

The Risk of Food and Water Contamination from Animal Manure

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Introduction

- **Increasing concern about zoonotic disease worldwide**
 - **Impact of CAFOs**
 - **Outbreaks of waterborne and foodborne disease associated with zoonotic pathogens**
 - **Bioterrorism/agroterrorism**

Public Health and Animal Waste

- **Agents present in animal waste of public health importance**
 - Infectious (bacteria, virus, protozoa)
 - Chemical (nitrate, antimicrobials)
 - Other (algae)
- **Other concerns**
 - Antimicrobial residues
 - Antimicrobial resistance



Common Zoonotic Diseases

Infectious diseases resulting from contact with animals or animal waste

Salmonellosis
Collibacillosis
Yersiniosis
Leptospirosis
Campylobacteriosis
Chlamydia (Ornithosis)
Brucellosis
Erysipeloid
Q Fever
Listeriosis
Streptococcal meningitis
Pasteurella aerogenes
Cryptosporidiosis
Giardiasis
Hepatitis E (?)

Most common animal source

Cattle, chickens and others
Cattle
Pigs
Cattle, pigs
Cattle, chickens
Sheep, turkeys
Cattle, pigs
Pigs, turkeys
Sheep, cattle
Ruminants
Pigs
Pigs
Cattle
Cattle
Pigs

From: Cole et al., 1999.

Risk of Hepatitis E Virus Infection from Swine Manure?

- High HEV detection rates reported in sewage from swine farms in several countries
- In nonendemic areas, higher seroprevalence among human populations with occupational exposure to swine (Drobeniuc et al., 2001)
- Close genetic relationship between HEV strains from swine in the Netherlands and human HEV strains from Europe and America (van der Poel et al., 2001)

Potential Routes of Human Exposure to Zoonotic Pathogens

- **Oral**
 - Food consumption
 - Drinking water
 - Recreational water
- **Dermal via recreational water**
- **Inhalation of aerosols**
- **Occupational exposures (farm workers, vets)**



CAFO

Concentrated Animal Feeding Operation

- Confined animals: \geq 1,000 cattle
 \geq 2,500 swine
 \geq 100,000 chicken
 \geq 55,000 turkeys
- Animal waste stored
 - Lagoons
 - Under-facility pits
 - Waste spread onto fields as fertilizer or soil amendment



Concerns about CAFOs

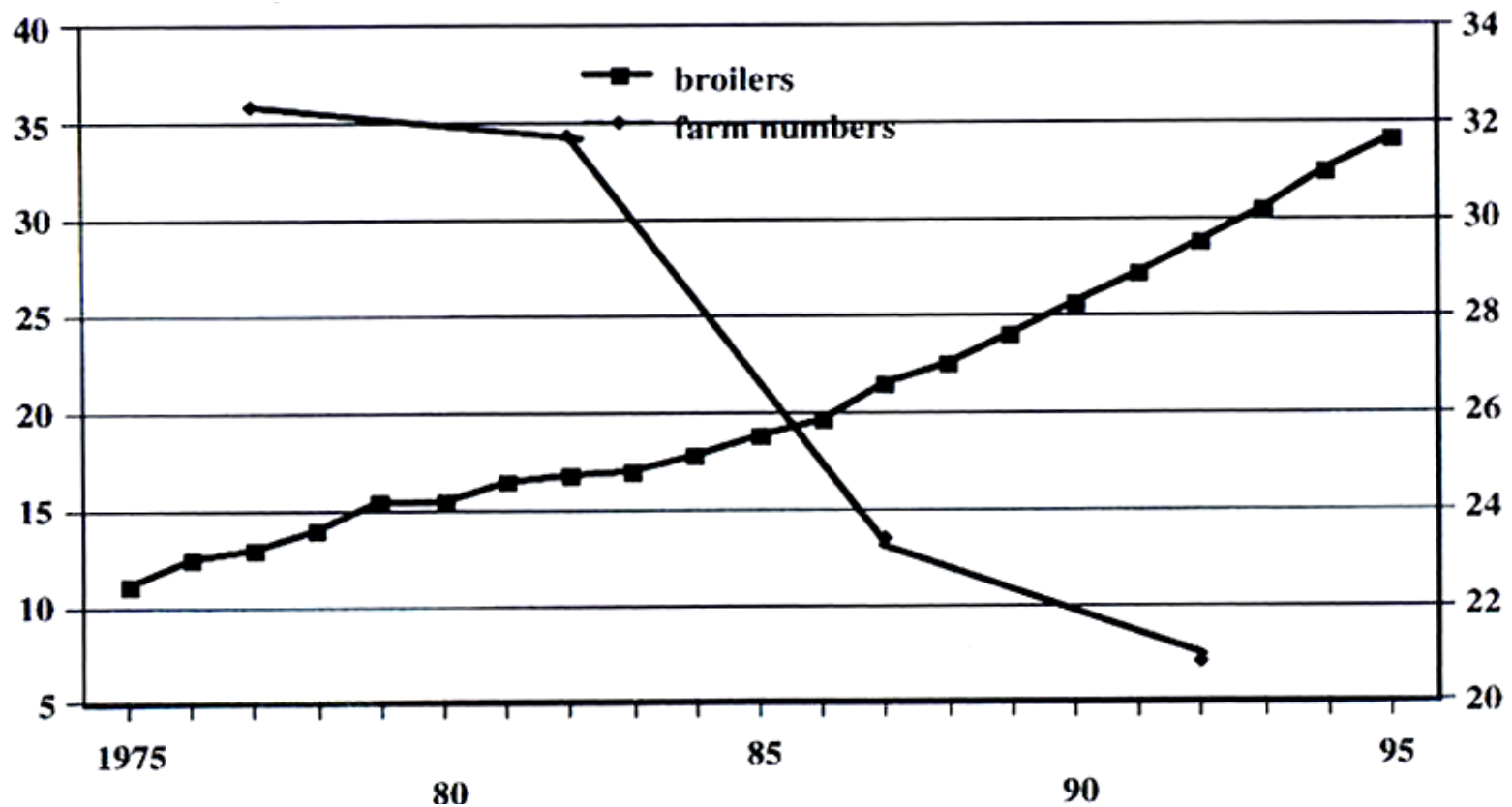
- ~450,000 CAFOs
- 132 million metric tons dry animal waste (1997)
 - Swine, poultry, beef and dairy cattle
 - Applied to land
 - “untreated”
- 22 million metric tons human waste (1997)
 - 5 ton animal waste produced /person in U.S.
 - Treated prior to discharge
- Growth and changes in industry
 - High-profile events
 - Potential negative health impact?



