Science and research on packstock and waterborne pathogens

~ misperceptions, realities, and the way forward ~

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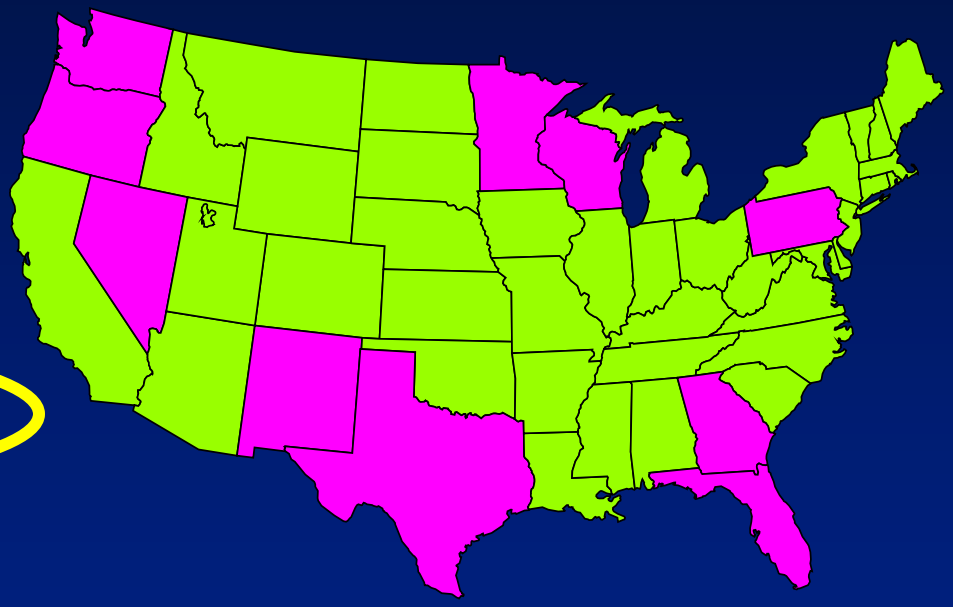
1993 outbreak of *Cryptosporidium parvum* associated with drinking water, Milwaukee

YEAR		CASES
1984	Texas	2,006
1996	New Mexico	78
1987	Georgia	12,960
1991	Pennsylvania	551
1992	Oregon	15,000
1993	Wisconsin	403,000
1993	Minnesota	27
1993	Washington	7
1994	Nevada	103
1994	Washington	104
1995	Florida	77
1998	Texas	32



California communities respond with much finger pointing

A4 THE TIMES • MONDAY, MARCH 24, 1997

LOCAL

Water district backs away from cattle grazing ban around lake

By DENIS CUFF
Times staff writer

Shying off a proposed cattle ban to protect drinking water from a harmful parasite, a Contra Costa water supplier may allow some grazing on lands around the Los Vaqueros Reservoir.

Contra Costa Water District planners say it's enough to continue grazing by selectively banning it in some areas, fencing off the reservoir, and banning young calves on most of the 18,000 acres around the reservoir.

Manure from young calves has the highest risk for spreading cryptosporidium, a bug that has made the water industry wary.

Widely found in America's waterways and in feces of many wild and domestic animals, cryptosporidium can reveal otherwise and slip through many water filters to make healthy people sick and kill those with weak immune systems.

"Calves are the major shedders of crypto. By eliminating them, we can control the risk," said John Steere, a district watershed planner. "The

JOE PAULO, foreground, and Russell Jackson keep an eye on their cattle from horseback on Walker Ranch, where Jackson leases land for his herd to graze

RECOMMENDATIONS

[illegible] would install fencing to keep

Joe DiDonato

San Francisco water district targets cattle

In February, the San Francisco Public Utilities Commission (PUC) seemed poised to ban cattle from its southern Alameda County watershed. In announcing a possible moratorium on livestock grazing, the commission cited concerns about contamination of the water supply with *Cryptosporidium*, a waterborne intestinal parasite

ness (cryptosporidiosis) lasts only a few days i most people with healthy immune systems, bu those with severely weakened immune system can develop chronic, life-threatening infections Those at greatest risk include AIDS patients and people taking immunosuppressive drugs, such as some cancer chemotherapies.

Contra Costa Ti

[illegible] 227 Monday, January 6, 1997

Tiny parasite has water districts, cattle ranch

By DENIS CUFF
Staff writer

Cattle and water. They go together on many California landscapes where cows roam valleys above deep blue reservoirs.

A nasty bug has intruded on the pastoral scene: a parasite in animal droppings that can sicken people, even kill them when it gets into water sources.

Now some drinking water suppliers are questioning whether it's safe to mix cattle and reservoir lands.

The bug is cryptosporidium, a tough, tiny parasite that hits most people like the flu, but can kill AIDS patients or others with compromised immune systems.

Cryptosporidium has captured the attention of the water industry in the past three years because of some unusual features.

NORBERT VON DER GROEBEN/Times

JOHN GARRETT JACKSON, 15, herds cattle recently from one of his father's fields [illegible] another on the family's leased ranch property off Vasco Road.

Parasite

FROM PAGE 1A

cord. "I think we are just beginning to understand that cryptosporidium is going to be a major water concern for the quality of drinking water in California."

The Contra Costa Water District this month recommended phasing out grazing in the buffer lands around its Los Vaqueros Reservoir under construction south of Brentwood. The reservoir will store drinking water for 400,000 people.

The neighboring East Bay Municipal Utility District is looking into tighter grazing restrictions on its land [illegible]

Scientists seek watery solution to halt 'mystery spore' outbreak

By DENIS CUFF
Staff writer

You might call it the mystery bug. Scientists did, giving this parasite the name cryptosporidium that translates as "mystery spore."

The parasite repeatedly stumped scientists, who didn't discover until 1976 that the microscopic organism could harm people.

It took until the early 1980s to document the first case of the parasite moving through drinking water to infect a human and cause

tection Agency and the Centers for Disease Control.

