

OREGON.

[SIXTEEN EASTERN COUNTIES ONLY.]

Total population (average per square mile 1.27).....	89,495
Number of farms (11.35 per cent of population).....	10,159
Number of irrigators (31.01 per cent of farm owners, 3.52 per cent of population).....	3,150
Area (70,528 square miles).....	45,137,920 acres..
Area irrigated in census year.....	do..... 177,914
Area of all farms, 56.11 per cent improved.....	do..... 3,537,231
Cereals raised in census year, including 2 acres in buckwheat and 5,796 acres in rye.....	do..... 333,921
Barley, average production, 21.61 bushels per acre.....	do..... 28,808
Corn, average production, 15.07 bushels per acre.....	do..... 6,189
Oats, average production, 23.07 bushels per acre.....	do..... 27,482
Wheat, average production, 11.78 bushels per acre.....	do..... 265,644
Alfalfa.....	do..... 15,740
Total value of all farms, including land, fences, and buildings.....	\$36,183,030
Estimated total value of the farms irrigated in whole or in part.....	\$10,143,000
Estimated value of all farm productions (sold, consumed, or on hand) for 1889.....	\$7,517,370
Estimated value of productions, as above, from farms irrigated in whole or in part.....	\$2,473,000
Average size of irrigated farms.....	acres.. 56
Average size of irrigated farms of 160 acres and upward.....	do..... 300
Per cent of acreage of irrigated farms of 160 acres and upward to total acreage irrigated.....	42.80
Average size of irrigated farms under 160 acres.....	acres.. 35
Average first cost of water right per acre.....	\$1.61
Average annual cost of water per acre.....	\$0.94
Average first cost per acre of preparation for cultivation.....	\$12.59
Average value of irrigated land, including buildings, etc., in June, 1890, per acre.....	\$57.00
Average annual value of products per acre in 1889.....	\$13.90

GENERAL DESCRIPTION.

The above figures, as stated, apply only to the 16 eastern counties of the state, namely, those lying east of the Cascade range, together with 2 counties in the southwestern part of the state, where irrigation has begun to make headway. These, as arranged in alphabetical order, are Baker, Crook, Gilliam, Grant, Harney, Jackson, Josephine, Klamath, Lake, Malheur, Morrow, Sherman, Umatilla, Union, Wallowa, and Wasco. All comparisons of this state as far as irrigation is concerned apply only to the portions mentioned. With this understanding, it appears that Oregon stands sixth as respects number of irrigators and eighth in the area of land irrigated in 1889. For average size of farms it occupies an intermediate position and in many respects it differs little from Idaho, on the east, either as regards cost of water or value of products. In fact the conditions prevailing in eastern Oregon are a repetition of those throughout the Snake river drainage and the northern part of the great interior basin.

The topography of Oregon gives rise to sharp contrasts in the agricultural possibilities of the state as a whole. The most striking feature is the Cascade range, which, at a distance of about 120 miles from the coast, divides the state into two parts, differing widely in climate and general appearance. To the west of the range the rainfall is abundant, and vegetation flourishes in profusion, while on the eastern side the precipitation is small and barely sufficient for the needs of plant life. The range itself consists of a chain of lofty peaks of volcanic origin, the highest, Mount Hood, rising to an altitude of 11,225 feet. From the plateau on which stand these high, conical peaks the country slopes off toward the ocean, broken, however, by the intervening Coast range, which has an altitude of from 2,000 feet upward. Between these two ranges is the Willamette valley, one of the finest agricultural areas in the United States, possessing a genial climate, an abundant rainfall, and a fertile soil. In the southwestern part of the state there is no large valley between the Cascade and Coast ranges comparable to the Willamette, for the streams issuing from the Cascade range flow westerly to the sea and are bordered by less extensive areas of agricultural land. East of the Cascade range, and occupying the greater part of central Oregon, is a vast lava covered plateau, whose surface has an elevation of from 2,000 to 5,000 feet above the ocean. It is apparently a continuation of the vast lava plains which border the Snake river and cover the greater part of southern Idaho. Into this enormous sheet of lava, the general thickness of which is unknown, the streams of the region have cut for themselves channels of from 100 to 1,000 feet or more in depth, and they flow northerly to the Columbia river through deep canyons or gorges. On this vast plateau the rainfall rarely amounts to over 15 inches a year, nearly all the precipitation occurring in the winter and little or none in summer.

In the northeastern portion of the state, between the Snake and Columbia rivers, is a great irregular mass of mountains, whose structure is at present little known. The summits of these, the Blue mountains, rise to heights of over 6,000 feet. The base of the mass is deeply buried beneath the ever present lava, into which the Snake and Columbia rivers have cut their gorges. These mountains exert an influence beneficial to agriculture, for their peaks, rising abruptly from the plateau, encourage the precipitation of rain or snow, and give rise to many streams of great importance in irrigation. Their mineral contents give employment to a large population, and the grazing upon the mountain slopes adds to the wealth of the country. South central Oregon forms still another topographic division of the state, since it belongs to the great basin region and is characterized by the structure peculiar to that unique area. It contains a number of short mountain ranges, which are in reality blocks of the earth's crust slightly uptilted, the upper surface sloping off gently on one side, while the broken edges present bold faces with cliffs and precipices aggregating from 2,000 to 3,000 feet in height. Between these mountain blocks are the valleys, deeply filled with sediment, the surface being so nearly level that rain and flood waters form vast marshes or shallow lakes.

In eastern Oregon, namely, that part lying east of the Cascade range, there is, as a rule, sufficient moisture two or three years out of five to raise fair crops of wheat and other cereals, the success of such crops depending, however, largely upon the care and skill shown by the farmer, and not merely upon the occurrence of fortunate rains. The character of the soil also has an important bearing upon the abundance or failure of crops, some soils retaining a small amount of moisture for a longer time than others. There is always considerable uncertainty as to the success of the cereals, and there are some crops, as well as small fruits, which are never of value without an abundant perennial supply of water. It may be said, therefore, that in one sense irrigation is not absolutely essential, in that farmers can make a living, although a precarious one, without it. As a result, at all points east of the Cascade range, wherever the opportunity offered of diverting a perennial stream upon a piece of arable land there the pioneer has taken up his abode and has cultivated a small acreage of cereals, a garden patch, and as large a forage crop as he can irrigate. Irrigation has been quietly and gradually introduced and practiced in a simple manner, each farmer building his own ditch. Occasionally a few settlers have joined together to accomplish an undertaking too great for any one alone, and in rare instances outside assistance has been called in, but up to the census year it may be said that irrigation in Oregon was in the earliest stage of development, namely, that of individual effort. That year, however, and the one preceding, were times of unusual drought, and the interest in such matters was greatly stimulated by the investigations into the benefits and possibilities of irrigation. The advantages to be obtained through irrigation canals began to be appreciated, as well as the great increase of land values throughout the arid regions. Many projects, therefore, were set on foot in 1890 looking toward the more complete utilization of the water supply of the eastern part of the state. This is especially the case along the rivers issuing from the Blue mountains, the Wallawalla and the Umatilla, and also as regards the wonderful water supply of Klamath lake and its tributaries.

Not only has irrigation received a stimulus in that part of the state where it is essential but its benefits are beginning to be seen in regions where it is usually considered that there is an abundant rainfall. Even in the Willamette valley irrigation is being introduced in a small way, at present mainly for gardens and orchards, for vegetables and berries, or for the late forage crops, artificial watering being of especial benefit during the months of July, August, and September, when the rainfall is at its minimum. At the same time irrigation is creeping around the southern end of the Cascade range, being already of great importance in Jackson and Josephine counties, and is gaining a foothold in Douglas county to the north, although many of the inhabitants indignantly deny that any such method of agriculture will ever be necessary.

WATER SUPPLY AND PRECIPITATION.

Measurements of the amount of water flowing in the streams have been made at two points in eastern Oregon, namely, on the Owyhee, a short distance above its mouth, and on the Malheur, at Vale. Both of these streams are bordered by lands to which water can be brought and large areas rendered highly productive. The fluctuations in the water supply are, however, very great, and must be carefully considered before any general improvement of present systems of irrigation can be entered upon. The behavior of the water in these streams is in a broad way characteristic of that in other rivers of eastern Oregon, since all the streams receive their supplies from comparatively low mountain areas upon which the snow melts early in the season. In this respect the rivers present a marked contrast to those issuing from the main range of the Rockies or from the Sierra Nevadas, the floods occurring earlier in spring and the summer flow decreasing to a less proportional quantity than in rivers from these latter mountains. The distribution of the water by months is shown by the percentages contained in the table on the following page, exhibiting these in connection with the fluctuations of rainfall. From an inspection of this table it is apparent that in April over one-third of the entire amount of water for the year was discharged, and in March, April, and May three-fourths of the whole quantity. Nearly all of this goes to waste, for in most localities it is too early in the season to begin thorough irrigation.

The distribution of the rainfall in the state has been discussed by General A. W. Greely, Chief Signal Officer, in a pamphlet upon the climate of Oregon. (a) In this report are given tables showing the precipitation and temperature at various points, the facts being shown graphically upon maps. In eastern Oregon there are comparatively few stations at which records of rainfall have been kept for any considerable length of time. At Camp Harney, near Malheur lake, observations were maintained at intervals from 1867 to 1880. The average annual rainfall for 7 full years was a trifle less than 11 inches, and of this amount less than 2.5 inches, or 23 per cent of the whole, fell during the 5 months from May to September, inclusive. At Fort Klamath, situated at the head of Klamath lake and almost immediately at the eastern foot of the Cascade range, the record of rainfall has been kept, with occasional breaks, from 1864 to the present year. The mean annual rainfall at this point, which has an elevation of 4,200 feet, was 22.6 inches, while the amount falling in the 5 months from May to September, inclusive, was 3.3 inches, or nearly 15 per cent of the total. At Dalles, on the Columbia river northeasterly from Mount Hood, the average annual rainfall since 1875 has been 16.5 inches, 2.1 inches falling during the 5 months above mentioned. The rainfall for the extreme eastern side of Oregon is perhaps best shown by the record for Boise, Idaho, which has been kept since 1877, the average being 14.3 inches, 2.9 inches of this amount falling during the 5 months from May to September, inclusive. Combining the rainfall observations at Dalles, Fort Klamath, Camp Harney, and Boise, Idaho, and assuming that the averages obtained represent the monthly distribution of rainfall over eastern Oregon, the percentages of total precipitation shown in the following table are obtained:

AVERAGE MONTHLY DISCHARGE OF RIVERS AND PRECIPITATION IN EASTERN OREGON.

MONTHS.	Discharge of rivers. (Per cent.)	Precipita- tion. (Per cent.)
January	2.2	16.2
February	7.6	12.0
March	25.9	10.5
April	30.0	8.7
May	19.6	6.3
June	5.4	5.1
July	1.6	1.9
August	0.9	1.3
September	1.0	2.7
October	1.3	7.4
November	2.5	11.2
December	2.0	16.7

The distribution of the rainfall throughout the year is strongly marked. In general it may be said that there are two seasons, the wet and the dry. The greatest amount of rain falls usually in December or January, and from that time onward the rainfall gradually diminishes to July or August, when the drought is at its maximum. In September and October there is a slight increase in the amount of rain, and this continues to midwinter. May, June, July, August, and September can be considered as dry months, while the period from October to April, inclusive, is the wet season, during which from 75 to 85 per cent of the rain falls. Comparing the distribution of rainfall with the river flow, it appears that the point of maximum precipitation of rain or snow is reached in December or January, at least 3 months before the time of the greatest river flow, while, on the other hand, the periods of minimum rainfall and riverflow approximately coincide, occurring in August. The fact that the discharge of the streams does not coincide more nearly in behavior with the monthly distribution of rainfall is due principally to the effect of the temperature. During the winter months a large part of the precipitation occurs as snow, and this remains upon the mountains until melted by the warm winds of spring, causing a general increase in the quantity of water carried by the rivers.

It is evident from the examination of the distribution of river flow throughout the spring and summer that these and similar streams can not be made of the greatest possible use to irrigation until methods are devised for holding back this surplus water of early spring, and keeping it to increase the low water during the period of low water a few months later. Storage reservoirs must be built in all favorable localities, and controlled in such a manner that the waters can be employed by the irrigators all along the course of the river. In order to accomplish this result, however, many engineering difficulties must be overcome and favorable legislation enacted both as regards the construction and maintenance of such works and the distribution of the water thus saved.

LEGISLATION.

Up to the time of the census the laws of Oregon were not favorable to the development of irrigation. The majority of the population live west of the Cascade range, where the rainfall is abundant and irrigation not necessary. The laws regarding water, therefore, have been those suitable to a humid climate, and in the direction rather of

a Climate of Oregon and Washington territory, Fiftieth Congress, first session, Senate Executive Document No. 282.

preventing diversions from the streams than of favoring the use of the water for irrigation. Of late, however, the necessities of the case have been impressed upon the public mind and legislation favorable to irrigation enterprises has been placed upon the statute books. Irrigators state that their water rights have been in the greatest confusion, and that they have had no protection or security in their possessions, and since in arid regions the land values rest directly upon the ability to secure a continuous supply of water the titles to property have been in a somewhat precarious condition. (a)

DITCHES.

The irrigating ditches of the state are as a rule quite small, and have been built by stock raisers to irrigate a few acres on their ranches, or by other settlers who have come into the country with scanty means and have been compelled to make use of temporary expedients in order to obtain a crop. There are very few ditches of large size already constructed and in operation, although a number have been projected. Most of the ditches have been built for a number of years, and their owners do not remember the details of their cost and construction. Taking, however, the statistics as given by irrigators, it appears that there was an independent ditch from some stream for every 200 acres of crop irrigated. The average cost of the small ditches under 5 feet in width was \$260 per running mile, of those of 5 feet in width and over and less than 10 feet the cost was \$1,060 per mile, and for those of 10 feet and over, \$1,300 per mile.

WELLS.

Throughout eastern Oregon, wherever water can not be procured from running streams there has been a general discussion as to the feasibility of obtaining water from wells. Many attempts have been made to obtain water in this way by digging or boring, and in a few instances flowing water has been struck. These instances are comparatively rare, and success appears to be due to some local peculiarity of geologic structure. The largest flowing wells yet reported are those in the vicinity of Baker, being situated in the broad valley through which the Powder river flows. This area is partially inclosed by spurs of the Blue mountains, the main range of which is to the northwest. The depth of these wells is reported to be about 150 feet, and the discharge may be as high as one-fourth of a second-foot, the statements on this point being meager.

Other flowing wells are reported in Gilliam and Wasco counties along the Columbia river, where are a number of large springs, some of which may have been considered as wells by the owners. Attempts made to reach flowing water by drilling through the lava covered plateaus have not as yet been successful, and the probabilities are against it. In the vicinity of the lakes of Harney, Lake, and Klamath counties it is possible that small flowing wells can be found, judging from the similarity of geologic conditions there with those of other parts of the great basin region. It has been found that as irrigation is practiced on the edges of these broad valleys, as in the case of Utah Lake valley and Salt Lake valley, in Utah, the lower gravel beds become saturated, and when pipes are driven on the lower ground to a depth of from 20 to 100 feet, penetrating these gravels, a small, though constant, discharge is obtained. Although flowing wells may not be found on the higher plateaus, yet these drillings can not fail in many localities to reach water of some kind, and if this water should prove to be fresh and palatable, it can be pumped, as is already done in a few localities, furnishing a supply for domestic purposes and for the watering of stock, and even for irrigating small patches of ground. In an arid country even these areas, though insignificant in size, are relatively of great importance to the development of other interests, such as stock raising and mining.

VALUE OF PRODUCTS.

An examination of the average value of products per acre, given in the following table, shows that the supply of water in the census year could not have been ample, but a comparison of these figures among themselves and with those for other states demonstrates that the cause tending to make these averages small prevailed throughout all the agricultural communities. It is a well known fact that farmers as a rule undervalue their products, especially those consumed, and there is a strong presumption that they overestimate the size of the areas cropped. Much of the land, especially in counties where grazing is the chief industry, is but carelessly irrigated. The water is applied to large areas and allowed to make its own way across the fields; the hay crop from this land is given a very small valuation by ranch owners, and since these areas are relatively large the average value of products is

a In February, 1891, a law was enacted providing for an appropriation of water from lakes and running streams for purposes of irrigation, for the condemnation of lands for right of way of irrigating ditches, for extinguishing the claims of riparian owners, and in general for facilitating the construction and maintenance of irrigating works. The employment of the waters of lakes and streams for irrigation and household purposes or for watering stock upon dry lands is declared to be a public use, and the right to collect compensation for such water franchises. All existing appropriations of water for beneficial purposes, made in accordance with laws or established customs, are to be respected and upheld to the extent of the amount of water actually appropriated. New canals are to be constructed by the most direct route practicable, and two or more ditches are not to be made through a tract of land when the water can be conveyed in one ditch. All corporations must supply water to consumers applying therefor, upon the tender of the customary rates and the construction of necessary distributaries, unless there shall be an insufficient amount available. Dues for water become a preferred lien upon all crops raised by its use. Interference with irrigating works is prohibited by penalty, and, on the other hand, corporations are held liable for damages due to neglect or want of strength in structures built by them.

correspondingly small. By multiplying the average value of products per acre by the average number of acres in crop the average annual return to each farmer should be obtained. In the case of Oregon this is approximately \$778, which is apparently the average earnings per irrigated farm, excluding the profits from stock raising, which, however, is the principal source of revenue to the farmer.

CONDITION OF IRRIGATION IN EACH COUNTY.

NUMBER OF IRRIGATORS, AREA IRRIGATED, FARMS, AND CROPS IN EACH COUNTY IN OREGON IN 1889.

COUNTIES.	Number of irrigators.	Area irrigated in acres.	Average size of irrigated farms in acres.	OWNERS OF FARMS. (a)		IRRIGATORS.			Area of counties in acres.	FARM AREA.		AREA IRRIGATED.			Average value of products per acre.	
				Total number.	Per cent of population.	Per cent of farm owners.	Per cent of population.	Acres.		Per cent improved.	Cereals. (Acres.)	Alfalfa. (Acres.)	Per cent of area of county.	Per cent of total farm area.		Per cent of land owned by irrigators.
Total	3,150	177,944	56	10,159	11.35	31.01	3.52	45,137,920	3,537,231	56.11	333,921	15,740	0.39	5.03	15.89	\$13.00
Baker	495	31,471	77	455	6.73	89.07	6.03	1,200,800	111,295	54.59	6,629	1,278	2.50	28.28	20.45	12.92
Crook	245	8,618	35	622	19.17	39.39	7.55	5,216,000	176,089	33.92	3,090	1,113	0.17	4.80	0.00	17.01
Gilliam	78	1,937	13	673	18.69	11.59	2.17	1,088,000	269,360	36.44	17,441	357	0.10	0.39	2.07	20.20
Grant	325	16,718	58	624	12.28	52.08	6.40	3,562,080	399,590	42.19	3,205	519	0.53	9.38	14.29	14.34
Harney	240	26,289	110	482	18.84	49.79	9.88	6,784,000	469,813	46.90	2,457	250	0.30	5.00	18.31	13.98
Jackson	169	3,230	19	798	6.97	21.18	1.48	1,843,200	228,055	59.21	24,654	3,479	0.18	1.42	5.81	22.42
Josephine	144	2,598	18	398	8.16	36.18	2.95	1,027,200	71,143	29.98	3,952	310	0.25	3.65	6.01	24.95
Klamath	56	5,639	102	332	13.58	16.87	2.29	3,532,800	137,841	54.68	4,404	74	0.16	4.13	15.68	17.16
Lake	355	25,549	72	372	14.29	95.43	13.63	5,145,600	151,968	75.93	1,898	53	0.50	16.81	20.88	11.37
Malheur	329	22,937	67	378	14.53	87.04	12.65	6,359,040	87,190	43.80	1,761	1,937	0.35	25.27	26.65	10.91
Morrow	45	870	20	700	16.65	6.43	1.07	1,292,800	273,873	80.97	29,981	1,620	0.07	0.32	2.81	30.59
Sherman	8	142	18	373	20.81	2.14	0.45	326,400	150,789	58.04	34,161	80	0.04	0.09	9.51	14.53
Umatilla	148	3,571	24	1,372	10.25	10.79	1.11	1,846,400	526,082	73.04	139,137	2,004	0.19	0.68	6.18	32.59
Union	346	21,947	63	1,104	9.17	31.34	2.87	1,942,400	320,673	56.95	46,134	2,075	1.13	6.84	22.72	19.03
Wallowa	111	4,147	37	603	16.47	18.41	3.03	1,849,600	119,189	40.60	4,246	27	0.22	3.48	16.27	16.17
Wasco	143	2,012	14	873	9.51	16.38	1.56	2,121,600	244,327	61.60	10,111	564	0.09	0.32	5.02	33.73

a Includes owned and hired farms, assuming one farmer to each.

BAKER COUNTY is in the eastern end of Oregon, extending from Snake river to the Blue mountains on the west, and from Powder river on the north southward to the divide between Burnt river and the tributaries of the Malheur. The surface of the county is in general hilly or even mountainous, especially in the western part. The rocks, most of which are of eruptive origin, contain small quantities of gold, and the streams which flow from the Blue mountains to the Snake river pass through rich deposits of gold-bearing gravels. This mineral wealth attracted the earlier settlers, and it was only after the establishment of several important mining camps that stock raising and the cultivation of the soil were undertaken. Placer mining is still carried on whenever there is sufficient water, but its relative importance has considerably diminished. Crops can not be raised in the eastern end of this county without irrigation. The only exception to this statement is perhaps in the case of rye, which, if planted early in the spring, may mature without artificial watering. The water supply for irrigation is not of the best, as the streams depend largely upon the melting snows of the mountains. The altitude of the range is not sufficient to cause the accumulation of great masses of snow, and in some years the precipitation is light. As a consequence of the general low altitude of the mountain masses, the snows often melt early in the spring, causing floods in March, April, or May, before there is need of irrigation. Later in the season, when the demand for water is greatest, the streams become almost dry. Water storage, therefore, is urgently needed, and is already being attempted in a small way.

Powder river flows easterly from the southern spur of the Blue mountains, then turns north into a broad valley and continues along the foot of the range, receiving on its way various tributaries from the mountains to the west. After flowing in this direction for from 30 to 40 miles, it turns abruptly to the southeast and finally enters Snake river. Farmers have settled in the valleys along this river, and water is diverted for irrigation from the tributaries coming in from the west, as well as from the river itself. Nearly all of the ditches are small, and have been built by individual farmers, there being few owned by corporations. Burnt river rises south of Powder river and flows in a general easterly course to Snake river. The sands of this river and its tributaries are especially rich in gold, as are also those of Willow creek, which is still farther to the south, in Malheur county. There are also extensive deposits of auriferous gravels on the low divide between these streams, and the waters of Burnt river have been diverted by long and expensive ditches to work these higher placers. The amount of water available is so small that this kind of mining can be carried on only for from 1 month to 3 months in each year. Farmers have settled along Burnt river and in favorable localities have taken out small irrigating ditches. As is usually the case where miners and farmers use water from the same stream there is more or less complaint on the part of the irrigator that the mining companies interfere with his operations by diverting the water or by overloading it with

sediment. The older settlers also assert that the increasing use of water for the irrigation of new land farther up the stream is gradually depriving them of their share, and that they can not raise crops on more than two-thirds of the land formerly tilled.

CROOK COUNTY is in central Oregon, lying east of the Cascade range and west of the southern spur of Blue mountains. The surface of the country is in general rough and broken, and it is covered by vast sheets of lava, into which the rivers have cut deep canyons. In the western half of the county are extensive tracts of high lands known as the "Desert". Much of the soil of this area is covered by sand, and occasionally rough blocks of lava appear above the surface. The county as a whole is well adapted for stock raising, as the nutritious bunch grass is found almost everywhere, even on the "Desert". Sagebrush and juniper abound, the latter being used for fuel and also for fencing. Few crops can be raised without irrigation. Rye, the principal cereal, is generally cultivated without the artificial application of water, but other cereals are usually irrigated if possible. By summer following, however, fair crops of wheat, oats, and barley are raised on the higher grounds whenever the drought is not too severe. Along the river bottoms, wherever water can be taken out farmers have dug small ditches, and are bringing land under irrigation as rapidly as their means will allow. There are large tracts of higher level lands above the reach of water unless it is held by storage among the hills.

The greater part of Crook county is on the head waters of Deschutes river, which flows northward into the Columbia. A small part of the northeast corner borders on Johnday river, which drains Grant county, and also flows northward, entering the Columbia a few miles above the mouth of the above mentioned river. Deschutes river receives the greater portion of its water supply from the eastern slope of the Cascade mountains, where are a number of lakes, each at the head of a tributary of the stream. Owing to the influence of these lakes or to the gradual percolation of water to the river the amount discharged fluctuates within comparatively narrow limits. It is reported that the height of the river ordinarily does not vary more than from 18 inches or 2 feet during the course of the season. It is possible that some of the waters of this river can be taken out upon the high arid plains along its upper course, and it appears not improbable from the reports of irrigators in the county that a great irrigating system can be profitably constructed along this river. There seems to be no question as to the permanence of the water supply, the fertility of the land when irrigated, and the favorable character of the climate.

