Grazing and Debris Burning on Pinyon-Juniper sites—Some Chemical Water Quality Implications

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Highlight: *During 1973 and 1974 a water quality study was conducted in San Juan County, southeastern Utah. Water quality data were collected from the study location which had been chained to remove pinyon-juniper vegetation six years earlier. Debris burning and livestock grazing treatments were studied. An "undisturbed, natural" woodland was left adjacent to the treatments in order to serve as a control area.*

Following burning, significant increases in potassium and phosphorus were observed in overland flow from infiltrometer plots. No significant treatment changes were detected for sodium, calcium, or nitrate-nitrogen. No treatment differences due to grazing were detected at the soil surface following cattle use (stocking rate was 2 ha/AUM).

Pinyon-juniper vegetative type conversions have been made on millions of acres of semiarid rangeland. Chaining, a technique which mechanically uproots the trees with a large anchor chain suspended between two crawler tractors, is frequently employed. Double chaining, with debris-left-in-place, has been shown to be hydrologically sound in terms of infiltration rates and sediment production, at certain locations in the Southwest (Gifford et al., 1970).

While it is possible to establish good seeded grass stands by broadcast seeding, problems still exist with chained, debris-left-in-place vegetative type conversions. Rapid regrowth of the pinyon and juniper trees is common, access through the site by livestock may be impaired due to heavy accumulations of debris, and aesthetics of the area may be damaged since the skeletons of the chained trees remain on site for years.

With such considerations in mind, a study was designed to determine answers to some hydrologic and water quality questions associated with cattle grazing and burning chained pinyon-juniper debris several years after the chaining treatment on sites which support a good growth of crested wheatgrass.

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The objective of the study was to determine the impact of burning and grazing on the water quality parameters of phosphorus, potassium, sodium, calcium, and nitrate-nitrogen on sites which had been chained and then seeded to crested wheatgrass.

Site Description

The study is located near Coyote Flat, approximately 1 km west of Utah Highway 261, between Natural Bridges National Monument and Mexican Hat, Utah. The study area is located at an elevation of 2,150 m and is within the confines of the Colorado Plateau.

The soil at this location is derived from a sandstone parent material and extends to a depth of approximately 1.5 meters. The pH of the soil is slightly basic, averaging about 8.0. Organic matter content is low, slightly less than 2.0%. Soil texture is a sandy loam, with few rocks present (Gifford, 1973).

Methods

Primary treatment (chaining) was applied to the site in the fall of 1967. The original treatments involved double chaining with debris-left-in-place and chaining with debris windrowed. Both treatments were broadcast seeded at the rate of 9.1 kg/ha (8 lb/acre) to crested wheatgrass (*Agropyron cristatum*). The study area was then fenced to exclude livestock.

Secondary treatment using controlled burning was applied to the debris-in-place study area after the 1973 growing season was nearly over and a full season of "baseline" information had been collected from the area. However, antecedent rainfall had dampened the fuel and the fire did not carry well. Therefore, selected debris piles and open grassy sites were chosen randomly throughout the area and burned by hand on September 20, 1973. These "islands" of fire (void of vegetation) were subsequently used to conduct postburn experiments.

Subsequent regrowth on the grassy openings during 1974 restored that cover to 5 to 54% ($\bar{x}$ = 23.58%) total cover of which 1 to 19% ($\bar{x}$ = 6.11%) was litter, and 1 to 38% ($\bar{x}$ = 12.83%) was crested wheatgrass. Areas which had been previously occupied by large debris piles remained essentially bare throughout 1974.

During June 1974, six head of 2-year-old bulls and four mature cows (three with nursing calves) were allowed to graze on the debris-windrowed location for 2 weeks. The cattle were stocked in the area at the rate of 2 ha/AUM (about 55% forage utilization). This stocking rate parallels the stocking rates

which the local Bureau of Land Management officials attempt to attain on well-established crested wheatgrass seedings, according to Assistant Area Manager Ken Moore (1974, personal communication).