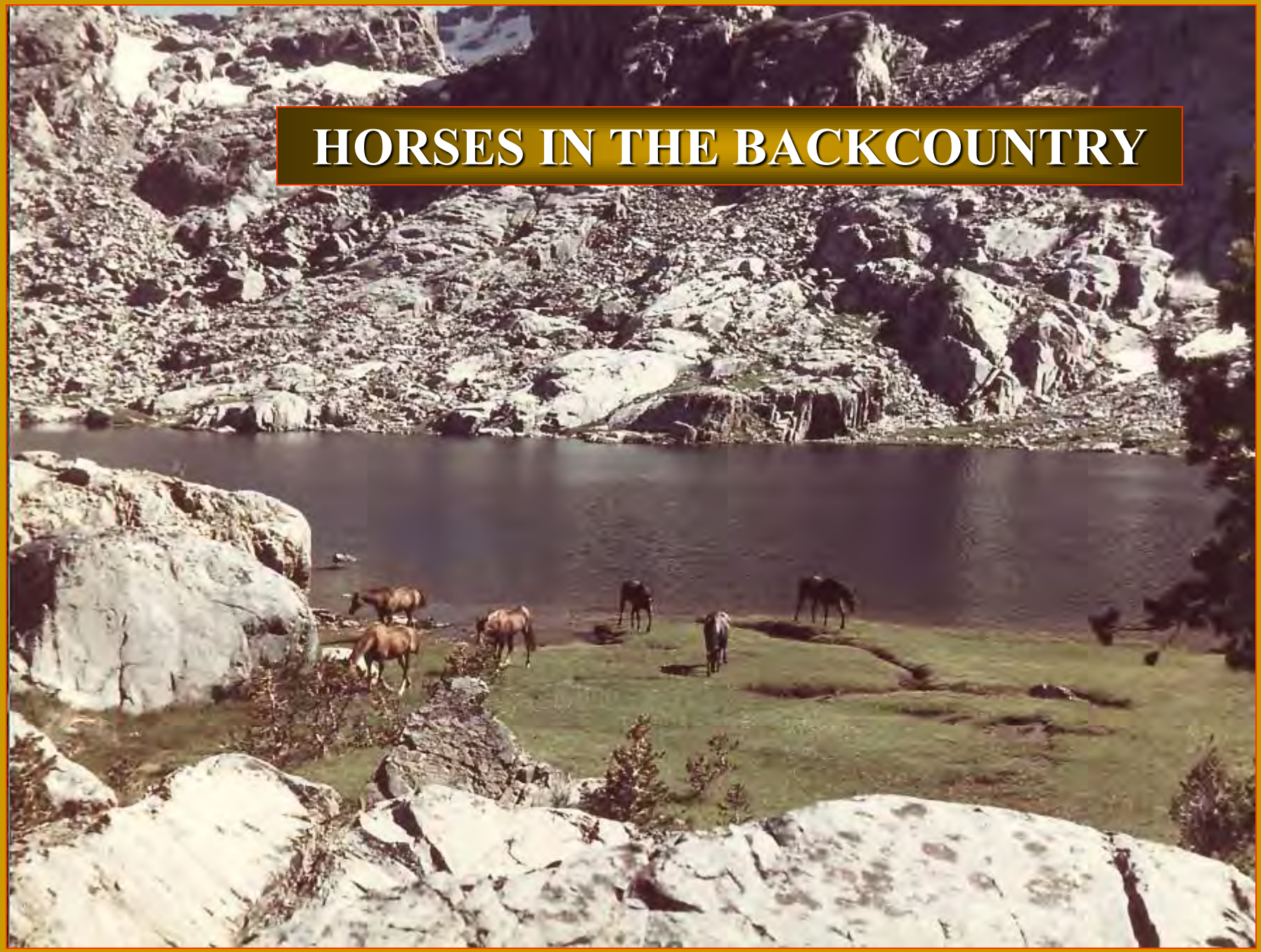
Under a new information collection rule, the EPA is requiring large water suppliers next month to begin monitoring for cryptosporidium.

California has reported no water-transmitted outbreaks of the parasite. Water managers, however, have reported outbreaks in other states where the suppliers met federal regulations for water treatment.

The worst of America's six known outbreaks was in Milwaukee in 1993, where 400,000

Parasite risks i

Cryptosporidium [illegible] mammals, especially calves. C[illegible] banning cattle — or maybe just the Los Vaqueros watershed. T[illegible] of contracting cryptosporidiosis [illegible] but the district doesn't want to


HORSES IN THE BACKCOUNTRY

1990's team on waterborne protozoal pathogens

Epidemiology (Atwill), hydrology (Harter), range ecology (Tate), livestock and wildlife biology, extension & outreach, regulatory agencies, affected industries & stakeholders

UCDAVIS VETERINARY MEDICINE

UCDAVIS COLLEGE OF AGRICULTURAL & ENVIRONMENTAL SCIENCES

UNIVERSITY of CALIFORNIA Agriculture & Natural Resources

USDA APHIS Wildlife Services

NATIONAL PARK SERVICE

San Francisco Water Power Sewer

CALIFORNIA Water Boards

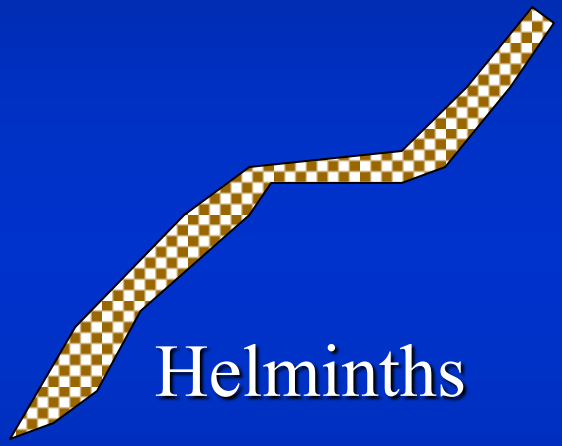
California Department of Public Health CDPH

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

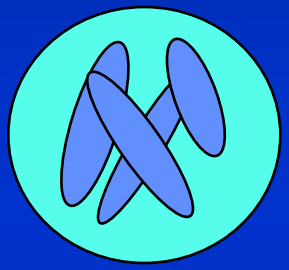
Backcountry Horsemen of California

Waterborne zoonotic pathogen

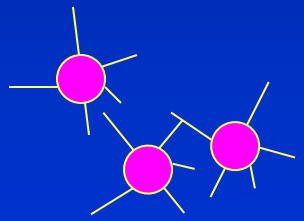
1. Infectious agent is *pathogenic* for humans
2. Biological reservoir includes an *animal*
3. Modes of transmission include w*aterborne*



Helminths

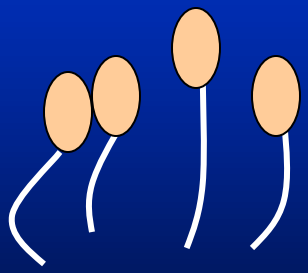


Protozoa



Viruses

Bacteria



Fungi

Prions

Waterborne Zoonotic Pathogens

Organisms shed by animals and capable of producing disease in humans following a waterborne route of exposure

Protozoa--1º importance

- ***Cryptosporidium parvum***
- ***Giardia duodenalis***
- ***Etc.***

Bacteria--1º importance

- ***Campylobacter***
- ***Salmonella***
- ***E. coli:*** indicator vs virulent
- ***Etc.***

Viruses--2º importance

- ***Rotaviruses***
- ***Hepatitis E***
- ***Etc.***

Helminths--2º importance

- ***Fasciola (liver flukes)***
- ***Etc.***

Developing beneficial management practices (BMPs): 1° goal is to match pathogen flux with local BMP efficacy

Key processes driving waterborne zoonotic transmission

A. Vertebrate pathogen loading: *who sheds the pathogen?*
B. Hydrological transport: *how are pathogens reaching water?*
C. Inactivation kinetics: *can the pathogen survive long enough?*
D. Inter-species infectivity: *is the pathogen infectious for humans?*

Early studies on fecal shedding of *Cryptosporidium* and *Giardia* in horses and mules

