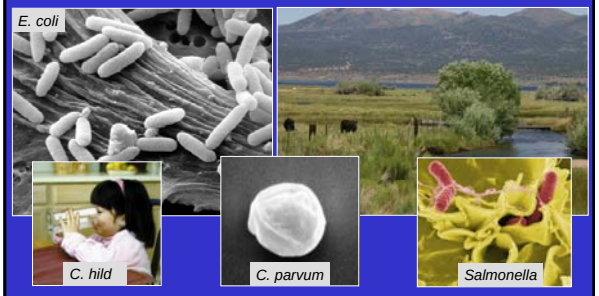
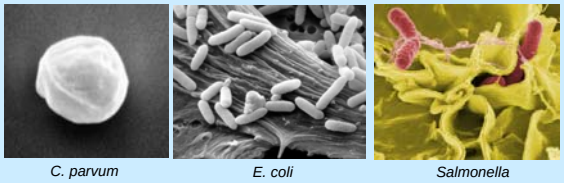
Ambient conditions and monitoring for livestock associated pathogens and indicators in CA waterways



1. Overview of pathogens and indicator bacteria of concern.
2. Indicator bacteria dynamics in runoff from rangeland and irrigated pasture.
3. Correlations between indicator bacteria and pathogens of concern.

U.S. waterborne disease outbreaks causing gastroenteritis 1989 through 1996

Type of organism	Agent	No. outbreaks	Drinking water	Water recreation
Protozoa	*Giardia duodenalis*	27	18	9
	Cryptosporidium	21	8	13
Bacteria	*E. coli* O157:H7	11	3	8
	Campylobacter jejuni	3	3	
	Salmonella	2	1	1



C. parvum *E. coli* *Salmonella*

A decade of produce outbreaks traced back to CA

Year	Food Vehicle	Pathogen	Cases
1996	Mesclun lettuce	*E. coli* O157:H7	61
1996	Unpasteurized apple juice	*E. coli* O157:H7	70
1996-1998	Alfalfa or clover sprouts (6 outbreaks)	*E. coli* O157:H7 *Salmonella*	600
2000-2001	Raw almonds	*Salmonella*	168
2002	Romaine lettuce	*E. coli* O157:H7	29
2002-2004	Raw almonds	*Salmonella*	47
2003	Baby spinach	*E. coli* O157:H7	16
2006	Baby spinach	*E. coli* O157:H7	205
2006	Iceberg lettuce	*E. coli* O157:H7	77
2006	Iceberg lettuce	*E. coli* O157:H7	80

Livestock Pathogens of Waterborne & Public Health Concern:

Protozoa: "hard" to eliminate during water treatment, low infectious dose, mild to moderate illness

- ***Cryptosporidium parvum***
- ***Giardia duodenalis***

Bacteria: "easy" to eliminate during water treatment, higher infectious dose, mild to serious illness

- ***pathogenic E. coli* (e.g., Stx 1&2, O157:H7)**
- ***Salmonella***
- ***Campylobacter***

Indicator bacteria v. pathogens

total coliforms, fecal coliforms, indicator *E. coli*, *Enterococcus*

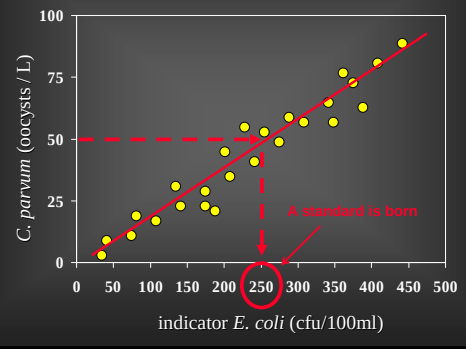
Bacteria that when present in water indicate the presence of fecal material and pathogens.

