RESPONSE TO COLIFORM BACTERIA CONCENTRATION TO GRAZING MANAGEMENT[1]

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Bacterial contamination of surface waters may impact human health by transmitting pathogenic organisms. For several decades, the fecal group of Escherichia coli have been used to indicate the presence of fecal material which may contain pathogens. State and federal water quality regulations employ fecal coliform counts to monitor point source fecal contamination and to define the sanitary status of urban watercourses. When the 1972 Federal Water Pollution Control Act (PL 92-500, Section 208) required evaluation of non-point source pollutants, the same techniques and similar standards were applied to wildland streams. However, certain aspects of fecal coliform behavior in wildland watersheds require careful interpretation for rangeland monitoring purposes. For example, coliform concentrations in streams readily respond to runoff events (Kittrel and Furfari, 1963; Morrison and Fair, 1966; Stephenson and Street, 1978; Doran and Linn 1979; Hanks et al., 1981). Apparently, cowpies can provide a protective medium which allows coliform survival for at least a year, during which time the bacteria could be carried to the stream with overland flow (Buckhouse and Gifford, 1976; Clemm, 1977). Only two to three percent of the bacteria theoretically available from an eastern United States pasture actually reached the stream (Kunkle, 1970) and runoff carried viable coliform only about three feet on a Utah range (Buckhouse and Gifford, 1976). However, when cattle concentrate in a riparian area, the stream might be within transport distance. In addition, on western United States rangelands, high intensity-short duration storms produce conditions which lower infiltration and increase the volume of runoff available to transport bacteria (Hanks et al., 1981).

Once in the streams, the organisms tend to bind to suspended sediments and settle out (Kittrel and Furfari, 1963; McSwain and Swank, 1977; Speck et al., 1981). In fact, coliform concentrations exhibit a hysteresis loop characteristic of suspended sediment concentration associated with high flows (Kunkle, 1970). Bottom sediments are apparently a significant reservoir for fecal coliform which may be resuspended by streamflow or animal disturbance (Kunkle, 1970, VanDonsel and Geldreich, 1971; Stephenson and Rychert, 1982). However, coliform bacteria may die-off in riffle areas due to increased contact with bacteria predators and good aeration (Kittrel and Furfari, 1963). Unfortunately, little is known about the behavior of pathogens in bottom sediments; Salmonellae apparently survive in mud similarly to fecal coliform (VanDonsel and Geldreich, 1971).

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1 This work was funded by the U.S.D.A. Forest Service, Range and Wildlife Habitat Laboratory, La Grande, Oregon.

It appears that coliform bacteria concentrations from non-point sources may be indicating fecal contamination, entering with overland flow, or, mimicking suspended sediment concentrations. There is even some evidence, stemming from research related to septic tanks, that coliform bacteria may survive in some soils and move laterally as far as a few hundred feet with subsurface flow under saturated flow conditions. Well-drained colluvium apparently favored bacterial movement (VanDonsel et al., 1967; Hagedorn and McCoy, 1979; Moore et al., 1981). It may be crucial to understand the mechanism by which the fecal coliform arrive in the stream and the behavior of the pathogens in each circumstance.

Livestock grazing is considered a major source of fecal pollution on wildland streams. Doran et al. (1981) estimated that one third of all water pollutants in the United States are from non-point sources and that animal wastes from grazing are an important non-point source. Several studies have correlated fecal contamination with livestock grazing (Morrison and Fair, 1966; Kunkle and Meiman, 1967; Darling and Coltharp, 1973; Johnson et al., 1978, Stephenson and Street, 1978; Doran and Linn, 1979; Dixon et al., 1981; Gifford, 1981). One week to several months may be necessary for coliform counts to return to background levels following livestock removal (Johnson et al., 1978; Stephenson and Street, 1978). However, other mammals, such as wildlife, also transmit coliform bacteria. When local big game populations concentrated in a protected watershed in Montana, the water produced higher coliform concentrations than did a comparable watershed open to recreation (Walter and Bottman, 1967; Stuart et al., 1971). Background levels of coliform may vary with wildlife use.

