Range Forage Production Changes on a Water Spreader in Southeastern Montana[1]

F. A. BRANSON

Assistant Professor of Range Management, Montana State College, Bozeman, Montana

Range water spreaders are a well known means of improving forage production but quantitative studies of changes that occur due to the practice are rare. None of the studies reviewed contain information on changes one might expect in nutritive content of forage. The following is a report on chemical analyses, measurements of kinds of plants, yield determinations, and some costs and benefits on a water spreader near Alzada, Montana.

The most extensive study of the effects of diverting flood waters is that by Hubbell and Gardner (1944, 1950) at the Navajo Experiment Station in New Mexico. These authors conclude that water spreading is economically practicable. Forage yields were increased four times in a year of light flooding and nine times during a year of heavy flooding. The authors state that livestock preferred to graze the flooded areas and the forage species appeared to be more resistant to grazing pressure when they received the additional water.

The report by Hubbard and Smoliak (1953) is somewhat unique in that cost of construction is presented. The cost of construction of dikes 1.5 to 2 feet high was $0.36 per acre. Production on the flooded area was 3,770 pounds per acre, on the adjacent area the production was 110 pounds per acre or production was increased over 34 times.

Valentine (1947) reports that none of the five types of mechanical structures were effective in bringing about improvement of vegetation cover. Soil factors (apparently sandy soil) were thought responsible for the failure of these structures to bring about improvement.

Several authors (Semple and Allred, 1937; Monson, *et al.*, 1940; Miles, 1944, and Hubbard, 1949) have given estimates of forage increases varying from 100 to 400 per cent due to water spreading structures. Two Montana bulletins (Bingham and Monson, 1937; and Monson and Quesenberry, 1940) contain information on kinds of mechanical structures usable in flood irrigation.

Description of Area

The water spreader of the present study is located about 5 miles west of Alzada, Montana. The basin has low to moderate relief with maximum slopes of 2 to 3 per cent. It is underlain by the Belle Fourche shale member of the Ganerous formation of upper Cretaceous age, a dense thin-bodied marine shale. The flatter areas, particularly the area of spreading operations, are covered by an alluvial fill ranging up to 20 feet in thickness. Both the soil mantle and the alluvial fill are very fine textured and made up of weathered shale which breaks down to form a heavy clay and silt soil. Infiltration is slow and runoff is immediate and direct. Portions of the alluvial valley floor are devoid of vegetation. These spots are termed locally "clay slicks" (Rennick, 1953).

Formerly the valley floors were undissected, but during the past few decades a major gulley has developed that extends through almost the full length of the drainage basin. This gulley is 8 to 12 feet deep and 20 to 50 feet wide. A dam was built above the gulley and a long training dike extended to the head of the spreading system. The total acreage draining to the spreading system is about 1,060 acres. The spreading area studied covers about 275 acres giving a ratio of drainage area to spreading area of about 4 to 1.

The spreading dikes were designed to slow down the flow by forcing water to move back and forth through them (Fig. 1). The

Table 1. Average yields, in pounds per acre (oven-dry weights), on the water spreader and control areas. Data based on ten 9.6 sq. ft. samples.

Location	Plant Groups	1952	1953	1954	1955	Total	Ave.
Spreader	Grasses	513	724	1,133	1,102	3,472	868
	Forbs	4	132	10	69	215	54
	Shrubs	112	68	16	68	264	66
	Total	629	924	1,159	1,239	3,951	988
Control	Grasses	224	148	271	401	1,044	261
	Forbs	28	118*	16	64	226	56
	Shrubs	48	91	33	53	225	56
	Total	300	347	320	518	1,495	374
Annual precipitation (*ins.*) at Albion**		7.8	15.7	11.8	12.2		

*Annual sunflowers were abundant this year on the control.
**Approximately 15 miles from the study area.

[1]*This has been a cooperative study by the Bureau of Land Managment, U. S. Geological Survey, and the Montana Agricultural Experiment Station. The assistance of personnel of the first two listed agencies is gratefully acknowledged.*

Contribution from Montana State College, Agricultural Experiment Station. Paper No. 383 Journal Series.

