Journal of RANGE MANAGEMENT
September, 1960
Volume 13, Number 5

Effect of Mima-Type Microrelief on Herbage Production of Five Seeded Grasses in Western Colorado[1]

WILLIAM J. McGINNIES

Range Conservationist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Fort Collins, Colorado

Mima-type microrelief has been commonly observed in the treeless areas of the western United States. This microrelief is characterized by low mounds or soil pimples, commonly called "Mima mounds" after the Mima Prairie in western Washington, where they were described by Dalquest and Scheffer, (1942). Some contend that the Mima mounds are a result of physical actions of ice wedges and erosion (Newcombe, 1952; Ritchie, 1953) while others feel that the mounds are built largely by the activity of fossorial rodents such as pocket gophers or prairie dogs (Arkeley and Brown, 1954). Present evidence tends to favor the formation of the mounds by rodents in Colorado and adjacent areas. The subsoil in mounded areas usually contains a cemented hardpan, bedrock, gravel bed, or water table, which limits root growth and the activity of fossorial rodents. In Colorado, the mounds vary in height from less than a foot to several feet and in diameter from 15 to 25 feet; the diameter is approximately equal to the territory of a pocket gopher. The mounds may be closely or widely spaced. The presence of Mima-type microrelief in Colorado has been reported by Scheffer, (1958). Dalquest and Scheffer (1942) reported that in Washington herbage production on top of Mima mounds was greater than between the mounds in spite of pocket gopher disturbance on the mounds. The writer observed the same pattern of higher yields on the mounds in a range seeding study area on the Uncompahgre Plateau, in western Colorado.

In 1959 a study was made to determine the extent of the effect of Mima mounds on the variability of herbage production of five seeded grasses. This study is reported herein.

Description of Area

The study area is on 25 Mesa, a part of the Uncompahgre Plateau, 25 miles southwest of Delta, Colorado (Figure 1). Elevation is about 8000 feet, and the average annual precipitation is estimated to be 17 inches. The site, an opening in the ponderosa pine forest, was dominated by big sagebrush (*Artemisia tridentata*) before seeding. Soil parent material is sandstone.

The sagebrush was removed with a brushland plow in 1949. One-tenth-acre plots were seeded by the Rocky Mountain Forest and Range Experiment Station, U. S. Forest Service, in 1949, 1950, 1952, and 1953 to intermediate wheatgrass (*Agropyron intermedium*), crested wheatgrass (*A. desertorum*), smooth brome (*Bromus inermis*), Russian wildrye (*Elymus junceus*), and big bluegrass (*Poa ampla*). Some light grazing by cattle and horses had been permitted in recent years, but the area was protected during the first few years following planting of the grasses.

The mounds on the study area fit closely the description of and criteria for Mima mounds given by Dalquest and Scheffer (1942) and Arkley and Brown (1954) and are presumed to be the result of past activity by pocket gophers. The characteristic microrelief of the Mima mounds was not destroyed by the plowing, and they retain an appearance similar to nearby Mima mounds that were not plowed. The mounds are 12 to 24 inches high, 15 to 25 feet in diameter, and 30 to 60 feet apart (mound center to mound center). A sandstone bedrock underlies the entire area; the bedrock is 12 to 18 inches below the intermound areas and 30 to 36 inches below the top of the mounds.

[1]*Contribution from the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture in cooperation with the Rocky Mountain Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, and the Colorado Agricultural Experiment Station.*

FIGURE 1. General view of study area on Uncompahgre Plateau in western Colorado, showing typical Mima-type microrelief.

Methods

Only those few mounds and adjacent intermound areas that were entirely within a seeded plot were sampled. Because the seeded plots were long and narrow, very few mounds fit this requirement. Of the 10 mounds sampled, 3 had been planted to intermediate wheatgrass, 3 to crested wheatgrass, 2 to smooth brome, and 1 each to Russian wildrye and big bluegrass. Herbage samples were clipped from one 9.6-sq. ft. plot on top of each mound and one 9.6-sq. ft. plot on the adjacent intermound area in late July, 1959. The plots were systematically picked as being representative of the two sampling sites. The herbage samples were air-dried and weighed to determine herbage yield. A numerical stand rating (O = no stand, 10 = best possible stand) was made on both the mound and the intermound area just prior to clipping.

