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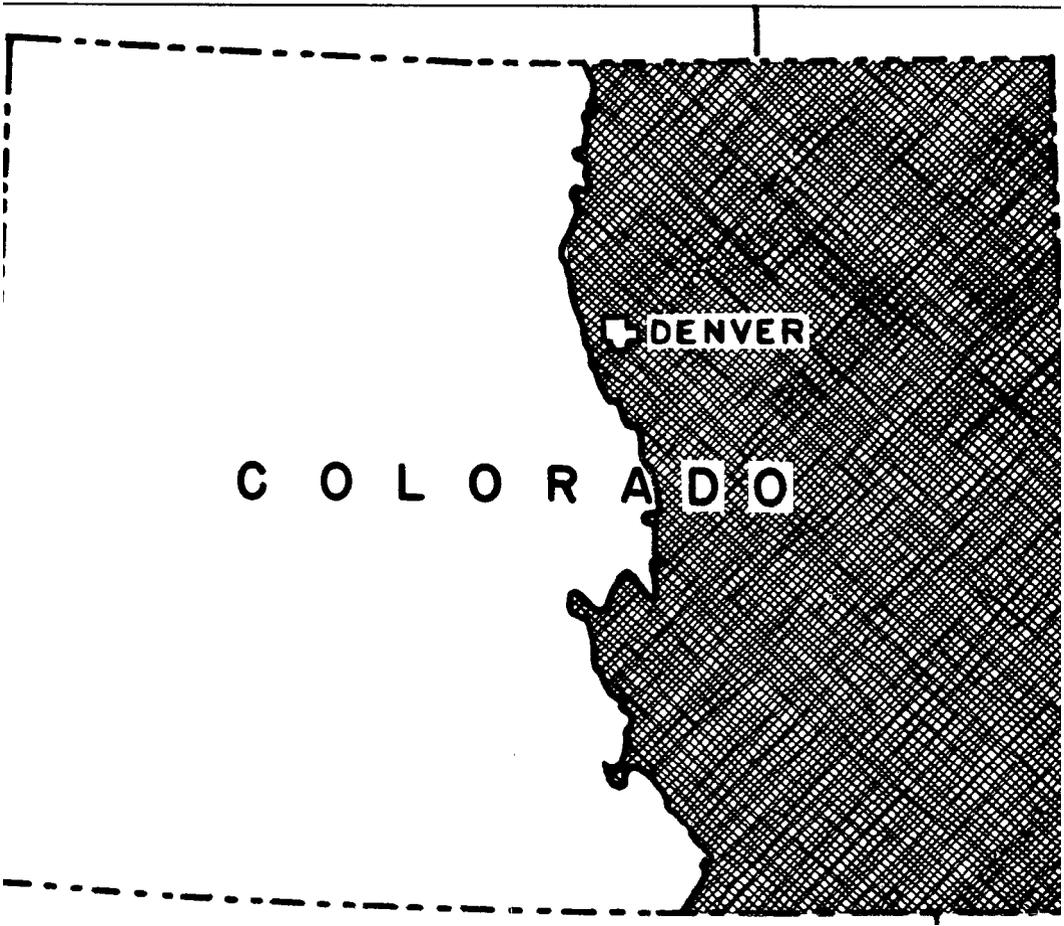
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Land Types in Eastern Colorado

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COLORADO AGRICULTURAL EXPERIMENT STATION
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Land Types in Eastern Colorado

Their Influence on Crop Yields and Land Use in the Various Climatic Zones of the Area (Dry Land)

L. A. BROWN, D. S. ROMINE, R. T. BURDICK, AND ALVIN KEZER¹

IN PLANNING LAND USE many criteria and indices of values have been used. The physical features of the land too often have been relegated to a place of secondary importance.

Whether a farmer is planning next year's crops, or a county is planning for the coming generation, or a nation is planning its possibilities of production under the burdens of war, plans can be no more sound than the analysis of the basic data. Basic physical factors include soils, slope or lay of land, and climate.

The primary object of an analysis of physical factors affecting crop production is to determine their effect on yields of adapted crops. It is the purpose of this bulletin to contribute to the knowledge of the land resources of eastern Colorado by showing the distribution of the various land types in the area and how these land types, in conjunction with the prevailing climatic conditions, influence crops grown, yields obtained, cultural practices, and land use on non-irrigated lands in the various climatic zones.

A land type map, graphs, and tables are included to show some of the relationships of land types and crop yields in eastern Colorado.

AREA COVERED IN THE ANALYSIS

Eastern Colorado is regarded as that portion of the State that is in the High Plains region. It is east of the Rocky Mountain Range front (fig. 1) and occupies about 45,000 square miles. Figure 2, a relief map of Colorado, shows the eastern part of the State as a relatively smooth eastward sloping plain crossed by the rather shallow valleys of the South Platte, Republican, and Arkansas Rivers and their major and minor tributaries.

Eastern Colorado is about 3,350 feet above sea level at its lowest point where the Arkansas River flows into Kansas. The highest portions of the area are the Platte-Arkansas Divide, known as the

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Credit is due R. H. Hausenbuiller and J. M. Allen, former student assistants in agronomy, for drafting assistance on the land type map and graphs. J. F. Brandon, superintendent, U. S. Dry Land Field Station, B. G. West and J. L. Nielsen, soil scientists, Soil Conservation Service, contributed valuable comments in the preparation of the final manuscript.

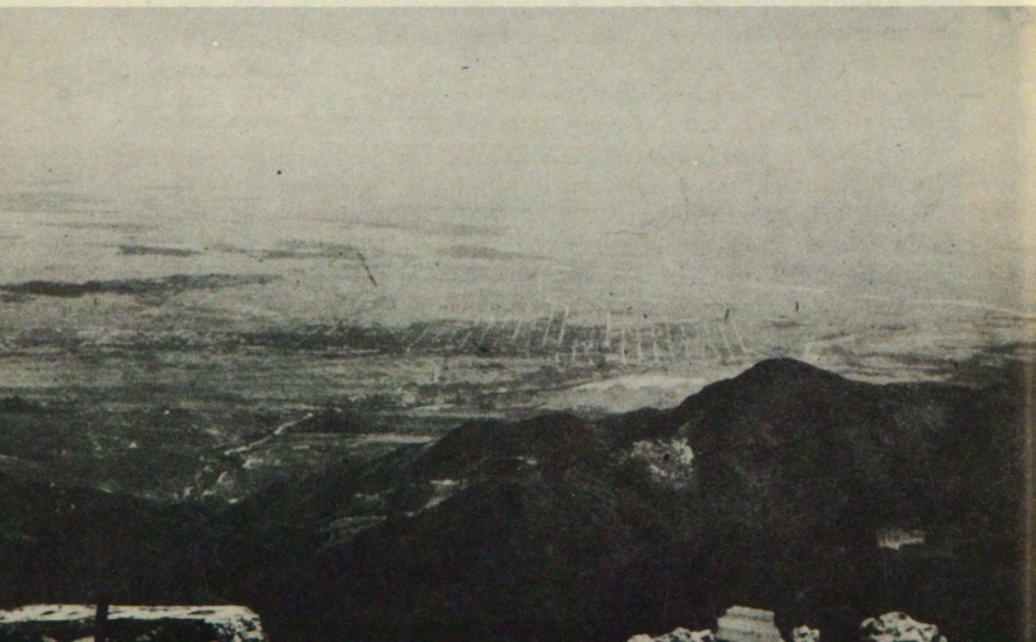
Black Forest (fig. 3), which is about 7,500 feet, and Raton Mesa, near Trinidad, which is about 9,000 feet above sea level.

The climate of eastern Colorado is continental and temperate. It is characterized by high summer temperatures, low winter temperatures, and variable, relatively low precipitation. Mean annual precipitation varies from 11 inches in parts of the Arkansas Valley to about 18 inches in the northeastern part of the area and in parts of the Black Forest. Furthermore, precipitation as low as 2.4 inches and as high as 36.2 inches has been recorded for a single year. This range in precipitation and differences in other climatic factors produce a wide variation in soil properties and the effectiveness of the moisture in producing plant growth. Dotted line boundaries on the accompanying land type map divide eastern Colorado into four climatic zones, dependent on the effective precipitation. The lines are based on U. S. Weather Bureau records of precipitation, seasonal distribution of the rainfall, temperature, and evaporation. Mature soil characteristics, altitude, and crop yields were used in certain parts of the area as a guide in determining the effective precipitation zone boundaries.

EROSION IN THE AREA

Land in eastern Colorado is subject to both wind and water erosion. The susceptibility of the grass land to erosion depends primarily on the extent of the vegetative cover. In general, the

Figure 1.—Looking eastward over the plains from Pikes Peak. The city of Colorado Springs is in the middle background. Wooded areas of the Black Forest show in upper left background.



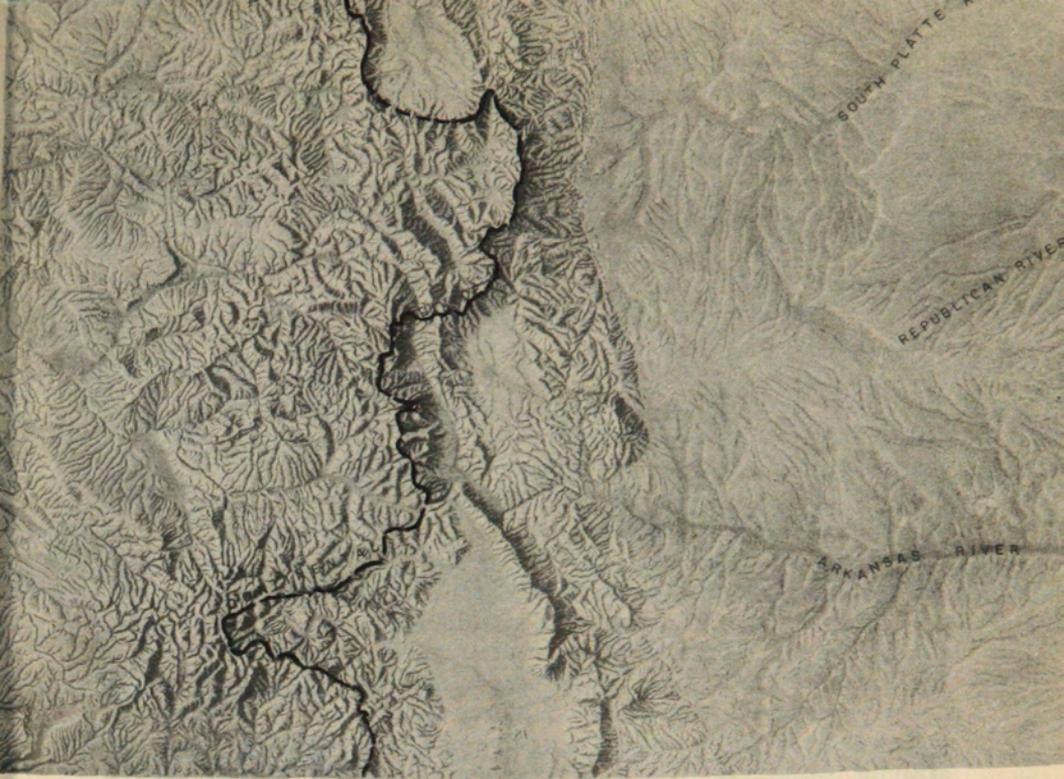


Figure 2.—Relief map of Colorado showing Continental Divide and the drainage basins of the South Platte, Republican, and Arkansas Rivers.

damage to grazing land caused by soil removal, except in overgrazed areas, is slight. However, severe damage to grassed areas by soil deposition from wind action has occurred on range land adjacent to eroding cultivated fields. These eroding areas are the source of the accumulations that blow across and destroy the native grass cover.

The land under cultivation varies widely in its susceptibility to wind and water erosion, depending primarily on relief, degree of protection by vegetative cover, intensity of the rainfall, and the inherent erodibility of the soil itself. Many areas of highly erodible soils that have been broken at various times in the past for crop production have been severely damaged by both wind and water erosion.

In general, sandy soils, particularly those low in organic matter, are more highly susceptible to wind action than are silty soils in the same precipitation zone (fig. 4). Sand soils and sands blow readily because of the low content of organic matter, silt, and clay which are the binding substances necessary for the formation of wind-resistant soil aggregates. The raw sands are loose and incoherent, and susceptibility to wind erosion is extremely high. In

the sandhill areas many "blowout" spots occur near watering places and bed grounds where the protective cover is usually thin or entirely lacking.

In discussing the susceptibility of sandy soils and silty soils to wind erosion, it is important to point out that under the same climatic conditions revegetation and consequent stabilization are less difficult to establish and maintain on the sandy soils than on the hard-land soils. This favorable characteristic of the sandy soils, to revegetate more easily and rapidly than the hard-land soils, constantly prevails in the lower precipitation zones and holds true over the entire area during years when precipitation is average or below.

Hard-land soils are less subject to wind erosion than sandy soils after early spring cultivation and seeding. However, like the sandy soils they are readily damaged by soil blowing if they are low in organic matter or if there is not sufficient cover of vegetation or its residue to protect the soil during late winter and early spring, the critical period when wind erosion is most likely to occur. Their susceptibility to wind erosion is progressively higher in the lower precipitation zones, because crop failures are more frequent and vegetative protection and organic matter content become more difficult to maintain. Large areas of hard-land soils as well as sandy soils in southeastern Colorado were subjected to serious blowing during the severe drought continuous from 1931 to 1940.

Serious damage to homesteads and fences (fig. 5) was caused by soil deposition. Soil blowing also had harmful effects on people and livestock in the area. Extensive damage occurred to crops,

Figure 3.—Eastern end of the Black Forest, El Paso County.

