Managing Livestock to Deliver Safe Water to Society

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To all our cooperators from across California

be they ranchers, growers, or regulators, activists, resource managers, and the public

THANK YOU!

From all of us

UNIVERSITY of CALIFORNIA Agriculture & Natural Resources

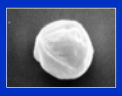
Waterborne zoonotic pathogens of *primary* concern

North American list

(1) pathogenic for humans
(2) shed by an animal
(3) proven waterborne transmission

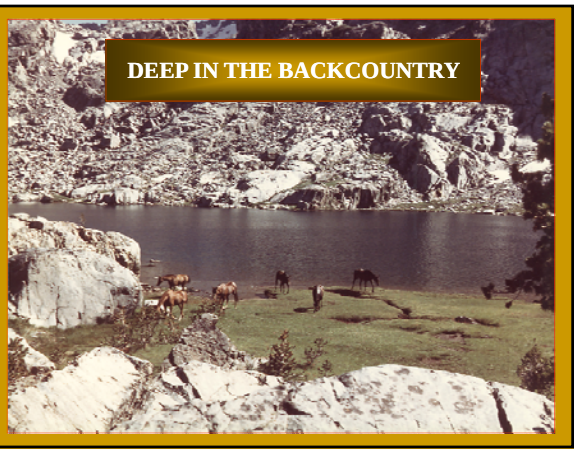
Protozoa:

- *Cryptosporidium* sp.
- *Giardia duodenalis*



Bacteria:

- Enterohemorrhagic *E. coli* (e.g., O157:H7)
- *Salmonella enterica*
- *Campylobacter jejuni*



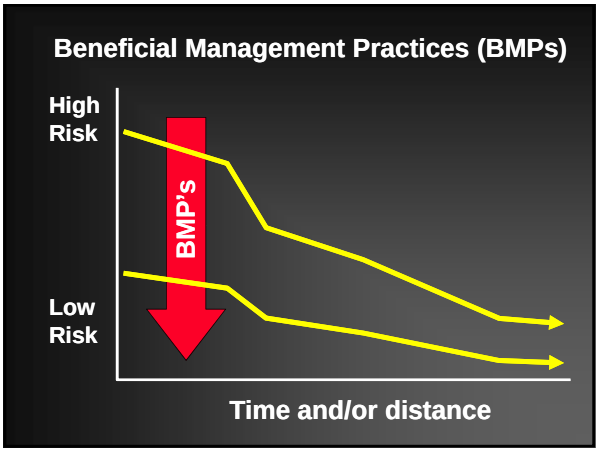
Cow-calf production

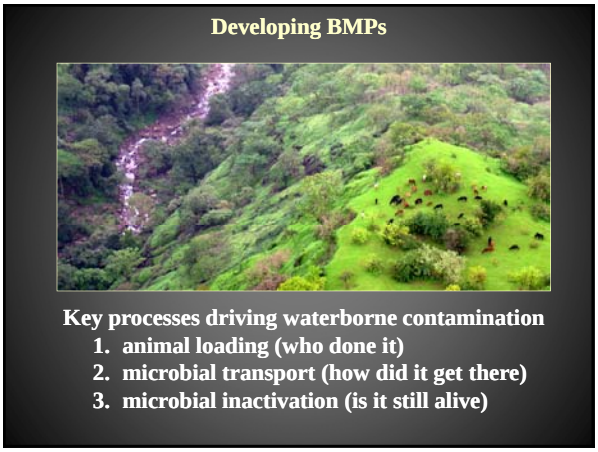
Foothills

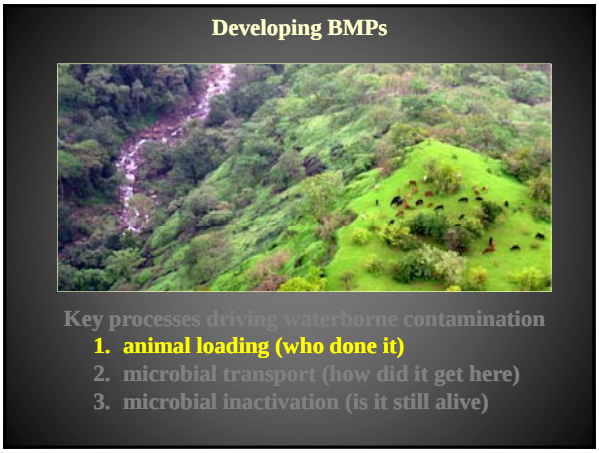
Mountain meadows


Shellfish & wildlife concerns
Thanks to Robert Campbell for permission to use this image


