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# Mixed Species and Crops Considerations

Pastured Poultry Workshop  
October 27, 2015

Alda Pires, DVM, MPVM, PhD, Dipl. ACVPM  
Urban Agriculture & Food Safety, UC ANR CE Specialist  
School of Veterinary Medicine



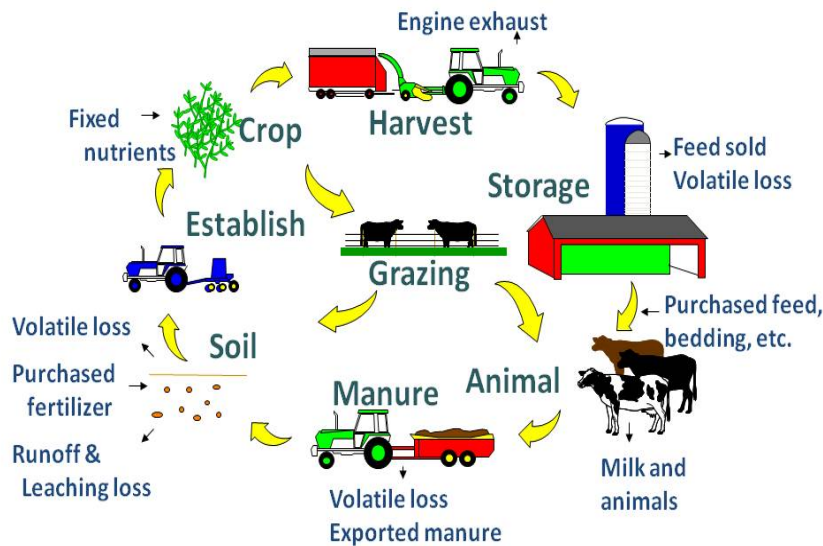
University of California  
Agriculture and Natural Resources

# Background

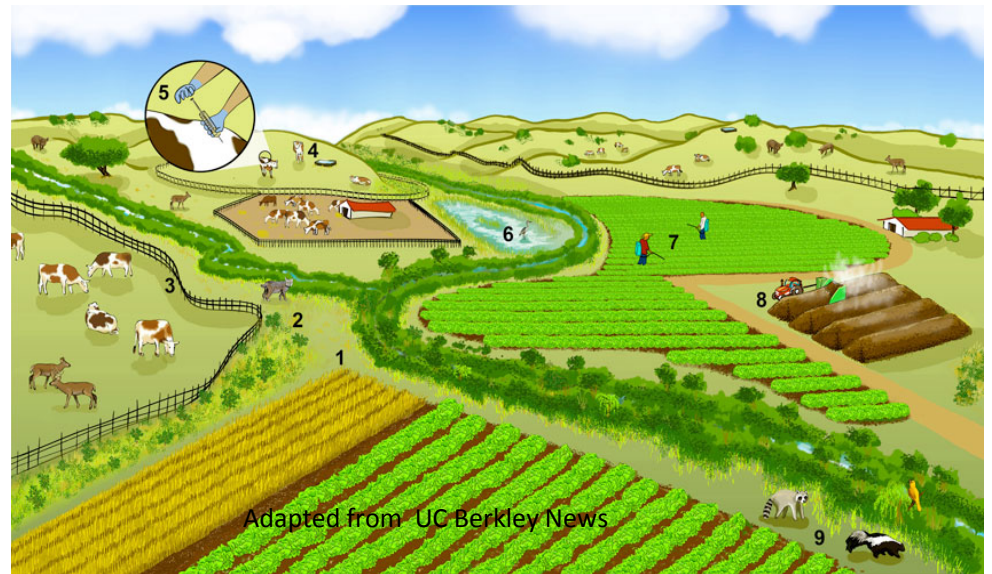
- Extension Specialist for **Urban Agriculture & Food Safety**, UC ANR CE, UC Davis School of Veterinary Medicine
- Veterinary Epidemiologist, research in **Food Safety and Epidemiology of Infectious Diseases**, CADMS, UC Davis School of Veterinary Medicine; College of Veterinary Medicine Michigan State University
- **Food Animal Clinician (small to large scale farms) and Lecturer**, School of Veterinary Medicine, UC Davis & Portugal

# Mixed Crop-Livestock Systems

- Mixed/integrated crop-livestock systems are farms where animals and crops are raised with the goal of utilizing the products of one for the growth of the other (Hilimire, 2011)



Adapted from [www.ars.usda.gov](http://www.ars.usda.gov)





# Mixed Crop-Livestock Systems

## Specialized systems



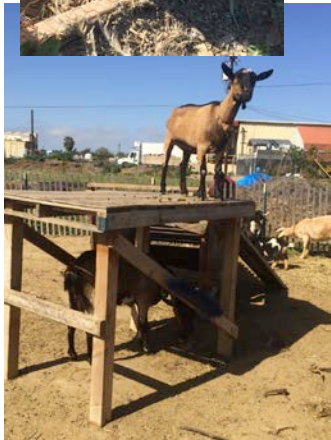
## Integrated systems





# Mixed Crop-Livestock Systems

## Spatially Separated



## Rotational



## Fully Combined



Adapted from reuters.com

# Mixed Crop-Livestock Systems Benefits

- **Fertilize the soil** with on-farm input, livestock manure
  - Encourage and allow growers to maintain semi-permanent pasture fields, which can **improve soil quality**
  - Increase **crop yield**
  - Enhance **on-farm bio-diversity** and related ecosystem services: pollination, weed/pest management
  - Enhance **economic gain** to growers
  - Confer **social benefits** to **growers and communities**
- (Hilimire, 2011)

# Mixed Crop-Livestock Systems Challenges

- Confronting a loss of **animal husbandry knowledge\***
  - **Animal Health**
  - **Cross-species Transmission & Cross-contamination**
    - **Parasites**
    - **Enteric/Foodborne Pathogens**
- **Regulations** designed for specialized agro-ecosystems\*
  - **Food Safety**
- Erosion of **animal genetic diversity\***
  - Heirloom species
- Limited **meat processing infrastructure** for small-scale production\* (\*Hilimire, 2011)