Soil samples of the surface 6 inches were taken from the plots after the herbage was clipped. These samples were analyzed by Colorado State University for ⅓—and 15—atmosphere moisture percentages, soil texture, pH, soluble salts, organic matter, phosphate (P_2O_5), and potassium (K_2O).

Results and Conclusions

Great differences in the abilities of these five cool-season species to produce herbage on mound and intermound areas were observed (Table 1). Air-dry herbage yields from the tops of the mounds were greater than the yields from between the mounds, by an average of 94 percent (intermediate wheatgrass), 180 percent (crested wheatgrass), 323 percent (smooth brome), 358 percent (Russian wildrye), and 542 percent (big bluegrass). The reasons for the consistently higher yields on tops of the mounds are not entirely clear, but the differences are apparently a result of differences in stand quality, soil fertility, and soil volume above the bed rock. These are discussed separately below.

Stand quality (as indicated by stand ratings) was better on top of the mounds, where the average rating was 8.0 (out of a possible 10) as compared with an average of 5.1 between the mounds. Stand ratings on the mounds were better than intermound ratings by 29 percent for Russian wildrye, 43 percent for intermediate wheatgrass, 45 percent for crested wheatgrass, 67 percent for big bluegrass, and 183 percent for smooth brome (Table 1). Whether the higher ratings on the Mima mounds are a result of better initial establishment of the seedings or a result of greater drouth mortality between the mounds could not be determined. However, the plants on the mounds were generally more robust despite their higher density, but variation between species was great. For example, while Russian wildrye

Table 1. Average herbage yields and stand ratings of five grasses on top of and between Mima mounds in western Colorado, 1959.

Species	Location of samples	No. of mounds studied	Air dry herbage yield	Stand ratings	Soil organic matter
			(lb/A)		(percent)
Intermediate wheatgrass	Mound	3	1030	10.0	4.9
	Intermound	3	530	7.0	2.6
Crested wheatgrass	Mound	3	1100	7.7	4.5
	Intermound	3	393	5.3	2.5
Smooth brome	Mound	2	635	8.5	4.0
	Intermound	2	150	3.0	3.0
Russian wildrye	Mound	1	550	9.0	5.1
	Intermound	1	120	7.0	3.4
Big bluegrass	Mound	1	770	5.0	5.6
	Intermound	1	120	3.0	3.1
Average of all species	Mound		817	8.0	4.8
	Intermound		263	5.1	2.9

had only a 29-percent better stand on the mound, it had a 358-percent higher yield on the mound, but intermediate wheatgrass had a stand 43 percent better on the mound while the yield was only 94 percent greater. Thus, differences in stand quality alone cannot account for the differences in yield.

Soil pH averaged 6.4 and soluble soil salts averaged .06 percent, but differences between the mound-top and intermound values were not significant. Phosphorus and potassium averaged 70 and 259 pounds per acre on top of the mounds and 58 and 150 pounds per acre between the mounds. Neither of these elements would be considered deficient under this arid climate, and limited trials have shown no benefits from adding either of these on other range lands in this area. However, increases in yield are frequently observed on seeded stands when nitrogen is added. Soil nitrogen is difficult to measure accurately, but it is usually considered to be proportional to organic matter content. Organic matter averaged 4.8 percent on the mounds and 2.9 percent between the mounds (Table 1). Thus, nitrogen in the surface 6 inches of the soil on the mounds would be about 66 percent greater than in the intermound areas. This difference in nitrogen no doubt accounts for at least part of the differences in yields.

