4-1940

Deterioration of Midwestern Ranges

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Ecology, Vol. 21, No. 2 (Apr., 1940), pp. 216-236

DETERIORATION OF MIDWESTERN RANGES *[1]

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The native grasses of the mixed prairie and short-grass plains disclimax have been subjected for a long period of years to extreme drought, much overstocking, and severe damage from dust. Behavior of the vegetation during the dry year of 1933, the extreme drought of 1934, and the terrible dust storms and intermittent periods of desiccation during subsequent years, has been continuously observed (Weaver and Albertson, '36). Previous studies in this area furnished a background which enabled one to compare present conditions with those of the pre-drought period (Weaver, '24; Clements and Weaver, '24; Albertson, '37). A large series of exclosures and permanent quadrats supplemented by phytometers and measurements of environmental factors have revealed the nature and causes of changes in vegetation over extensive areas in western Kansas. While these data are being evaluated, and especially because of the recurrent severity of the summer drought of the present year (1939), it seemed advisable to compare the grasslands of the western half of Kansas with those of a much wider area which has undergone similar vicissitudes.

During August, a careful study was made of pastures and range lands of western Kansas and Nebraska and portions of South Dakota, and of great areas in eastern Wyoming and Colorado, and the Panhandle of Oklahoma. Eighty-eight representative ranges have been examined in the six states, including several that have been under observation for a period of ten or more years.

This survey of the midwestern grasslands (exclusive of vegetation on light, sandy soils) consisted very largely in a study of two great dominants which are, with exceptions, the most important and often nearly the sole components of the vegetation. These are blue grama grass, *Bouteloua gracilis,* and buffalo grass, *Buchloe dactyloides. Carex stenophylla* and *C. filifolia* (niggerwool) were important in certain areas northward; needle-and-thread, *Stipa comata,* and western wheat grass, *Agropyron smithii,* also were often intermixed with the short grasses, especially in the more northerly ranges. But the sod-formers and not the bunch grasses have become relatively more abundant since the advent of overgrazing, and the latter have also suffered far greater losses during the drought. One of the most outstanding effects of drought upon the grasses is the usually uniform distribution of the remaining individuals.

THINNING OF THE PLANT POPULATION

When the great drought came, it alone rarely or never killed all of the vegetation. The effect was that of thinning the stand. In this selective process many of the less xeric species of grasses and forbs were killed outright and today only a few dwarfed relicts are to be found, often after long search in the most favorable situations. Among the most drought resistant grasses, it seems certain that the younger and consequently more poorly rooted individuals succumbed. Likewise, the less vigorous among the older and long established plants were destroyed. Much of this thinning occurred as a result of the intense heat and extended drought of 1934, but losses continued in 1936 and 1937 and recurred at other times during the seven-year period of general desiccation. The normal precipitation of 17 inches over the western edge of the

* Contribution from the Department of Botany, University of Nebraska, No. 123.

[1] This study was made with the aid of a grant from the Penrose Fund of the American Philosophical Society. The publication of the excess illustrations in this article has been made possible by funds other than those of the Ecological Society of America.

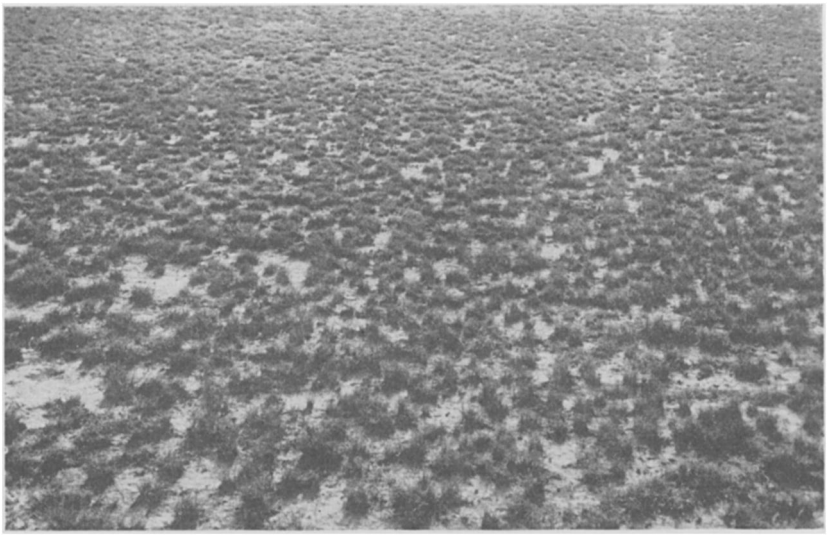

FIG. 1. A formerly fine range of blue grama and buffalo grass on hard land near Seibert, Colo., illustrative of the better pasture conditions today. The basal cover of about 85 per cent is now reduced to 18. Note the wide spacing of the individuals and the fact that all portions of the range have some grass remnants. The buffalo grass occurs in small bunches or rows and constitutes about one-third of the vegetation.

region often fell as low as 6 inches. Amount of destruction and the extreme test experienced by the survivors may be understood when it is known that many excellent ranges with 65 to 90 per cent basal cover have been reduced usually to a scant cover ranging between 20 and 1 per cent (figs. 1, 2, and 3).

Death among the perennial forb population was so widespread during the initial severe period or similar recurring ones that today only scattered individuals of six or eight species regularly occur. By practically eliminating species least fitted to endure hardships and by wide spacing of those best adapted, the grassland has adjusted itself to the new environment imposed upon it. Even widely spaced survivors have barely the necessary amount of soil moisture for their existence. Such an ecological process parallels in a general way that of the human population. Extensive abandonment of ranches and emigrations of settlers have been followed by wider spacings and larger holdings of the remaining population, most of whom have learned by long experience how to endure the hardships of drought.

CAUSES OF DAMAGE TO THE RANGE

Although the ranges have been depleted in stand, vigor, and carrying capacity as a result of the great drought, damage has not been due to intense heat and desiccation alone. Overgrazing and untimely pasturing of many ranges before this great catastrophe subjected them to the onslaught of desiccation in a much weakened condition. Moreover, during this long period of adversity much pasture land has literally been stripped of the last vestige of vegetation by hungry stock and grasshoppers. Despite these adversities, extensive areas throughout the range country would have survived with only moderate losses had it not been for partial or complete burial by dust, or for injury by wind erosion and attending disastrous consequences. Damage to grassland has been enormously increased as a consequence of injudicious breaking and unwise tilling of enormous stretches

of range lands. As stated by Newport ('37) for the southwestern Great Plains:

> Recent years of agricultural expansion destroyed vast areas of native sod. The depression which followed, coupled with severe droughts, frequently resulted in indifferent farming or outright abandonment. The bare, unprotected soil was readily moved by the preying winds. Overgrazing joined with drought and was aided in the erosional process by the abandonment of neighboring fields. Depletion of land, often complete denudation was the result.