In many areas, livestock depend on access to streams for water, and feed on the succulent vegetation throughout the season. For economic reasons, controlling fecal contamination by use of a particular grazing system is preferable to livestock exclusion. The only study of the influence of different grazing systems on coliform counts found lower counts on a deferred rotation system compared to a continuous grazing system (Speck et al., 1981). The comparison was based on data from streams in mountain allotments. Recognizing the potential for management applications, the Forest Service Pacific Northwest Forest and Range Experiment Station initiated a multidisciplinary case study at Meadow Creek on the Starkey Experimental Forest and Range in northeastern Oregon in 1975. The study was conducted through the Range and Wildlife Habitat Lab in La Grande, Oregon, and spanned five years of controlled grazing. One of the objectives of this study was to compare levels of fecal contamination associated with different systems of grazing cattle.

METHODS

Our Meadow Creek study examined five grazing options. Four pasture rest-rotation, deferred rotation, season-long grazing and no grazing systems were applied to two blocks with one block open to big game (elk and deer) use and one block closed to big game. In addition, late season, high intensity-short duration grazing was tested in September and October. Season-long grazing was studied on pastures which had been rested one to four years. All pastures contained about one-quarter mile of stream frontage.

Water samples were cultured for fecal coliform bacteria following standard methods described for the membrane filter technique (American Public Health Association, 1975). Water samples (250 milliliters) were collected above and below each pasture every three to four weeks. The time of sampling remained constant for each station, but the sample collection period extended from 1000 hours to 1400 hours. On 1200 foot stream stretches, water flowing from one grazing treatment into the next confounds sampling in the lower pasture. Therefore, the arithmetic difference in counts as the stream enters and leaves a grazing treatment was considered representative of that treatment. The t-test was applied to above and below treatment pairs to determine whether changes were significant and confidence intervals were used to compare treatment means.

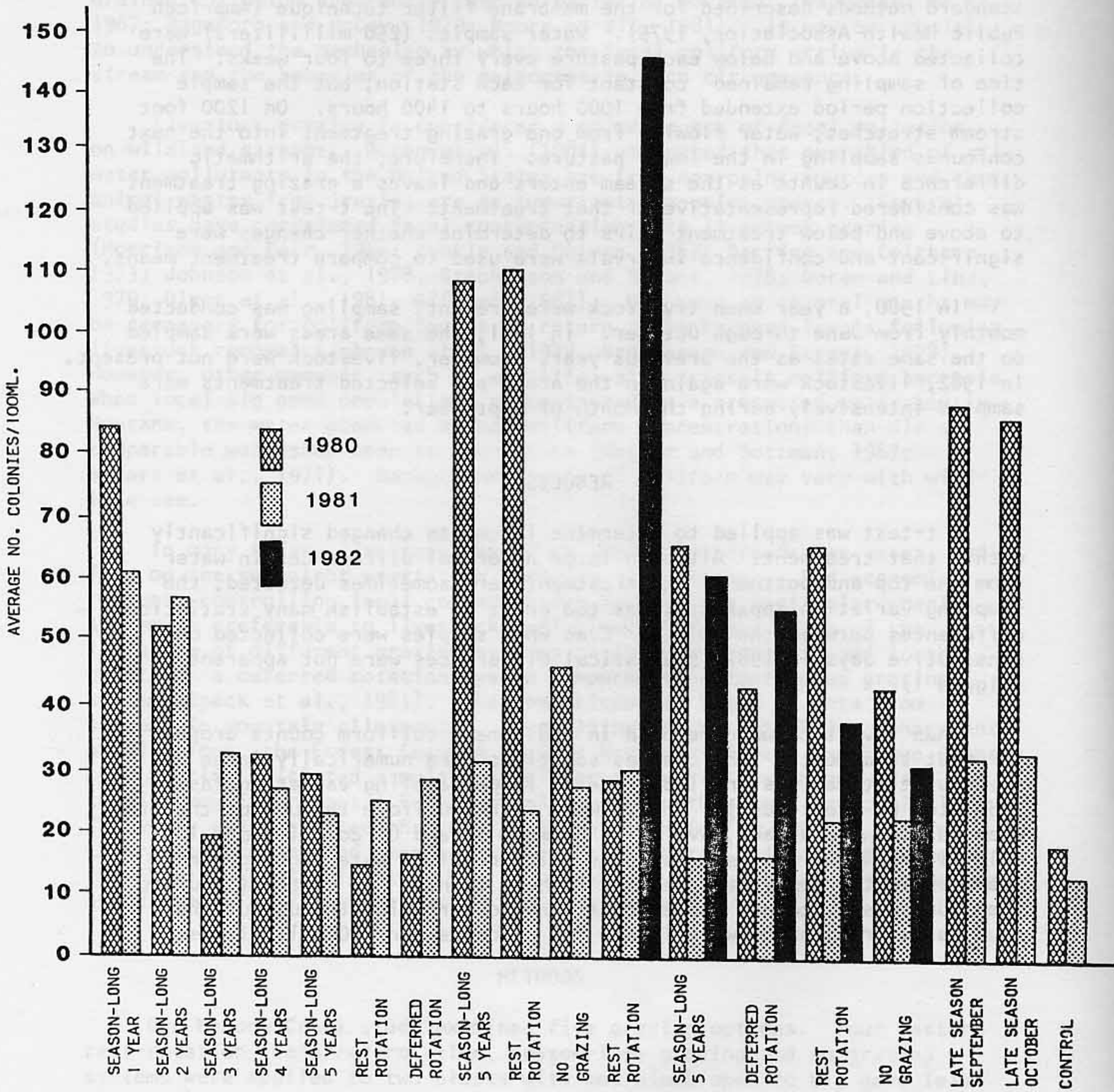
In 1980, a year when livestock were present, sampling was conducted monthly from June through October. In 1981, the same areas were sampled on the same dates as the previous year. However, livestock were not present. In 1982, livestock were again on the area, and selected treatments were sampled intensively during the month of September.

