Public Health Impacts of Industrial Farm Animal Production

James A. Merchant, MD, DrPH

Visiting Professor, UNC Gillings School of Global Public Health

Professor, Colleges of Public Health, Medicine and Nursing

Founding Dean, College of Public Health

The University of Iowa

April 22, 2009

Occupational Health

Agricultural Dusts

Animal Products

- feces
- hair
- feathers
- urine
- dander

Plants & Products

- feed (Grain & Additives)
- pollen
- insects/parts

What is in Agricultural Organic Dusts?

High levels of microbes and their byproducts (bacteria, molds)

Inflammatory substances

1. Endotoxin
2. Glucans
3. Proteinases

Other toxins/irritants/allergens

1. Mycotoxins
2. Allergens (mites, roaches, their feces)
3. Tannins
4. Plicatic acid

Hazards increase with:

1. Degree of confinement
2. Degree of microbial contamination
3. Length and concentration of exposure
4. Concurrent exposures
   - Ammonia
   - Smoking
5. Genetics

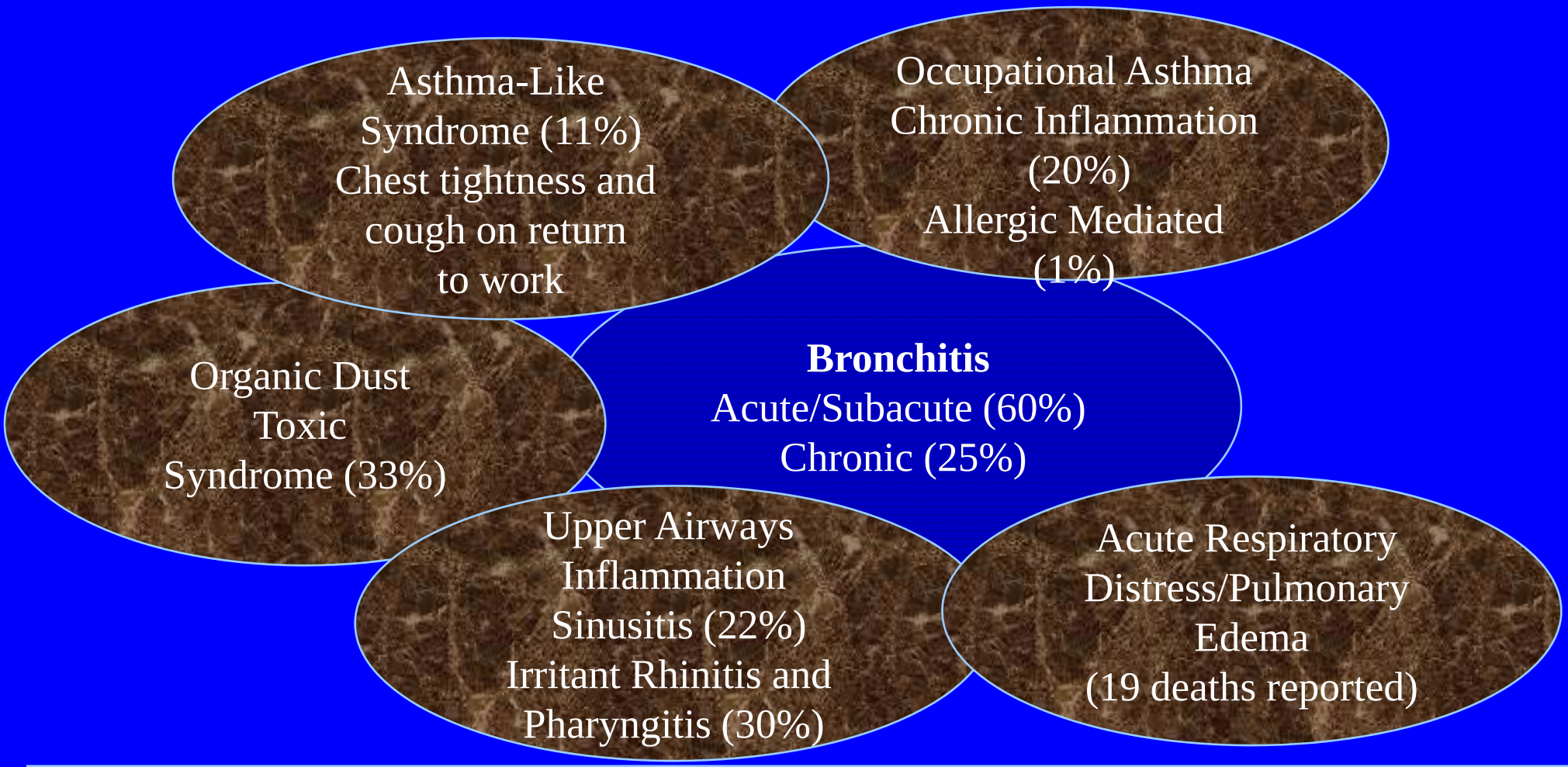
Gases Associated with Manure

1. Ammonia
2. Liquid systems
   - Ammonia
   - Anaerobic degradation
     - Hydrogen Sulfide (H_2S)
     - Methane (CH_4)
     - Carbon Dioxide (CO_2)
     - Some 160 other gases

Hydrogen Sulfide Exposure

- Liquid manure
- Anaerobic (> 3 feet down)
- Agitation
- Confined space
- Cellular toxin
- Extreme irritant
- Predilection for CNS
- Paralyze sense of smell
- Sudden unconsciousness
- Respiratory cessation
- Pulmonary edema

The Respiratory Health Complex of CAFO Workers



The circles indicate overlapping symptoms and conditions. The percentages indicate approximate rates of swine workers who experience these conditions.

Components of an Agricultural Occupational Health and Safety Program

- Worker Identification and Documentation for State, National Surveillance, Reporting
- Employment Medical Examinations
  - When first hired
  - Annually
    - Physical examinations
    - Spirometry, pre-and post-shift
    - Influenza vaccination
  - Referral for further examination treatment with asthma, significant impairment, zoonotic infectious disease, trauma, other medical conditions

Components of an Agricultural Occupational Health and Safety Program

- **Industrial Hygiene**
  - Hazard identification and signage (language appropriate)
  - Employee education
  - Wellness and prevention
  - Respirator program with face fit and maintenance
  - Periodic environmental sampling
  - Exhaust ventilation sampling dust control