Broiler production and number of farms in the USA, 1975-95

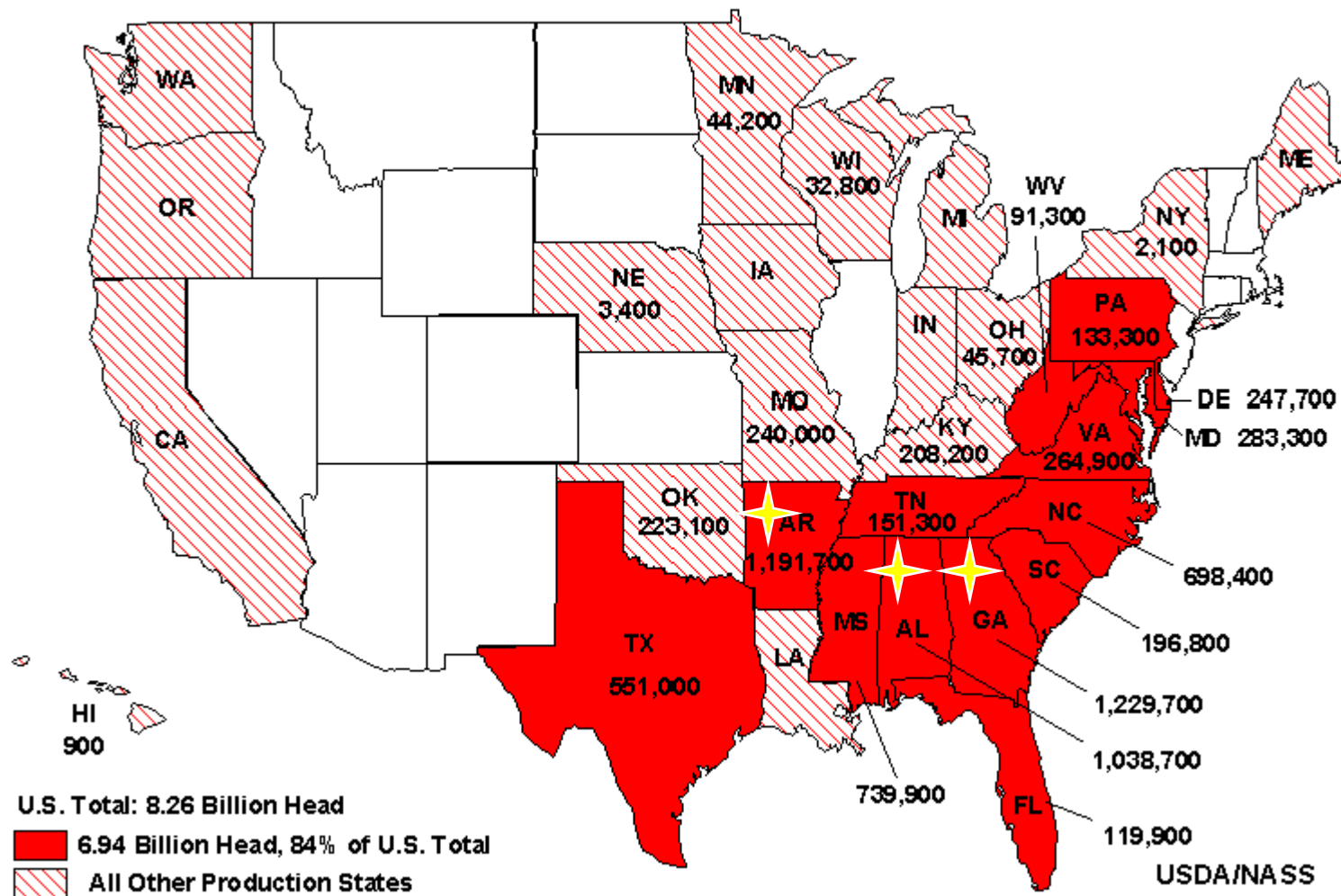
millions of pounds

thousands



Source: USDA/NASS, and Census of Agriculture, various years

BROILER PRODUCTION BY STATES NUMBER RAISED (000), 2000



USDA/NASS
04/25/01



Potential sources of human exposure to animal waste

- Leakage or discharge from storage lagoons
 - Surface water
 - Groundwater
- Application to fields
 - Runoff into surface or groundwater
 - Direct effect on crops
- Exposure to aerosols



Impact of CAFOs on Water

- Impact on surface waters
 - Drinking water supplies
 - Estuaries and HAB
- Impact on ground water
 - Drinking water



Waste Spills and Discharges

- Discharges intentional and unintentional
- Spills due to lagoon failure or storm load



Documented Discharges from Animal Operations to Surface Waters

- Swine operations
 - 110 incidents, 1987-1997
- Beef and Dairy operations
 - 57 incidents, 1985-1998
- Poultry operations
 - 18 incidents, 1987-1997

Source: USEPA, 2001

Impacts of Animal Waste Spills

- **1995 North Carolina**
 - 35 million gallons swine waste
 - 10 million fish killed
 - 360,000 acres of shellfish harvesting beds closed
- **Iowa, Minnesota and Missouri**
 - 1992: 20 reported spills, ~55,000 fish killed
 - 1996: 40 reported spills, ~670,000 fish killed
 - 1998: 31 reported spills (IA), >465,000 fish killed
- **1998 Minnesota dairy feedlot discharge**
 - 125 million gallons manure
 - ~700,000 fish killed

Leaking Lagoons

- “All lagoons should be expected to leak”
 - Iowa State University, 1999 study of lagoon design
- Carolinas swine and poultry lagoons