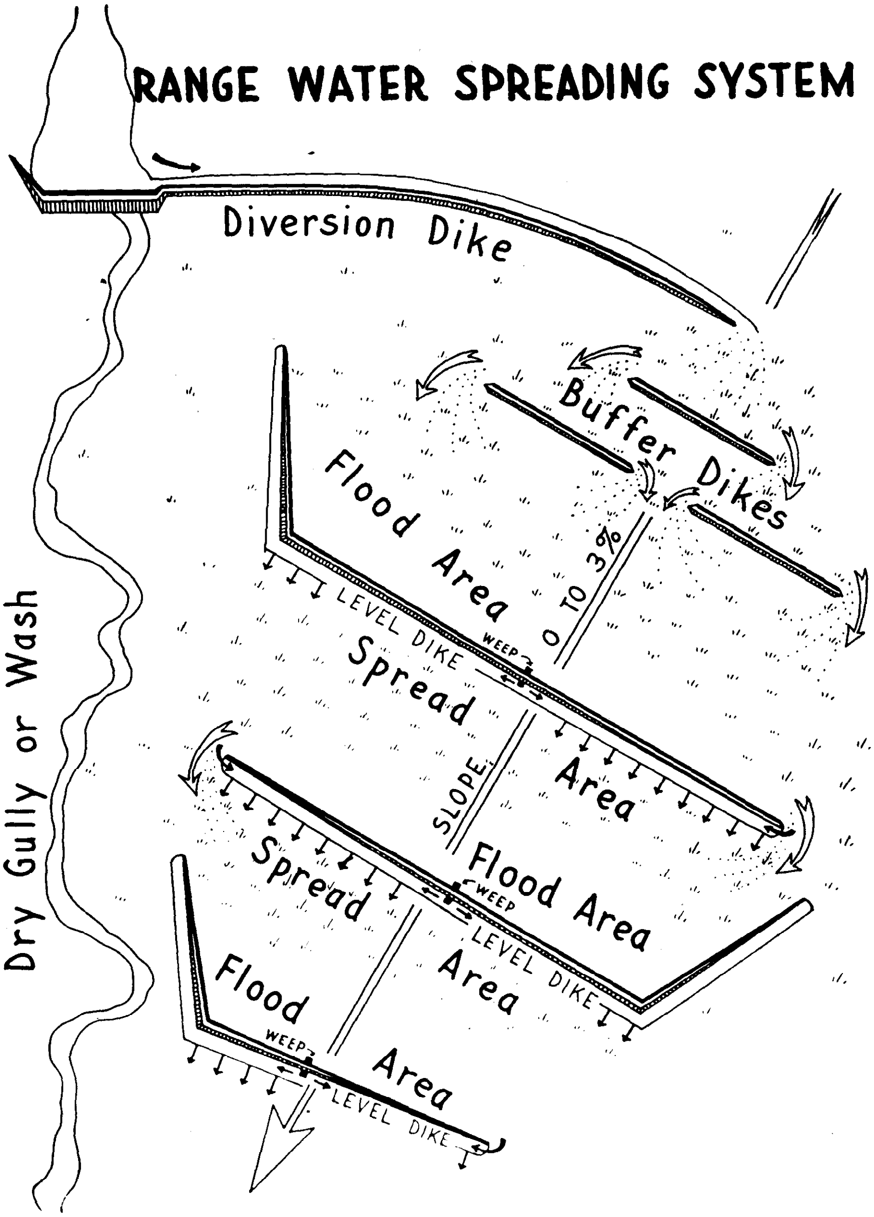

Figure 1. Diagram of a water spreader similar to that studied.

dikes were placed on contour so flow occurred only when there was sufficient head built up behind the dike to cause flow toward the open end. Alternate opposite ends of dikes were tied to higher ground on each side of the spreading area, the opposite end being left open to permit flow.

The dikes at the upper end of the spreader were about 3 feet high with side slopes of about 2 to 1. The remaining dikes were 2 feet in height. The original construction costs for several similar structures in the area (1948-1950) was $5 to $6.55 per acre. Construction costs for the water spreader studied were $9.96 per acre (1949-1950) which includes the cost of seeding dikes with crested wheatgrass and sweet clover. Pierson (1955) has indicated that costs for similar systems have varied from $1 to as high as $20 per acre, depending on the complexity of the system and the amount of construction involved. Cost of maintenance has varied from almost nothing on some spreaders to $6.55 (1950 through 1955) per acre on the water spreader of this study.