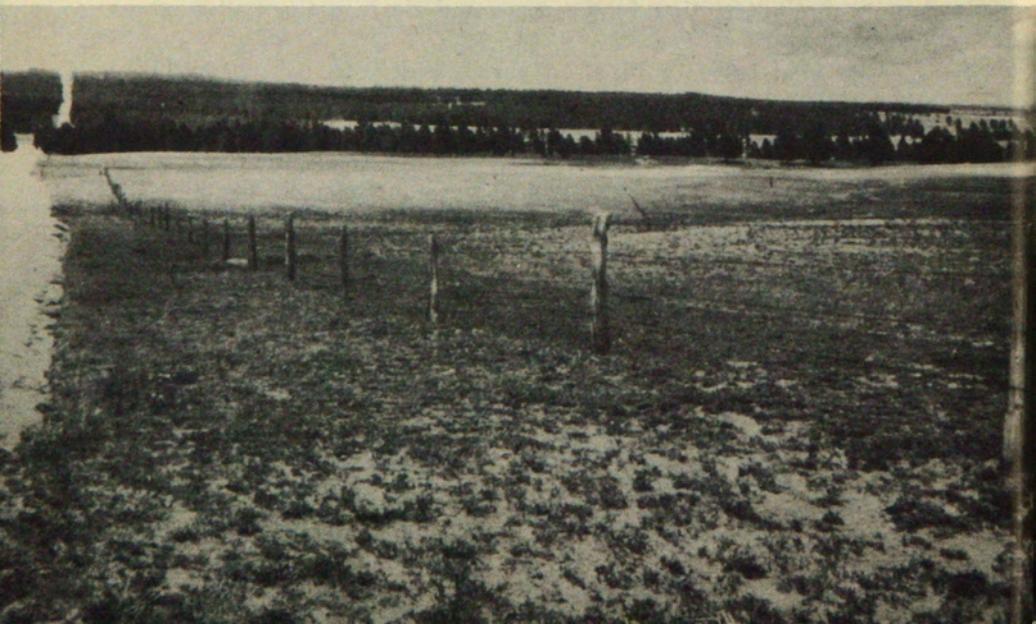


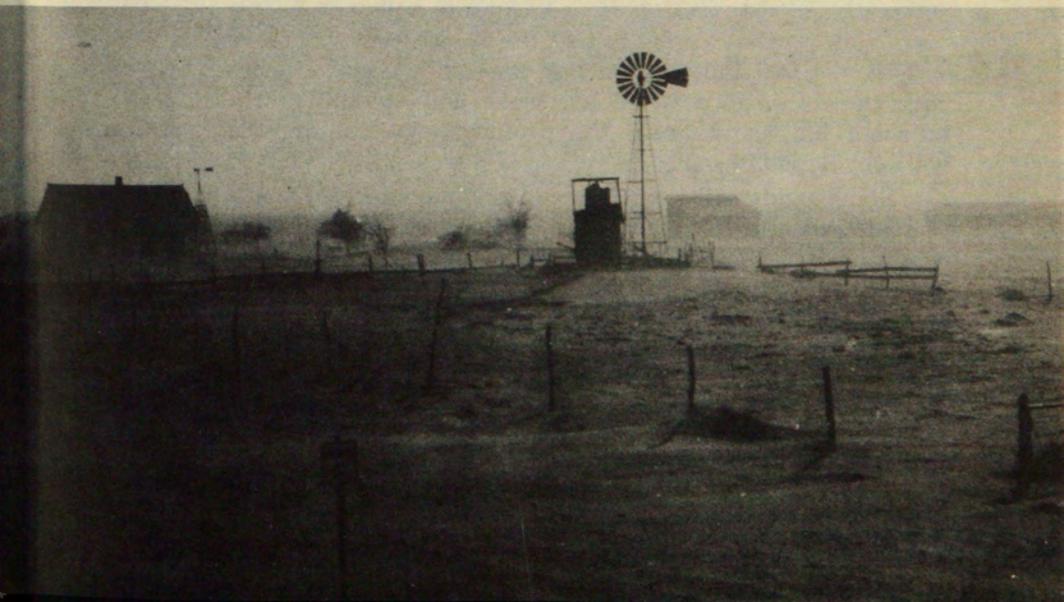


Figure 4.—Accumulations caused by wind are detrimental to cultivated fields, pastures, and fences. “Brown sandy soils of the nearly level uplands,” Kit Carson County. Courtesy Soil Conservation Service.

native pastures, roads, railroads, farm machinery, and other property. Dust storms during the drought period from 1931 to 1940 caused many areas in southeastern Colorado to be uninhabitable. Abandoned homesteads stood and some still remain (1944) as pathetic reminders of wasted human energy and resources.

Wind erosion becomes a hazard on nearly all cultivated areas of eastern Colorado soils in direct proportion to the percentage of

Figure 5.—Typical dust storm in Baca County during the severe drought that was continuous from 1931 to 1940. Picture taken November 17, 1938. Courtesy Soil Conservation Service.



years when crops do not make sufficient vegetative growth to protect the soil. The danger is, therefore, much greater in the lower precipitation zones. A very unstable condition occurs on many tracts in these less favorable rainfall areas. As a result of wind action, entire fields may be made unfit for cultivation, either because of soil movement within or from the fields, or because of deposition from an adjacent unprotected area. These severely eroded fields are a menace to adjoining lands. Crops and grass are often cut off by moving soil or covered over and destroyed. Wind is responsible for the greater part of the erosion damage on lands of less than 3-percent slope, while on the more sloping areas both wind and water erosion may be active.

Water erosion in eastern Colorado occurs most frequently on the sloping hard lands (fig. 6). Sloping areas of loose shallow surface soils overlying dense subsoils with slow permeability are especially susceptible to water erosion. The soils which are highly erodible generally have thin surface layers and the removal of only a few inches of soil may expose raw parent material. This loss of surface soil is of more significance on the shallow soils of the hilly lands than on the deeper soils. Water erosion on slopes of less than 3 percent may be difficult to detect by examination of the soil profile, but does occur as is evidenced by the presence of sheet and rill washing and consequent alluvial deposits on the lower areas in cultivated fields (fig. 7) and in adjacent roadside ditches. Gully erosion is in evidence and occurs both on the sloping hard lands and on sandy lands where definite drainage systems exist.

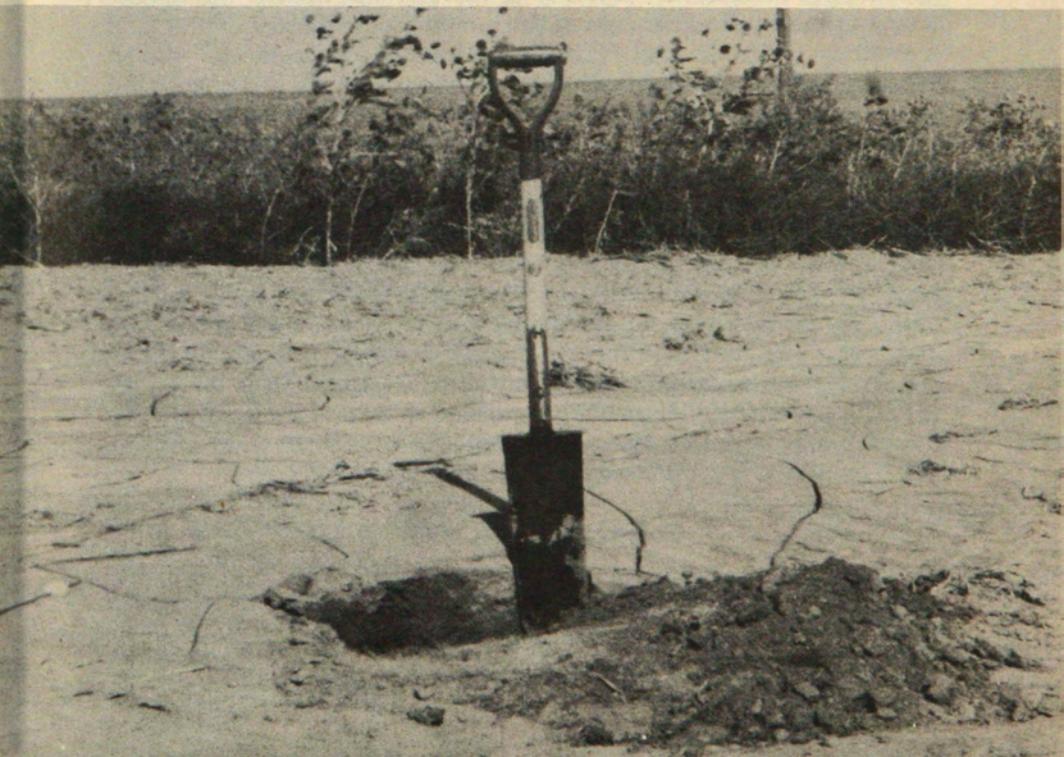
Under nearly all conditions sandy soils are less susceptible to water erosion than are silty soils. The sandy surface is generally more open and porous, thus permitting more rapid infiltration and allowing a greater proportion of the water to enter the soil. Consequently, surface runoff is reduced and soil removal is less than on the silty soils. Evidence that the surface runoff is less on sandy soils is the fact that in many of the sandy areas in eastern Colorado the drainage patterns are weak and indefinite, while on the adjacent hard-land areas the drainage systems are distinct and well developed.

Some sandy soils, when low in organic matter, have a tendency to seal over after a beating rain, causing runoff and erosion. This condition is especially pronounced in the Black Forest area where the soils are developed from arkosic materials. Soils with a sandy surface overlying silty subsoils will erode freely when the surface is saturated, particularly when the intensity of the rainfall is of torrential proportions. Gully erosion on sandy soils may be severe where a definite drainage system does occur and causes concentration of a head of water sufficient in size to move the saturated soil.



Figure 6.—Sheet and gully erosion from an uncounted field following a rain storm. Seeds or seedlings are washed out on the slopes and covered by soil in the lower areas. "Brown silty soils of the rolling uplands," Washington County.

Figure 7.—Water erosion on the "dark silty soils of the nearly level uplands," Yuma County. Eight inches of soil were deposited at the foot of a 2-percent slope in one rain storm.



The change in the fertility of soil which accompanies erosion is difficult to evaluate in eastern Colorado because no quantitative field tests have been made. Many of the cultivated areas that are highly susceptible to erosion have suffered severe damage. Low or unsatisfactory yields are the result, particularly in places where unproductive subsoils, zones of high concentration of carbonates, or areas with low organic matter content have been exposed by removal of the surface soil. Where proper soil and moisture conservation practices are not in use, these severely eroded areas will continue to increase in number, grow in size, and become an ever-increasing menace.

Observation over a period of several years indicates that most of the non-irrigated soils in eastern Colorado, except the extremely sandy areas, have sufficient available plant nutrients to produce as large a yield as is possible with the limited precipitation, thus emphasizing the need for making best use of the precipitation through water conservation practices.

The effects of erosion, however, are not confined to its influence on the supply of available plant nutrients. Native plant food in the soil is a valuable resource. It becomes immediately useful to mankind only when transformed into agricultural products. The environmental conditions and hazards which accompany active wind erosion prevent full utilization of this potential capacity to produce. Some of the most important reasons why uncontrolled wind erosion greatly reduces the stability of the soil and lessens the opportunity to take full advantage of the production capacity of the land in eastern Colorado are: (1) Erosion tends to accelerate erosion because drifting soil gradually becomes more sandy in texture and consequently more subject to wind action. (2) Stable soil aggregates are destroyed and conditions become less and less favorable for the natural formation of erosion-resistant aggregates. (3) Soil lower in organic matter and consequently more susceptible to wind erosion is exposed. (4) Crop stands become more and more difficult to establish, and replanting is necessary where the young seedlings are covered and killed by shifting soil during early spring. (5) The unstabilized fields require extra control operations and may not be in readiness for the operator to take full advantage of the production capacity of the land when precipitation is favorable. (6) The use of heavier machinery becomes necessary for the more complex and intensive operations required to control wind erosion. (7) The cost of production is increased.

LAND TYPE MAP

A generalized map showing the distribution of land types in eastern Colorado is enclosed in the back of this bulletin. A small

sketch at the upper right hand corner of the land type map shows, by shading, areas where semi-detailed and reconnaissance soil survey data were available for preparation of the map. Generalized land class and soil maps were used as a basis for showing land types where there is no shading. The map may be used as a basis for general land planning over rather large areas (not less than four townships), but will not serve as a detailed land resource inventory for any portion of the State included in the area.

LAND TYPES

Soil types of eastern Colorado have been grouped into ten land types. Each land type within itself represents a product of soil characteristics, slope, and effective precipitation that have given rise to areas similar in productivity and in general land use.

A few primary principles concerning precipitation-soil-crop relationships must be kept in mind if one is to understand the reasons for crop yield variations and the grouping of soils within this region. First, the amount of yearly precipitation in various parts of eastern Colorado varies from considerably less to slightly more than that necessary to produce satisfactory crop yields. Second, most of the non-irrigated soils contain enough available plant nutrients to produce a higher yield of any adapted crop than is possible under the limited precipitation. The crop-producing power of nearly any arable soil in the high plains is dependent on the amount of water it can absorb and retain for the use of plants. It is, therefore, important to **catch and hold the rainfall on the land where it falls.** All soils in eastern Colorado, except sands and a few gravelly or stony areas, are capable of holding all moisture they absorb close enough to the surface to be reached by plant roots. Soils having silty surface layers absorb water fairly rapidly, but they hold large amounts in the upper few inches of soil where it can be lost by evaporation. Sandy soils absorb water more rapidly, hold smaller amounts near the ground surface, and thus lose less by evaporation than do silty surface soils. Sandy soils, therefore, deliver more water to plants than silty soils and, in general, produce higher crop yields where precipitation is the limiting factor. The hard lands, however, serve as a larger reservoir for holding stored rainfall during high precipitation years.

A short description of the soil and slope characteristics and soil-crop relationships of each land type follows.

Dark Silty Soils (Hard Lands) of the Nearly Level Uplands and Terraces

This land type occupies most of the so-called "hard land" or "wheat land" portion of the northeastern part of Colorado. (See

map.)² It is highly important to the dry-land wheat farmers of the State, as it produces more wheat per unit area than any other land type (fig. 8). More than 90 percent of the land shown as this group on the map is nearly level.³ However, numerous rolling areas, too small to be shown on a map of the scale used, are included, as are the small basins that dot the uplands. These basin-like depressions vary in depth from only a few feet to as much as 20 feet below the level of the surrounding land. Storm water collects in the depressions to form intermittent lakes which persist over varying but usually short periods.