 - 66% leached into ground water



CDC Studies of CAFO Impact on Water

- CDC Health Studies Branch (NCEH)
 - Iowa (swine operations)
 - Ohio (poultry operations)



CDC Pilot Environmental Studies

- Iowa: 9 swine CAFOs
 - Waste and environmental samples
- Ohio: 5 poultry CAFOs
 - Environmental samples
- Convenience samples
 - Producer cooperation
 - Anonymous



Objectives of Studies

- Methods development/baseline data
- Assessment of pollutants near CAFOs

– Chemical

- nutrients
- trace metals and common ions
- pesticides
- antimicrobial residues

– Microbial

- zoonotic enteric pathogens
- antimicrobial susceptibility
- parasitic oocysts

Summary of Findings

- Identified pollutants in surface and groundwater proximal to CAFOs

- Nutrients

- Antimicrobial residues

- Bacteria

- zoonotic enteric pathogen



- Antimicrobial resistant bacteria

- Resistance to antibiotics commonly used in human and veterinary medicine

Other Environmental Studies

- **Tetracycline resistance genes in swine lagoons and underlying ground water**
 - University of Illinois (Chee-Sanford, et al; 2001)
- **Association between livestock density and human Shiga Toxin -*E. coli* cases**
 - University of Guelph (Valcour, et al; 2002)

Waterborne Outbreaks and Animal Waste

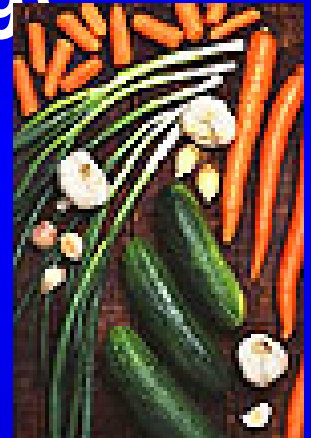
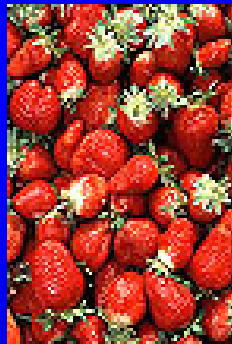
- **Washington County Fair, NY (1999)**
 - *E. coli* O157:H7 and *Campylobacter* spp.
 - 148 confirmed cases, 2 deaths
- **Walkerton, Ontario, Canada (2000)**
 - *E. coli* O157:H7 and *Campylobacter* spp.
 - 2300 cases of GI illness, 7 deaths

