

TITLE: Coliform bacteria in tinajas of the Waterpocket Fold: changes correlated with the presence of cattle in Capitol Reef National Park.

OBJECTIVES:

1. To establish a baseline level of fecal coliform bacteria in tinajas of 4 tributary drainages of Hall's Creek before cattle return to graze during the winter.
2. To document changes in fecal coliform bacterial counts throughout the year, while cattle are grazing, and after cattle have been removed in the spring, and through the summer.
3. To document changes in fecal coliform bacterial counts in tinajas formerly accessible to cattle, but fenced off to exclude cattle, to be sampled concurrently with tinajas cattle still have access to.
4. To document changes in fecal coliform bacterial counts in bottom sediments of tinajas accessible to cattle, and tinajas cattle cannot reach.

HYPOTHESES:

- H1: Fecal coliform bacterial counts from a given tinaja cattle have access to, prior to introduction of cattle, will not differ from counts from the same tinaja after cattle begin grazing in the area.
- H2: Fecal coliform bacterial counts from tinajas accessible to cattle will not differ from counts from tinajas cattle cannot reach.
- H3: Fecal coliform bacterial counts from tinajas accessible to cattle will not differ before and after fencing of the tinajas to exclude cattle.
- H4: Fecal coliform counts from sediment from accessible tinajas will not change during the year in correlation to the presence of cattle.
- H5: Fecal coliform counts from sediments from accessible tinajas will not differ from inaccessible tinaja sediment sample coliform counts.

A significant difference will be shown between accessible and inaccessible tinajas by rejection of each null hypothesis at $p \leq 0.05$.

JUSTIFICATION:

Contamination by cattle feces of water used by humans for drinking and/or recreation can create serious health problems, including salmonellosis and leptospirosis (Buckhouse and Gifford 1976, Willrich 1967). As recreation increases in areas grazed by cattle, risks to human health also increase. Many diseases can be transmitted between different mammal species via water as well

(Diesch 1970). There is a need to determine levels of fecal contamination of water sources used by livestock, backcountry visitors, and wildlife.

The correlation between cattle grazing and increased levels of fecal bacteria is well established, and assumed to be a cause and effect relationship (Coltharp and Darling 1973, Darling and Coltharp 1973, Kunkle 1970, 1979). Studies of water quality related to livestock in arid ecosystems are rare (Buckhouse and Gifford 1976), and extrapolations from more mesic sites are of limited value. Water quality studies in arid systems are needed to evaluate the impact of livestock on the rare water sources available to recreational users, and wildlife in these areas.

Tinajas represent the primary source of water for wildlife and backcountry park users, as well as cattle in the southern end of the Waterpocket Fold in Capitol Reef National Park. Fecal contamination of these pools by cattle represents a definite health hazard to backcountry park visitors, and the native wildlife. With cattle grazing in CARE, there is a need to assess the water quality of tinajas, and the extent to which degradation of water quality is directly attributable to fecal contamination by livestock.

The Utah State Bureau of Water Pollution Control will be re-evaluating and re-classifying the waters of the state in 1987 (Mike Reichert pers. comm.). Most of the water sources of CARE are not classified at this time. Classification can provide protection of water quality for certain water sources, and will formally identify water sources considered to be important for

wildlife and/or backcountry visitor use in CARE. Data from this study, as well as the Waterpocket Ecology study would help the Water Pollution Control Committee in their decisions on determining classifications for the water sources of CARE (Mike Reichert pers. comm.).

LITERATURE REVIEW

There have been few studies of bacterial water quality of wildland waters, especially in arid or semi-arid regions (Buckhouse and Gifford 1976). Studies in other areas point to fecal contamination by livestock and/or wildlife as primary sources of potentially hazardous disease organisms in streams, ponds, lakes, and reservoirs.

Fecal coliform bacteria are perhaps the best single enteric bacteria group to use to test for possible fecal contamination by mammals of a water source (Kunkle 1979, D. Sorensen pers. comm.). Presence of fecal coliform bacteria have been correlated with the presence of disease organisms that are transmitted via fecal contamination (Kunkle 1979).

Counts of fecal coliform bacteria have been shown to increase when livestock use a watershed (Coltharp and Darling 1973, Darling and Coltharp 1973, Kunkle and Meiman 1967, Meiman and Kunkle 1967, Morrison and Fair 1966, Skinner et al. 1972). Large wildlife populations can also cause high fecal coliform counts (Bissonette et al. 1970, Stuart et al. 1971, Walter and Bottman 1967). Presumably, the risk of disease increases as fecal coliform counts increase (Geldreich 1970, Willrich 1967).

