Effects of Water Spreading on Range Vegetation in Eastern Montana[1]

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Water spreading is a recognized means of improving forage quality and production on much of the dry range lands of western United States. Despite increasing use of this practice, little is known of the quantitative changes in range vegetation that occur. This paper reports changes in vegetation production, growth, and composition on a water-spreading system near Miles City, Montana, in approximately the geographical center of the Northern Great Plains range area.

Water spreading is a crude form of irrigation which usually entails diversion of intermittent channel flow over adjacent floodplains with a minimum of control. It was probably the first form of irrigation used by man. Spreading systems have been in use in the Northern Great Plains probably since the arrival of the earliest settlers. These systems are still used on some Indian lands in southwestern United States in much the same form as several hundred years ago.

Perhaps the most detailed study of the effects of water spreading in the Northern Great Plains was that of Branson (1956) made not far from the area described here. Branson indicated that herbage yields were increased an average of 160 percent. Total basal ground cover of vegetation was increased in all parts of the system. The major compositional changes observed were a decrease in big sagebrush *(Artemisia tridentata)* and plains pricklypear *(Opuntia polyacantha)* and an increase in foxtail barley *(Hordeum jubatum)*. Branson also indicated that the plant constituents of protein, phosphorus, and calcium were increased.

In an intensive study of water spreading in New Mexico, Hubbell and Gardner (1944) concluded that herbage yields were increased 4 to 9 times. The amount of increase was dependent on the duration of flooding. They found that silting reduced production in some areas near the head of the system. They also indicated that vegetation on the irrigated area seemed more resistant to grazing and that livestock grazed the flooded areas more intensively.

In studies conducted by Hubbard and Smoliak (1953) increases in herbage production due to water spreading as high as 3400 percent were indicated.

Effects of soil characteristics must be considered in any water-spreading system. Valentine (1947) found that on some soils —in this case sandy soils—there was no improvement in vegetation from water spreading. Additional factors that should be considered are area, slope, soil depth, amount and kinds of soil salts, size and slope of watershed area, expected storm intensities, and quality of the runoff water.

Several studies have given construction costs of water-spreading systems. Hubbard and Smoliak (1953) showed cost of construction of dikes 1.5 to 2 feet high as $0.36 per acre. In their most recent report Monson and Quesenberry (1958) gave construction costs of the system herein described with dikes 2 to 2.5 feet high as $1.38 per acre. Costs depend primarily on slope and acreage involved.

Two sources of information on the many technical considerations in water spreading and on types of structures are Pierson (1955) and Monson and Quesenberry (1958).

Description of Study Area

The water-spreading system described herein was established in 1951 near the northern boundary of the U. S. Range Livestock Experiment Station about 6 miles west of Miles City, Montana. It is on the north side of the Yellowstone River with drainage generally from north to south. The soils range from clays and clay loams on the west and south, to sandy loam near the upper center, to slightly saline clay on the upper east portion of the spreading system.

Vegetation is typical of the drier portion of the Northern Great Plains region. The dominants are blue grama grass *(Bouteloua gracilis)* and western wheatgrass *(Agropyron smithii)*, with small amounts of foxtail barley, buffalo grass *(Buchloe dactyloides)*, and Sandberg bluegrass *(Poa secunda)*. Other species present are Hood's phlox *(Phlox hoodii)*, scarlet globemallow *(Sphaeralcea coccinea)*, and in the northeast portion of the system an abundant stand of black greasewood *(Sarcobatus vermiculatus)*.

The weather and climate of the study area are typical of a large portion of the Northern Great Plains. Approximately 75 percent of the total precipitation comes during the growing season—April 1 to September 30—and 45 percent during spring—

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[1] *Study initiated by the former Northern Rocky Mountain (now Intermountain) Forest and Range Experiment Station, U. S. Forest Service, Missoula, Montana. Conducted in cooperation with Animal Husbandry Research Division, Agricultural Research Service, U. S. Department of Agriculture.*

April 1 to June 30. The 82-year average annual precipitation recorded at Miles City is 12.90 inches.

During the study period precipitation was generally low. Annual and growing season totals were below normal in 1952, 1954, 1956, 1958, and 1959. Approximately normal precipitation was recorded in 1951, 1953, 1955, and 1957.

Details of dike construction, drainage, contour interval and spacing, and acreage were ably described by Monson and Quesenberry in their 1958 report.

