daries and in recording the patents or deeds; while the water, which alone gives value, has hardly been considered, and the rights to its use have often been left to be adjusted largely by local or temporary expedients. It would have been far better, if one or the other of these items must have been neglected, to have given first thought to the water and secondary consideration to the land, subdividing this with reference more to the possibility of obtaining water than for convenience of survey.

To remedy this and bring about such a condition that the remaining public lands may furnish the greatest possible number of homes, is an object worthy the sustained effort of enlightened and patriotic citizens. To assemble the facts upon which intelligent action can be based is a task to which the best efforts of aspiring students or investigators may be directed. These facts pertain first of all to the water supply and its limitations, since, in a country where arid land is in excess, the agricultural area is limited by the available water.

CHAPTER II.

THE ARID REGIONS.

THE arid regions of the United States include about two-fifths of its entire area, and extend from about the middle of the continent west nearly to the Pacific Ocean. There are no sharply marked lines or divisions between the arid and humid areas, but intermediate, especially near the centre of the United States, is a broad belt neither distinctly arid nor humid, which has sometimes been called the subhumid, or again the semiarid, region. This belt extends over South and North Dakota, western Nebraska, and western Kansas into Oklahoma and the "pan handle" of Texas. In some years of excessive moisture the subhumid region creeps up toward the foothills of the Rocky Mountains, while, during the dry years, the greater part of the plains region west of the Missouri becomes semiarid.

In a general way arid regions are taken as including those of twenty or less inches of average annual rainfall; thus, the arid regions of the United States are but a portion of those of

North America, which embraces a considerable part of Mexico on the south and of Canada on the north. The relative extent of these regions of humidity and of aridity can best be shown by a small diagram (Fig. 2).

Modern civilization has developed largely in humid regions, and we have thus come to regard

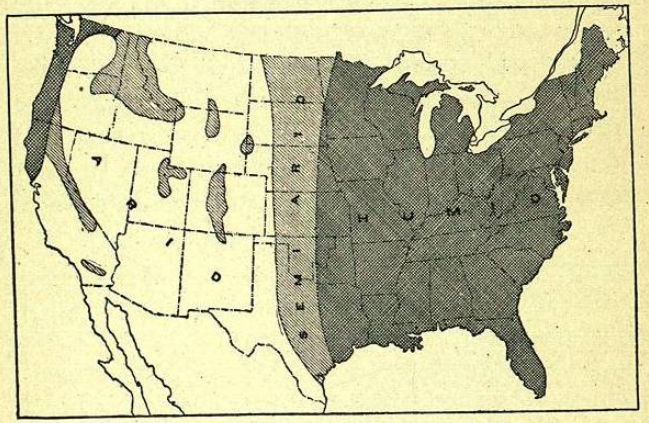
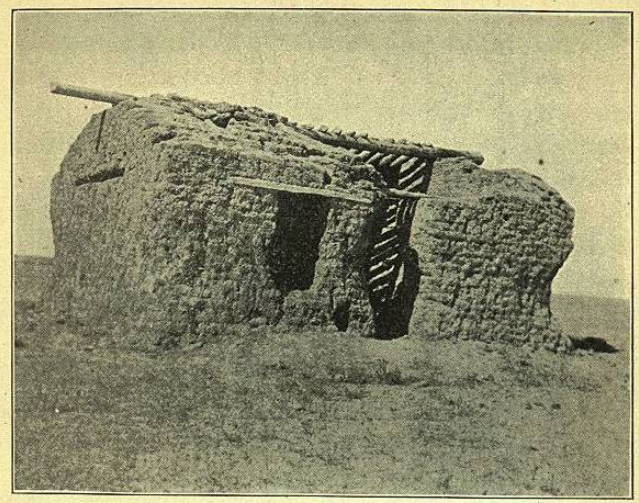
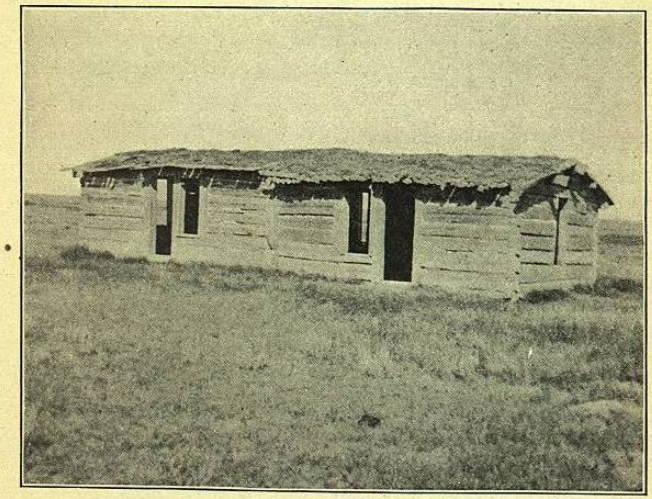