C. parvum

E. Coli O157:H7

Salmonella

Ideal world: strong, reliable correlation between indicator bacteria and bovine pathogens in water



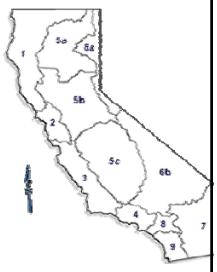
Indicator Bacteria Standards: Surface Waters

Fresh water standards exist for both "indicator" *E. coli* and fecal coliforms across CA: varies by water board

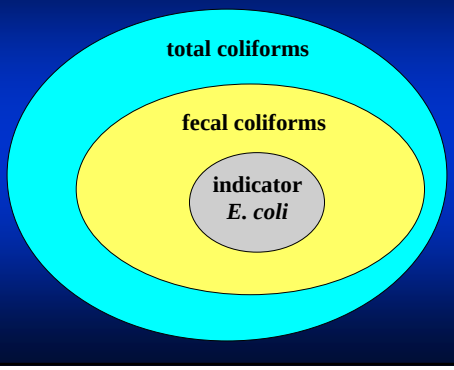
USEPA Recommends *E. coli*

1. geometric mean <126 bacteria per 100 ml from 5+ samples in 30 days

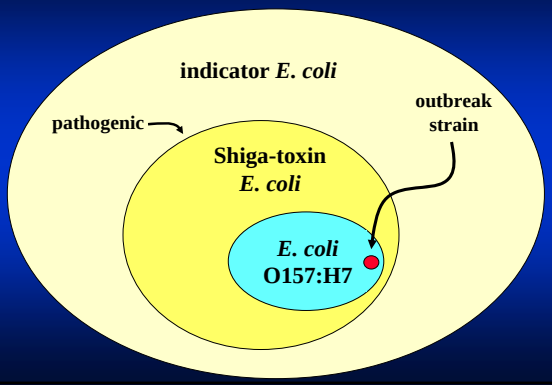
2. single grab samples should not exceed 235 bacteria per 100 ml



Indicator Bacteria: One Big Happy Family



E. coli: A malcontent in every family



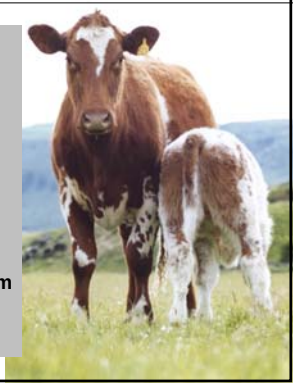
Beef cattle - indicator bacteria

Fecal coliforms:

10,000,000 to 100,000,000 per gm feces – all classes

Indicator *E. coli*:

1,000,000 to 10,000,000 per gm feces – all classes.



Indicator dynamics in runoff from rangeland and irrigated pasture.

Spatial Scale: Pasture to the watershed to the Delta.

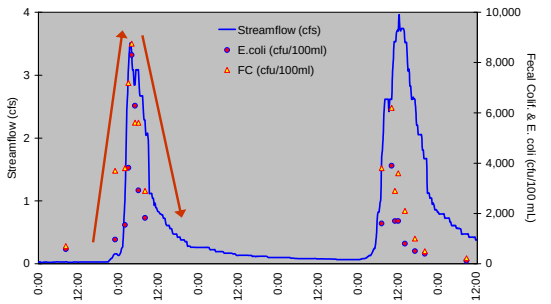
Temporal Scales: Runoff event to the water year.

Ramifications for monitoring and meeting water quality standards.

Small watershed scale – annual rangelands

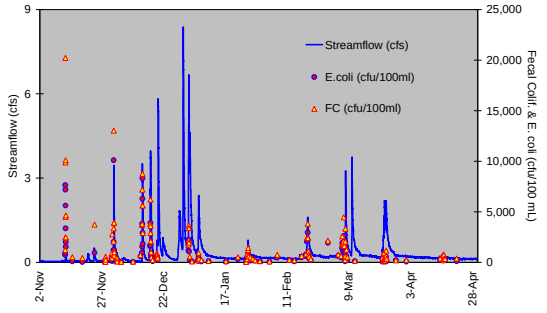
- Experimental watersheds
  - HREC (7), SFREC (4)
  - Grazing and fire treatments
  - 20 to 300 acres in size

SFREC – heavy grazing/rangeland – can observe an order of magnitude or greater change during a storm event.