Environmental Health

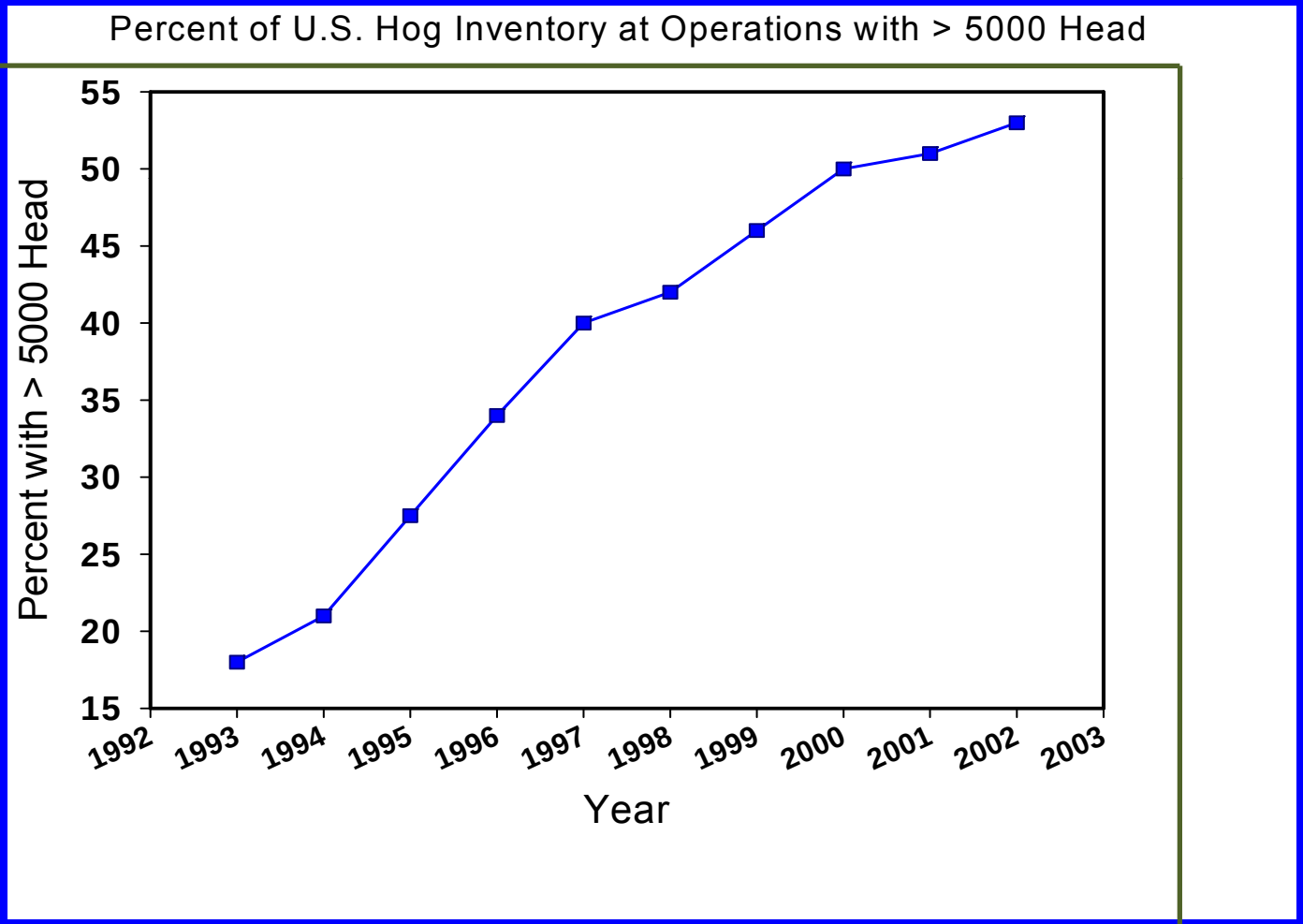
- Aerial spraying of manure slurry produces further transport and higher airborne exposures

Duplin Co. NC. Air spraying of swine waste to lower lagoon level.
Source: Statement of Richard J. Dove before the Senate Cmte on Env & Public Works, Sept. 6, 2007

"Center pivot irrigation is a widely used method of (manure) application at many of our farms."
Source: www.psfarms.com

Industrialized Operations Dominate

110 operations nationwide with >50,000 hogs produce over half the nation's pork

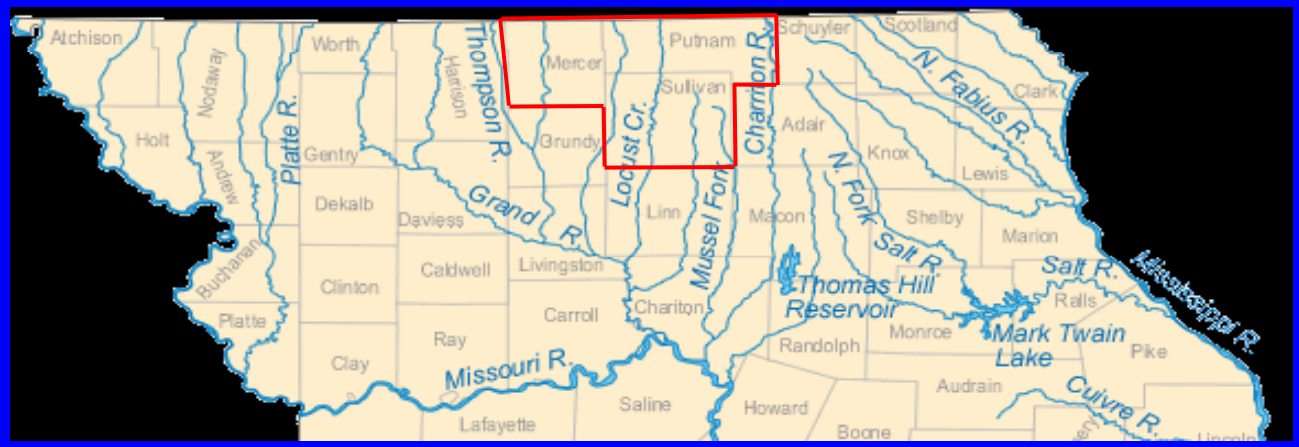


- **Now 71.5% of hog inventory at >5,000 head**
- **Regulatory frame- work is still that of small family farms**
- **Right-to-farm laws not consistent with industrial livestock production**
- **Decisions on siting made at state level**