FIG. 2. — Map of humid, semiarid, and arid regions of the United States.

aridity as something exceptional; as a matter of fact, however, a great part of the countries of the Old World have less than twenty inches of annual rainfall, and according to our ideas must be considered as arid. The civilization of former times grew up in these arid regions, and we cannot fully appreciate the writings of the ancients and the true meaning of many familiar phrases handed down





RESULTS OF ATTEMPTS TO MAKE HOMES ON THE PUBLIC LANDS WITHOUT FIRST PROVIDING METHODS OF IRRIGATION.

to us without bearing in mind that theirs was an arid region, where agriculture was successful only through irrigation.

The small map (Fig. 3) illustrates the great extent of aridity, and shows that the Mediterranean countries, including Egypt, the seat of ancient civilization, are for the most part arid and

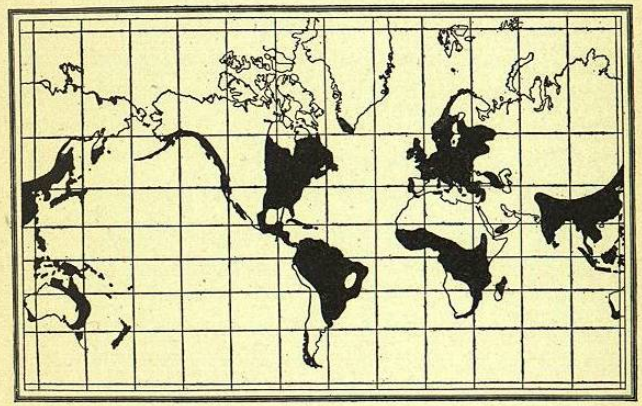


FIG. 3. — Map of humid and arid regions of the world [the humid indicated by the black areas].

desert-like in character. The dense foliage of the forests of eastern United States and of Europe and the verdant covering of turf so common in our modern towns and villages were practically unknown to the races who produced the sacred books of the East; and their constant reference to the life-giving qualities of water furnishes innumerable instances of the high esteem in which this was held.

PRECIPITATION.

Aridity, or rather the unequal distribution of moisture, is largely the result of topography, or inequalities of land surface. If the earth were perfectly flat, it is probable that the winds, meeting with no obstructions, would distribute the rains with considerable uniformity in broad bands approximately parallel to the equator; but the relatively thin layer of dense atmosphere surrounding the globe is disturbed in its uniform flow by the lofty mountain masses which traverse the continents. The atmosphere surrounding the earth extends outward for many miles, but it is the layer, a mile or two in thickness, resting immediately upon the surface, and relatively dense, within which occur the changes or disturbances that make up what we know as "weather." The movements of the air above this thin layer concern us little; but the behavior of the clouds and the winds near the surface of the ground brings success or failure to the farmer, and affects more or less directly other industries, and even health.

Taking the United States as a whole, the general atmospheric movement is from west to east; the moisture-laden winds from the Pacific, encountering the mountain masses which extend along or parallel to the coast, are forced upward and cooled, depositing much of their moisture, especially in the winter season. They then pass easterly as dry

winds, leaving the broad plains east of the Sierra Nevada parched and sterile. In the summer, however, when the mountains have become relatively warm, winds from the Pacific pass over them without leaving their moisture, and the result is the summer drought characteristic of the Pacific coast. Passing onward, the winds not deprived of humidity give up from time to time some of the precious fluid, and thus in the interior there are the occasional summer rains which tend to make amends for the deficient precipitation of the winter season.