SOIL CHARACTERISTICS.—Keith, Sherman, Dunlap, Goshen, Rosebud, and Dawes loams, silt loams, and clay loams are included in this group. These soils occur in a higher effective precipitation zone than the adjacent brown soils of nearly level relief. This environment has favored a more luxuriant grass vegetation under virgin conditions. The accumulation of organic matter has, therefore, been greater, causing the surface soil of this group to be darker in color than that of the adjacent brown soils. The first

²**Land Type Terminology:** Locally land types in eastern Colorado are given such names as "hard land," "wheat land," "sandy land," and "row crop land." In order to have terms consistent with each other, it has been necessary to designate the land types according to texture of soils and their topography. Relation of local terms and those textural terms used here follow: Silty soils are hard lands, clay soils are gumbo or heavy lands, sandy soils are sandy lands, and sand soils and sands include sandhills and the associated nearly level to gently sloping sand soils.

³**Relief Terminology:** Nearly level areas are those having a slope of less than 3 percent, gently rolling areas those having a slope of 3 to 7 percent, rolling areas those having a slope of 5 to 12 percent, hilly to steep areas those having a slope of more than 12 percent.

Figure 8.—Combining wheat on the "dark silty soils of the nearly level uplands," Yuma County. Bumper wheat crops can be expected in from 1 to 3 years out of 10 over a large part of eastern Colorado.



four named have mellow, dark grayish-brown surface soils 10 to 20 inches thick underlaid by brown silty subsoils 8 to 12 inches thick that commonly become lighter colored with depth. They contain an abundance of lime carbonate below depths of 20 to 30 inches. Goshen soils occupy swale positions and receive some local runoff from adjoining soils. They are somewhat deeper than the other soils of this group. The substrata of Keith, Sherman, and Dunlap soils are limy, light-colored, silty materials. The Dawes soils have thin (4 to 7 inches) grayish-brown surface soils underlaid by dark grayish-brown columnar clay subsoils 8 to 12 inches thick. The Rosebud and Dawes soils rest at shallower depths on limy, light-colored, silty materials and soft sandstone.

LAND USE AND CROP YIELDS.—About 85 percent of this land type is under cultivation. Wheat is the main crop with forage sorghums and corn of less importance.

Crop yields vary widely from year to year and are remarkably well correlated with the total precipitation for the 12-month period ending when the crop is ready to harvest.*

TILLAGE PRACTICES AND EROSION CONTROL.—Farming practices on these soils are much the same as on the wheat farming areas throughout the High Plains. Wheat is planted in September, makes a small growth in the fall, remains dormant through the winter, resumes growth in the spring, and matures in July. Large type machinery is used for most of the tillage, planting, and harvesting operations. Alternating clean fallow with wheat is a common practice. Continuous wheat cropping is often practiced on this land type during cycles of favorable precipitation when the soil is moist to a depth of 30 inches or more at seeding time. Forage sorghums and corn are planted late in the spring, row-tilled until midsummer, and harvested in the fall. Water erosion on these soils is slight, except on the included sloping areas. However, there may be considerable runoff and consequent loss of moisture from fallow land even on slopes as low as 1 percent. Wind erosion may become a hazard in years of relatively low precipitation.

To check wind erosion, farmers attempt to reduce wind velocities at the surface of the ground. This is accomplished by one or more of the following practices: growing a crop, leaving a high stubble, strip cropping, blank listing, and maintaining a cloddy condition of the surface soil. The soils in this group retain a cloddy surface much longer than the more sandy soils.

*Figures 21, 22, 23, and 24, pages 29, 30, 31, and 32, show the expected average yields and most probable yield distribution over an average 10-year period of the main crops grown on this land type in comparison to those obtained on other land types in eastern Colorado and in comparison to the average "cost of production" yields. More detailed data on crop yield distribution are given under the discussion on "Crop Yields" on page 27.

A number of methods designed to increase yields on these soils by retaining the precipitation where it falls are being practiced successfully by a number of farmers in eastern Colorado. These methods include contour farming, the use of level broad base terraces (fig. 9), and maintaining a trashy surface, generally referred to as trashy tillage. Stubble mulching as a moisture conservation and erosion control practice is still under study in eastern Colorado. All these methods are designed to reduce surface runoff. The stubble mulch also decreases evaporation losses. Timely tillage and weed control to conserve moisture are valuable aids to increase production and may make the difference between a crop and a failure.

Dark Sandy Soils (Sandy Lands) of the Nearly Level Uplands and Terraces

The soils in this land type occupy most of the "corn land" in northeastern Colorado. They are highly important to the dry-land agriculture of the State even though they occupy a much smaller total area than several other land types. This is because their level of productivity for corn and adapted sorghums is the highest of any major area of non-irrigated land in Colorado.

Most of the land shown as this type on the map is nearly level, but many sandhill areas, too small to be shown on the map, are

Figure 9.—Level broad base terrace on a 1½-percent slope. "Dark silty soils of the nearly level uplands," Kit Carson County. Terraces like this, constructed without a channel above or below the terrace, can be farmed readily with heavy machinery. Courtesy Soil Conservation Service.



included. Likewise, many small areas of dark sandy soils are included in the "sandhill" land type on the map.

SOIL CHARACTERISTICS.—Haxtun sandy loams and loamy sands are the major soil types in this group. They have dark grayish-brown sandy surface soils 10 to 30 inches thick, and loamy to sandy clay loam subsoils of lighter colors 8 to 16 inches thick. The underlying material is limy and consists of any sandy or silty mantle rock common to the region. In general, the physical characteristics of these soils are nearly ideal for the maximum year after year yields of dry-land crops, particularly corn. The surface soils are high in plant nutrients and possess a rapid absorbing rate for moisture but a rather low moisture holding capacity. Thus, the surface soils pass a relatively large percentage of the precipitation into the subsoil. The subsoils contain a higher percentage of clay than the surface soils, so they are capable of holding large amounts of water for plant use.

LAND USE AND CROP YIELDS.—Most of this land type is under cultivation. Corn is the dominant crop, with sorghums and small grains of minor importance.

Crop yields do not vary as widely from year to year as on the dark silty soils, but vary with the total precipitation for the 12-month period ending when the crop ceases growing.

TILLAGE PRACTICES AND EROSION CONTROL.—Times of planting and harvesting crops on this land type are about the same as on the "dark silty soils," page 11. Tillage methods are, however, more specifically designed to prevent wind erosion. Corn is planted in deep furrows, the corn stubble is left standing through winter and spring, and winter wheat, where grown, is seeded between corn rows (fig. 10), harvested the following summer, and the stubble listed in the fall crosswise to the prevailing wind. This procedure provides a source of organic matter and helps to reduce wind velocities at the surface of the ground so that shifting of the sandy surface is held to a minimum.

Wind erosion, if not controlled on these soils, is a hazard to young crops, but water erosion is seldom extensive enough for its effects to be observed. Approved wind-erosion control practices on this land type are drilling fall grain between rows of intertilled crops, blank listing, and proper stubble management, which includes trashy tillage and leaving a high stubble. Such measures as emergency tillage and emergency plantings become necessary in some instances to control active wind erosion. A crop or crop residue cover should be maintained as much of the time as possible. Keeping the topsoil well supplied with organic matter helps to prevent wind erosion on this land type.



Figure 10.—Wheat seeded between corn rows on "dark sandy soils of the nearly level uplands," Phillips County.

Brown Silty Soils (Hard Lands) of the Nearly Level Uplands and Terraces

This is the most extensive land type in eastern Colorado. It occupies large continuous areas in nearly all parts of Precipitation Zones II and III. The agricultural utilization of these soils differs markedly between the two zones, and the areas shown as this land type on the map in reality represent two different groups of agricultural lands shown in the same color but separated by the precipitation zone lines.

More than 90 percent of the land shown as this type on the map is nearly level. However, numerous rolling areas, too small to be shown on the map, are included, as are the small intermittent lake basins.

SOIL CHARACTERISTICS.—Weld, Rago, Platner, Campo, Baca, Nunn, Colby, and Fort Collins silt loams, clay loams, and loams are the dominant soils in this group. The first six have grayish-brown silt loam, clay loam, or loam surface soils, 3 to 8 inches thick, underlaid by prismatic or columnar clay loam, 8 to 16 inches thick. The substrata are dominantly limy loess and limy fine-grained sandstones. The Fort Collins soils have brown, silty surface soils, 5 to 10 inches thick, underlaid by limy, light brown, silty material extending to depths of 3 feet or more.

LAND USE AND CROP YIELDS.—In Precipitation Zone II, about 75 percent of this land type is or has been under cultivation. Wheat and forage sorghums are the main crops, with corn grown to some extent in the northern part of the zone, and grain sorghums becoming a major crop in the southern part.

In Precipitation Zone III, less than one-half the land area in this type is under cultivation. Forage sorghum is the main crop in the drier years, but the wheat acreage is high when soil moisture conditions are favorable at seeding time. Corn is a minor crop in the northern part, and grain sorghums are grown in the southern part on this land type.

Crop yields vary widely from year to year and are remarkably correlated with the total precipitation for the 12-month period, ending when the crop is ready for harvest.

TILLAGE PRACTICES AND EROSION CONTROL.—Farming practices are essentially the same for these soils as for the "dark silty soils of the nearly level uplands and terraces," page 11. However, years of low precipitation are more frequent on areas of the "brown soils," and erosion hazards resulting from short crops or crop failures are more intense. Contour farming (fig. 11), strip cropping,

Figure 11.—Field of shocked sorghum planted on contour, "brown silty soils of the nearly level uplands," Cheyenne County. High stubble was left for soil protection against wind erosion.

Farming on the contour helps to hold moisture where it falls, giving it ample time to penetrate the soil. The additional moisture held on the land increases yields and helps to keep the soil in proper condition to resist blowing.



broad base terracing, trashy tillage (fig. 12), rough cloddy tillage (fig. 13), blank listing, proper stubble management, timely tillage, and weed control are approved practices for erosion control and moisture conservation on this land type. Emergency tillage and emergency plantings are immediate measures used to prevent and check active wind erosion on unstabilized areas.

Brown Silty Soils (Hard Lands) of the Rolling Uplands

These soils occur generally as long, rather narrow areas along the larger streams in all four of the precipitation zones in eastern Colorado. (See map.) The agricultural utilization of this land differs from zone to zone and the areas shown as this land type on the map in reality represent four different groups of agricultural lands shown in the same color but separated by the precipitation zone lines.

Within this land type, the surface is rolling, but numerous nearly level upland and long narrow stream valley areas, too small to be shown on the scale used, are included.

SOIL CHARACTERISTICS.—Colby, Stoneham, Renohill, and Elbert loams and silt loams are the dominant soils in this group. The first three named have brown, commonly limy silt loam or loam surface soils, 4 to 10 inches thick, and lighter colored, usually highly limy subsoils, and substrata of any fine sandy or silty and clayey parent materials common to the region. Elbert soils have brown or grayish-brown non-calcareous surface soils, 4 to 8 inches thick, and

Figure 12.—Trashy tillage on the "brown silty soils of the nearly level uplands," Logan County. Courtesy Soil Conservation Service.

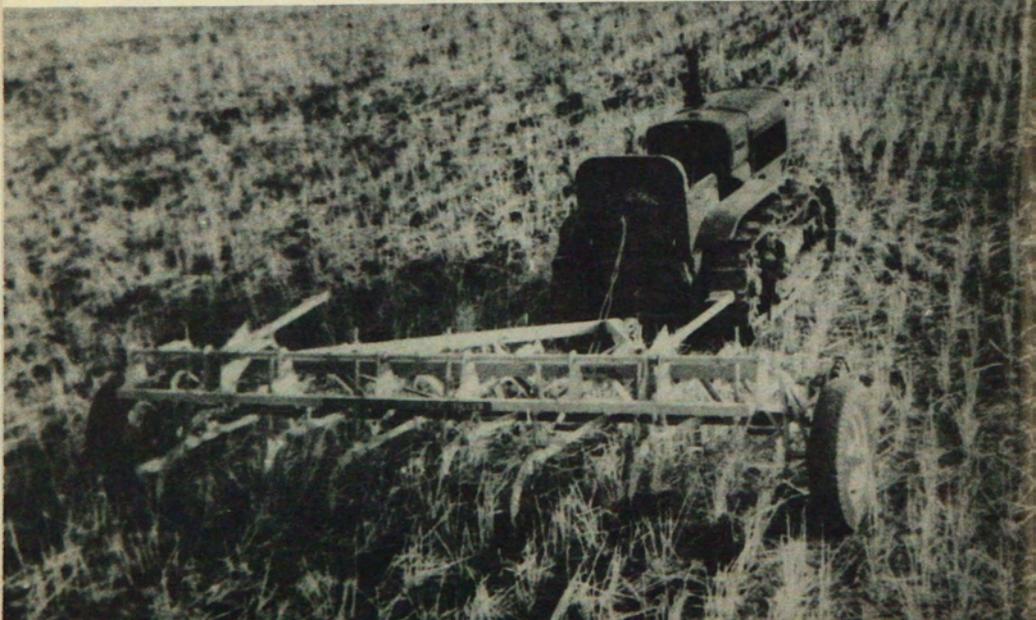




Figure 13.—Rough cloddy tillage with crop residues left on the surface prevents damage by wind erosion and helps to conserve moisture. "Brown silty soils of the nearly level uplands," Lincoln County.

brown to dark brown clay loam to light clay subsoils, 14 to 20 inches thick. Lime occurs at from about 2 to 5 feet. The Colby silt loam occupies over 85 percent of the land type. It is generally a silt loam texture from the surface to depths of 3 feet or more.

LAND USE AND CROP YIELDS.—In Precipitation Zone I, about one-third of this land is under cultivation; the remainder is utilized as native pasture. The cultivated areas are used mainly for the production of corn and forage sorghums.

