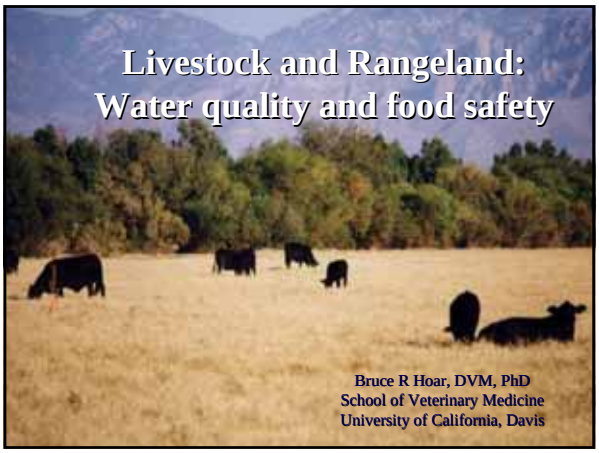
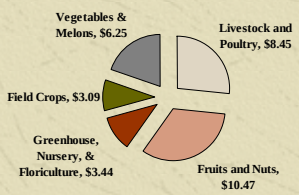


Today's presentation

- Importance of livestock in CA agriculture
- Potential risks posed by livestock
- Methods to reduce potential risks
  - Reduce pathogens in animals
  - Minimize transport and viability
  - Removal of livestock?
- Discussion and conclusions

California Agriculture
Gross Cash Receipts, 2005

Total value = $31.7 Billion



http://www.cdfa.ca.gov/Statistics.html

"The Range Livestock Industry"

- Is a commodity industry ("Price taker")
- Prices cycle over about a 7 year period
  - Supply, demand, time required to produce calves/lambs
- During lowest prices, only most efficient producer with lowest breakeven will be making money.
- *For long term survival producers of a commodity product must have a breakeven cost that is at or below average for the industry*

Beef cattle industry in California

- California has >100M acres of land, 38M of which are range and pasture lands, with >20M acres privately owned
- ~ 2M hamburgers/day served in CA restaurants
- ~700,000 cows that have calved in CA
- 500,000 to 1,000,000 "stockers" fed / year
- $1.75 billion gross income in 2005

Sheep industry in California

- 650,000 sheep and lambs in CA
- $57 million gross income in 2005
- Useful in vegetation management in agricultural systems: alternative to herbicides, tillage, and mowing

Bottom line

- Economic production of red meat products in CA relies on the availability of inexpensive forage for grazing.

Background

- Contaminated drinking water has greatest impact on human health worldwide
- Surface water contamination and role of domestic and wild animals of concern
- Multi-barrier approach required
  - Control entry of pathogens into watersheds
  - More cost effective and sustainable than improvements in treatment technology

Important human enteric pathogens

Pathogen	Animals?	Pathogen	Animals?
Salmonella spp.	Yes	*Shigella* spp.	No
Campylobacter spp.	Yes	*Leptospira*	Yes
E. coli	Yes	*C. parvum*	Yes
Helicobacter pylori	Unk	*Cyclospora* spp.	Unk
A. hydrophila	Yes	*Giardia lamblia*	Yes
Yersinia spp.	Yes	*Entamoeba histolytica*	Rare
Vibrio spp.	Yes	*Balantidium coli*	Yes
Brucella	Yes	*Toxoplasma gondii*	Yes
Mycobacteria spp	Rare		

Many of these pathogens shed in feces of wildlife, humans, livestock, and pets

Quantitative shedding of two genotypes of *Cryptosporidium parvum* in California Ground Squirrels *(Spermophilus beecheyi)*.

- Sixteen percent of CA ground squirrels were found to be shedding an average of 53,875 *C. parvum* oocysts/g of feces.
- Oocyst loading rate was ~8.7×10^5 to 9.5×10^5 oocysts/ha/day

Atwill ER, et al. Appl Environ Microbiol 67:6;2840-43.

Environmental loading rates of *Cryptosporidium parvum* in certain domestic and wildlife species in California.

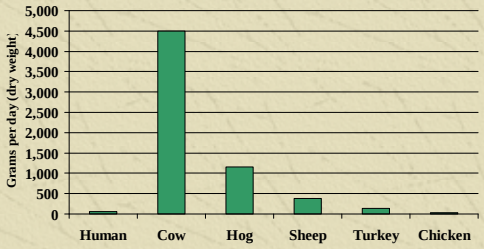
Species	Oocysts/kg	Kg feces/day	Oocysts/day
Beef cow	150	40	6,000
Beef calf	150,000	4	600,000
Striped skunk	2,800,000	0.05	140,000
Ground squirrel	6,500,000	0.012	78,000
Coyotes	205,000	0.2	41,000
YB marmot	10,400,000	0.02	208,000