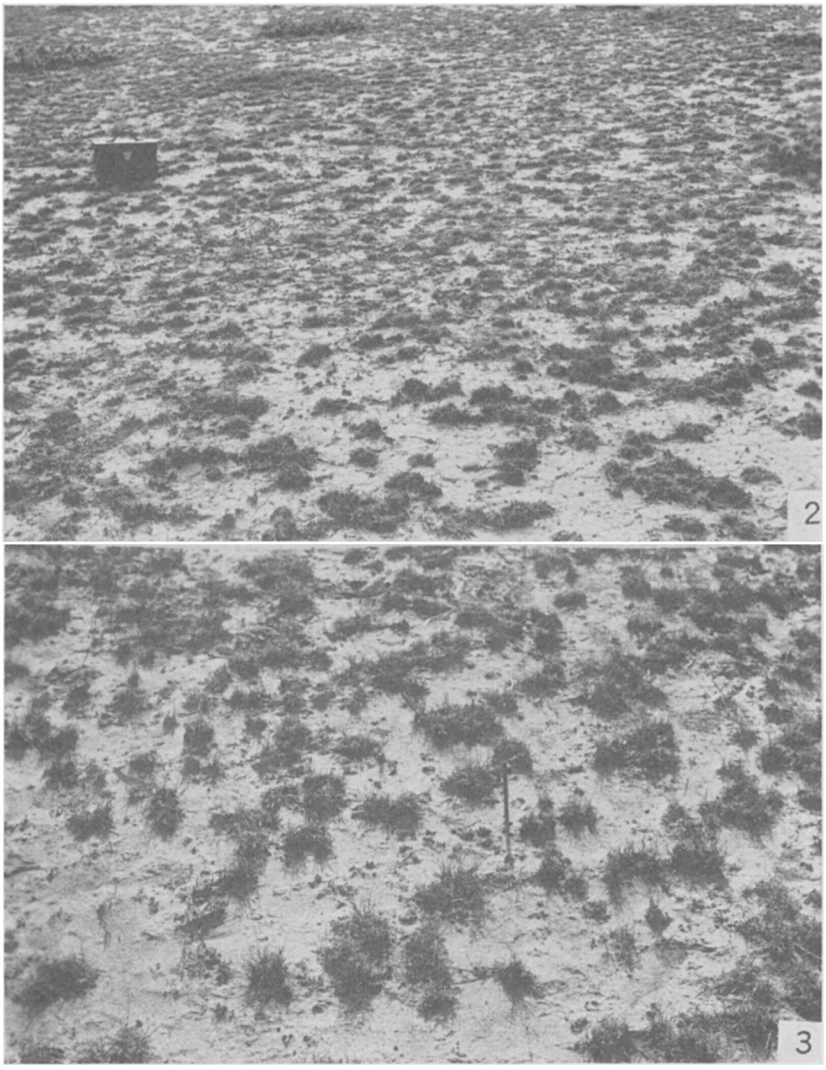

FIG. 2. Pasture on hard land near Brush, Colo. The former basal cover of 70 to 80 per cent has been reduced to about 8 per cent. Of this, however, approximately only 1 per cent remains alive. Practically the entire cover is blue grama grass.

FIG. 3. Sample area of grama-buffalo grass range near Eads, Colo., which has been very much overgrazed and trampled. This is representative of the entire large level pasture with a former cover of 80 to 85 per cent, but now reduced to 2 per cent in many places. Note the dead crowns of the grasses to the left of the pencil. Large, entirely bare areas, however, did not occur.

Overstocking and Understocking

A survey of the situation reveals clearly that too close grazing of the buffalo-grama grass ranges usually occurred where stock raising was carried on in conjunction with production of farm crops. Too much grazing pressure was permitted in pastures of moderate size (80 to 160 acres or more). This occurred somewhat regularly both before and often during the drought. Overgrazing even of the extremely resistant short grasses is doubly harmful. Not only is the vigor of the tops and crowns greatly reduced

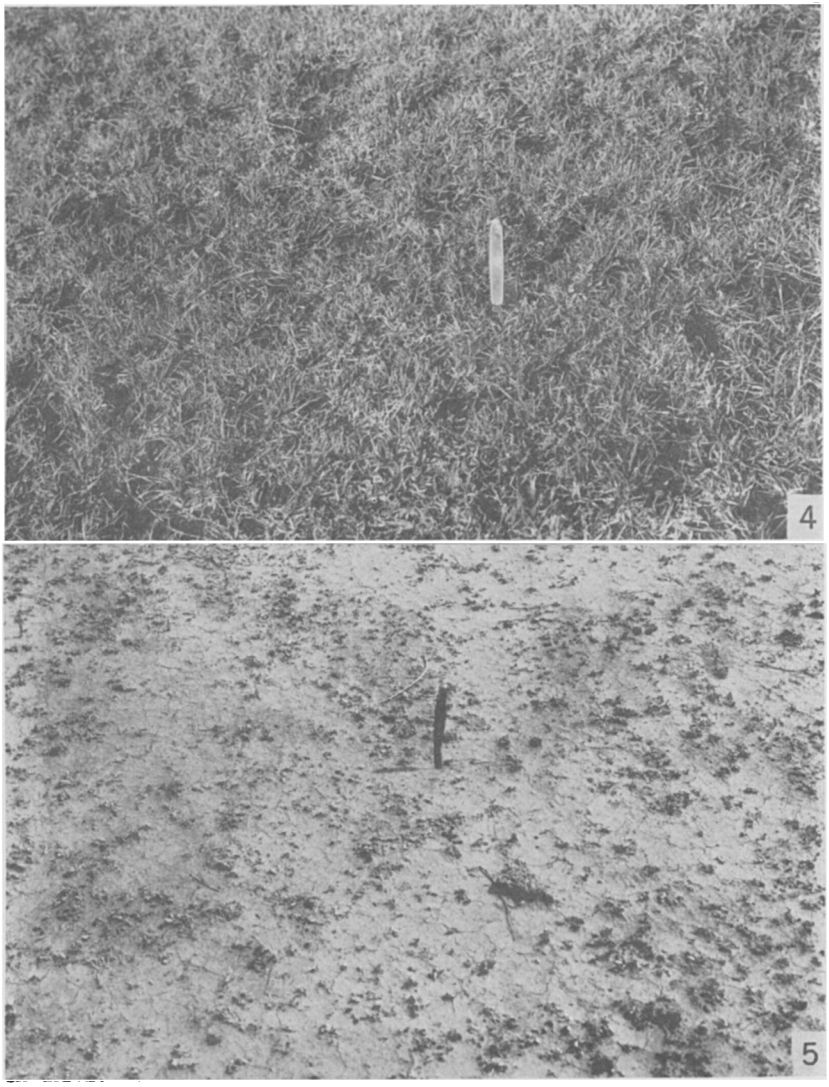

Fig. 4. Detail of vegetation in a pasture of 160 acres near Scott City, Kans., in 1937. Despite the previous drought damage, this buffalo-grama grass range is in good condition with a cover well reestablished since the 1934 drought, although it is now being grazed to within an inch of the soil.

Fig. 5. Detail of the same pasture in 1939. Owing to excessive grazing and trampling scarcely a living plant remains, though the dead crowns bear mute evidence of its previous condition as shown in figure 4.

and the store of reserve food therein constantly decreased, but also the root system itself is greatly weakened by reduction in depth, lateral spread, and in efficiency as an absorbing organ. Any slight gains by stolon production may be immediately checked (figs. 4 and 5). On larger holdings, pastures are many square miles in area; not infrequently, the sweep of unbroken, level or undulating range land extends to the horizon on all sides. Where stock raising is the chief industry, usually more attention has been given to grazing practice on these privately owned ranges. But even here the pressure of starving stock during the early drought resulted in a high degree of overgrazing, and subsequent adverse conditions have prevented much recovery even where cattle have been shipped out. Nearly all

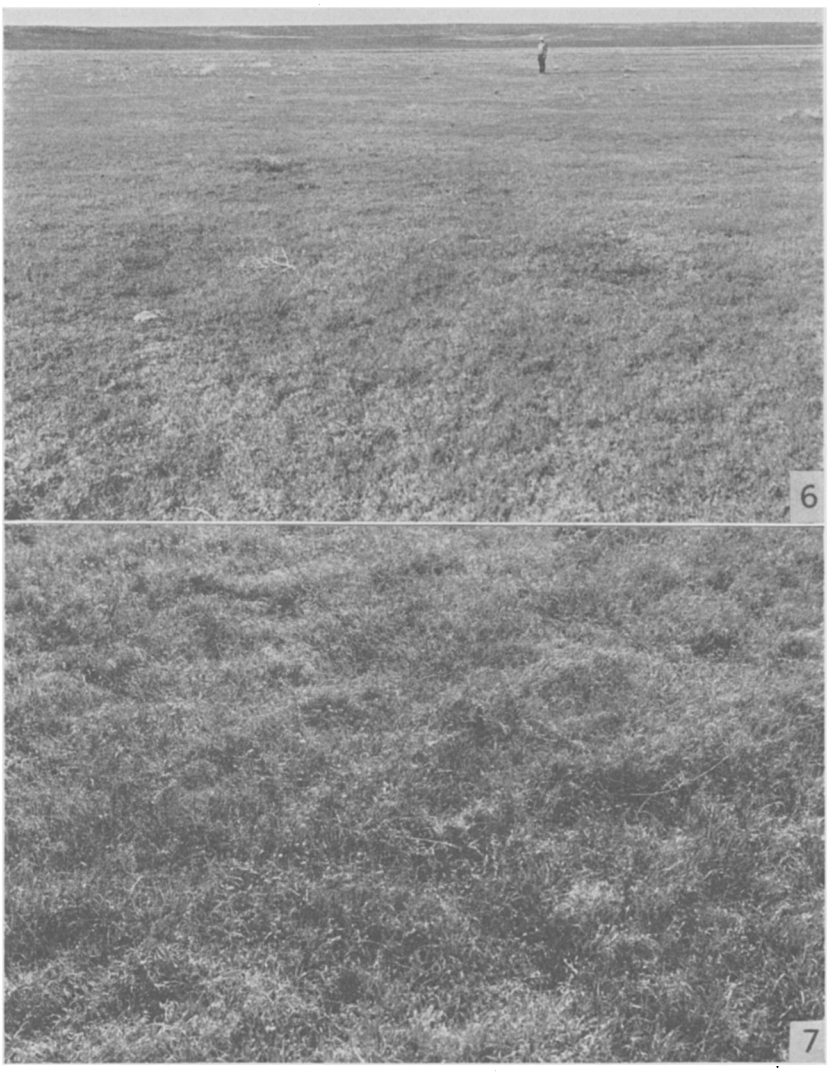

FIG. 6. Low lying land in the valley of Ladder Creek near Tribune, Kans., where protection from dust, moisture from run-in water, and judicious grazing maintained an excellent stand of short grasses.

