hog and Pig Sales as Percent of Agriculture Sales, by County, 2012



Source: USDA NASS, 2012 Census of Agriculture.

Sources: odor, water, air pollution.

Air, land, groundwater, surface water

Odor

- People living near the swine operations reported more often depression and fatigue (Schiffman et al, 1995; 2000).
- Stress-mediated impacts on immune function: decreased IgA levels during periods of odor (Avery et al, 2004).
- Children and adults: higher rates of wheezing in closer proximity to hog farms (Mirabelli et al., 2006).
- Impaired neurobehavioral functions and pulmonary functions (Keil et al, 2011).
- Acute blood pressure increase → could contribute to development of chronic hypertension (Kilburn, 2012).

Hog farms and ammonia sources

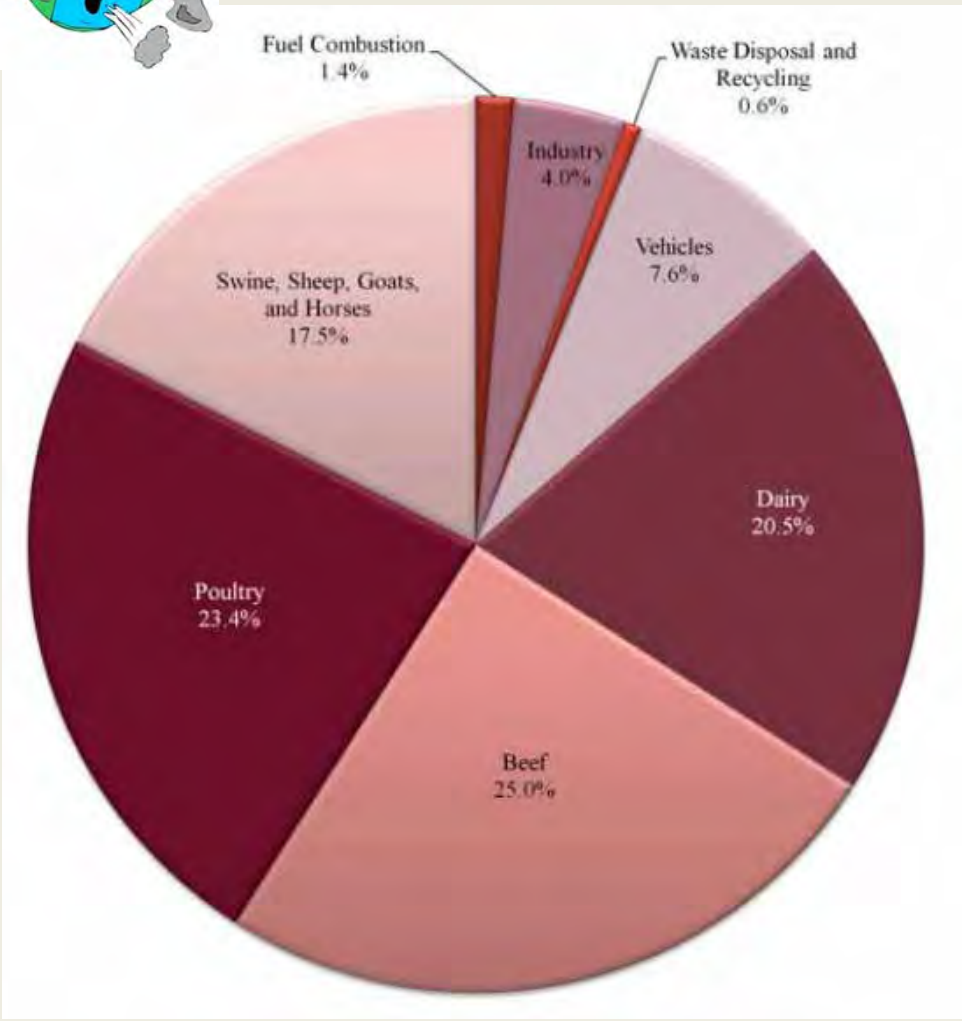


Figure: Estimated contribution of U.S. ammonia sources based on the National Emissions Inventory (EPA, 2008).

The US National Research Council has recommended a comprehensive program to quantify emissions from CAFOs and to identify the factors that control them (*Hagenstein et al, 2003*).