# Mixed Crop-Livestock Systems Challenges

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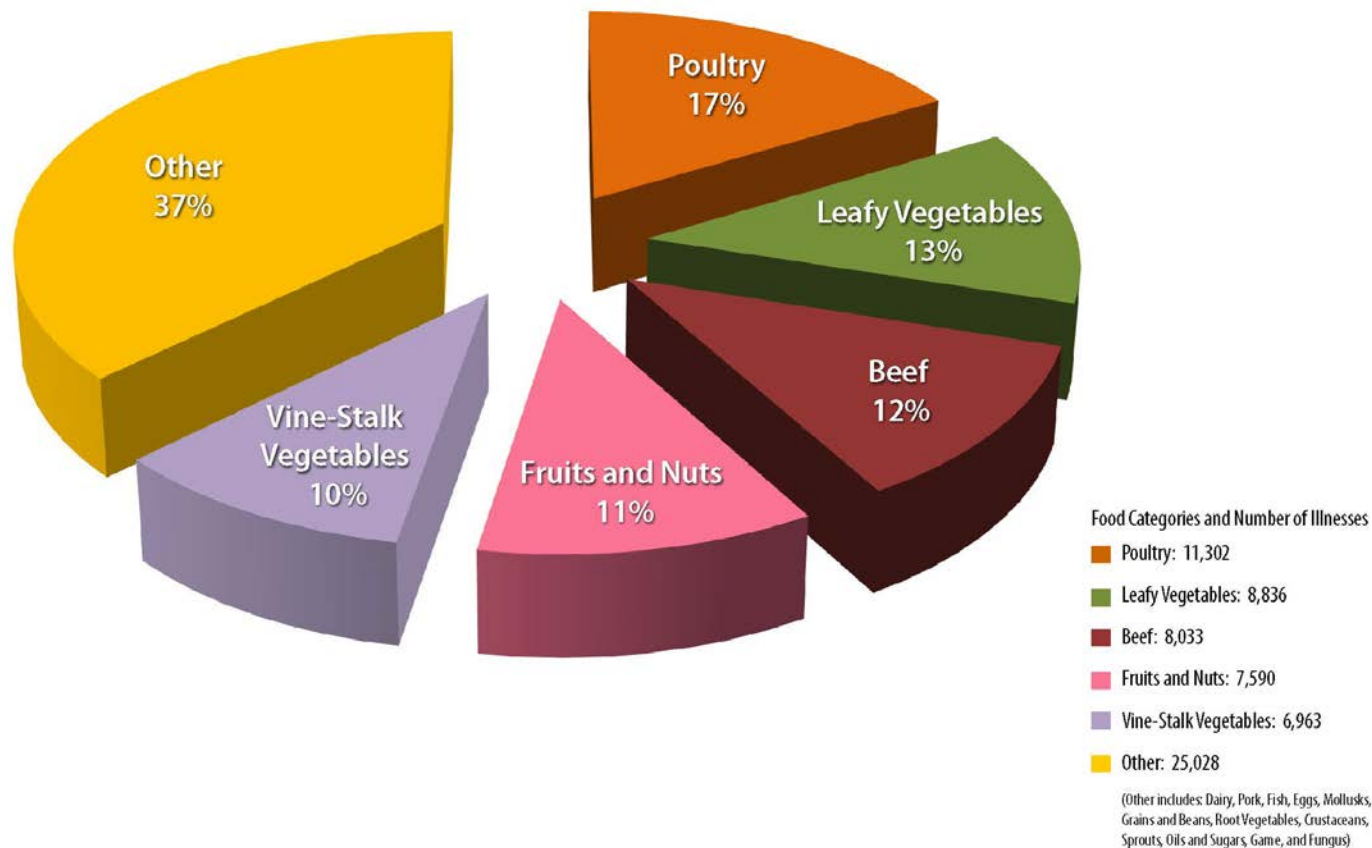
# Mixed Crop-Livestock Systems

## Foodborne Pathogens

- CDC estimates that each year roughly 1 in 6 Americans (or 48 million people) gets sick, 128,000 are hospitalized, and 3,000 die of foodborne diseases ([www.cdc.gov](http://www.cdc.gov))
- *Salmonella*, *E. coli* O157:H7 and *Campylobacter* are major causes of foodborne diseases in the United States
- Livestock species

# Mixed Crop-Livestock Systems Foodborne Pathogens

Foods Linked to Outbreak-Associated Illnesses, 1998 - 2008

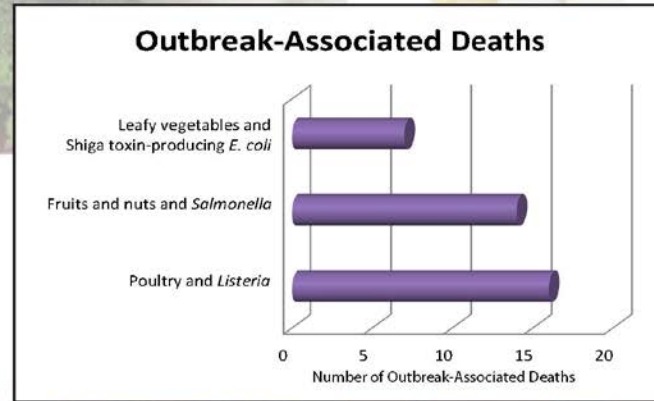
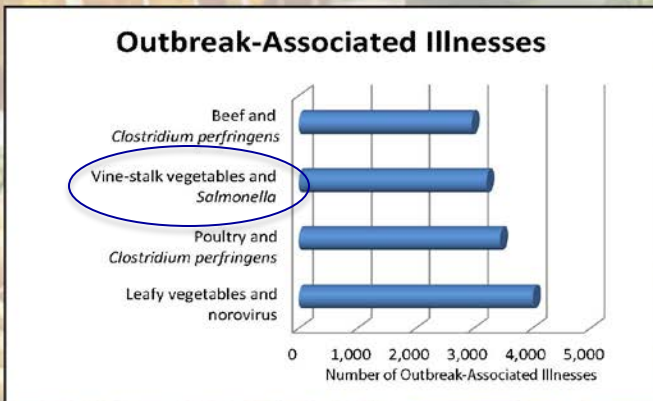
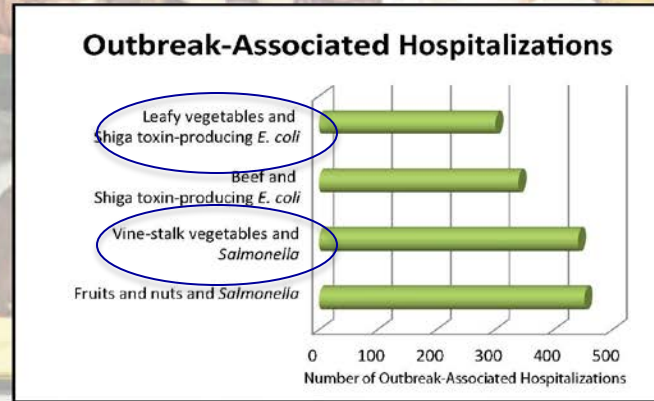
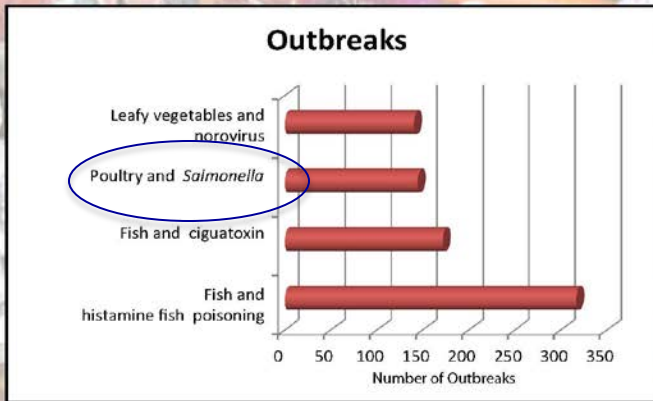


# Mixed Crop-Livestock Systems

## Foodborne Pathogens

### Impact of Outbreaks Traced to Contaminated Foods

These snapshots show how many outbreaks, and outbreak-associated illnesses, hospitalizations, and deaths occurred in the United States during 1998-2008.