FIG. 7. Detail of typical complete cover of buffalo-grama grass range shown in figure 6.

of the ranges observed had been excessively grazed.

In the midst of range lands greatly depleted by drought and dust damage, however, one finds favorably located tracts of land where damage to the range, if any, must be attributed largely to grazing abuses alone. A striking example is a low-lying, almost level area north of Tribune, Kansas. It is several square miles

FIG. 8. Overgrazed area in same valley across the fence from the preceding. The cover is reduced to about 20 per cent, *Lappula occidentalis, Monolepis nuttalliana,* and other annual weeds are abundant, and much bare soil is exposed.

FIG. 9. Short-grass pasture near Alma, Nebr., showing abundance of buffalo grass (light colored) and blue grama grass (in bloom in front of black cloth). This is a good pasture, conservatively used and weeds are practically absent. While patches of sand dropseed (*Sporobolus cryptandrus*) occur in the broken sod (see foreground), they are relatively small except on the hills where cattle trample and graze closely (Photo. August 15, 1939).

in extent and nearly surrounded by grass-covered hills, the unbroken range extending well back over the upland. Consequently, there was no deposit of dust on the excellent growth of buffalo and grama grass sod which was favored by run-in water from the slopes. The basal cover was 95 per cent and the foliage almost completely concealed the soil (figs. 6 and 7). This, of course, was the result of good range management and decreased grazing pressure during the dry years. But portions of this lowland had suffered from overstocking. This was shown by the common occurrence and spread of cacti, by reduction of the basal cover (which was scarcely exceeded by the foliage cover) to 20 per cent, and by the presence of an abundance of weedy annuals (fig. 8).

Exceptions to general range damage by whatever cause sometimes occur. These may be due to opportune rains having permitted a previous return toward normal, to more judicious range management, or to protection from damage by dust burial.

During the extreme periods of drought of the past 7 years, it has been necessary intermittently to ship starving cattle to eastern and southern pastures. In many instances, notably in central and western Kansas and Nebraska, the herds have not been replaced (or only in part) and pastures are undergoing year-long protection or, at least, light grazing. Many such ranges have somewhat recovered from drought depletion. In the eastern portion of the region with mean annual precipitation of 20 to 23 inches, increase in abundance and vigor of the vegetation is often marked. Buffalo grass, especially, has reclaimed much formerly bare area by means of rapidly spreading stolons, and mats of this grass, frequently 4 to 6 inches thick, completely conceal the soil. In the drier ranges farther westward, recovery has often been very slow even under protection, so greatly were the plants weakened and so limited has been the precipitation (figs. 9 and 10).

Nature of Injury from Dust

Accompanying the extremely high temperatures and almost rainless summers

Fig. 10. Detail of buffalo-grama grass range on hard land near Springfield, Colo. The basal cover averaged about 40 per cent and the plants are vigorous. With continued decrease in grazing pressure and moderately favorable rainfall, this network of vegetation will soon reestablish the original nearly complete cover.

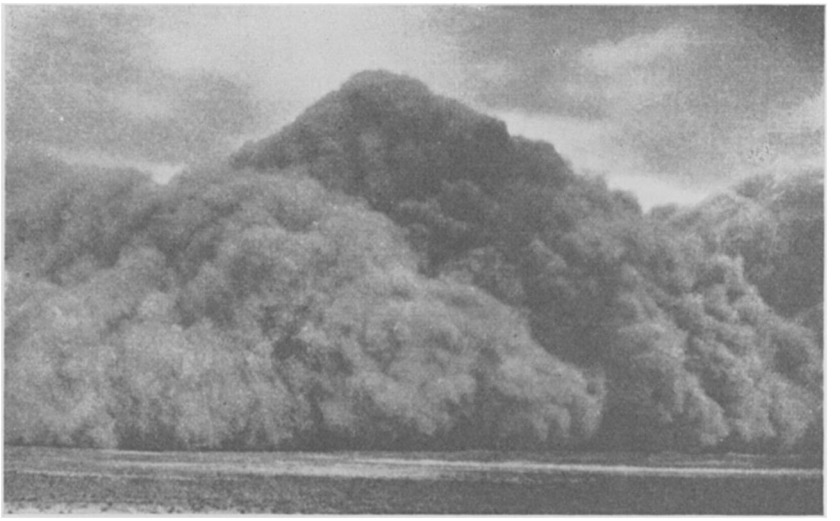

FIG. 11. Approaching dust storm in the middle west. Photo. by Conard.

were unusually high winds. These great storms carried enormous amounts of earth from parched fallow fields and cropped land and deposited it on other fields and pastures (fig. 11). The depth of deposit varied greatly depending upon distance from the source of supply, topography, and nature of vegetation. Whether a good cover of native vegetation or a depleted, weedy one offered obstruction to the dust laden wind, the result was a covering of soil more or less uniformly deposited to a depth of .5 to 2 or more inches. Dust drifts and mounds sometimes to 2 to 3 feet or more in height were formed. Often the grasses were only partially destroyed, but in many instances practically all vegetation was smothered. It should be emphasized, that had the land not been broken, decrease in the amount of vegetation would have certainly resulted from the intense heat and drought, but not such overwhelming denudation. An enormous amount of dusting, as this phenomenon is designated in the affected region, occurred in the spring of 1935. Even when the compacted dust deposit reached a depth of only an inch, it usually killed much of the short-grass cover.

After the dust-covered vegetation died and disintegrated, the tops no longer held the soil against wind erosion. Once more the soil began to shift before the force of the wind. Much of it was transported, often to be deposited in drifts 1.5 to 2 feet or more high where centers of accumulation were afforded by the crop of annuals, most generally Russian thistles, which had previously sprung up in the pastures. Much drifting in pastures occurred in 1937 and 1938, when great areas of grassland were laid bare by the blowing away of the accumulated silt. Indeed, the chief source of supply of silt for some of the worst dust storms during these years was from the earth formerly deposited in pastures.

Abundant evidence of the sequence of deposit and subsequent erosion—sometimes by torrential rains as well as by wind—was offered by the dead crowns and decaying stolons of the grasses, which usually remained plainly in view on the windswept, bare surface. The roots were still anchoring them in place. Other evidence was found in the crowns and taproots of forbs, a few of which often remained alive as much dwarfed survivors. In many instances two or three years elapsed before the former soil surface was uncovered.