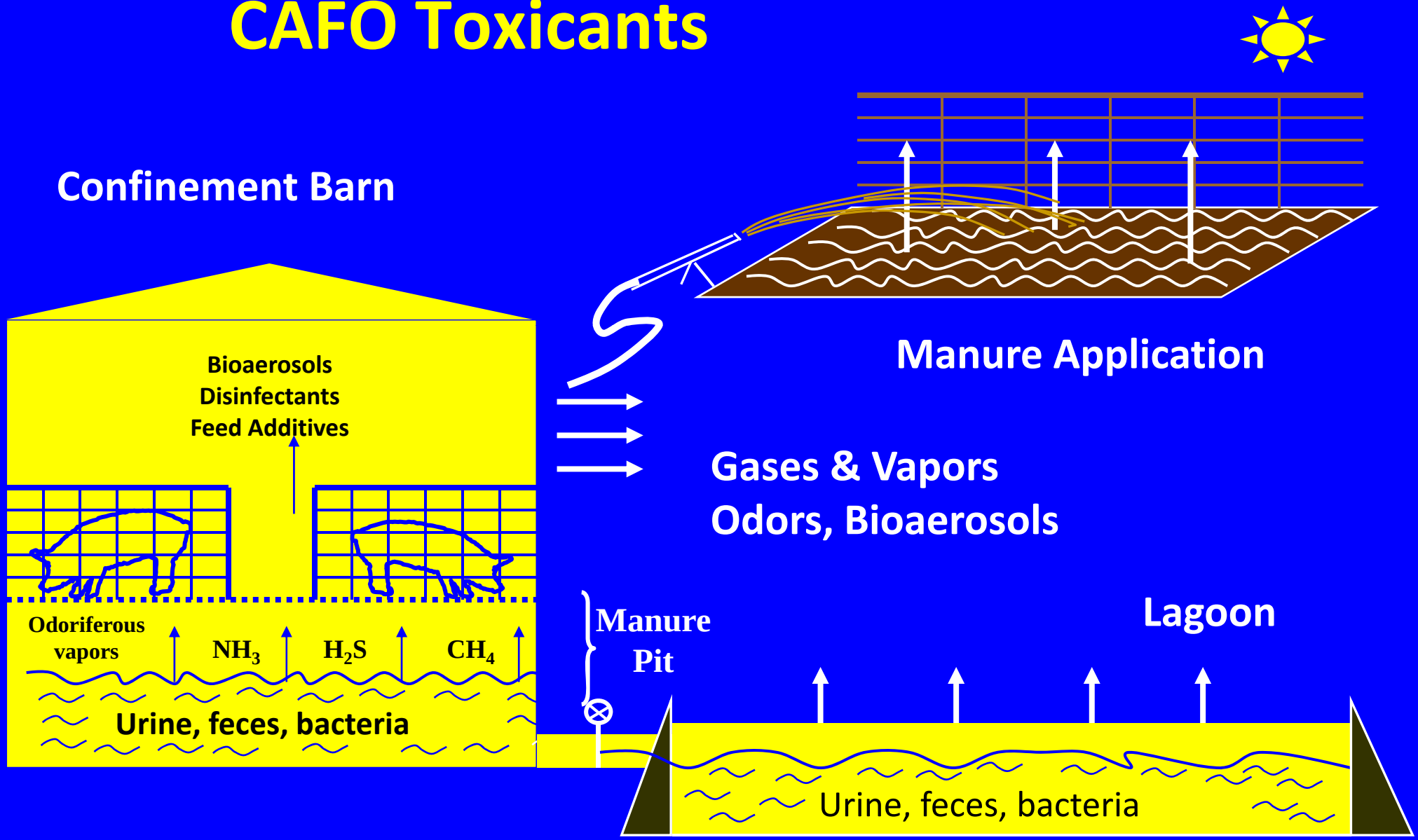
Scope of the livestock industry: an example

- Premium Standard Farms is permitted to confine >900,000 hogs at its CAFOs in Mercer, Putnam and Sullivan Co, MO
- PSF produces two million hogs annually in Missouri.
- PSF stores and applies more than 750 million gallons of animal waste annually on more than 83,000 acres in northern Missouri.
- PSF's CAFOs, slaughterhouses and retailing pork operations are fully integrated.

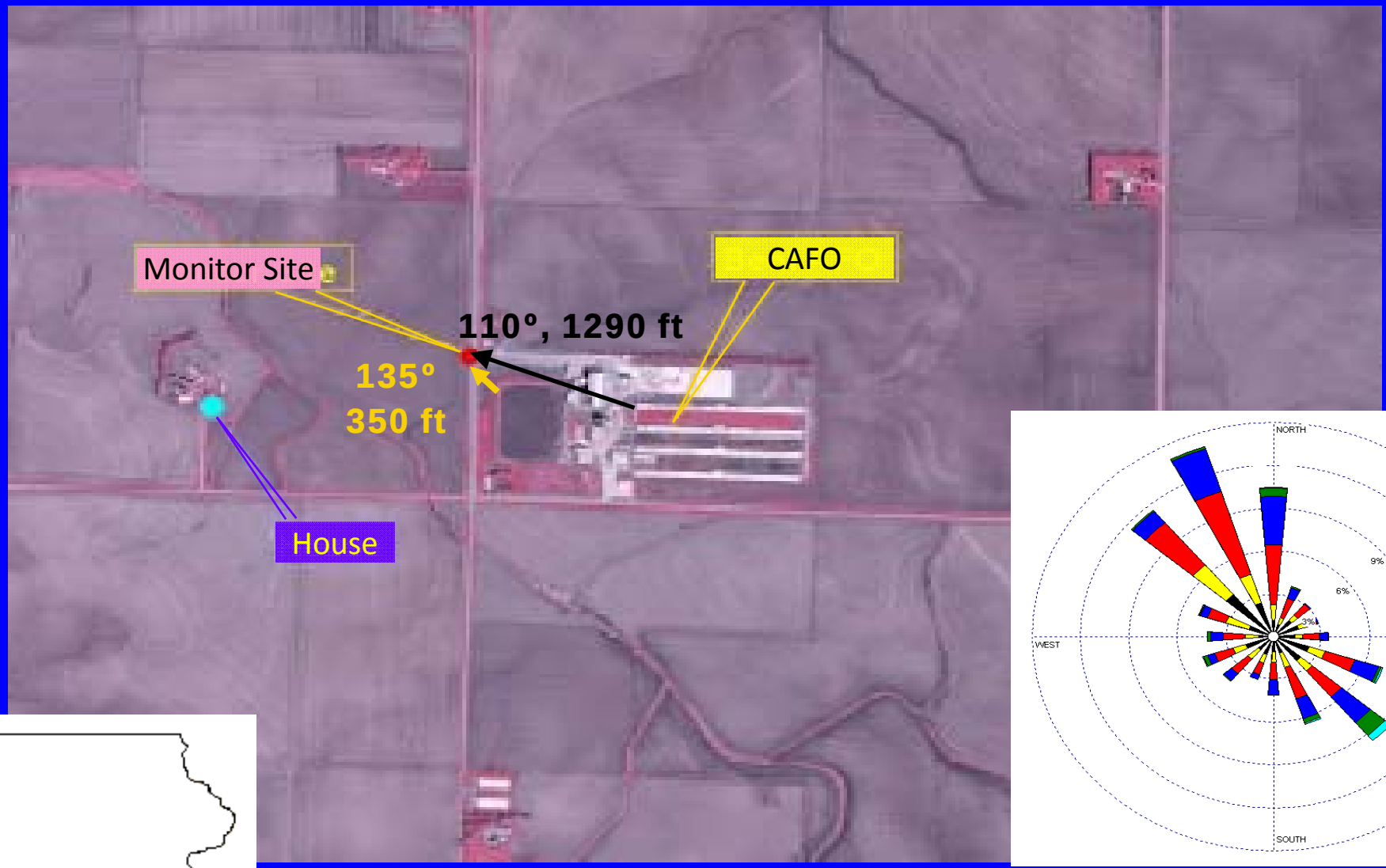
Source: U.S. EPA Civil Settlement, 2001.