As a result, a number of studies on measurements of CAFOs emissions have been done with specific attention to ammonia (NH_3) contributing to PM formation ($PM_{2.5}$) *(Paulot et al, 2014*).

We found up to 90% correlation between the levels of ammonia (from ground monitors) and number of hogs in hog operations facilities.

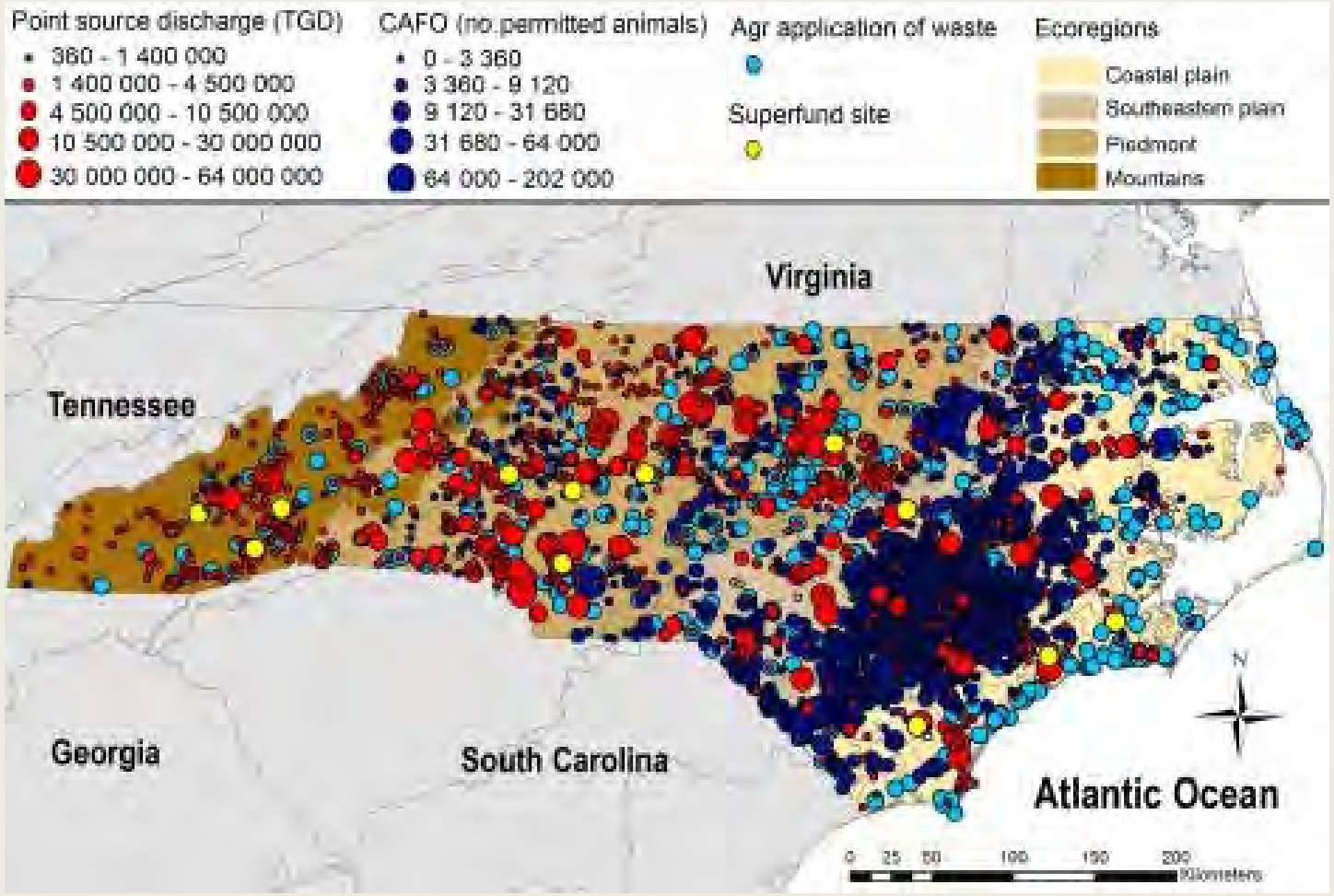
We did not find an association between disease-specific mortality and the poultry or beef facilities in NC.