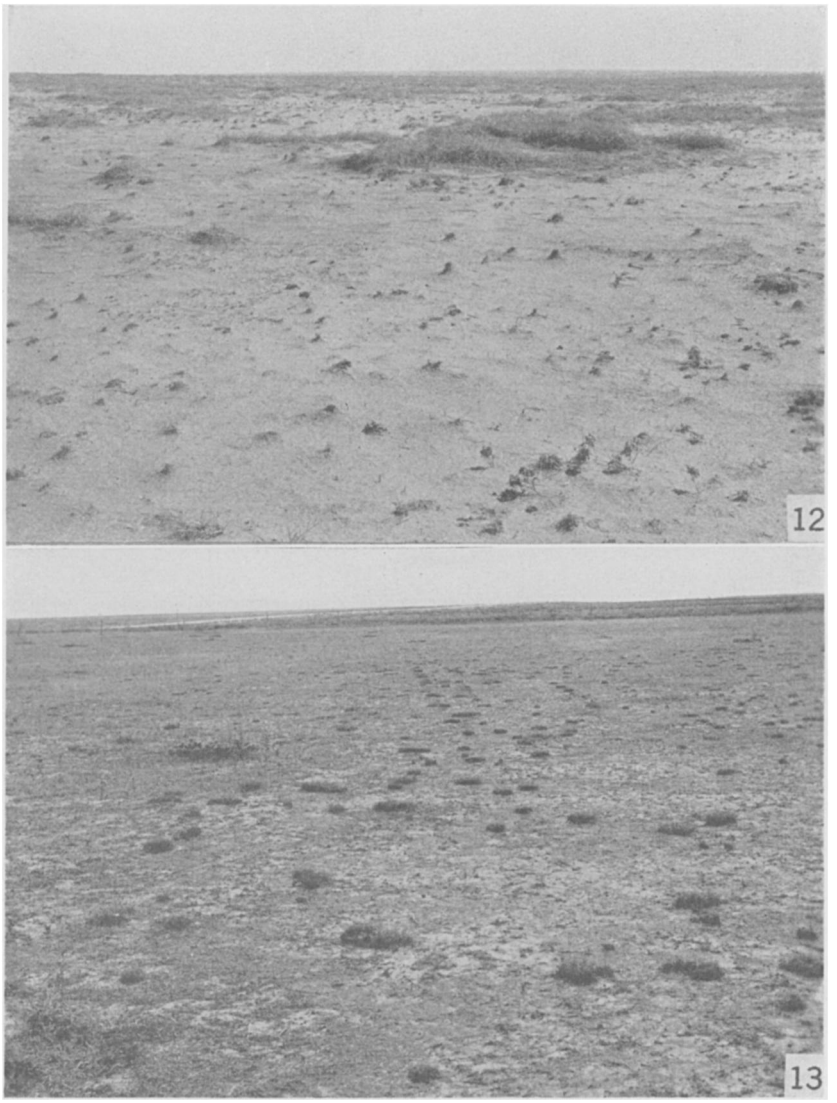

FIG. 12. Former buffalo-grama grass range on hard land near Lamar, Colo. A very extensive area has been covered with dust which has smothered the vegetation. Upon the death of the plants, the wind has blown the soil clean in places and heaped it up into irregular mounds 3 to 15 feet long to a height of 1 to 2.5 feet wherever Russian thistle or other obstacle furnished a nucleus for deposit. The dead crowns of buffalo and grama grass, the latter sometimes grouped in sods 6 inches in diameter, are now 3 to 6 inches above the general soil level. Figures 1 and 3 also show elevation resulting from water and wind erosion.

FIG. 13. Portion of a large, level, dust-covered pasture near Limon, Colo. The cover (bunches) of blue grama and buffalo grass has been decreased to less than one per cent. These widely spaced clumps are not only alive but have increased in size subsequent to their partial burial. Only a few of the most drought resisting perennial forbs have survived. Many annuals have made a precarious growth, succumbed to drought, and given the landscape its gray, barren aspect.

FIG. 14. Portion of a quarter section of range land near Springfield, Colo., farthest from cultivated fields and consequently least damaged by dust. Fully nine-tenths of this pasture was buried so deeply that practically all of the grasses were killed and the dead crowns again exposed. It is now a waste of Russian thistles. In the best portion, the areas between the heaps of silt, which support thistles, have a surviving cover of 18 to 20 per cent.

The scarifying action of dust-laden winds contributed to the death of many pasture plants. Smaller pastures of 80 to 160 acres in area were often wholly surrounded by cultivated fields. They suffered more injury than larger ones. Partial dust burial often caused the living vegetation to reestablish its base 1 to 4 inches above the former soil level. Thus, when the loose soil was later removed, or when erosion lowered the old soil level, the plants, including various forbs, were elevated on columns quite above the surrounding soil. This exposure, of course, aggravated drought and most of the plants died (fig. 12).

Pastures were sometimes listed in order to check the removal of blowing soil. This usually held the soil on the field and promoted an excellent growth of annual weeds but practically destroyed the native plants. So thoroughly did the soil deposits from fields and the subsequent drifting destroy the vegetation, that after the roots and rhizomes decayed, wheat was drilled on the one-time range without further preparation of a seedbed.

Some of the greatest losses to ranges by dust burial probably occurred in and adjacent to the Panhandle of Oklahoma, which with considerable areas in the four adjoining states is designated as the dust bowl. This resulted from a combination of factors, one of which was the large amount of tilled land that furnished an unlimited amount of wind-blown soil. But similar damage was found throughout western Kansas and Nebraska, and in Wyoming, as well as throughout eastern Colorado. It is a very general rather than a local phenomenon and is apt to recur wherever unprotected, drought-parched soil adjacent to grassland is subjected to high winds (figs. 13 and 14).

DAMAGE BY GRASSHOPPERS

Still another factor in reducing the vigor of vegetation was the hordes of grasshoppers which accompanied the drought. For example, from 8 to 15 per square foot were observed during the summer on certain ranges in western Kansas. They ate the leaves and tender stems of the grasses, stripped the foliage

of the ubiquitous peppergrass and Russian thistle, and devoured nearly all vegetation including the only plant cover remaining in many pastures—the mat-like *Monolepis nuttalliana.* Even on ranges where stock was excluded, grasshoppers had sometimes eaten practically all of the scanty growth of vegetation. Moreover, buffalo grass was particularly retarded in its development not only by the injury or loss of foliage, but the always hungry grasshoppers cut the stolons at the nodes where they are tender and where the growing tissue is sweet. Thus segregated from the parent plant, the poorly rooted, younger offspring succumbed.

Changes in Structure of Vegetation

As a result of the combined forces causing deterioration in range and pasture, there have been marked changes in vegetational structure. The mixed prairie, distinguished by more or less distinct layers of mid grasses and short grasses, has, at least in the several thousand square miles examined, almost entirely been converted into short-grass plains. This has resulted from the loss of the mid grasses. Before the great drought, it is true, there were many ranges that had lost most of the vegetation of the upper layer through continuous overgrazing. But relicts were always present and usually abundant in wet years. Moreover, adjacent grassland less severely abused showed clearly the true nature of this relationship. This grazing disclimax is much more pronounced today, and extends quite to the eastern border of the association. Since 1932, the writers have recorded from year to year the increasing losses of *Andropogon scoparius, Aristida longiseta, A. purpurea, Sitanion hystrix,* and other mid-grasses and accompanying forbs. Today an open short-grass carpet with widely spaced, most xeric forbs alone remains. This conversion of mixed prairie to a short-grass disclimax is indeed one of the most interesting features of this grassland.

Over vast stretches, in 1939, the several species of *Aristida, Sitanion hystrix, Koeleria cristata, Stipa comata, Andropogon scoparius,* and *Agropyron smithii* were entirely absent. Undoubtedly remnants remain underground and in favored places, but the long-time drought and the grazing of the grass almost into the soil have been extremely destructive to the mid grasses.

Many of the less xeric forbs such as *Astragalus crassicarpus, A. mollissimus, Lepachys columnaris, Antennaria campestris, Grindelia squarrosa,* and others have likewise practically vanished. Certain of the most persistent native forbs were nearly always present in this survey, often as mere remnants. The most drought resistant are *Malvastrum coccineum, Sideranthus spinulosus, Lygodesmia juncea,* and *Allionia linearis. Psoralea tenuiflora, Liatris punctata,* and *Cirsium undulatum* are slightly less so. *Kuhnia glutinosa* and (southwestward) *K. hitchcockii* are likewise very resistant to drought injury. Even these xeric forbs were always greatly dwarfed and usually only 2 to 5 inches tall. Early spring revealed an abundance of *Anemone caroliniana* and *Allium nuttallii,* plants with large storage organs, but these soon disappeared above ground.

The opening up of the plant cover and the abundance of bare soil permitted the growth of hordes of short-lived annuals, some of which were so thickly placed as to quite obscure the remaining grasses. Among the most persistent and widely distributed were *Lepidium densiflorum, Lappula occidentalis, Hordeum pusillum, Plantago purshii, P. spinulosa, Monolepis nuttalliana,* and *Cryptantha crassisepala.* But they were soon overtaken by drought, their dead remains giving the dull leaden gray or, later, black color to the landscape.

