Effect of Contour Dykes and Furrows on Short-Grass Prairie

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Introduction

EARLY in the establishment of the Range Experiment Station at Manyberries, in southeastern Alberta, it was realized that moisture was the limiting factor of range forage production. Even though precipitation there is low and evapo-transpiration high, the spring run-off is heavy. One method of reducing moisture losses was the spreading of run-off by the use of earth structures. Accordingly, following a survey of work done in western and southwestern United States (Bailey and Croft, 1937; McCorkle and Dale, 1941; Miles and Bradford, 1943), several experimental projects in terracing, contour furrowing, and spring flooding structures were established in 1937. The effect of water-spreading devices has been assessed by measuring plant succession and changes of forage yield over a period of twelve years.

Review of Literature

Contour furrows and dykes are not new. Contour furrows were used successfully in South Africa as early as 1876, and in Texas in the 1880's on grassland, since plowed for wheat production (Bennett, 1939). Bennett also states that, "the contouring of range lands has proved a very beneficial practice."

Barnes (1948), working in Wyoming, states: "it was found that only furrows or structures placed at close intervals were of any general value in improving range production. Furrows placed at intervals of 10 feet or more made little or no difference in production. At intervals of 2 to 8 feet significant improvement in the forage production resulted."

In tests on range land in Texas, Langley and Fisher (1939), using a lister showed grass yield to increase as much as 3.9 times as a result of increased soil moisture and depth of penetration. Native grass increased in both ground cover and production.

Appraisal of the tangible economic aspects of water spreading was made at Alzada, Montana. Spreading water on 760 of the 980 acres in the project brought about an increase in carrying capacity of 3.5 times. The literature indicates that the success of any water-spreading project depends upon the kind of structure and the edaphic and climatic factors of the area.

Soil and Climate

The greater part of the region represented by the Station is from flat to gently rolling. In places the prairie is deeply cut by coulees, steep-banked eroded water courses which are dry most of the year. Where erosion has been most severe, badlands have formed. These areas are sparsely, if at all, vegetated owing to the constant action by wind and water. Drainage is largely into sloughs, although the local drainage basin is a part of the Milk River system, which in turn flows into the Missouri River.

The soils of the area are mainly light loams. The profile is associated with the residual rock formations which, in this case, are principally Bearpaw and Belly River shales. Practically all of the area has a solonized profile, with characteristic eroded pits due to the patchy removal of the A or surface horizon. These eroded pits may or may not support vegetation. The exposed B_1 horizon is usually dark in colour and very hard, thus preventing or limiting water penetration into the subsoil.

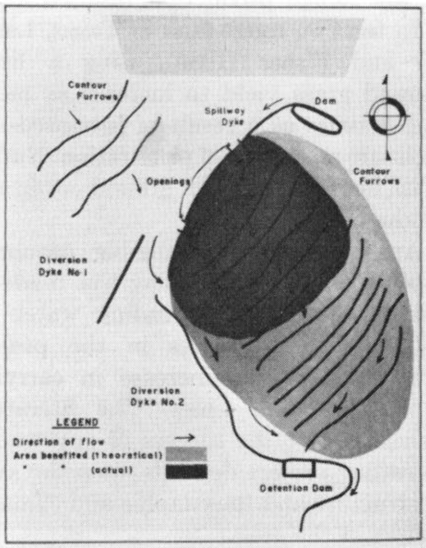

FIGURE 1. Diagrammatic view of Project 1, showing location of dams, dykes, and furrows and direction of water flow in the spreader system.

The climate of the area is marked by low precipitation, a high rate of evaporation, great extremes of temperature, frequent high winds, and abundant sunshine.

The average total annual precipitation is only 11.18 inches, and the precipitation: evaporation ratio is 0.35. This factor is the principal climatic condition limiting plant growth. While an average annual snowfall of 34.12 inches may appear high, it does not remain throughout the winter because of the many warm chinook winds which melt the snow, often as soon as it falls.