Method of Study

Permanent transects were established on five sites in 1951 at the time of construction (Figure 1). Three sites were established near the western side on clayey soils dominated by western wheatgrass. Site 1—used as a control—was located at the west end of the system above the first dike on a slight rise of land. Site 2 was located farther east below but near dike number 2. Water drained over this area before being ponded above dike 3, but water was never ponded on site 2. Site 3 was placed below site 2 and above dike number 3. Water was intermittently ponded on site 3 for various periods depending on the amount and duration of flow.

Two sites were established near the upper east center of the system on sandy loam soil dominated by blue grama grass. Here site 4—also used as a control—was located above the first dike on a slight slope. Site 5 was located south of site 4 approximately midway between dikes 2 and 3. Water was not ponded on site 5 except possibly during intense flooding.

At each site three parallel, 50-foot transects were established, and the ends permanently marked. During July of 1951, 1953, 1955, 1957 and 1959 observations of ground cover and vegetation species were recorded at 6-inch intervals along a steel tape stretched over each transect. An offset, wire loop of ¾-inch diameter was plumbed to ground level. A hit was recorded on litter if any litter was present on the plot. A hit on a plant species was recorded if any portion of the plant base was within the plot.

At each sampling date approximately 50 maximum plant heights of western wheatgrass including leaf length were measured at each site. In 1955, 1957 and 1959 herbage production was determined at each site. Production of shrubs and pricklypear was not included.

FIGURE 1. Aerial view of Sadie Bottom waterspreading system. Numbers show location of experimental sites. Photographed in spring of 1953 shortly after system was flooded. Light areas indicate standing water.

Results

Herbage Yields

The effects of water spreading on herbage yield were very marked during all years these observations were recorded (Table 1). There were also substantial differences between areas and between two flooding durations.

On the western wheatgrass sites considerable differences in average herbage production were evident between the control and the two flooding durations. The flooded site produced 38 percent more than the control in 1955, 97 percent more in 1957, and 77 percent more in 1959. The ponded site produced 227 percent more than the control in 1955, 163 percent more in 1957, and 120 percent more in 1959. The average production increase on the two sites was 62 percent and 189 percent, respectively, for the three sample years.

It is evident that on these clayey soils dominated by western wheatgrass, duration of flooding strongly influenced production. It is also apparent that productivity varies greatly between parts of the system on this site even near the upper part where flooding occurs most often.

On the blue grama grass sites the flooded area produced 648 percent more herbage than the control in 1955, 162 percent more in 1957, and 133 percent more in 1959, an average increase of 353 percent.

The average production increase on this area was considerably more than on the western wheatgrass site except in 1959. In that year relative production increases on the blue grama and western wheatgrass ponded site were almost equal.

Western Wheatgrass Heights

The height of western wheatgrass plants also differed sub-

Table 1. Total herbage production per acre (air-dry) on five sites under water spreading

	Site	1955	1957	1959	Average	Relative production
		Pounds				Percent
Western wheatgrass—control	1	1031	591	351	658	100
Western wheatgrass—flooded	2	1424	1162	620	1069	162
Western wheatgrass—ponded	3	3374	1556	773	1901	289
Blue grama grass—control	4	1026	1206	325	852	100
Blue grama grass—flooded	5	7672	3155	757	3861	453

stantially between areas and with duration of flooding (Table 2).

On the two blue grama grass sites, average maximum plant heights were approximately equal in 1951. By 1953 they had increased on both sites but were considerably greater on the flooded site. This difference remained about the same through 1959.

Table 2. Average maximum heights of western wheatgrass on five sites under water spreading

Site	1951	1953	1955	1957	1959
			Centimeters		
1	13.2	27.3	26.1	17.8	15.8
2	14.7	22.6	20.9	17.2	16.8
3	18.0	32.2	32.5	24.3	20.1
4	11.2	25.2	24.0	18.9	15.7
5	12.5	54.9	51.0	30.2	27.0

On the western wheatgrass area differences in average maximum heights of western wheatgrass were not consistent. Plant heights increased in a similar manner on the control and ponded sites in 1953 and 1955 and then decreased similarly in 1957 and 1959. However, average plant heights were distinctly greater on the ponded site than on the control throughout the period. Plant heights remained at a fairly constant level throughout the study period on the flooded site, with average plant heights at a lower level than the control in both 1953 and 1955.