Human Food and Animal Wastes

- Foods vulnerable to waste contamination
 - Produce
 - Seafood
- Possible mechanisms of contamination
 - Water
 - Irrigation, processing, habitat
 - Soil

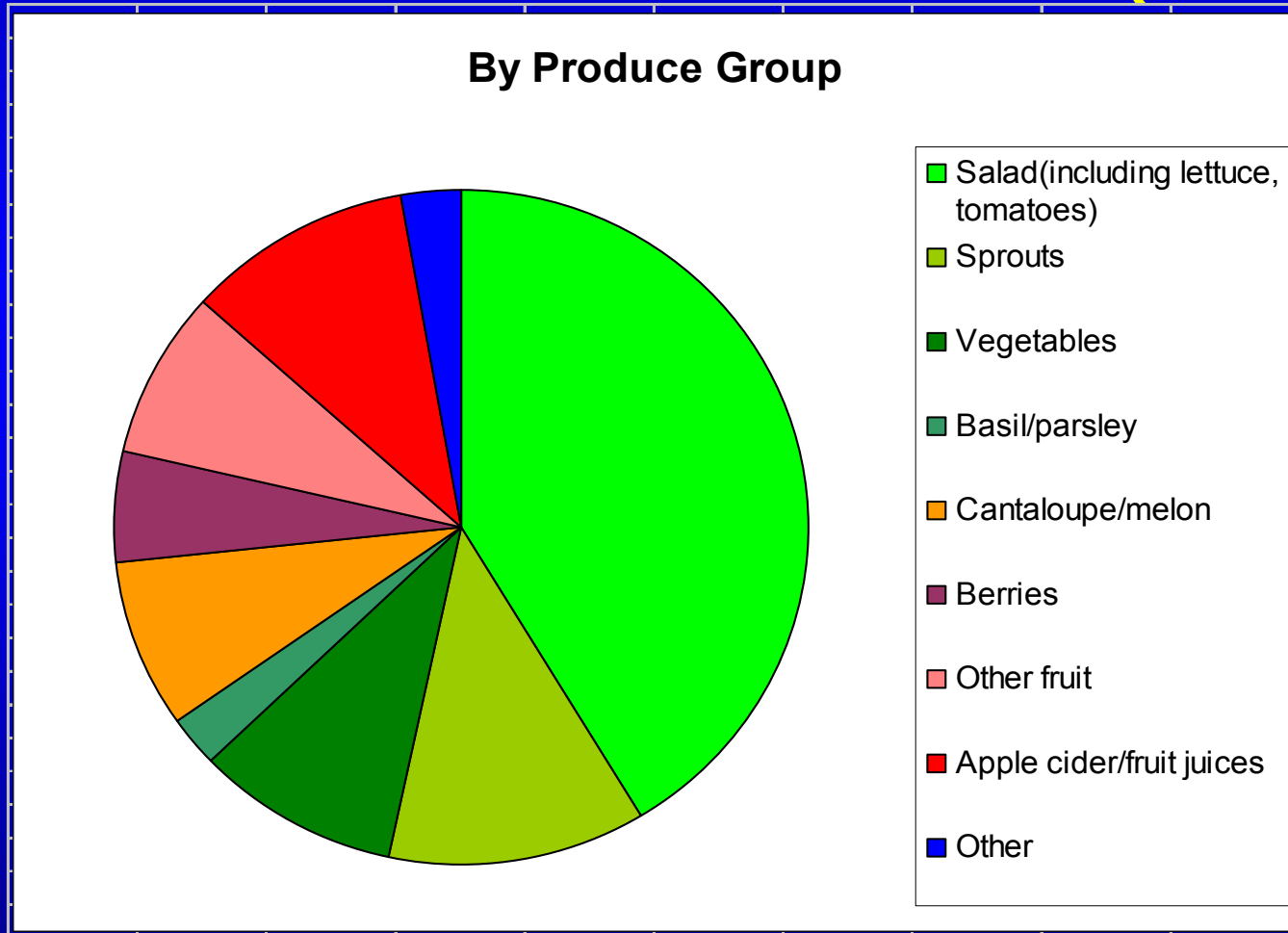
Produce Contamination and Human Illness

- 76 million cases of foodborne illness in US per year (Mead et al., 1999)