# Mixed Crop-Livestock Systems Foodborne Pathogens

- **Few outbreaks linked to small-farms & farmers markets**
  - Oregon Strawberry Outbreak (*E. coli* O157:H7, 2011)
  - Guacamole-based products, Iowa (*Salmonella* Newport, 2010)

## Food Safety News

Breaking news for everyone's consumption

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### Did Deer Cause Oregon's Strawberry Outbreak?

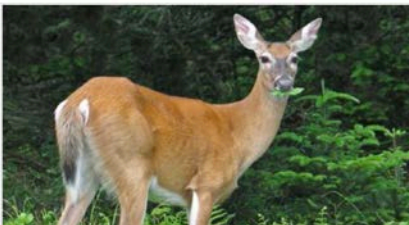
BY GRETCHEN GOETZ | AUGUST 9, 2011

Strawberries sold at roadside and farmer's markets last month in Oregon have been implicated in an outbreak of *E. coli* O157:H7 infection that has caused one death and sickened as many as 15 others, the Oregon Department of Public Health announced Monday.

The outbreak sent four people to the hospital and two suffered hemolytic uremic syndrome. One, an elderly woman from Washington County, died from kidney failure caused by the disease.

So far, health investigators think deer may be to blame for the *E. coli* contamination. Deer tracks and deer feces were observed in several strawberry fields at the suspect farm, according to health investigators.

Tracing the berries to that farm was no easy task. Between July 10 and 29, at least 10 and as many as 16 people fell ill in Oregon with *E. coli* O157:H7 infections. It was not until last week – when genetic



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### Salmonella Outbreak Linked to Cashew Cheese Sickens 15

BY NEWS DESK | DECEMBER 31, 2013

At least 15 people in the western U.S. have been sickened with *Salmonella* in an outbreak linked to pasteurized cashew cheese produced by The Cultured Kitchen, according to the California Department of Public Health.

Three patients have been hospitalized. Of the 15 who became ill, 12 reside in California.

The company has initiated a voluntary recall on its cashew cheese products with expiration dates on or before April 19, 2014. The products were sold in natural food stores in northern California and northern Nevada, as well as at farmers markets in Sacramento County.



The products were sold in eight-ounce plastic containers in the following flavors: herb, smoked cheddar, pepper jack, habañero cilantro lime, basil pesto and white cheddar. Cashew cheese is a non-dairy vegan alternative to



# Mixed Crop-Livestock Systems

## Foodborne Pathogens

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**Food Safety News**

### Low Risk ?? Underreporting ????

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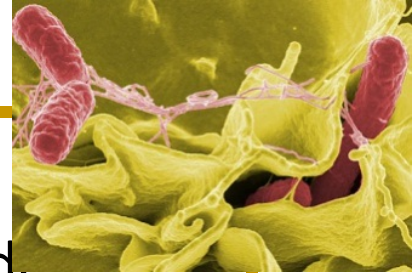
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# Mixed Crop-Livestock Systems

## Foodborne Pathogens



- ***Salmonella***
- Can be found in the gastro-intestinal tract of a wide variety of domestic animals and wild (>2,500 serovars)
- Colonizes poultry, cattle, small ruminants and swine
- High infectious dose
- Leading cause of foodborne bacterial illness
- Poultry and poultry products



# Mixed Crop-Livestock Systems

## Foodborne Pathogens

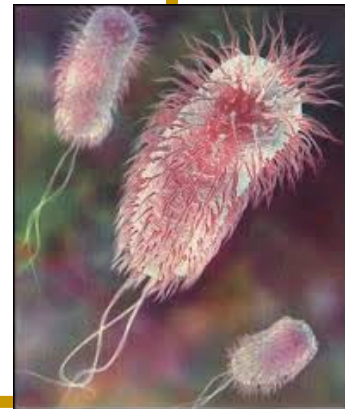
- ***Campylobacter***
- Can be found in the gastro-intestinal tract of a wide variety of domestic animals and wild
- Colonizes poultry as commensal
- 2<sup>nd</sup> cause of foodborne bacterial illness
- Low infectious dose (~ 500 bacteria may cause human disease)
- Outbreaks associated with raw milk
- Poultry and poultry products
- High susceptible to stress