VEGETATION

The vegetational cover is classified as short-grass prairie, and is characterized by the dominance of blue grama grass, *Bouteloua gracilis*, which comprises over one-third of the total vegetational cover, and common spear grass, *Stipa comata*. Other important grasses are western wheatgrass, *Agropyron smithii*, June-grass, *Koeleria cristata*, and dwarf blue-grass, *Poa secunda*. Involute leaved sedge, *Carex eleocharis* is abundant, while nigger wool, *Carex filifolia* is of frequent occurrence. Common broad leaved plants include pasture sage, *Artemisia frigida*, dwarf phlox, *Phlox hoodii*, broom weed, *Gutierrezia diversifolia*, winter fat, *Eurotia lanata*, salt sage, *Atriplex nuttallii*, and hoary sage bush, *Artemisia cana*. Cactus, *Opuntia polyacantha*, is very common at local points. Little club moss, *Selaginella densa*, is very abundant over all of the area. In general, the vegetation is highly nutritive and palatable, but is of low productivity. The combined cover of all grass species is usually less than 10 percent, but forbs and weeds increase the total vegetational cover from 20 to 35 percent.

WATER SPREADING SYSTEMS

The original studies at the Manyberries Station consisted of 6 projects all dealing with the problems of water conservation, with the object of utilizing spring run-off water for the purpose of increasing the grass cover and to test the types of structures used.

SPREADER SYSTEM

Project 1. This consisted of a combination of dams, dykes and furrows (Fig. 1).

In the spring of the year the run-off water is collected in the main dam, after this has been filled to capacity the water moves along the spilling dyke. This dyke is about 325 feet long and 2 feet high, with two 8-foot openings. Through these openings the spillway water passes and is spread by three small diversion dykes. The water then flows down on to the 6580 feet of contour furrows. The furrows were constructed to aid in spreading the water and restricting its movement to increase the depth of penetration of the water. The vertical interval between the furrows averaged a little over 2 feet. Below is a listing of the work done on this project:

Total amount of earth moved—33.90 cubic yards
Total amount of rip-rap laid—135.5 square yards
Total amount of furrowing—6580 feet
Acreage benefited—7.6 acres.

Project 1 also included four other sub-projects. Project 1(a) consisted of a diversion dyke approximately 1,200 feet long with two 8-foot openings, through which the run-off water passed. The water was held and spread by 4 contour furrows. These furrows had a vertical interval of 1.0 foot, a depth of 5 inches, and a total length of 3240 feet. The total earth moved was 338.0 cubic yards, and the acreage benefited was rated at 4.5 acres.

Project 1(b) consisted of one main diversion dyke 873 feet long, with two 8-foot openings and three flood dykes (Fig. 2, left), with a total length of 1930 feet. These dykes were 1.5 to 2.0 feet high. The total earth moved was 284 cubic yards and the acreage benefited was rated at 2.7 acres.

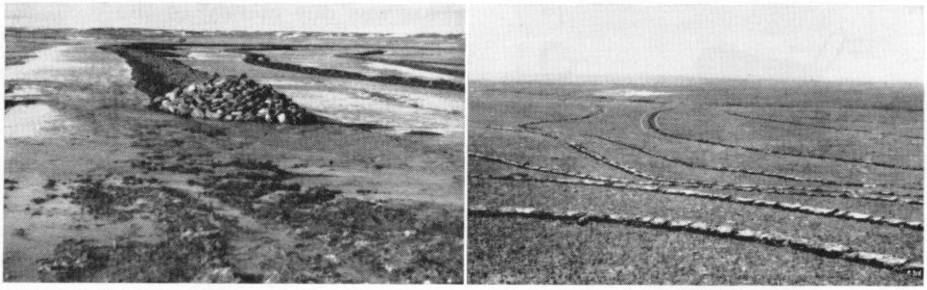

FIGURE 2. TYPES OF STRUCTURES FOR WATER SPREADING. *Left*—Riprapped dyke, with water flowing around the end in the spring of the year. *Right*—Recently constructed contour furrows.

Projects 1(c) and 1(d). This scheme consists of two sets of contour furrows which were constructed with the purpose of spreading and retaining run-off water derived from melting snow (Fig. 2, right). The furrows were located on both sides of a coulee. The furrows on the west side had a vertical interval of 2.0 feet, a depth of 5 inches and a total length of 4890 feet. There were 20 contour furrows and the acreage benefited was rated at 4.8 acres. On the east side of the coulee the vertical interval of the furrows was 2.0 feet, the furrow depth 5 inches and the total length was 14,780 feet. There were 17 furrows and the acreage benefited was rated at 20.4 acres.