Sometimes the pastures were reddened after a period of showers by a thick growth of *Portulaca oleracea.* More frequently they varied through several shades of green, depending upon the direction of the incident light, and finally to black as the ubiquitous Russian thistles pro-

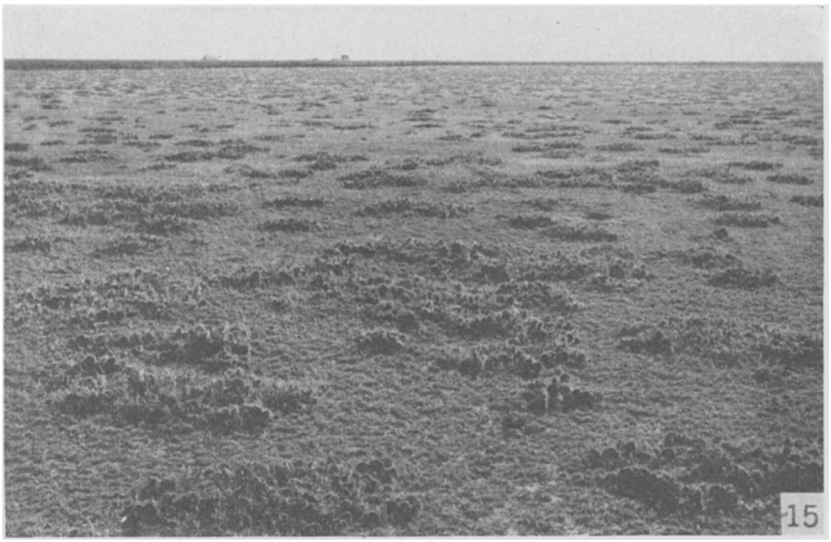

FIG. 15. Pasture of blue grama grass near Carpenter in southern Wyoming, where about one-fifth of the area is occupied by cactus. The grass cover averages 20 per cent but only a few live shoots were present in the many bunches examined. The cacti are elevated somewhat on accumulated dust heaps. All but the cactus was grazed by sheep to within one-half inch of the soil. *Malvastrum coccineum, Sideranthus spinulosus, Liatris punctata,* and *Psoralea tenuiflora* were the only other living perennials.

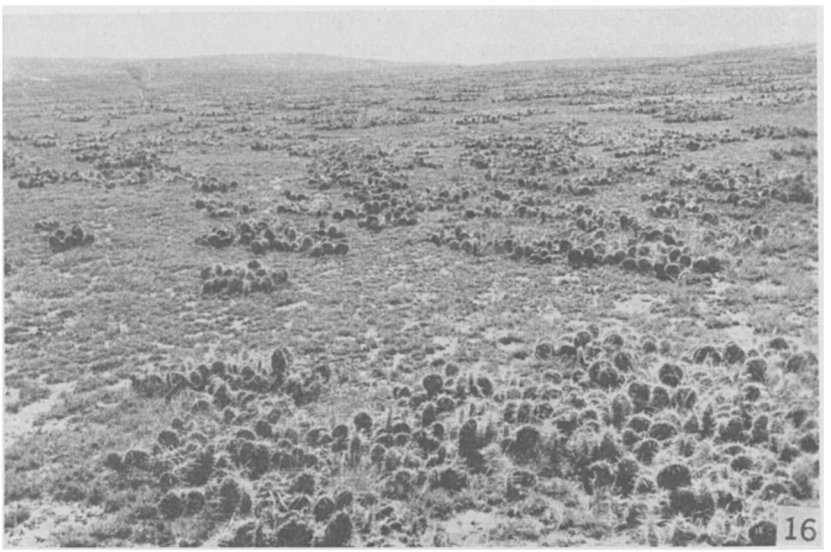

FIG. 16. Range of blue grama and niggerwool with traces of sand dropseed, wheat grass, etc., near the South Dakota-Wyoming state line west of Custer. Cactus occupies about 20 per cent of the area and the closely grazed grasses furnish a 20 per cent cover over the remainder.

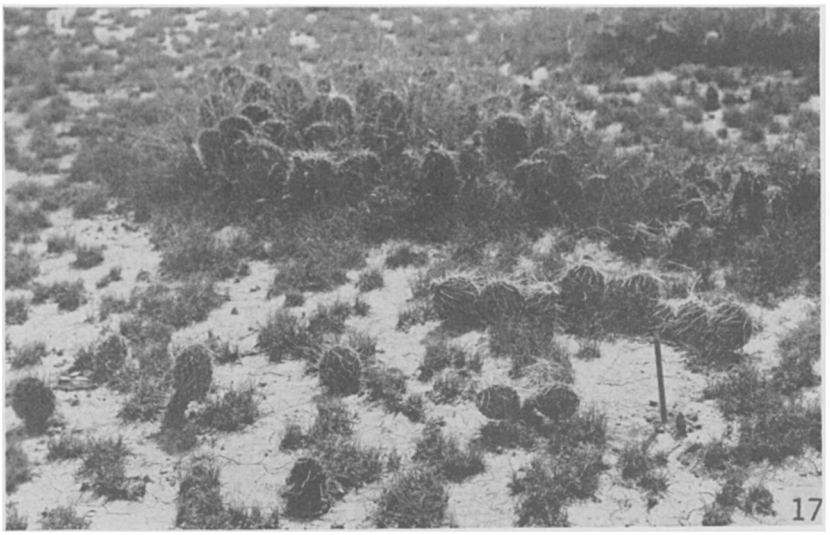

FIG. 17. Propagation of cactus by seedlings. The youngest, about 3 months old, is near the pencil; those with a single flat joint are probably one year old, while the plant showing 8 branches (beyond the pencil) has grown for several seasons. Note the typical openness of the vegetation in the foreground. Photo. August 18, 1939, near Limon, Colo.

ceeded through their early stages of development until they were killed and dried by drought. Large numbers of annuals —notably *Amaranthus retroflexus, A. blitoides, A. graecizans, Chenopodium album, C. leptophyllum,* and *Solanum rostratum*—were scattered in dusted pastures or grew thickly in the deposits of silt. Their stature was determined by the rainfall; they were mostly dwarfed in 1939 and only infrequently exceeded a height of 2 to 6 inches.

One of the worst perennial weeds is the cactus. Several genera are concerned but by far the most important are the species of *Opuntia.* The increase in numbers has resulted from the opening up of the grass cover. Even before the great drought many ranges were highly infested as a result of too close grazing. Since the great destruction wrought by this recent disaster, cactus has increased almost throughout. Much branched, circular individuals 3 to 5 feet or more in diameter and spaced only 6 to 10 feet apart occupy a large portion of the range land (figs. 15 and 16). Occupancy of 20 per cent of the soil by this pest is not uncommon. Ranges with greatly increased numbers and with only 50 to 25 per cent of the soil unoccupied by cacti occur. Some ranges are thus entirely worthless for grazing, and even jack rabbits are said to avoid them. Propagation in bare soil is rapid; it has been estimated that these plants are now 4 to 7 times as abundant as in 1934. Seedlings occur in untold millions, and are especially abundant about the parent plants. Joints of the stems are broken off by stock and frequently become rooted when the surface soil is moist, thus increasing the number (fig. 17).

In eradication of cactus by scraping them from the soil with a grader blade and removing them from the range, it is necessary to repeat the operation when the millions of shoots again grow from the fleshy crowns and roots. Manyspine prickly pear, *Opuntia polyacantha,* is very difficult to eradicate by grubbing because its widely spreading underground parts are capable of producing many new shoots (Harvey, '36). Although many

cacti were weakened by long periods of wilting, so intense and prolonged was the drought, yet it is probable that few died directly as a result of the heat and lack of water. They remained on areas of level land which were eroded as bare as a floor, except for the cacti, by dust laden wind. Burial by drifts of dust was fatal to many or to all in various situations, as is shown by their dead remains after the