In Zone II, about one-fifth of this land is under cultivation; the remainder is utilized as a native pasture. The cultivated areas are used mainly for the production of forage and grain sorghums. In Zones III and IV, nearly all this land type is utilized as native pasture.

Although these soils lose more water by surface runoff than do silty soils of more nearly level land, they average a little higher in fine sand content, absorb water more readily, and lose less moisture by evaporation than do adjacent level silty soils. Vegetative growth per plant is usually less, but plant survival is greater on this land type than on the adjacent level silty soils. As a result, the "brown silty soils of the rolling uplands" on slopes of less than 6 percent produce similar yields of most crops in years when precipitation is average or below average.

TILLAGE PRACTICES AND EROSION CONTROL.—Under cultivation, soils of this land type are subject to considerable removal of surface soils by water erosion. The "soil washing" often damages the crop stand and may remove organic matter and available plant nutrients to an extent sufficient to reduce crop yields.

Farming practices on these soils are similar to those used on the adjacent level silty areas, as many cultivated fields consist of both level and rolling silty soils. Contour tillage and terracing are very effective for erosion control as well as for moisture con-

ervation and increased production. Strip cropping, trashy tillage, rough cloddy tillage, blank listing, timely tillage, conservation of crop residue and stubble, and weed control are effective measures for erosion control and moisture conservation on this land type. Immediate measures used to prevent and check active wind erosion are emergency tillage and emergency plantings. Contour furrows (fig. 14) and water spreading are effective soil and moisture conservation practices on the range land.

Brown Sandy Soils (Sandy Lands) of the Nearly Level to Gently Rolling Uplands and Terraces

The soils in this land type are highly important to the "dry-land" production of field crops in Precipitation Zones II, III, and IV, even though they occupy much smaller total area than the level silty soils of those zones. (See map.) This is because their level of productivity for corn and sorghums is much higher than that of any other non-irrigated lands in the vicinities where they occur.

Most of the land shown as this type on the map is nearly level to gently rolling, but many sandhill enclosures, too small to show on a map of this scale, are included. Likewise, many small areas of nearly level to gently rolling brown sandy soils are included in the "sandhill" land type on the map.

Figure 14.—Snow held in contour furrows on range land, "brown silty soils of the rolling uplands," Elbert County. Courtesy Soil Conservation Service.





Figure 15.—Grain sorghums rarely fall on the sandy lands of eastern Colorado. "Brown sandy soils of the nearly level to gently rolling uplands," Baca County.

SOIL CHARACTERISTICS.—Vona, Blakeland, Otero, Ascalon, Bresser, and Greeley loamy sands and sandy loams are the main soils included in this land type. They have brown sandy surface soils, 6 to 16 inches thick. Substrata are sandy, commonly limy, light colored materials. Lime is at or near the surface in the Otero, below plow depth in the Vona and Greeley, and below 4 feet in the Blakeland and Bresser soils. Ascalon and Bresser soils have sandy clay loam subsoils and are generally referred to as moderately sandy soils.

LAND USE AND CROP YIELDS.—In Precipitation Zone II, most of this soil is under cultivation. Corn is the major crop in the northern part and broomcorn, forage sorghums, and grain sorghums (fig. 15) predominate in the southern part of the area.⁵

In Precipitation Zone III, about two-thirds of this land type is under cultivation; the remainder is utilized as native pasture. Corn and forage sorghums are the main crops in the northern part, and forage and grain sorghums predominate in the southern part of the region.

In Precipitation Zone IV, less than one-fourth of these soils are under cultivation; the remainder of the area is utilized as native pasture. Forage and grain sorghums are the main crops as a source of supplemental feed. Because of the low rainfall and wind erosion hazards, dry farming is not advisable in this zone.

⁵Broomcorn yields average from 200 to 250 pounds per acre. Other crop yields are shown on Figures 21, 22, 23, and 24, pages 29, 30, 31, and 32.

TILLAGE PRACTICES AND EROSION CONTROL.—Farming practices, type of erosion hazards, and methods of reducing these hazards are essentially the same for this land type as for the “dark sandy soils of the nearly level uplands,” page 14. Strip cropping (fig. 16) is more generally practiced on this land type than on the “dark sandy soils.” Contour tillage is generally recommended as an additional erosion control practice for this land type on slopes of more than 3 percent. Terracing has given good results on the moderately sandy soils in this group occurring on slopes of more than 3 percent. Wind erosion on these soils becomes increasingly severe in Precipitation Zones II, III, and IV, since the proportion of years when a vegetative cover for the land is not produced becomes increasingly larger. Consequently, the need for such measures as timely tillage, emergency tillage, and emergency plantings becomes more intense.

Light Brown Silty Soils (Hard Lands) of the Nearly Level to Gently Rolling Uplands and Terraces

Soils of this group occur on nearly level to gently rolling silty areas in Precipitation Zone IV. There are some areas of undulating silty soils and nearly level sandy soils, too small to be shown on a map of the scale used, included with this light brown silty land type.

SOIL CHARACTERISTICS.—Prowers, Tyrone, Minnequa, and Rocky Ford silt loams and clay loams are the dominant soils in this group. They all have light brown or light grayish-brown, limy, silty surface soils 3 to 5 inches thick. The subsoil and substrata differ only slightly in visible characteristics from the surface

Figure 16.—Strip cropping with sorghum and beans. “Brown sandy soils of the gently rolling uplands,” Elbert County. The high sorghum stubble reduces soil blowing and catches drifting snow.



soils, being only slightly lighter colored and commonly slightly more clayey in texture.

LAND USE AND CROP YIELDS.—Only a few fields are used to produce cultivated crops on this land type, except where the soils are irrigated. Dry-land crops have only a small chance of producing a profitable crop yield.⁶

TILLAGE PRACTICES AND EROSION CONTROL.—The soils in this land type are highly erodible but generally are protected by native grass. This grass cover should be maintained and protected by controlled grazing and proper range management. Contour furrowing, pasture corrugation, and water spreading are practiced for moisture conservation on range land.

Clay Soils (Gumbo or Heavy Lands) of the Nearly Level to Gently Rolling Uplands and Terraces

This land type is most extensive in the south central part of eastern Colorado. On the map it includes numerous level to rolling areas of silty or sandy soils that are too small to segregate on a map of the scale used. In general, the land type is nearly level. However, part of the land has slopes of 3 to 7 percent.

SOIL CHARACTERISTICS.—Pierre, Ordway, Orman, and Billings clays are the most extensive soils in this group. They have light to heavy clay, commonly limy, light brown to dark brown topsoils 3 to 10 inches thick. Under the surface soil is massive clay or clay shales extending to depths of more than 3 feet. Layers of gypsum or other alkali salts are common throughout these soils.

In general, the texture profiles of these soils are the least adapted for crop production of any land type in eastern Colorado. The surface soils are so high in clay that they are only slowly permeable to water; therefore, a large proportion of all torrential rain is lost by surface runoff. They also hold large amounts of water near the surface, where it is lost by evaporation. The amount of available water remaining for plants is obviously quite small.

LAND USE AND CROP YIELDS.—Most of this land type is utilized as native pasture. Some areas are under irrigation, and a few attempts have been made to "dry farm" some of these soils with unsatisfactory results. Crop yields are considerably lower than for adjacent areas of silty soils on nearly level land.

TILLAGE PRACTICES AND EROSION CONTROL.—The soils in this type, even when protected by native grass cover, are subject to serious damage by gulying (fig. 17). Contour furrowing, pasture corrugation, and water spreading, to reduce the velocity of runoff

⁶Figures 21, 22, 23, and 24, pages 29, 30, 31, and 32, compare expected average yields from these soils with those of other land types.



Figure 17.—Severe gully erosion on the “clay soils of the nearly level to gently rolling uplands and terraces,” Elbert County. Such destruction of the terraces and swales by gully erosion greatly reduces the carrying capacity of this land type. Courtesy Soil Conservation Service.

water and prevent water accumulation in channels or small gullies, appear to greatly retard the gullying of these pasture areas. Proper stocking is very important not only for erosion control but for increasing production of pasture grasses.

Undifferentiated Shallow Soils (Hilly Land) of the Rolling to Steep Uplands

This land type occupies many large and small areas throughout eastern Colorado. Unfortunately, numerous areas of this type are too small to show on a map of the scale used so were included in other land types. In general, these soils and parent materials are on slopes greater than 12 percent.

SOIL CHARACTERISTICS.—Canyon and Apache stony loams, Colby silt loams, steep phase, Travesilla stony sandy loam, Larimer gravelly loam, Lismas clay, and exposures of the parent materials of these soils occupy most of the areas shown on the map as belonging to this land type. Except in coves or at the foot of slopes, the surface soils are less than 6 inches thick and rest directly on parent material of limy silty loess, soft limy sandstone, hard lime-free sandstone, gravel, or shale.

LAND USE AND CROP YIELDS.—Practically all areas of these soils are utilized as native pasture. Their maximum grass production varies, depending on annual precipitation, soil characteristics, steepness of slope, and proportion of area occupied by bare spots and narrow alluvial valleys.

TILLAGE PRACTICES AND EROSION CONTROL.—On slopes as steep as 12 percent or more, good range management practices have been more successful in increasing the production of pasture grasses and controlling soil erosion than have mechanical methods.

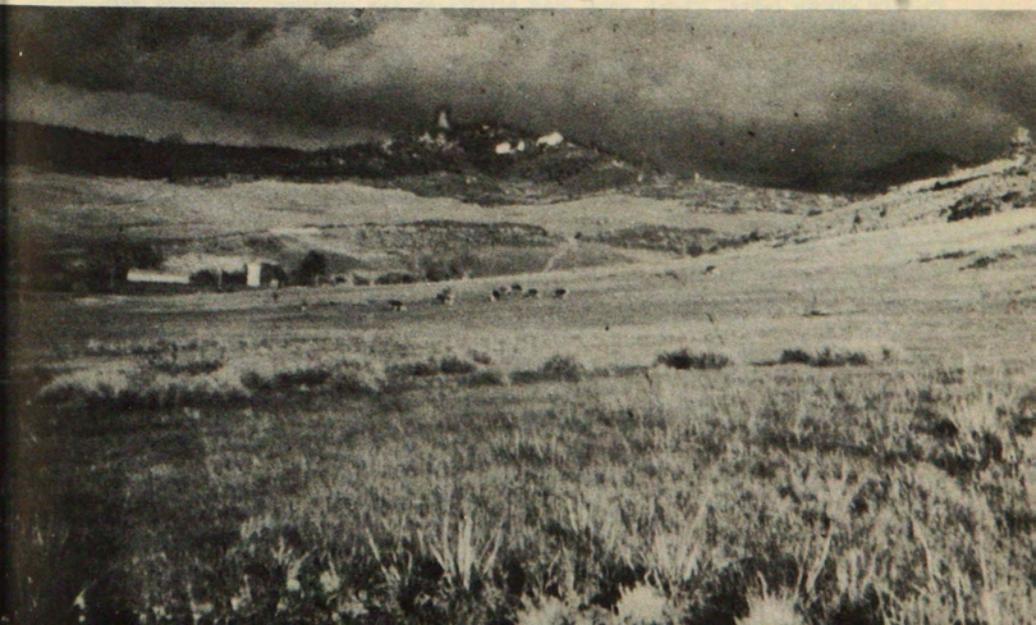
Undifferentiated Soils (Sandy Land and Hard Lands) of the Rolling to Steep Mountain-Plains Transition

This land type occupies a rather extensive area along the mountain front or west side of eastern Colorado. It is characterized by an intricate association of soils on a variety of slopes (fig. 18) from many widely different parent materials. However, most of the land surface has a slope of greater than 12 percent. Numerous small nearly level upland areas and narrow alluvial lands are included in this land type on the map.

SOIL CHARACTERISTICS.—Falcon, Kettle, Peyton, Pring, and Breece sandy loams, Table Mountain loam, Rampart, Travisilla, and Amherst stony loams, and exposures of the parent materials of these soils occupy most of the land area designated as this group on the map. They have dark to light colored, sandy to heavy textured, usually non-limy surface soils 4 to 10 inches thick. Under the surface soil is sand and gravel, loam, or some bedrock common to the region. This group includes such a mixture of soils that a general description would not give any definite information.

LAND USE AND CROP YIELDS.—Although most of this land type is utilized as native pasture, small areas are cultivated and produce variable yields of small grains, corn, beans, and potatoes. Part of this area, known as the Black Forest, has only a limited utilization

Figure 18.—Mountain-plains transition, Douglas County.



as pasture and a source of small timber because of the high erodibility and shallowness of the soils.

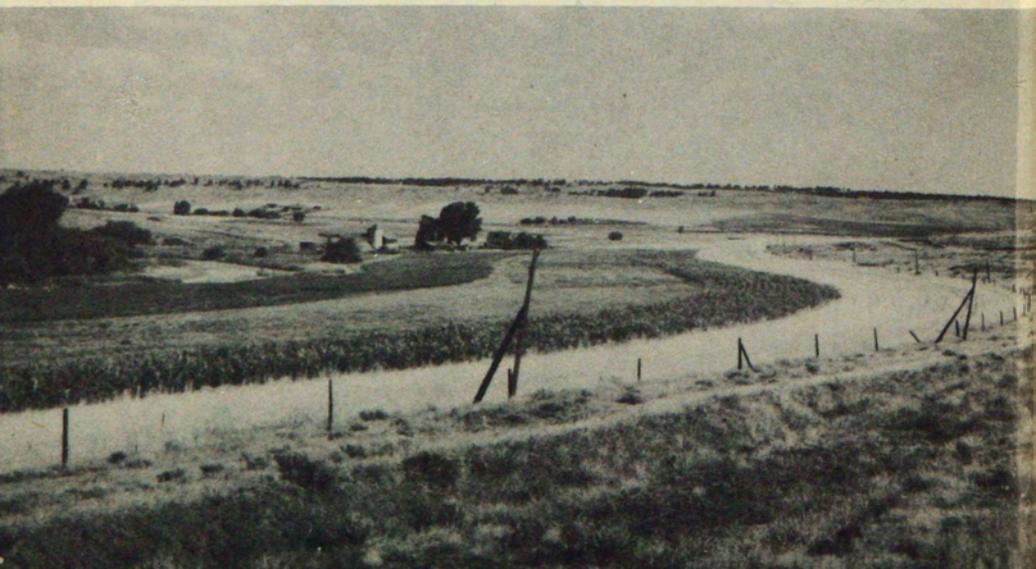
TILLAGE PRACTICES AND EROSION CONTROL.—Tillage practices on the cultivated areas are similar to those on other land types, except that most of the farm machinery is smaller. Some cultivation is practiced on slopes over 8 percent. On these areas water erosion is quite extensive. Gully erosion is especially severe. Contour cultivation (fig. 19) and terracing have been practiced on some fields with favorable results. Contour furrowing and water spreading on pasture areas have reduced the flood hazards from Monument and Cherry Creeks.