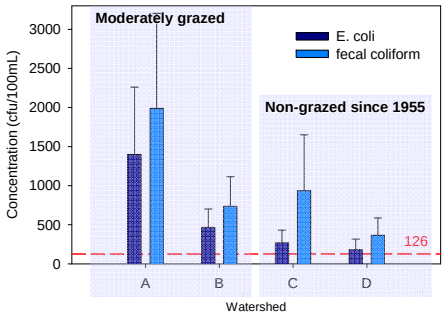
Two storms in mid December

SFREC – heavy grazing/rangeland – can observe an significant reduction in concentration from start to end of rainfall season.



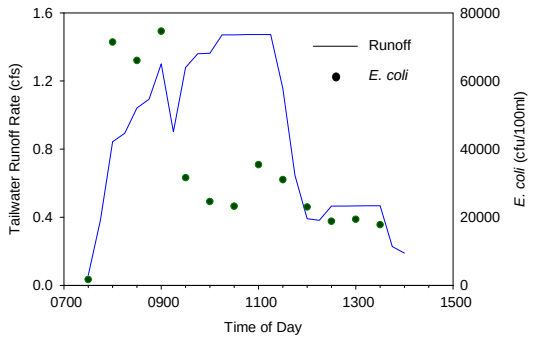
One rainfall-runoff season

HREC – observe variable differences between moderately grazed and non-grazed watersheds, background does not = 0.

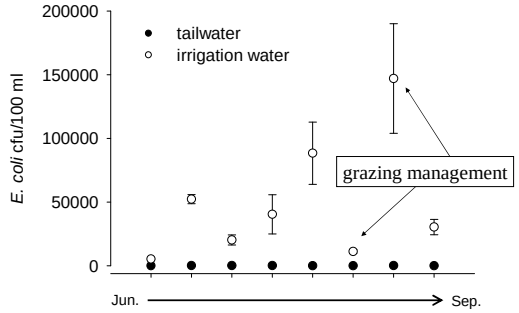


Valley and Foothill Irrigated Pastures

E. coli Levels in Irrigated Pasture Tailwater
A 7 hour irrigation event



E. coli Levels in Irrigated Pasture Tailwater
8 Irrigation Events

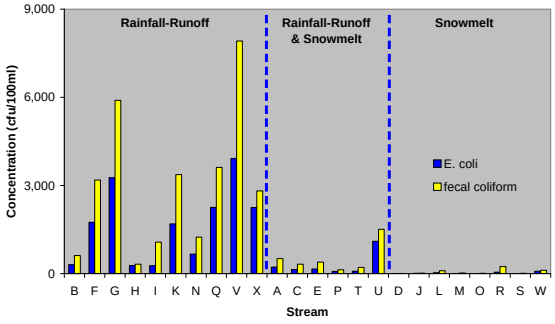


Two Year Survey of WQ in 24 California rangeland streams

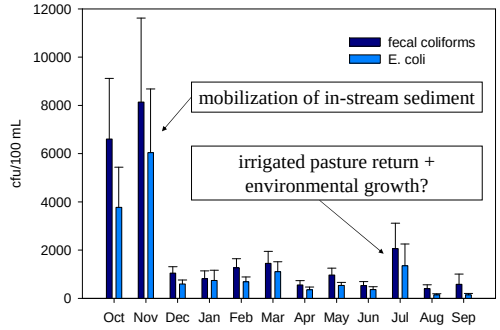
2000 & 2001

~1000 grab samples under storm and base flow conditions

Indicator *E. coli* and FC concentrations were dependent upon watershed hydrology – elevation



Indicator *E. coli* and FC concentrations were variable across the water year on annual range watersheds.