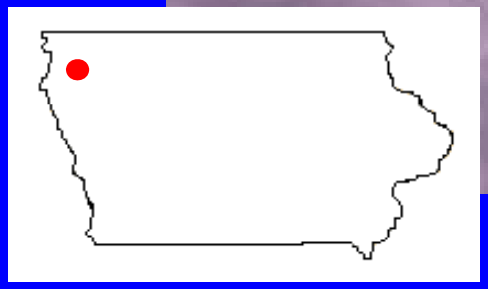


CAFO Toxicants

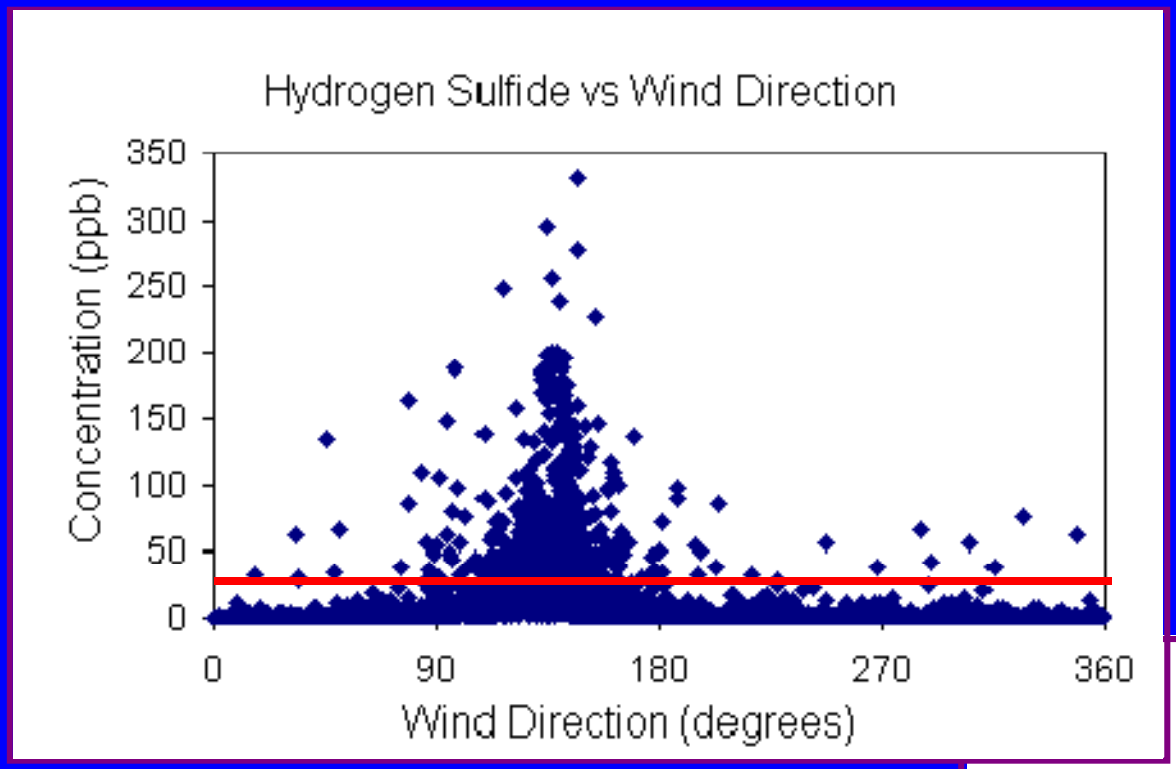


Industrial Livestock Facility – NW Iowa





Prevailing winds are from the NNW and SE

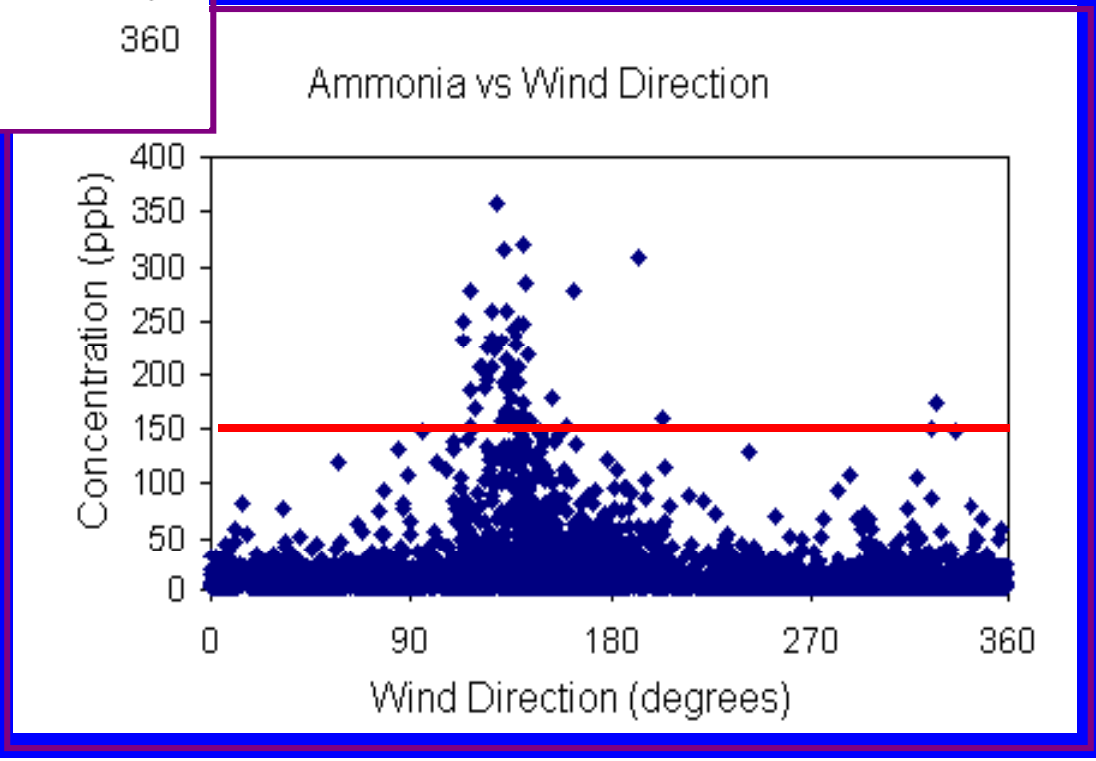


H_2S and NH_3

1,290 ft from a CAFO

10 months monitoring data

— Health Guidelines:
30 ppb H_2S
150 ppb NH_3



Air Emissions – Particulate Matter

Microorganisms	Plant Materials in Feed Dust
Bacteria, fungi, viruses. Amoebae	Proteins, starches, carbohydrates
Products of Bacteria	**Feed Additives**
Endotoxin, peptidoglycans, CpG DNA, spores	Antibiotics, Vitamins, minerals, amino acids
Products of Fungi	**Aeroallergens**
Spores, β(1-3)-glucans, mycotoxins	Animal dander, plant pollens, mite feces, arthropod allergens