Methods

Permanent 50-foot transects wer established at random on the con trols and spreader. A modificatio of the Canfield (1950) line inter ception method was used. Basa intercept measurements were i millimeters. Crown intercepts o shrubs and forbs were measure separately and were tabulated sep arately. Only basal intercept meas urements of grasses, forbs, an shrubs were used in computin botanical composition.

Twenty-five transects were use to sample the control areas estab lished above and below the wate spreader so as to provide for th obvious transition in soil condi tions in the upper and lower por tions of the spreader. Samplin units were stratified within th spreader system: 23 transects wer placed between dikes, 9 acros dikes and 9 across borrow pits.

Forage yields were obtained fro 20 portable exclosures in 195 when cattle and sheep grazed du ing the growing season. Durin the following four years no ex closures were used since sheep di not graze the area until Septem ber 1.

Forbs, shrubs and grasses wer clipped separately from twent 9.6-sq. ft. plots, ten from the con trols and ten from the spreade Yield determinations were mad yearly on the basis of oven dr weight.

Composite forage samples wer collected during the summe months. Six samples were obtaine from the controls and six from th spreader at intervals of three week during 1955. Fewer samples wer collected in earlier years. Sample were analyzed for protein, phos phorus, calcium, and moisture.

Results and Discussion

In measuring differences tha might be present on the wate spreader and controls, it was as sumed that the total area betwee dikes would be benefited. This as sumption was incorrect in tha flood waters did not reach th lower dikes during any of th

Table 2. Basal area, shrub and forb aerial cover on the water spreader, control, dikes and borrow pits in 1951 and 1955. Percent composition was computed from basal area measurements made by the line interception method.

Species	Spreader		Control		Dikes		Borrow pits	
	1951	1955	1951	1955	1951	1955	1951	1955
	% cover							
Basal area	1.1	2.0	1.2	1.5	0.2	1.8	0.1	2.3
Shrub aerial cover	9.4	5.9	8.2	9.6	–	–	–	0.2
Forb aerial cover	–	–	–	–	7.8	25.2	5.2	4.7
	% composition							
Streambank wheatgrass (*Agropyron riparium*)	46.3	49.9	55.1	46.6	–	18.2	–	3.7
Western wheatgrass (*A. smithii*)	31.6	12.1	9.0	2.6	39.9	36.5	33.3	46.9
Sandberg bluegrass (*Poa secunda*)	5.3	21.7	0.8	13.5	–	–	–	–
Foxtail barley (*Hordeum jubatum*)	0.3	8.1	–	–	–	40.0	–	47.7
Crested wheatgrass (*A. cristatum*)	–	–	–	–	–	1.8	–	–
Tumblegrass (*Schedonnardus paniculatus*)	1.3	2.4	–	1.1	–	3.5	–	–
Prairie junegrass (*Koeleria cristata*)	–	–	1.2	2.3	–	–	–	–
Dooryard knotweed (*Polygonum aviculare*)	–	–	–	0.2	–	–	33.3	–
Pricklypear cactus (*Opuntia polyacantha*)	10.1	3.4	20.9	14.6	–	–	–	–
Nuttall monolepis (*Monolepis nuttlallianus*)	–	–	–	0.3	–	–	33.3	–
Plains bahia (*Bahia oppositifolia*)	1.1	0.4	–	0.2	–	–	–	–
Yellowblossom sweetclover (*Melilotus officinale*)	–	0.2	0.2	–	38.7	–	–	–
Stonecrop (*Sedum sp.*)	–	–	–	1.8	–	–	–	–
Hymenoxys (*Hymenoxys sp.*)	–	–	2.0	2.2	–	–	–	–
Hood's phlox (*Phlox hoodii*)	–	–	5.5	3.4	–	–	–	–
Big sagebrush (*Aremisia tridentata*)	2.6	0.6	2.8	9.2	20.0	–	–	–
Other species	1.4	1.2	2.5	2.0	1.4	–	–	1.7

years of study. However, observations indicated that the lower portion was benefited to some extent by holding snow and rain and in holding runoff from adjacent slopes. Production was much greater on flooded areas than on non-flooded portions of the water spreader.