East of the Sierra Nevada and Coast ranges, and of the plains and deserts at their base, are scattered irregular mountain ranges, and the great Cordillera or Rocky Mountain system, whose high summits intercept some of the rain-bearing winds, and these for the most part are well watered, while the low lands are parched with drought. From the east face of the Rocky Mountains the High Plains stretch out through the Mississippi Valley, dropping gradually in altitude to the rolling plains and prairies.

The average monthly precipitation is illustrated by the accompanying diagram (Fig. 4), which brings out graphically the contrast between the distribution of precipitation on the western coast and in the interior. The height of each of the small black columns represents the average amount of rain for the corresponding month. Taking, for

example, San Francisco, it is seen that the rain for January averages more than four inches, the amount decreasing during February, March, and April, and becoming less than one-half an inch

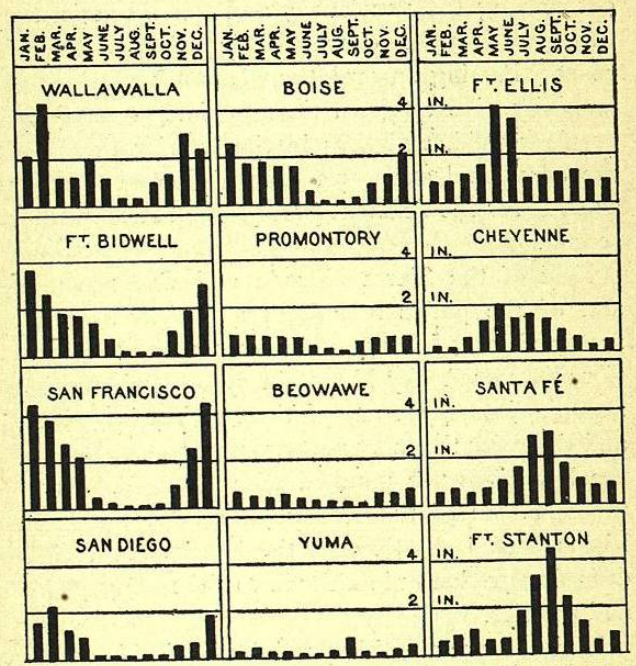


FIG. 4. — Mean monthly precipitation at twelve localities in western United States.

in May. In June, July, August, and September there is practically a drought, with sudden increase in amount of precipitation in October, November, and December. In contrast to this is the distribution of rainfall at Santa Fé, where the spring and winter months have comparatively little rainfall, the greatest amount occurring in July and August. Thus it may happen that, although there is more than twenty inches of rainfall each year at points near the Pacific coast, yet irrigation is necessary during the latter part of the crop season, and especially in the summer; while in other localities having less annual rainfall, but with heavy summer precipitation, the artificial application of water is not needed.

This diagram (Fig. 4) illustrates the actual amount of rain and snow fall in an average year at the various points, and shows that there is a wide difference in the quantity received. In some localities there is about the same amount of rainfall each month, and in others there are summer droughts. This matter is brought out more clearly when we compare, not the actual amount of rain each month, but the proportion which this bears to the total precipitation of the year; that is to say, calling the average annual rainfall for each locality 100, the amount for one month, if the rain fell equally throughout the year, would be 8.33, or $\frac{1}{12}$ of the whole, whether the total amount for the year be 15 inches or 50 inches. By thus obtaining monthly percentages, it is possible to compare the character of the rainfall in different parts of the United States. This is done in the following diagram (Fig. 5), which shows, not the actual

depth of rain, but the percentage for each month in four localities, namely: Buffalo, New York;

