the plants, it will soak into the ground and soon increase the supply of forage.

There is a balance which must be preserved between the interests of the cattlemen in keeping the largest possible number of cattle on a range and those of irrigators and the public in general in securing the best ultimate use of the lands. Too many cattle means the destruction of the forage plants, washing of the soil, rapid run-off, and accumulation of silt in the lower rivers. In a larger way it is really to the interest of the cattlemen not to overstock the range, but for immediate individual gain this is always likely to happen unless regulated.

By totally excluding cattle from certain depleted areas it may be possible to restore these after a few years, and the natural growth can be further increased by the construction of inexpensive embankments thrown up by suitable machines or graders, such as to bring out upon the grazing land the waters which from time to time come rushing down the little gullies. It has been shown on a small scale by the experiments at Tucson that these embankments can be made by hand at a cost of less than $1.00 per acre, sufficient to distribute the storm waters and allow these to soak in, resulting in a yield of grass in that dry climate dense enough to be mowed by a machine. Instead of three-quarters of the water rushing off to waste, practically all of it can thus be held on the upper

catchment basins of the rivers and the value of the range land enormously increased.

Under present conditions there is no inducement for any person to guard or protect the open range land, and as a result the valuable forage plants are eaten down so closely as to be destroyed. If, however, one man or an association of men had the exclusive right to the grazing on a certain area for a term of years, it would be to his or their advantage not to overstock the range, but to treat it in such a manner that it would not deteriorate.

Should any law be enacted regulating the temporary use of the public land for grazing, it should be framed in such a way as not to retard the development of irrigation and the settlement of the land by homesteaders. It is probable that the licenses granted for grazing could be made subject to the deduction of relatively small areas for settlement without in any way interfering with the value of these licenses. The great object is to promote the permanent settlement of the country and the making of homes.

In order to provide wise laws, it is necessary to take cognizance of the customs which have resulted from experience. In nearly all counties of the arid states certain practices have arisen in regard to grazing, many of which might be recognized as binding, temporarily at least, until better systems are devised. For example, it has been customary to take sheep from the winter feeding grounds,

where forage raised by irrigation has been provided, and drive them out along certain portions of the cattle range up into the mountain valleys to spend the summer, later bringing them back again by a different route. This right of transit must be recognized in any license given for cattle grazing, and yet must be so guarded as not to be capable of abuse by keeping the sheep too long on the road and allowing them to eat too great a proportion of the vegetation.

Provisions in permits for sheep grazing can be made comparatively simple, since the sheep are always herded and are under complete control. With cattle and horses, however, close herding is impracticable, except in the case of small numbers owned by settlers. It is generally impossible to assign a definite range to a certain owner, as the cattle cannot be kept within bounds without expensive fences, and the fencing of the public domain is and should continue to be illegal. The use of individual cattle ranges is to a large extent impracticable except by owners of great herds. As a rule, it will be necessary to allow the cattle range to be used in common by many owners, the number of head of stock being agreed upon.

This matter of the regulation of grazing has been emphasized in the preceding pages, as it is one of fundamental concern in any new country, and has an intimate relation to the development of irrigation and the complete utilization of the public

domain. The land laws, which, as before noted, have been made with reference to the humid conditions, have not recognized this fact, and thus the rights of the pioneers have been left undefined and to the arbitration of force rather than of law.

CULTIVATED LANDS.

The cultivated lands of the western half of the United States, especially those within the arid region, form but a very small portion of the total land surface, in some states being less than one per cent. Dry farming — that is, the cultivation of the soil without the artificial application of water — has been attempted, but has been only moderately successful west of the 97th meridian, except in the humid regions near the Pacific coast and in a few localities where the conditions of soil and of local rainfall have been favorable. The accompanying map (Fig. 12) has been prepared to illustrate the extent to which dry farming has been attempted. In the extreme western portion of Kansas and eastern Colorado, experiments have been conducted on a large scale, but have rarely been successful; yet at many of the spots shown in the centre of the map, and particularly in Washington, Oregon, and California, wheat and other cereals are successful where the annual rainfall is even less than in eastern Colorado.

One of the notable features on this map is the fact that these dry farming areas are found in

nearly every state and territory of the arid region. Agriculture without irrigation is thus widely prac-

FIG. 12. — Map of dry farming.

tised, although it must be considered as exceptional. The area is gradually being extended as skill is acquired in the cultivation of some of the

more hardy or drought-resisting plants, and as species or varieties suited to the climatic conditions are found. The cereals, such as rye, wheat, and barley, form the greater part of the crops thus raised by dry farming, the growth or development of these being made possible by thorough tilling of the soil and by planting at a season of the year when the largest amount of moisture is available.