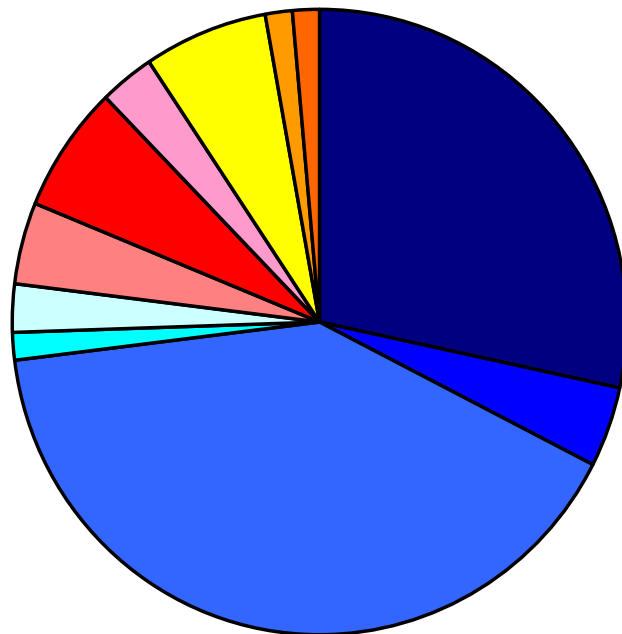
- Foodborne illness associated with produce is increasing over time

Reported Produce-Associated Outbreaks of Known Etiology United States 1990-1998 (N=74)



Reported Produce-Associated Outbreaks of Known Etiology United States 1990-1998 (N=74)

Etiologic agents



- Salmonella
- Shigella
- E. coli
- V. cholera
- Campylobacter
- Giardia
- Cyclospora
- Cryptosporidium
- Hepatitis A Virus
- Norwalk Virus
- Other viral

Sources of Pathogens

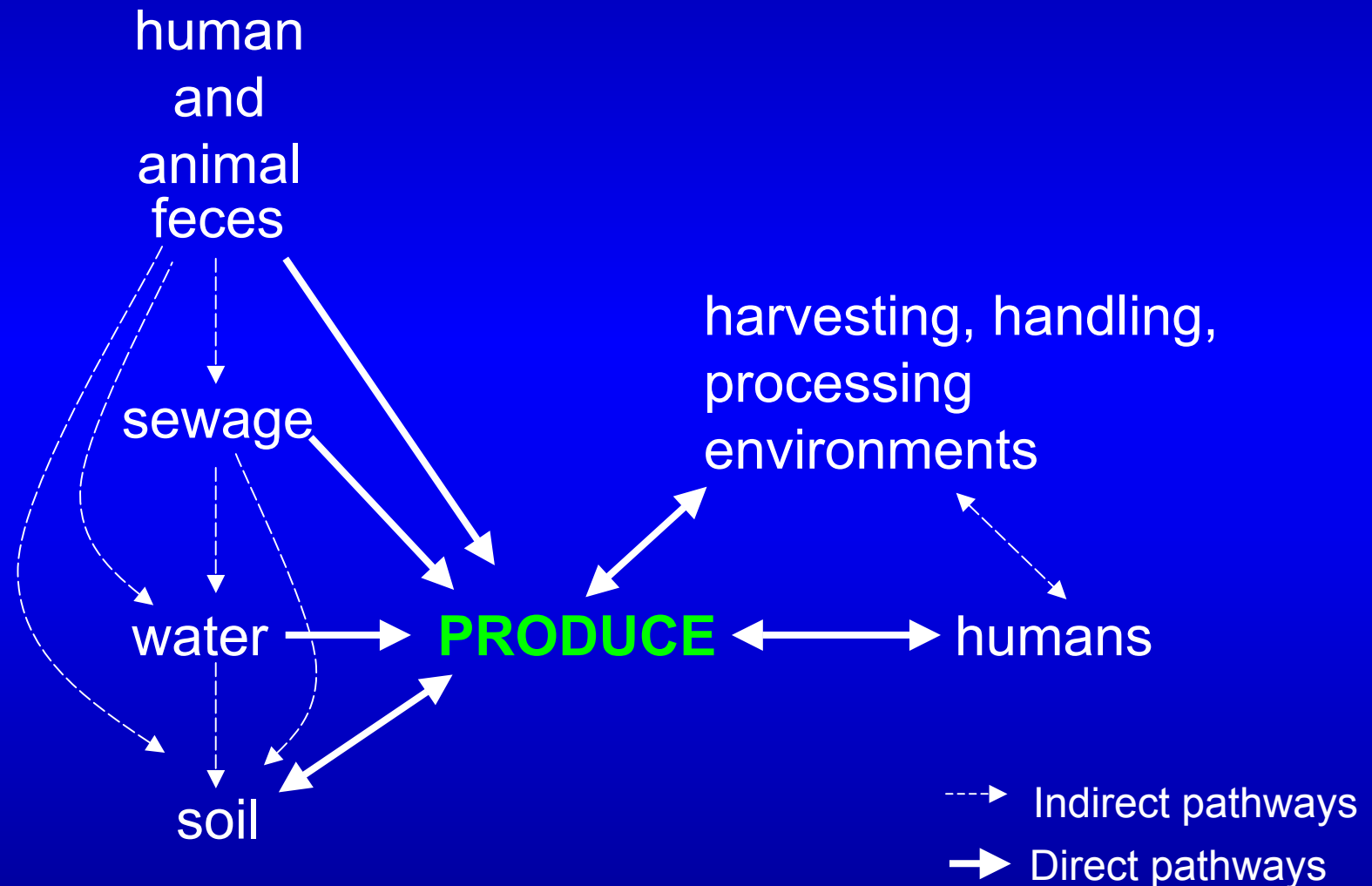
- **Source of Produce:**
 - 47% of outbreaks domestic produce
 - 18% of outbreaks imported produce
 - 35% of outbreaks - unknown source