2006 spinach outbreak of E. coli O157:H7
Rangeland runoff & irrigation water


Beneficial Management Practices (BMPs)
High Risk
Low Risk
BMP's
Time and/or distance


Developing BMPs
Key processes driving waterborne contamination
1. animal loading (who done it)
2. microbial transport (how did it get there)
3. microbial inactivation (is it still alive)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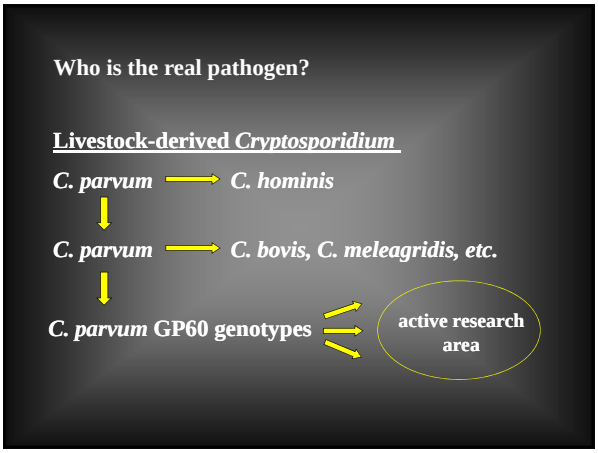

Who is the real pathogen?
Livestock-derived Cryptosporidium
C. parvum → C. hominis
C. parvum → C. bovis, C. meleagridis, etc.
C. parvum GP60 genotypes
active research area

Giardia duodenalis

Assemblage A: humans, primates, livestock, companion animals, rodents and other mammals

Assemblage B: humans, primates, dogs, horses, cattle

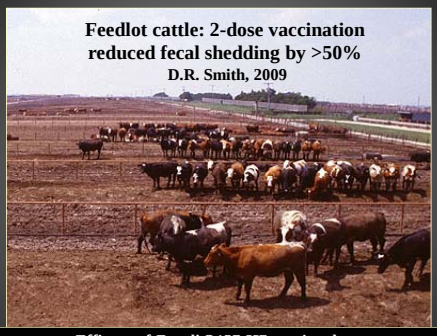
Assemblage C&D: dogs

Assemblage E: cattle and some other livestock

Etc.

Is there a magic bullet that eliminates animal infection?

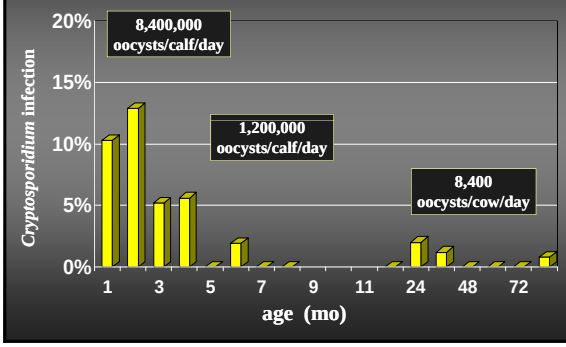
Feedlot cattle: 2-dose vaccination reduced fecal shedding by >50%
D.R. Smith, 2009



Efficacy of *E. coli* O157:H7 vaccine that targets type III secreted proteins (Bioniche Life Sciences Inc.)