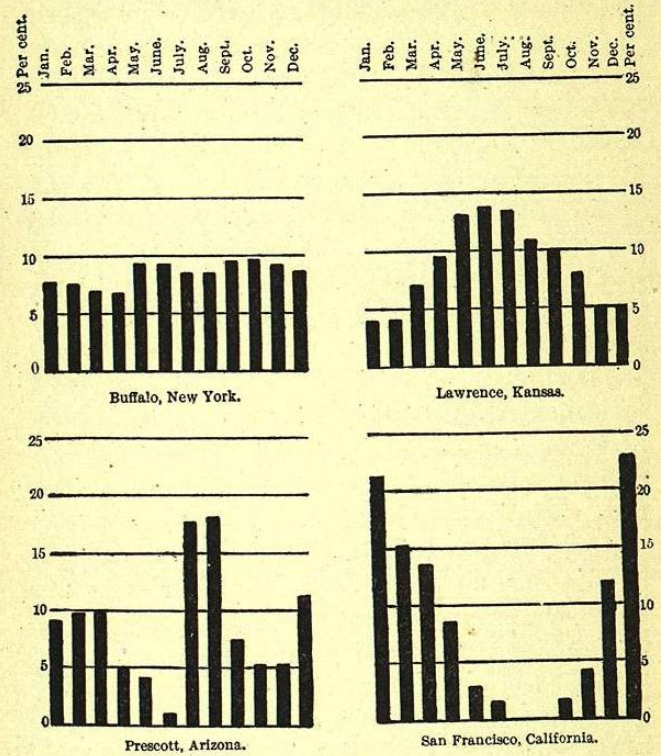


FIG. 5. — Types of monthly distribution of precipitation, shown by percentages of average annual rainfall.

Lawrence, Kansas; Prescott, Arizona; and San Francisco, California.

In the case of Buffalo it is seen that the average

rainfall for each month ranges from 7 to 10 per cent, never quite reaching the latter, and thus showing that throughout the year very nearly the same amount of precipitation occurs. Comparing this with Prescott, Arizona, it is seen that the average precipitation in one month, June, is less than 2 per cent, while in the next two months it is raised to over 17 per cent, showing the great irregularity and the necessity of providing against a June drought.

The diagrams for Lawrence, Kansas, and for San Francisco, California, are seen to supplement each other, although in San Francisco the extremes are far greater than in Kansas. There is no month in the latter state when the rain averages less than 4 per cent of the total, while in California, during July and August, the precipitation is practically nothing.

These diagrams, being illustrative of averages of a considerable number of years, exhibit a regularity which does not occur in any one year. The monthly rainfall, while tending to follow in the long run a certain law, is from season to season extremely erratic, — the amount in one year being sometimes one-half as much or twice as great as that of another. To illustrate these fluctuations the accompanying diagram (Fig. 6) is given, showing the variation in annual rainfall at three points near the centre of the arid regions, viz., Salt Lake City, Utah, Fort Wingate, and