Litter Cover

The effect of water spreading on litter cover was more noticeable at the blue grama sites than at the western wheatgrass sites despite wide fluctuations on both (Table 3). On the blue grama area in both 1951 and 1953 there was more litter cover with the control treatment. After 1953, however, the greatest litter cover was present on the flooded area.

On the western wheatgrass sites there were no consistent differences in litter cover between the treatments. In 1951 at the time of establishment there was considerable variation between sites with the greatest litter cover on the flooded site and the least on the ponded. The differences between sites narrowed after that date, and by 1959 litter cover was practically identical regardless of treatment.

Table 3. Ground cover on five sites under water spreading. Percent of total hits based on an adaptation of loop-plot method.

Cover	Site	1951	1953	1955	1957	1959
Litter						
	1	56	74	42	81	65
	2	61	86	43	72	72
	3	21	70	53	75	70
	4	48	67	17	57	44
	5	38	56	29	65	63
Plant						
	1	22	11	25	12	27
	2	23	14	27	19	26
	3	23	22	36	19	29
	4	33	33	66	42	52
	5	37	33	60	33	34

Live-Plant Cover

The amount of live-plant cover was also apparently more influenced by the water spreading at the blue grama area than at the western wheatgrass area (Table 3). In 1951 there was more vegetation cover on the flooded blue grama site than on the control. In 1953 there was about the same amount on each site. However, after that date the greater amount was on the control treatment despite wide fluctuations evident on both.

On the western wheatgrass sites there were no consistent differences or trends in plant cover between treatments. In 1957 the control area was sparsely covered compared to the other areas. In 1953 and 1955 there was more plant cover on the ponded site than on the other two.

Plant Composition

The change in plant composition on the blue grama area was very pronounced (Table 4). In 1951 the vegetation was 5 percent western wheatgrass and 90 percent blue grama grass. Flooding almost reversed these proportions by 1955. Between 1955 and 1959 vegetation composition on this flooded area remained essentially constant at about 20 percent blue grama and 70 percent western wheatgrass. On the

Table 4. Plant composition on five sites under water spreading. Based on an adaptation of the loop-plot method

Site	1951 Asm[1]	1951 Bgr[2]	1953 Asm	1953 Bgr	1955 Asm	1955 Bgr	1957 Asm	1957 Bgr	1959 Asm	1959 Bgr
					(Percent)					
1	77	17	65	29	69	28	44	56	62	34
2	97	....	98	....	91	....	98	....	90	....
3	99	....	100	....	100	....	100	....	94	....
4	8	83	6	92	6	89	9	88	7	90
5	5	91	26	74	74	22	67	27	76	19

[1]Western wheatgrass.
[2]Blue grama grass.

control site, plant composition remained relatively constant at less than 10 percent western wheatgrass and about 90 percent blue grama grass.

Changes in plant composition on the western wheatgrass sites were not as great during the 8-year period (Table 4). Both flooded sites were practically pure western wheatgrass in the beginning and remained so. Blue grama was not present at any time on these areas. On the western wheatgrass control area there was an increase in the proportion of blue grama and an equal reduction in the amount of western wheatgrass from 1951 through 1957. From 1957 to 1959 there was a reversal of this trend. The reason for this is not known, but it is doubted that establishment of the diking system affected moisture on the control site.

Other species such as Sandberg bluegrass, foxtail barley, silver sagebrush *(Artemisia cana)*, scarlet globemallow, and buffalo grass never amounted to over 10 percent of the total vegetation and were usually less.

Discussion

Waterspreading increased total herbage production, generally increased plant heights, and favored increased composition of western wheatgrass. It is also evident that, at least on areas of clayey soils dominated by western wheatgrass, the trend toward increased production and plant height was influenced by the duration of flooding.

The change from blue grama to western wheatgrass domination on blue grama flooded sites was not observed by Branson (1956). It was, however, noted by Hubbard and Smoliak (1953). It is possible that Branson's study area did not include a comparable site. Some increases in foxtail barley and squirrel tail *(Sitanion sp.)* were observed over the system but not on the study sites. This agrees with part of Branson's findings.

Costs and Returns

The economics of water spreading are difficult to isolate. Costs vary enormously—from the $0.36 per acre reported by Hubbard and Smoliak (1953) to $25 or $30 per acre on small, isolated areas. Returns may be calculated from the increases in herbage production. However, long-time average increases are needed. On much of the highly erosive soils of the Northern Great Plains, silting becomes a problem in the water-spreading systems and may reduce the effective duration of the systems.