The principal tributary of Deschutes river in this county is Crooked river, which flows in from the east, carrying the water which drains from the mountains of the western part of Grant county. The supply of water in this stream is in general large enough for the area of irrigable land in the narrow valleys along its course. The smaller tributaries, however, become nearly, if not quite, dry early in the summer, and without storage are of comparatively little value for irrigation. Under the stimulus of recent legislation a number of enterprises have been undertaken with the object of diverting water from Crooked river or its tributaries. Among these may be mentioned the ditch of the Prineville Irrigation Company, which takes water from Crooked river south of Prineville and runs out on the west side of the stream. When completed the ditch will be 15 miles long and 12 feet wide, and it is estimated to cost \$12,000. Work was begun in October, 1890. There are small ditches taking water from Ochoco river, the principal tributary of Crooked river, as well as from the latter stream, and, in short, wherever water can be taken out upon arable land at little expense ranch owners throughout the county have done so. By far the greater acreage irrigated is for forage, since there is very small demand for other products. During the drought of 1888 and 1889 the streams shrunk to a volume so small that only a small portion of the hay crop could be irrigated. As a consequence, the yield was far below the average, and great numbers of cattle perished for want of food.

GILLIAM COUNTY is in northern Oregon, northeast of Crook county, from which it is separated by Johnday river. It extends along the east side of this river in a comparatively narrow strip from the mountains on the south to the Columbia river on the north. Like that of Crook county, its surface is broken and the principal streams flow in canyons or narrow valleys far below the general level of the plains. In many years crops can be raised without irrigation, and most of the farmers trust to an occasional rainfall to bring these to maturity. Along the valleys, however, farmers are irrigating gardens and small patches of alfalfa wherever a perennial supply of water can be found. The higher lands of the county, being far above the reach of water from the large streams, can not be irrigated except in a few localities where storm water can be held in storage reservoirs. The farmers of the county are endeavoring to cultivate such crops as will require the least moisture. Often, however, they are compelled to bring water for several miles for domestic uses, and it is with difficulty that even this small amount can be procured.

GRANT COUNTY is east of the center of Oregon, lying between Baker and Crook counties. It is on the west side of Blue mountains, and contains the greater part of the head waters of Johnday river. As in the counties just mentioned, the surface as a whole is broken, the rivers having cut deep canyons, in which they flow at places several hundred feet below the general level. Mining and stock raising are the principal industries of the county.

and agriculture proper is slowly gaining in importance. There are no railroads in the county; transportation is difficult and expensive, and the area of arable land is, in comparison, so small that it seems probable that stock raising will for some time remain the principal occupation of the settled population. Very little can be raised without irrigation. In some places rye or barley yields a fair return without the application of water, but, as a rule, it is a matter of considerable risk to cultivate any crop without having an abundant water supply at hand. The altitude of the agricultural lands ranges from 3,000 to 5,000 feet, and thus the climate of a part of this area is so cool that frosts may occur even during the summer months. The principal farms of the county are those along the banks of Johnday river, which are so situated that water from that stream can be brought upon them. Some of this lowest land is flooded by the annual overflow of the river and requires little, if any, artificial watering. Besides the farms on the river, there are a large number of ranches situated upon the creeks which flow from the higher mountains. Water is used on these for raising hay and for the small amount of produce required for home consumption.

The water supply of the county as a whole is good, from the fact that the area of level land is limited, and there are large areas of elevated catchment from which water comes. Johnday river carries throughout the year a large amount of water, but the smaller streams after the spring floods decrease rapidly in size, and many of them become almost, if not quite, dry during the summer season. Farms along the main river, so situated that water can be brought to them, possess a great advantage in this regard over those on the smaller streams. The main branch of Johnday river rises in the mountains on the east side of the county and flows nearly west for about 60 miles, passing through what is known as Johnday valley, containing the principal body of farming land in the county. On its way it receives numerous tributaries which enter the valley from both sides and furnish, at least in the spring, a supply of water for the higher lands. The farming land along the valley averages about 1 mile in width, while that used for grazing is from 10 to 20 miles wide. At the western or lower end of the valley the south fork comes in, and the stream turns almost due north, passing through a spur of Blue mountains. It then receives the waters of the north and middle forks and turning to the west passes out of the county. On the southern edge of the county is a portion of the head waters of Silvies river, which flows south into Harney county. Some irrigation is done from this stream, but the altitude is so great that only the hardier crops are raised.

The earliest ditches were built for mining and are still employed to a large extent for this purpose whenever there is sufficient water. Irrigators use the surplus waters from these ditches, there generally being an abundance until the middle or end of June, but when a time of scarcity occurs they are compelled to pay for the water used. Most of the irrigating ditches have been built by individuals, although along Johnday valley there are cases where farmers have joined in partnership in the construction of irrigating systems. Although there is an ample supply of water in this stream, no attempt has been made to take out a large canal to cover the higher lands on account of the engineering difficulties and the expense involved in the construction of such works in this hilly country.

HARNEY COUNTY is in the southeastern part of Oregon, lying south of Grant county. The greater part of this area, as well as that of Lake county to the west, is within the great basin, the streams flowing into shallow lakes or sinks from which the water escapes only by evaporation, the contained mineral matter tending to accumulate and to make the water saline, similar to that of Great Salt lake, in Utah. None of these lakes are as salt as this great body of water, and in many of them the water is so fresh that it can be used for domestic purposes and for watering cattle. Other lakes, as, for example, Summer and Abert, contain a strong solution of potash and soda salts. An explanation given by Gilbert of the nonsaline character of some of these lakes is that they occupy basins which in a comparatively recent time were completely dry. A very slight change in the climate, as, for example, a small decrease in annual rainfall, would cause these lakes to disappear, while, on the other hand, a slightly increased annual precipitation would fill some of them to overflowing. This is the case with Malheur lake, which in past times has overflowed and contributed water to the Malheur river.

The oscillations of climate indicated by the ancient shores of these lakes are of especial interest as showing that in times past there have been great changes in the water supply of this area. As shown by the beaches, the valleys have been filled with water in some instances to a depth of several hundred feet and have again been completely dry, the climate having apparently been far more arid than at present. This period of excessive aridity was followed by an increase of rainfall, so that again the water filled the valleys to a height even greater than before. Then came a gradual decrease to a second period of aridity, which has continued with small oscillations to the present, the slight changes of this century being almost insignificant in comparison with those which have taken place within geologic time.

On the eastern edge of Harney county the middle and south forks of the Malheur rise in the mountains, forming the rim of the basin, and flow out in a general easterly direction across Malheur county into the Snake river. On the northern side of the county is a low range or detached spur of the Blue mountains. These rise to heights of 6,000 feet or over, and from them numerous streams flow in nearly every direction. Those which go toward the south come out upon the broad Harney valley, after passing through the low foothills, in which are

numerous smaller valleys. In time of flood the water traverses the broad plains and finally collects in the lowest parts, forming sinks, the most important of which are Malheur, Harney, and Silver lakes. The waters of these lakes are increased also by streams which come into this basin from the south from Stein mountains, whose altitude is upward of 8,000 feet.

The principal industry of the county is stock raising, a little hay being cut for winter feed, and also some barley, rye, oats, corn, and vegetables being produced for home consumption. There are excellent cattle ranges in the mountains to the north of the county and also on those south of Malheur lake. Comparatively little irrigation is done, and it is mainly from small springs among the hills, the water of the larger rivers being controlled to a great extent by cattle companies and used to flood large areas of meadow. Agriculture proper has hardly been introduced in the county, and irrigation everywhere is carried on imperfectly. Some of the settlers who are too poor to construct ditches have attempted to raise crops without an artificial supply of water, but they have generally failed, and in some instances they have been compelled to abandon their homestead claims. In other cases where a small amount of land was irrigated successfully for a few years, the decrease in the amount of water flowing in the streams during the two years of drought has resulted in such a scarcity of water that these lands could not be irrigated, and they also have been abandoned. There have been disputes concerning the distribution of water, and the owners of the smaller ranches complain that large cattle companies monopolize the present supply and prevent irrigation development.

The crop areas of the county are in the small valleys among the mountains in the northern end of the county, or in Harney valley along the streams near the point where they leave the foothills. There are also ranches along the streams which flow from Stein mountains, in the southeastern part of the county. The principal settlements, however, are to the north of the lakes, which occupy nearly the center of Harney valley. Harney valley contains the most extensive area of nearly level, fertile land in eastern Oregon, and would be capable of supporting large agricultural communities if water could be secured for the irrigation of all of its rich soil. The streams entering it do not furnish enough water to supply even a small fraction of this area. Water can be found in most places at a depth of from 10 to 20 feet, and in quantities sufficient for domestic purposes and for cattle. It is probable that if this water can be raised to the surface by some cheap mechanical means areas of considerable size can be cultivated. At present the land is almost valueless, and the valley is in appearance nearly as wild as when discovered.

The principal stream, coming from the north into Harney valley and emptying into Malheur lake, is known as Silvies river. This is a perennial stream to the point where it leaves the foothills, but beyond this place its channel at times becomes dry. At the point where it enters the valley the discharge is reported to be usually from 50 to 60 second-feet. To reach Malheur lake it must traverse the valley for a distance of about 25 miles, and it can do this only in time of flood. During the irrigating season of 1888 the river flowed for a distance of over 9 miles into the valley and in 1889 it extended only 7 miles. In 1890 the waters reached the lake, but did not continue to do so for any long period. Harney valley is so nearly level that in times of flood the water of Silvies river and other streams spreads out over the surface or subdivides into numerous channels or sloughs before reaching the open lake. During the time of the annual flood therefore it is a matter of no great labor or expense to divert the water by little channels or furrows and cause it to flood large areas, from which crops of hay can be cut later in the season. In times of drought, however, as in 1888 and 1889, these lower level lands do not receive any water, and irrigation can be carried only at points higher on the stream. On the lowest lands in this valley there is, during years of unusual flood, an excess of water in March, April, and May, but by the first of July the supply is always scanty.

Near the head waters of Silvies river is Silvies valley, over 10 miles in length and from 1 mile to 3.5 miles in width. The river flows through the center of this valley and is bounded by bottom lands for the greater part of this distance. On each side are sagebrush plains sloping up to the hills, which are partially covered with the species of pine common to that part of the country. The elevation is about 5,400 feet, and the climate is generally cold and frosty, although during some summers there is no frost for a period of from 2 to 3 months. Irrigation is carried on in this valley for the purpose of raising hay, the greater part of the water supply being owned or controlled by a cattle company. West of Silvies river is Silver creek, which flows southerly and southeasterly toward Harney lake. The water supply, however, is deficient and does not supply the needs of the irrigators depending upon it. In the northeastern part of the county in the vicinity of Drewsey, on the middle fork of the Malheur, considerable irrigation is practiced, mainly by means of water from the small streams flowing from the mountains.

JACKSON COUNTY is in southern Oregon, west of the Cascade range. It thus lies outside of the arid regions of the United States, since the rainfall on the western side of the Cascade range is usually sufficient for the needs of agriculture. Irrigation is carried on to a certain extent, as larger crops per acre can be raised by this means. The principal industries of the county have been mining and stock raising, but, since there is a railroad running through the county furnishing transportation from California to the Columbia river, the cultivation of small grains and fruits has assumed a greater importance. These are successfully raised without the artificial application of

water, but it has been found that certain soils, apparently barren and sandy, can be rendered very productive by irrigation. This is especially the case in the cultivation of certain forage plants, alfalfa, timothy, and other native grasses yielding under this method of cultivation a large return on tracts otherwise almost worthless. The climate, like that of all the counties near the coast, is mild and favorable for the production of fruit, many of the orchards being irrigated.

The water supply of the county is large. Nearly all the streams are tributary to Rogue river, which flows in a general westerly direction into the Pacific ocean. The valleys in general are narrow, and are at an elevation of from 1,200 to 2,000 feet and upward. The amount of level land is comparatively small, and it is necessary, therefore, in most cases to build long and somewhat expensive canals in order to cover a large area of irrigable land. With the abundant water supply and genial climate it is probable, however, that large irrigating systems can be profitably constructed in this county. The principal areas at present irrigated are in the vicinity of Ashland on Bear creek, near Brownsboro on Little Butte creek, and near Uniontown and Applegate on Applegate creek. Mining has been carried on principally in the western part of the county, and the waters of the streams have been diverted largely for this purpose. As the mines were worked out, the water has been used more and more for purposes of irrigation. This is especially the case in the vicinity of Applegate, where there are numerous claims to water rights, and large reservoirs have been constructed, furnishing water for many miles of ditches and flumes constructed for the mining companies. This water is easily transferred to the adjacent fields and gardens, causing a rapid increase in the areas irrigated. In the Rogue River valley, in the center of the county, are a large number of streams coming from the steep mountain slopes. The waters are used on areas near Ashland, where the soil is dry and requires thorough irrigation. Also along Little Butte creek the soil and underlying gravel deposits require thorough saturation before agriculture can be made profitable.

JOSEPHINE COUNTY is in southwestern Oregon, west of Jackson county, to which it is similar in many respects. Mining and lumbering are the principal occupations, agriculture being relatively of small importance. The valleys are narrow, and the tilled lands are in general at a distance from the railroad too great to repay the expense of transportation. As in the case of Jackson county, the water supply is large, although there are instances in which it is inadequate for present needs. This is due, however, largely to lack of proper care in distributing and using the amount available. The county lies almost wholly within the drainage basin of Illinois river and Leland creek, both of which are tributary to Rogue river. In all parts of the county crops are successful without irrigation, but it has been found advantageous to use river water on account of the increased productiveness of the soil. The areas irrigated are in general small, and consist principally of orchards and fields of alfalfa or other hay producing plants. By irrigation these forage plants produce a second or third crop in the summer, when otherwise the summer's drought would not permit their growth. The principal areas irrigated are in the vicinity of Waldo, Althouse, and Kerby, on the head waters of the Illinois river; also on Applegate river, below the town of that name, and along Leland creek. Irrigation has developed but little, and it may be said to be still in its infancy. On some of the smaller creeks the older irrigators are already complaining that the late comers do not respect their priority of right, and are diverting waters which should be used by those who first settled the valleys. Thus, even here, in this humid climate the necessity of a systematic distribution of the water is beginning to be appreciated. There are as yet no corporations selling water, and very little, if any, outside capital has been invested in irrigation works. Thousands of acres of good land, however, can probably be brought under irrigation with profit. This is especially the case on the higher lands, which in the latter part of the summer become too dry for successful farming.

KLAMATH COUNTY is in southern Oregon east of the Cascade range. In many respects it is similar to Harney and Lake counties, which lie to the east, but it is unlike them in the fact that its principal lakes have an outlet to the sea. Although it is topographically similar to the great basin region yet the greater part of the county is included within the drainage basin of the Klamath river. A large part of the county, especially in the northern end, contains small lost river basins, that is to say, drainage areas within which the water collects in some small lake or marsh and is gradually lost by evaporation. The Klamath lakes, however, in the southern part of the county, when at a higher level cut a narrow channel through the Cascade range, through which the surplus water now escapes. The principal industry of the county is stock raising, and agriculture proper is making but slow progress. Crops are often raised without irrigation, and in many years wheat, oats, rye, barley, and vegetables are successfully produced, although the yield per acre is only about one-half or one-third that on irrigated land. Irrigation is gradually gaining a foothold and promises a rapid development in the future. There appears to be excellent opportunities for the construction of canals to cover the level lands in the vicinity of Klamath lakes and along Lost river and Tule lake. Irrigation construction has been retarded by lack of capital and by the unfavorable condition of legislation affecting water rights.

The principal stream of the county is Sprague river, which rises in the mountains on the eastern edge of the county and flows westerly into Klamath lake. This river, and especially its middle and south forks, carry a large amount of water, sufficient to irrigate the greater portion, if not all, of the level lands along the stream. South

of this is Lost river, which empties in time of flood into Tule lake. Along the course of this stream are a number of large valleys with fertile lands, but the amount of water in the river is not sufficient to irrigate more than a small portion of them. A very small part of the amount at present available is utilized.

The loss of crops following the drought of 1888 and 1889 has caused the inhabitants of the county to look upon irrigation as a necessity, and attempts are being made to increase the area under ditch. There are many localities favorable for the construction of irrigation works, especially in the vicinity of the Klamath lakes, where the soil is especially rich and large crops are raised whenever there is sufficient rain. On the eastern side of the county there are a few small ditches for irrigation, but the land is wet mainly by the overflow of the small streams in the springtime. There is an abundance of water near the higher mountains, but as a rule, wherever even a small crop can be raised without artificial watering, no irrigation is attempted. A few farmers living remote from rivers have been able to do a little irrigation by means of springs. Ditches are usually a mile or so in length, being built by each irrigator to bring water to his own land. For example, one taking water from the south fork of the Sprague river runs along the south side of the river for about a mile, with an average width of 2 feet. The dam in the river is rebuilt each year, as it is destroyed by high water. About 50 acres of hay are irrigated, 20 acres timothy and the balance native grass.

In the western end of the county, however, in the vicinity of the Klamath lakes, are several large irrigating systems. One of these, the Big Klamath ditch, takes water from Klamath lake about 1 mile above the town of Linkville, Oregon. It runs southerly on the east side of Link river to the town of Linkville, and then turns eastward toward Lost River valley. The total length of the ditch is 16 miles, the average width 20 feet, depth from 2 to 3 feet, and the cost was approximately \$20,000. The water is taken directly from the lake, the level of which fluctuates but slightly each year. The ditch is owned by the Klamath Falls Irrigation Company, which delivers water to irrigators at the rate, it is stated, of \$4 per miner's inch. About 2,000 acres were watered by this ditch in 1889, a large proportion of this being in grain and alfalfa. It is estimated that a miner's inch measured under a 4-inch head will irrigate 1 acre. The water supply for this ditch is far in excess of its capacity, and it is proposed to enlarge it as the demand for more water arises.

The Little Klamath ditch takes water from the lake of that name at a point about 3 miles south of the state line in Siskiyou county, California, and runs northerly through a tule marsh for nearly 3 miles, then through a dry lake bed for 1.5 miles, and thence by a deep cut to Lost River valley, along which it flows northerly for over 2 miles and crosses the channel of Lost river by a flume. After passing through the deep cut a branch of the ditch continues southeasterly about 3 miles down Lost River valley. The total length of the main ditch is 16 miles, average width 20 feet, depth about 2 feet, and slope of ditch nearly 2 feet per mile. The total cost is variously stated at from \$20,000 to \$40,000. Water is delivered to the users at the rate of \$2 per miner's inch per season, or for about \$1 per acre, a permanent water right costing \$8 per acre. The land with water right is valued at \$20 per acre.

LAKE COUNTY is in the center of southern Oregon, lying adjacent to California and Nevada. It is within the great basin, all of the streams rising in the mountains flowing out upon broad valleys, or being lost in shallow lakes or in the marshes which have resulted from the gradual filling of these lakes. The agricultural settlements of the county are mainly in the vicinity of Lakeview, at the northern end of Goose lake, or near Paisley, along the Chewaucan river. There are also ranches in the vicinity of Summer, Silver, and Warner lakes. The principal industry is stock raising, and the crops are mainly for forage purposes. The climate and soil are capable of producing almost any of the crops of the temperate zone, but owing to the lack of transportation facilities it is evidently impracticable to attempt to raise anything which can not be consumed on the spot. The nearest railroads are from 150 to 200 miles from the towns of this part of Oregon, so that it is unprofitable to export anything except cattle, which can be driven out. During the great drought of 1888 and 1889 the feed for the cattle became so scanty that great numbers perished during the cold weather, the losses being almost incredible.

A few crops, mainly of wheat, oats, barley, and rye, can be raised without irrigation, especially in the higher valleys, but the yield is small and does not compare in quantity with that obtained from irrigated lands. On the lower lands the grain sometimes fills without irrigation, but the kernels are larger and plumper after the application of water to the soil. Hay must be irrigated in order to produce a quantity sufficient to repay the labor of cutting. The methods of irrigation in this and adjoining counties are of the simplest and crudest kind, and for the most part consist in producing large artificial marshes or meadows by causing the spring floods to spread over the level ground. The valleys are nearly level, and the streams after leaving the mountains meander through them, sometimes dividing into several channels, and unless the waters are lost by evaporation they flow to the lowest part of the valley, where they form marshes or shallow lakes. During the spring floods the lakes rise and increase the area of marsh land, and during the summer the waters evaporating retreat and the marsh gradually dries. The irrigators to a large extent imitate this natural process. During the spring floods they cause the water of the streams to spread over the ground by placing temporary dams or obstructions in the streams. Sometimes a few short ditches are dug, but usually the flooding is done by furrows, or by allowing the water to find its own way.

The snow generally begins to melt shortly after the first of February, or from that time on to the latter part of March, according to the lateness of the season. The floods, which begin at that time, spread over the nearly level valleys and cause the grass to spring up. If the water is diverted from these low grounds for any length of time, as a week or more, the soil quickly dries and becomes hard, and the grass withers.

The natural marshes occupying the lower portion of the valley are generally owned by cattle men, who claim that the waters flowing into these marshes should not be diverted at any point above, but allowed to flow undiminished to these lands. Irrigators who have built ditches to take the water out upon dry land above or around the marshes have been restrained from so doing under what are known as the riparian laws, the effect of which is to prevent interference with the natural flow of the streams. In this way the owners of the marshes preserve them as meadows, although the same amount of water which floods them annually could probably be used to far greater advantage upon higher lands by the construction of systematically planned irrigating ditches.

The valley about Goose lake is the best watered of any in the county, and is consequently most thickly settled. There the crops in ordinary years do fairly well without irrigation, but in times of drought irrigation is necessary to prevent a failure. There is an abundance of water flowing from the surrounding mountains into the lake, much of which can be utilized only by the construction of reservoirs and canals. The mountains are well timbered and afford an excellent summer range for stock. In Drew valley, about 15 miles northwest from Goose lake, are ranches raising hay by means of water taken from the creeks. Each irrigator has his own small ditch, and the water is divided according to circumstances. The meadows around Goose lake, which are wet by the seepage and overflow, fluctuate in area according to the rise or fall of the lake. In 1889 the lake was unusually low, there being less water than there had been for many years previous. As a result, there was considerable loss of crops in the vicinity, and during the succeeding winter thousands of cattle perished owing to the diminished supply of forage.

In Warner valley, which lies east of Goose lake, are extensive marshes created by the annual overflow of Warner lake. The greater part of this area is held as swamp land by cattle owners. In the northern end of this valley is a large body of desert land, some of which may possibly be irrigated by means of canals, which at the same time would reclaim a great portion of the swamp land. These canals and necessary reservoirs would be very expensive. East of Warner valley is a mountain block presenting a precipitous face toward the lake, but having a gentle slope toward the east. This slope affords fine grazing lands, watered by numerous springs which flow out and gradually disappear into the desert.

Beyond the mountains to the north of Goose lake is Chewaucan valley, watered by the river of the same name, one of the most important streams of the county. This river rises in the wild, rugged region between Summer and Goose lakes and, cutting through one of the uplifted mountain blocks, it enters the valley to the west of Lake Abert. Here its waters are lost in a great marsh, which was at some former time a shallow lake, but is now filled by sediment brought in by the running water. The town of Paisley is located at the point where the river leaves the mountain gorge through which it has cut, and where the valley begins to widen. Northerly from this town there are reported to be about 20,000 acres of excellent sagebrush land to which the waters of the Chewaucan might possibly be conveyed. Also surrounding the great marsh on the east and west is much good farming land needing water. Irrigation companies have already been formed, and probably in a few years all the available water of the Chewaucan will be used.

At the south end the upper marsh narrows, and a stream flows for about 1.5 miles between sagebrush flats and spreads again, forming the lower marsh. It is estimated that these two marshes contain approximately 19,000 acres. It is highly probable that by careful use of the water upon the higher lands much of this marsh could be reclaimed and cultivated. The overflow from the marsh land cuts through a second uplifted mountain block into the valley beyond, where it is lost in Lake Abert, the waters of which are strongly saline.

Besides Chewaucan river there are several streams flowing into these marshes. These come mainly from the southwest side of the valley, and their waters are now all appropriated, as are also those of Crooked creek, which flows into Lake Abert. Probably no more land can be irrigated from these except by the construction of reservoirs. Northwest of Chewaucan valley, and in about the center of the county, is Summer lake. The agricultural land is mainly in a narrow strip along the west side of the lake and at the foot of a precipitous mountain mass from which many small streams flow. These are used for irrigation, although the land, on account of its proximity to the mountains, is not very dry. On the east and north of Summer lake, however, the land is extremely arid and consists of sand hills and alkaline flats. There are a number of large springs here, some of the water being used for irrigation.

Silver lake is northwest of Summer lake, and, unlike the latter, its waters are fresh. In 1880 the lake averaged about 10 feet in depth, but in 1889, on account of prevailing droughts, the bed was dry.^(a) The streams entering this valley are diverted as they leave the canyons by each land owner, and are held by dams, ditches, and levees on as great an area of land as possible. The natural meadows have thus been extended and some sagebrush land brought under irrigation, the natural swamps being partially dried. Several ditches have already been constructed

^a Its area in 1881 was from 12,000 to 15,000 acres and depth about 5 feet.

to convey water upon the fertile sagebrush plains, where there are perhaps 10,000 acres susceptible of irrigation, but as a whole there is a general lack of system, and much of the best land is injured by excess of water. By properly conserving the water in reservoirs and carefully utilizing it large areas could be brought under irrigation, and possibly a portion of the bed of the lake kept dry, affording excellent farming lands.