E. coli O157:H7 Outbreaks

- October 1996
- 2 outbreaks associated with apples
 - Unpasteurized cider (CT)
 - Unpasteurized juice (Western US and Canada)
- 78 cases, 1 death
- “Drop” apples contaminated by cattle manure?
- Lab studies show E. coli O157:H7 can survive up to 4 weeks in apple cider



Possible paths of pathogen transmission to produce



Produce Contamination

- **FDA CFSAN Surveys of Fresh Produce**
 - Imported (1999)
 - Domestic (2001) produce

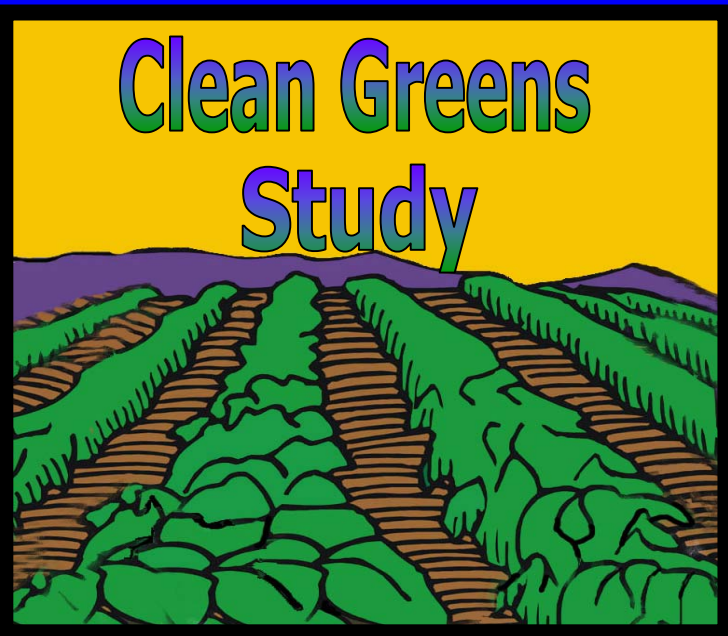
 - Zoonotic pathogens
 - *Salmonella*, *E. coli* O157:H7
 - Human pathogens
 - *Shigella*

FDA Produce Surveys

- **Imported produce**
 - **44/1003 (4%) contaminated**
 - **35 (80%) *Salmonella* detections**
 - **9 (20%) *Shigella* detections**
- **Domestic produce**
 - **12/767 (1.6%) contaminated**
 - **6 (50%) *Salmonella* detections**
 - **6 (50%) *Shigella* detections**

Clean Greens Study

NCEH Health Studies Branch, Emory University
North Carolina State University
Texas Agricultural Extension Service