How a pathogen is expressed in livestock population

Cow-calf herds: data from late 1990's. Redo for 2012-2013

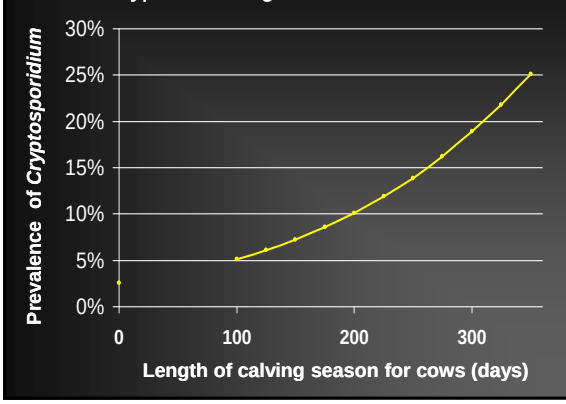


California sheep study, 2009-2010

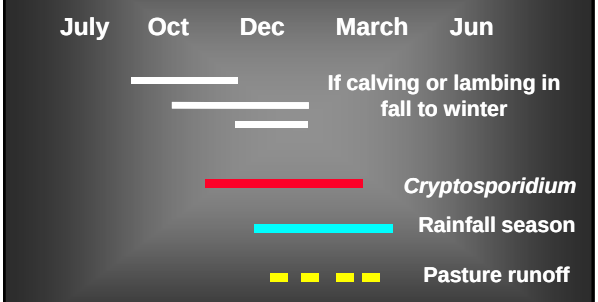
	Cryptosporidium	*Giardia*
Lamb (n=385)	31%	49%
Yearling (n=41)	12%	39%
Ewe (n=372)	3%	15%

much of the *Giardia* is assemblage E (not infectious for humans)

Crypto shedding in 1-4 month old beef calves



Calving & lambing season, *Cryptosporidium* shedding, rainfall and pasture runoff



Developing BMPs

Key processes driving waterborne contamination

1. animal loading (who done it)
2. **microbial transport (how did it get there)**
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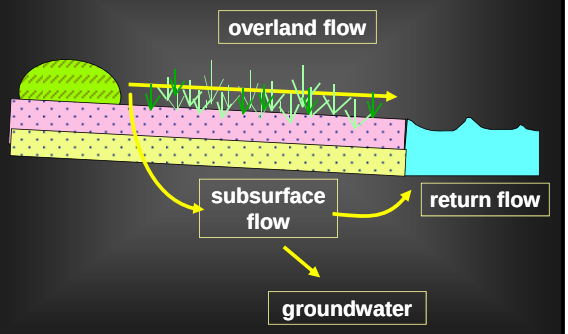
How do you manipulate cattle distribution so that fecal deposition occurs away from water?

Vegetated buffer strips



Soil box studies

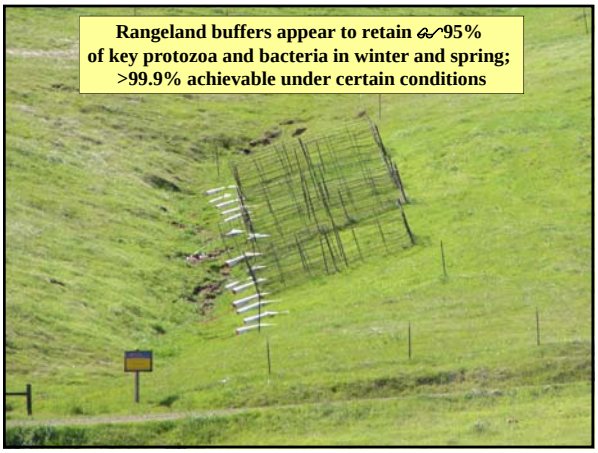
Sierra Foothill Research & Extension Center, University of California

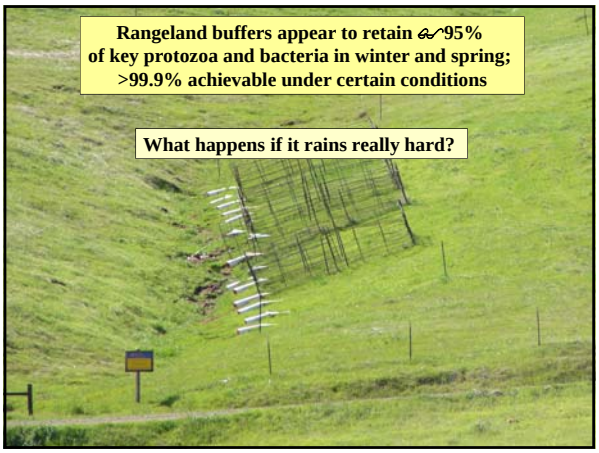
Buffer width (m)
0.1, 1.1, 2.1

Land slope (%)
5, 20, 35

RDM (kg/ha)
225, 560, 900, 4500

Rangeland buffers appear to retain ~95% of key protozoa and bacteria in winter and spring; >99.9% achievable under certain conditions