# Mixed Crop-Livestock Systems

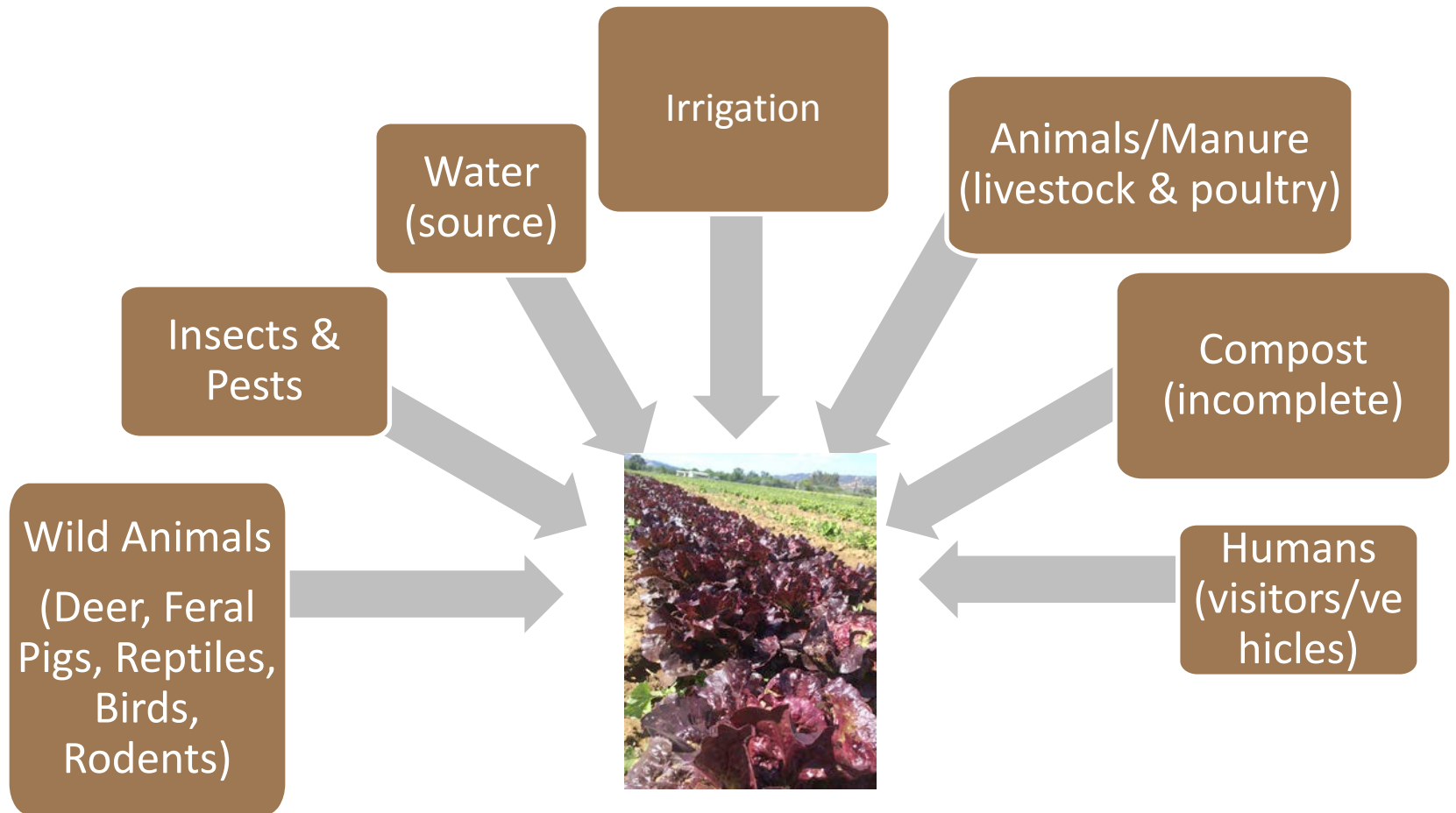
## Foodborne Pathogens

- ***E. coli O157: H7***
- *E. coli* is a normal inhabitant of the intestine of all animals
- Shiga-toxin-producing *E. coli* (STEC)- *E. coli* O157:H7 <50 total organisms may cause human disease
- Cattle, Goats, Sheep, Swine (Cattle is the main reservoir)
- Outbreaks associated with raw ground beef, spinach, lettuce, cheese curds, alfalfa sprouts
- *E. coli* O157:H7 rarely reported in poultry



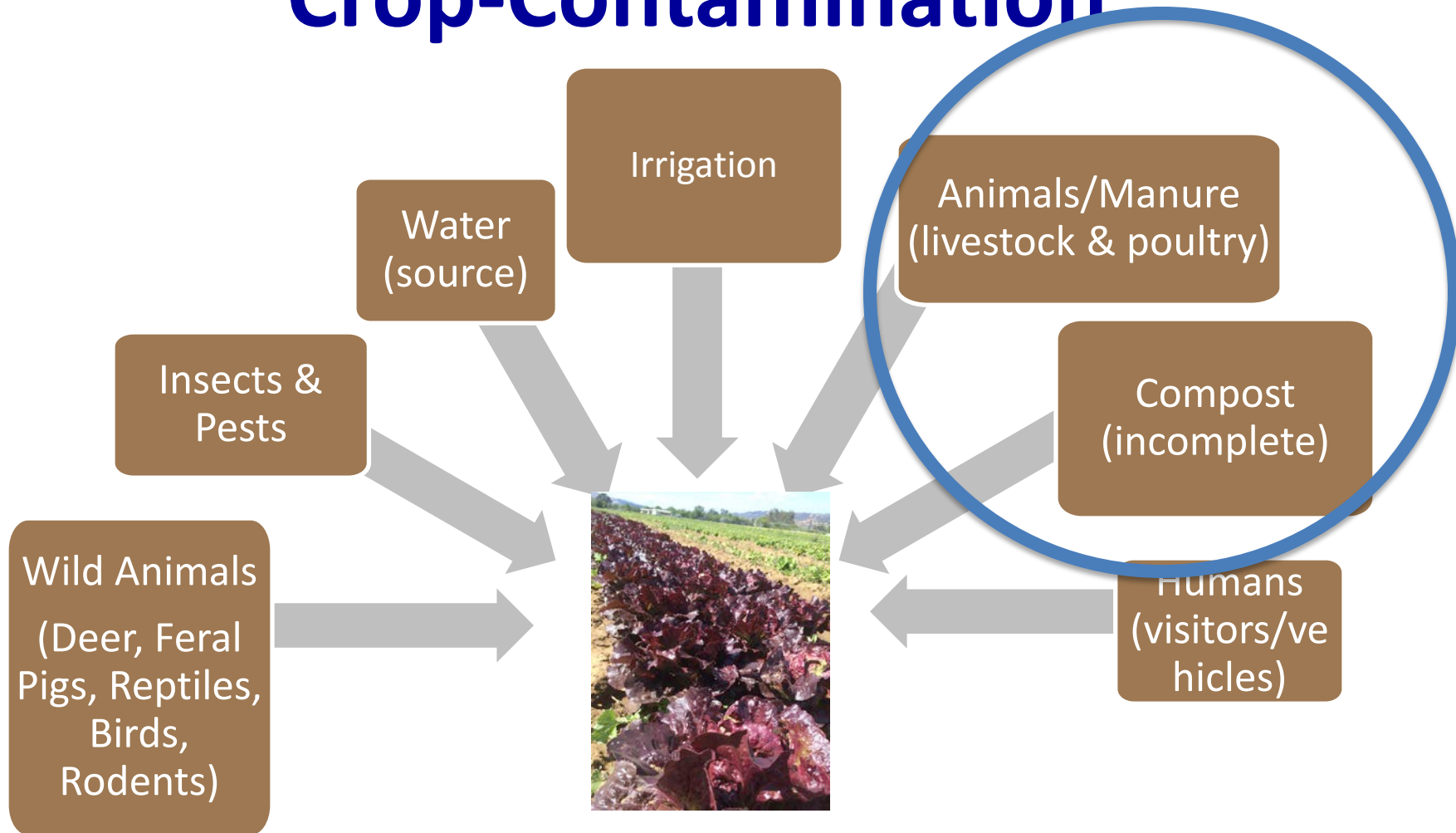


# Crop-Contamination



**Introduction of Foodborne pathogens in produce crops (vegetables & fruits)**

# Crop-Contamination



**Introduction of Foodborne pathogens in produce crops (vegetables & fruits)**

# Mixed Crop-Livestock Systems

## Foodborne Pathogens & Pasture Poultry

Table 1. Farm level prevalence of *Campylobacter* and *Salmonella* in the organic/pasture raised poultry and conventional poultry farms in the United States.