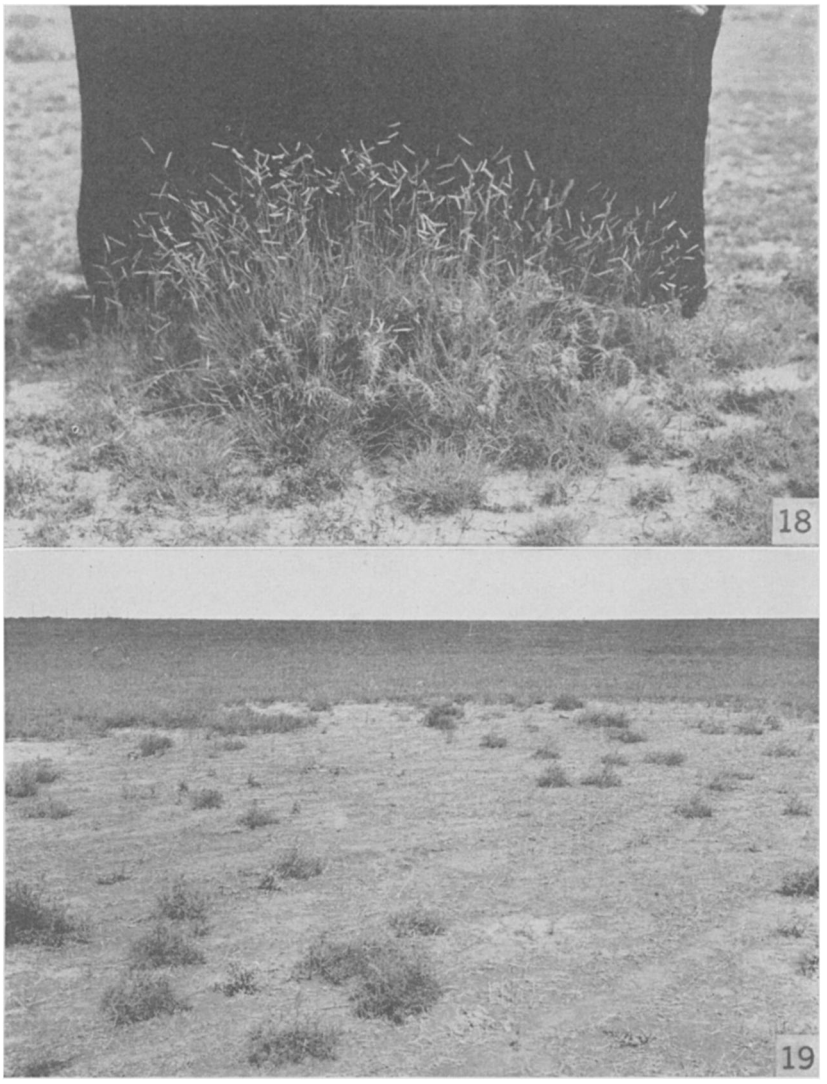

FIG. 18. Blue grama producing seed in a closely grazed range near Limon, Colo. Several of these bases often occur in a square rod. Where the cacti are smaller and isolated, grasses are less abundant and shorter. The surrounding vegetation, mostly blue grama, furnished a basal cover of only 15 per cent. The former vegetation was approximately one-half buffalo grass. Buffalo grass seems less drought resistant and sometimes almost completely disappears.

FIG. 19. Pasture near Oakley, Kans. The whole area has been dust-covered and the dust later removed. Russian thistles occur in the foreground and a dense, continuous growth of peppergrass 3 to 6 inches tall clothes the background. All grasses have been killed.

dust was again blown away. Elsewhere they grew upward through the accumulating heaps of silt and are now commonly elevated 4 to 6 inches above the former soil level. Other destructive agents are caterpillars, grubs, cochineal bugs, etc. Unless eradicated by man, however, many decades must probably elapse under the most favorable climatic conditions before the recuperated grasses can reclaim this territory once held by them.

Cacti, however, like most weeds, render certain valuable services in nature. Such are stabilizing the soil against wind and running water and furnishing oases of protection for range grasses against grazing animals (fig. 18). Here many species reproduce unharmed. Snow accumulates, and runoff water is dammed back until it enters the soil. The seedling grasses and forbs grow in partial shade and evaporation from the soil surface is much reduced. Where the cactus plants merge, such havens may extend several yards, often at right angles to the slope, and thus afford considerable areas for seed production by grasses and forbs. Buffalo grass is less likely to thrive, because of its unfavorable reaction to shade and the accumulated debris.

Pasture or Field

So great has been the disturbance to the grassland and so regularly have ruderals taken possession that it is frequently difficult to determine, except by close study, whether or not the land has been tilled. The landscape in summer for miles about is often one of Russian thistles in field and pasture (figs. 19, 20, and 21).

Reconstruction of the original cover from the dead remains is an interesting task. The fragments of rootstocks, the bits of stolons, the strong taproots of forbs, and even the grass roots themselves, together with comparison of adjacent more protected areas, make identification certain. Whether the dusting is recent or occurred during the earlier years of drought can often be determined. Previous knowledge of the area when vegetation was intact, and study during the several processes of deposit and denudation, as has been the opportunity of the writers, lends certainty to the exactness of sequence.

Degree of Deterioration

Drought damage to grasslands in true prairie can readily be determined, since many areas of variable size, often 80 to 160 acres or more, are kept for the production of hay, and stock is excluded (Weaver, Stoddart, and Noll, '35; Weaver and Albertson, '36 and '39). This, however, is not the practice in the mixed prairie, except on the extreme eastern edge, and on low lands unusually favored by run-in water. Practically all grassland is grazed, at least during drought. Hence, the present study is one of pastures and ranges.

A total of 88 well spaced, typical areas on non-sandy lands in the six states were carefully examined and basal cover determined. According to the amount of remaining cover of range grasses, they have been separated into five groups. Ranges with a cover of 21 per cent or more (exclusive of weeds) formed only 16 per cent of the total. Those with 11 to 20 per cent cover constituted another 16 per cent. The largest group, 28 per cent, presented a cover of 6 to 10 per cent. The basal cover of another 16 per cent ranged from 2 to 5 per cent, while nearly one-fourth of the grasslands (24 per cent) had a basal cover of only 1 per cent or less. Distribution of the good and bad conditions were not at all uniform. This was to be expected when so many causes or combinations of causes have operated to produce degeneration. The outstanding fact is the very poor cover.

Further Depletion or Recovery

Long continued drought imposes ever increasing hardships upon an already

weakened plant population. Drought has now prevailed, although intermittently, for a period of seven years. At the beginning of the catastrophe the store of seed on and in the soil was great. With the advent of showers many of the seeds germinated and developed seedlings, only to be destroyed by lack of a further moisture supply. This process has been repeated again and again, each interval of relief from drought witnessing the appearance of successively fewer seedlings,

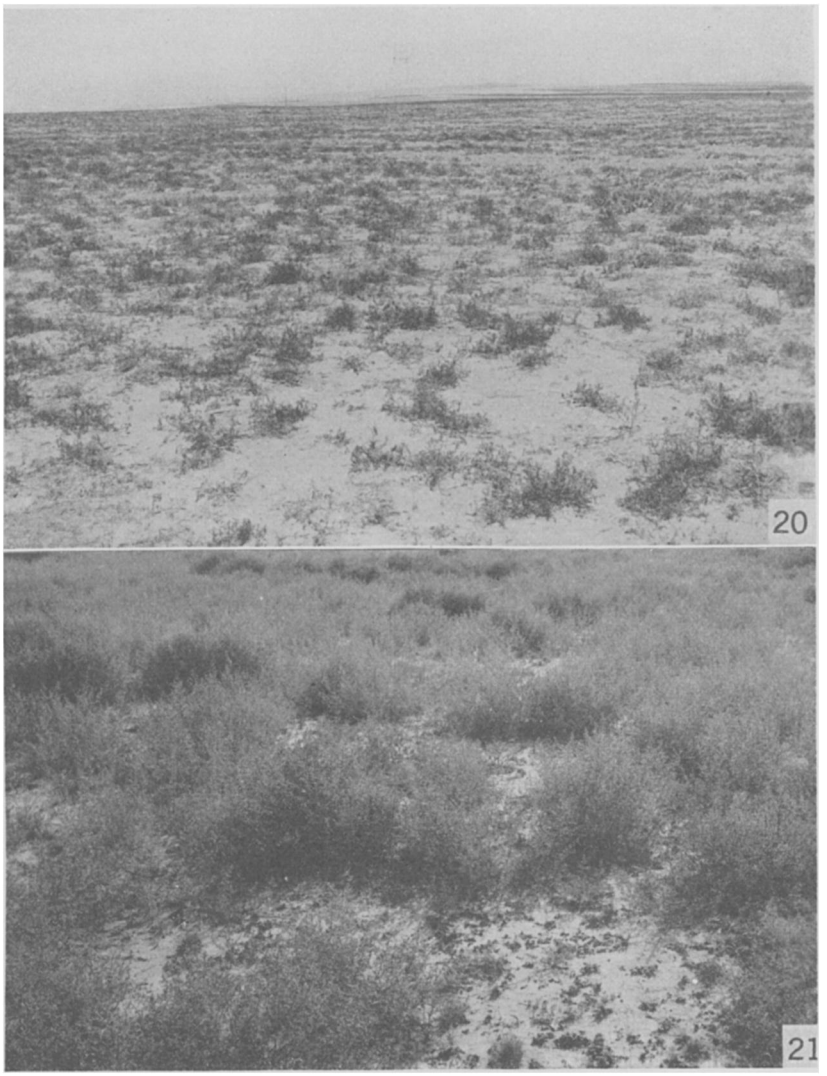

FIG. 20. Appearance of range near the Jay Em Ranch about 30 miles south of Lusk, Wyo. The soil is slightly sandy. The conspicuous plants are Russian thistles. The original cover consisted of blue grama, niggerwool, and needle grass, of which only remnants remain.