Proc 20th Vertebr. Pest Conf, UC Davis, 2002 (241-243)

Background

- Need to know sources and occurrence of pathogens in watersheds
- Surface water near agriculture activities have:
  - Higher levels of *Giardia* and *Crypto* than pristine supplies? (LeChevallier, 1991; Ong, 1996)
  - Lower levels than pristine supplies? (Mager, 1998)

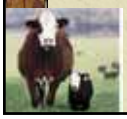
Daily production of manure



Background

- Cattle have been associated with outbreaks of human illness e.g. Milwaukee 1993
- Cow → Fecal pat → Water → Tap → Human

Infected and shedding | Transported to water | Treatment plant | Sufficient dose



Fresh water standards in CA

- Based on "indicator bacteria": total or fecal coliform and/or a subset of these (*E. coli*)
  - Low cost, analytically simple compared to most pathogens
- Standards range from 20 to 2,000 cfu/100 ml sample, depending on use

Fresh water standards in CA

- Correlation between indicator bacteria and microbial pathogens of concern likely varies between and within watersheds

Reducing the potential that livestock contaminate water with pathogens

- Reduce pathogen infection within the animals
- Minimize transport and pathogen viability: manure management, vegetative buffer strips
- Remove livestock from the watershed

1. Reduce pathogen infection within the animals

- Vaccination of cattle significantly reduced the prevalence of *E. coli* O157:H7 in a clinical trial conducted in a typical feedlot setting. This strategy could be used to reduce the risk of human disease.

Decreased shedding of *Escherichia coli* O157:H7 by cattle following vaccination with type III secreted proteins. Vaccine 22 (2004) 362-369.

1. Reduce pathogen infection within the animals

- Specific strains of Lactobacillus-based direct-fed microbials effectively reduced the prevalence and concentration of *E. coli* O157 in harvest-ready cattle, whereas others did not.

Prevalence and enumeration of *E. coli* O157 in steers receiving various strains of direct-fed microbials. J Food Prot 70 (2007) 1252-1255.

1. Reduce pathogen infection within the animals

- Substantial fecal shedding of *C. parvum* by cow-calf herds was limited to calves 1 to 4 months old, with low prevalence detected in older animals.

Age, geographic and temporal distribution of fecal shedding of *Cryptosporidium parvum* oocysts in cow-calf herds. Am J Vet Res 60 (1999) 420-425.

1. Reduce pathogen infection within the animals

- Risk of contamination of watersheds with *C. parvum* was limited to those periods when young calves were in the herd.

Age, geographic and temporal distribution of fecal shedding of *Cryptosporidium parvum* oocysts in cow-calf herds. Am J Vet Res 60 (1999) 420-425.

1. Reduce pathogen(?) infection within the animals

- *C. hominis* is spread only between humans
- The major reservoir for *C. parvum* is domestic livestock and direct contact with infected animals is a major transmission pathway along with indirect transmission through drinking water.
- For *Giardia duodenalis* the evidence does not, in general, support zoonotic transmission as a major risk for human infections.

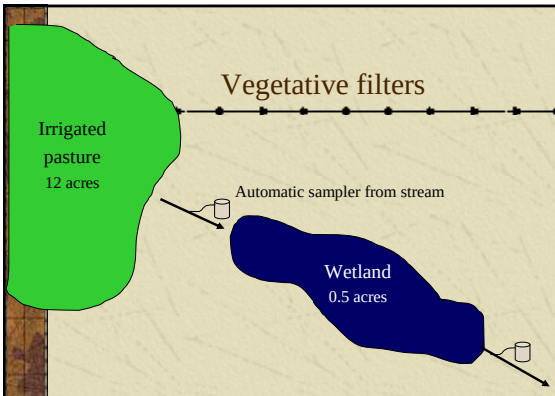
The zoonotic transmission of Giardia and Cryptosporidium. Int J Parasitol 35 (2005) 1181-90

2. Minimize transport and pathogen viability

Management reduces *E. coli* in irrigated pasture runoff. California Agriculture 2007 (61):159-165. Knox AK, Tate KW, Dahlgren RA, Atwill ER

- Three approaches to reduce microbial pollutant concentrations from pastures:
  - Vegetative filters
  - Irrigation management
  - Pasture grazing management

Vegetative filters



Range of *E. coli* concentrations

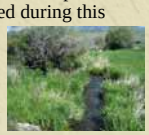
	Minimum*	Median*	Maximum*
Pasture effluent	420	5,400	158,000
Wetland effluent	10	1,283	74,600