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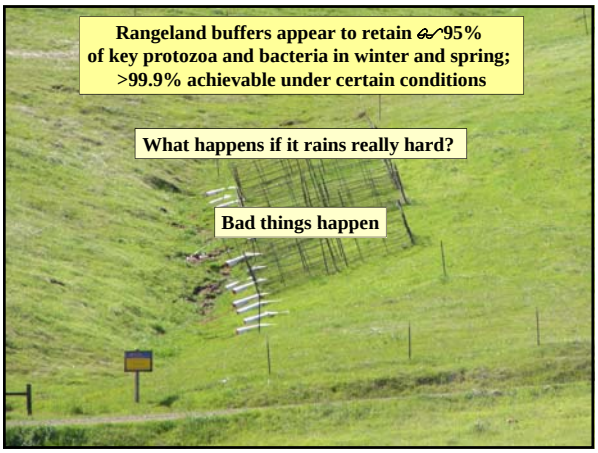
What happens if it rains really hard?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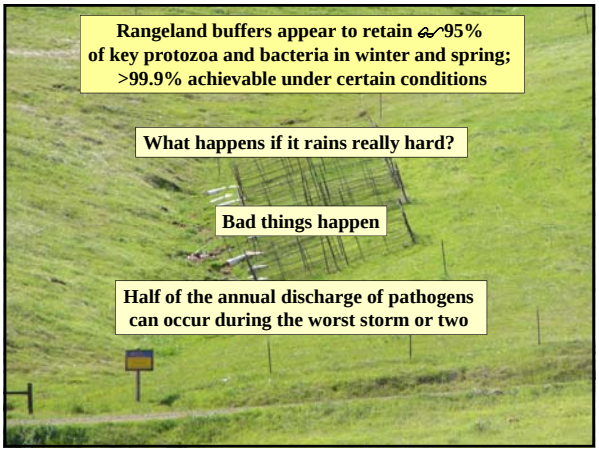
Rangeland buffers appear to retain ~95%
of key protozoa and bacteria in winter and spring;
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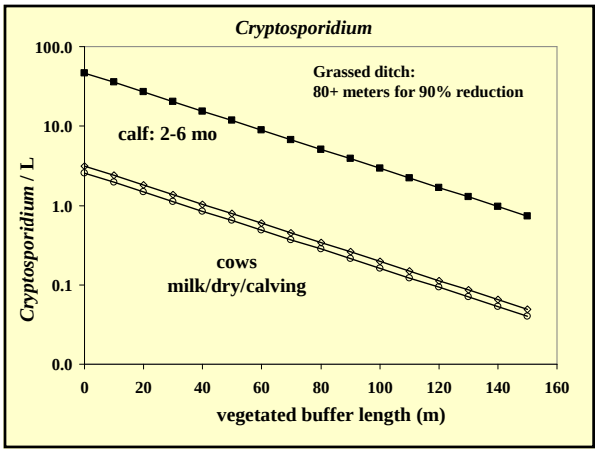
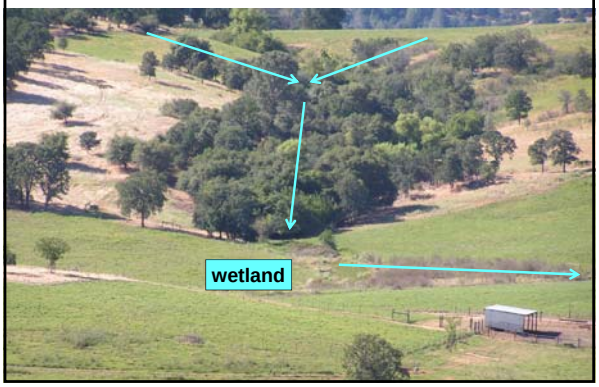
What happens if it rains really hard?
Bad things happen
Half of the annual discharge of pathogens
can occur during the worst storm or two