Pathogen	Poultry type	Organic/pasture (%)	Conventional (%)	Reference
<i>Campylobacter</i>	Broiler	30	32 to 68	Hanning et al., 2010; McCrea et al., 2006
	Laying hen	25.8	7.6	Salaheen et al., unpublished data
<i>Salmonella</i>	Broiler	5.6	38.8	Alali et al., 2010
	Laying hen	20.2	13.9	Almario et al., unpublished data

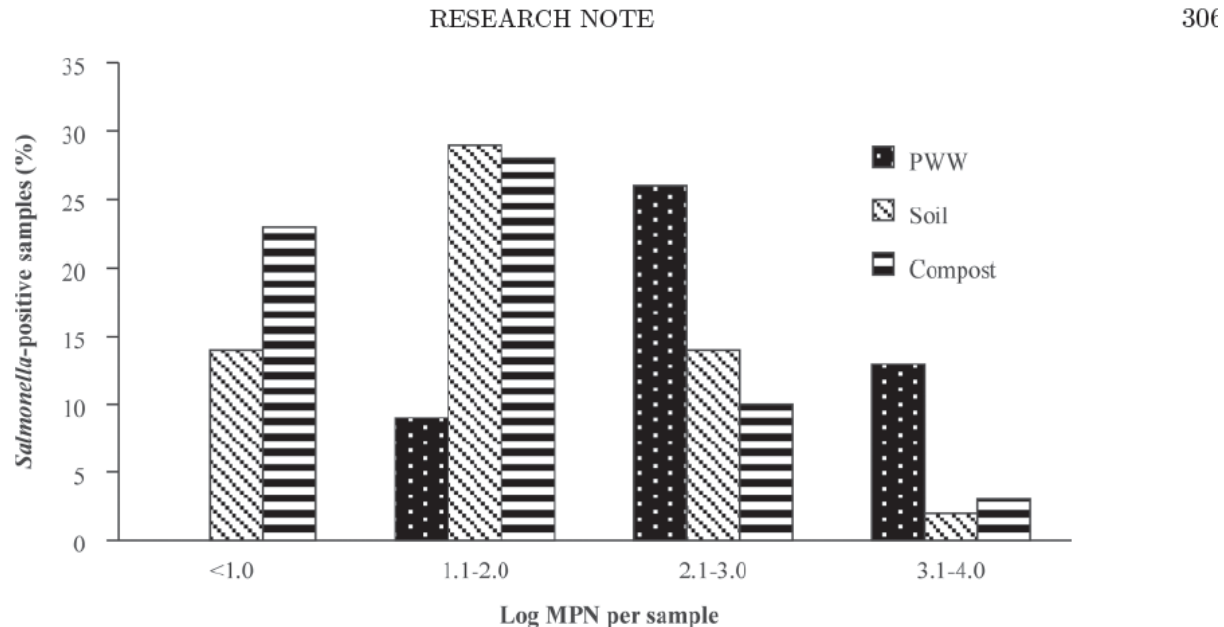
- *Salmonella* prevalence on farm is lower in organic (5% vs 38.8% in conventional) (Alali et al, 2010)
- *Salmonella* prevalence is higher on organic poultry carcass (Melendez et al, 2010)
- They are the same-prevalence is a function of producer not rearing type (Hardy et al, 2013)



# Mixed Crop-Livestock Systems

## *Foodborne Pathogens & Pasture Poultry*

- *Salmonella* in the processing environment of small-scale farm pastured broiler farms (Timble et al, 2013)

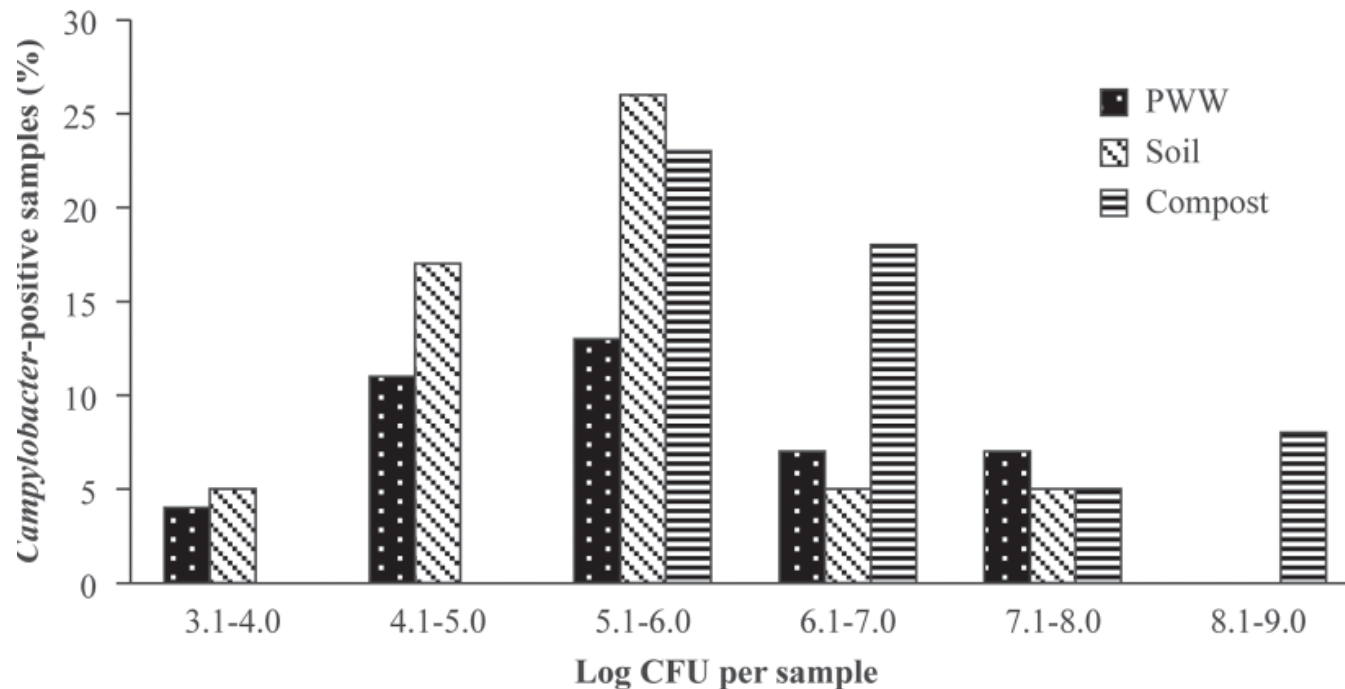




# Mixed Crop-Livestock Systems

## Foodborne Pathogens & Pasture Poultry

- *Campylobacter* in the processing environment of small-scale farm pastured broiler farms (*Timble et al, 2013*)



# Mixed Crop-Livestock Systems

## Foodborne Pathogens & Pasture Poultry

### *Soil*

- Enteric Pathogens can persist for long periods in the soil:
  - *Salmonella* can persist in the litter applied to fields almost **4 months**
  - *Campylobacter* can persist for about **25 days**
- Factors affecting the survival in the soil (& compost): livestock species, pathogen, manure type, composition (e.g., humidity, dry matter), soil type, environmental conditions (e.g. season, ambient temperature, rainfall, sunlight, etc.)