Forage Yields

Yields on the spreader were about 2.6 times greater on the water spreader than on the controls (Table 1). The average total yield on the spreader was 988 pounds per acre while that of the controls was 374 pounds. In general, forbs and shrubs contributed a smaller proportion of the yield on the spreader than on the controls. Although flooding killed much of the big sagebrush on the spreader, light flooding apparently stimulated its production. The average yield of this shrub was slightly greater on the spreader than on the controls.

Yields on the controls followed the trends in annual precipitation quite closely except in 1955. Although yields on the spreader were somewhat related to annual precipitation, there was a consistent increase in production not accounted for by variation in precipitation. It is possible that improved infiltration rate due to increased vegetation accounted for this continued rise in forage production.

Vegetational Changes

Vegetational measurements in 1951 show some interesting contrasts when compared to 1955 measurements (Table 2). The basal area increased on the controls and on the water spreader. Basal area almost doubled on the spreader and increased slightly on the controls. On the dikes basal area increased about nine times and on borrow pits was about 23 times greater in 1955 than in 1951. Aerial cover of shrubs, primarily big sagebrush, decreased on the spreader but increased slightly on the controls. The most abundant grasses on the spreader and controls were streambank wheatgrass and western wheatgrass. These species are difficult to differentiate in the field, but it is believed that the proportions listed are nearly correct. Sandberg bluegrass increased in basal area on the controls and on the spreader. Foxtail barley increased on the spreader and on dikes and borrow pits. This increase was especially

Table 3. Chemical analyses of soil samples from water spreader and control.

Location	Soil Depth	Salt Concentration $(K_x 10^3)$*	pH**	Organic Matter	Total Extractable Calcium	Phosphorus (CO_2 soluble)
	ins.			*%*	*mg./gm.*	*ppm.*
Control	0-6	5.0	7.3	1.73	9.10	2.0
	6-12	5.8	7.4	1.38	7.36	2.0
	12-24	5.8	7.4	1.34	11.16	2.0
Spreader	0-6	1.4	7.7	1.97	6.92	4.5
	6-12	1.4	7.8	1.94	5.96	3.4
	12-24	5.4	7.7	1.73	6.60	2.0

*Determined on saturated soil extract.
**Determined on saturated soil paste.

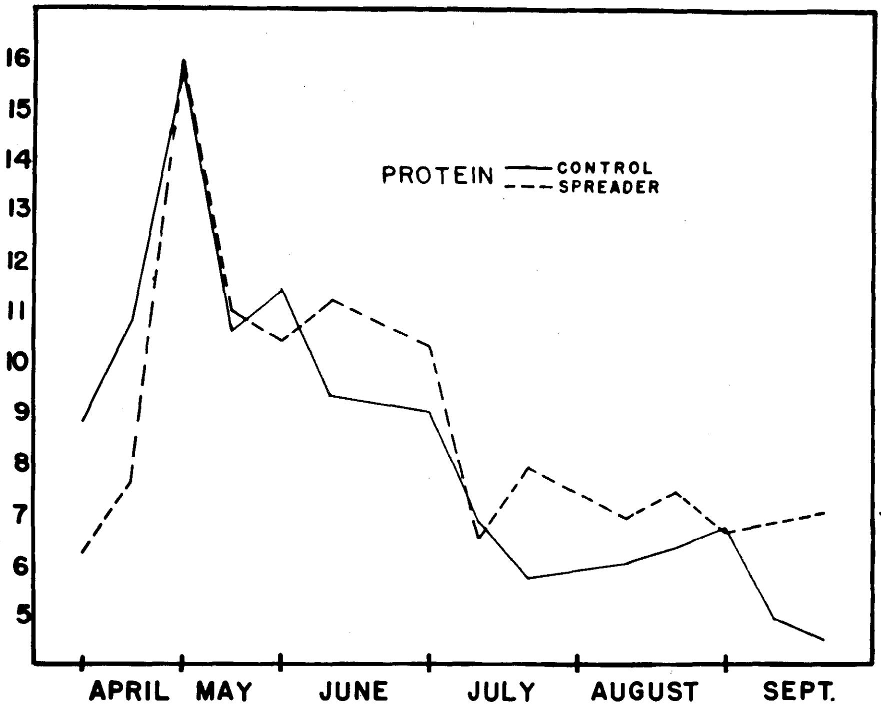

FIGURE 2. Protein content of forage samples from the water spreader and control, based on samples taken from 1952-1955.

noticeable on areas flooded for long periods of time. Pricklypear cactus decreased on both spreader and controls with the greatest decrease being on the spreader. Big sagebrush showed a marked decrease in aerial cover on the water spreader but increased on the controls.