After the cattle were removed, the area was composed of 5 to 55% ($\bar{x}$ = 31.78%) total cover, of which 4 to 39% ($\bar{x}$ = 21.22%) was litter and 0 to 26% (x = 10.56%) was crested wheatgrass cover. This represents a vegetative production of approximately 319.4 lb/acre and a subsequent consumptive use of 177.1 lb/acre or 55.5% utilization.

A Rocky Mountain infiltrometer (Dortignac, 1951) was used to generate runoff from small, movable plots, each plot being 0.23 m^2 in size.

All plots were prewet prior to application of simulated rainfall in order to eliminate confounding effects of antecedent moisture. Artificial rainfall was then applied to the plots at a rate of approximately 7 cm per hour for 28 minutes. Both runoff and "rainfall" were collected initially after 3 minutes and, subsequently, at 5-minute intervals during the rainfall period.

Six samples per treatment area per treatment date were run. Two clusters of three plots were located at random within each of the observed areas (undisturbed woodland, chained with windrowing, and chained with debris-left-in-place). Each of the six observations were considered independent samples and were treated as such in all data analyses.

Water analysis of the runoff and "rainfall" water was made by standard certified laboratory analysis (Utah State University, Soils and Meteorology Department, Soil and Water Testing Laboratory). The water samples collected in the field were refrigerated and transported on ice between collection and delivery. At the laboratory the waters were examined to determine the concentrations of selected chemical elements. The laboratory analysis involved testing, by means of an atomic absorption device, for sodium (Na), calcium (Ca), potassium (K), and phosphorus (P). In addition to these certified analyses, field observations of nitrate-nitrogen were made on-site, employing a portable laboratory. Thus net changes due to soil nutrient losses were detected in the runoff water.

Results and Discussion

Phosphorus and Potassium

Runoff waters from simulated rainfall showed a significant increase of about 0.2 ppm phosphorus (P) following burning in the debris-in-place treatment. Although 0.2 ppm seems to be a small amount, this represents about a 400% increase in measured phosphorus levels (Fig. 1).

The increase in phosphorus is significant at the .05 level in terms of treatment and year. Apparently this 0.2 ppm increase is due to a "release" of the nutrient by burning. In particular, the large (two- to three-tree) P-J debris piles represent a large store of "tied-up" nutrients. Following the burn, the release of nutrients was apparently sufficient to cause a detectable increase of the element at the soil surface where it could be picked up by runoff waters.

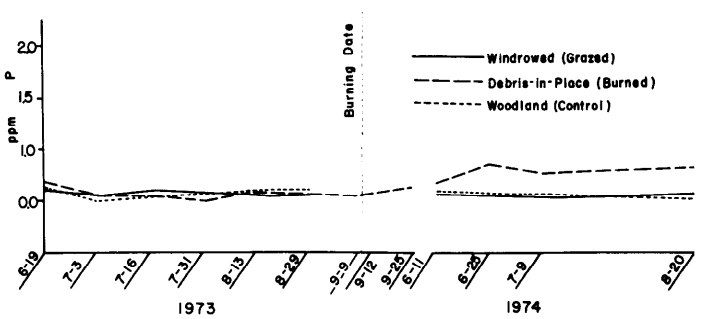

Fig. 1. *Mean net changes in ppm phosphorus. Samples collected from small plot infiltrometer runoff under several treatment conditions.*

A pattern of nutrient release similar to phosphorus was noted when analyzing for potassium (K) (Fig. 2). A significant, (four ppm) four-fold increase in potassium was observed under simulated rainfall following the secondary treatment of burning.

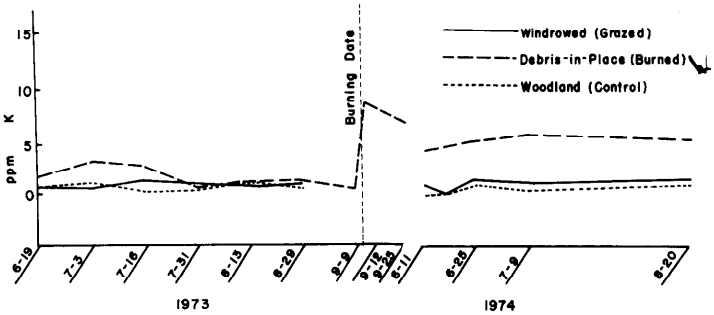

Fig. 2. *Mean net changes in ppm potassium. Samples collected from small plot infiltrometer runoff under several treatment conditions.*

The significant increase in potassium on the debris-in-place site persisted throughout the entire 1974 field season (a full year after the burn).