California coast and dairy production systems


Cryptosporidium
100.0
10.0
1.0
0.1
0.0
Cryptosporidium / L
Grassed ditch:
80+ meters for 90% reduction
calf: 2-6 mo
cows
milk/dry/calving
0
20
40
60
80
100
120
140
160
vegetated buffer length (m)


Channelized ditch not as effective

Wetlands can filter pathogens as well

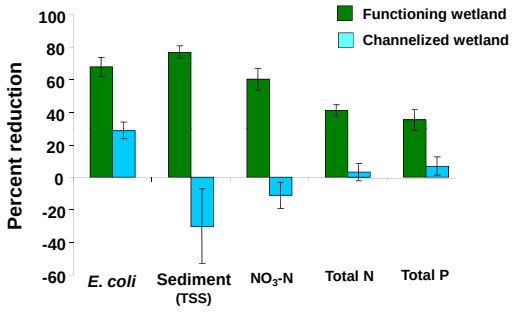


Two wetlands enrolled in the study

Functioning Wetland

Channelized Wetland

Reduction of Pollutants due to Wetland

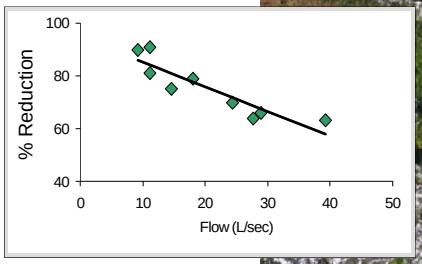


Effectiveness is dependent on flow dispersion, infiltration, and residence time

Functioning Wetland

Channelized Wetland

E. coli reduction by a functioning Wetland



60 to 90% reduction in *E. coli* load

Efficiency decreased with increased tailwater runoff rate

Developing BMPs

Key processes driving waterborne contamination

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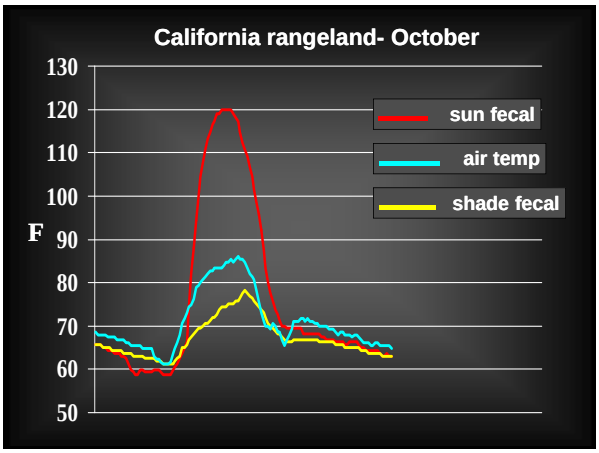
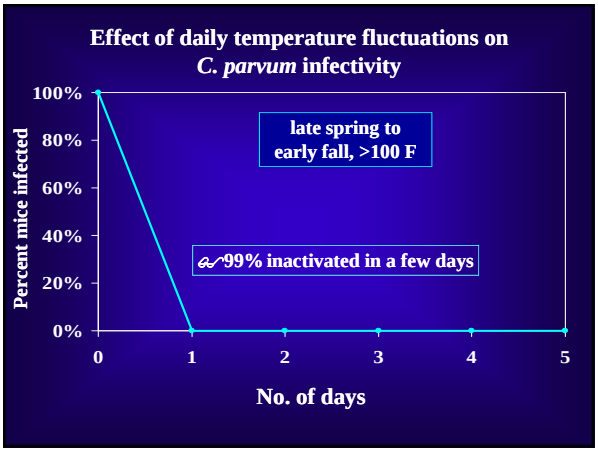
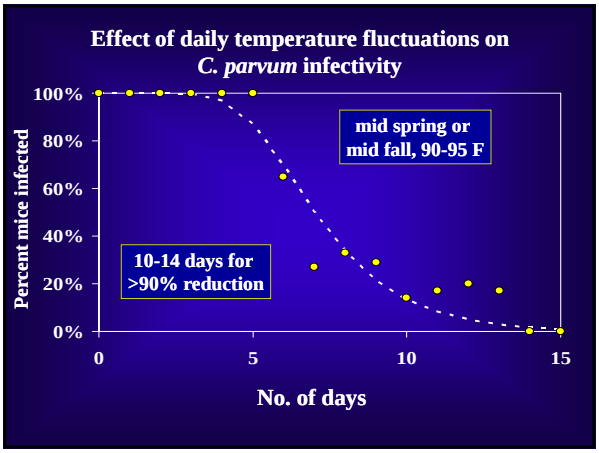