FLOODING OR SYRUP PAN SYSTEM

Project 2. This scheme consisted of a syrup pan system of dykes for flooding (Dickson *et al.*, 1940), and seven contour furrows below the dyking system. The run-off water is first collected in the diversion dam (Fig. 3). From here it moves out along the diversion dykes and into the syrup system of dykes. This moves the water back and forth across the area. The water then flows down on to the contour furrows. The total acreage flooded was 6.1 acres and the acreage benefited was rated at 14.3 acres.

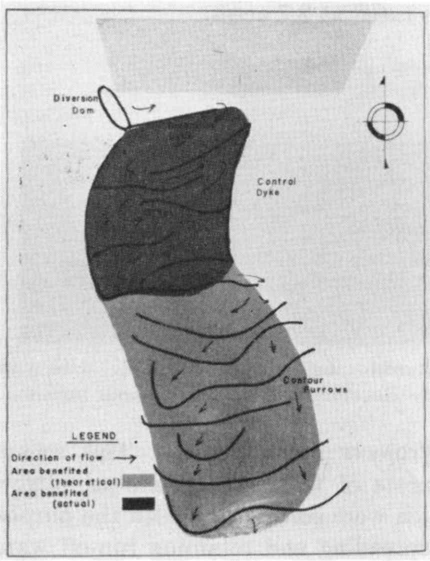

FIGURE 3. Diagrammatic view of Project 2, showing the location of the dykes and furrows in the flooding, or syrup pan system.

Project 3. This system consists of a dam, one spillway dyke with five openings, one diversion dyke and five flood dykes. These furrows were placed at the lower end of the slope. When the run-off water filled the dam to capacity the excess moved between the spillway and the diversion dyke. The water then flowed through the five openings and out along the five flood dykes. Any water that passed out through the channel of the spillway and diversion dyke was held and spread by the furrows. The acreage flooded by the dykes was 6.6 acres. The total acreage benefited was rated at 10.6 acres.

Project 4. This system is composed of one diversion dam, approximately 144 feet long, one diversion dyke 210 feet long, and six flood dykes with a total length of 7,315 feet. It was constructed to divert spring run-off water and flood a portion of the slope. Total acreage benefited was rated at 10.5 acres.

In all projects the area actually benefited by the additional water was less than half of the rated benefited area. This was due mainly to the ineffectiveness of the contour furrows. *The benefited land was that area that produced a greater volume of forage than adjacent areas due to increased moisture in the soil.*

Plant and Forage Studies

The vegetation on the projects was originally charted in 1937, and in some cases recharted in 1940, using the area-list method on meter quadrats. Unfortunately, most of the permanent quadrats were destroyed by 1949; because of this it was decided to use the point method of vegetation analysis. The reason for this decision was based on unpublished information from the Manyberries Station, which showed the difference between the two methods was not significant.

Yields were taken by throwing a meter frame and clipping random plots, both on the benefited and adjacent area.

In Table 1 a summary is presented of projects 1, 1(a), 1(b), 2, 3, and 4. Projects 1(c) and (d) have been eliminated because no results were obtained as the contour furrows proved to be of no value. On the contour dykes crested wheatgrass and brome were seeded to help stabilize the soil. It can be seen from the table that crested wheatgrass established itself very readily and spread to a limited extent on to the prairie adjacent to the dykes. In the case of Project 1, the increase in yield was due in part to the increase in sand grass (*Calamovilfa longifolia*). It can be observed from the table that the dryland species like blue grama grass are gradually disappearing due to the competition of the more mesic species. One apparent reason for the increase in sand grass is the sandy nature of the soil. Sand grass appears to grow more prolifically in light soils. Yields on the areas actually benefited by the water were higher for all projects than those on adjacent areas. The yields of native vegetation were extremely low in 1949 as the June rainfall was only 0.76 inches. In this area there is a very high correlation between volume of forage produced and June rainfall. The average forage produced is 276 pounds per acre, on native rangeland. On some of the benefited areas volume of forage has been increased as much as 16 times, by the use of contour dykes.

Costs

No accurate records were kept but an estimate was made at the time the work was done in 1937. Using this information the cost figures are those of 1950.