FIG. 21. Pasture near Boise City, Okla., on nearly level land that has been covered with silt and again uncovered. It is indistinguishable from the highway from weedy tilled land. Many of the Russian thistles are growing on drifts of soil. Although less than 1 per cent of the pasture cover remains, its former presence is clearly indicated by stolons and dead plant bases.

most of which met the same fate as the first. In addition, enormous supplies of seeds have been lost by dust burial, and by being eroded into low places and washed away. Thus the reserve may have been largely depleted. Moreover, fewer seed producing plants are available, and they are greatly weakened. Buffalo grass is not a good seeder normally, and blue grama tends to reseed

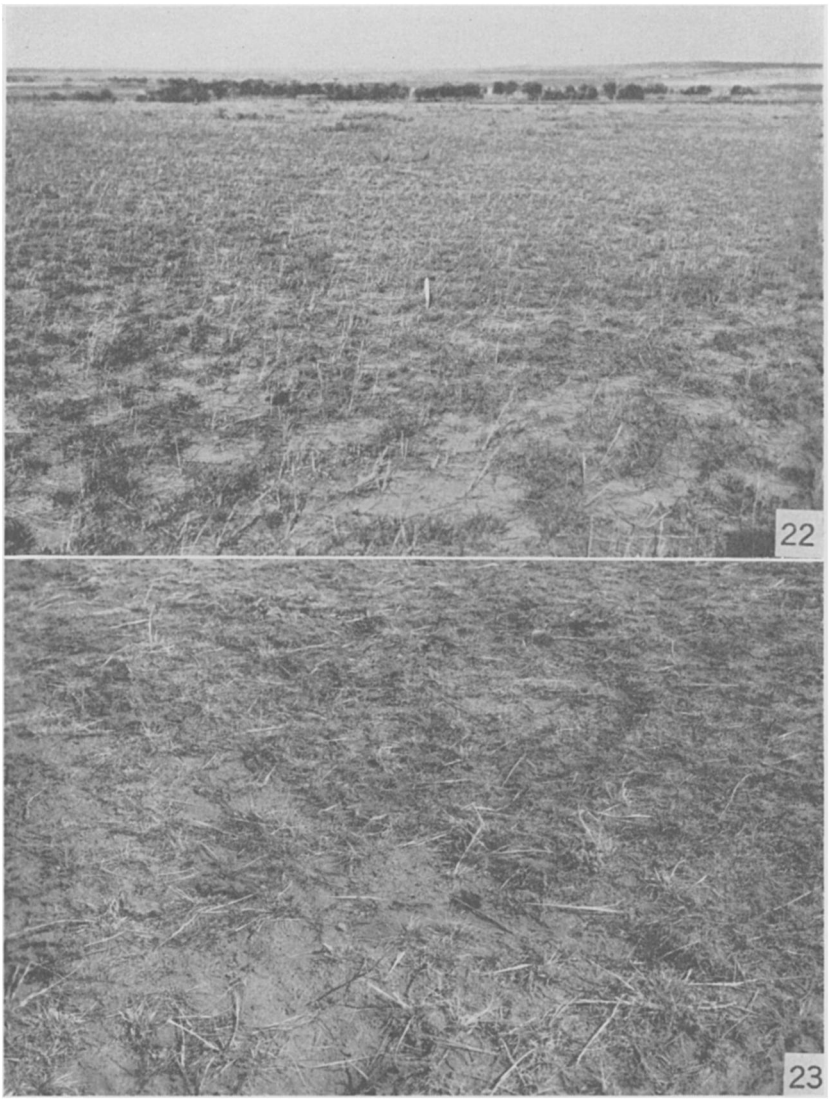

FIG. 22. A glimpse of an extensive overgrazed range near Ardmore, S. Dak. This is the blue grama-buffalo grass-wheat grass type. Although the dead stems of the mid grass are widely spaced, the rhizomes are alive and the tops would rapidly thicken up under protection and normal rainfall. The basal cover has been reduced to 10 per cent.

FIG. 23. Pasture near Lusk, Wyo., in needle grass-blue grama-niggerwool type, illustrating the evil effects of close grazing and trampling during drought. Basal cover is about 8 per cent. Grazing has been deferred until the stalks of the widely spaced bunches of *Stipa* were dry. They dried when only 6 inches long and have been trampled to the ground.

itself only slowly under conditions of grazing.

Conversely, many grass seeds are "hard" and remain viable for a very long time. In addition, various plains grasses, notably buffalo grass and blue grama can produce viable seed after only a few weeks of favorable weather for growth. Since scattered torrential rains occur over limited areas even during general severe drought, local new seed crops are usually produced each year. More-

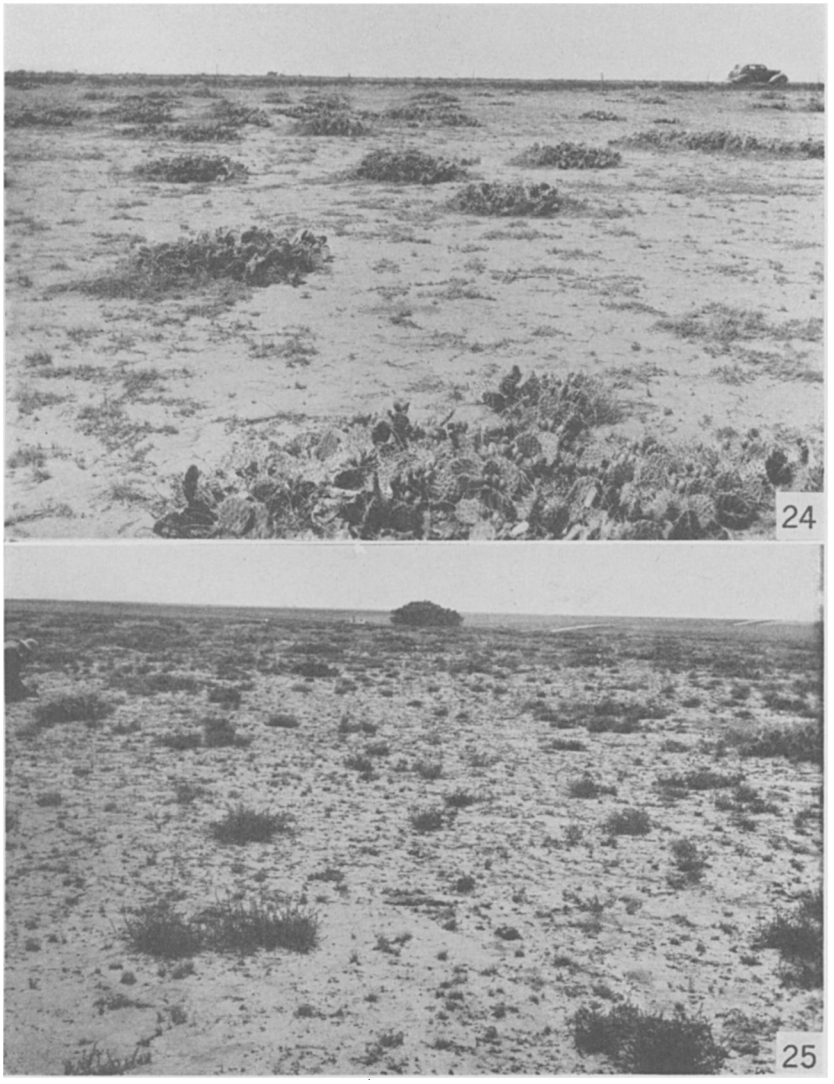

FIG. 24. Windswept pasture near Meade, Kans., which was formerly covered with dust. The cacti are on mounds 6 to 12 inches high. There are still remnants of the short grasses although the cover, aside from cactus, is reduced to 5 per cent or less. In many parts of this large pasture, seedlings of sand dropseed and other grasses were scattered, often thickly.