Exposure to bioaerosols is a risk factor for serious respiratory diseases:
- asthma, chronic rhinitis, organic dust toxics syndrome, multi-drug resistant *Staphylococcus aureus* (MRSA), allergy

Air Emissions – Gases & Vapors

- VOCs
  - sensory and pulmonary irritants
- Vapors
  - ammonia, hydrogen sulfide, hydrazine
- Odoriferous volatile fatty acids
  - butyric, valeric, caproic acids
- Odoriferous nitrogen-containing compounds
  - amines, indoles, skatoles, pyridines, methyl pyrazines
- Phenolic compounds
  - phenols, cresols
- Greenhouse gases
  - carbon dioxide, methane, nitrous oxide

Principal Emissions of Gases and Vapors

Volatile Organic Compounds

- Acetaldehyde
- Acetone
- Acetophenone
- Acrolein
- Benzaldehyde
- Benzene
- bis (2-ethylhexyl) phthalate
- 2-butanone
- Carbon disulfide
- Carbonyl sulfide
- Chloroform
- Crotonaldehyde
- Ethyl acetate
- Formaldehyde
- Formic acid
- Hexane
- Isobutyl alcohol
- Methanol
- 2-methoxyethanol
- Naphthalene
- Pyridine
- Tetrachloroethylene
- Toluene
- Triethylamine
- Xylene

Vapors and gases

- Ammonia
- Hydrogen sulfide
- Dimethyl sulfide
- Hydrazine
- Sulfur dioxide
- Carbon dioxide
- Carbon monoxide

Odoriferous volatile fatty acids

- Butyric and isobutyric acid
- Caproic and isocaproic acid
- Valeric and isovaleric acid
- Propionic acid
- Phenylpropionic acid
- Lauric acid
- Acetic and phenylacetic acid

Phenolic compounds

- Phenol
- Ethyl phenol
- Cresols

Nitrogen-containing compounds

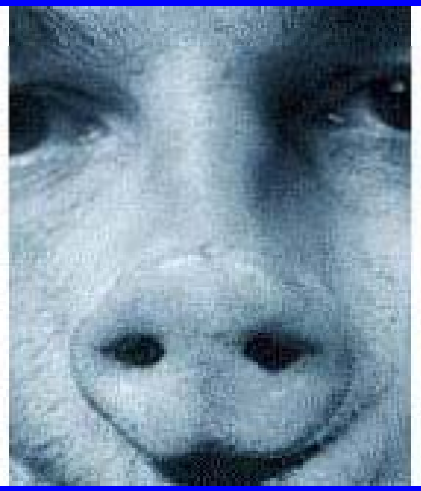
- Ammonia
- Amines
- Pyridines
- Indole
- Skatole
- Trimethylamine
- Tri- and tetra-methyl pyrazines

Odorous Compounds Measured by GC-MS

Compound	CAS #	Odor Threshold, ug/m^3
Indole	120-72-9	0.2
Methyl mercaptane	74-93-1	2.1
Skatole	83-34-1	3.1
Dimethyl sulfide	75-18-3	5.9
Trimethyl amine	75-50-3	5.9
p-Cresol	106-44-5	8.3
iso-Valeric acid	503-74-2	10.5
n-Butyric acid	107-92-6	14.5
n-Valeric acid	109-52-4	20.4
Dimethyl disulfide	624-92-0	47.9
Propionic acid	79-09-4	110
Benzaldehyde	100-52-7	186
Carbon disulfide	75-15-0	302
Acetic acid	64-19-7	363
Phenol	108-95-2	427

Descriptors of Odor Quality

Chemical Name	Smell
Hydrogen sulfide	Rotten eggs
Dimethyl sulfide	Rotting vegetables
Butyric, isobutyric acid	Rancid butter
Valeric acid	Putrid, fecal smell
Isovaleric acid	Stinky feet
Skatole	Nauseating, fecal
Indole	Intense fecal



U.S. Greenhouse Gas Inventory for Agricultural Emissions

- **Agriculture accounts for 7.4 % of the total U.S. release of greenhouse gases**

	Source	Gigagrams	Teragrams CO_2 Equivalent
Methane, CH_4	Total	7674	161.2
	Enteric fermentation	5340	112.1
	Manure management	1966	41.3
	Other	369	7.8
Nitrous Oxide, N_2O	Total	1210	375.1
	Agric. Soil management	1178	365.1
	Manure management	31	9.5
	Other	2	0.5

Source: U.S. EPA 2007, IPCC 2001.

Health Effects of Low-Level Exposures

- **Ammonia, NH_3**

  Sensory irritation, cough, excessive airway mucus production, epithelial damage in upper airways, inflammation

  Irritation of eyes, nose, sinuses, skin

  At higher levels: pulmonary edema, lung scarring, ocular damage, reactive airways dysfunction syndrome

  ATSDR chronic minimal risk level = 300 ppb

  UI-ISU AQS: 150 ppb at residence; 500 ppb at CAFO property line (1 hr average) and no more than 7 exceedances per calendar year (with 48 hr notice)

Health Effects of Low-Level Exposures

- **Hydrogen sulfide, H_2S**

  Eye & throat irritation, headache, nausea, lung irritation, cough, sleeplessness

  Elevated rates of respiratory infection, asthma, chronic bronchitis

  Neuropsychologic disturbances, mood disorders, visual impairment

  Lethal at higher concentrations

  ATSDR intermediate minimal risk level = 30 ppb

  UI-ISU AQS: 15 ppb at residence; 70 ppb at CAFO property line (1 hr average) and no more than 7 exceedances per calendar year with 48 hr notice