Percentages of sand, silt, and clay averaged respectively 44.8, 49.9, and 5.3 on top of the mounds and 42.0, 47.5, and 10.5 between the mounds. Field capacity of the soils (1/3 atmosphere of tension) on top of the mounds and between the mounds averaged 17.5 and 17.7 percent moisture, and wilting point (15 atmospheres) averaged 8.6 and 8.0 percent, respectively. Thus, there was no particular difference in the percentage of moisture available between field capacity and the wilting point. The soil was more friable and less compact on top of the mounds because of the higher organic-matter content, and the better structure may have had some influence on increasing water infiltration and yields. However, because of the underlying sandstone bedrock, the volume of soil available to the plants growing between the mounds is only about half of that available to plants growing on the mounds. Since the available water holding capacity per unit of soil volume is the same for both soils, with twice the volume of soil in the mounds, the plants on the mounds would have access to twice the amount of stored water from winter snows available to the plants growing between the mounds. In this part of western Colorado, where June is a dry month, the stored water would have a very important influence on herbage yields, particularly those of these cool season species that make much of their annual growth during this dry period. In the dry spring and early summer of 1959, the water stored in the mounds was sufficient for the plants growing on the mounds to mature seed, while the plants in the intermound areas produced mostly vegetative growth and almost no seed heads (Figure 2). Even in favorable years, seed heads are rare in the intermound areas.

Discussion

The type of mounds mentioned in this study are probably much more common than is generally realized, although in most cases they are not so well developed and obvious as the mounds reported here. However, it can be predicted that the effect of the Mima mounds on herbage production will be similar and will differ only in the degree of effect. The Mima-type microrelief will frequently show up from the air or on aerial photographs when it is not otherwise easily identifiable. Because of the effect of the mounds on herbage, recognizing the Mima-type microrelief when it does exist is important if herbage sampling or small-plot studies are contemplated. Methods can be developed or techniques can be used to reduce the great sampling variability that would otherwise be present.

Summary

Mima-type microrelief and its influence on herbage yields in western Colorado have been described. An area on the Uncompahgre Plateau with typical

FIGURE 2. Intermediate wheatgrass on intermound area (foreground) and on Mima mound (lighter colored plants) on the Uncompahgre Plateau, Colorado. The higher yielding grass plants on the mound matured seed while the lower-yielding plants in the intermound area did not produce seed heads.

Mima mounds was seeded to intermediate and crested wheatgrasses, smooth brome, Russian wildrye, and big bluegrass in 1949-53. In 1959 yield determinations and stand evaluations were made on the mounds and between the mounds to determine the effects of microrelief on the seeded species.

Herbage yields on the Mima mounds were 94 percent (intermediate wheatgrass) to 542 percent (big bluegrass) greater than between the mounds. Stands were better on the mounds by 29 percent (Russian wildrye) to 183 percent (smooth brome). Nitrogen, as estimated from organic matter, was 66 percent greater on the mounds than in the intermound areas. Although water holding capacity was about the same for both locations, the depth of soil above bedrock was twice as great in the mounds as between the mounds, allowing greater volume of water to be stored in the mounds.

It is suggested that the higher yields on top of the mounds result from a combination of better stands, more nitrogen, and a greater soil volume available for water storage.

LITERATURE CITED

ARKLEY, R. J., AND H. C. BROWN. 1954. The origin of Mima mound (hogwallow) microrelief in the far western states. Proc. Soil Sci. Soc. Amer. 18: 195-199.

DALQUEST, W. W., AND V. B. SCHEFFER. 1942. The origin of the Mima mounds of western Washington. Jour. Geol. 50: 68-84.

NEWCOMB, R. C. 1952. Origin of the Mima mounds, Thurston County region, Washington. Jour. Geol. 60: 461-472.

RITCHIE, A. M. 1953. The erosional origin of the Mima mounds of southwest Washington. Jour. Geol. 61: 41-50.

SCHEFFER, VICTOR B. 1958. Do fossorial rodents originate Mima-type microrelief? Amer. Midland Naturalist. 59: 505-510.