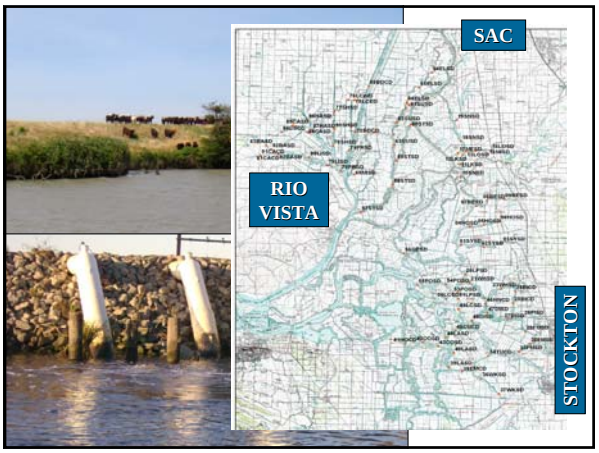


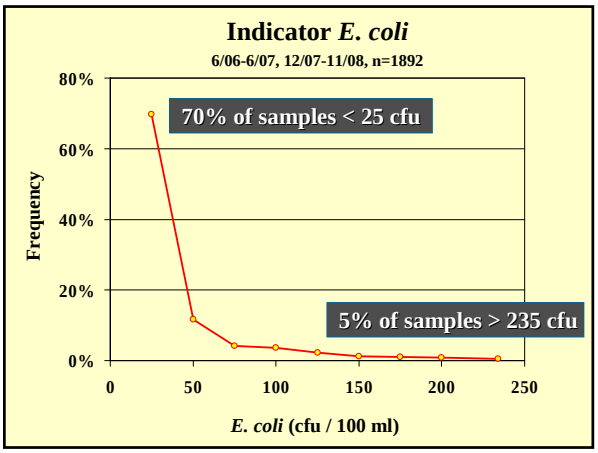
Delta Project:

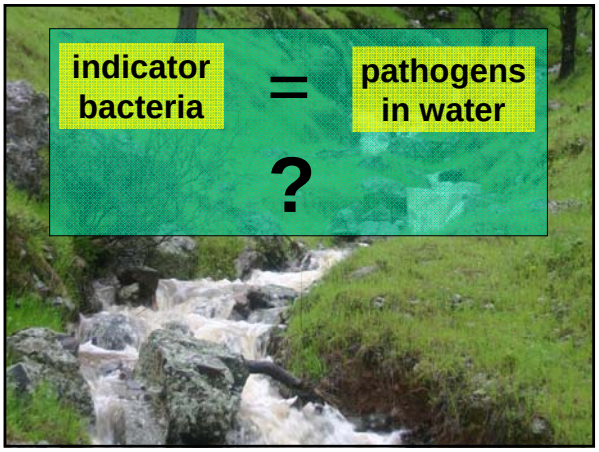
88 sites monitored once a month for two years

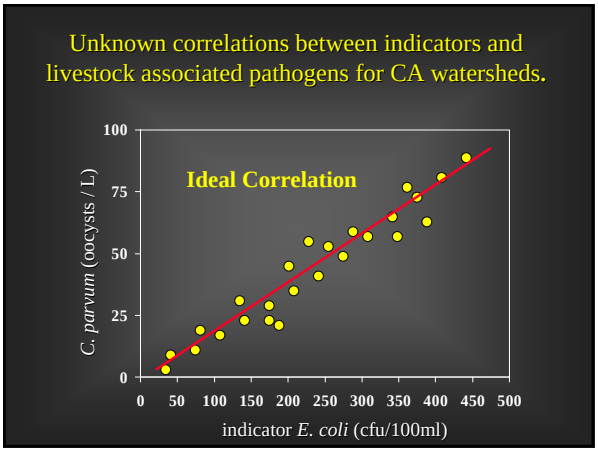
Bacterial indicators:
fecal coliforms, *E. coli*, *Enterococcus*

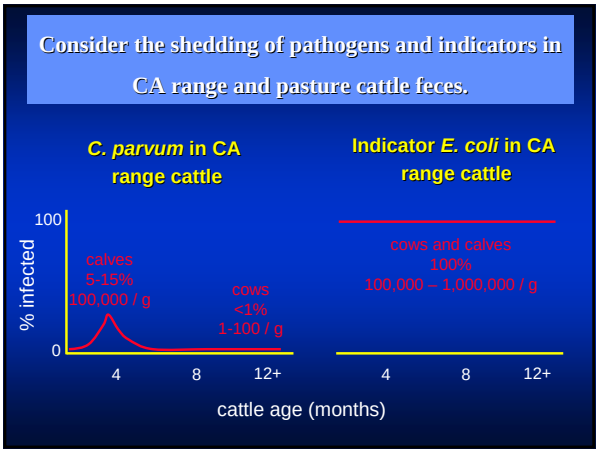
Bacterial pathogens:
Salmonella, *shigatoxin 1&2 E. coli*, *Campylobacter*