MALHEUR COUNTY is in the southeastern corner of Oregon, extending in a north and south direction along the eastern boundary for a little over half the width of the state. The Snake river flows along the northeastern side of the county and receives the waters of the streams of this part of the state not lost by evaporation. The Owyhee river, rising in Nevada and southwestern Idaho, flows northerly through the county into Snake river, and the Malheur river crosses the county from west to east, emptying a short distance north of the Owyhee. The tilled lands are mainly in the northern end of the county, along the Malheur and its north fork, and on Bully and Willow creeks. There are also some farms near the mouth of the Owyhee, and settlements of considerable size in Jordan valley, which lies farther toward the southern end of the county, the upper part of this area being in Owyhee county, Idaho, and known as Pleasant valley. There are other ranches scattered among the mountains throughout the county wherever there is a sufficient water supply for cattle and for irrigating crops of hay and grain.

The water supply of the county, taking it as a whole, is below the needs of the present population, for, according to the statements of the farmers, there has not been during the past few years an amount of water sufficient to irrigate the areas usually tilled or from which hay crops have been cut. This was notably the case in the summers of 1888 and 1889, when unusual drought prevailed throughout this portion of the country. In these years there was great suffering among the irrigators living along the lower part of the streams, where, owing to the diversion made above, there was little or no water. The Malheur receives a large portion of its water from the low mountain ranges on the north and northwest sides of the county. These mountains are so low, rarely reaching heights of over 6,000 feet, that the snows of winter melt rapidly in the spring, causing the floods from the rivers to occur very early in the season, so that the greater part of the water has passed down the stream before the farmer begins irrigation. The channels of the streams are generally broad and sandy, and after the flood season the greater portion of the water is gradually lost by seepage and evaporation as it passes over the pervious beds. The irrigators near the head waters are usually able to secure water throughout the season, while those situated near the mouth of the Malheur can not obtain an amount sufficient for their needs.

On the Malheur river settlements now extend from the mouth for 100 miles, and in this distance there are at least 20 ditches of considerable size. Those highest on the stream do not have a surplus of water after the end of June, and those lower are nearly, if not quite, dry. There is less water during the latter part of the crop season at Vale, about 15 miles above the mouth of the stream, than at Juntura, about 60 miles above. The valley of the lower Malheur is broad, and is bounded by low foothills having a rich and fertile soil, capable of producing large crops if water could be brought upon it. The bottom lands are wide, extending along each side of the river and up Willow creek and other tributaries. With the present water supply only about one-half of the low land can be cultivated. During high water the bottoms are wet by seepage from the river, so that hay can be raised with little or no artificial irrigation. In the Malheur valley, as well as throughout the county, the ditches in general are poorly constructed, having been hastily built to supply the immediate needs of the farmers. There is need of a better system of ditches or canals by which larger areas of land can be covered with greater economy. The majority of the irrigators are principally interested in stock raising, the largest crop being hay for winter feed, general agriculture not being as yet highly developed.

In the lower Malheur valley and also along Willow creek are a large number of wells furnishing an unfailing supply of water at a depth of 20 to 30 feet below the surface. Many windmills have been erected for the purpose of raising this water for cattle, the excess being allowed to flow upon the ground, irrigating small areas of land. It is probable that in the aggregate several hundred acres are cultivated in this manner. The supply of water appears to be so great that it is probable that larger pumps can be used to advantage in bringing it to the surface. The cost of fuel is so great that it has not become profitable to employ steam power. Along Willow creek are several ditches, each supplying water for one or two ranches. Several of the irrigators report that in 1889 on account of the drought there was little or no water to be had. Away from the immediate vicinity of the stream, near the little settlement of Dell, there is no farming, and the entire country on every hand is a bleak, barren desert, with no vegetation save an occasional tuft of bunch grass or clump of sagebrush. The soil is rich, however, and thousands of acres of excellent farming land can be brought under cultivation if an abundant water supply can be had. Higher, near the mountains, are many springs whose waters seldom flow to any great distance, being soon lost in the pervious basaltic rocks. All this land is now valueless, except as a range for cattle.

The ice on the rivers generally breaks in February or early in March, and the floods soon follow. Water is usually turned into the ditches about the 20th of March or the early part of April and used until October or November, or until the streams become dry. Malheur river has been gaged at Vale. The maximum discharge was in March, 1890, when the river carried 4,445 second-feet. It has been estimated that the maximum flood of the past 7 years has amounted to from 7,000 to 8,000 second-feet. During the summer months the river is practically

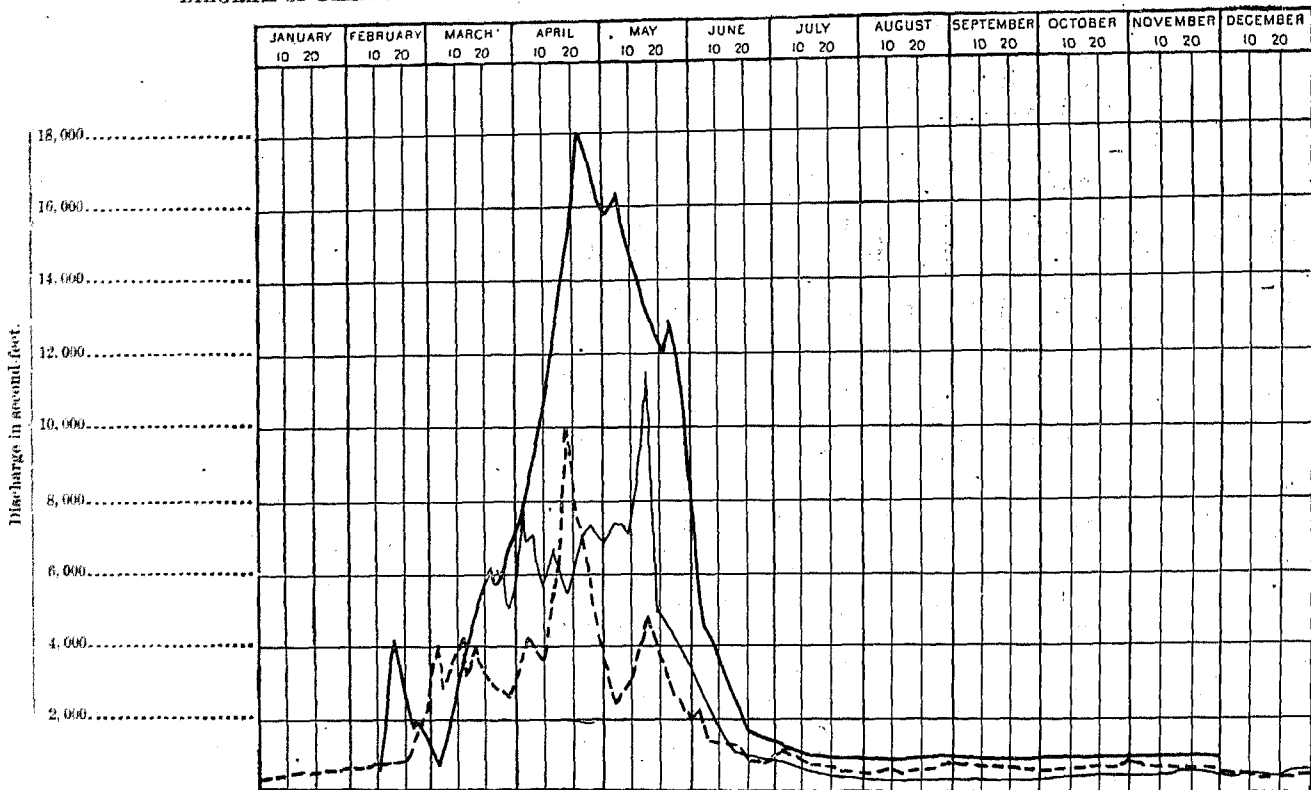
IRRIGATION.

dry below Vale, the water being taken out by a large number of irrigation ditches higher up stream.^(a) The quantity of water in Owyhee river has been ascertained by gaugings made below the canyon and about 4 miles above the mouth of the river, this point being about 20 miles south from Ontario. The results of the measurements show that the average discharge for nearly three years is over 2,100 second-feet, the amount varying from 200 second-feet in times of drought to 18,000 second-feet in flood. The daily fluctuations are best shown by the accompanying diagram, one of the most noticeable features of which is the early occurrence of the spring floods and the rapidity of their rise and fall.

MORROW COUNTY is in northern Oregon, between the western spur of Blue mountains and Columbia river. The surface in general is hilly or rolling, but for the most part is covered with rich sandy loam. Crops of all kinds are raised without irrigation, although in some years, owing to drought, the yield is small. The county is drained by a number of creeks which flow northerly into the Columbia river. These carry but little water during the summer, and will not yield a supply sufficient for irrigating canals without the use of storage reservoirs. Wherever possible, however, ditches are now taken out from these streams upon the narrow strip of farming land along the

^a In the diagram the discharge for 1890 is indicated by the lighter continuous line, that for 1891 by the broken line, and that for 1892 by the heavier continuous line.

DIAGRAM OF DAILY DISCHARGE OF OWYHEE RIVER AT RIGSBYS, MALHEUR COUNTY, OREGON.



DISCHARGE OF MALHEUR RIVER AT VALE, OREGON.

(Drainage area, 9,900 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.		MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maxi-mum.	Mini-mum.	Mean.		Depth in inches.	Second-feet per square mile.		Maxi-mum.	Mini-mum.	Mean.		Depth in inches.	Second-feet per square mile.
1890.							1891.						
March 29 to 31.....	4,445	1,840	2,912	179,088	0.34	0.29	January.....	115	70	88	5,412	0.01	0.01
April.....	3,450	2,180	2,770	164,815	0.31	0.28	February.....	2,820	80	319	17,704	0.03	0.03
May.....	2,890	590	1,627	100,060	0.19	0.16	March.....	1,460	260	703	43,234	0.08	0.07
June.....	520	120	254	15,113	0.03	0.02	April.....	665	325	511	30,404	0.06	0.05
July.....	90	25	43	2,644	0.005	0.004	May.....	325	115	217	13,345	0.03	0.02
August.....	25	15	17	1,011	0.002	0.002	June.....	185	45	78	4,641	0.01	0.01
September.....	15	15	15	893	0.002	0.001	July.....	40	20	30	1,845	0.003	0.003
October.....	62	15	44	2,706	0.005	0.004	August.....	30	20	26	1,599	0.003	0.003
November.....	150	70	118	7,021	0.013	0.012	September.....	25	20	23	1,368	0.003	0.002
December.....	115	62	83	5,105	0.009	0.008							

bottoms. The supply, however, often becomes scanty by the middle of June; the channels sometimes becoming dry after that time. The farmers are compelled to trust to the rainfall, as from unfavorable topography and lack of abundant water supply they can not irrigate. They recognize the benefits of irrigation, for it is carried on in a sufficient number of places to show that the soil is wonderfully productive. The summits of the Blue mountains at this point are too low to yield an abundant perennial supply of water, and if artificial watering is to be done recourse must be had to storage of the spring floods. Attempts have been made to secure artesian water, and at Heppner a well was sunk to the depth of 650 feet. Water can be pumped from this well at the rate of from 40 to 60 gallons per minute, but it does not flow. The success of the farmers depends to a large extent upon the condition of the ground at the time of the snow storms of winter. For example, in the winter of 1884-1885 the soil was not frozen when the snow fell. As a consequence, the ground received a thorough saturation, contributing to the success of the crops of the succeeding year. In the winter of 1887-1888, on the contrary, the surface of the ground was frozen at the time the snow fell, and in early spring the water flowed away rapidly, leaving the soil underneath dry. The evil effects of the succeeding drought were thus intensified, and as a result the crops were almost a failure.

SHERMAN COUNTY includes the comparatively small area south of the Columbia river, between Johnday and Deschutes rivers. The surface in general is level, although deeply cut in places by the streams, which flow in canyons at a depth of from 100 to several hundred feet. The soil is a rich, sandy loam, ranging in depth from 3 to 50 feet, in most places completely concealing the underlying lava. It apparently has the property of retaining moisture well, and thus, although the rainfall is very small during the summer, nearly all kinds of crops are successfully raised without irrigation. It would be almost, if not quite, impossible to bring water upon most of this rich land on account of its relatively high elevation. About the only irrigation carried on at present in the county is on low lands near the Columbia, where gardens and fruit trees are wet by means of the waters from springs which issue from the cliffs, or from the waters of some small stream. The results obtained at these places demonstrate the great benefits to be derived from thorough systems of irrigation, and lead many of the farmers farther inland to discuss the advisability of attempting to introduce irrigation in their own localities. During the drought of 1888 many of the crops were a complete failure, and the matter was thus more strongly forced upon their attention. The water supply for domestic purposes is often poor, and many of the farmers are compelled to haul water for long distances during certain months of the year. In some places wells reach water at a moderate depth, as, for example, at Wasco, where it is reported that an ample supply is found at a depth of from 20 to 40 feet beneath the surface.

UMATILLA COUNTY is in northeastern Oregon, west of Blue mountains, extending from the summits of this range westward to the Columbia river. The eastern part of the county adjoining the mountains is rough and broken, but the surface becomes more level on approaching the river. The average rainfall is sufficient to produce

DISCHARGE OF OWYHEE RIVER AT RIGSBYS, OREGON.

(Drainage area, 9,875 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.		MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maxi-mum.	Mini-mum.	Mean.		Depth in inches.	Second-feet per square mile.		Maxi-mum.	Mini-mum.	Mean.		Depth in inches.	Second-feet per square mile.
1880.							1891.						
March 20 to 31.....	7,350	5,100	0,140	377,610	0.72	0.02	October.....	360	280	325	10,987	0.04	0.03
April.....	8,225	5,305	0,558	300,201	0.74	0.06	November.....	400	320	370	22,372	0.04	0.04
May.....	11,230	3,010	5,913	363,649	0.69	0.60	December.....	320	320	320	10,650	0.04	0.03
June.....	2,850	020	1,403	83,478	0.16	0.14	Per annum ..	10,000	200	1,332	963,080	1.83	0.14
July.....	560	200	343	21,094	0.04	0.03	1892.						
August.....	200	170	170	11,108	0.02	0.02	January.....	320	320	320	10,680	0.04	0.03
September.....	170	170	170	10,115	0.02	0.02	February.....	4,165	320	1,250	71,875	0.14	0.13
October.....	170	170	170	10,455	0.02	0.02	March.....	7,500	630	3,930	239,850	0.45	0.39
November.....	280	200	221	13,150	0.02	0.02	April.....	18,000	7,500	13,430	801,227	1.52	1.35
December.....	300	280	309	10,004	0.04	0.03	May.....	16,400	6,700	13,082	804,543	1.53	1.31
1891.							1892.						
January.....	400	320	360	22,140	0.04	0.04	June.....	6,230	1,200	2,930	177,310	0.34	0.30
February.....	3,205	450	932	51,726	0.30	0.09	July.....	1,100	700	948	58,302	0.11	0.10
March.....	4,335	2,000	3,313	203,649	0.39	0.34	August.....	700	560	594	36,531	0.07	0.06
April.....	10,000	2,000	4,084	296,548	0.56	0.51	September.....	500	500	506	30,107	0.06	0.05
May.....	4,000	2,075	3,114	191,511	0.36	0.31	October.....	700	570	570	35,055	0.07	0.06
June.....	2,150	500	1,207	75,380	0.14	0.13	November.....	800	700	723	46,588	0.09	0.08
July.....	800	240	448	27,552	0.05	0.04	December.....	800	800	800	49,200	0.09	0.08
August.....	320	200	232	14,268	0.03	0.02	Per annum ..	18,000	320	3,268	2,370,268	4.61	0.33
September.....	360	280	317	18,801	0.04	0.03							

large crops of the cereals, but an occasional drought, as in 1888, has proved destructive. The precipitation during the summer is so small that fruit trees do not always flourish, and irrigation has been used for fruit trees as well as for gardens and meadows. The water supply of the county is comparatively large. The waters flowing from Blue mountains form two rivers, the Wallawalla on the north and the Umatilla in the center of the county. The banks of the first named river are in general low, and water has been diverted by many small ditches leading from the main river and its tributaries and irrigating the bottom lands in the vicinity of Milton. There have been no large systems constructed, but each irrigator has dug his own ditch or joined with one or two neighbors in so doing. The Umatilla river offers many advantages for the construction of irrigating canals, and a number of projects are on foot, some of them involving the expenditure of large capital, in order to irrigate land in the vicinity of Pendleton and at points along McKaye creek and the lower course of Umatilla river.

Along the foothills there is a belt of land relatively humid where crops of nearly all kinds are raised without irrigation. Beyond this is the subhumid area, where occasionally good crops of wheat and oats are obtained, and at still lower altitudes adjacent to the Columbia river are the lands which may be designated as arid. It is in these latter localities that irrigation will be especially valuable. Plans have been made for diverting the water of Umatilla river by a canal heading at a point about 18 miles above Pendleton. The water will first be conducted through a flume for about 4 miles and then by a side hill canal, the line following up Wild Horse creek, then crossing and ending at a point about 2 miles north of Pendleton. Another project, that of the Columbia Valley Land and Irrigation Company, involves the diversion of water from the lower part of Umatilla river at a point near Echo, the canal line, covering lands to the west, crossing Butter creek at about the sixth mile. Beyond this creek is a place where water can be held in a large depression, thus furnishing a supply for lands further to the north. On the upper waters of McKaye creek are localities reported to be favorable for the storage of flood waters, and the Blue Mountain Irrigation and Improvement Company proposes to utilize one or more of these, taking the water thus obtained out upon the bench land between McKaye and Birch creeks, and also upon lands to the east. (a)

UNION COUNTY includes an irregularly shaped tract of land in northeastern Oregon, east of Blue mountains. The county comprises the head waters of Grande Ronde river and the western portion of its drainage basin. Its tributary, the Minam, and the lower course of the Grande Ronde form the eastern boundary of the county. On the south it extends over into the drainage basin of Powder river, and easterly along the south side of Powder River mountains to Snake river. It thus includes portions of two drainage systems, namely, the Grande Ronde, flowing toward the north into the state of Washington, and Powder river, flowing to the southeast into the Snake. Irrigation is not absolutely necessary, and the greater part of the crops is raised by dependence upon the rainfall. The bottom lands along the creeks are usually sufficiently moist, and are now cultivated, but on the higher lands bordering the valleys the soil is dry, and, although it is often of superior quality, is at present useless.

In the valley of Powder river, along the southern boundary of the county, and also along the tributaries which flow into this stream and into Snake river, the settlers have taken out small ditches to irrigate meadows, gardens, and fruit trees. The developments in some of the smaller valleys have already proceeded so far that all the available water supply is now utilized, and there are complaints from the older settlers that their prior rights are not respected and that other persons are depriving them of their share of water. In these smaller streams the amount of water diminishes rapidly after the early spring flood, and by July 1 there is barely enough for the needs of the land now under cultivation. In many cases water storage is already a necessity.

In Grande Ronde valley there is an ample water supply, and irrigation has been begun by using the waters of the smaller tributaries. The main river, especially in the northern part of its course, has cut itself a channel too deep to admit of water being taken out upon the valley lands. Among the hills are small patches irrigated from

^a The amount of water in Umatilla river at Pendleton has been estimated by Mr. A. L. Adams, chief engineer of the Umatilla Irrigation Company. The following table gives by months or half months the maximum, minimum, and mean discharge as obtained by him:

ESTIMATED DISCHARGE OF THE UMATILLA RIVER AT PENDLETON, OREGON.

MONTHS.	Day.	Maxi- mum.	Mini- mum.	Mean.	MONTHS.	Day.	Maxi- mum.	Mini- mum.	Mean.
1891.					1891.				
February	1-28	320	140	180	October	1-31	65	35	50
March	1-15	2,250	140	380	November	1-30	580	60	172
Do.	15-31	2,250	1,080	1,715	December	1-31	520	410	510
April	1-30	2,250	770	1,430	1892.				
May	1-15	520	420	425	January	1-31	830	470	587
Do.	15-31	520	140	391	February	1-29	2,030	630	1,120
June	1-15	180	140	150	March	1-31	2,800	1,000	1,753
Do.	15-30	370	180	253	April	1-30	3,870	1,000	1,706
July	1-15	770	270	403	May	1-31	3,250	920	2,090
Do.	15-31	580	60	200	June	1-30	920	125	455
August	1-31	60	60	60	July	1-31	125	45	74
September	1-30	55	35	45					

springs or from small streams, but as a general rule irrigation is not considered essential for anything except fruit trees. The Emele ditch takes water from Powder river, carrying it out upon the north side of the stream near the mouth of Big creek. It is 7 miles long, 4 feet wide, and cost \$6,000. The water is diverted by means of a wooden dam placed permanently in the stream. There are 8 flumes, with an average length of 100 feet, along the ditch. The Farmer ditch takes water from Eagle creek, one of the tributaries of Powder river, carrying it out on the west side above the town of Newbridge. It is 4 miles long, about 4 feet wide, and has cost about \$1,000. About 600 acres are irrigated, of which the principal part is in alfalfa. Fish Lake ditch heads in a small lake, the outlet of which has been partially closed in order to increase the storage capacity. From the lake the water flows in the ditch for about 2 miles across a divide, then follows for 4 miles down Fish creek, from which it is taken around another divide to Dry creek, down which it continues for 5 miles, and is recovered for a third time and brought around to Warm Spring valley. This was built by three men, and cost them about \$1,200. Wheat, oats, alfalfa, clover, and potatoes are irrigated, about 200 acres of crops being raised in 1889.

WALLOWA COUNTY is in the northeastern corner of Oregon, being partially inclosed by Union county. It is bounded on the east by the Snake river and on the south by Powder River mountains, from which the streams flow in a general northerly course into the Snake or Grande Ronde river. The county as a whole is sparsely settled, and the surface is mountainous, or rough and broken. The principal industry is stock raising, large herds of cattle and sheep finding pasturage on the hill slopes and small plateaus. Tilling the soil is carried on in a small way near the towns and on the principal ranches, the main crop being for forage. In the valley bottoms irrigation is not always necessary, but upon the higher lands few crops can be raised without water. Rye, when sown in the fall or early spring, will grow and make a fair crop without irrigation, being ready to be cut for hay by the last of June, or completely matured during July. In 1888 and 1889 the crops were so nearly a failure that unusual attention was given to the consideration of better systems of irrigation, and in 1890 active work was begun on ditches taking water from the Wallowa river and from Sheep creek and other streams.

On the eastern side of the county is the Innaha river, which flows northerly from the Powder River mountains for the greater part of its course parallel with the Snake, into which it finally empties. In the valleys along its tributaries, as, for example, on the Big, Little, and Middle Sheep creeks, are many places at which water can be diverted to advantage and a large amount of land brought under cultivation. Most of the ditches now in use are very short and cover a small acreage on each farm. There is an ample supply for all the land that can be irrigated from the main stream, but the greater portion of the arable land is at an elevation so great that only the smaller streams can be brought to it, and in these the volume decreases to an almost insignificant amount during the summer. The western side of the county is drained by Wallowa river, which flows into the Grande Ronde. At the head of this river is a large lake, which is apparently well adapted for water storage. By holding the spring floods in this lake a large area of land in the vicinity of Joseph and north of that point can be irrigated.

WASCO COUNTY is in northern Oregon, east of the Cascade range. On the north is the Columbia river, and on the west rises the great volcanic cone known as Mount Hood. The Deschutes river flows north through the county, in the lower portion of its course forming the boundary of Sherman county. The river receives the drainage from the eastern side of Mount Hood and the high mountain range stretching off toward the south. The water supply is large and well distributed over the western part of the county. There are valleys in this county possessing a rich alluvial soil. In summer the rainfall is often so small as to jeopardize the growth of fruit trees and of many of the crops. Generally, however, most of the cereals can be grown without irrigation, although with it the yield is from two to three times as great as it is without it. Corn is usually planted after summer fallowing, grows without irrigation, and is cut for fodder before it matures, the ground being sown to fall wheat without replowing. Potatoes on good ground and when well cultivated yield heavily without watering.

Irrigation has been practiced in a small way since the settlement of the county, but as it is not absolutely necessary developments have been slow, and there are no larger systems in operation. The principal irrigated areas are along Hood river and near Dalles. Besides these localities there are places scattered throughout the county at which small areas are irrigated by the waters of tributaries of Deschutes river or from springs. In the Hood River valley are a number of small ditches owned by individuals or associations of farmers, but their total capacity is far below the needs of the arable land. There is a demand for large canals to take water out upon both sides of the valley and cover large areas of land now unproductive. The farmers state that they are not able to build a comprehensive system without the aid of outside capital. The expense of clearing the land and bringing it under cultivation is very large, so that when the cost of irrigation is added to this the amount becomes too great for the means of the average settler.

The ditches in Hood River valley take water from the small tributaries, few, if any, making use of the abundant supply in the principal stream. As an example of these, may be cited one ditch 4 miles long, 2.5 feet wide, and which cost nearly \$2,000. It receives water from springs on Mount Defiance and carries this out upon the west side of Hood River valley. The water supply is small, and only fruits and vegetables are irrigated. In the vicinity of Dalles are a number of small ditches, few of which are over a mile in length, and which, like the one above mentioned, are used almost entirely for gardens and other small areas of crops.