Hazardous Air Pollutants (HAPs), other toxic air pollutants, and odorants found in air pollution emissions from CAFOs *(Rumsey et al, 2012; 2014)*

Acetaldehyde
Ammonia
Benzene
Butyric acid
Carbon disulfide
Chloroform
1-Chloro-3-methylbenzene
Cresols
Cyclohexane
Dichlorobenzene
1,2-Dichloroethane
Diethlybenzene
Dimethyl sulfide
Dimethyl disulfide
Dimethyl trisulfide
Ethylbenzene
Ethylphenol
Ethyltoluene
n-Hexane
Hydrogen sulfide
Indole
Isobutyric acid
Isoprene
Isopropylbenzene
Methanol
Methanethiol
2-Methyl butanoic acid
3-Methyl indole
Methyl isobutyl ketone
Phenol
n-Propylbenzene
Styrene
Tetrachloroethylene
Toluene
Tribromomethane
1,1,1-Trichloroethane
Trichlorobenzene
Trimethlybenzene
2,2,4-Trimethylpentane
Valeric acid
Xylenes

Multiple air pollutants (including ammonia, nitrogen oxides, hydrogen sulfide, volatile organic compounds, and many others) are emitted by livestock operations *(Aneja et al, 2008; 2009; Erisman et al, 2008)*.

Estrogenic compounds



Places where estrogenic compounds have being discharged into the water.

Many of these sources are related to human and animal waste: waste water treatment plants, agricultural areas where human sewage is applied to the land, and farms with confined animal feeding operations. *(Sackett et al, 2015*).

Health effects:
what has been reported.

Cancer risk factors and non-cancer reference concentrations for HAPs emitted by CAFOs *(US EPA, 2014)*

Pollutant	Risk factors and reference concentrations for chronic health effects				Threshold concentrations established under various systems for acute health effects (m3/m3)				
	URE 1/(ug/m^3)	RFC (mg/m^3)	Affected organ or effect	Weight of evidence	AEGL-1 (1-hr)	ERPG-1	MRL	REL	IDLH-10
Acetaldehyde	0.0000022	0.009	Respiratory	B2	81	18		0.47	360
Benzene	0.0000078	0.03	Immune	A	170	160	0.029	1.3	160
Chloroform		0.098	Liver	B2			0.49	0.15	240
Dimethyl disulfide			Reproductive		0.092				
n-Hexane		0.7	Neurological						390
Hydrogen sulfide			Respiratory		0.71				
Methyl isobutyl ketone		3	Developmental						
Phenol		0.2	Liver	D	58	38		5.8	96
Styrene		1	Neurological		85	210	21	21	300
1,2,4-Trichlorobenzene		0.2	Liver	D					
1,1,1-Trichloroethane		5	Neurological	D	1300	1900	11	68	380
o-Xylene		0.1	Neurological					22	390

Notes: AEGL = Acute Exposure Guideline Level, ERPG = Emergency Response Planning Guideline, MRL = Maximum Residue Limit, IDLH = Immediately Dangerous to Life and Health, URE = unit risk estimates for cancer health risks, RfC = reference concentrations for non-cancer health effects

Infections

- Reported a variety of microbial agents related to hog operations *(Cole et al, 2000).*
- Residents living near the hog operations: increased occurrence of diarrhea *(Wing, Wolf, 2000).*
- Transmission of *Y. enterocolitica* may occur in the hog farms occupational settings *(Merilahti-Palo et al, 1991; Seuri and Granfors, 1992).*
- Swine influenza: pigs may be involved into the next generation flu pandemia. Large hog farms may have many animals with nάive immune system and that may cause developing of new viruses mutations *(Gray et al, 2007).* An industry mechanism can introduce virus from NC farms (e.g., moving trucks with food) to the half of the U.S. territory.
- Swine populations may be increasingly infected with the DT104 strain of *Salmonella typhimurium* that causes severe diarrhea in humans *(Besser et al, 1997; Petersen et al, 1998*).
- 58% of sporadic cases of leptospirosis could be attributed to meat processing *(Crawford et al, 1969).*
- Brucellosis has been reported in pork packing plants after its nearly successful eradication in the US *(Trout et al, 1995).*
- Since 1968, adult meningitis caused by *S. suis* has been recognized as an occupational disease in swine operations workers *(Dupas et al, 1992; Zanen and Engel, 1975).*
- The possibility of zoonotic transmission of hepatatis E virus between swine and humans has being explored *(Meng et al, 1998).*
- Hog farmers have the highest prevalence of antimicrobal resistance in fecal isolates compared to the other groups *(Tenover, 1996).*