# Mixed Crop-Livestock Systems

## Foodborne Pathogens & Pasture Poultry

### *Composting*

- Heat treatment of poultry litter before land application
- Heat inactivation of pathogens at composting temperature ( $\approx 140^{\circ}\text{F}$ )
- Factors affecting the survival: C:N ratio (organic source), temperature, humidity,  $\text{O}_2$ , bedding (straw, rice hulls, wood shavings, etc.), turning, time
- Efficacy of composting litter on small-scale farms



Figure 1. Backyard composting systems. From left to right: three bin composter, tumbler composter, enclosed static bin. At far right is the start of a pile.

# Mixed Crop-Livestock Systems

## Food Safety Risks

- Because poultry may carry foodborne pathogens, such as *E. coli*, *Salmonella*, or *Campylobacter* in their gastrointestinal tract
- There is an increased risk of pathogen spread via food products (e.g., vegetables, fruits and nuts) when **manure is applied to crop fields**

# Mixed Crop-Livestock Systems

## Food Safety Risks

- **Rotational Grazing or Pasture?**
- Integration of sustainable practices such as the use of grazing animals in fields destined for vegetable cultivation may introduce additional food safety risks ??





# Mixed Crop-Livestock Systems

## Food Safety Risks

- Regulations to prevent crop microbial contamination of crops are based on **time-interval criteria** between the application of **animal-based soil amendments** (manure & compost) and time of crop harvesting
- The **National Organic Program (NOP)** regulations, which **require that untreated animal manure be applied at least 120 days or 90 days prior** to the harvest of crops, depending on whether the edible portions come into direct or indirect contact with the treated soil



### National Organic Program

The National Organic Program (NOP) is a regulatory program housed within the USDA Agricultural Marketing Service. We are responsible for developing national standards for organically-produced agricultural products. These standards assure consumers that products with the USDA organic seal meet consistent, uniform standards. Our regulations do not address food safety or nutrition.

#### Key Activities

- Maintain the list of certified organic operations and help new farmers and business learn how to get certified

# Mixed Crop-Livestock Systems

## Food Safety Risks -FSMA

- FDA, Food Safety Modernization Act (FSMA)
- Prevention:
  - Preventive Controls for Food Facilities
  - Produce Safety Standards
  - Authority to prevent Intentional Contamination
- Inspection and Compliance
- Response
- Imports
- *The final Produce Rule of the Food Safety Modernization Act (FSMA), expected final release in 2015*



The screenshot shows the FDA website page for Produce Safety Standards. The header includes the FDA logo and the text "U.S. Food and Drug Administration". Below the header, there is a navigation breadcrumb: "Home > Food > Guidance & Regulation > Food Safety Modernization Act (FSMA)". The main heading is "Produce Safety Standards". Below the heading, there are social media sharing options for Facebook, Twitter, LinkedIn, Print, Email, and Print. The page content includes a list of links: "Introduction", "Guidance and Rules", "Sections of the Law Relating to Produce Safety Standards", "Alliances", "Coordination with USDA on Produce Safety", "FDA Outreach on Produce Safety", and "Public Meetings". At the bottom, there is a sub-heading: "Prevention is Key for Produce Safety Standards".

# Mixed Crop-Livestock Systems

## Food Safety Risks -FSMA

### **2. Manure strategy to be further studied**

- The FDA is removing the nine-month proposed minimum-time interval between the application of untreated biological soil amendments of animal origin (including raw manure) and crop harvesting. The agency is deferring its decision on an appropriate time interval until it pursues certain actions. These include conducting a risk assessment and extensive research to strengthen scientific support for any future proposal, working with the U.S. Department of Agriculture and other stakeholders.
- At this time, the FDA does not intend to take exception to farmers complying with the USDA's National Organic Program standards, which call for a 120-day interval between the application of raw manure for crops in contact with the soil and 90 days for crops not in contact with the soil.

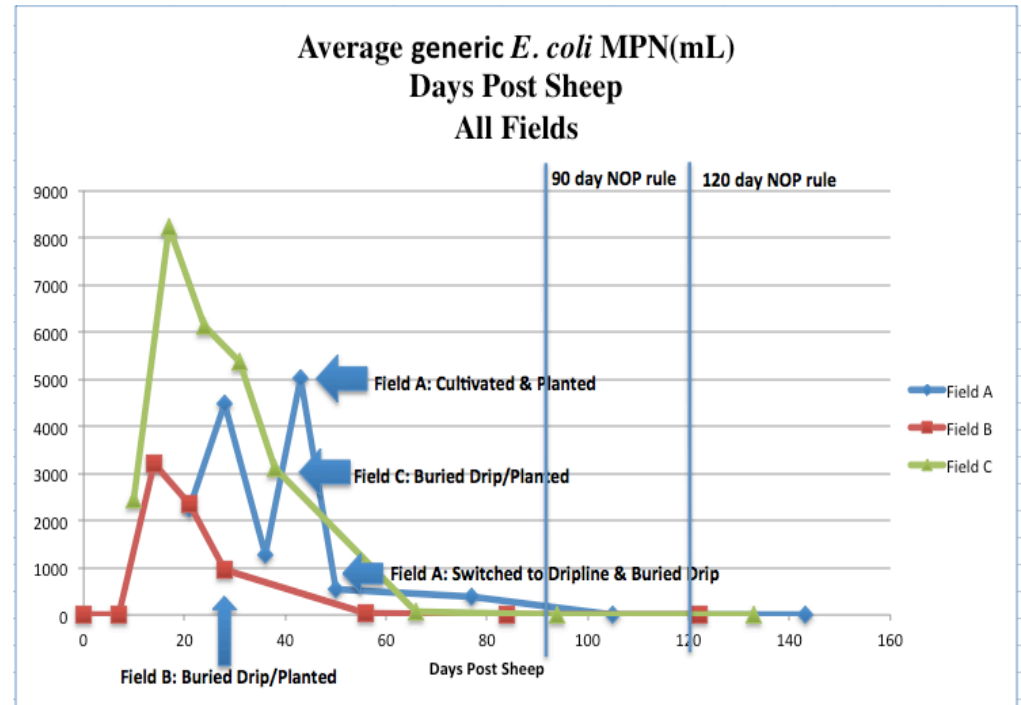
# Mixed Crop-Livestock Systems

## Food Safety Risks -FSMA

- The FDA's proposed Produce Safety Rule states: “If **animals are allowed to graze or are used as working animals in fields** where covered produce is grown and under the circumstances there is a reasonable probability that **grazing or working animals will contaminate covered produce**, require, at a minimum, an **adequate waiting period between grazing and harvesting for covered produce** in any growing area that was grazed, and measures to prevent the introduction of known or reasonably foreseeable hazards into or onto covered produce (proposed § 112.82)”

# Food Safety Risks-Rotational Grazing

Preliminary data:



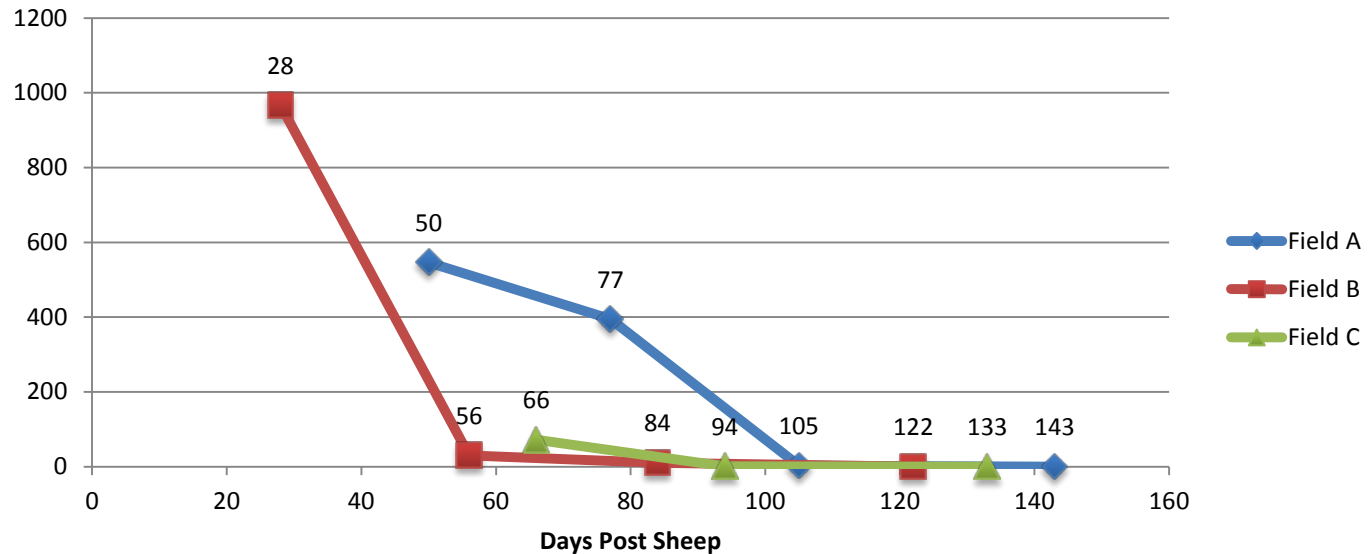


# Food Safety Risks-Rotational Grazing

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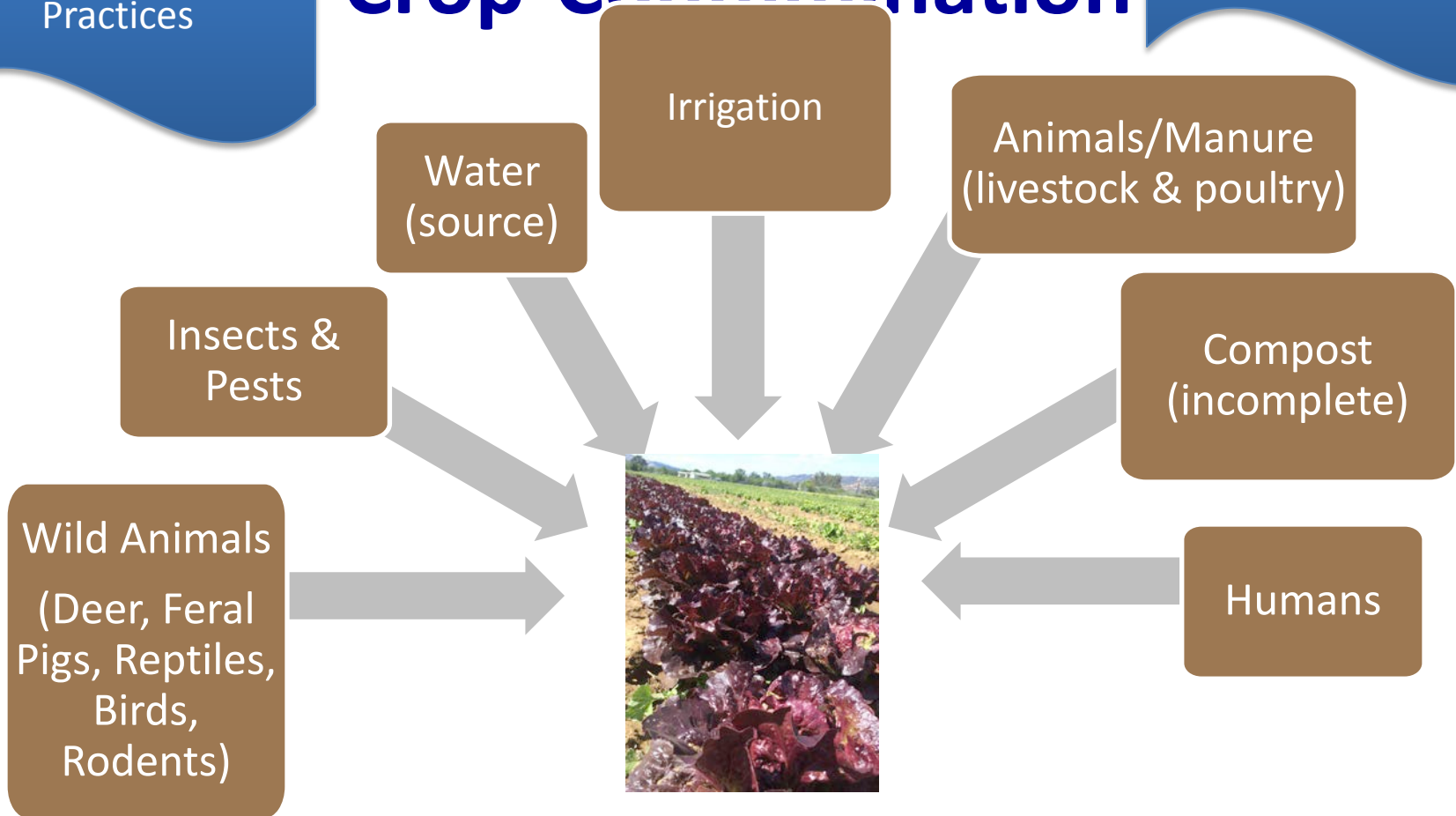
Average generic *E. coli*  
below MPN 1,000 (mL)



# Prevention Crop-Contamination

Good Agricultural Practices

Good Husbandry Practices



**Introduction of Foodborne pathogens in crops (vegetables & fruits)**

# Mixed Crop-Livestock Systems

## Mixed livestock species



*Grazing turnips in the fall provides sheep and goats with "clean" grazing and excellent nutrition during breeding season. Photo: Linda Coffey, NCAT*

Adapted from Tools for Managing Internal Parasites in Small Ruminants: Pasture Management, 2012, IP401, [www.attra.ncat.org](http://www.attra.ncat.org)



Adapted from Pastured Poultry Nutrition and Forages, IP453, 2013 [www.attra.ncat.org](http://www.attra.ncat.org)



# Mixed Crop-Livestock Systems

## Grazing behaviors

### Dietary Preferences for different livestock species



Cows prefer grass; sheep prefer forbs; goats prefer trees and shrubs. Nevertheless, there is regular crossover among the three types of feeders.