Apparently, potassium, as well as phosphorus, is "released" from the biomass as a result of burning. However, no significant changes in either element were noted following grazing.

Maximum permissible quantities of phosphorus and potassium are not listed by the Public Health Service (1962). Apparently there is no particular human health hazard directly associated with these two elements. However, they are both essential elements for plant growth and are frequently included as an integral part of commercial fertilizers. Herein lies the problem: fertilizer elements become undesirable in water supplies due to eutrophication. Eutrophication is a process of fertilization of water supplies, encouraging algae blooms and subsequent algal decay. While it is extremely doubtful that potentially troublesome volumes of these fertilizer elements would originate from this point source even if a hydrologic runoff event occurred, it is conceivable that a short term, localized problem could result from such a hydrologic event occurring on a large watershed that had been completely burned.

Sodium

A picture different from that of potassium and phosphorus is presented by the measured sodium (Na) values (Fig. 3). In this instance a significant yearly fluctuation was observed, but no differences between any treatments were demonstrated.

Calcium

The least definitive picture of the several elements observed was presented by the measured calcium values (Fig. 4). As was the case with the measured sodium values, calcium values showed significant yearly variations. However, no significant differences were noted following burning or grazing treatments. Extremely high natural variability among individual plots apparently accounts for the confusing pattern of calcium removed by runoff.

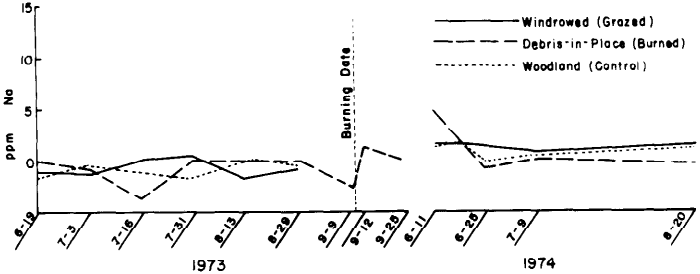

Fig. 3. *Mean net changes in ppm sodium. Samples collected from small plot infiltrometer runoff under several treatment conditions.*

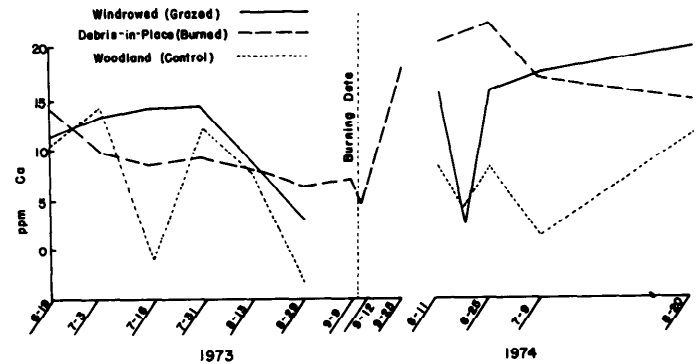

Fig. 4. *Mean net changes in ppm calcium. Samples collected from small plot infiltrometer runoff under several treatment conditions.*

Nitrate-nitrogen

Very low (< 0.3 ppm) nitrate-nitrogen levels were detected in the runoff waters. No significant differences were detected at the .05 level. It appears, therefore, that primary chaining treatments and the secondary treatments of grazing and burning produced no significant changes, detectable at the soil surface, toward the "release" of this element.

Conclusions

Grazing, at a stocking rate of 2 ha/AUM, apparently had little effect on the elemental components of phosphorus, potassium, calcium, sodium, or nitrate-nitrogen in the surface runoff waters following a simulated storm, since no significant changes attributable to the livestock were noted.

Season long, increased amounts of phosphorus and potassium were measured in runoff from simulated storms following burning on the chained with debris-left-in-place location. However, no significant (.05 level) changes were detected in calcium, sodium, or nitrate-nitrogen levels.

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