Respiratory diseases

- Mixtures of ammonia, hydrogen sulfide, volatile organic compounds, dust, and endotoxins may cause respiratory dysfunction in hog farms workers and possibly in nearby residents *(Donham et al, 1977; Bongers et al, 1987; Crook et al, 1991; Zuskin et al, 1991; Larsson et al, 1994; Vogeizang et al, 1995; Donham et al, 1995; Iversen, 1997; Swinker, 1998; Wing, Wolf, 2000)*.
- Hog odor and hydrogen sulfide (H2S) were associated with upper respiratory symptoms *(Schinasi et al, 2011).*
- The standardized morbidity ratio (SMR) (by age, race, and gender) of tuberculosis in eastern NC in 1966-1986 was nearly twice higher than in western NC and was unexplainable by its demographics *(Weber et al, 1989).*
- Increased asthma risk in hogs operations workers *(Schwartz et al, 1992)*, suggested to be due to ammonium and aldehydes or chloramine disinfectants *(Vogeizang et al, 1997; Preller et al, 1995).*
- NC study found a 23% higher prevalence of asthma symptoms among children attending schools where staff noticed livestock odors indoors twice/month or more *(Mirabelli et al, 2006).*
- Livestock farmers were more likely to have chronic bronchitis and COPD *(Eduard et al, 2009).*

Other diseases

- Higher rates of stroke mortality in white population of NC in 1962-1982 in the areas which now have large hog farms *(Wing et al, 1988*).
- Stress from hog farms' odor was associated with short-term increase of blood pressure *(Wing et al, 2013*).

- Slurry ponds for collecting pig excrements can contaminate the soil and ground water with high levels of zinc, that inhibits copper and iron absorption when ingested by humans, leading to anemia and kidney function damage *(Brooks, 2009).*

- Occupational exposures to hydrogen sulfide at hog farms can be associated with CNS transitory symptoms *(National Research Council, 2003).*
- Children are particularly susceptible to neurological effects *(Hannah et al, 1991).*

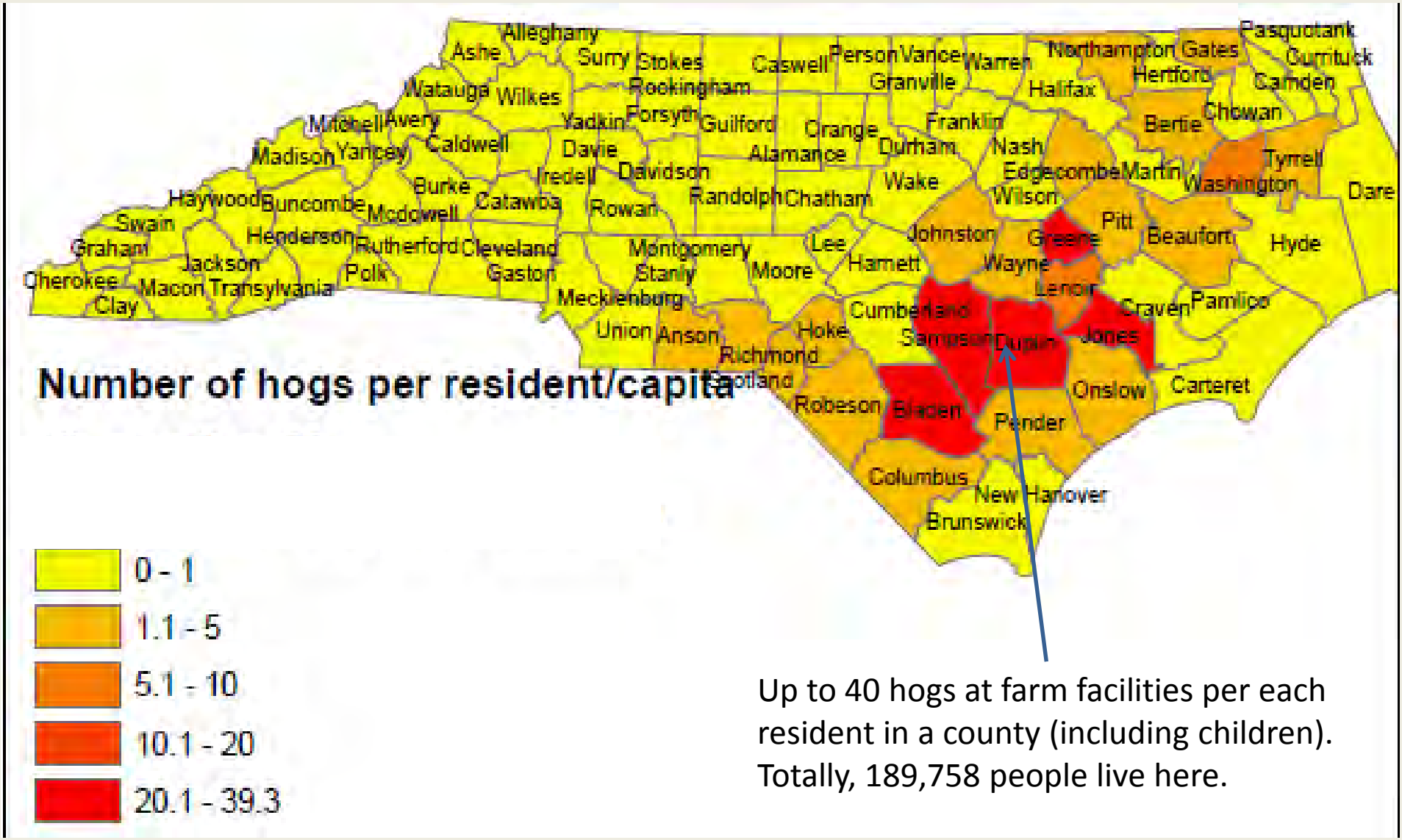
- Excessive nitrate ingestion has been associated with miscarriages and the CDC blamed water contaminated with nitrates from a swine farms for some miscarriages occurred in 1993 and 1994 *(Fan, Steinberg, 1996; Kramer et al, 1996).*