As an example of what is being accomplished without irrigation may be given the bench lands around Cache Valley in Utah. These high lands, to which water cannot be brought by ditches, were ten years ago considered as valueless. Experiments were made by the farmers in growing wheat on the lower lands without irrigation, and gradually the cultivated areas were extended up the hill slopes to the higher lands. Various varieties of winter wheat were tried, and it was found that these bench lands, receiving a covering of snow during the winter, were capable of producing good crops of wheat. The yield, although not so large as on irrigated land, is sufficient to afford a fair profit.

There is reason to hope that, with the activity in searching for new and valuable plants, and the numerous experiments being made, the extent of cultivable land can be greatly increased on the areas of good soil for which water cannot be had. It is not reasonable to suppose, however, that dry farming will ever add greatly to the population

and wealth of the arid region; it will rather tend to perpetuate the condition of sparse settlement and careless tilling of large areas. It is only by practising irrigation where water can be had that intensive farming is possible, and with this the best development of the country.

In this connection it is interesting to note the relative proportion of lands cultivated to those which may be considered as cultivable, taking a belt across the United States. The accompanying figure, prepared by Mr. Willard D. Johnson, is in-

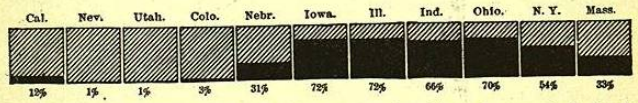


FIG. 13.— Comparison of cultivable and cultivated areas in belt of states across the United States. [The solid black show the cultivated and the cross-lined portions indicate the uncultivated but cultivable land.]

tended to illustrate the great difference which exists. Beginning with Massachusetts, with 33 per cent of the cultivable area in use, the proportion gradually increases westward to Illinois and Iowa, with nearly three-quarters of the land capable of cultivation in crop, and then decreases rapidly, until in Nevada only 1 per cent is utilized. With complete water conservation and systems for its distribution, the cultivated area of Utah, Nevada, and adjacent states might be increased many fold.

The actual amount of land which is irrigable has been variously estimated at from sixty to one hundred millions of acres. There is possibility of wide difference of opinion, since all estimates must be based on certain assumptions as to the completeness with which the floods can be saved and waters beneath the surface brought back to the fields. Noting the wonderful progress in engineering and in various applications of scientific knowledge, there seems to be ground for the most optimistic view. On the other hand, when progress already made is considered, arguments can be advanced against the practicability of utilizing much of the erratically distributed water supply of the arid region. In order to present, however, some general conception of the possibilities of irrigation, the accompanying diagram (Fig. 14) has been prepared, showing by black spots the areas irrigated and by dots the lands irrigable under a better development of the water resources.

The irrigated lands, whose relative position is indicated by the black spots, are of necessity greatly exaggerated; the lands which are actually under ditch are so scattered and relatively small in area that on a map of this scale it is impossible to show them in anything like their true magnitude. The object of the illustration is to bring to the eye the fact that the irrigated lands are scattered throughout the West, forming in aggregate less than 1 per cent of the total land area, and are surrounded by tracts 5 or 10 times as large, which are capable of being irrigated under ideal conditions.

The following table gives in round numbers the relative extent of the grazing, woodland, forest, desert, and improved land in the arid and semiarid

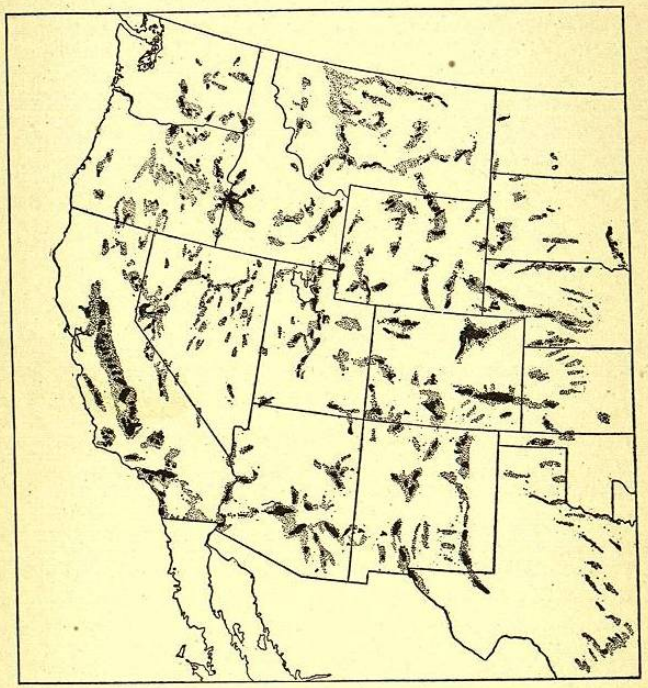


FIG. 14. — Map of irrigated and irrigable lands.

public land states. The totals are given in millions of acres, omitting the figures of less than a million in all cases except where the totals of improved or irrigated land are below one million. There is also

appended a statement of the estimated water supply, in similar terms, assuming a complete development and conservation of the water resources.