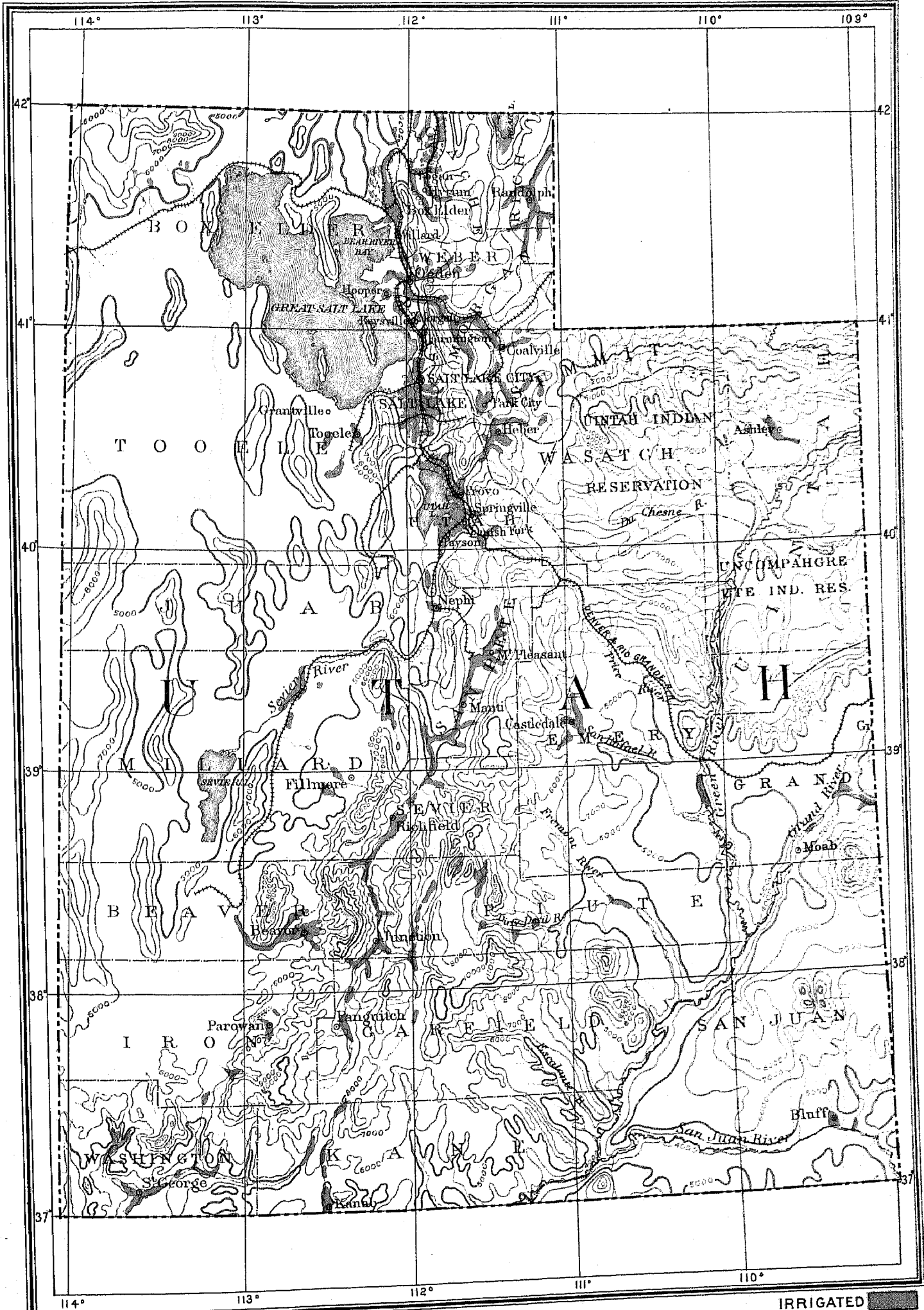
UTAH.

Total population (average per square mile, 2.53).....	207,905
Number of owners of farms (5.06 per cent of population).....	10,517
Number of irrigators (92.46 per cent of farm owners, 4.68 per cent of population).....	9,724
Area of territory, land surface (82,190 square miles).....	52,601,600 acres
Area irrigated in census year.....	263,473 do.
Area of all farms, 41.42 per cent improved.....	1,323,705 do.
Cereals raised in census year, including 15 acres in buckwheat and 3,389 acres in rye.....	122,878 do.
Barley, average production, 25.35 bushels per acre.....	6,440 do.
Corn, average production, 14.66 bushels per acre.....	5,782 do.
Oats, average production, 26.29 bushels per acre.....	22,747 do.
Wheat, average production, 17.93 bushels per acre.....	84,505 do.
Alfalfa.....	88,152 do.
Total value of all farms, including land, fences, and buildings.....	\$28,402,780
Estimated total value of the farms irrigated in whole or in part.....	\$22,198,000
Estimated value of all farm productions (sold, consumed, or on hand) for 1889.....	\$1,891,460
Estimated value of productions, as above, from farms irrigated in whole or in part.....	\$4,750,000
Average size of irrigated farms.....	27 acres
Average size of irrigated farms of 160 acres and upward.....	312 do.
Per cent of acreage of irrigated farms of 160 acres and upward to total acreage irrigated.....	9.81
Average size of irrigated farms under 160 acres.....	25 acres
Average first cost of water right per acre.....	\$10.55
Average annual cost of water per acre.....	\$0.91
Average first cost per acre of preparation for cultivation.....	\$14.85
Average value of irrigated land, including buildings, etc., in June, 1890, per acre.....	\$84.25
Average annual value of products per acre in 1889.....	\$18.03

GENERAL DESCRIPTION.

Utah stood next to California in the number of irrigators in the census year and was exceeded only by three states in the area of land irrigated. In size of farms, 27 acres, it stood at one extreme, while Nevada, with 192 acres, was at the other. This minute subdivision of the irrigated lands in itself testifies to a relatively large amount of care bestowed upon each area and implies that there should be a correspondingly large average value of products, as was the case, the average value, \$18.03 per acre, being second only to that of California. It would have been first were it not that in California the average value of products was increased by the profits from the cultivation on a large scale of the highest class of fruit. In percentage of entire land surface irrigated Utah stood next to Colorado and California, and in percentage of total number of farms irrigated it was first, since a trifle over 90 per cent of all the farms of the territory were under irrigation to a greater or less extent. The relative proportion of the farm area irrigated, however, was somewhat small, coming below Arizona, Colorado, Idaho, and Montana, since only 22.03 per cent of the area of the farms was actually irrigated in the census year. The large irrigated farms, that is, those of 160 acres and over in size, formed less than 10 per cent of the total area irrigated, testifying again to the minute subdivision of agricultural lands. Deducting these, the average size of the small irrigated farms was only 25 acres. In first cost of water right Utah came next to California, while in average annual cost it stood sixth in the list.

Utah may be divided into two great divisions, distinct in topography and climate. The northern and western parts of the territory lie within the great interior basin of the continent, from which no water escapes except by evaporation, and the western and southern parts of the territory are in the drainage basin of the Colorado river, everywhere distinguished by lofty plateaus and deep canyons. The Wasatch range runs in a general north and south direction through the center of the northern half of the territory, wringing from the clouds the moisture which renders the counties along its western base so prosperous. The streams issuing from this great range, as a general rule, have cut through the mountains, and pour their waters toward the west, ultimately flowing into the Great Salt lake. This lake is but the remnant of a great body of fresh water which occupied all the principal valleys of western Utah, and from which came the rich sediments which render the broad bottom lands so fertile. Those valleys which are situated at the base of the mountains, although arid in climate, receive many streams, carrying a large part of the precipitation which has fallen upon the higher summits, and thus are most favorably



IRRIGATED

situated for cheap and effective irrigation. The valleys farther to the west, although equally fertile, do not receive streams as large or permanent, as the mountains bounding them are of less altitude, and therefore these enormous stretches of rich land, for the most part, must remain unproductive desert wastes, with only occasional patches or oases, where some small stream or spring, natural or artificial, is discovered.

The Colorado basin presents a great contrast to these conditions. Lofty plateaus, uplifted in great masses, have been deeply carved into canyons, the most stupendous in the world. On top of the plateaus the rainfall is light and irregular; the water quickly collects into rills, which soon seek a narrow gully, and then find their way into a canyon. In many localities, especially at rainy seasons of the year, grazing is good, and stock raisers have penetrated and taken possession of much of the country. Small towns have grown up in places where the canyons open out into valleys sufficiently wide to afford room for agriculture, and there the streams have been diverted upon the strips of fertile alluvial soil. These streams, however, flowing from a country of cliffs and naked rocks, are subject to sudden floods of great violence, since the rain of local storms does not soak into the ground, but rushes off at once, collects in the stream, and sweeps down with violence, carrying away dams, headworks, and even parts of canals.

Utah occupies the central position in the arid region, and therefore the details of irrigation in this territory possess more than ordinary interest, as they represent conditions intermediate between those of the north and south, the east and west. Besides, the irrigation methods and systems have been developed by men of English speaking origin, who, unaided by previous experience, have introduced methods of their own, and, taught by repeated failures, finally achieved success. Throughout the territory, excepting perhaps in the Colorado River drainage, there is more arable land than available water, and consequently the value of the land is dependent wholly upon the amount of water to which it is entitled, the most fertile areas without water being almost valueless. The point was long since reached when all the easily available water was appropriated, and the increase of cultivated area has been due to a more careful utilization of that supply.

PRIORITY OF RIGHTS AND DIVISION OF WATER.

Utah offers a striking contrast to the rest of the arid regions in the details of the customs of distribution of water according to priority of right, and also in the control of the water by the irrigators. Almost without exception the canals and systems of ditches have been built by farmers and are controlled by them in every minute detail. An apparent exception is in the case of the municipalities or chartered cities which have built and now own systems of irrigation, but this exception is only apparent as these cities, so called, are controlled by the farmers, so that the water is administered by officers representative of the irrigators as a class. The municipalities, however, have a certain advantage over farmers' associations, in that they can levy taxes for the use of water and collect them through the ordinary machinery of such organizations.

In nearly every valley of Utah there is now more land under cultivation than is supplied with water to mature the crops in all years. The first settlers in these valleys, finding that there was more land than could be cultivated by themselves, encouraged other farmers to come in, and gradually cultivation extended, until at last a time came when the water would not serve all the land under cultivation. The principle was early established that those farmers who first made use of the water should ever afterward be entitled to sufficient water to irrigate the amount of land originally cultivated by them, and that the later comers, whenever scarcity occurred, should not take the water until those enjoying prior rights had satisfied their needs, the latest comer being the first to be deprived, and those settling before him losing their water supply in succession as it became less and less.

For convenience, however, the rights are not held in the exact order of settlement, but are divided into classes, all the individuals of one class or group sharing the water according to their respective claims. For example, all older settlers who used water for a certain acreage before some arbitrarily fixed date are considered as having prior rights; those who cultivated other lands at a later time are considered as having rights secondary to these, and those who cultivated lands during a still later period have third rights, and so on. The farmers owning first rights are entitled to the use of the water to the amount originally appropriated until their needs are satisfied; those owning the second rights can enjoy the use of the surplus water after the prior rights have been supplied, while those owning third rights are by law only allowed to use such water as the farmers having first and secondary rights can not use or claim. A farmer having prior rights may also have secondary rights, and even third rights, to the water for lands not covered by his first rights, and thus in times of scarcity he does not lose all his water, but is able to mature a small portion of his crop. The man, however, who has last rights only can not be sure of success, and unless the snowfall in the mountains is heavy during the winter he may not dare to plant in the spring, knowing that he can not secure water later in the season.

Those irrigators who own prior rights to the water practically enjoy a monopoly of it, for with the advance of settlement everywhere in the territory and the bringing under cultivation of more land than can be readily watered lack of supply becomes chronic among later irrigators. This monopoly, although often regarded as a great injustice by these later comers, is unquestionably essential to the success of irrigation, for were all irrigators required each

year to divide the water among all who might demand it, in a short time there would not be enough distributed to any one man, and suffering would ensue among all, instead of among those who may be considered the excess of population. This principle of monopoly of water by a certain few of the farmers is recognized not only by custom but even by law throughout the arid lands, and the claimants possessing this monopoly can alone be sure of maturing their crops. These primary rights, however, are not always clearly defined or carefully guarded. There is a tendency among the owners of first rights to claim more water than was originally appropriated by them, and on the other hand, the irrigators having second and third rights encroach upon the supply claimed by the owners of prior rights. Those having the second or last rights do not always tamely submit on seeing their crops parch and wither and their trees die for lack of water while their neighbors are enjoying an ample supply, and quarrels are constantly arising. The attempt to farm without a prior right to water is by some declared to be a curse, and demands are made for a more just and equitable division.

With the present unregulated water supply the success of farming depends largely upon the amount of snowfall in the mountains and the time of year in which this occurs. If the snow falls early in the winter it usually becomes hard, and does not melt until the heat of summer has become intense and the needs of the crops are greatest. On the other hand, if the snow falls late in the winter, it does not have time to become compact, but melts in the early spring, and runs to waste long before the farmers have the greatest necessity for it. A number of attempts have been made in various parts of the territory to regulate the supply, and storage works have been built on a small scale, some of which are successful. These, when placed in suitable localities out of the reach of floods, not in the course of a river or the drainage from a large area of barren rocks, have justified the plans of their builders, and have rendered possible the cultivation of numerous tracts of valuable lands.

The person at the lower end of a long ditch, or taking water from a ditch far down the course of a stream after it leaves the canyon, is always at a disadvantage in the summer, for if his proportion is allotted at the point where others take their water, this amount is usually lost in traversing the distance to his fields. It often happens in summer that if water is allowed to flow by the head gates of one canal company for the purpose of supplying a ditch below, the whole amount is evaporated or lost in the channel before reaching the lower ditch, and neither party is benefited. After the water is taken into the main canal there is often considerable loss in the height of the irrigating season, due to the weeds, which grow luxuriantly in the water wherever the current is sluggish, and may completely choke the channel if not cleaned out. Sometimes these are pulled up by rakes or mowed under water. In a few cases it has been found necessary to turn the water out of the canal entirely, even when crops were almost in danger, in order to allow the aquatic plants to dry and be killed by the sun. Another source of annoyance and expense is found in the burrowing habit of gophers or moles. These little creatures dig into the banks of ditches or into earth dams and often cause leaks, resulting in the sudden washing away of portions of these structures.

Owing to the difficulties and uncertainties concerning the supply and distribution of water, many farmers in the northern counties have declared that dry farming is preferable wherever it is possible, and that in many localities, by carefully preparing the land by summer fallowing and planting at a proper season, cereals can be raised to greater advantage than by irrigation, although the yield per acre is far less. Alfalfa, or, as it is usually termed, lucern, is raised in many counties without water, one cutting of the plant being made, and then, no water being applied, a crop of seed is raised. The number of cuttings of alfalfa, the crop which varies most with the season, depends directly upon the water supply. If the supply is ample throughout the season three cuttings are obtained, but when water is scarce, it is used upon the grain, vegetables, and trees, and the alfalfa is generally allowed to run to seed.

WELLS.

The flowing wells throughout Utah have great similarity in character, since they are found in localities whose topography and general surroundings have many points of resemblance. The successful wells are confined to the low grounds of valleys composed of unconsolidated lake beds, and are usually below the level of lands irrigated for many years. Beginning in the northern part of the territory, small flowing wells are found in the lower part of Cache valley, in Cache county, and along the Malade valley, in Boxelder county. From this locality southerly large numbers are to be found along the eastern shore of Great Salt lake, especially near Ogden, in the western end of Weber county, also in Davis county and on the low grounds of Salt Lake county. The line of wells continues, with occasional breaks, along the southeastern shore of Great Salt lake and down into Tooele county, in the neighborhood of Grantsville and the town of Tooele.

Passing southward, into Utah county, similar flowing wells are found in great numbers on the northern, eastern, and southern shores of Utah lake, and still farther south, in Juab county, near Nephi. In the drainage basin of the Sevier river, wells almost identical to those of the valleys farther north are in use in the Sanpitch valley, in Sanpete county, also on the low grounds of Sevier county and far down the river on the Sevier desert, near the towns of Oasis and Deseret, in Millard county.

In all these localities the tubing or casing of the well passes through alternations of clay, sands, and gravel, the two last named layers being usually filled with water, which, from the basin-like structure of the beds, is under pressure sufficient to bring it to or above the surface of the center of the valley. These sands and gravels approach or reach the surface near the edge of the valleys, and there receive water either from rainfall or from the streams flowing from the mountain slopes.

Such a well consists of a pipe of from 1.25 to 4 inches in diameter forced down to or into the water-bearing strata to depths usually of from 100 to 150 feet, the lower end of the pipe being perforated or having suitable devices for admitting the water. This is usually clear, cool, and palatable, suitable for the ordinary purposes of household supply. It, however, often contains a notable amount of mineral matter, and is occasionally even salty. Most of the wells have been put down by farmers near their houses or barns, and the excess of water is conducted away to the shade trees or to kitchen gardens. Comparatively few of the wells are used for irrigation in the broad sense, that is, for field crops, but the great majority of those not near houses are in pastures, or meadows occasionally used for pasturage.

In putting down the wells there have been comparatively few failures to obtain flowing water, for the farmers have learned to keep within the bottom lands inside the defined artesian area. The increase in number of wells, however, has begun to result injuriously in many cases, and a large number of wells are reported to have decreased materially. In the various basins all stages in the history of artesian exploitation can be found. For example, in some of the larger basins the wells, comparatively few in number, show no signs of diminution in flow; in others the quantity discharged from some of the older wells has decreased by one-half or one-quarter, and again in other basins many of the wells barely flow, fluctuating with the changes of the season. Deep drilling, namely, beyond 400 or 500 feet, so far as has been ascertained, has been unsuccessful in obtaining fresh water. With increased depth the water is liable to be brackish or even heavily charged with saline matters. In some of the wells along the eastern shore of Salt Lake inflammable gas has been found, and a small amount of petroleum has been reported.

VALUE OF PRODUCTS.

The variation in the average value of products per acre for each county, as shown in the following table, is due somewhat to the character of the crop, but more to the state of cultivation and the water supply, and to some extent to the location of the land with regard to markets. In the northern end of the territory, as, for example, in Rich county, the average value of products is low, since forage crops are raised principally, and, the altitude being great and the water supply somewhat limited, the average yield is small. The average size of the farms also is large, showing that cultivation is carried on in a broad way, and that the greater part of the irrigation is for crops which require but little care.

In the counties lying along the base of the Wasatch mountains, near the markets of the cities of Salt Lake, Ogden, and Provo, and other centers of population, the farms are small and highly cultivated, and, as a consequence, the value of products is large, the counties on either side showing as a rule a lower average value. An exception to this is found in the case of the counties on the Colorado drainage, where the water supply is scanty and the cost of irrigation is at a maximum, for here (as, for instance, in the case of Washington county) the expense of bringing water to the land is so great that the farms are very small and the products per acre large. The semitropical character of the fruit and other crops in this great drainage basin also tends to give a greater value to these averages.

CONDITION OF IRRIGATION IN EACH COUNTY.

NUMBER OF IRRIGATORS, AREA IRRIGATED, FARMS, AND CROPS IN EACH COUNTY IN UTAH IN 1889.

COUNTIES.	Number of irrigators.	Area irrigated in acres.	Average size of irrigated farms in acres.	OWNERS OF FARMS. (a)		IRRIGATORS.		Area of counties in acres.	FARM AREA.		AREA IRRIGATED.			Average value of products per acre.		
				Total number.	Per cent of population.	Per cent of farm owners.	Per cent of population.		Acres.	Per cent improved.	Cereals. (Acres.)	Alfalfa. (Acres.)	Per cent of area of county.		Per cent of total farm area.	Per cent of land owned by irrigators.
Total.....	9,724	263,473	27	10,517	5.06	92.46	4.08	52,601,600	1,323,705	41.42	122,878	88,152	0.50	19.99	22.03	\$18.03
Beaver.....	200	7,082	38	210	6.29	85.24	5.99	1,730,560	16,165	57.28	2,224	1,106	0.44	47.52	58.40	9.92
Boxelder.....	350	10,472	29	478	6.25	75.10	4.70	4,490,240	430,383	13.63	10,932	3,784	0.23	2.43	2.57	15.25
CACHE.....	908	30,923	34	1,065	6.87	85.26	5.85	697,600	100,108	55.23	24,549	4,077	4.43	20.89	34.13	14.30
Davis.....	585	12,866	32	682	10.10	85.78	8.67	185,600	81,965	50.55	13,363	9,664	6.93	15.70	25.22	32.93
Emery.....	204	7,344	28	206	5.24	99.25	5.20	3,662,720	29,611	45.07	3,375	3,110	0.20	24.80	25.47	17.01
Garfield.....	82	2,294	27	93	3.79	88.17	3.34	872,960	7,161	62.23	1,172	485	0.26	31.20	38.99	11.84
Grand.....	56	1,139	20	56	10.85	100.00	10.35	2,032,000	6,055	32.54	411	381	0.06	18.81	18.81	19.05
Iron.....	193	3,539	18	188	7.38	97.47	7.19	2,199,040	5,689	88.22	2,394	1,218	0.16	62.21	62.97	14.94
Juab.....	85	1,946	23	97	1.74	87.63	1.52	2,449,920	15,295	45.46	241	597	0.08	12.80	14.30	11.05
Kane.....	107	1,798	17	120	7.12	89.17	6.35	2,670,080	7,861	45.97	848	528	0.07	22.87	27.84	21.81

a Includes owned and hired farms, assuming one farmer to each.

NUMBER OF IRRIGATORS, AREA IRRIGATED, ETC., IN EACH COUNTY IN UTAH IN 1889—Continued.