Sand Soils and Sands (Sandhills) of the Dunelike or Hummocky Uplands

The sandhills of eastern Colorado occupy a large total area, but are divided into a large number of small and large areas scattered throughout most of the region. In general, the land surface is characterized by a succession of irregularly distributed, sharply rolling hillocks and ridges, most of which rise 10 feet or more above intervening wind-formed valleys, pockets, and swales. Surface drainageways are usually absent, because the sands rapidly absorb the precipitation.

Sandhill swales large enough to furnish cultivable areas but too small to segregate on a map of the scale used are included in this land type.

Figure 19.—Contour strip cropping on terrace and alluvial slope soils associated with "the mountain-plains transition land type," Douglas County. Picture shows fence, wheat, corn, and alfalfa on the contour. Courtesy Soil Conservation Service.



SOIL CHARACTERISTICS.—Dune sand (stabilized) and Valentine and Dwyer sands and loamy sands occupy most of the sandhill area in eastern Colorado. They are light brown sands or loamy sands commonly darkened in the upper 4 to 8 inches by organic matter staining, and containing some free lime at varying depths. They are completely dominated by sands to depths of more than 4 feet.

LAND USE AND CROP YIELDS.—Nearly all this land type is utilized as native pasture. Grazing control and careful range management serve to keep the carrying capacity at a maximum level and prevent wind action from destroying the grasses.

Irrigated and Alluvial Land

In eastern Colorado the addition of irrigation water to many of the soils greatly increases their productive capacities and reduces the importance of effective precipitation. The increased production intensifies problems of soil fertility maintenance.

Since soil problems on irrigated land in eastern Colorado differ markedly from those on dry-land areas, irrigated land is segregated as a specific land type on the map, but its highly complex productivity and problems cannot be logically discussed on the basis of a general land type map.

Most alluvial lands or soils occurring on stream flood plains in eastern Colorado in areas large enough to show on the land type map are partially or fully under irrigation or receive supplemental water as runoff from higher levels. It appears logical, therefore, to include these soils with the irrigated land on a map of the scale used.

CROP YIELDS

Productivity ratings have been made for most of the soil types of our more extensive agricultural regions during the past several years. The methods used to express these ratings have varied considerably, but the objective of "evaluating the soil in terms of expected crop yields under the climate that generally prevails" has at all times been kept in mind. In eastern Colorado, crop yields are primarily limited by the amount of water available to the plants. Since there is a wide range in precipitation from year to year, and some seasons are too dry to produce certain crops, the distribution of high, moderate, and low or failure crop yields becomes fully as important as the average yield. Yields discussed are on a planted acreage basis and may be considered as the best estimates possible with the data available. They are based on good farming practices and in general are somewhat higher than "county average" yields on harvested acreages as given in Colorado Agricultural Statistics. In some instances they are lower than those obtained by the most successful farmers.

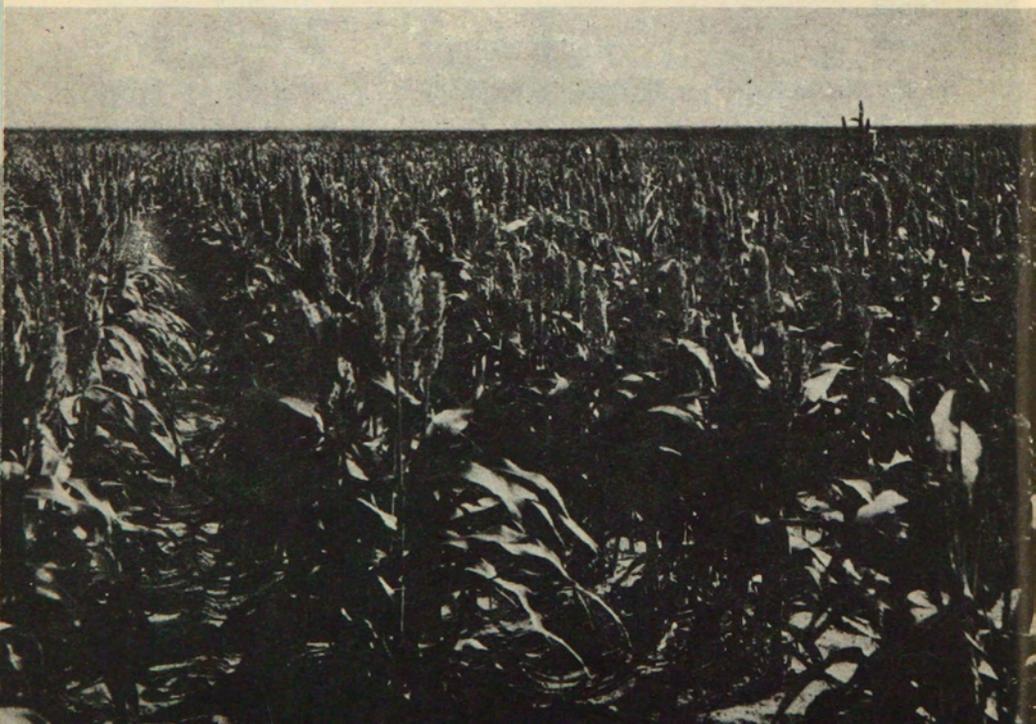
Records of the "Dry Land Stations" at Akron, Colo., Colby and Garden City, Kans., and Dalhart, Tex., based on planted acreages, show that high yields of all major crops are obtained in years when the total precipitation for the 12-month period ending when the crop matures is more than 20 inches. Moderate crop yields result when precipitation for a similar period is from 17 to 20 inches. Lower yields result from precipitation of 14 to 17 inches.⁷ Corn and wheat fail, or nearly fail, on less than 14 inches of precipitation, but sorghums usually produce profitable yields (fig. 20) even with this small amount of precipitation.

Figures 21, 22, 23, and 24 show the most probable yield distribution, average yields, and the average "cost of production" levels for corn, wheat, grain sorghum, and forage sorghum, the four major crops grown in the dry-land portions of eastern Colorado.⁸ These yields are shown only for those land types where information available allowed a fairly satisfactory estimate of average yields. Failure years were considered in determining the average yields. The average "cost of production" in terms of crop yields is indicated

⁷A basis for rating the productivity of soils on the plains of eastern Colorado. Colo. Exp. Sta. Tech. Bul. 25. 1938.

⁸See pages 39 to 43 for items involved and rates used.

Figure 20.—Dual purpose sorghum varieties are grown successfully on both the hard lands and sandy lands over a large part of eastern Colorado. Crop failures rarely occur. Courtesy Soil Conservation Service.



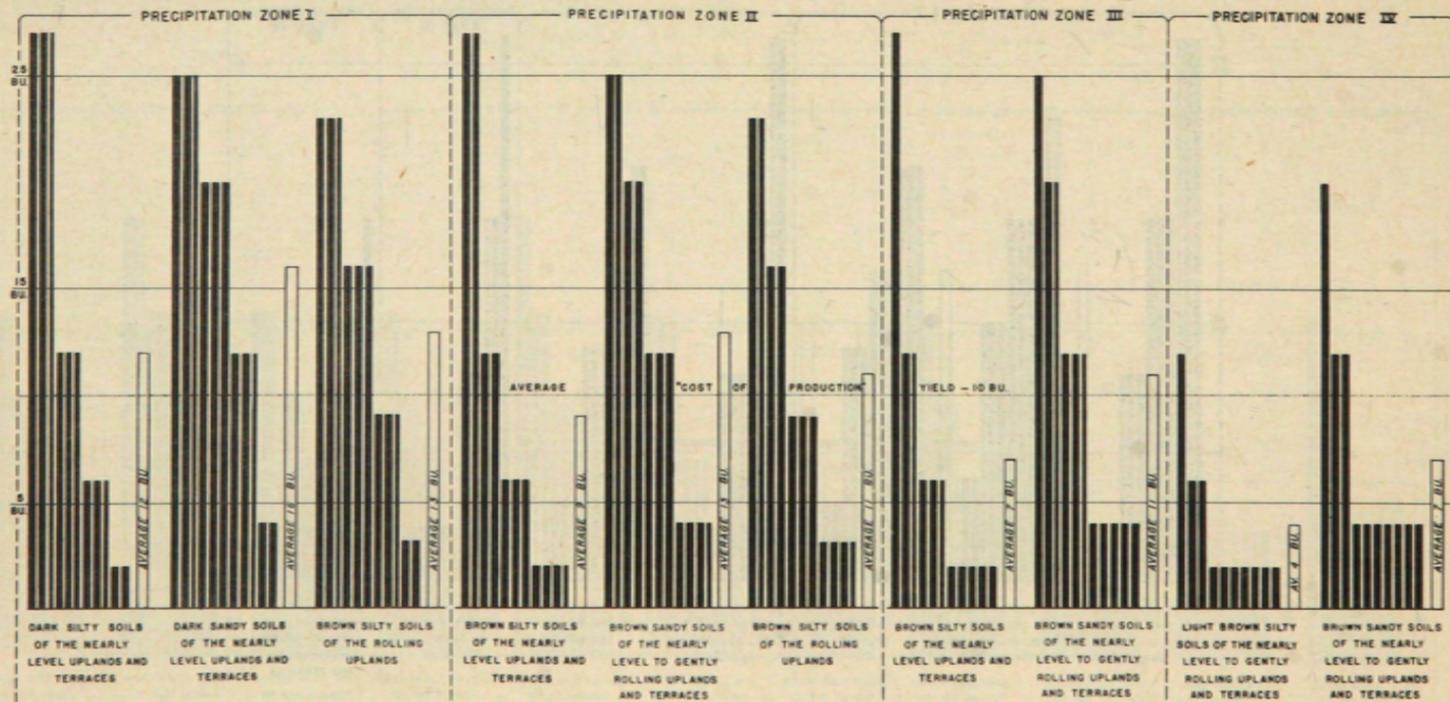


Figure 21.—Corn—average yield and most probable yield distribution over an average 10-year period on six land types in eastern Colorado. Sandy soils have a much more favorable distribution of corn yields than do silty soils in the same precipitation zone.

Height (or length) of the black bars represent yields, while the number and thickness of the bars represent proportion of years. For example, in Precipitation Zone I for each land type, two and one-half bars, representing 2 and one-half years in an average 10-year period, are longer than the others, three bars representing 3 years are shorter, but all are above the average "cost of production" yield, while four and one-half bars are below. Two bars are very short, representing quite low or failure years.

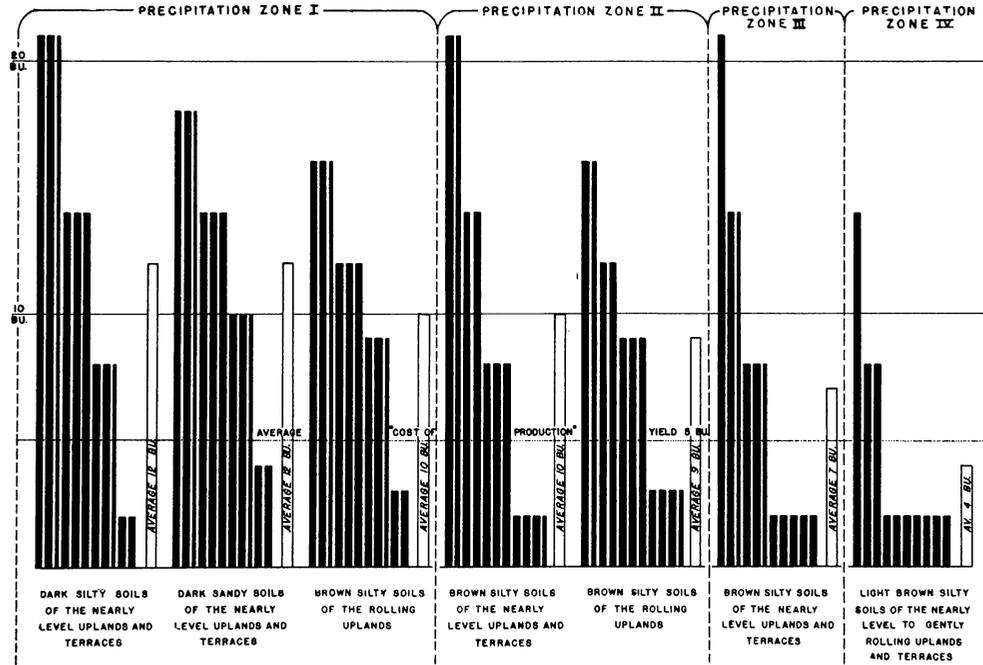


Figure 22.—Wheat—average yield and most probable yield distribution over an average 10-year period on five land types in eastern Colorado. Below “cost of production” yields must be paid for by the higher yields.

Wheat yields on fallowed land: Summer fallow of land in preparation for the growing of wheat has been tested at the U. S. Dry Land Field Station at Akron, Colo., for many years. The following conclusions can be drawn from these tests:

- (1) Winter wheat yields on fallow are about twice those obtained by continuous cropping where the land is clean fallowed and operations are timely.
- (2) Total wheat from a given area can be expected to be greater from continuous cropping during a series of years of favorable precipitation and less during unfavorable years.
- (3) Wheat failures are from two to three times as frequent on continuously cropped land as on fallow.