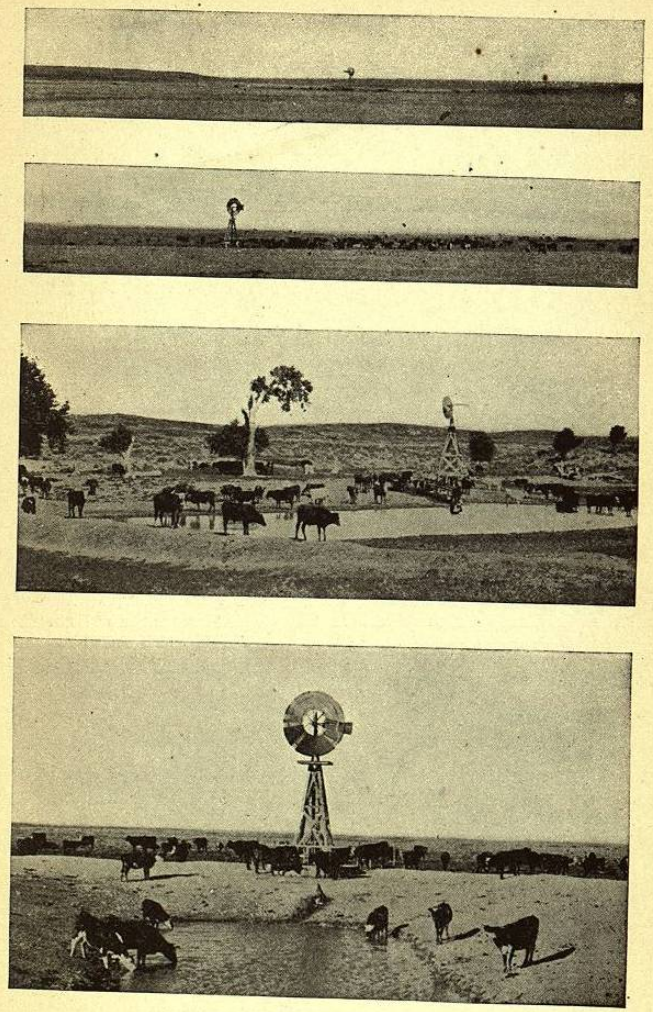
GRAZING, WOODLAND, FOREST, DESERT, AND IRRIGATED LAND, AND EXTENT OF WATER SUPPLY, IN WESTERN PUBLIC LAND STATES, IN MILLIONS OF ACRES.

States and Territories.	Land Surface.	Grazing.	Woodland.	Forest.	Desert.	Improved.	Irrigated.	Water Supply.
Arizona	72	38	14	5	15	0.2	0.2	2
California	99	20	19	19	20	15	1.5	17
Colorado	66	40	9	5		2	1.2	8
Idaho	54	20	12	11		1	0.5	5
Montana	93	56	7	12		1	0.8	11
Nebraska	49	25	2			22		2
Nevada	70	42	6	1	20	1	0.5	2
New Mexico	78	57	12	4		0.5	0.2	4
North Dakota	45	38	1			6		2
Oregon	60	18	9	19		5	0.3	3
South Dakota	49	38	1			10		2
Utah	52	18	16	4	10	2	0.5	4
Washington	43	9	13	13		2	0.1	3
Wyoming	62	39	3	4	5	1	0.5	9

The desert-like lands — those upon which no grazing is possible even in winter or after the rains of early spring — are relatively small; they are found mainly in the states of California, Nevada, Utah, Wyoming, and the territory of Arizona. In all they aggregate about 70,000,000 acres, as noted

on page 28. The surface of these areas is mainly sand and barren rock, the soil often being charged with an excess of soluble earthy salts, so that, even when moistened, plants cannot grow. Such, for example, are the broad flats adjacent to Great Salt Lake, in Utah, and the land around the sinks of the Humboldt, Carson, and Walker in Nevada. Other plains, such as those of southeastern California adjacent to the Colorado River, have a soil which is fertile and produces large crops whenever water can be had. Portions of these lands are reclaimable by deep or artesian wells, or by storing in reservoirs the intermittent floods of small streams which flow from the bordering mountains.

On Pl. VII are shown views of the broad expanses designated in the geographies of a generation ago as deserts, impassable for lack of water. Beneath the surface of many of these almost boundless wastes water has recently been found, and by means of windmills it is brought to the surface, making oases and rendering possible the use of the land for grazing. The herbage, though scanty, is nutritious; and by placing windmills and tanks at intervals of 10 or 15 miles, cattle can graze over the whole region.



CATTLE ON THE OPEN RANGE.