**A field study of produce
farms and packing sheds
in the Southwestern
United States**

Funded by USDA

Data Collection

- **Farm and Packing Shed Surveys**

Agricultural water

Processing water

Manure and biosolids

Worker health/hygiene

Sanitary facilities

Harvest considerations

Transportation

Tracking

Packing shed sanitation

- **Water sampling and microbiological analyses**

- **Produce sampling and microbiological analyses**

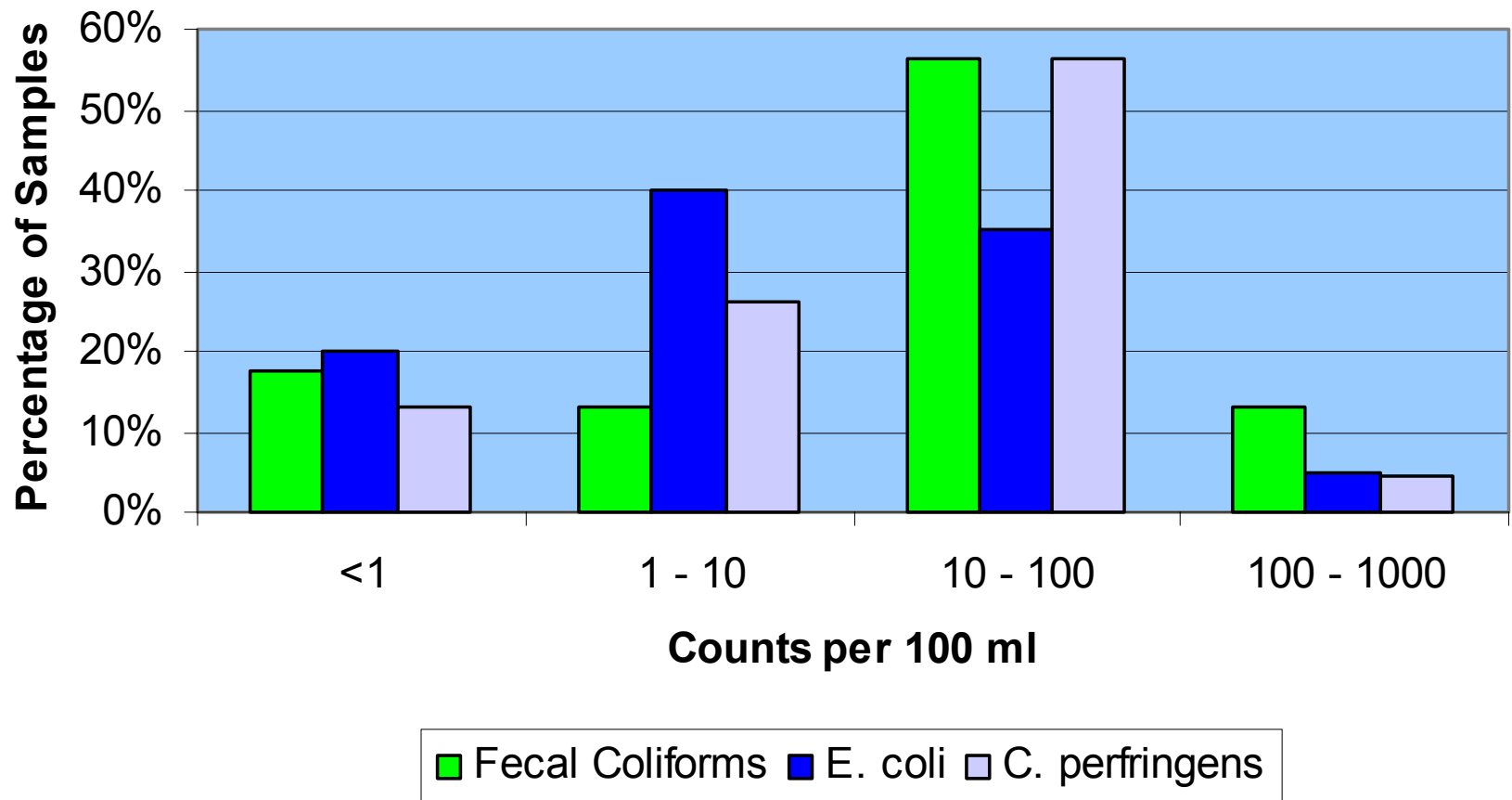
Manure and Biosolids

- **Is manure applied to fields?**
- **What type of manure is used?**
- **Is manure treated?**
- **How and where is manure stored?**
- **Are practices and structures in place to ensure that animals are kept away from fields and water sources?**