1997, Johnson et al., J Vet Diagn Invest

0/91 horses shedding *Crypto* and *Giardia*

1998, Fio and Atwill, Center for Equine Health, UC Davis

2/108 (2%) shedding *Crypto* among foals and weanlings

0/75 shedding *Crypto* among yearlings

12/1148 (1%) shedding *Crypto* among adults

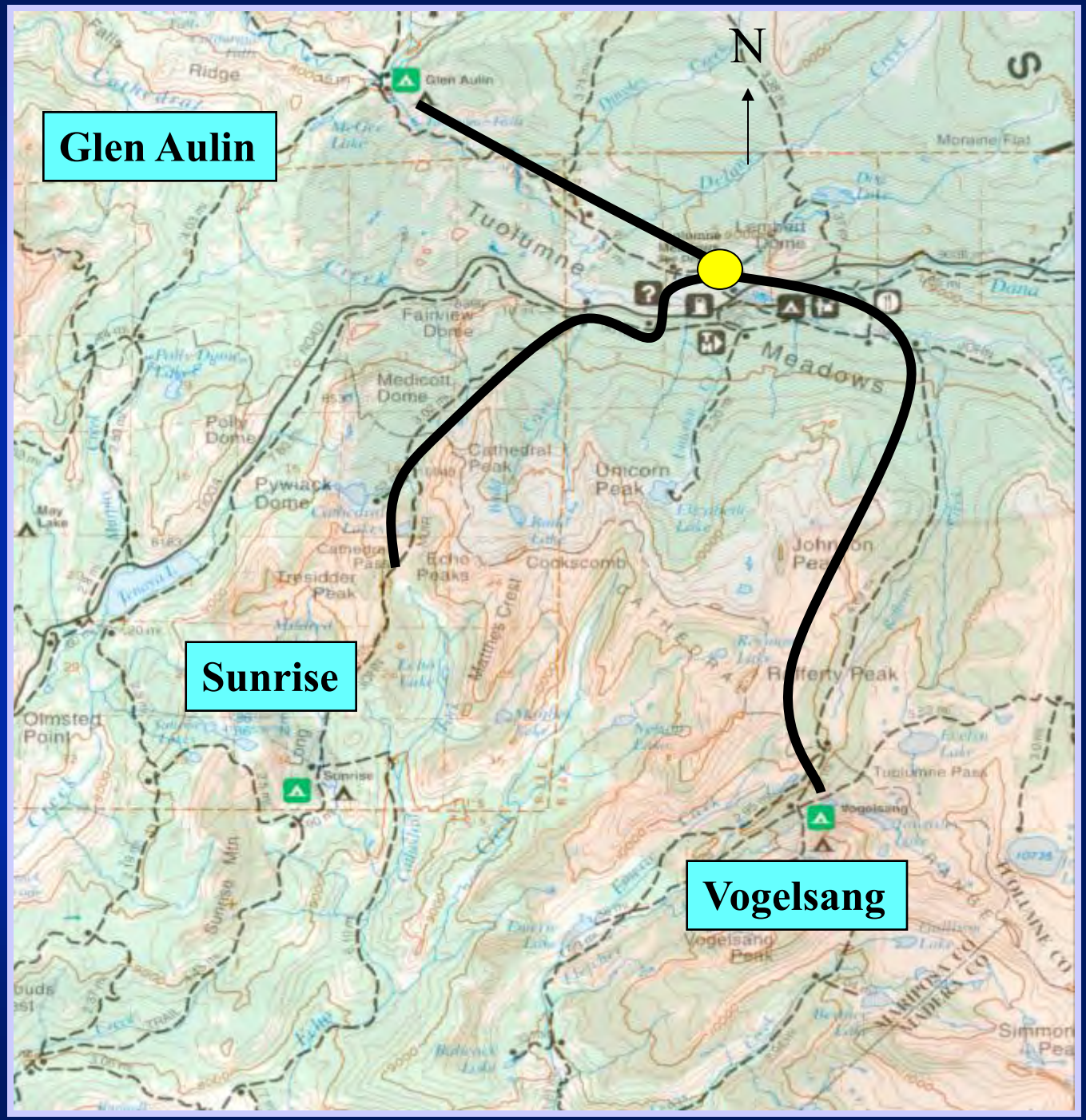
2000, Atwill et al., Equine Vet Journal, packstock animals