*Grazing buffer zones, lanes between tree rows, and riparian edges can help maintain the landscape while making these areas productive parts of the farm.  
Photo: Joan Burke, USDA, ARS*

Species	Grass (%)	Weeds (%)	Browse (%)
Horse	90	4	6
Cattle	70	20	10
Sheep	60	30	10
Goats	20	20	60

Source: Multi-species Grazing can Improve Utilization of Pastures



# Mixed Crop-Livestock Systems

## Parasites of Ruminants

### Parasites

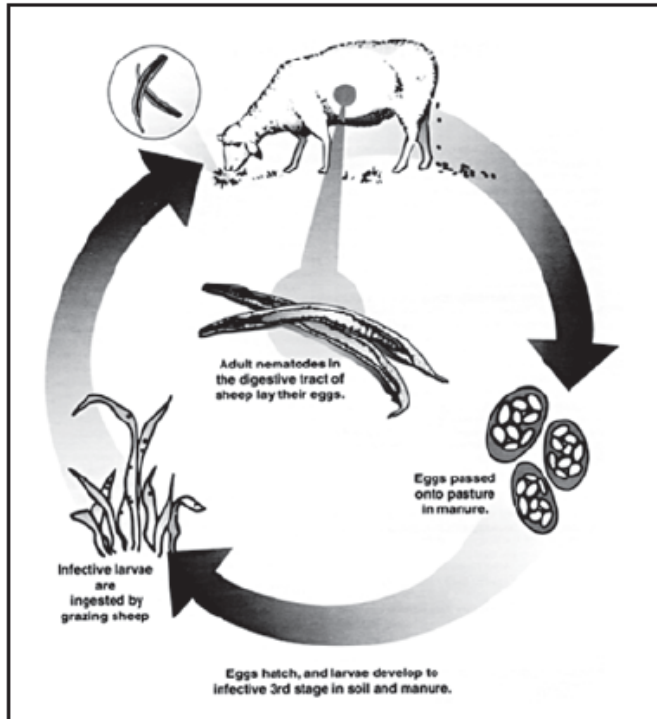


Figure 1: The lifecycle of a gastrointestinal parasite. This image is courtesy of Virginia Tech Cooperative Extension.

Adapted from MA&VA Cooperative  
Extension Parasite Control Fact Sheet

### Parasites

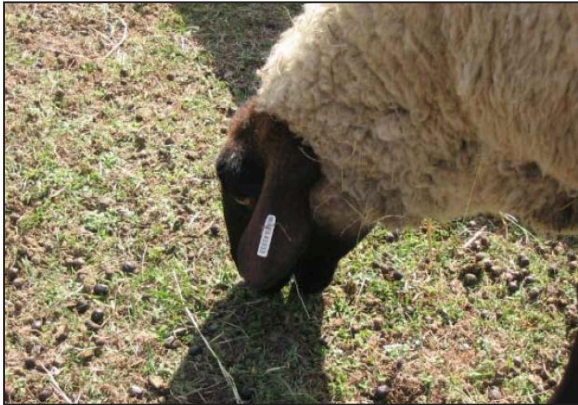
- *Nematodes (Roundworms):*
- Abomasum:
  - *Haemonchus* spp (sheep, goats, cattle)
  - *Ostertagia* spp (cattle)
  - *Trichostrongylus* (ruminants, horses)
- Small Intestine
  - *Trichostrongylus*
  - *Cooperia*
- Lung
  - *Dictyocaulus* spp
- *Protozoa (coccidia)*
- *Trematodes (flukes)*
- *Cestodes (tapeworms)*



# Mixed Crop-Livestock Systems

## Parasites of Ruminants

### Parasites



*This sheep is getting no nourishment but plenty of parasites in this situation. Photo: Linda Coffey, NCAT*



Figure 5: This picture shows a goat that is browsing, or grazing at shoulder-height.

ATTRA

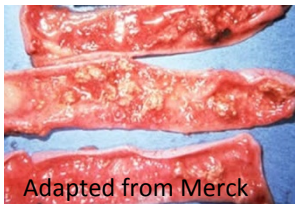
### Prevention:

- Pasture Rotation
- Animal Management
- Multi-species grazing
- Rotation between different anthelmintic
- Herd dogs (parasites)

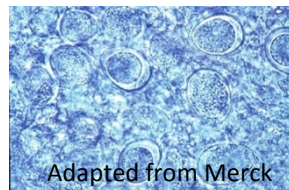
# Mixed Crop-Livestock Systems

## Parasites of Poultry

### Parasites



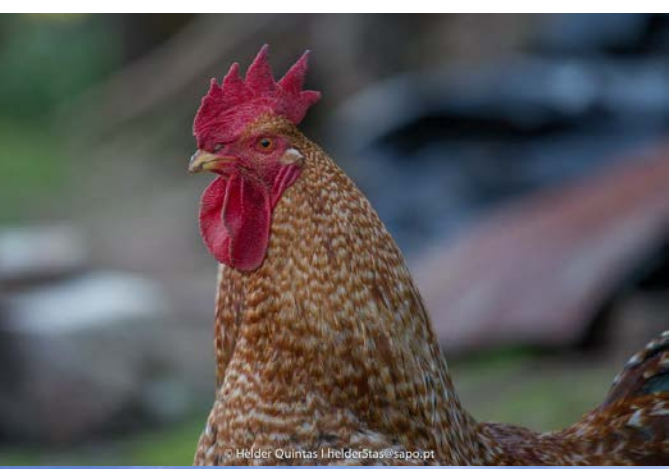
Adapted from Merck



Adapted from Merck

### Coccidia

- Host and site specific (GI)
- Occurs under conditions of warmth and humidity (e.g., wet litter)
- One sporulated oocyst can produce 100,000 offspring!
- Oocyst very resistant (can survive 18 months in the environment)



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# Thank you for your attention!




Alda Pires, DVM, MPVM, PhD, Dipl. ACVPM  
Urban Agriculture & Food Safety  
School of Veterinary Medicine

[apires@ucdavis.edu](mailto:apires@ucdavis.edu)

530-754-9855



University of California  
Agriculture and Natural Resources



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# Mixed Crop-Livestock Systems

## Foodborne Pathogens & Pasture Poultry

### ***Composting***

- *Enclosed or within-vessel composting:*
  - Active compost must maintain a minimum of 131 F for 3 days
- *Windrow composting*
  - Active compost must maintain aerobic conditions for a minimum of 131F or higher for 15 days or longer, with a minimal of 5 turnings during this period
- *Aerated static pile composting*
  - Active compost must be covered with at least 12 inches of insulating materials and maintain a minimum of 137F for 3 days
- **Enteric pathogen criteria (LGMA)**
- Fecal coliforms <1000 MPN/gram
- Salmonella negative / <1/30gram
- E. coli O157:H7 negative / <1/30gram