The tractor used is assumed to be a \$2,400 machine working 800 hours a year. The plow is valued at \$450 working 200 hours. For interest charges a rate of six percent on one-half of the replacement value is used.

Interest cost per hour of use for the tractor is:

$$\frac{0.06 \times 0.5 \times 2400}{800} \text{ equals } \$0.09$$

Interest cost per hour of use for the plow:

$$\frac{0.06 \times 0.5 \times \$450}{200} \text{ equals } \$0.06$$

Depreciation is based on a probable life for the tractor of 10,000 hours, and 3,000 hours for the plow.

Depreciation for the tractor per hour is:

$$\frac{\$2{,}400}{10{,}000} \text{ equals } \$0.24$$

Depreciation for the plow per hour is:

$$\frac{\$450}{3{,}000} \text{ equals } \$0.15$$

Repair cost for tractor based on 10,000 hours of use is 80 percent of present replacement cost. Repair cost for plow is 100 percent replacement cost based on 3,000 hours of use.

Repair cost per hour for tractor is:

$$\frac{80}{100} \times \frac{\$2{,}400}{10{,}000} \text{ equals } \$0.19$$

Repair cost for plow is:

$$\frac{100}{100} \times \frac{\$450}{3{,}000} \text{ equals } \$0.15.$$

Fixed cost for hour of use of tractor and plow is \$0.52 plus \$0.36 equals \$0.88.

Total cost of operation is as follows for tractor and plow:

Fixed costs	\$0.88
Fuel charges at \$0.26 a gallon using 2 gallons per hour	\$0.52
Oil and grease at \$0.08	\$0.08
Local labor cost including room and board	\$1.00
Total operating cost per hour of use for tractor and plow	\$2.48

In second gear, the tractor will operate at 3.75 miles per hour at a cost of \$2.48 per hour. This includes interest, depreciation, repairs, fuel oil, grease and labor. Assuming the average speed to be 3 miles per hour and the cost of running with no load 10 cents less than with load, the cost per mile of furrow, working in only one direction, and returning empty, would be \$1.60. If a machine was used that can turn furrows in either direction the cost would be a little more than half. Depending on the slope, vertical and horizontal spacing, one mile of contour furrowing will serve 2 to 4 acres. Therefore, using a machine that will plow only one way the cost per acre would be $0.40 to $0.80 an acre.

in the neighborhood of 16 cents an acre and dykes cost anywhere from $0.36 to $0.60 an acre.

Conclusions and Discussion

The contour furrows as constructed at the Range Station were of no value in holding and spreading water. This is due in part to the furrows being only 4 to 5 inches deep, consequently they were soon filled with ice and snow. Another objection to the furrow construction was the use of a single breaker bottom plow. This turned the furrow slice over, leaving it exposed to water and wind action. More efficiency might have been obtained if special contouring machines had been used. The Kansas machine picks up the furrow slice and sets it to the side without overturning, thus saving much of the sod. A machine developed in Iowa lifts a slice of sod so as to destroy no sod, and

TABLE 1

Percentage of basal cover provided by the principal species on areas affected by additional water as recorded in 1937 and 1949, also adjacent areas in 1949 at the Range Experiment Station, Manyberries, Alberta, Canada

SPECIES	PROJECT 1			PROJECT 1 (a)			PROJECT 1 (b)		
	Benefited		Adjacent	Benefited		Adjacent	Benefited		Adjacent
	1937	1949	1949	1937	1949	1949	1937	1949	1949
	Percent								
Bouteloua gracilis	2.58	0.70	3.29	3.83	1.72	4.23	3.02	0.80	2.01
Stipa comata	2.63	2.00	1.89	1.11	0.31	0.90	1.03	0.90	1.00
Koeleria cristata	1.30	1.00	0.90	0.29	0.10	0.31	0.02	0.62	0.54
Agropyron smithii	0.53	4.60	0.50	1.43	3.42	1.24	1.51	0.64	0.74
Agropyron cristatum	0.00	0.10	0.00	0.00	1.46	0.00	0.00	3.00	0.00
Poa secunda	0.99	0.50	0.30	2.44	0.89	0.94	1.37	0.10	0.84
Bromus inermus	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.51	0.00
Calamagrostis montanensis	0.04	0.00	0.02	0.00	0.00	0.00	0.18	0.06	0.10
Calamovilfa longifolia	0.00	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carex eleocharis	0.60	0.90	0.80	0.12	0.07	0.18	0.00	1.51	0.72
Artemisia frigida	0.15	0.00	0.10	0.52	0.47	0.28	0.24	0.10	0.20
Selaginella densa	1.20	0.20	6.10	0.32	0.30	1.56	1.00	0.00	0.50
Yield in pounds per acre		1217	106		3770	110		470	98

The dykes constructed on the Station totalled 1.82 miles and involved moving 3,466 cubic yards of earth at a cost of $0.36 per acre.