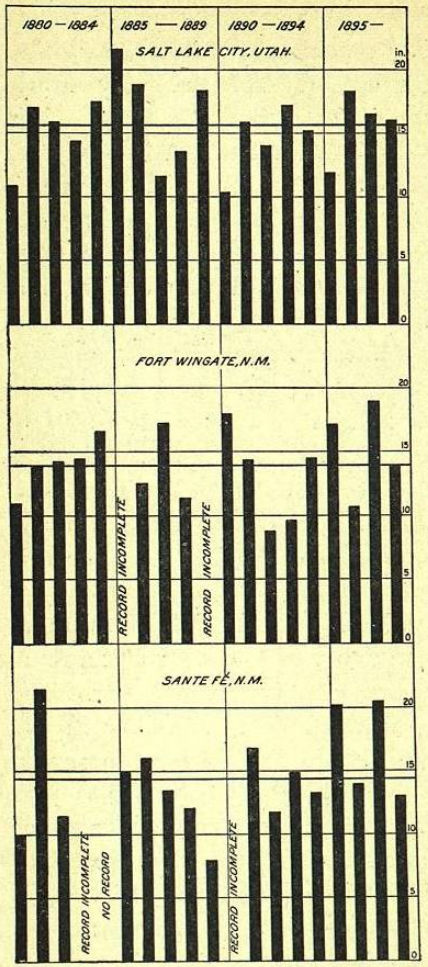
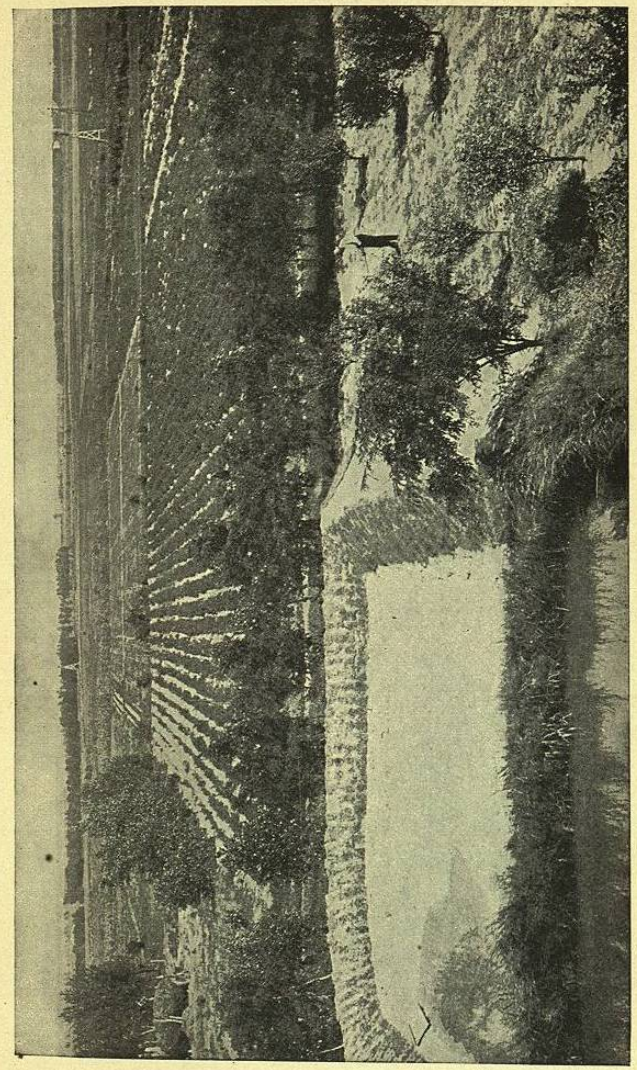


FIG. 6. — Variation in annual rainfall at points in the arid region.

Santa Fé, New Mexico. The average annual rainfall, indicated by the heavy horizontal line, is for Salt Lake City a little over 15 inches. In 1880, however, the amount was 11 inches, and in 1885 nearly 22 inches, fluctuating, as shown on the diagram, between 10 and 22 inches. Similar differences can be seen in the diagrams for Fort Wingate and Santa Fé. It is to be noted, however, that the years of excess and deficiency are not



RESULTS ATTAINED BY IRRIGATION.

coincident even in the localities not so very far apart.

When deficiency occurs, the effects of the aridity are notably increased, and an exceptionally large amount of water is needed to supply the lack of rain. These same fluctuations occur in humid climates, but their effects are not so marked. For example, in a country like that of the Atlantic seaboard, where the precipitation averages 50 inches, a deficiency of 10 inches during the year may not have a noticeable effect upon the crops and industrial conditions, but in a country of 20 inches of annual rainfall a deficiency of 10 inches may result in the disappearance of rivers and the destruction of the scanty vegetation, so valuable in cattle and sheep industries.

The amount of precipitation on the surface of the country, although varying greatly from season to season and from year to year, has been found to have a certain stability when looked at in a large way. That is to say, although for a series of years the rainfall may apparently have been increasing or diminishing, yet, taking a long record, as for example one hundred years, it has been found that the average for the first quarter or third of this is practically the same as that for the last third or quarter. In short, it has not been possible to detect any progressive increase or diminution in the amount of precipitation when records extending over thirty or forty years are had.