* cfu / 100 ml

Percent reduction of E. coli ranged from 33% to 91%, with an average of 73%

Other vegetative filter studies

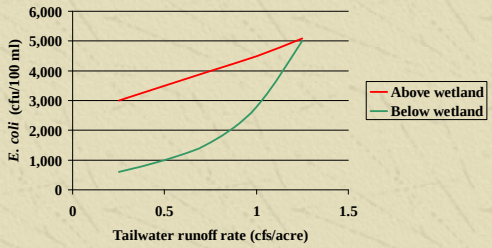
- A vegetated buffer strip of length > or = 3 m should function to remove > or = 99.9% of *C. parvum* oocysts from agricultural runoff generated during events involving mild to moderate precipitation.
  - J Food Prot 2006 (69) 177-184
- We found 0.3 to 3.1 log10 reduction in *E. coli* discharge per additional meter of vegetative buffer across the range of residual dry vegetation matter levels, land slope, and rainfall and runoff conditions experienced during this project.
  - J Environ Qual 2006 (35) 795-805



Irrigation management

- As irrigation tailwater runoff rates increased, *E. coli* concentrations increased both above and below the wetland
- Higher runoff rates increase the tailwater's capacity for pollutant mobilization and transport

Predicted *E. coli* in pasture tailwater



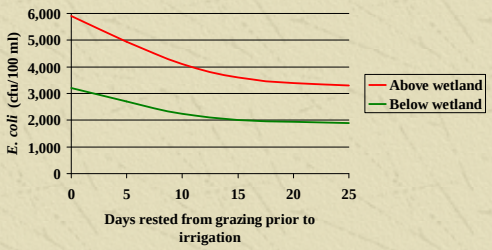
Irrigation management

- At high runoff rates, filtration capacity becomes overwhelmed
- Increase in tailwater runoff rate corresponds to a decrease in hydraulic residence time, which reduces time for processes which reduce *E. coli* concentrations, such as exposure to sunlight and predation by other microbes

Pasture grazing management

- *E. coli* concentrations in tailwater were highest when cattle were actively grazing during an irrigation event
- As rest time between grazing and irrigation increased, *E. coli* concentrations decreased (but not a linear relationship)

Predicted *E. coli* in pasture tailwater



Pasture grazing management

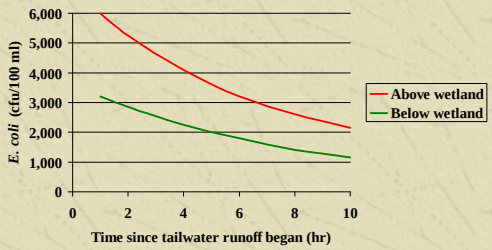
- As cattle fecal pats age the microbial pollutants in them naturally die off
- As the pats dry, they develop shells that trap the bacteria inside

Beaver, Oklahoma

Irrigation management

- During an irrigation event, *E. coli* concentrations initially spike, then decline
  - As irrigation event progresses, the tailwater volume increases and dilutes the *E. coli*
  - As the first irrigation water flows, it flushes the readily mobilized and transportable bacteria from the pasture
- To accurately characterize *E. coli* concentrations need to take multiple samples

Predicted *E. coli* in pasture tailwater



Attaining water quality standards

- Wetlands can significantly reduce *E. coli* concentrations
  - Feasibility and costs will be site-specific
- Minimize tailwater runoff rates and volume
- Allowing several days of rest from grazing prior to irrigation

3. Remove livestock from the watershed

- Some intermediate level of cattle grazing may maintain greater levels of native plant diversity than the alternative of cattle removal
  - Conserv Biol 2007 (21): 87-97
- Species richness and percentage of dominant species attributes were better in medium grazed plots than the other treatments.
  - Environ Manage 2002 (29): 279-289.

Indicator bacteria vs. pathogens

- Cattle feces may contain 500,000 to 1,000,000 cfu of *E. coli* per gram of wet feces
- Not uncommon to find high concentrations in pasture runoff

Indicator bacteria vs. pathogens

- Critical question: what is the load and concentration of actual pathogens?
  - e.g. *Crypto* found primarily in calves only, *E. coli* indicator bacteria consistently shed in all ages of cattle year-round
- Regulation based on indicator bacteria could lead to a false sense of human health protection, or to unnecessary management restrictions

Indicator bacteria vs. pathogens

- Coliform counts in feed and water were not associated with prevalence of *E. coli* O157 in cattle feces or water.
  - Appl Environ Microbiol 2005 (71):6026-6032.

Conclusions

- Watershed management plans are key
  - reducing contamination cheaper than water filtration
  - need to know quantitative sources, organism survival
- Grazing livestock produce a lot of fecal material
- This material may contain zoonotic pathogens

Conclusions

- Grazing land management strategies available to limit zoonotic potential
  - avoid overgrazing, proper fencing, develop wetlands, strategically plant shade trees
- Once defecated, pathogens must survive and get to water in order to be a human disease threat
- Benefits of grazing should not be overlooked

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Questions?