Health Effects of Noxious Odors

- Diminished quality of life, loss of use of property, emotional stress
- Neuropsychiatric abnormalities, mood disorders, sleep disturbances
- Measured by olfactometry in dilution factor for non-detection
- UI-ISU AQS-opinion 1: Limited to 7:1 dilution at the residence, 15:1 at the property line, up to 7 residence and 14 property line exceedances/yr (with 48 hr notice)

Epidemiological Studies
Association between CAFOs and Asthma

Merchant et al 2005	Keokuk County Rural Health Study (Iowa), 1000 rural households with high rates of childhood asthma, 44.1% among children living and often working on farms raising swine
Sigurdarson & Klein 2006	Iowa children in school proximate to CAFO, OR of 5.71 for doctor diagnosed asthma
Mirabelli et al 2006 a, b	NC children living within 3 miles of CAFO had significantly more doctor-diagnosed asthma, used more asthma meds and had more asthma-related ER visits and/or hospitalizations than children > 3miles
Radon et al 2007	Adults in 4 rural German towns in proximity to CAFOs reported asthma with increasing odor annoyance; the concentration of CAFOs within 500 meters was found to be a predictor of wheeze and decreased FEV1

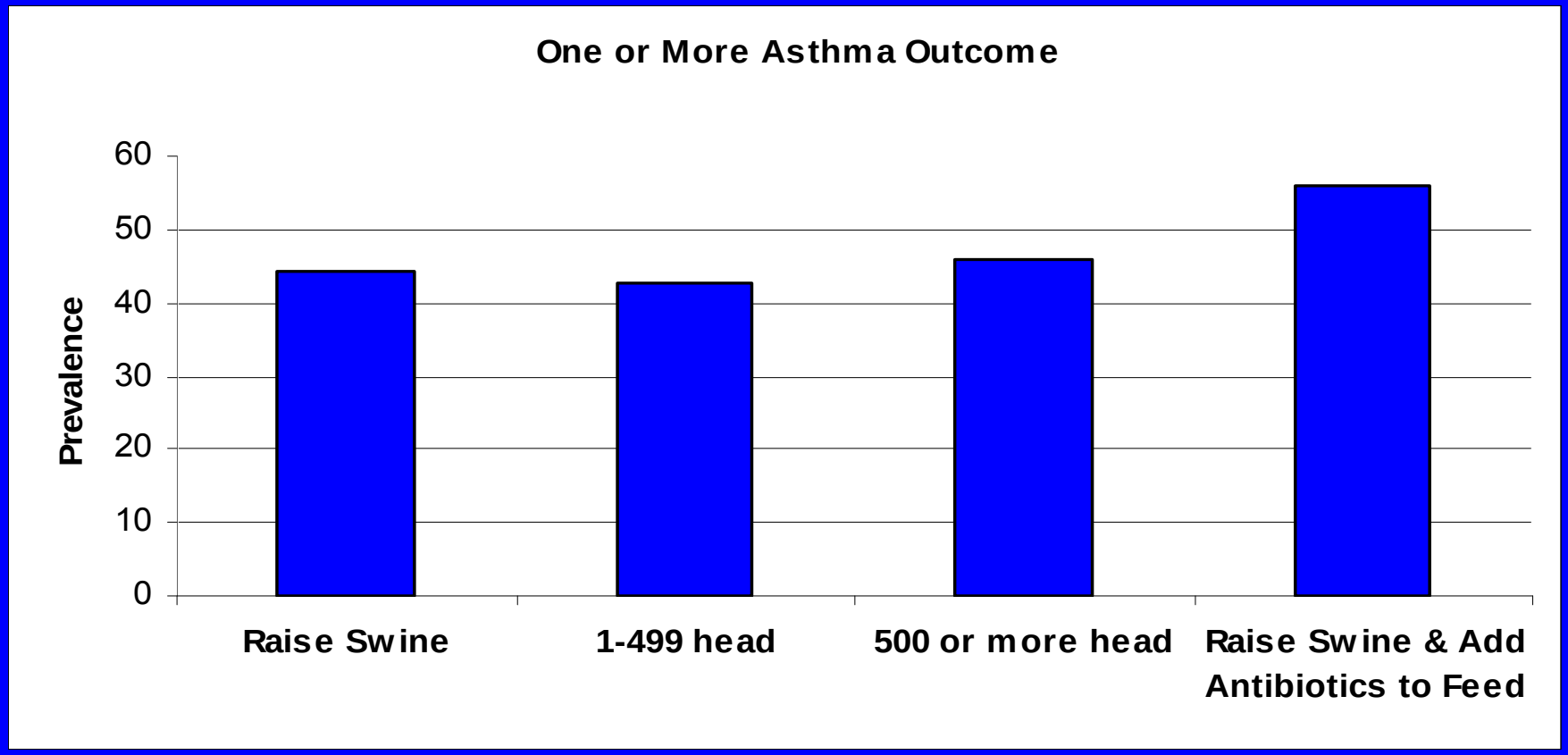
Keokuk County Rural Health Study – Round 1
Childhood Asthma Outcomes

- Doctor diagnosed asthma — 72/610 = 12%
- Asthma/medication for wheeze in last 12 months — 101/610 = 17%
- Current wheeze — 120/490 = 24%
- Cough with exercise — 117/493 = 24%

Source: *Environmental Health Perspectives, 2005;*113(3)