Only in 1953 and 1955 did water flow through the entire system described here. Although the system covered 1200 acres, probably only 900 acres or less received additional moisture during most years. Average herbage production increases were at a maximum near the head of the system but low on other portions of the 900 acre area. A realistic appraisal of average overall herbage increase would suggest something on the order of 150-200 percent, somewhat less than the 240 percent average increase indicated by the experimental data.

Establishment cost of the Sadie Flat spreading system was indicated by Monson and Quesenberry (1958) as $1649. Including later repair costs of $465 and prorating this over only 900 acres would indicate total cost per acre to date of $2.35 or $0.29 per acre per year. Gross return per acre per year of ordinary rangeland in eastern Montana is conservatively estimated at $1.50. For an average yearly expenditure of $0.29 per acre for a water spreading system, a gross return of $2.25 to $3.00 per acre could be obtained on the basis of increased herbage production alone. Or for an average annual expenditure of approximately 2 percent of the purchase price of more range land, productivity of the acreage in this system was approximately tripled.

The effects of water spreading on possible earlier grazing, higher permissible utilization, probably better responses to fertilization and seedings of more productive species, sediment retardation, restoration of ground water levels, reduction of channel erosion, and use of diverted water for stock watering are not considered. Conservation payments would reduce costs below the figures given here.

Because of the many factors of plant cover, soil, size of area and watershed, slope and quantity and quality of water supply which affect the feasibility, economics, and duration of waterspreading systems, it is recommended that technical advice be obtained prior to construction. The U. S. Soil Conservation Service and State Agriculture Extension personnel can provide technical assistance.

Summary

A study of vegetational changes on a range water-spreading system near Miles City, Montana, was made between 1951 and 1959. On a western wheatgrass dominated area of clayey soils two durations of water spreading were studied. Only one duration was studied on a blue grama grass dominated area of sandy loam soil.

Vegetation composition and cover were sampled by an adaptation of the loop-plot method. Heights of western wheatgrass and herbage production were determined.

From 1955 to 1959 herbage production was increased on the western wheatgrass area an average of 62 percent by flooding and 189 percent by temporarily ponding water. On the blue grama area average production was increased 353 percent by flooding. Production on all sites varied greatly between years.

Average heights of western wheatgrass plants were considerably increased by flooding on the blue grama area. Water spreading had little consistent effect on heights on the western wheatgrass area.

Litter cover on the blue grama area was slightly increased by flooding. There was no noticeable effect of water spreading on litter cover at the western wheatgrass area.

At the blue grama area flooding gradually reduced live-plant cover, but at the western wheatgrass area water spreading had little effect on plant cover.

At the blue grama area flooding almost reversed the proportions of blue grama grass and western wheatgrass, while on the control the far greater composition of blue grama grass remained unchanged. At the western wheatgrass area flooding caused no change in species proportions. However, on the control site the vegetation changed from predominantly western wheatgrass to an approximately equal mixture of western wheatgrass and blue grama grass.

Annual gross return per acre was probably seven to ten times the annual costs of the system per acre.

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RETIRED PROFESSORS' REGISTRY

A few years ago members of the Division of Biology and Agriculture, National Research Council, National Academy of Sciences, were interested in what was being done or ought to be done to help biologists who after mandatory retirement were able and willing to work. With the help of a grant from the Ford Foundation, these Associations set up an office at 1785 Massachusetts Ave., N. W., Washington, D. C., called the Retired Professors' Registry, under the direction of Dr. Louis D. Corson. The Registry was established in November 1957. Actually, the Registry does not limit its assistance to college and university personnel nor to those who want academic employment, though these are in the majority. Both civilian and military retirees from government or industry may register if they are qualified to teach or engage in other scholarly activities.

The Registry now has nearly 800 registrants about half of whom are employed. The Registry sends to inquiring institutions copies of all information provided by the registrants, and negotiations for employment are carried out between the interested institution and the registrant. The Registry makes no charge for its services.

Registrants are divided into five principal professional areas: administration, humanities, social sciences, biological sciences, and physical sciences. Dr. Corson says that the demand for registrants in the biological and physical sciences, now exceeds the supply. In the first list of registrants only 51 were listed in the biological sciences, 14 of these in psychology. Some were well over 70, and these, Dr. Corson finds, are hard to place. It is interesting and encouraging to know that retirees in the biological sciences are wanted in larger numbers than can be supplied by the Registry.