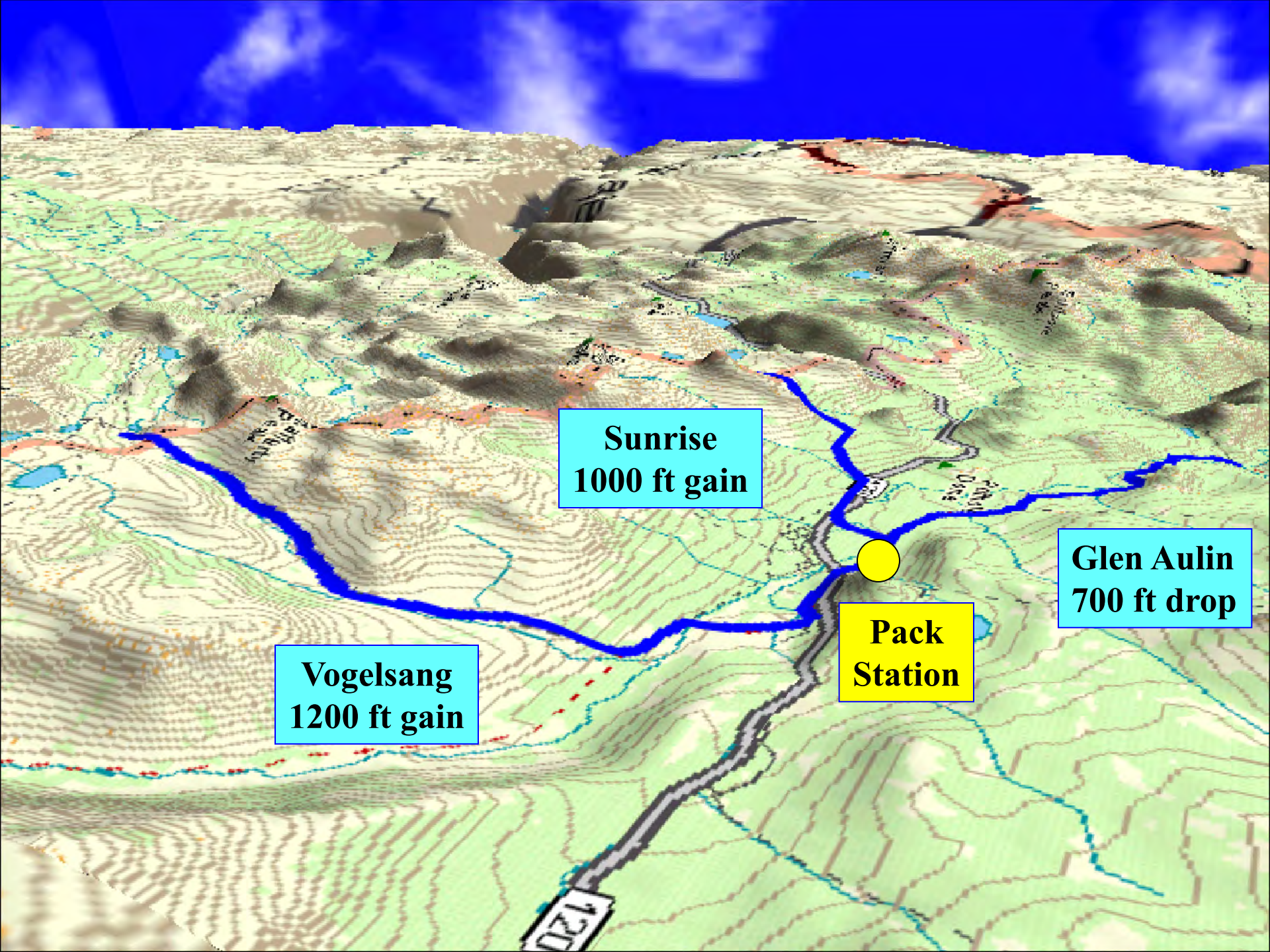
0/305 *Crypto*

14/305 (14%) *Giardia*, infection in corrals with high animal density


Dana Meadows
Yosemite National Park
2001-2003

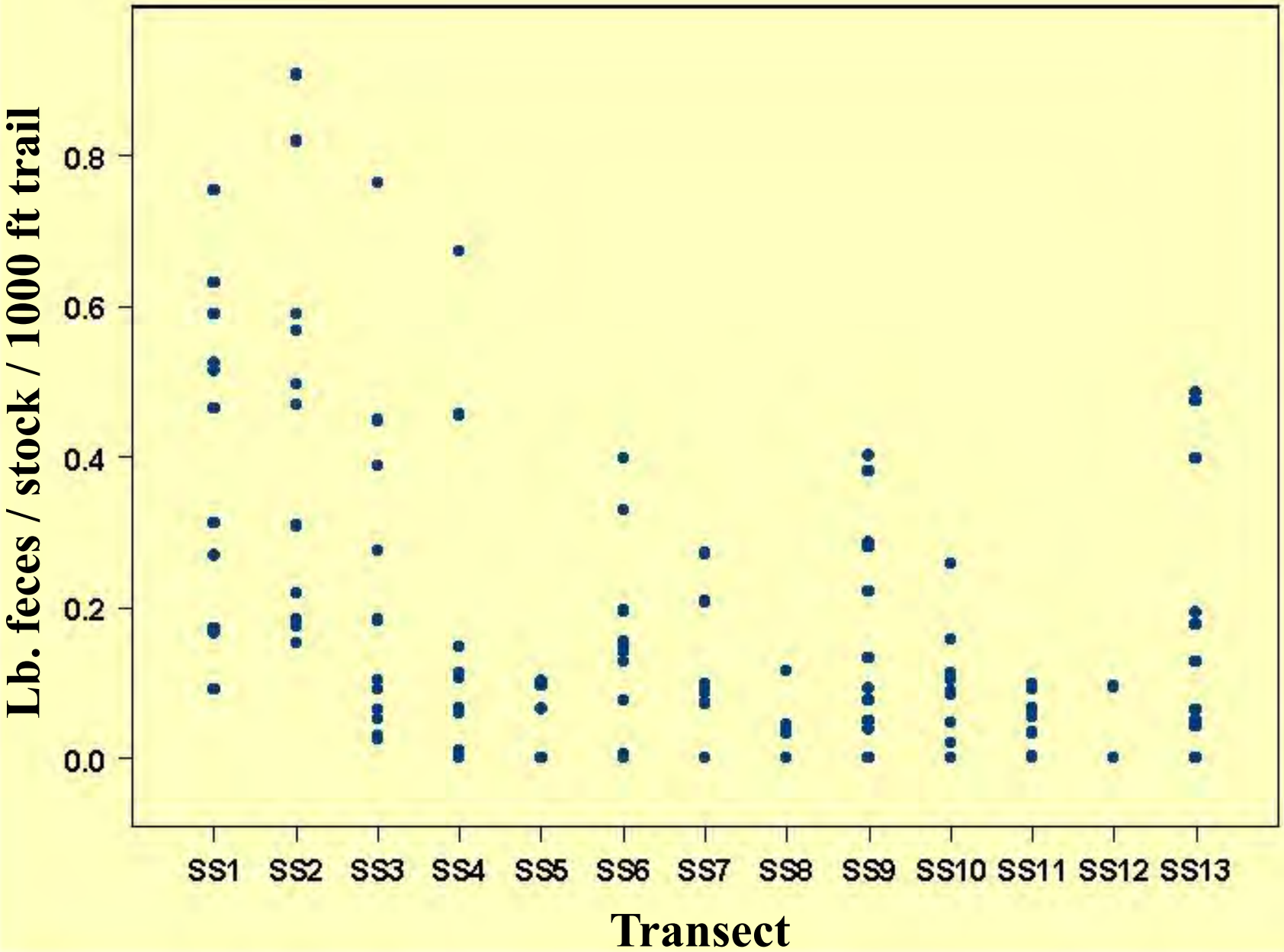
Actual measure of fecal deposition from stock