RESULTS

A t-test was applied to determine if counts changed significantly within that treatment. Although large numerical differences in water from the top and bottom of the treatment were sometimes detected, the sampling variation apparently was too great to establish many statistical differences between the points. Even when samples were collected on consecutive days in 1982, statistical differences were not apparent (Figure 1).

When livestock were removed in 1981, mean coliform counts dropped for most treatments. The changes sometimes were numerically large but never statistically significant due to large sampling variation (as indicated by the t-test). Counts were fairly uniform throughout the study when cattle were absent, averaging between 13 and 61 colonies per 100 milliliters. The upstream pastures which received water from grazed areas above the study recorded the highest counts. In contrast, during the 1980 season, counts showed considerable variation throughout the study area, ranging between 14 and 111 colonies per 100 milliliters.

FIGURE 1. AVERAGE NUMBER OF COLONIES: GRAZED VS. UNGRAZED YEARS



HEALTH STANDARDS

The Oregon Department of Environmental Quality requires that coliform bacteria in the waters of the Grande Ronde Basin do not exceed a log mean of 200 fecal coliform per 100 milliliters, based on five samples in a 30-day period. Furthermore, no more than 10 percent of those samples may exceed 400 colonies per 100 milliliters (Oregon D.E.Q., 1980). Although coliforms were never sampled five times within 30 days for the study, it is noteworthy that counts seldom exceeded 100 per 100 milliliters. Oregon State Health Division allows an arithmetic mean of one colony per 100 milliliters with any individual sample showing no more than four per 100 milliliters for drinking water. Few, if any, wildland streams meet this criteria regardless of grazing management.

SUMMARY AND CONCLUSIONS

1. Although large numerical differences sometimes were seen, differences between grazing systems were not statistically significant.

2. The number of colonies and the range of the counts generally decreased the first year livestock were not present. Although the changes were often numerically large, they were statistically insignificant.

3. Meadow Creek apparently conforms to Oregon's coliform standards for wildland waters in the Grande Ronde Basin.

4. Interpretation of coliform data from non-point sources must be cautious and must recognize a number of sources of variation. In addition, recent literature suggests large indicator bacteria populations are present in the bottom sediments and may or may not track with the pathogenic organisms.

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