The impact of dispersed livestock manure on stream water quality is apparently fairly low (Buckhouse and Gifford 1976, Kunkle 1970). Buckhouse and Gifford (1976, p112) to so far as to state that "there is no evidence based on this study to indicate significant public health problems presented by cattle grazing on open range...." The veracity of this statement is limited to "open range" where manure is dispersed, and human use of the land is confined to non-ingestive uses (e.g., hiking, hunting, etc.). A person would have to fall face first into a "cow pie" to suffer fecal contamination on the open range.

The situation in riparian zones, and other areas in and around water sources is quite different. Fecal contamination of water sources is a serious problem in arid and semi-arid areas because of the tendency of livestock to concentrate around the relatively few water sources. Defecation directly into the water is common, and additional contamination takes place as fecal material is carried into the water on hooves. Cattle trample banks, mixing feces into soil immediately adjacent to the water. Erosion of these soils during rainstorms can introduce more bacteria into the water sources. In these situations, high fecal coliform counts are directly related to livestock use (Coltharp and Darling 1973, Janzen et al. 1974, Kunkle 1970, 1971).

Fecal coliform bacteria can survive and even multiply in natural waters, increasing more rapidly at higher temperatures (Mack 1974). Hendricks and Morrison (1967) reported enteric bacterial growth in cold mountain streams and cited the stream's self-purification mechanism as being important in reducing growth

rates of these organisms. Buckhouse and Gifford (1976) reported that enteric bacteria remain viable for at least one grazing season, and perhaps for several years.

Tinajas may provide an environment where fecal bacteria introduced from cattle feces can survive and perhaps even increase in numbers, even after cattle have been removed. Tinaja water temperatures reached at least 30 C during the summer, and drop to less than 5 C during winter (unpubl. data). Water temperatures are well within the range reported for enteric bacterial growth (Hendricks and Morrison 1967, Mack 1974), and they do reach temperatures at which Mack (1974) reported higher growth rates. While tinajas are periodically flushed out, they do not have the "self-purification mechanism" of cold mountain streams to slow bacterial growth. Given the longevity of fecal bacteria in feces and water, it is possible that fall/winter grazing in Capitol Reef National Park can contribute to health hazards for park visitors in spring, summer, and fall, as well as during the winter.

Flushing of tinajas during flash floods may actually introduce more enteric bacteria into the water column. Stream sediments can act as a reservoir of fecal bacteria (Stephenson and Rychert 1982); sediments in tinajas are probably reservoirs of bacteria as well (unpubl. data). Periodic injections of fecal bacteria into tinaja water from tinaja sediments can take place during flash floods, even after cattle have been removed. Thus, cattle fecal contamination of water sources can pose a threat to park visitor health anytime of the year, even when the visual signs of contamination have been removed by flash floods.

Mammals other than man are also susceptible to diseases transmitted via water (Diesch 1970). Desert bighorn sheep, which were recently reintroduced to Capitol Reef use some of the same habitat as cattle in the park, including some tinajas (pers. obs.) Desert bighorns are quite sensitive to diseases, and exposure to domestic sheep generally results in the death of the bighorns from diseases carried by the domestic sheep (Tom Bunch, pers. comm.).

The impact of cattle on desert bighorn is unknown, although there are indications that diseases are being transmitted from cattle to bighorns in San Juan County, Utah (Jeff Connor pers. comm.). The potential for interactions between cattle and bighorns is great in Capitol Reef National Park, and the Resource Management staff is concerned over the possibility of water-mediated disease transmission into sheep that took considerable time, effort, and money to re-introduce into the park.

PROCEDURES

Water samples

Summer-Fall 1986:

Perform fecal coliform analyses of all tinajas being studied (four drainage systems, five tinajas in each drainage) three times: 4-5 Aug., 26 and 28 Aug., and 24-26 Sept. This will provide a background coliform count for the tinajas after cattle have been absent for at least 4 months (except at Fountain #5, Cottonwood #5, and Willow #5), and all tinajas will have been flushed out by the rains at least once.

Fall 1986-Spring 1987:

Cattle are put into the Hall's Creek area on 1 Nov., and remain until mid April at the latest. During this period, three samples will be taken from each of nine tinajas: four accessible to cattle, and five cattle cannot reach (Table 1). Willow and Cottonwood tinajas will be sampled biweekly; Fountain and Miaheyan tinajas will be sampled monthly.