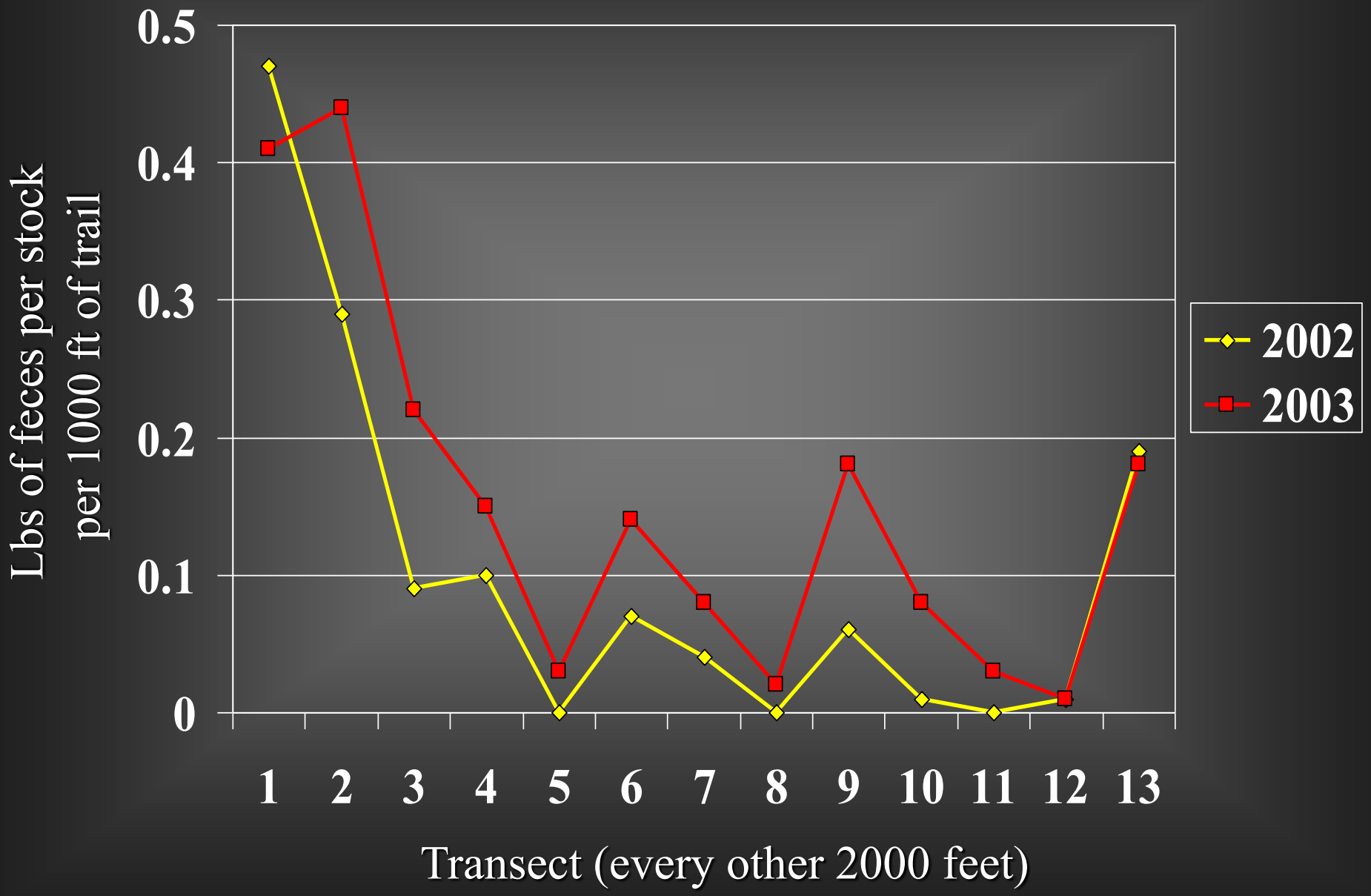

Sunrise
1000 ft gain
Glen Aulin
700 ft drop
Pack
Station
Vogelsang
1200 ft gain


Sunrise Trail
every other 2000 ft

Trail to Sunrise, 2003

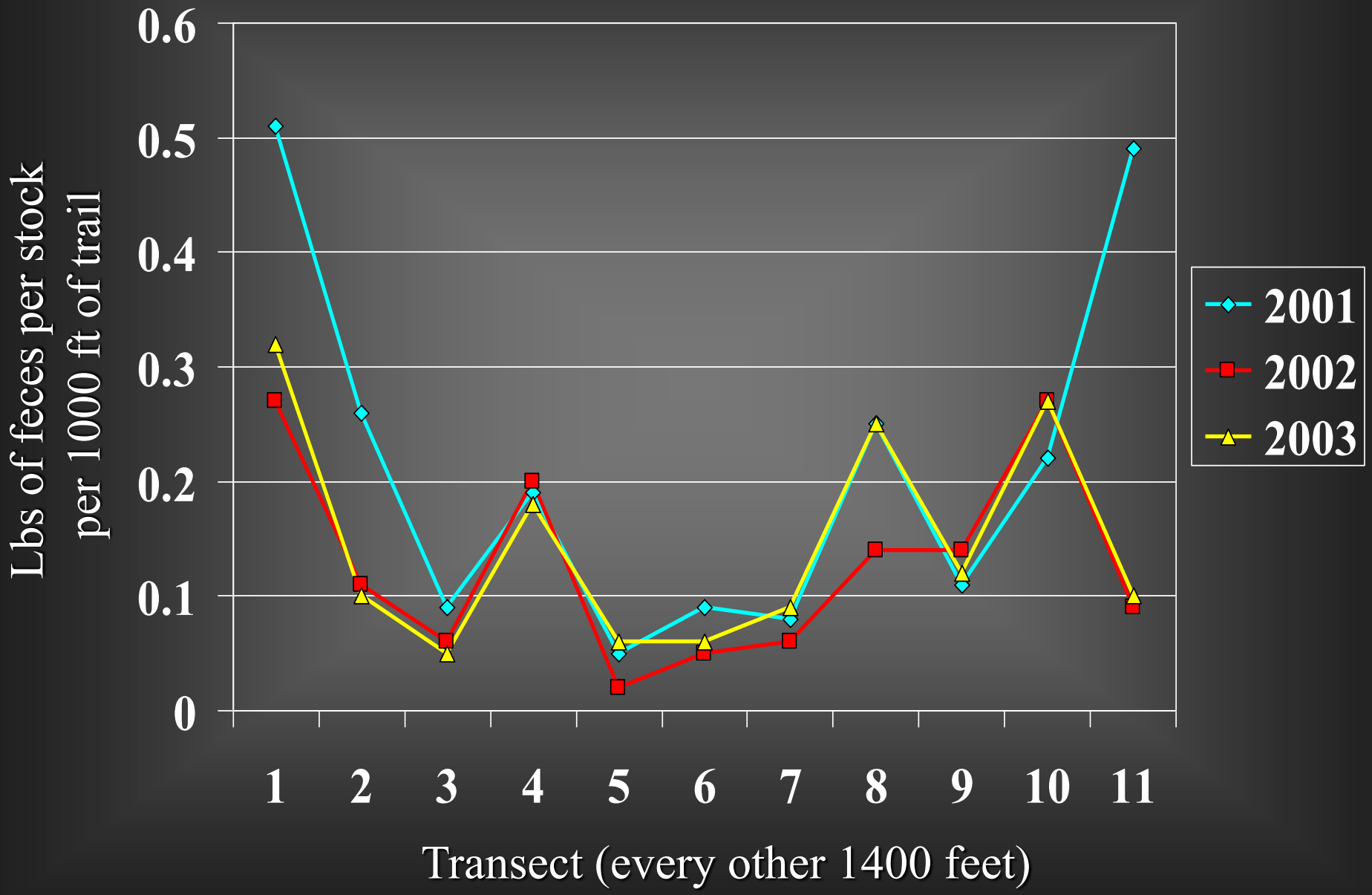


Fecal deposition along Sunrise



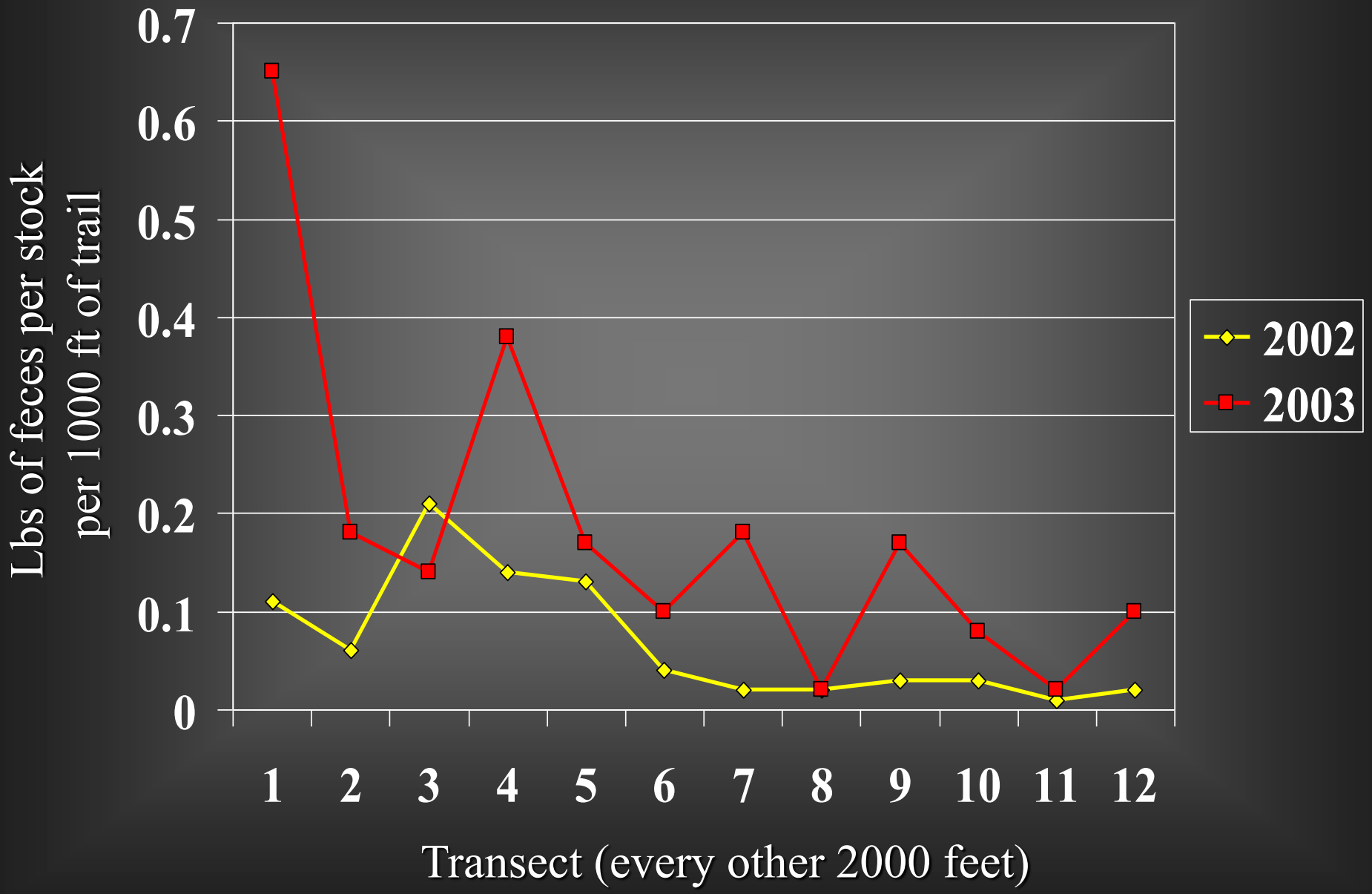

Glen Aulin Trail
every other 1400 ft
Pack Station
Trail
Lembert Dome
Tuolumne Meadows
Unicorn Peak
Pothole Dome

Fecal deposition along Glen Aulin




Vogelsang Trail
every other 2000 ft
Vogelsang
Fletcher Peak

Fecal deposition along Vogelsang




Fecal deposition averages from 0.1 to 0.6 lbs,
usually less than 0.2 lbs / stock / 1000 ft trail

What options are there for encouraging stock to defecate & urinate prior to entering a stream?