FIG. 25. Range near Cimarron, Kans., seriously damaged by dust burial. Dead crowns show clearly that the previous cover was high, probably 80 per cent. Some seedling grasses were found but have scant protection, if any, from wind and sun. The chief weed is Russian thistle.

over, rhizomes of xeric grasses remain alive in the soil for many years, and from even scattered bunches of relict mid grasses reseeding occurs at a surprising rate during times of favorable moisture supply (figs. 22 and 23). In western Kansas, for example, no grasses made any but slight growth during the spring and early summer of 1939. By midsummer they were completely dried. But responding to the rains of mid-August, flower stalks were produced in quantity

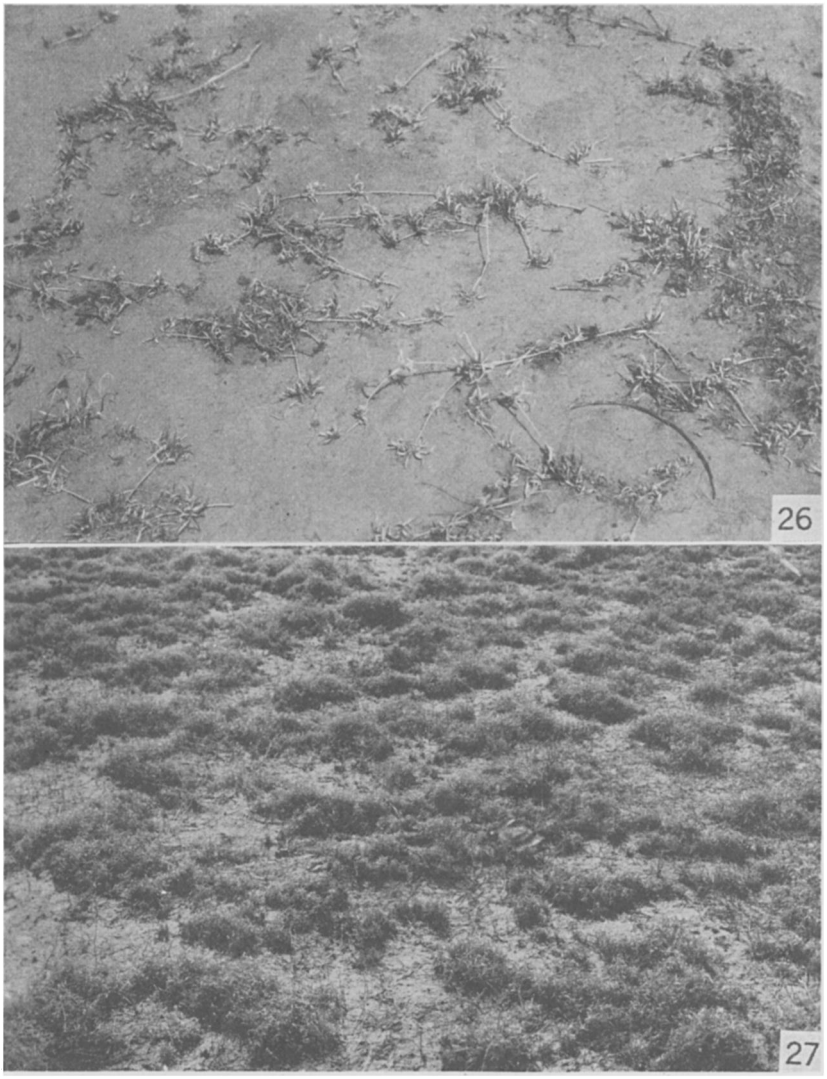

FIG. 26. Hard, windswept, level soil near Cimarron, Kans., where only a few widely spaced tufts of buffalo grass survived. Local showers permitted them to develop stolons, but the water supply was exhausted in mid summer and only the older and more deeply rooted offspring survived. This is typical of great areas where dusting has occurred.

FIG. 27. Buffalo grass pasture near Tyrone, Okla., showing the excellent recovery in almost pure stand, after great destruction as shown in figure 26. The proportions of grasses in this pasture are buffalo grass 85 per cent, blue grama 10, and sand dropseed about 5.

even from the widely spaced, drought relicts and some viable seed has been harvested. Such is the adaptation to life in the arid midwest.

Most pastures still contain sufficient grasses to provide a nucleus for rapid recovery under favorable climatic conditions (Savage, '37; Savage and Runyon, '37). Sand dropseed and side-oats grama, both prolific seeders, are widely scattered through this semiarid region. Many ranges, however, are so badly denuded that several favorable growing seasons will be required for them to develop a cover of good forage plants. The extremes approach abandoned, tilled fields where many believe 10 to 40 years is the necessary interval of time for the reestablishment of the climax (Clements and Chaney, '36).

Despite the arid summer of 1939, some pastures were found where surface moisture had been sufficient to promote the growth of abundant seedlings (figs. 24, 25, and 26). On bared areas, competition for water is less severe, unless weed infestations are very heavy, than in stabilized grassland. In fact, a moderate growth of taller cover is distinctly helpful in reseeding ranges. Abandoned lands are ordinarily prepared for grass seedlings by a previous crop of Sudan grass or other protective cover of an annual. This is mowed high to promote tillering but especially to prevent its forming seeds, later to develop seedlings which would compete with the young grasses for the precious water. The dead stubble and debris furnish protection from direct insolation, decrease evaporation, stabilize the soil by lessening the force of the wind in addition to increasing the supply of nutrients. A moderate growth of weeds in pastures and ranges has similar beneficial effects. If the tops of Russian thistles are mowed, the plants persist for a long time and do not so readily become detached from the soil and blow away (Savage, '39; Watson, '39).

During the period of drought certain mid grasses, notably side-oats grama and sand dropseed, have increased enormously in the eastern border of mixed prairie. Of the two most common short grasses of this association, blue grama is the more drought resistant but the slowest to reclaim the territory of which it has been deprived. Its sole method of propagation, aside from the very slow one of tiller production and short rhizome-like stem bases, is by reseeding. Buffalo grass, when conditions are favorable to growth, spreads rapidly and widely. Hence many grama-buffalo grass ranges have been transformed into pastures of nearly pure buffalo grass (fig. 27). On the other hand, this species has often greatly decreased in proportion to grama grass, and in many pastures has almost entirely disappeared.

The drying and rejuvenation of short grasses are of regular occurrence even during normal years. In drought-dormancy the color assumed varies from that of freshly ripened straw to tan, and then to shades of brown. But in death the characteristic bluish-gray or dark drab color is revealed. In many of the ranges during late summer of 1939, the vegetation crackled like straw when tread upon or crunched like dry snow. By brushing even lightly with the hand, the shriveled tops could easily be crumbled away. Close inspection showed that a few green shoots spaced well apart remained imbedded in the dried crowns. These are the sparks of life that still remain despite the drought in some areas practically without effective rainfall for an entire growing season. But the dark colored, tinder dry, shriveled tufts in some pastures gave no such sign of life, in fact life seemed extinct. Much depends upon autumnal rainfall. Although the writers know well the almost incredible ability of these range grasses to regenerate after drought, yet it seems that soil moisture before winter is not only needed but is in many places imperative to survival. Without such rains even further increases in range deterioration are inevitable.

Summary

A survey was made in the summer of 1939 of 88 ranges selected as representative of grazing lands in western Kansas and Nebraska, portions of southwestern South Dakota, eastern Wyoming and Colorado, and the Panhandle of Oklahoma.

Severe drought, overgrazing, burial by dust, and damage by grasshoppers have resulted in greatly reducing the cover of range grasses.

This portion of the mixed prairie has almost completely lost its upper story of mid grasses on the non-sandy lands. The short grasses and sedges have undergone a process of thinning which has resulted in only the most vigorous plants remaining alive. Many of the less xeric forbs have practically disappeared and only six or eight of the most xeric native forbs are regularly represented by much dwarfed and widely spaced individuals.

The basal cover of grasses was 21 per cent or more in only 16 per cent of the ranges. In another 16 per cent it ranged between 11 and 20 per cent. It varied between 6 and 10 per cent in 28 per cent, and was reduced to 2 to 5 per cent in another group totaling 16 per cent. The remaining one-fourth of the pastures (24 per cent) presented a cover of 1 per cent or less.

Extremely poor conditions varied with the better ones throughout. The bare soil during periods with moisture is populated with annual weeds, chief of which is Russian thistle. In many places it is only with difficulty that one can distinguish denuded pastures from weedy, tilled land. Cacti have increased greatly almost everywhere and constitute a serious problem.

Because of the low precipitation of 1939, most ranges have lost any gains made during favorable periods since 1934, and further reduction in vegetation seems certain if the winter also is dry.

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