The benefit derived from the contour furrows was little if any; however, it is safe to say that all areas on which contour dykes were used benefited. Even if we assume only a 50 percent increase in forage which is very conservative it is very logical to assume that the increase in forage over a period of years would easily offset the cost of construction of the dykes, especially where leased grass costs yet make a combination furrow and ridge 6 to 8 inches deep. All the contour furrows used were more than 10 feet apart. This may account for the fact that they proved of negligible value in increasing forage cover or forage production.

The results show that added water will change the vegetational climax. That is, blue grama grass and spear grass will be replaced where the soil is heavy, by blue joint. If the soil is sandy, sand grass will increase with the added moisture.

Contour dykes proved an excellent means of holding and spreading water where other water conserving structures are not feasible. For the relatively small areas that are benefited the carrying capacity may be increased 3 to 6 times. If the areas are not used for grazing a good hay crop may be secured.

TABLE 1—*Continued*

SPECIES	PROJECT 2			PROJECT 3			PROJECT 4		
	Benefited		Adjacent	Benefited		Adjacent	Benefited		Adjacent
	1937	1949	1949	1937	1949	1949	1937	1949	1949
	Percent								
Bouteloua gracilis	7.77	1.30	2.01	8.36	3.65	4.24	1.39	1.30	2.00
Stipa comata	0.24	0.50	0.36	0.34	0.60	0.60	0.42	0.20	0.49
Koeleria cristata	0.01	0.65	0.22	0.15	0.62	0.84	0.14	0.80	0.79
Agropyron smithii	0.71	3.50	0.86	1.26	4.28	1.34	2.65	3.20	1.87
Agropyron cristatum	0.00	3.33	0.00	0.00	0.20	0.00	0.00	0.86	0.00
Poa secunda	1.43	0.50	0.96	0.53	0.70	0.59	0.89	0.30	0.43
Bromus inermus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Calamagrostis montanensis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Calamovilfa longifolia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carex eleocharis	0.20	0.07	0.31	0.07	0.91	0.60	0.10	0.18	0.14
Artemisia frigida	0.09	0.30	0.24	0.26	0.50	0.38	0.06	0.05	0.07
Selaginella densa	0.88	2.88	2.00	5.31	3.00	4.24	0.49	0.12	0.20
Yield in pounds per acre		1859	99		488	104		325	102

SUMMARY

Most of the water available to the short-grass prairie is from spring rain. As the snow melts great quantities of water are freed. Utilization of this water is very important to the stockman, hence dams and dugouts have been constructed to conserve some of the water for the late, dry summer. As an added aid to conservation and utilization of spring run-off, contour furrows and dykes and dams were constructed to test the types of structures and to increase forage production on limited areas by additional moisture. After 13 years, clippings were made and vegetation analyzed to evaluate the benefit of the work. It was found that contour dykes were of real benefit in increasing the volume of forage produced. The contour furrows became filled with ice and snow during the winter and were of no value in holding or spreading water. All dykes should be seeded down soon after construction to prevent washing and erosion.

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CHARACTER

There are many qualities which we need alike in private citizen and in public man, but three above all—three for the lack of which no brilliance and no genius can atone—and those three are courage, honesty and common sense.—*Theodore Roosevelt.*

No amount of ability is of the slightest avail without honor.—*Andrew Carnegie.*

Character is property—it is the noblest of possessions.—*Ghandi.*

It is they who do their duties in everyday and trivial matters, who fulfill them on great occasions.—*Charles Kingsley.*

Talent is nurtured in solitude, character is formed in the stormy billows of the world.—*Goethe.*

Character, gentlemen, is a by-product. It comes, whether you will or not, as a consequence of a life devoted to the nearest duty. . .—*Woodrow Wilson.*