Crypto and Giardia infection

2001

sampled ~80 stock for 5 weeks, 371 fecals

Crypto-DFA	0/371 (0%)	
Giardia	2/371 (0.5%)	

2002

sampled ~100 stock for 11 weeks, 379 fecals

Crypto-DFA	1/379 (0.3%)	220 oocysts / lb feces
Crypto-IMS	1/73 (1.4%)	600 oocysts / lb feces
Giardia	23/379 (6.1%)	700,000 cysts / lb feces

2003

sampled ~120 stock for 11 weeks, 537 fecals

Crypto-DFA	0/537 (0%)	
Crypto-IMS	0/182 (0%)	
Giardia	14/537 (2.6%)	6,000 cysts / lb feces

ALL 3 Years

1,287 fecals

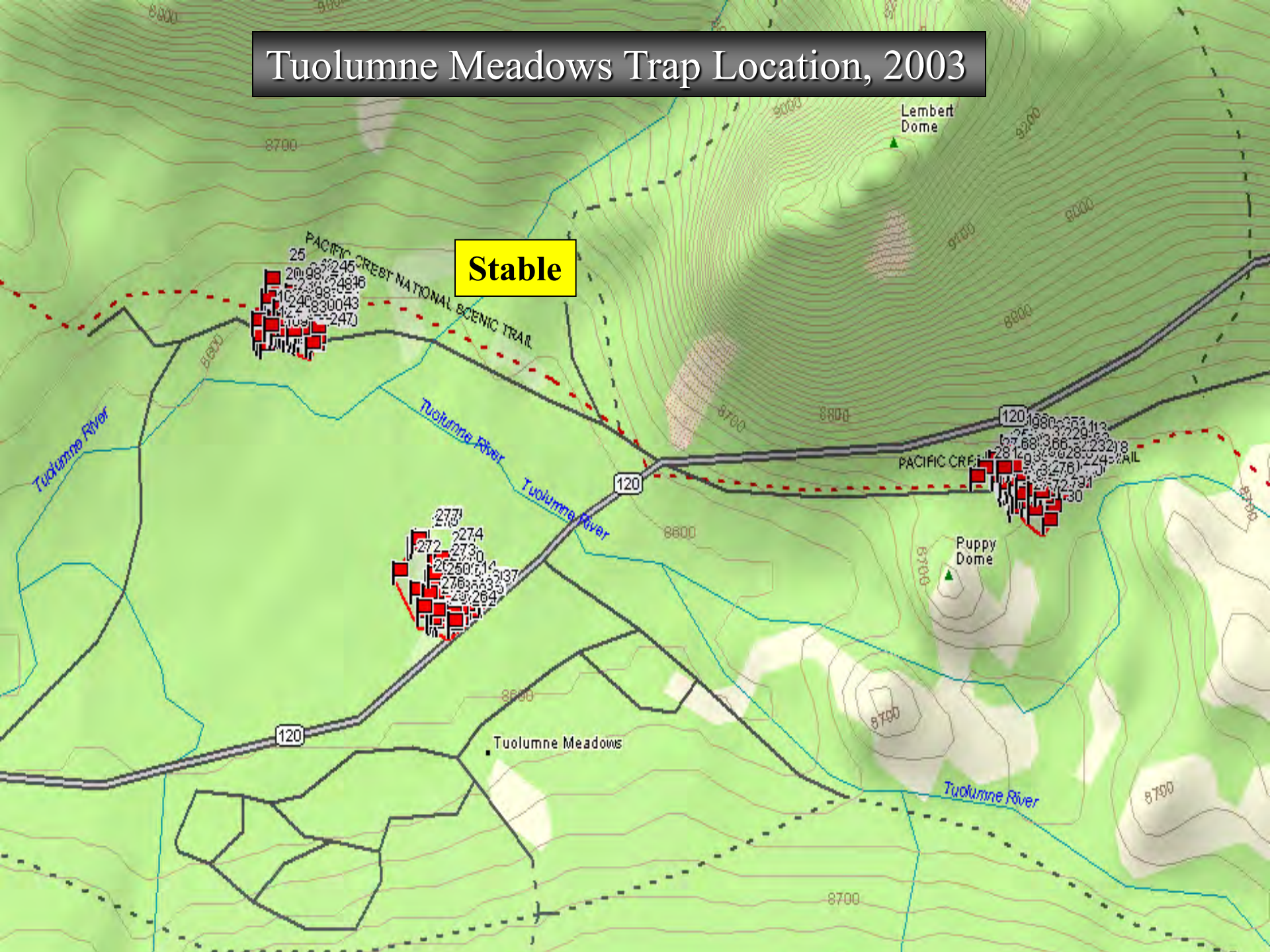
Cryptosporidium parvum
6/1287 (0.5%)
2 oocysts / lb feces

Giardia duodenalis
39/1287 (3%)
240,000 cysts / lb feces

0.2 lbs feces per stock per 1000 ft of trail

0.4 oocysts & 50,000 cysts

Belding's ground squirrels, or picket pins (*Spermophilus beldingi*)
wildlife contributions to backcountry pathogens


Tuolumne Meadows Trap Location, 2003
Stable
Lembert Dome
Puppy Dome
Tuolumne Meadows
Tuolumne River
PACIFIC CREST NATIONAL SCENIC TRAIL
120
8600
8700
8800
8900
9000
9100
9200

Cryptosporidium infection in Belding's ground squirrels

Tuolumne and Dana Meadows, 2003

	Prevalence	Oocysts / g feces
Adults	15% (42/284)	140,000
Juveniles	42% (84/199)	2,200,000
Overall	26% (126/483)	880,000

Most isolates are a new species of *Cryptosporidium* with no history of human infection, but 5% appear similar to *C. parvum*

Environmental loading of *Cryptosporidium* by Belding's ground squirrels, 2003

Mean body weight = 196 g (0.5 lb)

Defecate ~2% body weight per day

1 squirrel produces 100,000's oocysts / day

Density ranged from 5 to 20 squirrels / acre

1 to 10 million oocysts / acre / day in

Tuolumne and Dana meadows

Comparative loading of *Cryptosporidium* oocysts

Adult horse (1000 lb) :
Mean daily fecal production ~ 40 lb
2 oocysts / lb $\times$ 40 lbs feces =
80 oocysts / horse / day

Belding's ground squirrel (0.5 lb):
Mean daily fecal production ~ 0.01 lb
25 million oocysts / lb $\times$ 0.01 lb feces =
250,000 oocysts / squirrel / day

1 squirrel equals ~ 3000 horses!

What is the density of stock?
What is the density of ground squirrels?
100:1 squirrels to stock in Tuolumne and Dana Meadows, or more?