COUNTIES.	Number of irrigators.	Area irrigated in acres.	Average size of irrigated farms in acres.	OWNERS OF FARMS.		IRRIGATORS.		Area of counties in acres.	FARM AREA.		Cereals (Acres.)	Alfalfa (Acres.)	AREA IRRIGATED.			Average value of products per acre.
				Total number.	Per cent of population.	Per cent of farm owners.	Per cent of population.		Acres.	Per cent improved.			Per cent of area of county.	Per cent of total farm area.	Per cent of land owned by irrigators.	
Millard	304	8,199	27	306	7.59	99.35	7.54	4,295,680	41,438	35.49	2,326	3,452	0.19	19.79	21.89	\$14.58
Morgan	233	5,298	23	238	13.37	97.90	13.09	4,464,000	20,324	41.43	2,616	2,491	1.14	26.07	26.68	18.16
Piute	143	5,299	37	143	5.03	100.00	5.03	2,364,800	18,081	57.46	2,261	628	0.22	29.31	20.31	11.03
Rich	184	17,266	94	193	12.64	95.34	12.05	627,200	94,672	30.76	1,532	1,783	2.75	18.24	18.57	9.00
Salt Lake	1,264	25,392	20	1,366	2.34	92.53	2.16	501,760	73,271	65.44	6,962	12,928	5.06	34.65	40.96	26.73
San Juan	38	777	20	38	10.41	100.00	10.41	5,873,920	4,097	38.71	386	149	0.01	18.07	18.97	27.95
Sanpete	1,155	30,938	27	1,191	9.06	96.98	8.79	1,141,760	95,364	63.86	12,913	5,039	2.71	32.44	32.93	15.18
Sevier	311	11,547	37	312	5.03	99.68	5.02	1,198,080	27,579	66.61	6,075	2,423	0.96	41.87	41.87	11.63
Summit	276	10,140	37	302	4.68	76.24	3.57	1,959,680	34,986	52.21	1,551	2,109	0.52	28.98	37.85	15.03
Tooele	267	5,766	22	301	8.14	88.70	7.22	3,993,600	41,236	43.61	1,769	2,066	0.14	13.98	16.38	14.46
Uinta	186	7,611	41	186	6.73	100.00	6.73	3,733,760	19,789	67.65	3,579	2,688	0.20	38.46	38.46	10.61
Utah	1,161	25,296	22	1,198	5.04	96.91	4.88	1,271,040	68,637	74.05	8,500	13,583	1.69	36.77	38.68	22.50
Wasatch	259	6,475	25	289	8.04	89.62	7.20	2,204,160	19,796	68.85	2,718	1,723	0.29	32.71	38.67	10.22
Washington	176	2,251	13	187	4.66	94.12	4.39	1,565,440	4,872	74.59	1,235	1,196	0.14	46.20	48.84	32.19
Weber	928	21,385	28	942	4.15	98.51	4.08	416,000	59,358	65.45	8,946	10,044	5.13	35.94	36.07	22.72

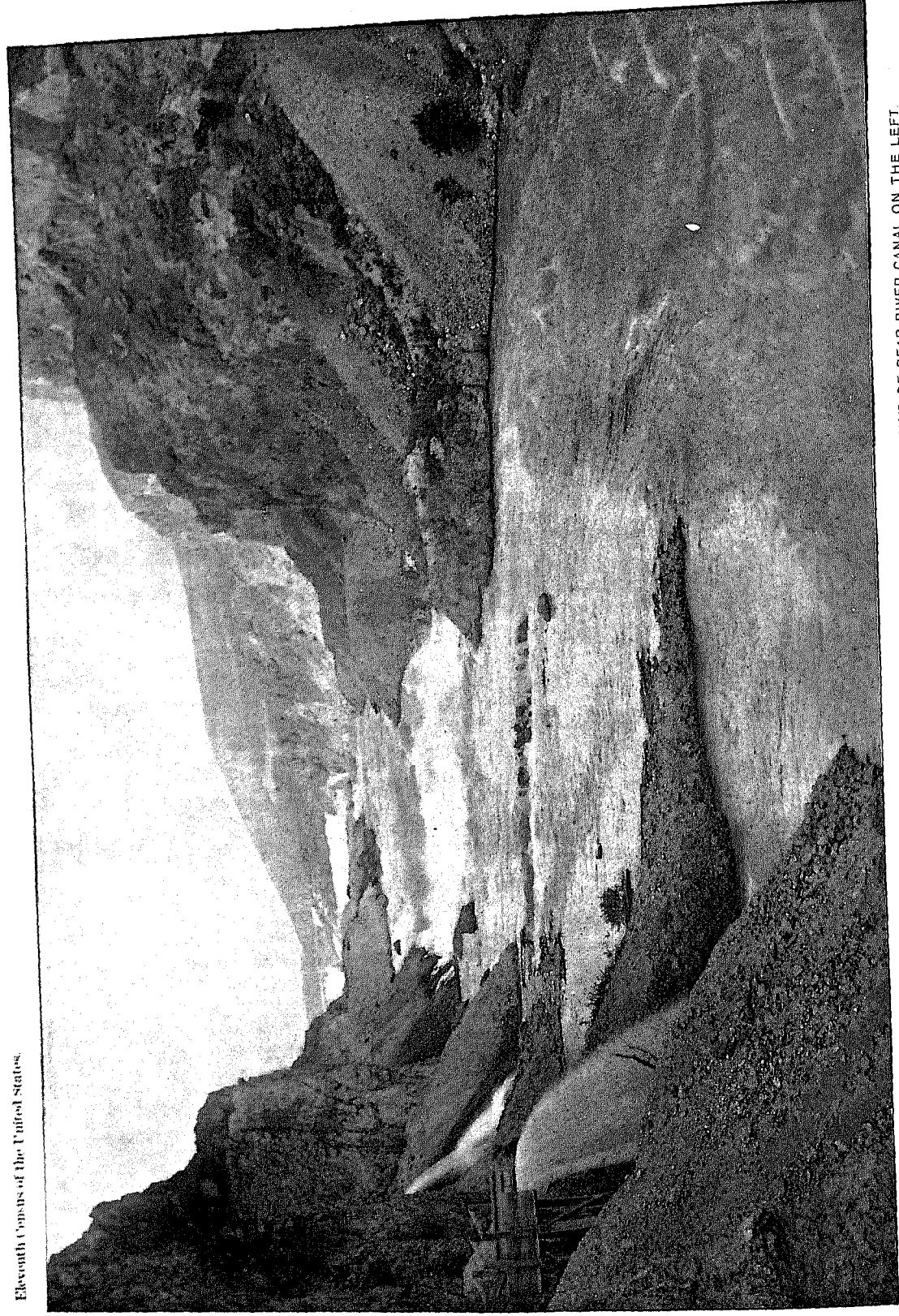
BEAVER COUNTY is on the western side of Utah, adjoining Nevada, and a little south of the center of the territory. It extends from the summits of the Tushar mountains westward into the desert region south and west of Sevier lake, or sink. The agricultural land is at the eastern end of the county, principally in the valley between the Tushar and the Mineral mountains, along Beaver creek and its tributaries, the principal towns being Beaver, Greenville, and Adamsville. A fourth town, Minersville, is situated lower on the creek, at the foot of the Mineral mountains, where Beaver creek leaves the foothills and enters upon the desert region. The average altitude of the agricultural land is about 6,000 feet. Alfalfa and the small grains are the principal crops, and in some localities there are a few orchards. The water supply of the early spring is ample for all the crops now under cultivation, but it becomes scanty during the latter part of May, and in July many of the crops which have not matured are lost.

Water storage has been attempted in a number of cases, but with little success, owing to lack of skill and care in constructing reservoir embankments. Many of the dams have been swept away during times of high water, resulting in great loss and discouragement. The experiments which have been made, however, lead the farmers to believe that with proper engineering supervision reservoirs can be made to hold ample water, not only for their present needs, but also to bring under cultivation a large amount of now useless lands. The only streams of importance in the county are Beaver creek and its tributaries, Indian, and North creeks. Various small canals lead from these creeks, and the waters are entirely appropriated in times of scarcity, only the irrigators near the head waters being able to obtain sufficient water for their needs.

BOXELDER COUNTY is in the northwestern corner of Utah, and includes the greater portion of Great Salt lake. The land north and west of the lake is for the most part level, much of it being a sandy desert, but the eastern border of the county extends to the summit of the Wasatch range, and is thus comparatively well watered. The principal body of cultivated land is along the foot of the Wasatch mountains and in the Malade valley. There is also some tilled land on the extreme western edge of the county along Grouse creek. Not all of the land under cultivation is irrigated, but there is a considerable acreage of dry farming in the long strip of land at the foot of Wasatch mountains, extending northward into the Malade valley. In the vicinity of Mantua, Honeyville, Deweyville, and Portage crops of wheat, oats, corn, rye, potatoes, and alfalfa, as well as fruit trees, are successfully raised. The yield is not as great as on the irrigated land, the amount being given as from one-third to one-half the product of land under irrigation. When alfalfa is raised in this manner, one cutting is made in July and the second crop is allowed to go to seed. Farmers attribute their success in dry farming to two causes: first, the nature of the soil, which retains its moisture for a long time, and, second, many small springs issue from the mountains and slowly percolating through the soil keep it moist.

Water storage in a small way has been tried to a considerable extent in this county. Small earthen dams have been built to retain a portion of the surplus spring flood, and the water has been used successfully. The irrigators state that this system has proved to be practicable; and that with greater care and skill large areas can be brought under cultivation. The unregulated water supply is ample for all needs until about the latter part of June. About the first of July it begins to diminish, and crops are often lost after that time. The present water supply of this county is derived from the various small streams which issue from the canyons. These being distributed along the mountains, there has been no necessity for large canals, but a great number of small ditches have been built. These are owned either by individuals or by the towns to which they bring water. In addition to the small streams there are two rivers of considerable size, the Bear and Malade. Both of these rivers flow at

Irrigation.



Eleventh Census of the United States.

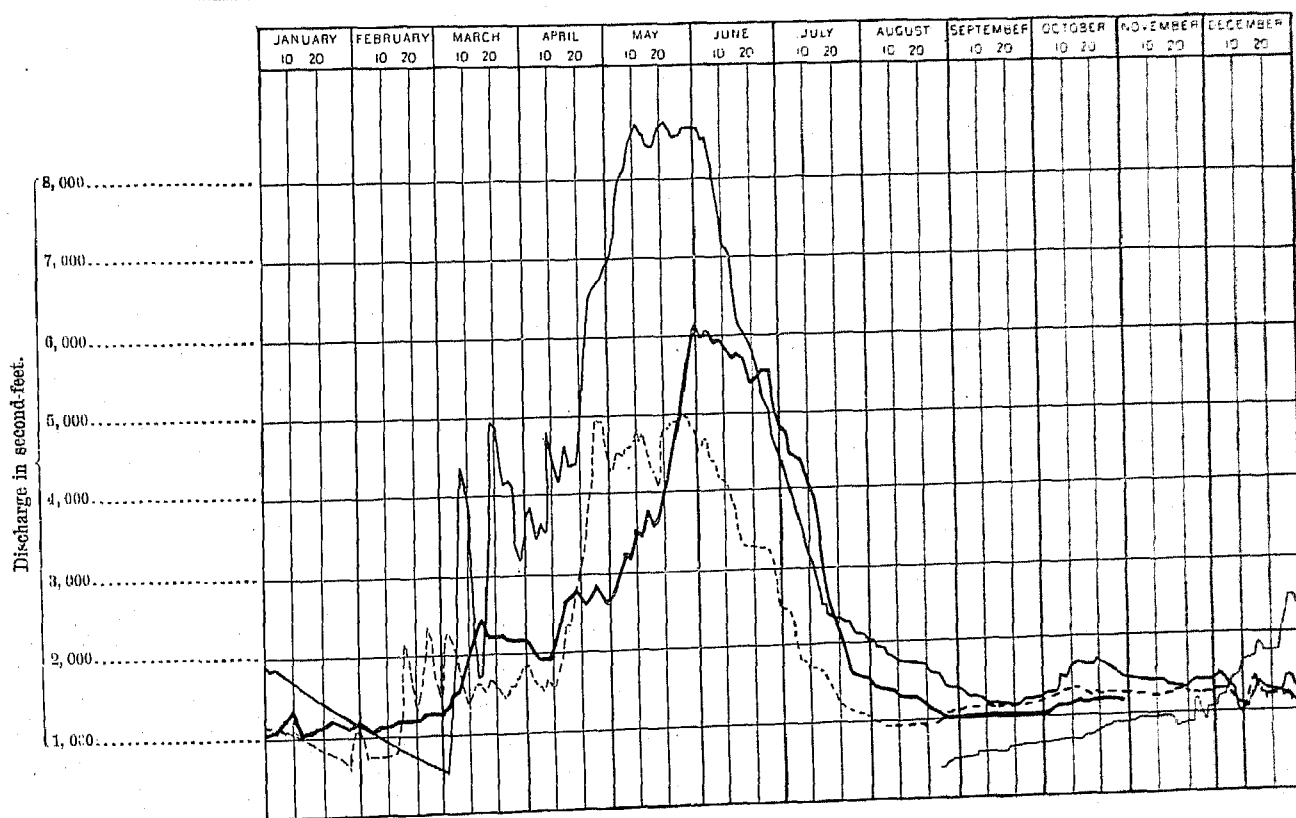
VIEW IN CANYON OF BEAR RIVER, BOXELDER COUNTY, UTAH, LOOKING EAST, SHOWING WASTE WAYS OF BEAR RIVER CANAL ON THE LEFT.

a depth of from 50 to 100 feet or more below the general level of the agricultural land, having cut their channels deep into the plain, once the bed of Salt lake. The waters of the Malade are impregnated with saline matter and are not suitable for irrigation.

Bear river enters the county by a narrow, rocky walled canyon, through which it passes with rapid descent. At the head of this canyon a low dam has been built to divert the waters into two canals, one on each side of the river. These canals are to pass through the canyon in tunnels or galleries in the rocky walls and then enter upon the fertile plains surrounding Great Salt lake. The accompanying illustration shows the general character of this canyon and of the tunnels by which the water is diverted. The canal on the west side of the river is nearly completed, but that on the east, leading southward toward the city of Ogden, is reported to have been temporarily abandoned. This great project, when completed, will be the largest of the kind in Utah, and will bring under cultivation thousands of acres of fertile land now useless or but poorly cultivated. The quantity of water in this stream has been measured at the lower end of the canyon and about a mile below the dam just mentioned. (a)

a In the diagram the discharge for 1890 is indicated by the lighter continuous line, that for 1891 by the broken line, and that for 1892 by the heavier continuous line. The fluctuations at this point are best shown by the accompanying table.

DIAGRAM OF DAILY DISCHARGE OF BEAR RIVER AT COLLINSTON, BOXELDER COUNTY, UTAH.



DISCHARGE OF BEAR RIVER AT COLLINSTON, UTAH.

(Drainage area, 6,000 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maxi- mum.	Mini- mum.	Mean.		Depth in inches.	Second- feet per square mile.
1889.			*800	47,600	0.15	0.13
June.....			362	22,263	0.07	0.06
July 24 to 31.....	385	340	417	25,645	0.08	0.07
August.....	450	385	500	30,285	0.09	0.08
September.....	610	450	728	44,772	0.14	0.12
October.....	825	610	848	50,456	0.16	0.14
November.....	1,000	780	1,395	85,702	0.27	0.22
December.....	1,925	955				

* Estimated.

CACHE COUNTY is in the northern part of the territory and includes the greater portion of the valley of the same name. The northern end of this valley is in Idaho, and thus the agricultural land and the water supply are divided between two great political divisions, giving rise to complications regarding water rights. Bear river flows southward into this county and then turns abruptly to the west, passing through a canyon into Boxelder county, as already described. This river flows at a considerable depth below the general level of the agricultural land and accordingly it has been found too expensive to bring the water out upon the lands of this valley. Various tributaries, however, come from the high mountains to the east, and it is upon the waters of these streams that the greater part of the agricultural operations depend.

The general elevation of the land under cultivation is about 5,000 feet, and the climate is highly favorable for wheat, oats, rye, and other small grains. The irrigated land is principally along the edges of the valley, extending up on the bench land or beaches left by the retreating waters of the lake, which once occupied this arm of the great basin. In the center of the valley and at other points where water is not available dry farming is being tried on a somewhat extensive scale. Wheat, rye, oats, corn, and potatoes are being raised by careful tilling, the product per acre being from one-half to one-third that on irrigated land. It is reported that from 12 to 15 bushels of wheat and from 10 to 12 bushels of rye to the acre is a fair crop. Fall wheat is extensively raised. To compensate for the smaller yield per acre larger tracts are farmed, and it is even claimed by some farmers that the average profits are greater, since the expense of the water is avoided and larger tracts are cultivated at less cost per bushel of wheat raised than is the case with the irrigated grain. This is notably the case in many seasons when the rainfall happens to be favorable. The use of water on the gravel bench lands surrounding the valley has caused some of the lower lands to be saturated by seepage, so that crops can be raised and even meadows formed. In some instances this saturation has proceeded so far that a system of drainage must be put in operation.

On the western side of the valley the water supply is far more scanty, on account of the lower altitude of the mountain range. Storage reservoirs have been attempted here and a few are in successful operation. At Newton there is a reservoir utilizing the surplus waters of Clarkston creek, and it is reported that 1,000 acres are cultivated by that means. The inhabitants of the towns on this side of the valley are preparing to increase the storage capacity by enlarging the old reservoirs and building new ones. Although agriculture in this county is in such a prosperous condition, there remain enormous tracts of good land, especially on the west side of the valley, still unproductive or from which only an occasional crop is obtained. It is known to be feasible to bring the waters of Bear river out upon this land, the engineering obstacles being by no means insuperable. There is a question,

DISCHARGE OF BEAR RIVER AT COLLINSTON, UTAH—Continued.

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.		MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maxi-mum.	Mini-mum.	Mean.		Depth in inches.	Second-foot per square mile.		Maxi-mum.	Mini-mum.	Mean.		Depth in inches.	Second-foot per square mile.
1890.							1801.						
January			*1,500	92,250	0.29	0.25	August	1,100	825	938	57,087	0.18	0.10
February			*1,000	55,500	0.17	0.17	September	1,200	825	986	58,667	0.18	0.10
March 2 to 31	4,860	1,100	3,188	106,062	0.61	0.53	October	1,310	1,200	1,235	75,952	0.24	0.21
April	6,680	3,600	4,953	294,703	0.92	0.83	November	1,310	1,200	1,262	75,089	0.24	0.21
May	8,220	6,890	7,924	487,326	1.52	1.32	December	1,545	1,100	1,216	74,784	0.23	0.20
June	7,940	4,440	6,234	370,923	1.16	1.04	Per annum	5,000	825	1,845	1,338,316	4.19	0.31
July	4,230	2,000	3,250	199,875	0.62	0.54	1892.						
August	2,060	1,545	1,754	107,871	0.34	0.29	January	1,545	1,000	1,202	73,923	0.23	0.20
September	1,425	1,310	1,344	79,968	0.25	0.22	February	1,310	1,000	1,200	69,517	0.22	0.20
October	1,665	1,365	1,544	91,956	0.30	0.26	March	2,480	1,310	2,037	125,275	0.39	0.34
November	1,425	1,305	1,403	83,478	0.26	0.23	April	2,760	1,925	2,397	142,621	0.45	0.40
December	1,545	1,000	1,243	76,444	0.24	0.20	May	6,260	2,480	3,860	237,943	0.74	0.64
Per annum	8,220	1,000	2,945	2,134,356	6.68	0.49	June	6,260	4,790	5,660	336,770	1.05	0.94
1891.							July	4,650	1,545	3,037	186,775	0.58	0.51
January			*1,000	61,500	0.19	0.17	August	1,545	1,000	1,195	73,492	0.23	0.20
February	2,200	825	1,308	72,594	0.23	0.22	September	1,000	1,000	1,000	59,560	0.19	0.17
March	2,340	1,425	1,760	108,710	0.34	0.29	October	1,200	1,000	1,131	69,556	0.22	0.19
April 1 to 11	5,000	1,665	2,729	162,375	0.51	0.45	November	1,310	1,100	1,195	71,102	0.22	0.20
May	5,300	4,020	4,569	280,993	0.83	0.76	December	1,425	1,100	1,235	75,952	0.24	0.21
June	4,720	2,480	3,595	213,902	0.67	0.60	Per annum	6,260	1,000	2,097	1,522,426	4.76	0.35
July	2,270	1,100	1,565	96,063	0.30	0.26							

*Estimated.

however, as to the practicability of so doing, both on account of the limited amount of water that can be relied upon at all times and on account of the complications arising from the peculiar position of Bear river, crossing, as it does, from one state into another. By a proper regulation of Bear lake and the waters of Bear river the success of any such enterprise could be assured.

On the eastern side of the valley are important streams draining the high mountains. On the north is Cub river and its tributaries, and at about the center of the county is Logan river, at the mouth of whose canyon is located the city of Logan. A number of irrigation works take water from these rivers, the most important of these being the Hyde Park and Smithfield canal, the Logan and Richmond, Logan and Hyde Park, and Logan and Benson; these carrying water northerly in a general parallel course along the bench lands. A few measurements were made of the discharge of Logan river at points above the high line canal. On August 14, 1889, the discharge was 126 second-feet; on August 17, 128 second-feet, and on August 24, 106 second-feet. The Logan, Hyde Park and Smithfield canal on June 12, 1889, was carrying 39 second-feet and the Logan and Richmond canal 68 second-feet. On June 14 the Logan and Hyde Park canal was carrying 35 second-feet and the Logan and Benson canal 38 second feet. Besides these there are a number of canals irrigating lands in the south end of the valley near Paradise, Hyrum, and Wellsville. Wherever water can be brought upon the bench lands the farmers are usually successful in producing large crops and in raising fruits of unusual excellence, the conditions being apparently more favorable than on the lower grounds.

DAVIS COUNTY lies between the Wasatch mountains and the shores of Great Salt lake, and extends from the canyon of Weber river on the north nearly to Salt Lake city. The agricultural land is thus in a long and comparatively narrow tract. The larger part is in the nearly level bottom of the ancient lake, but a portion extends up to the benches or old shores of the lake. The water supply is comparatively large, on account of the peculiar topography of the county. On the east are the lofty peaks of the Wasatch. The winds striking against them are deprived of their moisture in the form of rain or snow. Innumerable small streams issue from the mountains, and springs appear along the base. The water from these, if not used or evaporated, saturates the ground at the base of the mountains, and thus the little streams gradually disappear into the soil, whence the water is either slowly evaporated or ultimately finds its way into Great Salt lake. A small quantity of this water is recovered by flowing wells, the pipes for which are driven in the lower bottom lands. The supply thus obtained is of great value for domestic purposes, for watering stock, and for the irrigation of small patches of garden, as well as of fruit and shade trees. Many of the owners of these wells report that the water is slightly brackish and not always suitable for irrigation purposes.

One noteworthy feature of water conservation in this county is the development of springs by tunnels driven into the flanks of the mountain range. These tunnels are driven on a slightly ascending grade in the same manner as an ordinary mine or prospect tunnel, and after penetrating loose material and decomposed rock they usually reach the comparatively impervious strata. Here the course is often turned or lateral tunnels are driven along the solid or bed rock parallel with the surface. By means of these tunnels the small amount of moisture seeping through the beds on the lower slope is caught and conducted to the surface, where it can be used for domestic supply and irrigation.

The lower lands of the county are to a certain extent wet by the seepage from the springs and irrigation carried on above, so that large areas of wheat and barley are raised without artificial application of water. Wheat is usually sown in September and October, the land being prepared by summer fallowing, and it yields from 10 to 20 bushels per acre, and barley from 15 to 25 bushels per acre, the amount depending largely upon the winter rainfall. Farmers report that probably twice as much could be raised on the same land by irrigation, but taking all things into consideration the returns are probably greater than by using water, because of the smaller first cost of cultivation. On these lower lands the water must be carefully applied in order to avoid bringing the alkaline salts to the surface and thus ruining the land. Drainage is in many cases necessary, and it is probable that with the progress of irrigation large works of this kind will be required. Besides wheat and barley, one crop of alfalfa is raised without water, and in many instances it is stated that considerable acreages of this forage plant have been started from the seed and cropped regularly without irrigation. It is impossible, however, to raise vegetables or trees without a sufficient water supply.

The water supply being distributed along the base of the mountains, there are consequently many ditches, few of them, however, being of noteworthy size. The land under cultivation exceeds the ordinary supply of these ditches, and a loss of crops is the result. Considerable care, however, is taken in the management of the available water, and during the latter part of the season lands are irrigated both day and night, the water being in continual use by one irrigator or another. The farmers often complain that their lot is indeed hard when they are compelled to take water at any time of the night, and often to work all night in order to apply it to crops to the best advantage. The irrigators owning secondary rights to the water generally begin to irrigate in March and continue until about the middle of June, when the supply, usually ample to June 1, becomes so scanty that those owning primary rights demand the full stream in order to mature their late crops and water their orchards and gardens.

Thus a large number of the farmers do not venture to plant fruit and shade trees to an extent greater than can be watered by hand, because of the uncertainty of obtaining the necessary supply from the ditches during the summer. Water storage and conservation, although practiced to a very small extent in this county, are earnestly desired by most of the irrigators on account of the many difficulties and uncertainties which they encounter in spite of the comparatively good water supply. There have been a number of long and expensive legal controversies, and the water of their largest canal has been cut off for a time by order of court.

EMERY COUNTY is east of the center of the territory and lies wholly within the drainage of Green river, one of the forks of the Colorado. The county is composed principally of great plateaus, which descend rapidly to the east and south by steep escarpments. Through these plateaus deep canyons have been cut by the Price, San Rafael, and Fremont rivers and their tributaries, and also by the smaller streams flowing into Green river. On the plateaus and along the cliffs there is little vegetation, and whenever heavy storms occur enormous quantities of earth are loosened and washed down the narrow canyons, causing floods of great violence and destructiveness. Mud, sand, and bowlders are rolled along in these torrents, and the canyons are carved still deeper by this mass of turbulent material. Agricultural land is scattered along the streams in occasional narrow valleys wherever the canyons open, and also on the plateaus near the head waters of the streams before these have entered the deep canyons. The elevation of the tilled land varies from 4,000 feet along Green river to 6,000 feet or upward in the western part of the county. The water supply is derived from the streams just mentioned and is taken out upon the land by ditches made by the farmers, no crops being raised without irrigation. Along Green river small bodies of land are irrigated by means of norias or undershot water wheels, carrying buckets upon their rims.

The expense and labor involved in maintaining the irrigating ditches is large on account of the changeable character of the streams, which are liable at any moment to become raging torrents, carrying away head works or portions of canals, or even overwhelming the agricultural lands themselves. These floods often subside as rapidly as they come, and leave the channel almost, if not quite, dry. The principal towns are in the western part of the county, not far from the head waters of the streams, since at this place the water is more easily controlled and can be taken out upon the fields. The irrigators state that in order to bring all their land under cultivation it will be necessary to store a portion of the flood waters by diverting them from the streams into suitable depressions or into reservoirs, the facilities for whose safe construction are excellent.

GARFIELD COUNTY is in the southern part of Utah, extending in a narrow belt from the Colorado river westerly across the head waters of the Sevier. The county is thus composed for the most part of high plateaus and mountain ranges deeply cut by canyons, which rarely open to a sufficient width for agricultural operations. Sheep and cattle raising is the principal industry, the soil being tilled in the vicinity of home ranches of the herders or of the small towns from which supplies are obtained. There are a few broad valleys in the western part of the county, high among the mountains, where meadows are found or are made by turning the streams out upon the bottom lands.

The tilled land is along the head waters of the east and the west fork of the Sevier, and also to a less extent near the sources of the Paria and Escalante rivers, both flowing into the Colorado. The water supply is in general ample for all purposes, but when it is used freely from the streams flowing into the Sevier, farmers living in the valleys farther down stream suffer for lack of it. The peculiar manner in which the counties are divided in this portion of Utah stands in the way of water conservation, since it is difficult to enforce economy along the river, flowing, as it does, across several counties.

GRAND COUNTY was formed of that portion of Emery county between the Colorado line on the east and Green river on the west. The principal agricultural land is on the east side of Grand river, northwest of La Sal mountains, at an elevation of about 4,000 feet. The valleys, surrounded by high plateaus or mountains and thus protected from violent winds, have an almost semitropical climate. The water supply is derived from small streams, which issue from La Sal mountains in quantities more than sufficient for present needs, for agricultural resources have not been developed up to the easily available water supply.