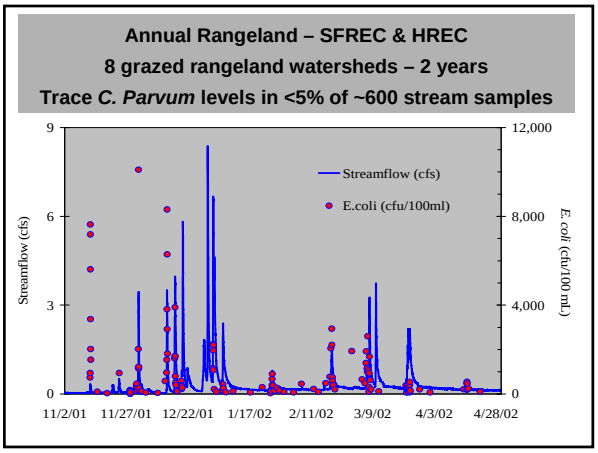

SAC
RIO VISTA
STOCKTON


Indicator E. coli
6/06-6/07, 12/07-11/08, n=1892
70% of samples < 25 cfu
5% of samples > 235 cfu
Frequency
80%
60%
40%
20%
0%
0
50
100
150
200
250
E. coli (cfu / 100 ml)


indicator bacteria
=
pathogens in water
?


Unknown correlations between indicators and livestock associated pathogens for CA watersheds.
Ideal Correlation
C. parvum (oocysts / L)
100
75
50
25
0
0
50
100
150
200
250
300
350
400
450
500
indicator E. coli (cfu/100ml)

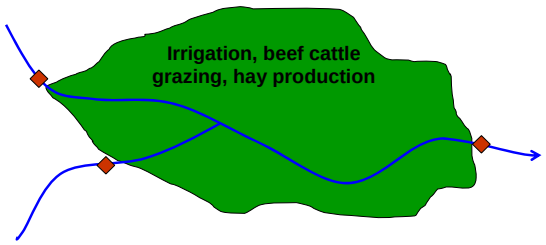

Consider the shedding of pathogens and indicators in CA range and pasture cattle feces.
C. parvum in CA range cattle
Indicator E. coli in CA range cattle
% infected
100
0
calves
5-15%
100,000 / g
cows
<1%
1-100 / g
cows and calves
100%
100,000 – 1,000,000 / g
4
8
12+
4
8
12+
cattle age (months)


Annual Rangeland – SFREC & HREC
8 grazed rangeland watersheds – 2 years
Trace C. Parvum levels in <5% of ~600 stream samples
Streamflow (cfs)
E.coli (cfu/100ml)
Streamflow (cfs)
9
6
3
0
12,000
8,000
4,000
0
E. coli (cfu/100 ml)
11/2/01
11/27/01
12/22/01
1/17/02
2/11/02
3/9/02
4/3/02
4/28/02

UFRW and Bridgeport Valley: 2007-08 Graze Season (May – Oct)

Sample monthly: indicator *E. coli* and FC, *C. parvum*, *Salmonella*, *E. Coli* O157:H7, *Campylobacter*