Marmots (*Marmota flaviventris*) and *Cryptosporidium* parasites in the high Sierras, 2012

1 Yosemite NP
2 Little Lakes Valley
3 Courtright Reservoir
4 Chocolate Lakes
5 Clover Creek
6 Gilbert Lake
7 Mineral King
8 Cottonwood Lakes

33/224 (15%) fecals test positive
mean of 1500 to 5000 oocysts / g
only 2 isolates DNA confirmed – *C. parvum*

Developing beneficial management practices (BMPs): 1° goal is to match pathogen flux with local BMP efficacy

Key processes driving waterborne zoonotic transmission

A. Vertebrate pathogen loading: *who sheds the pathogen?*
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CA statewide survey of 20 cow-calf herds, 2012-2013

Butte, Contra Costa, Humboldt, Kern, Lassen, Madera, Modoc, Mono, San Joaquin, San Luis Obispo, Solano, Stanislaus, Tulare and Yuba County (14 counties),

1412 cows and calves

Prevalence (%) of fecal shedding (positive/total)

	Salmonella	*E. coli* O157	*Cryptosporidium* sp.	*Giardia duodenalis*
Cow	0.4% (3/726)	5% (37/726)	9% (67/726)	23% (168/726)
Calf	0.15% (1/686)	5% (35/686)	20% (136/686)	42% (286/686)
TOTAL	0.3% (4/1412)	5.1% (72/1412)	14.4% (203/1412)	32% (454/1412)

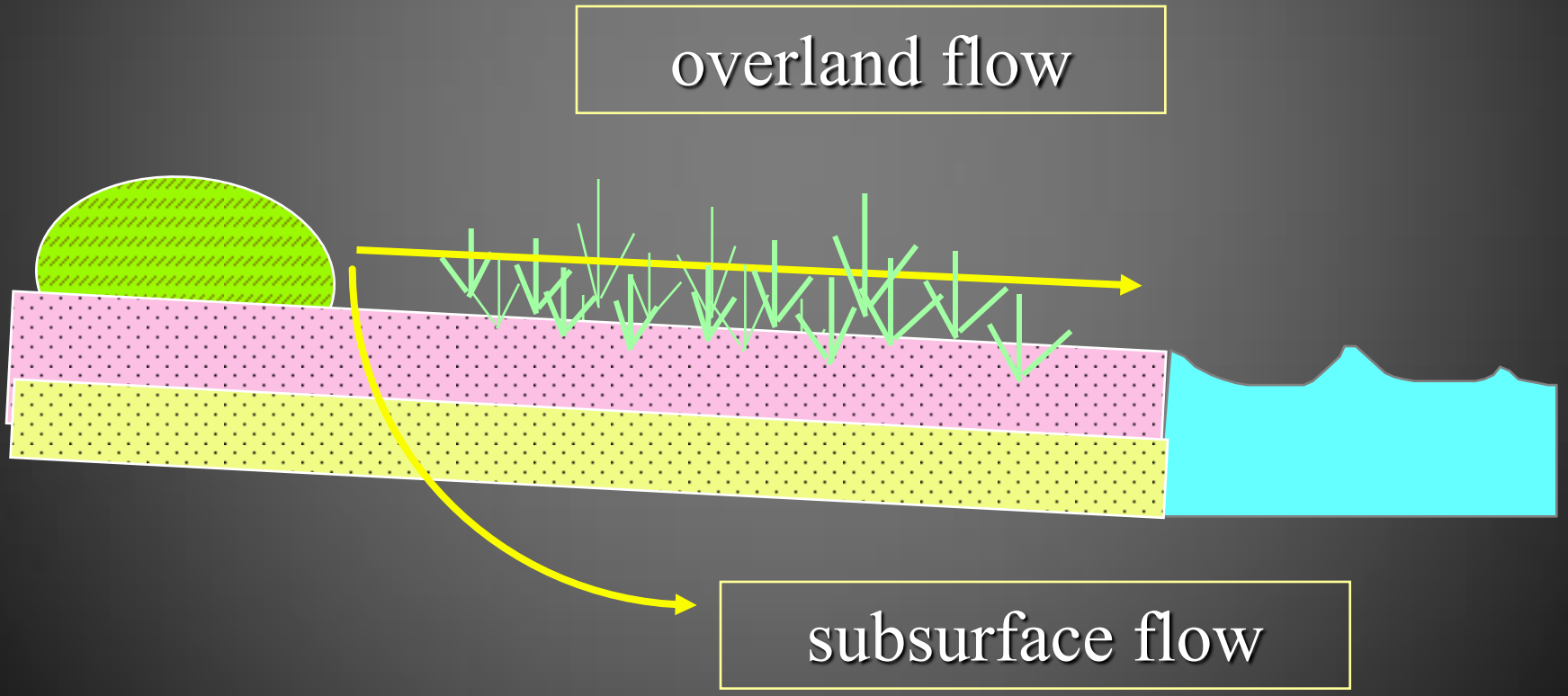
Cryptosporidium from CA beef cattle in this study appear to have low to no infectivity for humans

	C. andersoni	*C. bovis*	*C. ryanae*	*C. parvum*
Cow	0	1	18	0
Calf	1	18	43	0
Total	1 (1.2%)	19 (23.5%)	61 (75.3%)	0 (0%)

Giardia duodenalis from CA beef cattle in this study appear to have low to no infectivity for humans

	Assemblage E	Assemblage C	Unknown
Cow	56	8	2
Calf	128	7	4
Total	184 (90%)	15 (7%)	6 (3%)

Does rangeland, meadow or annual grassland remove pathogens in runoff?



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

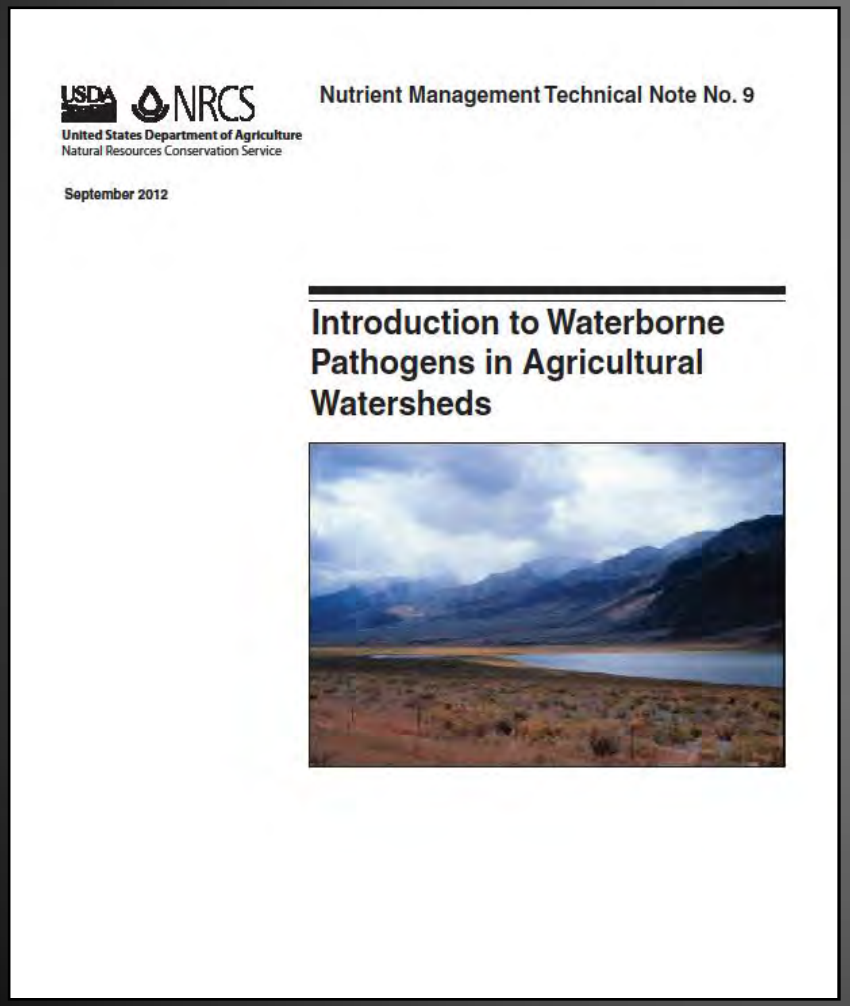
Take advantage of pathogen retention of rangeland and meadows.
Vegetated buffers can retain >95% of key pathogens in winter and spring; >99.9% achievable with sufficient infiltration; heavy rain leads to buffer failure (T-storms in summer?)