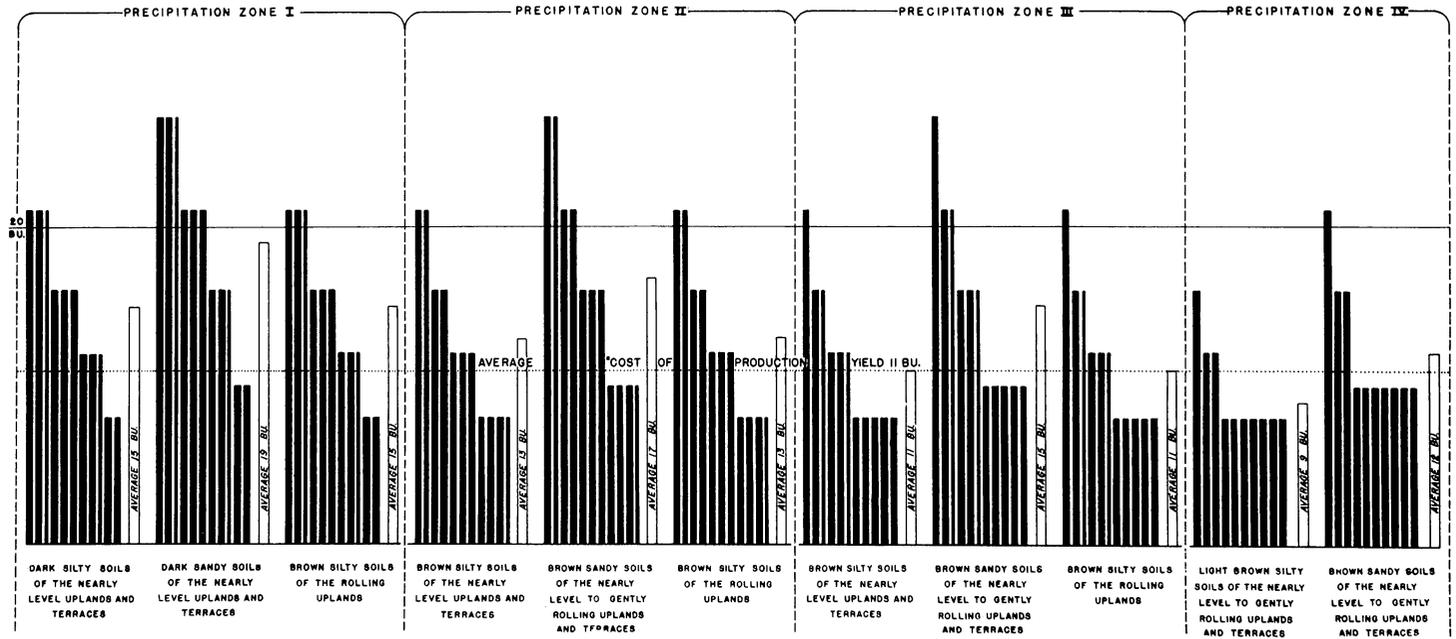


Figure 23.—Grain sorghum—average yield and most probable yield distribution over an average 10-year period on six land types in eastern Colorado.

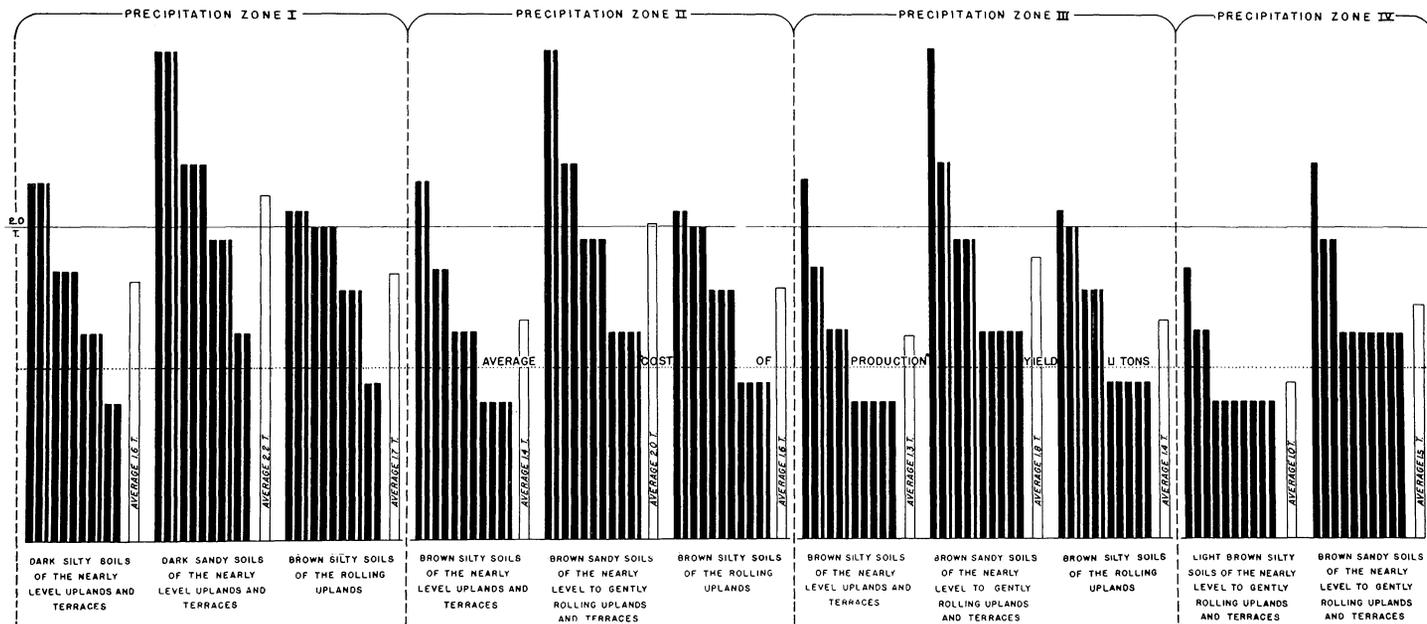


Figure 24.—Forage sorghum—average yield and most probable yield distribution over an average 10-year period on six land types in eastern Colorado.

on each figure by the horizontal dotted line. Figures 25, 26, 27, and 28 illustrate the relationship between these "cost of production" yields and the average yields which may be expected (based upon past records) on the various land types in the different precipitation zones. The reader should bear in mind that this "cost of production" yield will vary from farm to farm and from year to year. It will not remain in the fixed position shown on these graphs, but will rise or fall with changing conditions.

Basis for Crop Yields and Yield Distribution

Yield estimates for eastern Colorado are based on the crop yield-precipitation relationship, shown by crop yield and precipitation records over a 30-year period at four dry-land stations located in and near eastern Colorado. These were then extended over eastern Colorado by studies of soil moisture relationships, by precipitation records of the U. S. Weather Bureau, and by relative yield estimates of farmers and agricultural technicians of the area.

Frequency of crop failure or marked reduction in yields caused by natural hazards other than limited or ill distributed precipitation is quite variable over eastern Colorado. Hail, which generally is associated with wet years, insect pests, and diseases are the most common of these natural hazards. Although no quantitative data are available concerning these hazards, it is reasonable to assume they will reduce the yields of some crops more than of others. Wheat yields may be cut by hail from a bumper crop prospect to crop failure. Comparable damage to corn or grain sorghum by hail storms is much less frequent. Loss of a forage sorghum crop by hail is relatively infrequent, and heavy hail storms may reduce these yields only slightly.

The 1943 State hail insurance rate for wheat was 10 percent (8 percent in Range 67 and 7 percent in Range 68) for the following counties within the area covered by the land type map: Baca, Bent, Elbert, El Paso, Kit Carson, Las Animas, Lincoln, Logan, Morgan, Otero, Phillips, Prowers, Pueblo, Sedgwick, Washington, Weld, and Yuma Counties; 9 percent (8 percent in Range 67 and 7 percent in Range 68) for Adams, Arapahoe, Cheyenne, Crowley, Douglas, and Kiowa Counties; 7 percent for Huerfano County; and 5 percent for Boulder, Larimer, and Jefferson Counties.

Interpretation of Yield Graphs

In the interpretation of the graphs showing distribution and average yields (figs. 21, 22, 23, and 24), it is necessary to point out that crop adaptation differs from the northern to the southern part of eastern Colorado. In general, the northern half of the area, which has a mean annual temperature below 50°, has a markedly lower "growing season" evaporation rate than the southern half of

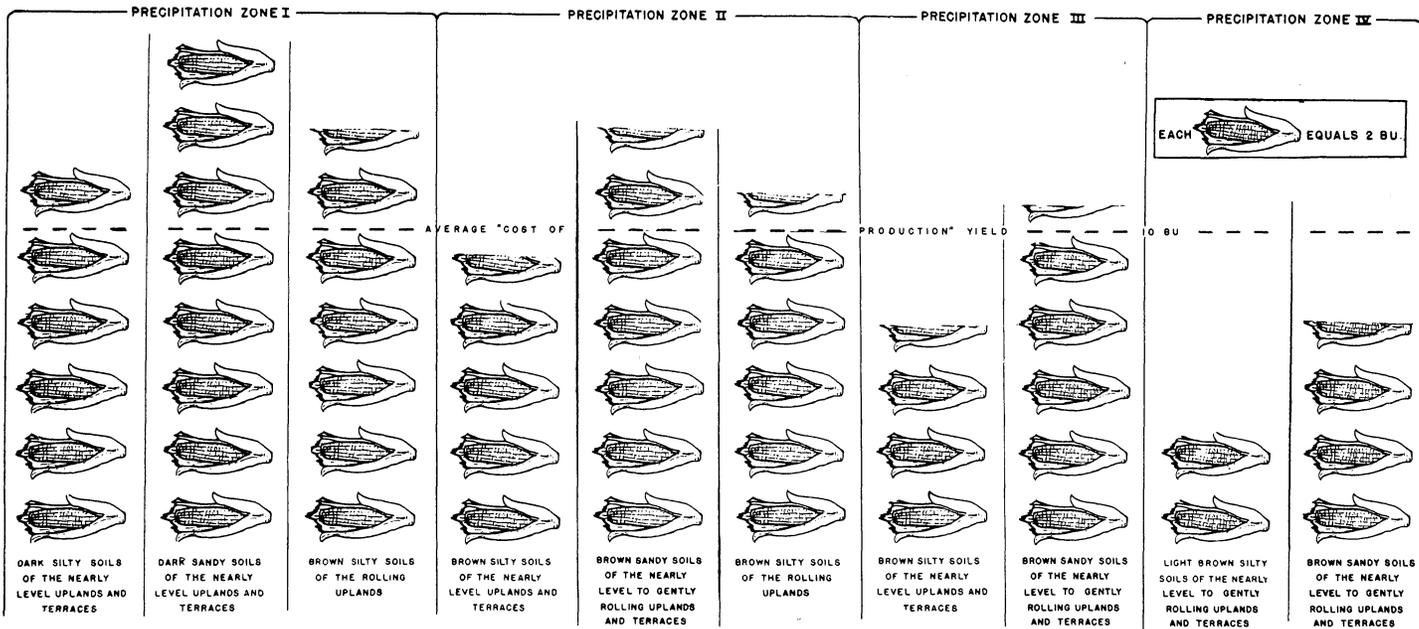


Figure 25.—Corn—relationship between average yields on six land types for an average 10-year period and average “cost of production” yield for the 3-year period, 1937 to 1939, prior to World War II.

The dark sandy soils in Precipitation Zone I is the only land type that produces corn yields well above the “cost of production” yield.

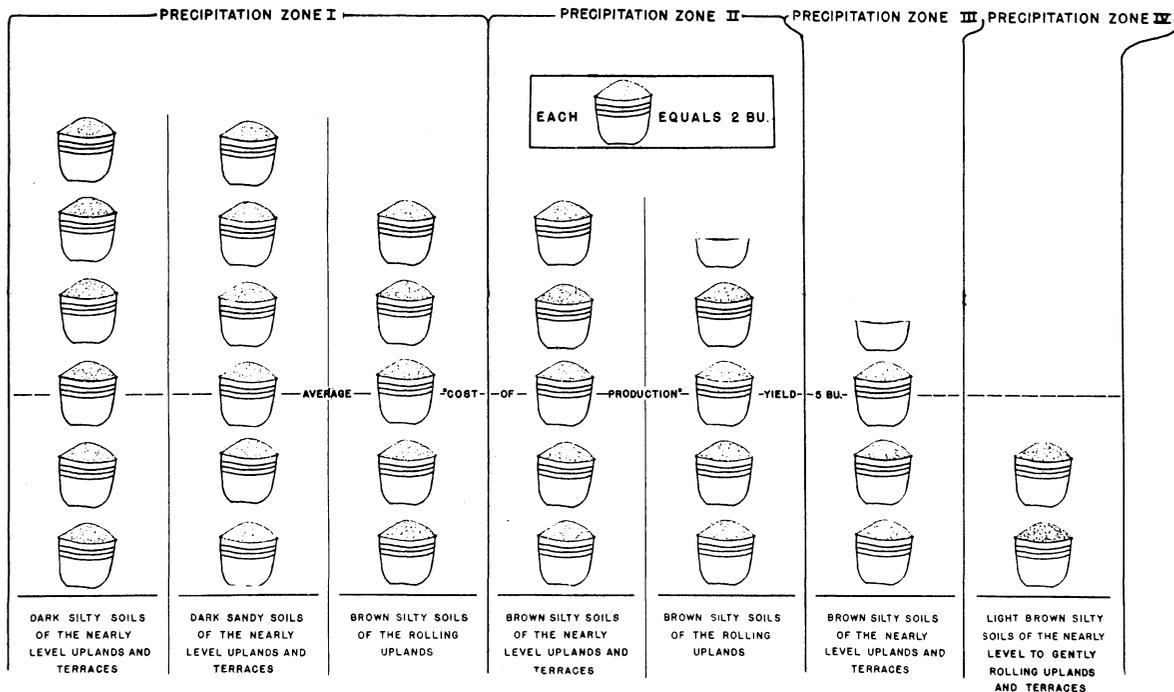


Figure 26.—Wheat—relationship between average yields on five land types for an average 10-year period and average “cost of production” yield for the 3-year period, 1937 to 1939, prior to World War II.