Chemical Analyses of Forage Plants

Chemical analyses of forage samples show that generally the nutrient content of plants on the water spreader was higher than that of plants on the controls (Figures 2 and 3). The protein content of samples from the water spreader was almost three per cent lower than that found in control plants in early spring. However, throughout most of the summer, plants on the spreader contained more protein than plants on the controls (Fig. 2). The low protein content in early April on the spreader may have been due to greater quantity of previous year's growth included in the samples. No attempt was made to separate old from new growth since the major objective was to determine the nutrient content of forage that would be consumed by grazing animals.

Both phosphorus and calcium were generally higher in samples from the water spreader than in samples from the controls (Fig. 3). The calcium content of all samples was in excess of the minimum requirement of 0.20 proposed by the National Research Council (1945, 1949). Phosphorus content was above the National Research Council minimum requirement (0.18 for cattle) during late April, May, June, part of July, and again in August. Selective grazing by livestock and some storage of phosphorus by animals would lengthen this period of adequate phosphorus.

Soil Analyses

Soil samples from the water spreader and controls were obtained in 1951 during the second year of operation of the spreader (Table 3). Soils from the controls contained a higher concentration of salts but were less basic than soils from the spreader. Apparently some of the salts from the controls contained anions of strong acids such as chlorides or sulfates. The salt content is slightly below the limit that would favor salt tolerant plants (halophytes) over other plants common in the region. The pH of the soils so nearly approached the neutral point that neither the acid range nor basic range would materially affect kinds of plants found on the area. Organic matter content was slightly greater in water spreader soils than in soils from the controls. On both areas the amount of organic matter was slightly less than would be optimum for plant growth under the climatic conditions present. Calcium was present in larger amounts in soils of the controls than on the spreader. In both areas the calcium content of the soils probably exceeded the minimum requirements for optimum plant growth. Available phosphorus was slightly more abundant in soils from the water spreader. From these analyses it may be concluded that soils on the water

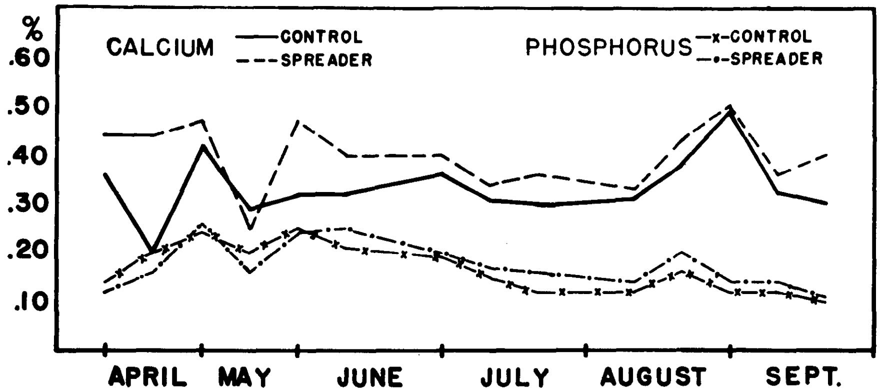

FIGURE 3. Calcium and phosphorus contents of forage from the water spreader and control, based on samples taken from 1952-1955.

spreader provided a slightly more favorable site for plant growth than soils of the controls.

Summary

Yields, vegetational changes, and chemical composition of plants and soils were studied on a water spreader in southeastern Montana. Yields were 2.6 times greater on the water spreader than on the controls. Basal area increased considerably on the water spreader, on dikes, and in borrow pits. The most striking vegetational changes on the spreader were a decrease in aerial and basal cover of big sagebrush and pricklypear cactus and an increase in foxtail barley.