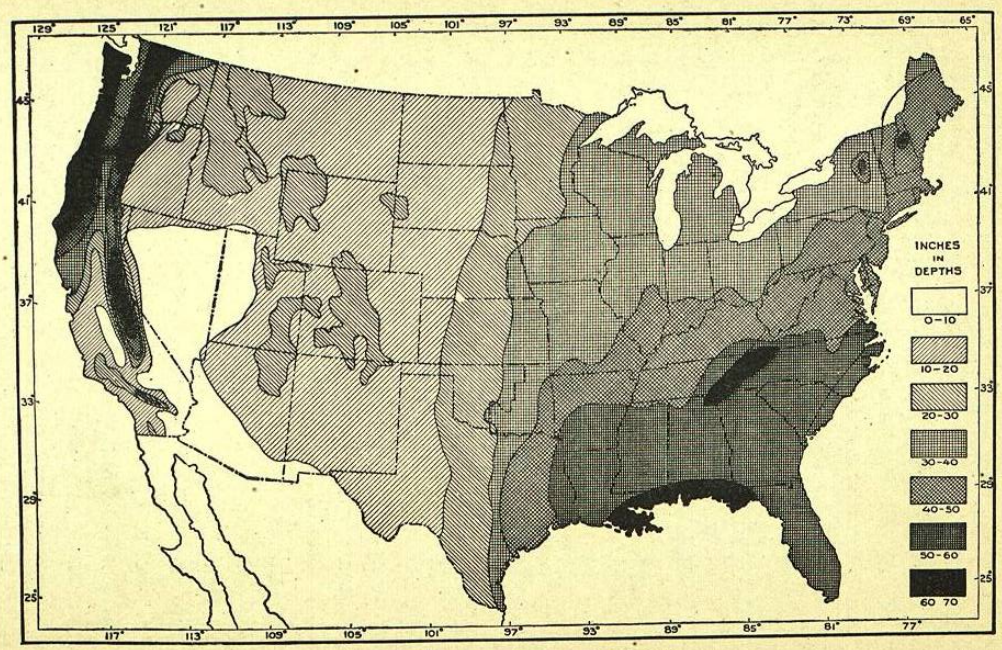


FIG. 7. — Map of mean annual rainfall.

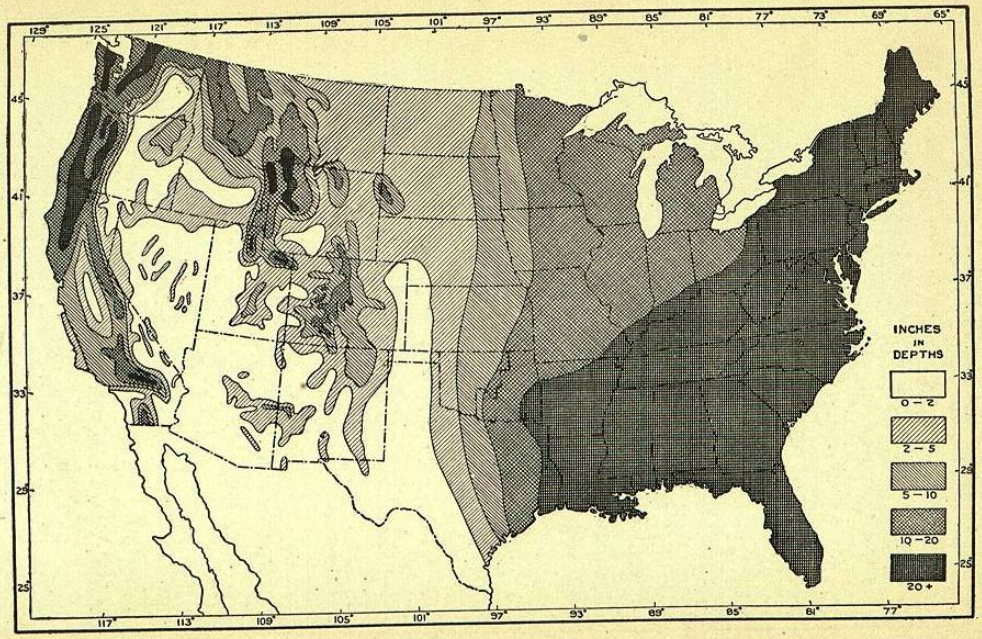


FIG. 8. — Map of mean annual run-off.

The average or what is termed the normal precipitation for each part of the country can be computed. Departures from this normal may be in one year or another very great, and for a series of years the rainfall may be above or below the normal; nevertheless, the weather conditions seem to swing back, no matter how far they have swayed. The climate may be regarded as fixed, although the weather changes widely and rapidly.