Average wheat yields are well above “cost of production” yield in Precipitation Zones I and II.

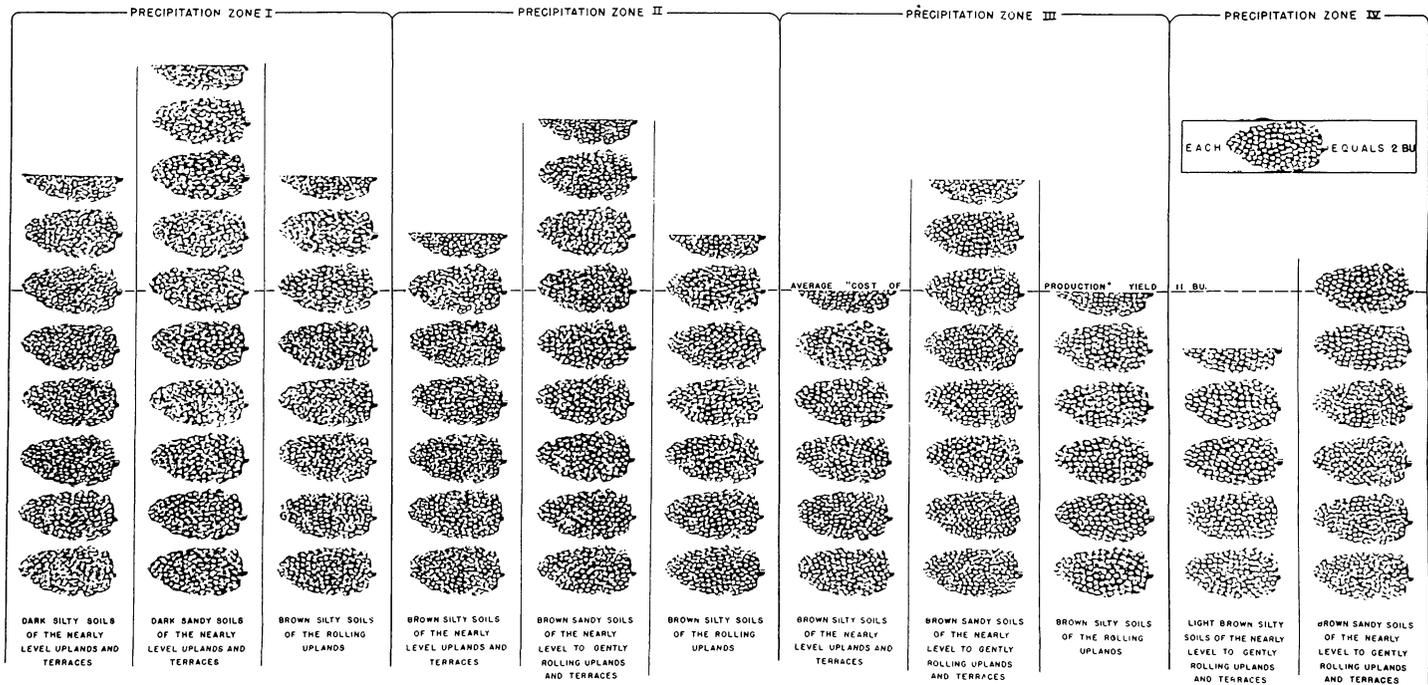


Figure 27.—Grain sorghum—relationship between average yields on six land types for an average 10-year period and average “cost of production” yield for the 3-year period, 1937 to 1939, prior to World War II.

Yields that fall far short of paying cost of production are rare. Thus, sorghums furnish the most dependable grain crop for this region.

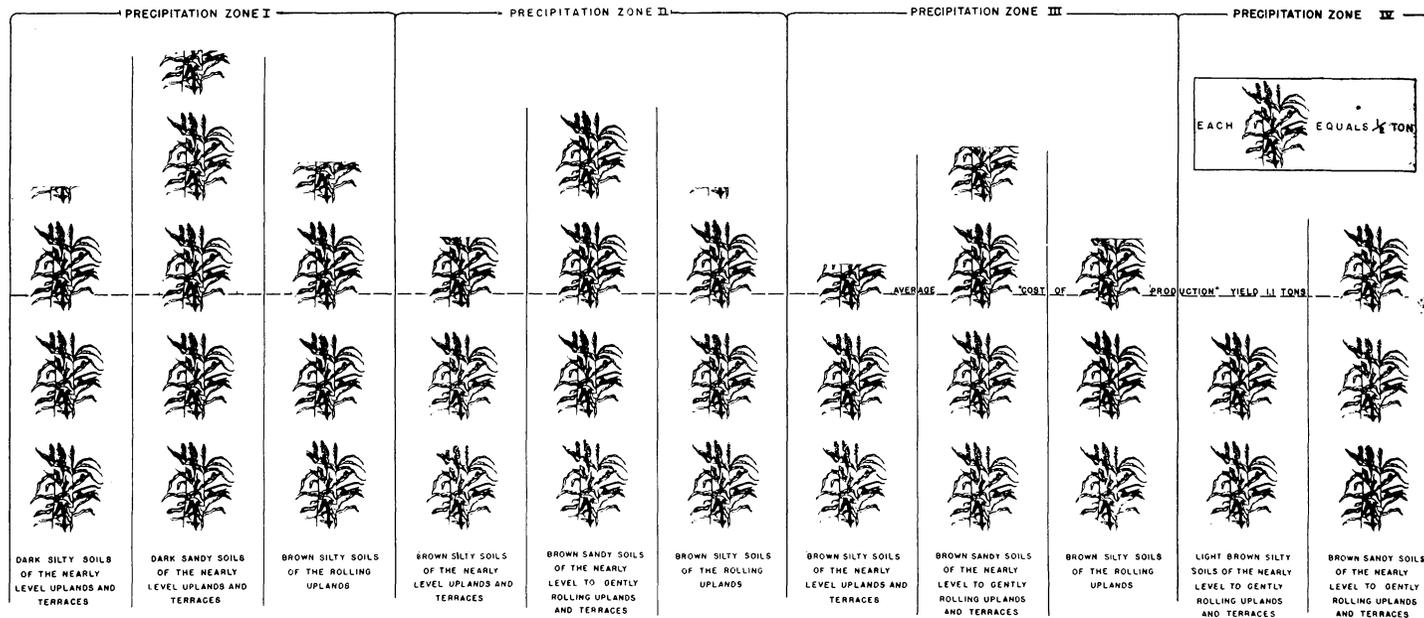


Figure 28.—Forage sorghum—relationship between average yields on six land types for an average 10-year period and average "cost of production" yield for the 3-year period, 1937 to 1939, prior to World War II.

Year in and year out the dry lands of eastern Colorado will come nearer paying cost of production for this crop than for any other.

the area, which has a mean annual temperature above 50°. Corn is not well adapted to the southern portion of the area, so is not a major crop in southeastern Colorado. Grain sorghums produce good yields in the southern portion of the area, so replace corn as a livestock feed. All soils in the northern part of the area tend to produce slightly higher crop yields than are shown in figures 21, 22, 23, and 24, and those in the southern part slightly lower yields.

With these facts in mind, information contained in the productivity graphs may be interpreted as follows:

1. Silty soils of nearly level areas in Precipitation Zones I, II, and III will produce high yields or bumper crops about 3 years out of every 10.

2. In years of high precipitation sandy soils tend to produce lower yields of all crops than do silty soils. In years of low precipitation crop yields are not so low on the sandy soils as on the silty soils. Bumper crop years are not as likely on sandy soils as on silty soils, and unsound expansion of farming operations is not as much of an inducement. Crop failures, however, are less frequent on the sandy soils. All these conditions encourage more stable farming on sandy soils.

3. A comparison shows that sorghum yield variations are not so great as those for wheat and corn and that the average yields of these crops are not so high as those of grain sorghums. This may lead to a still greater replacement of corn acreage by sorghums and perhaps a replacement of some wheat acreage by this more dependable crop.

Grouping Average Crop Yields

Average crop yields for corn, wheat, grain sorghum, and forage sorghum in eastern Colorado may be divided into four groups as a simplified basis for assigning a productivity index to soil and land types.

These groups or productivity ratings may be compared as follows:

- (1) Highest dry-land yield in eastern Colorado. Lands and soils rated at this level should be utilized for these crops insofar as it is possible to do so.
- (2) Good for eastern Colorado. The range in average crop yields expected is above the range in "cost of production" yields.
- (3) Average yields expected are within the same range as "cost of production" yields. It is questionable whether this land should be used for the crop that yields in this range. Need for livestock feed and ability of the farmer to reduce cost of production may determine its utilization.

- (4) Yields are so low that the crop cannot be expected to produce an average yield that will pay the cost of production.

The range in expected average yields of corn, wheat, grain sorghum, and forage sorghum in eastern Colorado within each productivity index is shown in table 1.

TABLE 1.—*Range in expected average yields represented by productivity indices in eastern Colorado.*

Productivity index	Crops			
	Corn	Wheat	Grain sorghum	Forage sorghum
	Bushels	Bushels	Bushels	Tons
1	15 to 19	11 to 14	15 to 20	1¾ to 2¼
2	11 to 15	8 to 11	11 to 15	1¼ to 1¾
3	8 to 11	6 to 8	8 to 11	¾ to 1¼
4	5 to 8	4 to 6	.....	.....

Table 2 gives productivity indices and estimated portion of area used for the main crops for six land types in the various precipitation zones.

Table 3 gives expected average acre yields and percentage of years when yields of corn, wheat, grain sorghum, and forage sorghum in eastern Colorado may be expected to be above "cost of production" yield.

Cost of Production in Terms of Crop Yields

The final result of variations in productivity may be measured by crop yields. Farmers need some basis for comparing probable yield with possible costs and sale prices if they are to operate on a sound basis.

Corn, wheat, grain sorghum, and forage sorghum are the crops most extensively grown in eastern Colorado. Therefore, estimates have been made of the customary expenses involved in producing these crops.⁹

Corn was analyzed under two methods of production: (a) One duckfoot or subsurface tillage in the fall, another in the spring, planting with two-row lister, and three cultivations with two-row cultivator, (b) one spring disking followed by listing and cultivation as in the preceding method. In each case 5 pounds of seed per acre were used.

Wheat was analyzed under conditions of continuous cropping and under summer fallow. For the summer fallow wheat a total of three and one-half surface tillages were assumed, while either

⁹The calculations as to labor and other expenses were based on an unpublished method of analyzing labor requirements recently developed as part of the doctoral dissertation of R. T. Burdick of the Economics and Sociology Section, Colorado Agricultural Experiment Station.

TABLE 2.—*Productivity ratings and estimated percentage of each of six land types used for corn, wheat, grain sorghum, and forage sorghum in the dry-land areas of eastern Colorado in four precipitation zones.*

Land type	Effective precipitation zone	Corn		Wheat		Grain sorghum		Forage sorghum	
		Pct. of area	Prod. index	Pct. of area	Prod. index	Pct. of area	Prod. index	Pct. of area	Prod. index
Dark silty soils of the nearly level upland and terraces	I	20-30	2	50-60	1	0-5	2	5-10	2
Dark sandy soils of the nearly level uplands and terraces	I	75-80	1	10-15	1	0-5	1	5-10	1
Brown silty soils of the rolling uplands	I	30-40	2	5-15	2	0-5	2	5-10	2
Brown silty soils of the nearly level uplands and terraces	II	5-15	3	20-40	2	5-20	2	5-30	2
Brown sandy soils of the nearly level to gently rolling uplands and terraces	II	20-50	2	5-10	*	10-30	1	10-30	1
Brown silty soils of the rolling uplands	II	0-10	3	0-5	2	5-15	2	5-15	2
Brown silty soils of the nearly level uplands and terraces	III	0-5	4	20-40	3	5-20	2	5-30	2
Brown sandy soils of the nearly level to gently rolling uplands and terraces	III	5-15	3	0-5	*	10-30	2	10-30	1
Brown silty soils of the rolling uplands	III	**	**	**	**	5-10	2	5-10	2
Light brown silty soils of the nearly level to gently rolling uplands and terraces	IV	0-5	4	0-15	4	0-10	3	5-10	3
Brown sandy soils of the nearly level to gently rolling uplands and terraces	IV	5-10	4	0-5	*	5-20	2	5-20	2

*Wheat is seldom grown on the sandy soils in Zones II, III, and IV, because their level of productivity for corn and sorghum is much higher than any other non-irrigated land in the vicinities in which they occur.

**Corn and wheat are not generally grown on the sloping hard lands in Zone III.

TABLE 3.—Expected average acre yields and percentage of years when yields of the four major dry-land crops in Eastern Colorado may be expected to be above “cost of production” yield. (Crop yield and precipitation records from four dry-land field stations in and near eastern Colorado served as a basis for estimating probable yields and percentage of years above “cost of production” yield.)

Land type	Effective precipitation zone	Corn		Wheat		Grain sorghum		Forage sorghum	
		Expected ave. yield	Years above “C-P” yield*	Expected ave. yield	Years above “C-P” yield*	Expected ave. yield	Years above “C-P” yield*	Expected ave. yield	Years above “C-P” yield*
		Bushels	Percent	Bushels	Percent	Bushels	Percent	Tons	Percent
Dark silty soils of the nearly level uplands and terraces	I	12	55	12	80	15	80	1.6	80
Dark sandy soils of the nearly level uplands and terraces	I	16	80	12	80	19	80	2.2	100
Brown silty soils of the rolling uplands	I	13	55	10	80	15	80	1.7	80
Brown silty soils of the nearly level uplands and terraces	II	9	35	10	65	13	65	1.4	65
Brown sandy soils of the nearly level to gently rolling uplands and terraces	II	13	65	**	....	17	65	2.0	100
Brown silty soils of the rolling uplands	II	11	35	9	65	13	65	1.6	65
Brown silty soils of the nearly level uplands and terraces	III	7	25	7	50	11	50	1.3	50
Brown sandy soils of the nearly level to gently rolling uplands and terraces	III	11	50	**	....	15	50	1.8	100
Brown silty soils of the rolling uplands	III	***	....	**	....	11	50	1.4	50
Light brown silty soils of the nearly level to gently rolling uplands and terraces	IV	4	10	4	30	9	30	1.0	30
Brown sandy soils of the nearly level to gently rolling uplands and terraces	IV	7	30	**	....	12	30	1.5	100

*“Cost of production” yield.