A microbe's journey between two locations is subject to numerous attenuating and inactivating processes

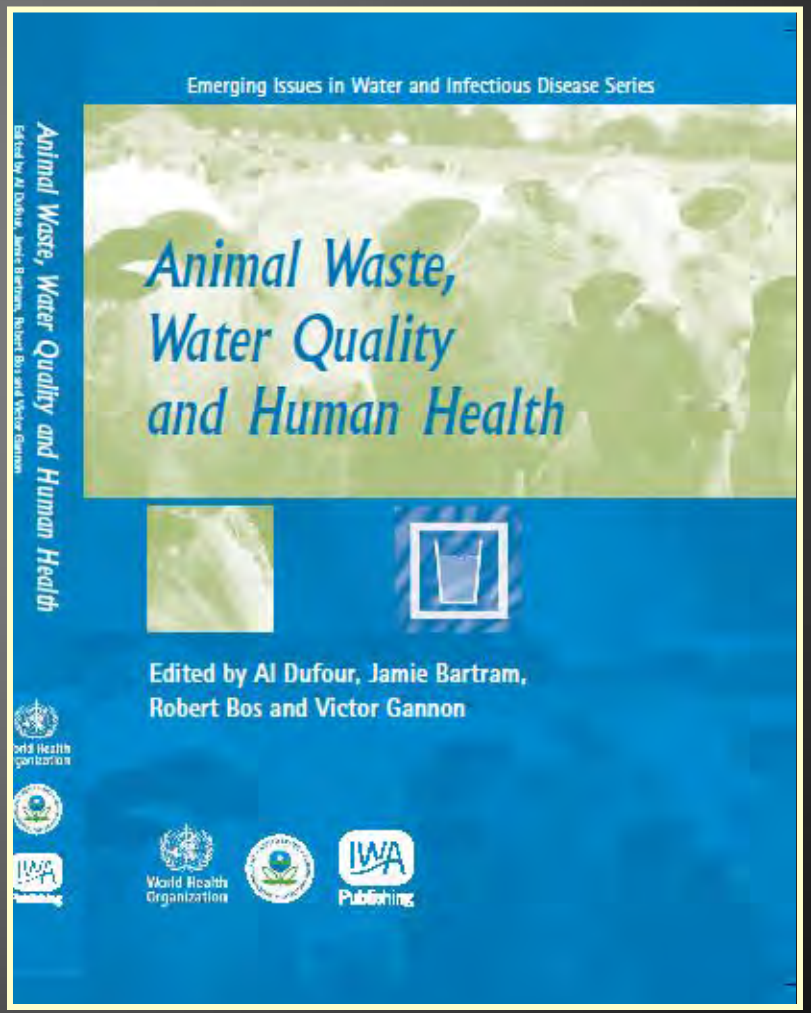
Instream filtration of pathogens: interaction with sediment and biofilms

2012 technical reports on waterborne pathogens and BMPs
both are FREE for BCH members

NRCS-USDA

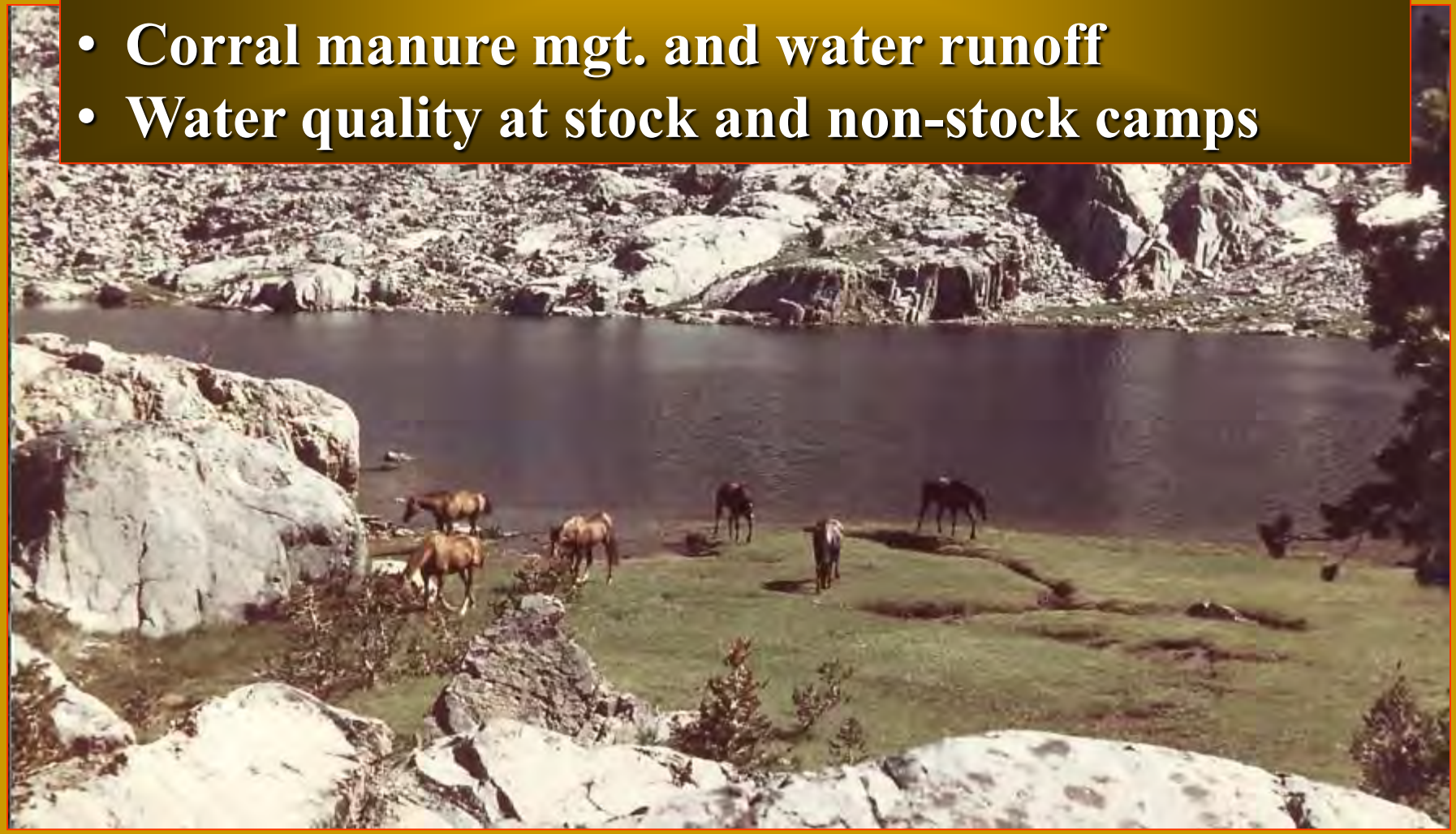


EPA & WHO



HORSES IN THE BACKCOUNTRY

- Setback distance & buffers at camps and corrals
- Dispersion of feces & solar inactivation
- Behavior of stock defecation & urination
- Corral manure mgt. and water runoff
- Water quality at stock and non-stock camps



Thank you, any questions?

Mann Lake, Oregon