Keokuk County Rural Health Study – Round 1

Asthma Outcome Prevalence and Swine Exposure

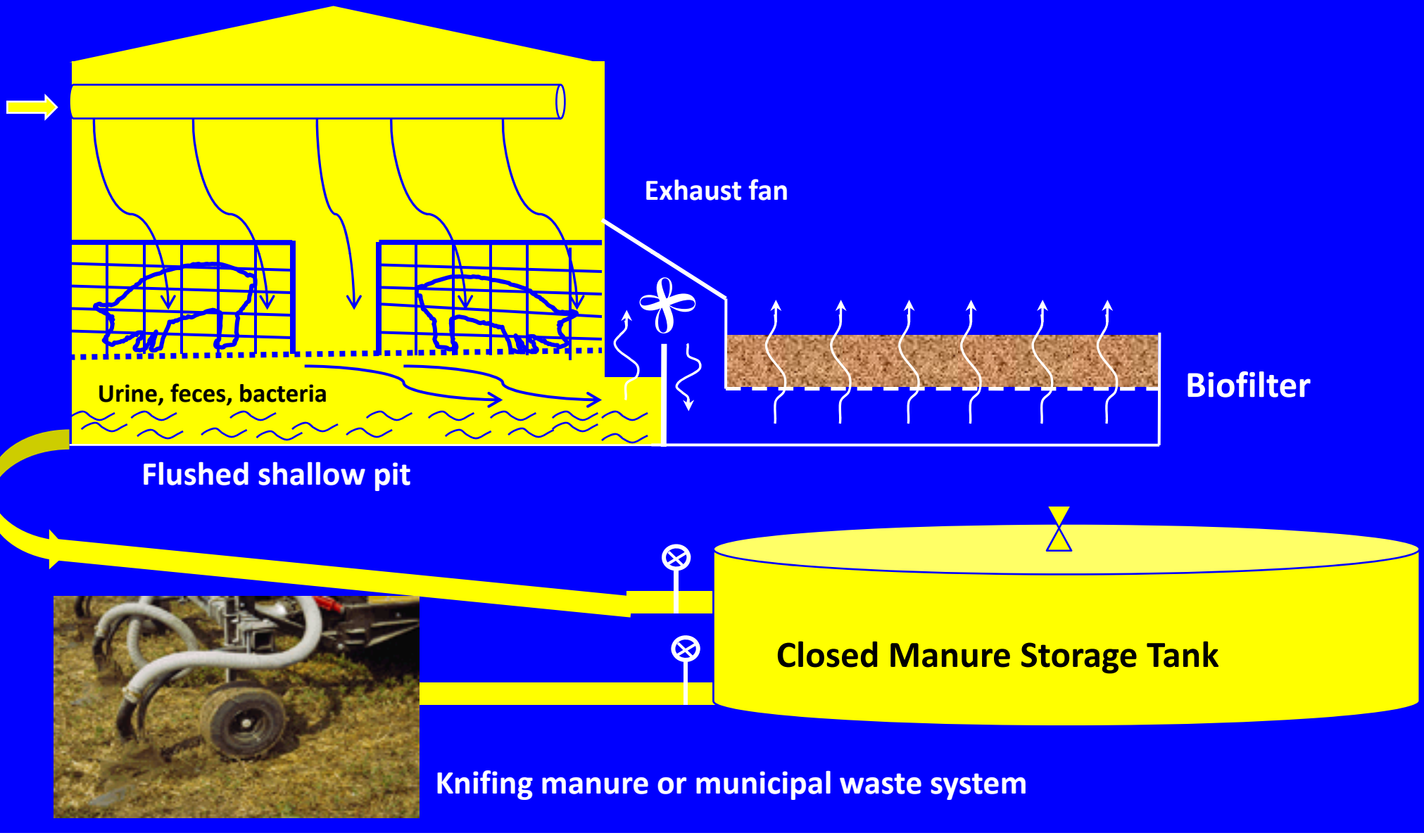


Source: *Environmental Health Perspectives, 2005;* 113(3)

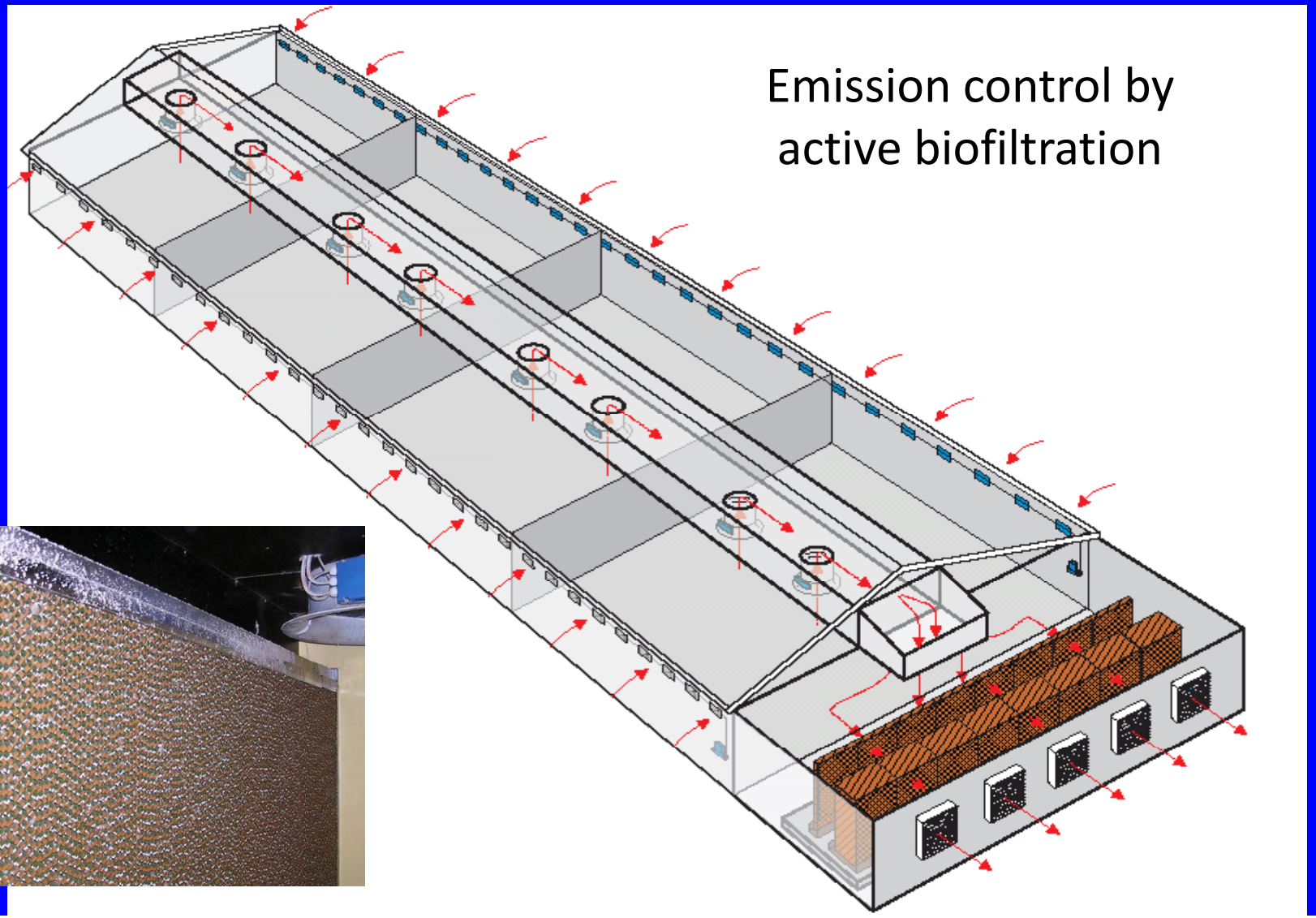
Control Approaches to Limit Exposures to Air Emissions

- Local control of zoning decisions (overturned in Iowa)
- County health department rulings (overturned by Iowa Supreme Court)
- Master Matrix to guide evaluation for permitting (Iowa)
- Set backs - typically 500 to 3000 ft
- Biofilters
- Enclosed manure storage
- Subsurface soil injection of manure slurry
- Industrial or municipal waste treatment systems
- Law suits, civil judgments, consent agreements

CAFO Emission Controls



Control of Airborne Exposures



Features of Emission Controls

- **Biofiltration**
  - Highly effective in Denmark and The Netherlands
  - Low capital investment
  - ~$3.00 per 1000 cfm per year to power fans
  - Power with wind turbines
- **Municipal wastewater treatment systems**
- **Innovative waste treatment models (e.g., Aitken, GIL)**
- **Knifing manure into the soil**
  - Reduces nutrient loss and surface water pollution.
  - Works with conservation tillage systems - less disruption of crop residues.

Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards - Searching for Solutions

- International Conference and Workshop
- Six workgroup consensus papers published in *Environmental Health Perspectives*, 2007
  - Overview of the issues and recommendations
  - Respiratory health effects
  - Modeling and monitoring of air toxics
  - Water quality issues
  - Influenza pandemics and antibiotic resistance
  - Community health and socioeconomic issues

Thorne et al. *Environ. Health Perspec.* 115(2);296-320, Febr. 2007.

Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards – Searching for Solutions

- The 31 scientists identified 26 priority research needs and 16 recommendations for translating science to policy

- "There was general agreement among all workgroups that the industrialization of livestock production over the past three decades has not been accompanied by commensurate modernization of regulations to protect the health of the public, or natural, public-trust resources."

Thorne et al. *Environ. Health Perspec.* 115(2);297, 2007.

Putting Meat on the Table: Industrial Farm Animal Production in America

A Report of the Pew Commission on Industrial Farm Animal Production

www.pcifap.org

Recommendations

National Commission on Industrial Farm Animal Production 2006-2008

- Funded by the Pew Charitable Trust through a grant to the Johns Hopkins Bloomberg School of Public Health
- Chaired by former Governor of Kansas John Carlin and included 14 other commissioners from the private and public sectors—all with substantial knowledge and experience in animal agriculture, public health, animal health, medicine, ethics, public policy and rural sociology
- Included 11 meetings and thousands of pages of peer-reviewed and technical reports and testimony
- Included commissioned reports on Antibiotic Resistance and Human Health, Occupational and Community Public Health Impacts, Environmental Impacts, Economics of Farm Animal Production, and Impact on Rural Communities
- Final report issued in April, 2008, targeting policy makers nationally and a continuing effort to disseminate and recommend policy options. See www.pcifap.org for technical reports and final report.

Report Contents

- How the Current System Developed
- Public Health
- Environmental Risks
- Animal Welfare
- Rural America
- Conclusions: Toward Sustainable Animal Agriculture
- Recommendations of the Commission

Public Health Recommendations

1. Restrict the use of antimicrobials in food animal production to reduce the risk of antimicrobial resistance to medically important antibiotics.

2. Clarify antimicrobial definitions to provide clear estimates of use and facilitate clear policies on antimicrobial use.

3. Require pharmaceutical companies to provide a calendar-year report of the quantities sold for use in farm animals.

4. Improve monitoring and surveillance of antimicrobial resistance in the food supply, the environment, and animal and human populations in order to refine knowledge of antimicrobial resistance and its impacts on human health.

Public Health Recommendations (continued)

5. Increase veterinary oversight of all antimicrobial use in food animal production to prevent overuse and misuse of antimicrobials.

6. Implement a disease-monitoring program and a fully integrated and robust national database for food animals to allow 48-hour trace-back through phases of their production.

7. Fully enforce current federal and state environmental exposure regulations and legislation, and increase monitoring of the possible public health effects of IFAP on people who live and work in or near these operations.

8. Increase research on the public health effects of IFAP on people living and working on or near these operations, and incorporate the findings into a new system for siting and regulating IFAP

Public Health Recommendations (continued)

9. Strengthen the relationships between physicians, veterinarians, and pubic health professionals to deal with possible IFAP risks to public health.
10. Create a Food Safety Administration that combines the food inspection and safety responsibilities of the federal government, including the USDA, FDA, EPA and other federal agencies into one agency to improve the safety of the US food supply.
11. Develop a flexible risk-based system for food safety from farm to fork to improve the safety of animal protein produced by IFAP facilities.
12. Improve the safety of our food supply and reduce use of antimicrobials by more aggressively mitigating production diseases (disorders associated with IFAP management and breeding)

Environmental Impact Recommendations

1. Improve enforcement of existing federal, state, and local IFAP facility regulations to improve the siting of IFAP facilities and protect the health of those who live near and downstream from them.

2. Develop and implement a new system to deal with farm waste (that will replace the inflexible and broken system that exists today) to protect Americans from the adverse environmental and human health hazards of improperly handled IFAP waste.

3. Increase and improve monitoring and research of farm waste to hasten the development of new and innovative systems to deal with IFAP waste and to better our understanding of what is happening with IFAP today.

4. Increase funding for research into improving waste handling systems and standardize measurements to allow better comparisons between systems.

Animal Welfare Recommendations

1. The animal agriculture industry should implement federal performance-based standards to improve animal health and well-being.
2. Implement better animal husbandry practices to improve public health and animal well-being.
3. Phase out the most intensive and inhumane production practices within a decade to reduce IFAP risks to public health and improve animal well-being.
4. Improve animal welfare practices and conditions that pose a threat to public health and animal well-being.
5. Improve animal welfare research in support of cost-effective and reliable ways to raise food animals while providing humane animal care.

Community Impact Recommendations

1. States, counties and local governments should implement zoning and siting guidance governing new IFAP operations that fairly and effectively evaluate the suitability of a site for these types of facilities.

2. Implement policies to allow for a competitive marketplace in animal agriculture to reduce the environment and public health impacts of IFAP.

Conclusions

- The highly integrated industrial farm animal production system in the US has resulted in adverse public health, environmental, animal welfare and community impacts—effectively transferring these human, environmental, animal and community impact costs to the affected rural communities.

- The Pew Commission on Industrial Farm Animal Production has thoroughly examined these several issues and has made a series of recommendations designed to mitigate these adverse impacts and to encourage transition of this industry to a more sustainable future

- Major forces including energy costs, limited water resources, and climate change dictate that this industry must adopt a more ecological approach to sustain its viability in the decades ahead

ACKOWLEDGMENTS

Many faculty members at the University of Iowa and College of Public Health made significant contributions to the Occupational and Community Public Health Impacts technical report and participated in a seminar that contributed to the development of the Community Impact technical report, including Kelly Donham, Greg Gray, Keri Hornbuckle, Patrick O'Shaughnessy, David Osterberg and Peter Thorne. I thank them for their expertise and generous contribution to this Pew Commission report and this presentation.

I also wish to thank Del Bonney who provided technical editing and other assistance in the development of the Occupational and Community Public Health Impacts technical report, and Ann Stromquist for her assistance in preparing this presentation.