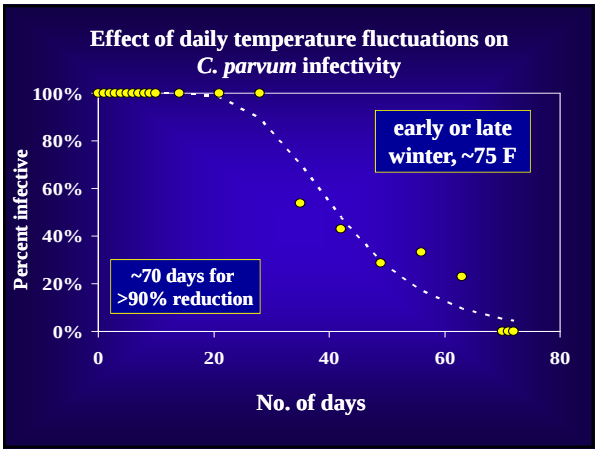
Do aged fecal pats release fewer pathogens?

Spike 5 million oocysts into a fecal pat
Rain 2 hours on fecal pat, 15 mm/hour
Summer in Tulare county, California

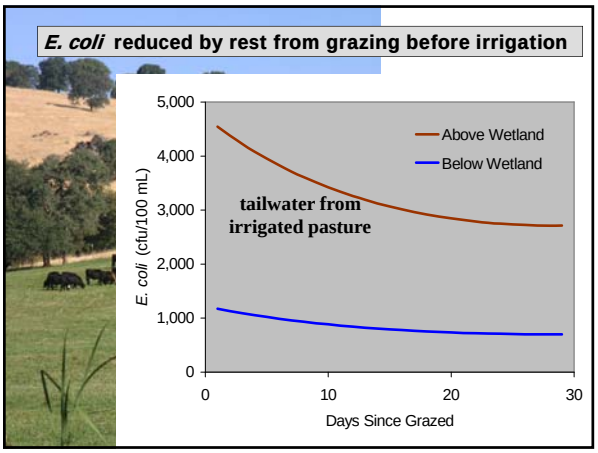
Age of fecal pat (days)	Total oocysts in runoff (T_t)	T_t / 5×10^6 oocysts (%)
0	25,498	0.51
1	334	0.007
2	106	0.002
3	201	0.004
4	631	0.013
8	194	0.004

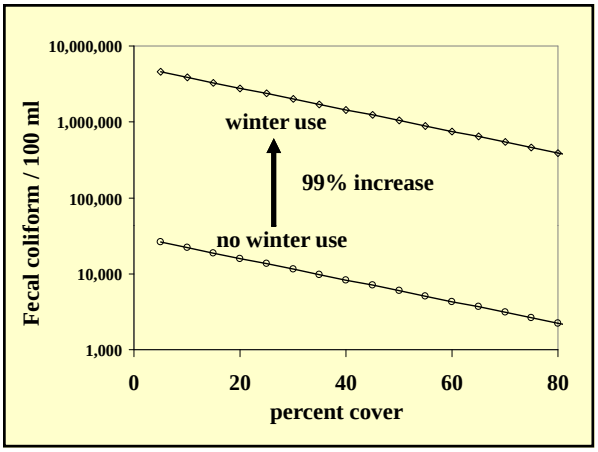






Rangeland, meadow, irrigated pasture grazing
- **Match onset of rainy season to exclusion dates**
- **Summer riparian grazing**
- **Rotational grazing timelines**





Key to BMP success

Match effectiveness to the pathogen load, fate and transport

"I tried that fix; it don't work!"

A pathogen's journey from livestock to water is vulnerable to numerous BMPs