Sample a total 16 sites: entering and exiting irrigated agriculture areas



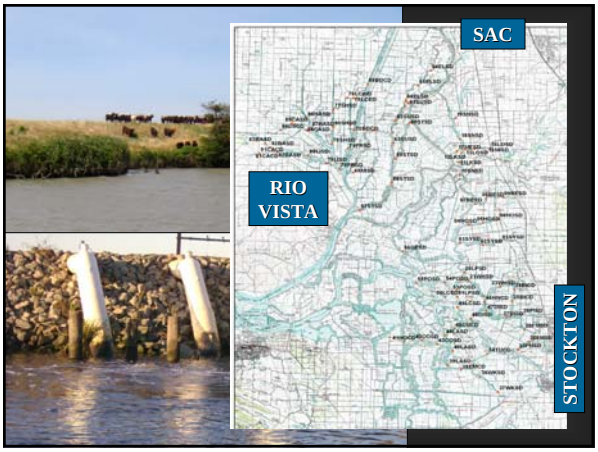
1,000 to 20,000 AU 1,500 to 32,000 ac irrigated

2007-08 Pathogen monitoring
UFRW and Bridgeport Valley
102-116 water samples taken, May-Oct

	indicator *E. coli* < 235 cfu/100 ml	indicator *E. coli* > 235 cfu/100 ml
Crypto 8=Yes	5 of 75 (6%)	3 of 27 (11%)
Salmonella 12=Yes	9 of 75 (12%)	3 of 27 (11%)
Campy 0=Yes	0 of 75 (0%)	0 of 27 (0%)
E. coli O157:H7 6=Yes	4 of 95 (4%)	2 of 21 (9%)

2007-08 Pathogen monitoring
UFRW and Bridgeport Valley

	above meadow	below meadow
Crypto 8=Yes	5	3
Salmonella 12=Yes	10	2
Campy 0=Yes	0	0
O157:H7 6=Yes	0	6

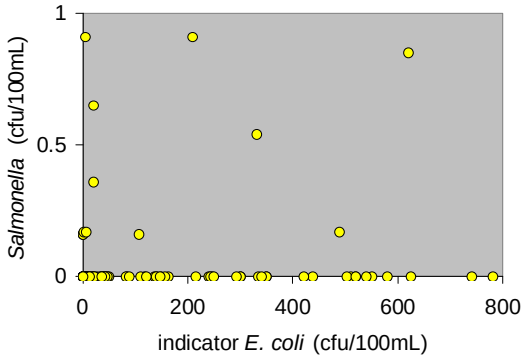


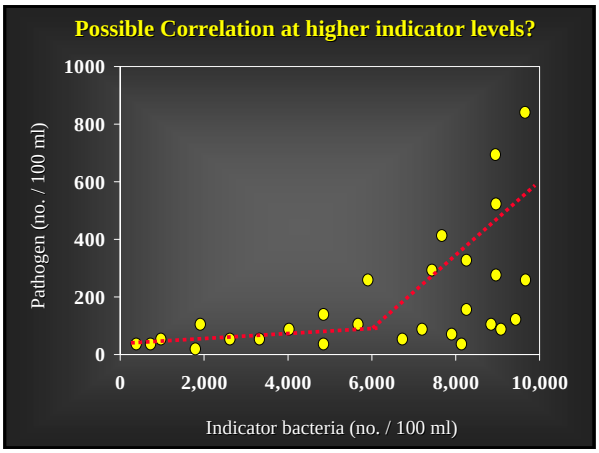
Delta pathogen – indicator monitoring
955 water samples, 2006-07

Mean Conc.	indicator *E. coli* < 235 cfu/100 ml	indicator *E. coli* > 235 cfu/100 ml
Indicator *E. coli*	22 cfu	470 cfu
Salmonella	0.30 MPN	0.25 MPN

1,829 *E. coli* isolates from across these 955 samples
2 of 1,829 had Stx 1 (0.1%)
2 of 1,829 had Stx 2 (0.1%)

Not so Ideal World: indicator *E. coli* concentrations not well correlated to *Salmonella*, *C. parvum*, etc.





Summary

- Significant indicator bacteria associated with direct range and pasture runoff,
- Conc. reduction with increased spatial scale: pasture>watershed>delta,
- Significant influence of watershed hydrology and livestock management on conc.,

Summary

- We consistently find very low levels of pathogens in these waters,
- Essentially non-existent correlations between pathogens and indicator bacteria in these waters,
- Management opportunities do exist to reduce microbial pollutant loads from