Hog farms in North Carolina

- Iowa, North Carolina, and Minnesota account for 55% of hog and pig sales, and NC remains the second largest US producer.

- Duplin county, NC, was ranked 1st in the nation (in 2012) hog and pig sales with 3% of the U.S. sales *(USDA Census of Agriculture, ACH12-4, June 2014)*.

Hogs farms in NC: number of hogs per county population



Our study: To evaluate the health and medical care of NC residents living near the commercial animal feeding operations (CAFOs).

- Why residential populations? While studies of occupational exposure of swine operation workers exist, few studies investigate health and medical effects of nearby residents. Residential populations include vulnerable groups: children, people with chronic diseases, and elderly.
  - **Study Group:** Counties with hog farms selected for analysis: Sampson, Duplin - >2,000,000 animals; Bladen, Wayne, Jones, Lenoir, Greene, Robeson, Pender, Columbus, Pitt, Johnston, Onslow, Edgecombe, Cumberland – from 100,000 to 760,000 animals.
  - **Control group:** Counties that do not have hog farms registered with the NC Division of Water Quality.

All analyses were adjusted by socioeconomic characteristics and smoking prevalence.

Populations living in counties with large hogs farms (>100,000 pigs) in NC has higher risk for ED visits, hospitalization, and death for various diseases, as compared to people living in counties without registered hog farms: although some of these diseases have been previously associated with CAFO, we report new associations with many chronic diseases.






Topics for further discussion

- Planning of medical resources and access to medical care in counties with large hog farms with focus of high-risk diseases and vulnerable populations, including poorer, rural, and non-white populations.
- Availability of medical insurance for residential populations, especially for those with low income.
- Children-oriented programs, especially for prevention, early diagnosis, and effective treatment of high-risk diseases such as asthma, tuberculosis, and intestinal infections.
- Standards for air quality for CAFOs areas.
- Ammonia can react with SO_2 or NO_2 to form PMs. Our recent study showed that improving air quality in NC was associated with decreasing deaths from respiratory, cardio- and cerebrovascular diseases. So, lower levels of SO_2, NO_2, and PMs may contribute to minimization of potential health impacts of ammonia.
- Most hog operations which use waste pits that contaminate groundwater are located in the areas with high dependence on well water for drinking *(Wing et al., 2000).*
- State of the art molecular markers for fecal pollution source tracking in water to distinguish between human, domesticated animals, and wildlife sources as the hosts of infections *(Roslev, Bukh, 2011; Ufnar et al, 2007).*

Let’s find the ways to co-exist and live a healthier life.