**Wheat is seldom grown on the sandy soils in Zones II, III, and IV, because their level of productivity for corn and sorghum is much higher than any other non-irrigated land in the vicinities in which they occur.

***Corn and wheat are not generally grown on the sloping hard lands in Zone III.

one duckfoot or one disking was assumed for the continuous wheat. In each case 30 pounds of seed per acre were used.

Grain and forage sorghums were analyzed under identical methods as those used for corn (up to harvest), except that 42-inch rows were assumed for sorghums in place of 44-inch rows for corn, and 2¼ pounds of grain sorghum seed or 5 pounds of forage sorghum seed were used.

For all crops, taxes at 29 cents per acre and interest at 39 cents per acre were uniformly charged (6 percent on \$6.50, 1938 dry-land assessed valuation). Labor and power costs for seedbed preparation and planting were charged at \$1.05 per tractor hour (to cover men at 30 cents per hour, equipment at 25 cents per hour, and tractor at 50 cents per hour). Harvesting costs were estimated at 9.5 cents per bushel for corn (to include shelling), at \$1.00 or \$1.50 per acre for combining wheat, at \$3.10 per acre for grain sorghum, and at \$1.35 for forage sorghum.

To all costs 20 percent was added to cover overhead expenses.

With the values at 55 cents per bushel for corn, 45 cents per bushel for grain sorghum, 70 cents per bushel for wheat, and \$4.00 per ton for forage sorghum, the necessary yield was calculated to cover estimated costs. It should be pointed out that the rates and values used in the cost calculations are based upon typical conditions for the 3-year period, 1937 to 1939, prior to World War II, and that no allowance was made for variations either in the productive capacity of the land or in operators' practices. Table 4 gives an analysis of production costs on a per-acre basis of corn, grain sorghum, forage sorghum, and wheat (continuous and fallow).

TABLE 4.—*Estimates of comparative per acre expense, dry-land crop production.*

Operation	Corn		Grain sorghum		Forage sorghum		Continuous wheat		Fallow wheat		
	Duck-foot	Disk	Duck-foot	Disk	Duck-foot	Disk	Duck-foot	Disk	Duck-foot	Disk	
	Hours	Hours	Hours	Hours	Hours	Hours	Hours	Hours	Hours	Hours	
Duckfoot	† .96		† .96								
Disk		.36		.36							.36
List		.50		.51							
Plant		1.50		1.53							.24
Cultivate†		2.96		2.40							
Total crew hours											1.92
Cost per acre											
At \$1.05 per hour	\$ 3.11	\$ 2.48	\$ 3.15	\$ 2.52	\$ 3.15	\$ 2.52	\$ 3.15	\$ 2.52	\$ 3.15	\$ 2.52	\$ 2.02
Seed	.15	.15	.08	.08	.08	.08	.08	.08	.08	.08	.60
Tax	.29	.29	.29	.29	.29	.29	.29	.29	.29	.29	.58
Interest	.39	.39	.39	.39	.39	.39	.39	.39	.39	.39	.78
Sub-total	3.94	3.31	3.91	3.28	3.91	3.28	3.91	3.28	3.91	3.28	3.98
Harvest	.95	.76	3.10	3.10	1.35	1.35	1.35	1.35	1.00	1.00	1.50
Sub-total	4.89	4.07	7.01	6.38	5.26	4.63	5.26	4.63	3.04	2.91	5.48
20 percent overhead	.98	.81	1.40	1.28	1.05	.93	1.05	.93	.61	.58	1.10
Total	5.87	4.88	8.41	7.66	6.31	5.56	6.31	5.56	3.65	3.49	6.58
Less fodder			3.00	3.00							
Net cost of grain			5.41	4.66							
Value per unit, bushel	.55	.55	.45	.45	5.00	5.00	5.00	5.00	T	T	.70
Necessary yield, bushel	10.67	8.87	12.02	10.36	1.26	1.11	1.26	1.11	T	T	4.99

*Once over.

†Twice over.

‡Three times over.

§Three and one-half times over.

Note: This comparison is made with 2-row lister and 2-row cultivator. If 3-row lister and cultivator are used, this reduces per acre costs by 85 cents. With 55-cent corn this would be 1.55 less bushels of corn; with 45-cent sorghum this would be 1.89 bushels less sorghum (or .17 less tons forage).

SUMMARY AND CONCLUSIONS

In the analysis presented, eastern Colorado is divided into four climatic zones. The zones are determined by the effective precipitation, which in turn is dependent upon total precipitation, seasonal distribution, temperature, evaporation, and altitude. Mature soil characteristics and crop yields were used in certain parts of the area as a guide in locating effective precipitation zone boundaries.

The soil types of eastern Colorado have been grouped into ten land types. Each type within itself represents a product of soil, slope, and effective precipitation. The important physical characteristics of the soils within each land type are given. Tillage practices and applicable erosion control measures are briefly discussed.

Wind and water erosion are hazards in eastern Colorado. Wind erosion affects a larger percentage of the area than water erosion, and the damage from soil blowing is of greater scope.

The change in the fertility of soil which accompanies erosion is difficult to evaluate in eastern Colorado because no quantitative field tests have been made. Observation over a period of several years, however, indicates that most of the non-irrigated soils have sufficient available plant nutrients to produce as large a yield as is possible under the limited precipitation. This condition emphasizes the importance of catching and holding the precipitation on the land where it falls.

Limited and erratic rainfall, high winds, and high evaporation characterize the prevailing climate in eastern Colorado. Such climatic conditions make the stability of the land and the physical condition of the soil as important in dry-land crop production as is the fertility level of the soil.

Expected average acre yields and the most probable yield distribution over an average 10-year period are given for corn, wheat, grain sorghum, and forage sorghum in each precipitation zone on the various land types where these crops are grown.

Yield estimates are based on the crop yield-precipitation relationships shown by crop yields and precipitation records over a 30-year period at four dry land field stations situated in and near eastern Colorado. These estimates were then extended over eastern Colorado by studies of soil-moisture relationships, precipitation records of the U. S. Weather Bureau, and relative yield estimates of farmers and agricultural technicians of the area.

Estimated cost of production in terms of crop yields are given for corn, wheat, grain sorghum, and forage sorghum. Rates and values used in the cost calculations are based upon typical conditions for the 3-year period, 1937 to 1939, prior to World War II.

Analysis of crop yields, yield distribution, cost of production, and the proportion of each land type used for corn, wheat, grain sorghum, and forage sorghum indicates the following conclusions:

1. Sandy soils have a much more favorable distribution of corn yields than do silty soils in the same precipitation zone.
2. The sandy soils in Precipitation Zones I and II are the most satisfactory soils for corn production on the dry lands of eastern Colorado.
3. Grain sorghums under dry farming produce more grain on all land types than does corn in eastern Colorado.
4. Forage sorghums will yield some feed on nearly any tillable area in eastern Colorado. However, yields are rather low on the silty soils of Precipitation Zones III and IV.
5. In Precipitation Zone I, corn and wheat are grown most extensively on the soils to which they are best adapted.
6. Corn and sorghums produce consistently higher yields on sandy than on silty soils.
7. Yields of corn and sorghums are as high on silty soils of the gently rolling areas as on the nearly level areas, but yields of wheat are lower.
8. Wheat, where grown on sandy soils, produces about the same average yield as on adjacent silty soils.
9. All land types that produce average wheat yields well above "cost of production" yields are in Zones I and II.
10. Cost of production estimates show that it is cheaper to produce wheat on fallow than on land continuously cropped.

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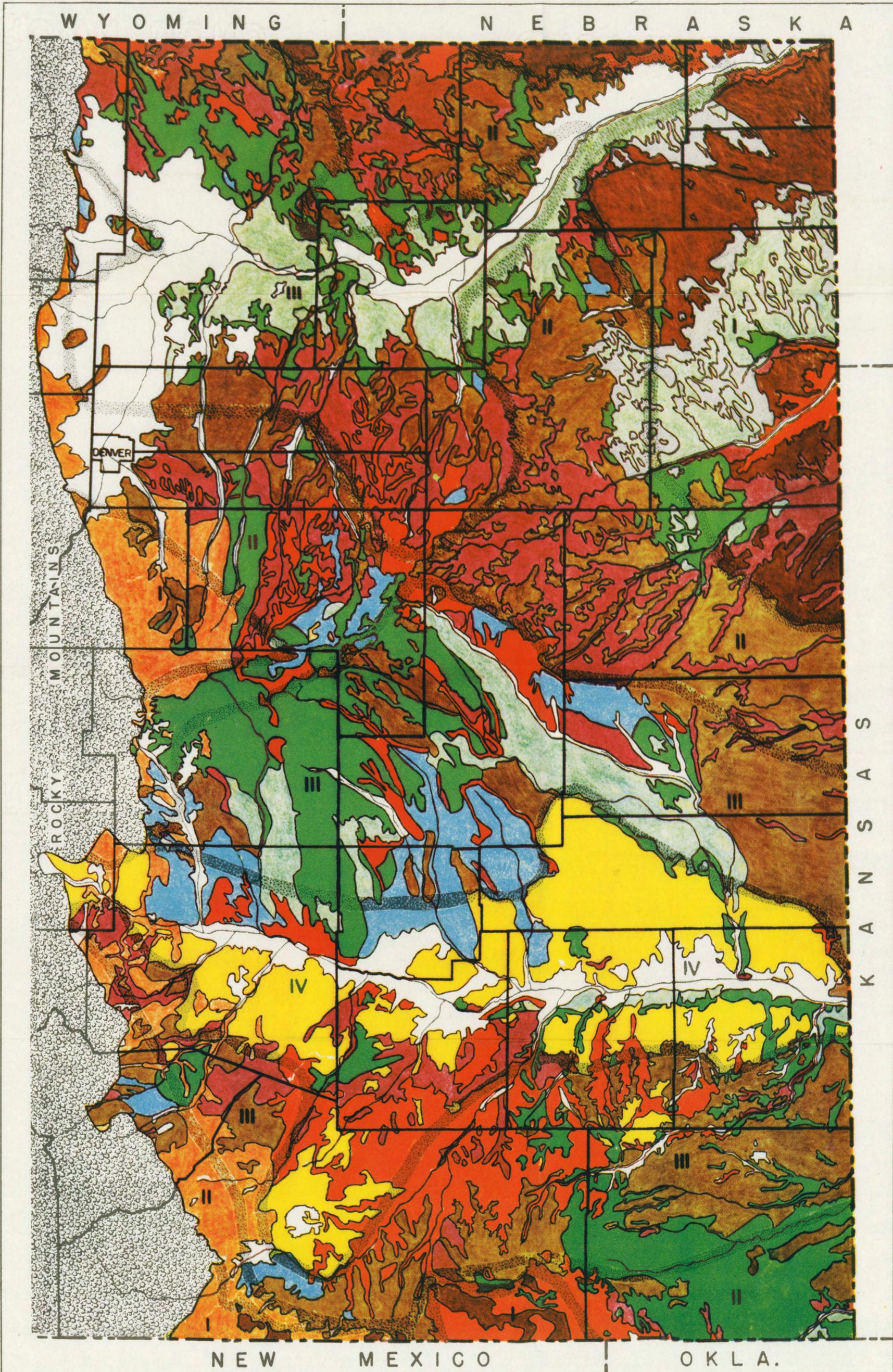
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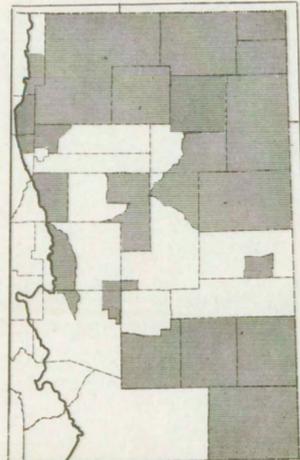
LAND TYPE MAP

EASTERN COLORADO

COLORADO AGRICULTURAL EXPERIMENT STATION
HOMER J. HENNEY, DIRECTOR



Source of Soil Survey Data



SHADED PORTION FROM SOIL SURVEYS.
UNSHADED PORTION FROM VARIOUS
GENERALIZED SOIL MAPS.

LEGEND

-  DARK SILTY SOILS OF THE NEARLY LEVEL UPLANDS AND TERRACES (HARD LANDS)
-  DARK SANDY SOILS OF THE NEARLY LEVEL UPLANDS AND TERRACES (SANDY LANDS)
-  BROWN SILTY SOILS OF THE NEARLY LEVEL UPLANDS AND TERRACES (HARD LANDS)
-  BROWN SILTY SOILS OF THE ROLLING UPLANDS (HARD LANDS)
-  BROWN SANDY SOILS OF THE NEARLY LEVEL TO GENTLY ROLLING UPLANDS AND TERRACES (SANDY LANDS)
-  LIGHT BROWN SILTY SOILS OF THE NEARLY LEVEL TO GENTLY ROLLING UPLANDS AND TERRACES (HARD LANDS)
-  CLAY SOILS OF THE LEVEL TO GENTLY ROLLING UPLANDS AND TERRACES (GUMBO OR HEAVY LANDS)
-  UNDIFFERENTIATED SHALLOW SOILS OF THE ROLLING TO STEEP UPLANDS (HILLY LAND)
-  SAND SOILS AND SANDS OF THE DUNELIKE OR HUMMOCKY UPLANDS (SANDHILLS)
-  UNDIFFERENTIATED SOILS OF THE ROLLING TO STEEP MOUNTAIN-PLAINS TRANSITION (SANDY LANDS AND HARD LANDS)
-  IRRIGATED AND ALLUVIAL LANDS

SCALE IN MILES