The principal settlements are at Moab, at the mouth of the Spanish valley, and in the Colorado valley, about 6 miles below the mouth of the Dolores river. As yet injurious insects and parasitic growths destructive to plant life have not invaded these isolated valleys, and farmers have been unusually successful in their attempts to raise fruits and grain. The tilled land is along the small streams, the topography being such that canals or large ditches have not been found necessary, the water being taken directly from the streams by short laterals to the fields. There are immense tracts of fertile land along Grand river awaiting the construction of suitable canals, and it is only a question of time when large areas now devoted to grazing will be brought under close cultivation.

IRON COUNTY is in the southwestern part of the territory, below Beaver county, to which it is similar in many respects. The tilled land is confined to the eastern end of the county, and lies in narrow valleys at an elevation of about 6,000 feet along the foot of the mountains or escarpments which bound the great plateaus of southern

Utah. The water supply is derived from the small streams which issue from these high table lands, the amount depending upon the depth of snow falling upon the high lands during the winter. These streams are subject to violent floods in the spring, and as a rule decrease in June, furnishing barely enough water for the land then under cultivation.

The county contains immense tracts of barren land, the soil of which is fertile and produces good crops where water is applied. The acreage now under cultivation is relatively very small, but it is as large as the present unregulated supply will permit. The farmers, like those of Beaver county, are convinced of the necessity and feasibility of storing the flood waters in order to bring larger areas under cultivation. The greater part of the flood water is now unused, although as much as possible is diverted upon the hay lands in order to saturate them, and thus produce some grass for grazing. In the fall, also, after the crops are matured, any water remaining in the streams is thus utilized. At some of the towns in this county, as well as in adjoining localities, instead of a water master or overseer, a "field committee" is appointed to regulate the water during the crop season, thus leaving the distribution of the irrigating streams to a number of men, instead of to one man.

JUAB COUNTY is in the center of the western side of the territory and consists of a long, narrow strip extending westward from the Wasatch mountains across the desert to the Nevada line. The tilled land is mainly in Juab valley, in the extreme eastern end of the county, along the foot of Mount Nebo and the Gunnison plateau. A number of small streams issue from these mountain masses, the principal one, known as Salt creek, rising on the east side of Mount Nebo and flowing south and west around its base.

The agricultural lands are at an elevation of 5,000 feet and possess a climate similar to that of Salt Lake valley, to the north. Little, if any, land is cultivated without irrigation, the only exceptions being in the case of small areas of rye, corn, alfalfa, and wheat, which are reported to be raised without the artificial application of water, but which may possibly receive a small amount of moisture from springs or by seepage. The present water supply is insufficient for the needs of the land already tilled, and attempts have been made to build reservoirs, but with small success, as the dams for these are built in the cheapest manner possible and have been washed out by floods. The excess water of the spring, therefore, goes to waste, except such portions as may be turned upon grazing lands.

KANE COUNTY is on the extreme southern border of the territory, adjoining Arizona. It extends from the Colorado river westward, including the head waters of the Virgin. Like most of the country tributary to the Colorado, it consists of lofty plateaus, deeply eroded, and intersected by narrow canyons. As a consequence the streams flow for the greater part of their course far below the general level of the tillable lands. The cultivated areas are mainly in the western end of the county, on Kanab creek, and on Valley creek, a tributary of the Virgin. The irrigated land receives its water from these streams and the valleys being exceedingly narrow the ditches are necessarily small, extending along each side and covering small strips of land. Nearly all the valley land to which water can be brought is cultivated, and the water supply is ample for these limited areas. In the higher parts of the county there are a few localities in which corn, rye, and wheat are cultivated with partial success without irrigation, but in the towns, where the elevation is from 5,000 to 5,500 feet, irrigation is necessary for all crops or trees.

The expense of irrigation is very great in this county on account of the destructive floods, which rush without warning down the narrow canyons, sweeping out portions of the ditches, and at times even excavating channels to a depth of 50 or 60 feet, or even more, leaving the ditches high above the stream. It is only by constant expenditure and wonderful perseverance that settlements are maintained in these localities.

MILLARD COUNTY, like the other counties in the western part of Utah, extends from the mountain ranges of the central part of the territory westward to Nevada. In the center of the county is Sevier lake or sink, into which the Sevier river flows, the water being lost by evaporation, leaving a great deposit of saline matter. This river enters the county in the northeastern corner and flows southwestward. The amount of water carried is usually small, from the fact that the greater portion of the stream has been diverted upon lands in other counties through which it flows. Much of this county consists of broad deserts, from which rise short, abrupt mountain ranges. The soil is fertile, but on account of the lack of moisture it can not support the forms of vegetation useful to man. At the eastern end of the county, along the foot of the Pavant mountains, are a number of small towns dependent mainly upon agriculture and stock raising, receiving the necessary water from the little streams, whose waters are thus entirely used. Attempts have been made to increase the available supply from these streams by storing the floods in reservoirs, but many of the dams constructed for this purpose have been swept away.

The water of the Sevier river is used upon land in the canyon where it enters the county, and it is also diverted by dams into canals supplying the towns of Deseret and Oasis. The expense of maintaining these dams has been enormous. They have been washed out many times, and finally at great expense a new system has been constructed for the town of Deseret, the river being diverted from its original channel in order to insure greater stability in the

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headworks of the canal. Measurements of the discharge of Sevier river were made at Leamington (a), being thus above the points of diversion of the canals taking water from the river to lands northeast of Sevier lake.

MORGAN COUNTY is in northern Utah, lying east of Davis county. The greater portion of the area is mountainous, agricultural land being found only along the Weber river and its tributaries, the principal of which is East Canyon creek. The valleys are very narrow, so that the tilled land is in long, narrow strips. Irrigating ditches are usually small and numerous, several ditches carrying the water that could be conveyed with greater economy in one large well located canal. The water is derived from Weber river and its affluents or from springs in the canyons. The area under cultivation exceeds that which can be supplied with water in all seasons, and unless there is an unusual snowfall in the mountains a portion of the crops is lost each year, except in the case of the irrigators owning prior rights. Water storage is needed, but the facilities for its construction are said to be very limited.

Economy of water under the present system seems to be impossible, as there are many small ditches, each independent of the other, and all constructed with the object of obtaining as much water as possible. For example, there are in the vicinity of Morgan 9 ditches, 4 on one side of the river and 5 on the other. Two well located and carefully built high line canals would probably furnish more water and cover a larger acreage. At present the water rights are in an unsatisfactory condition, and there is complaint of waste of water by those holding prior rights or those fortunately situated on the head waters.

PIUTE COUNTY lies north of Garfield county, and like it extends in a narrow belt from the Colorado river, including on the east the greater part of the drainage basin of the Fremont river and at its western end several valleys, through which flows the Sevier or its tributaries. The eastern part of the county consists principally of high plateaus cut by deep canyons, and it consequently contains but small areas of irrigable land. The towns are principally in the center of the county, near the head waters of the Fremont river, where the canyons are of less depth and the valleys sufficiently wide to give agriculture a foothold. A small portion of the head waters of the Fremont lies in Sevier county. Included in this area is Fish lake, a body of fresh water about 6 miles long and 1 mile wide. This is already used as a reservoir, a dam being constructed across its outlet by the irrigators along the river in Piute county.

a The quantity of water and its fluctuations are shown in the accompanying table:

DISCHARGE OF SEVIER RIVER AT LEAMINGTON, UTAH.

(Drainage area, 5,595 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.		MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-foot per square mile.		Maximum.	Minimum.	Mean.		Depth in inches.	Second-foot per square mile.
1889.							1891.						
August 23 to 31.....	60	40	48	2,952	0.01	0.01	May.....	1,386	608	1,114	68,511	0.23	0.20
September.....	89	48	53	3,153	0.01	0.01	June.....	1,140	567	952	56,644	0.10	0.17
October.....	169	48	111	6,826	0.02	0.02	July.....	526	140	207	18,265	0.06	0.05
November.....	444	216	274	16,363	0.05	0.05	August.....	245	140	195	11,902	0.04	0.03
December.....	526	280	395	24,292	0.08	0.07	September.....	185	160	175	10,412	0.03	0.03
1890.							1892.						
January.....	1,058	280	625	38,437	0.13	0.11	October.....	210	185	202	12,423	0.04	0.04
February.....	1,149	567	713	39,571	0.13	0.13	November.....	403	210	312	18,564	0.06	0.06
March.....	690	567	630	38,745	0.13	0.11	December.....	813	403	551	33,880	0.11	0.10
April.....	976	603	726	43,197	0.14	0.13	Per annum.....	1,386	140	535	386,680	1.20	0.10
May.....	2,329	976	1,705	104,857	0.35	0.31	1892.						
June.....	2,296	649	1,250	74,375	0.25	0.22	January.....	1,058	813	1,016	63,485	0.21	0.18
July.....	619	185	346	21,279	0.07	0.06	February.....	1,017	895	931	53,532	0.18	0.17
August.....	185	150	153	9,409	0.03	0.03	March.....	854	608	738	45,387	0.15	0.13
September.....	185	150	157	9,342	0.03	0.03	April.....	567	100	232	13,804	0.05	0.04
October.....	362	185	310	19,065	0.06	0.06	May.....	1,017	80	250	15,375	0.05	0.04
November.....	403	321	373	22,194	0.07	0.07	June.....	1,222	210	718	42,721	0.14	0.13
December.....	619	403	509	31,304	0.10	0.09	July.....	210	48	88	5,412	0.02	0.02
Per annum.....	2,329	150	625	451,775	1.48	0.11	August.....	80	48	53	3,250	0.01	0.01
1891.							1893.						
January.....	772	649	735	45,202	0.15	0.13	September.....	60	48	40	2,915	0.01	0.01
February.....	772	772	772	42,846	0.14	0.14	October.....	80	48	53	3,250	0.01	0.01
March 1 to 28.....	772	526	618	38,107	0.13	0.11	November.....	120	100	117	6,901	0.02	0.02
April 5 to 30.....	608	526	563	29,528	0.10	0.09	December.....	976	140	570	35,055	0.12	0.10
							Per annum.....						
							1,222	48	401	201,165	0.97	0.07	

The valleys of the western end of the county are comparatively broad and receive waters from numerous small streams which enter the Sevier from both sides. In the valley through which the Sevier river flows the ditches are generally taken out from the small streams rather than from the river itself, both for the sake of convenience and economy. Being near the head waters, most of the farms have an ample supply of water, and thus there is less demand for storage, but many farmers are apprehensive that with the development of irrigation in Garfield county they will not be able to receive their usual supply. The county contains a large number of excellent reservoir sites, notably on Otter creek, which flows from Sevier county. The lack of coincidence of the county lines with lines of drainage leads to many complications, since the reservoir sites needed by this county are in some cases beyond its jurisdiction, while in turn it contains reservoir sites of no use to its own people, but of great value to others.

RICH COUNTY is in the northeastern corner of Utah, adjoining Idaho and Wyoming. The agricultural land in this county lies in two valleys, separated by the Bear River plateau. On the east of this plateau is the Bear River valley and on the west is Bear Lake valley. The greater portion of this latter valley is in Idaho, there being a comparatively narrow strip of land along the southern and western shores of the lake. Bear River valley is a broad, open tract of country, lying at an elevation of nearly 7,000 feet. The climate is somewhat cold, but the hardier crops flourish. The water supply is derived from Bear river, which flows from south to north, and from numerous tributaries rising in the mountains to the west of the river.

In Bear Lake valley, in the vicinity of Laketown, are irrigated farms of considerable size. North and east of this place, however, the shores of the lake rise abruptly, leaving little room for agriculture. To the west of the lake, however, the slopes are more gentle, and the irrigated land extends in a long, narrow strip, receiving water from small streams and springs in the canyons. There are a number of notable springs in this county, due to the peculiar structure of the mountains and the prevalence of limestone, which in places has been dissolved, giving rise to underground water courses of considerable size, carrying in one case as high as 50 second-feet.

SALT LAKE COUNTY is southeast of Great Salt lake and lies between the summits of the Wasatch mountains on the east and the Oquirrh mountains on the west. On the south it is bounded by a transverse range of hills, through which the Jordan river has cut a deep notch. The agricultural land is at an elevation of from 4,300 to 5,000 feet, and enjoys a climate of the most favorable character, since from its central position and elevation it is not subject to great extremes of heat and cold. The natural facilities for irrigation in this county are not surpassed by those of any valley in the arid regions.

The water supply comes from two sources. The first consists of the various streams which issue from the Wasatch mountains, on the east of the county, flow westward through narrow canyons, and finally enter the valley, where, before irrigation was practiced, the water gradually disappeared into the sand, or in times of flood flowed into the Jordan river. The second source of supply is the Jordan river, the outlet of Utah lake, situated in the county of Utah. The water from this river is carried to the farming land by 5 large canals, 2 on the east side and 3 on the west, as well as by a multitude of small ditches, a few of which furnish power to mills.

Although the natural advantages of the water supply are almost unexcelled, yet the utilization of these advantages has not been of the most satisfactory character, from the fact that the irrigating systems have sprung up without plan and have been developed solely with reference to the needs of the individual owners, and not with regard to the general good of the county. For example, water which could be used on the high bench lands is taken from mountain streams down to the low lands beneath the level of canals taking water from Utah lake. The irrigating ditches thus cross each other, giving rise to complications and waste in construction, and water which might be employed to better advantage upon the higher lands is taken to the farms which apparently should be irrigated by lake water.

Utah lake is the great natural reservoir for Salt Lake county, and upon the proper utilization of its waters depend the prosperity and future extension of the farming land of that county and to a less degree the growth of the city of Salt Lake. Up to the present time, although the need of improving the water supply has been appreciated, no serious attempts or definite plans toward this end have been made. The employment of Utah lake as a reservoir, so that the water shall be used to the best advantage, is not a simple engineering problem, but is complicated by the fact that vested rights to its waters have been acquired by individuals and corporations, who can scarcely be expected to work in harmony, and, further, much of the land surrounding the lake and adjacent to its outlet has passed into the hands of proprietors whose interests are apparently antagonistic to those of the farmers of Salt Lake valley.

The control of the lake has been a source of dispute for many years between the two counties. On the one hand, the farmers of Salt Lake county deemed it necessary to hold back as much as possible of the flood waters in the lake, and, on the other hand, the residents of Utah county owning land around the lake wished to have the waters flow freely through the Jordan, in order that the lake might fall and the area of pasture lands be as large as possible. The contentions between these two parties finally culminated in a lawsuit for damages for injury caused by flooding lands in Utah county. The matter was finally settled by arbitration, and a compromise was agreed upon in 1885, by which a board of commissioners representing both counties was empowered to regulate

the height of the water in the lake and to hold it at a certain level. If the water should at any time be maintained at a higher level than agreed upon, the damages, if any, to the land in Utah county must be paid by the owners of the dam in the Jordan river.

Under the act of Congress of October 2, 1888, the lake and the surrounding lands were segregated as a reservoir. A survey of the shores was made by the United States Geological Survey and a study of the hydrography of that drainage basin was begun. The conclusions reached were, that to serve its best purposes as a reservoir the lake should be drawn to a lower level on account of the enormous evaporation from the present water surface, the supply of the lake not being in many seasons sufficient to counterbalance this enormous loss. At the same time, to provide storage room for unusual floods, the land below high water mark should be withheld from settlement and entry.

In consequence of uncertainties attending the amount and distribution of the water in complicated and wasteful ditch systems, there are great losses of crops, especially among the farmers owning second and third rights, and these irrigators complain bitterly of the apparent lack of economy among the older settlers, who enjoy prior rights. The majority of the farmers in the valley state that the way out of their difficulties is by a more careful and just regulation of the water and by the storage of the excess waters of the spring floods. They discuss the methods of water storage, especially in the reservoir sites at the head of the Cottonwood creeks, reserved for this purpose by the government, and express hopes of ultimately constructing dams for water storage in the more favorable localities. Experience has shown that, owing to the gradual accumulation of moisture in the soil, less water is required to irrigate an acre than formerly, and therefore a far larger acreage is now cultivated than appeared possible in the early history of the valley.

SAN JUAN COUNTY is in the southeastern corner of the territory, adjacent to Colorado, New Mexico, and Arizona. Settlement has progressed but slowly, as the arable lands have not been thrown open to agricultural entry to any considerable extent, and possible settlers have been deterred from entering upon them by the uncertainty as to the reservation of lands for the Ute Indians.

The San Juan river crosses the southern part of the county, flowing into the Colorado river, which forms the western boundary of the county. There is usually an ample supply of water in this river, but the bottom lands being narrow and the channel shifting in every flood the expense of bringing water upon the land is generally too great for the area to be cultivated. On account of the difficulty and expense of bringing water from the river by canal, it is a question among the farmers as to whether it would not be advisable to attempt to raise the water by machinery rather than try to build new dams each year in the unstable sandy channel. Along the tributaries of the San Juan and in the higher valleys a small amount of land is brought under irrigation. Stock raising, however, is the principal industry.

SANPETE COUNTY is in the center of Utah, and is the most southerly of the chain of thickly settled counties which, beginning with Cache county on the north, extends in a generally southern direction. The county includes the whole of the catchment area of Sanpitch river and a portion of the valley of the Sevier river, both above and below the junction with the Sanpitch. The agricultural land lies along these rivers and their tributaries and has an elevation of from 5,000 to 6,000 feet.

The Sanpitch valley is watered by various small streams, which issue through canyons leading down from the Wasatch plateau on the east. Between the Sanpitch valley and the Sevier is the Gunnison plateau, which, however, is not of a height sufficient to give rise to perennial streams of importance. The west side of the valley, therefore, receives very little water, and the principal towns are along the eastern edge of the agricultural lands. At the mouth of each canyon from which a creek issues a settlement has been made, and many of these have been incorporated as cities, the inhabitants, however, depending almost entirely upon the cultivation of the surrounding fields or upon sheep and cattle raising. The municipality controls the waters of the creek and apportions them to the town lots or fields in accordance with regulations made by the voters. The control of the water is under the direct supervision of a water master and his deputies, who regulate the head gates of the various ditches, turning the water to the users according to a schedule previously prepared. The water supply of each city and its surrounding fields is wholly within the control of the people, and they have no one but themselves to consult in regard to its conservation or employment. They may construct storage works, improve the channel, or make any regulations desired.

The conditions of control in that portion of the county situated in the Sevier valley are in marked contrast to those just mentioned in the Sanpitch valley, for here the water supply is received, not from independent sources, which can be controlled without interference, but from the Sevier or Sanpitch river, after having passed by the canal head works and agricultural lands of various irrigators. The waters of the Sevier river are used in three counties before reaching Sanpete county, and, therefore, there is but little available except in flood seasons. There is two or in places three times as much land under cultivation in the Sanpitch valley as can be supplied with water in ordinary seasons. It has become customary to let one-half the fields lie fallow for a year while the other half is being used, the fallow land being plowed once or twice in order to destroy the weeds. The water supply is scanty even for one-half the land, and the right to take water from each creek, by increase of settlement and subdivision, has become so complicated and has been so extended that it is difficult even for those owning prior

rights to get sufficient water to mature a fair crop. It is even worse with the later settlers, for, according to the regulations, they are only allowed the flood waters or such portions of the stream as their neighbors can not use. After a late comer has used the water for several years and has established a home it becomes a matter of great difficulty, both legally and actually, to deprive him of water, destroying his trees and fields, in order that the older settlers shall have enough, and yet, on the other hand, irrigators holding prior rights feel that it is not just for other men to come in and gradually destroy the value of their farms by acquiring the greater part of the water.

Sanpete county is a good example of the evils arising from the neglect of jealously guarding prior rights. As population increased, the older farmers, from friendship or compassion, allowed others to share their water supply, and frequently in times of scarcity good naturedly divided the scanty supply. Thus an increasingly large number of irrigators acquired certain rights to the water, until the limit has been reached, when in dry seasons all suffer together, and at other times there is barely enough water for all, and they do not receive sufficient returns to insure prosperity or contentment. Storage reservoirs and other projects for increasing the supply have been attempted. A number of reservoirs, all of small size, have been constructed or are now being made in various parts of the county. Owing to lack of experience and engineering skill several of the dams of these reservoirs have been swept away by floods, with considerable damage to property, while others have been so located that there is not a sufficient amount of water to fill the basin.

SEVIER COUNTY is in the central part of the territory, and includes the principal valley along the course of the Sevier river. In this broad valley are a number of towns of considerable size, all depending upon agriculture. Many canals receive water from the river, and various small ditches are fed from springs and streams which issue from the mountains on each side. Only a small portion of the valley land is tilled, thousands of fertile acres lying idle for want of water. Farming communities depending upon the smaller streams utilize them to their fullest extent, small reservoirs being built in various places to hold the flood waters until needed for maturing crops. The irrigators who depend upon the Sevier river do not enjoy the same security in regard to the permanence of their water supply, as agriculture is rapidly being developed above them in the valleys of Garfield and Piute counties, and thus the summer flow of the river tends to diminish.

There is a feeling of insecurity in regard to water rights along this large river, since settlers are pushing into every little valley and diverting upon their lands the springs or streams which formerly flowed into the river, thus tending to decrease the amount flowing through the lower valleys. At the same time, ditches along the course of the river are being enlarged and gradually extended to cover new land, and occasionally a new canal is built by an association of farmers, who, by better organization and co-operation, necessarily gain strength and importance, and by acquiring old water rights in one way or another diminish the amount available for the smaller ditches.

SUMMIT COUNTY is in the northeastern part of Utah, surrounding on two sides the re-entrant angle formed by the corner of Wyoming, which appears to encroach upon the territory of Utah. This county includes the head waters of Bear river, Weber river, and the principal branch of the Provo. The agricultural land is along the comparatively narrow valleys of these streams and their tributaries, receiving water from them or from the numerous springs issuing from the sides of the mountains.

The general elevation of agricultural land is from 5,500 to 7,000 feet, while the mountains rise to heights of from 10,000 to 13,000 feet. The water supply of this rugged country is generally ample at all times of the year, although in the lower valleys losses of crops have occurred. In 1889 the losses were especially great in this and the counties adjoining. Attempts were made by the irrigators of the lower counties to restrain the farmers of Summit county from using all the water, so that some might flow to the dry fields below. Men came up the river at that time with the intention of closing the head gates of the various ditches, but the attempt was not a success, and it does not appear that the irrigators of the lower counties were benefited.

Attempts have been made in a small way to store water, and several irrigators report that they are depending upon water from their own reservoirs and are increasing the supply by building new and better dams. The washing out of one dam, and consequent loss of property, have taught the farmers that great care must be used in these undertakings. Small crops of wheat and oats are occasionally raised without irrigation, but this method is very uncertain, and the yield is small unless there happens to be an unusual amount of rain. The success of farming, either with or without irrigation, depends directly upon the amount of precipitation. Whenever the snowfall during the winter is heavy, farmers look forward to a prosperous season, and when the snowfall is light, as it has been for several years, the prospects are discouraging, since the greater portion of the snow melts and runs away in the spring before the water is needed. In the upper valleys the seasons are short, frosts occurring late in the spring and early in the fall, rendering agricultural success a matter of uncertainty.

TOOBLE COUNTY is southwest of Great Salt lake and includes the greater part of the desert of the same name. The county extends from Oquirrh mountains on the east to the Nevada line on the west. It includes a number of small mountain ranges, rising abruptly from the broad and nearly level valleys and having a general north and south trend. The county lies almost within the center of the area formerly covered by the waters of the fresh water lake known to geologists as Lake Bonneville, and the soil of the broad valleys and deserts was deposited by these waters. The mountain ranges were islands in the lake, and still show the results of wave action in the broad terraces, successive beaches of the lake. The soil in the valleys is very fertile, but is heavily charged with alkaline

salts, so that care must be taken in applying water. On the terraces the soil is usually not so good, but it is comparatively free from alkali and is cultivated to a small extent.

The water supply of this county is very limited, so that a very small portion of the broad, fertile valleys can be irrigated. Along the foot of each mountain range there are a few springs which are utilized either for watering stock or, if sufficiently large, for irrigation. The mountain ranges do not rise to a height sufficient to receive a very heavy snowfall, and consequently the streams from them are small in size and variable in quantity. There is a prevailing opinion among the farmers that by driving tunnels into the mountains and cleaning out the springs the water supply can be increased. This is undoubtedly the case where, for example, the strata dip away from the valley and tend to carry the small amount of water which may be percolating through the rocks away to the opposite side of the mountains.

The cost of irrigation in this county is very great on account of the numerous failures to obtain sufficient water or the destruction of ditches by unexpected floods. Valley bottoms are at an altitude of about 4,200 feet, being but slightly above the level of Great Salt lake. The climate is extremely arid, and there is a considerable range of temperature, frosts sometimes occurring late in the spring or early in the fall, in spite of the high temperature prevailing during the summer. Among the mountains small acres of rye, wheat, and corn are cultivated without irrigation, although the yield is small and may not repay the labor of tilling the soil, unless the season happens to be unusually rainy. Some alfalfa is also raised in the same way, the cuttings being only from one-half to three-quarters of a ton to the acre, while on irrigated land they are 2.5 tons.

The principal towns are in the eastern end of the county, in Tooele and Rush valleys. They depend for their life largely upon mining and stock raising, the cultivation of the soil being of secondary importance. In the extreme western end of the county, on Deep creek, and especially in the vicinity of Ibapah, is a small amount of agriculture, the supplies being readily marketed at the Deep Creek mines.