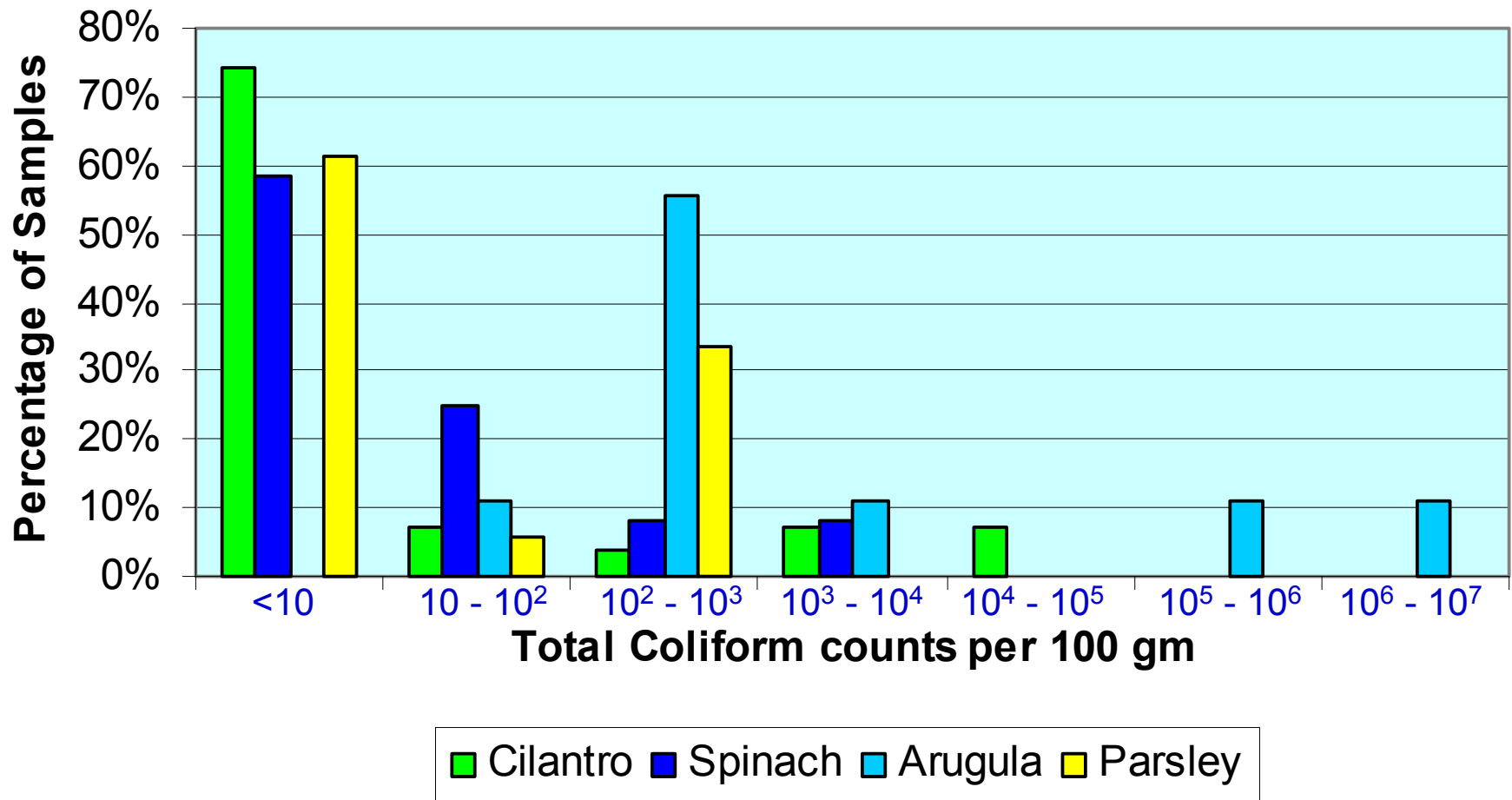
Clean Green Study: Prelim Results

- **71% report animals near water source, but only 14% have barriers to keep animals out of water source**
- **14% routinely test irrigation water for fecal indicators**
- **14% report animals near or in crop fields**
- **None use barriers to keep animals out of fields**
- **None test produce items for fecal indicators**

Microbiological Quality of Irrigation Samples (N= 23)



Microbial Quality of Field Samples



Other CAFO Issues

- Environmental justice
- Proposed new regulation of CAFOs and waste management



NC Study of Swine CAFOs

Wing et al., 1999

- 19 x more swine operations in census areas with greatest poverty vs. areas with least poverty
 - 7x more swine operations in poorest areas after adjusting for population density
- 5x more swine CAFOs in areas with greatest non-white population
- High concentration of swine CAFOs in areas where majority of population depends on groundwater for drinking water source

New EPA guidelines for CAFO effluent

- **All** beef and dairy CAFOs and **new** swine, poultry and veal CAFOs must assess whether groundwater beneath feedlot and manure storage area is linked to surface water
- Zero discharge requirement for swine, veal and poultry CAFOs
- Required routine inspections to ensure that wastewater, manure handling and storage are functioning properly

New EPA guidelines for CAFO effluent

- **Required assessment of crop nutrient needs and soil nutrient content to prevent manure application in excess of land capacity**
- **Required 100 foot setback between manure and wastewater application and surface water**
- **Required to maintain records of off-site transfers of manure and wastewater**

Summary and Conclusions

- Fewer operations with larger numbers of animals
- Multiple pathways of exposure to animal wastes through water and food
- Many documented disease outbreaks associated with contamination of drinking water, recreational water and food with animal waste
- Possibly chronic exposure via contaminated groundwater - health effects not known

Research Needs

- **Need to determine health significance of trace detection of antimicrobials, compound mixtures in groundwater**
- **Need for better detection sensitivity and source tracing tools**
- **Need for better understanding of specific agricultural practices that lead to food and water contamination**

Research Needs

- **Need for economically feasible, environmentally safe animal waste treatment and disposal practices for large and small scale animal operations**