In general, the protein, phosphorus and calcium contents of plants from the water spreader were higher than in plants from the controls.

Soil analyses indicated that the water spreader was a slightly more favorable site for plant growth than were the controls.

LITERATURE CITED

Bingham, G. H. and O. W. Monson. 1937. Flood irrigation. Montana Agr. Expt. Sta. Circ. 84.

Canfield, R. H. 1940. Sampling ranges by the line interception method. Southwestern Forest and Range Expt. Sta. Res. Rept. 4.

Hubbard, W. A. and S. Smoliak. 1953. Effect of contour dykes and furrows on short-grass prairie. Jour. Range Mangt. 6: 55-62.

Hubbell, D. S. and J. L. Gardner. 1944. Some edaphic and ecological effects of water spreading on range lands. Ecology 25: 27-44.

——— and ———. 1950. Effects of diverting sediment-laden runoff from arroyos to range and crop lands. U.S.D.A. Tech. Bull. 1012.

Miles, W. H. 1944. Water spreading. Soil Conservation 10: 73-76.

Monson, O. W. and J. R. Quesenberry. 1940. Range improvement through conservation of flood waters. Montana Agr. Expt. Sta. Bull. 380.

Pierson, R. K. 1955. Range water spreading as a range improvement practice. Jour. Range Mangt. 8: 155-158.

Rennick, K. 1952. Progress report on results of water spreading. North Creek spreading area near Alzada, Montana. Unpubl. rept., U. S. Geol. Surv.

Semple, A. T. and B. W. Allred. 1937. Range improvement by water spreading. Soil Conservation 2: 269-270.

Valentine, K. A. 1947. Effect of water-retaining and water spreading structures in revegetating semi-desert range land. New Mexico Agr. Expt. Sta. Bull. 341.

Water Infiltration Studies on the Bighorn National Forest, Wyoming

Abstract of thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, in the Sub-department of Range Management, University of Wyoming, Laramie, Wyoming, May, 1956.

Some of the more important factors affecting the intake of water are present and past vegetational cover, characteristics of the soil, and present management. The vegetation on rangelands and to some degree the characteristics of a soil are determined primarily by climate, but may be altered by livestock management.

Infiltration studies were conducted using a mobile raindrop applicator, designed by the former Soil Conservation Service Research Division at Fort Worth, Texas, in 1949. These tests were conducted over a three year period on four experimental pastures (two pastures heavily utilized and two pastures lightly utilized) located in the Bighorn National Forest, in North Central Wyoming. The objective of the study was to determine the infiltration rate on major grazing sites within the experimental pastures as influenced by the degree of utilization and different types and quantities of vegetation present.

During the summer of 1954, water-intake studies were conducted on two soil types, namely: Owen Creek silt loam (sedimentary) and Burgess fine gravelly loam (granitic). Under light use the amount of vegetation present on both the granitic and sedimentary soil was almost identical, although vegetational composition differed.

At the time of the test, the amount of standing vegetation present on the granitic soil under heavy utilization was 787 pounds or 36 percent less than on the heavily used pastures on the sedimentary soil. This difference is statistically significant at the .05 percent level.

Within a soil type during the second 30-minute period of the one-hour test, the lightly used pasture had a statistically significant higher water-intake rate than did the heavily used pasture. There were no significant differences in water-intake rates between soil types.

During the summers of 1953 and 1955 water intake studies were conducted on the Owen Creek silt loam soil on the heavily and lightly used pastures. When the amount of standing vegetation present at the time of testing was averaged for the two years (1953 and 1955) on the lightly and heavily used pastures, a difference of 1,106 pounds per acre was found in favor of the lightly used pastures. This was a difference of 34 percent and is statistically significant at the .05 percent level.

An average of water-intake rate for the two years (1953 and 1955) on the heavily used pastures on the sedimentary soils was 1.04 inches per hour, whereas that for the lightly used pastures was 1.41 inches per hour. A difference of 0.36 inches per hour more water-intake was noted for the lightly used pasture over the two year period. This difference was statistically significant.—*Frank Rauzi*, Agricultural Research Service, University of Wyoming, Laramie, Wyoming.