UINTA COUNTY is in the northeastern corner of the territory, adjoining Wyoming and Colorado. The mountain range of the same name crosses the northern end of the county, while the southern and western parts are covered by the Ute Indian reservation, thus leaving but a small portion of the county open to agriculture. The tilled land is mainly along Brush creek and Ashley fork, both of which flow into Green river. Water is taken from these smaller streams, as they can be readily controlled. Green river crosses the northeastern corner of the county and then flows diagonally through the county from northeast to southwest. Its waters, however, are in general too far below the agricultural land to be taken out, or at places where diversions may be feasible the expense has been too great for the present inhabitants.

UTAH COUNTY embraces some of the best agricultural land of the territory, its principal valley equaling if not excelling in advantages of location and water supply any other valley in the territory. This county is south of Salt Lake county and extends from the summits of the Wasatch westward to the Oquirrh range. In the center is the beautiful body of fresh water known as Utah lake, on the western shore of which is a short mountain range rising about 3,000 feet above the valley and known as the Lake mountains. These divide the county into two portions, Utah valley, containing Utah lake, on the east, and Cedar valley on the west. The contrast between these valleys is striking, the one with its well watered fields and broad lake, the other almost a desert, with but few small towns and limited agricultural possibilities. In soil and climate there is no appreciable difference, and it is the water supply alone that gives the great superiority to the valley on the east.

The natural water supply of this county is excellent, but farmers claim that the water is not distributed with due regard to economy or apparent equity. The greatest cause of loss is the duplication of canals, two, three, or even four small canals running in general parallel courses and carrying the water to land that one large canal would serve with far greater economy. As a consequence of the large number of ditches the construction is usually poor and the headworks and flumes are of temporary character. The dams and head gates are occasionally washed out or injured in floods, or, for instance, by the railroad ties which are floated down the river at the time of the spring freshets. In consequence of these injuries crops have been lost before the damage could be repaired.

The principal streams watering this valley are the American fork, Provo or Timpanogus river, Hobble creek, Spanish fork, and Salt creek. The Provo is by far the largest river. It drains an extensive area to the east of the main range of the Wasatch, through which it cuts a deep canyon. The excess water of these rivers, together with the drainage from the fields, finally finds its way into Utah lake, the regulation of which is mentioned in the description of Salt Lake county. There is more arable land than can be watered by the regulated flow of the rivers, and, as a consequence, the area of tilled land has increased until limited by the amount of water available in ordinary seasons. In times of drought, therefore, the land more recently brought under cultivation can not produce a crop, and considerable suffering exists among the later settlers.

Under the well established customs of Utah, previously mentioned, the water supply is given to those farmers who have used it the longest, the rights of each man being classed as first, second, or third, according to local regulations. In times of drought, as during 1888 and 1889, the farmers having only third rights lost their crops and most of their trees and vines, except such as were watered by hand. Those holding secondary rights also lost heavily, and even among those having first or prior rights the water was not sufficient for all demands.

Many of the larger irrigation works of Utah valley, as well as those of Salt Lake valley, are owned in part by persons who do not personally cultivate land, but who annually rent their water rights at the market value. There is no fixed price, the rental being a matter of agreement between the parties interested. Thus the owner of water rights may rent his rights to one irrigator for a given season and to another the next. These water rights, or, more properly, shares of stock in the canal, are supposed to entitle the owner to a certain amount of water, each share being intended originally to furnish water for one acre. In times of scarcity, however, one share of stock may actually furnish water sufficient for only one-third or perhaps one-fifth of an acre, and even, in some instances, for only one-seventh of an acre. There is very little dry farming in this county. A small acreage of wheat is planted in the fall and is sometimes successful.

The lower lands of Utah valley were first brought under cultivation and have prior rights to the water. After these were taken up agriculture began to encroach upon the higher bench lands or shores of the ancient Lake Bonneville, and later canals were taken out to water these benches, many of them, however, having rights only to the surplus water. The irrigation of the higher lands has a tendency to moisten the lower fields, and when an excessive amount of water is applied during the flood season the water slowly appears on the lands below, and later in the season may saturate those so completely as to make pasturage, or even injure it by creating marshes or by developing an alkaline crust. Thus in the future development drainage must be inaugurated as well as an improved system of distributing the water.

Water conservation has been attempted in a small way, and several reservoirs have been built in suitable places, by means of which a few farms have been successfully cultivated. Many sites are favorable for this purpose. In one or two instances attempts have been made with little success to increase the ordinary summer flow by tunneling into the mountains. On the lower lands, especially near the lake, there are a large number of flowing wells, which are useful not only for domestic supply and watering cattle but to a small extent for irrigation. They are confined mainly to lands so low that they are already wet by seepage. The well water is usually stated to be not as good as that from ditches, on account of its slightly saline qualities and lack of fine fertilizing sediment. (a)

WASATCH COUNTY is east of Utah county, the greater portion of it being included within the catchment area of the Duchesne river and its tributaries, a part of the Colorado drainage. Nearly all the county lies within the Uinta Indian reservation, but on the western end a small projection of the county lines extends across

a Observations on the flow of various streams are given in the following tables:

TABLE 1.—DISCHARGE OF PROVO RIVER ABOVE PROVO, UTAH.
(Drainage area, 640 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.		MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.		Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1889.							1891.						
July 27 to 31	150	140	150	9,225	0.27	0.23	January	280	240	255	15,682	0.46	0.49
August	149	144	145	8,917	0.26	0.23	February	500	280	311	17,240	0.51	0.46
September	174	144	150	8,925	0.26	0.23	March	1,316	280	492	30,258	0.89	0.77
October	200	174	180	11,070	0.32	0.28	April	930	280	478	28,430	0.83	0.75
November	280	200	224	13,328	0.39	0.35	May	1,764	851	1,226	75,399	2.21	1.92
December	630	240	384	23,616	0.69	0.60	June	1,470	851	1,190	70,805	2.07	1.86
1890.							1892.						
January	700	200	305	18,751	0.55	0.48	July	1,240	260	423	28,014	0.76	0.67
February	564	280	377	20,923	0.61	0.59	August	280	260	260	15,990	0.47	0.41
March	700	240	519	31,918	0.93	0.81	September	440	280	314	18,623	0.55	0.49
April	1,240	506	840	49,980	1.46	1.32	October	380	330	364	23,386	0.68	0.57
May	2,180	1,316	1,926	118,450	3.47	3.01	November	380	380	380	22,610	0.67	0.60
June	2,200	440	1,184	70,448	2.06	1.85	December	380	330	343	21,094	0.62	0.54
July	440	280	314	19,311	0.56	0.49	Per annum	1,704	260	503	365,591	10.71	0.79
August	280	240	252	15,498	0.45	0.39	1892.						
September	280	240	244	14,518	0.43	0.38	January	330	330	330	20,295	0.59	0.52
October	330	280	304	18,090	0.53	0.46	February	380	330	351	20,182	0.59	0.55
November	330	280	303	18,028	0.53	0.47	March	440	330	361	22,201	0.65	0.57
December	330	240	293	18,020	0.53	0.46	April	440	330	377	22,431	0.66	0.59
Per annum	2,260	200	572	414,341	12.13	0.89	May	1,780	774	1,079	66,358	1.95	1.68
							1893.						
							January						
							February						
							March						
							April						
							May						
							June						
							July						
							August						
							September						
							October						
							November						
							December						
							Per annum						

the head waters of the Provo river, and it is in this small corner of the territory that the principal towns and agricultural areas are situated.

The valley of the Provo at this point is comparatively broad, and the river, rising in the Uinta range, furnishes water sufficient to supply all or nearly all the land to which it can be taken. Along the tributaries of the Provo, however, are tracts of land for which the water supply is insufficient, and attempts have been made to increase this by small reservoirs among the mountains. The facilities for the construction of these are unusually good, from the fact that there are a number of small lakes and depressions of glacial origin whose outlets can readily be closed. It is estimated that the water can be stored at an expense of \$10 per acre of land irrigated. Besides the use of reservoirs, the attempt has been made to increase the amount of water available by cutting a ditch and tunnel across the divide and bringing the head waters of Strawberry creek, a branch of the Duchesne, over to the Provo side. In this way the demand for water, which is most strongly felt in July and August, can be in part supplied.

WASHINGTON COUNTY is in the southwestern corner of Utah, and includes the greater part of the drainage basin of the Virgin river. The agricultural lands are at an elevation of from 2,500 to 3,000 feet or more, and are mainly along narrow valleys between lofty mountain ranges. The Virgin river on the east drains a part of the high plateau of southern Utah, and thus flows in deep, narrow canyons, while its tributaries on the west receive water from steep mountains, which are almost entirely free from forests. The river is thus subject to violent floods whenever a heavy storm occurs, and at these times carries large quantities of sand and debris, cutting the banks and washing away or obliterating the irrigating ditches.

The climate of the valleys is very warm, the growing season being sufficiently long and hot to insure the success of cotton and semitropical fruits. The area of good land, however, is comparatively limited, and the unregulated water supply barely sufficient for the present area under cultivation. The irrigators, however, believe that water storage in side canyons and depressions not on the line of the streams can be successfully accomplished and larger areas thus brought under cultivation. On account of the erratic character of the streams the expense of maintaining the ditches and diverting water into them has been very great. The head works are frequently washed away, and several ditch owners state that they scarcely ever take water into their ditches at the same place two years in succession. As in the case of the other counties in the Colorado basin, the streams occasionally wash out their channels to a depth of many feet, necessitating the construction of long lines of canal to bring the water upon the land again. Stock raising and the cultivation of the soil are the principal industries, mining and milling of gold ores having diminished in importance.

WEBER COUNTY, in the northern part of the territory, includes some of the most easily watered lands in Utah, the supply coming mainly from the Weber and its principal tributary, Ogden river, both issuing from deep

TABLE 2.—DISCHARGE OF AMERICAN FORK AT BRIDGE IN CANYON, UTAH.
(Drainage area, 66 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.		MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.		
	Maxi- mum.	Mini- mum.	Mean.		Depth in inches.	Second- feet per square mile.		Maxi- mum.	Mini- mum.	Mean.		Depth in inches.	Second- feet per square mile.	
1889.														
August.....	66	10	38	2,327	0.66	0.58	1890.							
September.....	48	20	30	1,785	0.51	0.45	January.....	276	30	62	3,813	1.08	0.94	
October.....	66	6	33	2,029	0.53	0.50	February.....	108	48	72	3,996	1.13	1.09	
November.....	30	30	30	1,785	0.51	0.45	March 1 to 20.....	192	60	117	7,195	2.04	1.77	
December.....	108	30	67	4,120	1.17	1.02	April.....			380	22,610	6.43	5.76	
							May.....	885	495	666	40,990	11.62	10.11	
							June.....			208	12,300	3.51	3.16	
							July.....			45	2,765	0.78	0.68	
							Per annum.....	885	6	146	105,785	30.02	2.21	

Estimated.

TABLE 3.—DISCHARGE OF SPANISH FORK IN CANYON, UTAH.
(Drainage area, 670 square miles.)

1889.							1890.						
MONTHS.	Maxi- mum.	Mini- mum.	Mean.	Total for month in acre-feet.	Depth in inches.	Second- feet per square mile.	MONTHS.	Maxi- mum.	Mini- mum.	Mean.	Total for month in acre-feet.	Depth in inches.	Second- feet per square mile.
September.....	70	45	50	2,975	0.08	0.07	May.....	1,040	355	777	47,785	1.34	1.15
October.....	70	50	62	3,813	0.11	0.09	June.....	355	110	205	12,197	0.34	0.31
November.....	70	45	53	3,153	0.09	0.08	July.....	590	82	114	7,011	0.20	0.17
December.....	70	50	67	4,120	0.12	0.10	August.....	82	50	64	3,337	0.11	0.10
1890.													
January.....	230	50	68	4,182	0.12	0.10	September.....	95	50	63	3,748	0.10	0.09
February.....	95	50	76	4,218	0.12	0.11	October.....	95	50	64	3,036	0.11	0.10
March.....	355	50	143	8,794	0.25	0.21	November.....	50	50	50	2,975	0.08	0.07
April.....	770	150	387	23,026	0.64	0.58	December 1 to 13.....	50	50	50	3,075	0.09	0.07
							Per annum.....	1,040	50	172	124,784	3.50	0.25

canyons in the Wasatch range and uniting shortly after. The principal agricultural land is adjacent to these rivers, between the foot of the Wasatch mountains and Great Salt lake. In addition to this there is a large open valley on the head waters of Ogden river, being thus on the east side of the range. The quantity of water from these rivers, although large, has not proved to be sufficient for all of the land under cultivation. In the latter part of June need of more water is felt and in July and August there is often loss of crop. A number of large canals have been built from one or the other of the rivers, but most of these large systems have rights secondary to those of smaller claimants, and it thus has happened that, as in 1889, injunctions were obtained restraining one or more of these large canals from taking any water from the river. This has resulted in great loss to the farming communities not only by the injury to crops and trees but also in legal expenses. The amount of water flowing in these two rivers has been computed from measurements made by the United States Geological Survey. (a)

a The gauging station of the Ogden river was in the canyon near the powder mills above the city of Ogden and gave the total discharge of the stream. The results are shown in the following table:

DISCHARGE OF OGDEN RIVER AT POWDER MILLS, UTAH.

(Drainage area, 360 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.		MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maxi-mum.	Mini-mum.	Mean.		Depth in inches.	Second-foot per square mile.		Maxi-mum.	Mini-mum.	Mean.		Depth in inches.	Second-foot per square mile.
1889.							1890.						
August 9 to 31.....	60	40	50	3,075	0.16	0.14	May.....	2,178	1,475	1,818	111,807	5.82	5.05
September.....	70	50	52	3,094	0.16	0.14	June.....	1,433	624	910	54,145	2.82	2.53
October.....	145	70	89	5,473	0.28	0.24	July.....	624	326	459	28,167	1.47	1.27
November.....	253	60	105	6,247	0.33	0.29	August.....	473	215	312	19,188	1.00	0.86
December.....	735	145	421	25,891	1.35	1.17	September.....	235	195	206	12,257	0.64	0.57
1890.							October.....						
January.....	510	289	382	23,493	1.22	1.06	November.....	267	235	253	15,172	0.79	0.71
February.....	1,364	399	680	37,740	1.97	1.89	December.....			*240	14,763	0.77	0.67
March.....	1,401	362	978	60,147	3.13	2.72	Per annum.....	2,178	195	663	479,388	24.97	1.84
April.....	1,919	1,068	1,449	86,215	4.49	4.02							

* Estimated.

The gauging station on Weber river was above the railroad station of Uinta, about 10 miles southeasterly from Ogden. The results of the measurements are shown in the following table:

DISCHARGE OF WEBER RIVER IN CANYON ABOVE UINTA, UTAH.

(Drainage area, 1,600 square miles.)

MONTHS.	DISCHARGE IN SECOND-FEET.			Total for month in acre-feet.	RUN-OFF.		MONTHS.	DISCHARGE IN SECOND FEET.			Total for month in acre-feet.	RUN-OFF.	
	Maxi-mum.	Mini-mum.	Mean.		Depth in inches.	Second-foot per square mile.		Maxi-mum.	Mini-mum.	Mean.		Depth in inches.	Second-foot per square mile.
1889.							1891.						
October 13 to 31....	290	130	181	11,131	0.13	0.11	June.....	2,225	1,133	1,621	96,440	1.13	1.01
November.....	290	160	208	12,376	0.14	0.12	July.....	1,265	395	844	51,996	0.61	0.53
December.....	815	200	430	26,445	0.31	0.27	August.....	520	240	338	20,787	0.24	0.21
1890.							September.....						
January.....	815	290	457	28,105	0.33	0.29	October.....	520	290	402	23,919	0.28	0.25
February.....	1,400	200	547	30,358	0.36	0.34	November.....	665	520	599	36,838	0.43	0.38
March.....	2,130	200	1,091	67,096	0.70	0.68	December.....	665	520	534	34,663	0.40	0.36
April.....	4,280	970	2,184	129,948	1.52	1.36	Per annum.....	4,653	240	880	638,109	7.40	0.55
May.....	5,465	3,470	4,528	278,473	3.26	2.83	1892.						
June.....	3,635	1,220	2,017	120,011	1.41	1.27	January.....	890	520	599	36,838	0.43	0.37
July.....	1,220	290	549	33,769	0.40	0.34	February.....	890	520	695	39,962	0.47	0.43
August.....	450	200	280	17,220	0.20	0.18	March.....	1,220	590	800	49,200	0.58	0.50
September.....	290	2,400	265	15,707	0.18	0.17	April.....	1,220	450	900	53,550	0.63	0.56
October.....	450	200	331	20,356	0.22	0.21	May.....	5,755	590	2,705	166,357	1.95	1.69
November.....	340	290	298	17,731	0.21	0.19	June.....	4,530	2,035	2,867	170,586	2.00	1.79
December.....	340	240	290	17,835	0.21	0.18	July.....	2,035	160	819	50,368	0.59	0.51
Per annum.....	5,465	200	1,070	776,662	9.09	0.67	August.....	160	100	239	14,698	0.17	0.15
1891.							September.....						
January.....	450	290	303	18,634	0.23	0.19	October.....	290	200	240	14,760	0.17	0.15
February.....	1,220	290	461	23,589	0.30	0.29	November.....	450	290	357	21,241	0.25	0.22
March.....	1,220	450	625	38,437	0.45	0.39	December.....	890	395	476	29,274	0.34	0.30
April.....	2,420	520	1,502	89,369	1.05	0.94	Per annum.....	5,755	100	907	657,960	7.71	0.57
May.....	4,653	1,940	2,752	169,250	1.98	1.72							

WASHINGTON.

[THIRTEEN EASTERN COUNTIES ONLY.]

Total population (average per square mile 3.56)	116, 889
Number of farms (9.15 per cent of population).....	10, 692
Number of irrigators (9.78 per cent of farm owners, 0.89 per cent of population).....	1, 046
Area (32,812 square miles)	21, 018, 880
Area irrigated in census year	48, 799
Area of all farms, 49.90 per cent improved.....	2, 921, 759
Cereals raised in census year, including 1,449 acres in rye.....	460, 082
Barley, average production, 24.51 bushels per acre	50, 871
Corn, average production, 16.32 bushels per acre	9, 320
Oats, average production, 24.94 bushels per acre	38, 541
Wheat, average production, 17.04 bushels per acre.....	359, 901
Alfalfa	2, 924
Total value of all farms, including land, fences, and buildings	\$44, 016, 920
Estimated total value of the farms irrigated in whole or in part.....	\$2, 440, 000
Estimated value of all farm productions (sold, consumed, or on hand) for 1889	\$8, 386, 100
Estimated value of productions, as above, from farms irrigated in whole or in part.....	\$834, 000
Average size of irrigated farms	47
Average size of irrigated farms of 160 acres and upward.....	324
Per cent of acreage of irrigated farms of 160 acres and upward to total acreage irrigated.....	34. 54
Average size of irrigated farms under 160 acres.....	32
Average first cost of water right per acre	\$1. 03
Average annual cost of water per acre.....	\$0. 75
Average first cost per acre of preparation for cultivation.....	\$10. 27
Average value of irrigated land, including buildings, etc., in June, 1890, per acre	\$50. 00
Average annual value of products per acre in 1889.....	\$17. 09

As in the case of Oregon, the eastern counties of the state in which irrigation is practiced are grouped together and used under the name of the state in making the comparisons of the condition of irrigation in the census year. In number of irrigators this state stood at the foot of the list, having a few less than the territory of Arizona, and also had the smallest acreage of the 11 states and territories described. In value of lands irrigated the state occupied an intermediate position, while in average value of products it stood high, as should follow from the relatively small average size of irrigated farms. A considerable portion of the land was devoted to fruit culture, and as a whole irrigation, being in its experimental stages, was conducted with perhaps more care than in the adjoining states. The proportion of land owned by irrigators which was actually watered was small, only 17 per cent, so that the acreage cultivated in this manner could be greatly increased without adding to the number of persons using water. The first and annual cost for water was exceedingly small, in this respect the state coming next to Wyoming.

GENERAL DESCRIPTION.

The state of Washington, at least in its southern half, is similar to Oregon in climate and topography. The most conspicuous feature of surface relief is the Cascade range, which trends in a direction a little east of north across the state and at a distance of from 120 to 150 miles from the ocean. This range divides the state into two great parts, differing in climate and agricultural capabilities. On the western side of the range the annual precipitation is heavy and a dense forest covers the mountains and smaller hills, while east of the mountains the rainfall is much less and vegetation is comparatively scanty.

The great plains of the Columbia form the most striking topographic feature. These extend from the foothills of the Cascade range eastward to the mountains of Idaho, and from the mountainous or broken region below the border of British Columbia southward across the state. The Columbia river coming from the British possessions flows in a direction a little west of south until it has fairly entered the plain or plateau region, where it is diverted sharply toward the west, and with many meanderings it flows for some distance in the latter direction, then bends toward the south and southeast, describing roughly a half circle around the greater part of these high plains. Throughout this distance the river has cut for itself a deep gorge, in which it flows from 1,000 to 2,000 feet below the general level.

These plains owe their existence, in part at least, to extensive sheets of lava, which in former times flowed out over portions of southern Idaho, eastern Oregon, and Washington, filling pre-existing valleys and burying the older sedimentary beds. These sheets of basaltic rocks now stretch from the Cascade range away to the eastward and southeastward to the limiting mountain ranges which lie to the west of the Rockies. The surface features to a large extent have been modified by deformation and erosion of the rocks, and also by the sedimentation in lakes of comparatively recent geologic time, some of which lakes have been of large area. In many places the basaltic rocks are deeply carved by former drainage channels known as "coulees," having steep, almost vertical walls of several hundred feet in depth. The bottoms of these coulees, however, are far above the level of the Columbia, to which stream their relation is not yet evident. Much of the drainage on the surface of the plains is of the lost river type; that is to say, the streams flow into some small lake or swamp from which the water is lost by evaporation or disappears by percolation or by channels through or between layers of the basaltic rocks.

The water supply of the plains of the Columbia is exceedingly small. In the river itself there is an amount sufficient for all the needs of irrigation should it be possible or desirable to introduce it, but unfortunately the river is hundreds of feet below the level of the arable land and its waters can be taken out only upon a very narrow strip of sandy bottoms. The estimated summer discharge of the river at a point above its junction with the Snake is a little under 60,000 second-feet, carrying at least twelve times as much water as the Missouri river in Montana. Fortunately crops can be raised without irrigation nearly every year over a great part of these plains. Wheat is the staple crop, and when planted in the fall with the ground properly cultivated it yields heavily, the rains of winter and spring furnishing sufficient moisture to bring it to maturity. Wherever there is an available water supply, however, the farmers have begun to make use of it for irrigation in a small way, especially for watering such plants as are injured by the long summer droughts. Vegetables, fruit and shade trees, and the hay crops are thus irrigated wherever possible, and although the farmer can be successful by dependence upon the rainfall, yet it is slowly being recognized that the greatest prosperity can come only by a thorough employment of the available waters of the region.

The greater part of the irrigation of Washington is being done on the eastern edge of the Columbia plains or well within the foothills of the Cascade range in Kittitas and Yakima counties. Here the rainfall is probably less than it is farther to the east on the plains, but, on the other hand, the water supply is large and conveniently located. In short, there is no other portion of Washington which enjoys such facilities for the bringing out of water upon large bodies of fertile land. The rivers have not cut their channels into the late sedimentary deposits to a depth so great as to render it a matter of difficulty to divert water, and coming from high mountains they carry during the summer comparatively large amounts of water, thus rendering possible the construction of canals covering hundreds or thousands of acres of fertile land.

WATER SUPPLY AND PRECIPITATION.

Besides the rivers which flow from the eastern slopes of the Cascade range into the Columbia, the other streams important in irrigation are those flowing from the Blue mountains in the northeastern corner of Oregon, the principal of these forming the Wallawalla river. Northerly from this system of drainage and on the other side of the Snake are rivers and creeks flowing from the mountains of Idaho in a general westerly course and uniting in the Palouse or the Spokane river. These waters are comparatively little used, partly on account of the character of the topography, but mainly from the fact that irrigation is not considered essential. The floods in all these rivers occur early in the season, the rivers draining the lower foothills having their maximum discharge in March or April, while those from the more elevated mountains reach their highest point in May or June.

The Columbia river, as shown by the diagram of river heights published in the annual report of the chief of engineers, United States army, for 1889, page 2551, as a rule increases gradually in discharge through February, March, April, and May reaching its maximum in June. It then declines rapidly through July, August, September, and October, reaching its minimum in November or December. It is probable that the floods in the main river occur later in the season than those in the smaller tributaries from which water is taken for irrigation.

The average amount discharged by the Columbia river has not been ascertained, although a few measurements, mainly at low water, have been made. At Vancouver, just above the mouth of the Willamette, the low water discharge, as estimated by Major Thomas H. Hanbury, corps of engineers, was approximately 77,000 second-feet, while at a point above the Snake, as previously stated, the probable summer discharge has been placed at 60,000 second-feet. In comparison with this may be quoted the low water discharge of the Willamette, 15,000 second feet. the highest known flood of this latter stream, that of February, 1890, reaching probably 400,000 second-feet.

There are comparatively few stations east of the Cascade range at which the rainfall has been measured for a number of years. At Pleasant Grove and Ellensburg, in Kittitas county, the results of measurements continued a little over 2 years, as shown by the records of the signal office, give an annual precipitation of a trifle less than 10 inches, and at Fort Simcoe, in Yakima county, about 50 miles southerly from Ellensburg, the rainfall for 2 years averaged 10.6 inches. At Kennewick, near the mouth of the Yakima river, the mean rainfall for 3 years was 9.8 inches, and about 25 miles south of this point, at Umatilla, Oregon, the mean rainfall for 5 years was 9.8 inches.