Table 1. Tinajas being studied in the coliform bacteria monitoring program at Capitol Reef National Park

Drainage	impacted <u>tinaja</u>	unaffected <u>tinaja</u>
Willow	W5	W2
Cottonwood	C4,C5	C2
Fountain	F5	F1
Miaheyan	--	M1,M5

Spring-Fall 1987:

Monitoring of the 9 study tinajas will continue after cattle are removed to follow the attrition of fecal coliform bacteria after input ceases.

Fall 1987-Summer 1988:

During spring 1987, Cottonwood #4 and #5 will be fenced off, excluding cattle from these tinajas the following grazing season. Monitoring of all study tinajas will continue biweekly through the next year to assess the bacteriological recovery of tinajas previously exposed to cattle, once cattle are removed.

Sediment samples

Changes in coliform counts from sediment will be followed over time, as cattle are introduced to the area, during the grazing season, and after cattle are removed. Time taken to eliminate sediment reservoirs of fecal coliform bacteria after contamination will be determined by fencing off some tinajas, after a season of cattle use, and monitoring sediment fecal coliform counts.

Two sediment samples will be taken from each tinaja at each sample period during the study to assess the possible existence of a sediment reservoir of fecal coliform bacteria. A sediment reservoir is indicated by the results of coliform analyses on the Fountain tinajas immediately following a heavy rain that flushed all the tinajas and stirred up the bottom sediments. All 5

tinajas showed fecal coliform growth, ranging from 40-140 colonies/100ml, where the previous sample showed no fecal coliform bacteria in any of the Fountain tinajas.

All fecal coliform sampling will be done with Millipore Corp. field equipment, using procedures described in "Water microbiology: laboratory and field procedures" booklet (Anon.1986). Sediment samples will be shaken shortly before filtering to suspend bacteria, but the main sediment load will be allowed to settle before pipetting sample water to be filtered. The multiple tube technique (MPN) is a better procedure for analyzing water samples with a high sediment load (Kitrell and Furfari 1963), but we don't have the equipment to use this technique. The method described in Rodina (1972) may be a better way to separate bacteria from sediment, and some experiments comparing simple settling with this technique should be tried.

There are 4 indicator groups of bacteria that can be used for assessing fecal contamination of water sources: total coliforms, fecal coliforms, fecal streptococci, and enterococci (Kunkle 1979). Fecal coliforms give the best indication of fecal contamination (Kunkle 1979, D. Sorenson pers. comm.). The ratio of fecal coliform/fecal streptococci provides a more definitive determination of the source of the contamination (e.g., cattle vs. human feces). Because backcountry use is presently low, and fecal contamination by cattle is obvious--feces are present in many of the tinajas used by cattle--we are assuming that contamination is from cattle, and thus it is unnecessary to culture both fecal coliforms and streptococci.

An experiment on coliform longevity in feces similar to that done by Buckhouse and Gifford (1976) should be done. Samples from a fresh "cow pie" (it would be best if the cow was observed defecating to accurately document the cow pie's age) should be taken biweekly, or perhaps weekly if possible. The sample should be about 15cc in volume, and should be mixed with 1000mL distilled water (or boiled and cooled river water). Buckhouse and Gifford (1976) only allowed the feces to sit in the water for one hour before culturing for fecal and total coliform bacteria. Especially as the feces dries, the soaking time should be extended to allow more time for dormant bacteria to re-hydrate and become active. Perhaps a standard of 4 hrs soaking time should be used for all samples. A minimum of 3 replicates should be cultured from each sample. Filter 1mL of "manure tea" for each replicate.

BUDGET

Three water sample replicates, and 2 sediment sample replicates per tinaja:

(780 regular samples, 78 longevity test samples, total: 858 samples)

GS-5 Biological technician	30 days	\$1800.00
vehicle use	1056 miles @ \$0.195/mile	205.92
vehicle lease	0.8 months @ \$138.50/month	110.80
0.45 m membranes	200/pk, 5 pks @ \$59.20	296.00
M-FC broth, 2 ml ampoules,	24/box, 42 boxes @ \$16.50	693.00
Plastic petri dishes w/pads	100/pk, 10 pks @ \$19.30	193.00
Sterile phosphate buffer	25/box, 8 boxes @45.50	364.00
miscellaneous supplies (estimated)		250.00
utilities		50.00
TOTAL		\$3962.72