It is because climate has certain fixed relations to localities, that it becomes possible to make maps showing the general distribution of precipitation. The accompanying map (Fig. 7) gives the distribution of rainfall, including melted snow, over the United States. It indicates that in the East, along the Appalachian region and near the coast, there is a heavy rainfall, the amount decreasing inland, and increasing again very rapidly along the Pacific coast. The points of greatest rainfall are in northwestern Washington near Puget Sound, and at the opposite extreme of the country, near the Gulf and Atlantic coast.

The above-described map shows the depth of water which falls upon the land. If this did not flow off during the year, but all stood where it fell, the ground would be covered with water from an inch or two in depth in the arid region up to five or six feet, or even more, on the mountains and along parts of the seacoast. Some of this water, however, sinks into the soil or evaporates, and the

remainder flows off, forming streams. In the present discussion we are particularly concerned with that portion which runs off on the surface, and at this place a companion map (Fig. 8) is introduced to show the quantity of run-off, in comparison with the rainfall. This indicates that where the rain is heaviest the run-off is largest, while in localities where the rain is very light there may be no run-off and perennial streams do not exist. These matters are more fully discussed on page 58, but it should be noted that where there is the greatest rainfall, there is also the largest proportion of this — 50 per cent or more — flowing in the stream; while where the rainfall is least, only 1 or 2 per cent, or even none, goes to form rivers.

FORESTS.

The mistaken conception is sometimes held by citizens of the humid East that aridity implies desert conditions, the absence of vegetation, and the existence of naked rocks and sand glistening in the brilliant sunshine. On the contrary, the area of land which should be classed as desert is relatively small. West of the Great Salt Lake is a desert-like plain of sand and alkali, almost destitute of vegetation, where a few thorny or woody plants are to be found at intervals. Also, in southern California, west of the Colorado River, is the Salton Desert, embracing the bottom of an ancient arm of the Gulf of California, the land surface

being in some places three hundred feet below sea level, but shut off from the tides by the bars and ridges of mud brought down by the river. It is estimated that there are 70,000,000 acres of such desert in the United States out of the entire area of 973,000,000 acres comprising the western public land states and territories, or about 7 per cent of their land surface. The remainder of the arid regions, exclusive of these deserts, is covered with a more or less scanty vegetation of some value to mankind.

In this connection it is desirable to emphasize the fact that in the arid regions of the United States there are no desert conditions comparable in character and extent with those of Africa. There are all gradations of aridity, these differing for the same locality in successive years, owing to fluctuations in the amount of rainfall. In the somewhat arbitrary classifications just adopted, the assumption has been made that lands may be considered as desert where for a number of years in succession grazing is impossible. There may be seasons at rare intervals when the explorer or surveyor can cross even these areas and find occasional water and forage plants.

The higher mountain slopes and mesas whose abrupt rise forces upward the winds, and compels them to deposit moisture, have, as a consequence of the increased precipitation, a covering of trees. These are often scattered, but in many localities

they form dense and valuable forests. Within the arid and semiarid portions of the Western states it is estimated that nearly 124,000,000 acres are covered with woodland, the individual trees, though scattered, having value for firewood, fence posts, and other purposes essential to the success of the pioneers and farmers. In addition, however, over 97,000,000 acres are covered with heavy forests, having commercial value for timber and furnishing logs for sawmills (see page 55).

The aggregate of the area of desert, woodland, and forest forms a little over one-third of the extent of the arid and semiarid regions; the remainder, estimated at 446,000,000 acres, is grazing land. Thus, so far as area is concerned, it is evident that the grazing industry — the raising of range stock, cattle, horses, sheep, and goats is, and probably always will be, the great industry. When values are considered, however, there is another point of view.

The open range of the arid regions is generally stated to be capable of supporting a cow for every twenty or thirty acres; the same land, when watered and put in alfalfa, will frequently feed ten times as many cattle, or in orchards, with favorable climate, will support a family of three, or even five persons. The open range may have a value of 50 cents an acre, while under irrigation the selling price may rise to $50 per acre, or even $500 per acre when in orchards. Thus the value of the lands is