Farther to the east, at Wallawalla, on the river of the same name, the average rainfall for over 4 years was 16.2 inches, and at the fort south of the city the mean for 15 years was 17.0 inches. The elevation of Wallawalla is given at 930 feet above sea level.

Going easterly from the Columbia river toward the higher mountainous region of Idaho the amount of rainfall increases. For example, at Dayton, in Columbia county, where the elevation is approximately 1,600 feet, the average rainfall as obtained by 6 years' observation was 26.7 inches. At Pomeroy, in Garfield county, where the elevation is 1,900 feet, 2 years' observation of rainfall gave an average of 20.3 inches. At Colfax, in Whitman county, where the elevation is 1,974 feet, the average rainfall for 2 years was 26.1 inches.

This increase of rainfall from the plains region toward the mountains at the east is shown also in the case of the records at Fort Spokane and those at the city of Spokane. In the first instance, that at the fort, which is near the junction of the Spokane and Columbia rivers, at an elevation of 1,600 feet, the average rainfall for 7 years was 12.4 inches, while at Spokane, 50 miles farther east, and at an elevation of 1,910 feet, the mean annual rainfall for 9 years was 19.1 inches. Farther to the north, at Fort Colville, in Stevens county, the rainfall for 18 years averaged 17.2 inches. In comparison with the precipitation in eastern Washington may be noted that on the coast, where at one point the average has been upward of 110 inches per annum, the maximum being over 130 inches.

The distribution of precipitation by months has been obtained by compiling the records of the signal office relating to the principal rainfall stations of eastern Washington. The greatest amount of rain usually falls in January and the least in August, the amount increasing rapidly through the fall. Taking the mean of all the stations of eastern Washington at which observations have been continued for several years, it appears that in January there fell 16.0 per cent of the total precipitation of the year; in February, 13.0 per cent; in March, 7.4; April, 7.0; May, 7.0; June, 6.3; July, 3.7; August, 2.0; September, 5.0; October, 8.3; November, 9.3, and in December, 15.0 per cent. In December, January, and February 44.0 per cent of the total annual rainfall fell, while in July, August, and September only 10.7 per cent was precipitated.

Comparing the discharge of the rivers with the precipitation as regards distribution through the year, it is apparent that while the quantity of rain steadily diminishes from January until August the amount of water available, on the contrary, rapidly increases to May or June, and then falls off, the minimum river flow occurring a month or more after the time of least precipitation, both of these increasing toward winter.

The climate of the state has been discussed in publications prepared under the direction of the chief signal officer, one of these written in 1885 by Lieutenant Frank Green being a report on the interior wheat lands of Oregon and Washington. A second report by General A. W. Greely, on the climate of Oregon and Washington territory, printed in 1889, gives tables and diagrams illustrating the precipitation and temperature. Mention should also be made of the report by Lieutenant Thomas W. Symons of an examination of the upper Columbia river and the territory in its vicinity in September and October, 1881, and published in 1882. Briefly stated, it may be said that the climate of Washington is mild, the fluctuations of temperature being within relatively narrow limits. The winters are short and seldom severe except in the Big Bend country. The chief drawbacks are the long dry summer and the prevalence of winds, especially throughout the level country.

IRRIGATION DEVELOPMENT.

From what has already been stated it will be apparent that the relation of irrigation to agriculture in Washington is determined largely by convenience and the question of expense; that is to say, in eastern Washington agriculture is fairly successful in nearly every county without the artificial application of water, but wherever water can be obtained at moderate expense irrigation has been introduced, and the results obtained by this method of agriculture have demonstrated its value. On the other hand, where water can not be obtained the farmers claim that irrigation is unnecessary and seem to be content with the ordinary methods of farming, although it is apparent that many crops can not survive the scanty rainfall of summer combined with the effect of the almost ceaseless winds.

In most counties irrigation is still in the experimental stage, being used to tide over an occasional drought, and even in western Washington flooding of the lands is occasionally resorted to in order to increase the forage crops. For example, in Cowlitz and Skamania counties some of the smaller streams have been dammed in order to create artificial marshes, and even in Chehalis county the yield has been doubled by summer irrigation. One fact tending to retard the development of irrigation is the low selling value of cereals, together with the high rates of transportation. It obviously will not pay to irrigate lands to raise wheat when the farmers who are producing it in large quantities without irrigation can barely live.

There is a common saying among the inhabitants of eastern Washington that the bunch grass land, that is, the areas on which the rich, nutritious bunch grass grows, does not require irrigation. Wherever this flourishes wheat can be raised by proper cultivation. The bunch grass, which has the valuable property of self-curing or becoming a natural hay during the droughts of summer, is one of the most valuable of forage plants, and is so highly regarded that its name has become a synonym for anything valuable or prosperous. On the contrary, the lands on which the sagebrush grows, although having a rich soil, are too dry for cultivation without watering, and sagebrush land without water supply conveys ideas of worthlessness and poverty.

The methods of irrigation do not differ materially from those used elsewhere, the general practice being to flood the lands on which hay or cereals are raised, or to conduct the water through small furrows between rows of vegetables, corn, or other plants. Occasionally more systematic measures are used, as, for example, having the ground leveled and provided with low ridges of earth or checks by which the water is retained at a uniform depth over the inclosed area. The size of the space within the checks is regulated by the slope of the land, the more nearly level the larger the space. In one case the checks inclosed upward of 5 acres, and an irrigating stream was used sufficiently large to cover this ground in 2.5 hours. When one area is full, the water, unless the ground is very dry, is drawn off into the next area inclosed by checks, other water being run in at the same time by means of the small lateral ditches.

ARTESIAN WELLS.

Small artesian areas have been discovered near the eastern side of the plateau region, and also toward the western edge, not far from the foot of the Cascade mountains. Those on the east are at Pullman, in Whitman county, and near Latah, in Spokane county. At Pullman there are reported to be 8 wells from 70 to 180 feet in depth, 3 to 5 inches in diameter, and discharging on an average about 100 gallons per minute. The wells were put down for town supply, and none of the water has been used for irrigation, since there is usually an abundant rainfall. About 10 miles east of this locality are the flowing wells at Moscow, in Latah county, Idaho. In the Moxee valley, in Yakima county, two flowing wells are reported. Southeasterly from this point, near Pasco, in Franklin county, a well has been drilled to the depth of 527 feet without success. Attempts have been made in various parts of the state to obtain flowing water, but so far as can be ascertained they have been failures. At Tacoma the deep wells, although obtaining an ample supply of water, do not flow.

A geological reconnaissance by Israel C. Russell, of the United States Geological Survey, for the purpose of obtaining information as to the probable extent of artesian conditions in the counties of Yakima, Kittitas, and Douglas, confirmed the view that the geological structure of those counties is in general unfavorable to the hope of obtaining artesian waters. As described by him and by other writers, this country, together with the rest of central Washington, is underlain by a thick sheet of lava, composed of many layers, above which are heavy deposits of clay, sand, and volcanic dust. These two great formations were originally horizontal, but now are broken by many lines of fracture, blocks being tilted in various directions, their edges forming mountain ranges. Thus it is evident that there can not be a broad artesian basin extending from the Cascade to the Rocky mountains.

In a very few localities the strata have been upturned in such a manner as to form small basins, but even these have sometimes been broken or cut by drainage channels, destroying what might otherwise have been conditions favorable for small artesian wells. The most notable case where the artesian character is found is in the Moxee valley, where successful wells have already been obtained. In the eastern part of the Yakima Indian reservation also, as Mr. Russell points out, the facts seem to show that flowing water may be obtained. In the remainder of the region examined he does not consider that farther expense in drilling wells is warranted.

CONDITION OF IRRIGATION IN EACH COUNTY.

NUMBER OF IRRIGATORS, AREA IRRIGATED, FARMS, AND CROPS, IN EACH COUNTY IN WASHINGTON IN 1889.

COUNTIES.	Number of irrigators.	Area irrigated in acres.	Average size of irrigated farms in acres.	OWNERS OF FARMS. (a)		IRRIGATORS.			Area of counties in acres.	FARM AREA.				AREA IRRIGATED.			Average value of products per acre.
				Total number.	Per cent of population.	Per cent of farm owners.	Per cent of population.	Acres.		Per cent improved.	Cereals. (Acres.)	Alfalfa. (Acres.)	Per cent of area of county.	Per cent of total farm area.	Per cent of land owned by irrigators.		
Total.....	1,046	48,799	47	10,692	9.15	9.78	0.89	21,018,880	2,921,759	40.90	160,082	2,924	0.23	1.07	17.00	\$17.09	
Asotin.....	32	320	10	250	15.82	12.80	2.03	409,600	71,354	61.42	5,738	.....	0.08	0.45	3.66	37.50
Columbia.....	15	139	9	722	10.76	2.08	0.22	552,900	225,525	64.09	53,831	171	0.03	0.06	4.31	30.80	
Douglas.....	34	1,016	30	398	12.59	8.54	1.08	2,013,280	85,295	22.66	2,052	13	0.03	1.19	6.45	25.60	
Franklin.....	3	44	15	30	4.31	10.00	0.43	796,160	7,095	18.50	.....	9	0.01	0.02	4.86	8.50
Garfield.....	24	220	10	586	15.04	4.10	0.62	430,080	188,393	52.73	39,076	186	0.05	0.12	2.37	15.80	
Kittitas.....	350	25,212	72	497	5.66	70.42	3.99	2,140,160	122,216	38.97	5,286	252	1.18	20.63	26.77	16.60	
Klickitat.....	71	1,702	24	671	12.90	10.58	1.37	1,362,640	191,090	32.36	16,904	58	0.12	0.89	11.34	20.25	
Lincoln.....	12	238	20	1,327	14.25	0.80	0.13	1,469,440	402,270	47.78	37,113	6	0.02	0.06	11.13	20.80	
Spokane.....	3	80	27	2,132	5.69	0.14	0.01	1,075,200	441,602	34.71	46,681	1	0.01	0.02	6.46	.....
Stevens.....	66	1,350	20	488	11.24	13.52	1.52	3,964,160	82,316	25.52	2,686	2	0.03	1.64	11.41	18.30	
Walla Walla.....	121	2,809	23	850	6.95	14.24	0.99	829,440	344,222	77.98	108,168	1,161	6.34	0.82	7.97	36.90	
Whitman.....	22	531	24	2,351	12.30	6.94	0.12	1,359,300	672,878	56.27	138,895	49	0.04	0.08	5.59	20.70	
Yakima.....	293	15,129	52	390	8.81	75.13	6.62	3,686,400	92,443	31.69	3,052	1,069	0.41	16.37	19.03	17.80	

a Includes owned and hired farms, assuming one farmer to each.

ADAMS COUNTY is a little east of the center of Washington, comprising a portion of the high plains or prairie partially surrounded by the great bend of the Columbia. No irrigation has been practiced in this county on account of the difficulty of obtaining water. The soil is rich, and in spite of the summer droughts retains sufficient moisture to enable wheat, rye, oats, and barley to mature. It is reported, however, that corn is not always successful.

The county has been settled but a few years, and the principal occupation is wheat raising. Difficulty is experienced in obtaining sufficient water for domestic purposes, and frequently it must be brought a distance of 4 or 5 miles. Wells are sunk usually to a depth of from 100 to 200 feet, occasionally without success. It is probable that in future a small amount of irrigation will be introduced by the use of the water of the Palouse river, which flows along the southeastern corner of the county, or by the storing of some of the flood waters of early spring.

ASOTIN COUNTY is in the southeastern corner of Washington, adjoining Wallowa county, Oregon, and separated from Nez Perces county, Idaho, by the Snake river. It comprises a portion of the high plateau country between the Blue mountains and the deep gorges of that stream. The Grande Ronde river enters the southern part and flows easterly into the Snake, and to the north of this are a number of smaller streams flowing from the mountains in the same general direction. All these streams are bordered by precipitous walls, rising in places to a height of several hundred and even a thousand feet.

The surface of the high divides between the streams is usually nearly level, and is covered by a rich soil, which, with an abundant rainfall, produces heavy crops. In 1885 there is reported to have been an unusual amount of precipitation. Large crops were raised and settlers flocked in. After that time there was a succession of years during which the rain apparently diminished in quantity. The crops were scanty, so much so that many of the settlers were compelled to seek homes elsewhere. In many localities the population in the census year is alleged to have been one-third less than it was 4 years before, and the production of wheat fell in one instance from 30 bushels per acre to about 12. The principal industry at present is stock raising, the cattle depending almost entirely upon the native bunch grass, which is about the only forage plant adapted to the dry climate.

A little irrigation is practiced on the bottom lands bordering the Snake river and Asotin creek, water being brought to the small level areas by ditches from side streams wherever practicable. Great difficulty is experienced in taking water from the river, as the topography is such that ditches can not readily be built. In a few cases pumps have been tried, and 3 pulsometers have been in use. The cost of a pumping plant capable of delivering 300 gallons per minute, or 0.66 of a second-foot, to a height of 60 feet is reported to be \$1,000. The expense of operating this is \$6 per day of 10 hours, this representing the cost of wood for fuel and the wages of one man. At the rate given a pump would deliver nearly one-half acre-foot of water per day, and thus an acre-foot would cost over \$12. The water must evidently be used with very great care and a high duty obtained in order to make this profitable.

Another method of raising water to the top of the steep banks along the Snake is by means of waterwheels driven by the current. These are usually modifications of the ancient Egyptian noria, an undershot waterwheel carrying buckets upon its rim. A new device lately introduced consists of a wheel mounted upon a boat or raft securely fastened to the bank. This carries a tower 60 feet in height, to the top of which extends an endless belt carrying elevator scoops. The current drives the water wheel, and this in turn causes the scoops to carry water to the top of the tower, where it is discharged into a pipe leading down the tower, out to the shore, and up the bank nearly to the level of the top of the tower, where the pipe empties into a ditch.

COLUMBIA COUNTY is in southeastern Washington, extending in a narrow strip from the Snake river southward over the summits of the Blue mountains to the Oregon line. It is similar in topography and climate to Asotin county, from which it is separated by the narrow area of Garfield county. As in the case of those localities, wheat and other cereals and fruits are raised on the high rolling plateaus or hill lands, at elevations of from 1,500 to 3,000 feet. As a rule the higher grounds receive or retain more moisture than the lower, and crops are generally successful on them. In 1888, 1889, and 1890 the crops were lighter than usual, owing to the deficiency of rainfall.

The streams rising in the Blue mountains flow for a short distance northerly and then unite to form the Touchet river, whose general direction for a time is west, parallel with the Snake. After entering Wallawalla county it turns southward and empties into Wallawalla river, a tributary of the Snake. All these streams, like those of Asotin county, have cut deep gorges, rivaling that in which the Snake river flows. In the bottoms of these gorges are narrow strips of land, the soil of which requires irrigation in order to support plant life during the summer. With plenty of moisture the yield of fruit, alfalfa, and grasses for forage is very large, and farmers have been induced to attempt irrigation wherever practicable. The ditches are small, serving merely to irrigate a few acres of the bottom lands along the stream.

DOUGLAS COUNTY is a trifle east of the center of Washington and comprises a large part of the area known as the Big Bend country. It is bounded on the north, west, and partly on the south by the Columbia river, which, as before stated, describes roughly a great semicircle in this part of the state, cutting deeply into the high plain or plateau formed by the lava sheets which cover eastern Oregon and Washington. The surface of the county as a whole falls gradually from north to south, and is deeply cut by steep walled ravines, or coulees, as these are locally known. Of these Grand and Moses coulees are the most important, both traversing the northern half of

the county diagonally from northeast to southwest. The former begins on the Columbia near the east line of the county and continues for about 55 miles toward Badger mountains. The walls of this chasm are, according to the report of Lieutenant Symons, about 350 feet high, and are nearly perpendicular, being broken down in only one place about half way of its length. At some places the coulee reaches a width of nearly 4 miles and in others becomes quite narrow. The nearly level bottom is about 1,000 feet above the Columbia river. The soil in many places is rich, but crops can not be produced without irrigation.

Moses coulee is from 12 to 15 miles west of Grand coulee and lies nearly parallel with it. Between the two is high land with rich soil, producing good crops wherever cultivated. The difficulty of procuring water for stock and domestic purposes has, however, retarded the settlement of this area. West of Moses coulee and between it and Columbia river is another area of high land, on which are most of the farms of the county. This is well adapted for agriculture in every respect save that of water supply. On these high grounds crops are less liable to be injured by frosts than on the lower lands, and there is probably a greater amount of moisture in the soil, so that wheat, oats, rye, and barley, and even some fruit trees, thrive and produce abundantly. The early settlers tried the low lands first from the supposed better facilities for water, but soon discovered the greater natural advantages of the higher grounds, both in possessing more moisture and in freedom from alkali. In many cases, however, they are compelled to bring water for long distances for household use during the summer. All the higher lands are farmed without irrigation, but on the low lands, both along the Columbia river and in the coulees, owing to the intense heat of summer nothing can be raised unless watered. As yet the county is sparsely settled, few farmers having been there for more than 5 years, and the water facilities have been so poor that irrigation has made little progress. There are few creeks in the county, and these, like the Columbia river, flow in deep gorges, so that their waters can be used only on the fringing bottom lands.

The southern half of the county is lower and less fertile, having almost the character of a desert. Apparently the droughts are too severe for the cultivation of cereals, and the pasturage is comparatively poor. There are low lands along the Columbia near and below Priest Rapids, the river having left its canyons, 2,000 feet or more in depth, and the banks being so low water can possibly be taken out for irrigation. There is already a project on foot to construct a canal heading in the mouth of the canyon and bringing out water upon the low lands near Priest Rapids and in the extreme southern end of Douglas county, the canals possibly extending into Franklin county. Such projects will require the expenditure of great capital, and it is still questionable whether the profits will be sufficiently great to induce any persons or corporations to undertake the work. Wherever these lands can be brought under irrigation, either by water from the river or from some spring or small stream, the yield of the various crops is enormous, and it has been found that all the grains and fruits reach a high degree of excellence. The county is described as largely a sagebrush desert of little present value and where water can not be had for irrigation. In the vicinity of the thriving town of Waterville and along the border of Lincoln county the rainfall is usually sufficient for the production of a somewhat light crop of wheat. The rocks of the county are mainly basalt, having a thickness of about 2,000 feet. Beneath these lavas the rocks are much disturbed and deeply eroded, and the basin structure necessary to secure an artesian flow apparently does not exist.

FRANKLIN COUNTY is southeast of Douglas and south of Adams county, comprising that portion of the high plain of the Columbia north of and near the junction with the Snake river. It is in most respects similar in topography to the rest of the country within the great bend of the Columbia. As in the whole of this area, the cereals where raised are produced without irrigation, this latter method of agriculture being used only in the case of a few orchards on low ground. A project has been set on foot for irrigating some of the land along the Columbia by taking water from the Snake river a short distance above its mouth and bringing it by ditch to the vicinity of Pasco. It will be necessary to raise the water from the Snake river by machinery, and so far as can be ascertained the success of such a project is not yet assured.

GARFIELD COUNTY is in southeastern Washington, south of the Snake river, and between Asotin and Columbia counties. It consists principally of a high, deeply eroded plateau, around which the Snake flows almost in a semicircle, thus bounding it on the east and north. Toward the south the county extends in a narrow strip from 6 to 10 miles wide over the crest of the Blue mountains to the state line of Oregon. A number of small streams issue from this mountain area and flow outward to the Snake river. The principal of these are Alpowa, Deadman, Pataha, and Tokanon creeks, each of which flows in a deep gorge or canyon for the greater part of its course.

On the high and comparatively level lands wheat, rye, oats, and barley are raised successfully 3 or 4 years out of 5. Occasionally the drought proves too severe, and the farmers meet with losses and discouragements. Irrigation is carried on to a small extent on the narrow strips of land, from 100 to 300 feet wide, bordering the creeks just mentioned, and also on the small sandy bottoms or "bars" in the gorge of the Snake river. The success of peaches, plums, pears, apricots, grapes, and small fruits in these localities is wonderful, as the insect enemies of orchards and vineyards have not yet penetrated these regions. Water is diverted to the orchards and gardens in these places by means of small ditches from springs or from the stream itself. Along the Snake river a little water is raised to the sandy low lands by the use of pulsmeters, thus irrigating a few valuable orchards.

There is little probability that water can ever be brought out upon the wheat lands, as the streams are from 100 to 1,500 feet below the general level. The soil of these lands usually retains moisture to a remarkable degree, and if there is a heavy fall of snow during the winter the farmers' success is assured. Water for domestic purposes is usually obtained from wells from 10 to 50 feet in depth, although in some localities the farmers have found it necessary to haul water for several miles. Irrigation is being practiced wherever water is accessible, and the present supply is nearly all utilized. The largest of the creeks mentioned, and probably the only one having a surplus of water, is the Tokanon, the others, particularly Deadman and Pataha, discharging in summer, it is said, only sufficient to supply water for stock and domestic purposes.

KITTITAS COUNTY is in the central part of Washington, east of the Cascade mountains, extending from the summits of that range in a general southeasterly direction to the Columbia river. It is bounded on the north by the Wenatchee river and on the south contains the head waters of the Yakima river, which flows southerly into Yakima county. Among the mountains at the head waters of these streams are numerous beautiful lakes several miles in length. These tend to equalize the flow of water in the streams and thus increase the summer discharge.

The principal agricultural area within this county is in the Kittitas valley, near the center of which is the town of Ellensburg. This valley is 10 miles or more in width and 18 miles long. It is bounded on the north and west by mountains containing deposits of valuable minerals and covered with timber. Within the valley little, if anything, can be raised without irrigation, as the precipitation during the summer months is very small and the winds which prevail tend to promote rapid evaporation. As pointed out by Mr. Russell, this valley is so situated in reference to the Yakima river and to the creeks coming from its mountain borders that nearly all of its lower land can be irrigated. There are excellent sites for storage reservoirs among the mountains and foothills, water to fill which can be obtained from the numerous creeks. The valley is on the edge of the high, somewhat humid region along the foot of the Cascade mountains, and on the uplands is a most excellent pasturage. To the east, however, the lands extending to the Columbia are more arid and the vegetation is scanty.

Water for irrigation is taken from the Yakima river or from small tributaries of that stream. In the case of the river itself there is a supply of water sufficient for all demands now made upon it. The smaller streams, however, do not furnish an abundance during the summer, but there is such scarcity that only a portion of the crops cultivated can be thoroughly irrigated, and it often becomes necessary to cut some of them for hay. Some of the farmers propose to increase the summer flow of the creeks by the construction of reservoirs in the mountains to hold a portion at least of the flood waters which now run to waste before the beginning of the irrigating season. As a result of the deficiency of the water supply controversies regarding water rights have already arisen, and expensive litigation has been entered upon by many of the farmers, who can ill afford this drain upon their resources. The greater part of the eastern half of the county is composed of broken lands and sagebrush plains, on which crops can rarely be raised without the artificial application of water. There is no visible means of supply for the greater part of this area, and it is difficult to obtain water even for domestic purposes. Near the junction of the Wenatchee with the Columbia a small amount of land is irrigated, principally by means of the waters of springs. It is probable that a portion at least of the lower part of the level lands here can be irrigated by water taken from the Wenatchee or the Pechastin, but the expense of constructing a ditch of the length required is beyond the means of the present inhabitants. Near Ellensburg two wells have been sunk to considerable depth in the hope of obtaining an artesian supply, but as yet without success. In the Kittitas valley the ordinary wells average about 30 feet in depth.

There are many small ditches in this county and a few of large size. Among the smaller ditches may be mentioned First Creek ditch, taking water out of a stream tributary to Swauk creek, which flows into the Yakima east of Teanaway river. This ditch is about 12 miles long and 6 feet wide, and cost probably \$6,000 in all. It is owned by two irrigators, who divide the water equally. In 1889 about 600 acres were irrigated, about 500 acres being in wheat and the remainder in oats and vegetables. Gallaway ditch takes water from Wilson creek and carries it out in a southwesterly direction for about 8 miles. The average width is 5 feet. The ditch was constructed in 1877 by irrigators, who took advantage of an old channel of the stream which extends for a great part of this distance. In 1889, 400 acres were irrigated. Watt ditch takes water out of Manastash creek, which flows into the Yakima from the west side, nearly west of Ellensburg. The water is taken out upon the north side and carried a distance of 6 miles. The ditch is about 5 feet wide and cost probably \$2,000. It is owned by private parties, who divide the water among themselves. The owners of this ditch, as is the case with many other irrigators, have been compelled to enter upon suits at law for the protection of their claims to the water. Bull ditch takes water from the Yakima river near Ellensburg and carries it out on the east side. The length of this ditch is 7 miles, the width about 7 feet, and the cost was \$5,000. It is owned by farmers, who divide the water into tenths and distribute it according to the number of shares or tenths owned by each. In 1889 about 1,000 acres of meadow land and 500 acres of grain were irrigated. In the case of grain the water is turned into plow furrows from 60 to 100 feet apart, but the meadows are generally flooded, the flooding being repeated from two to four times each year.

The principal ditches of the county are those taking water from the Yakima river and carrying it out upon both sides in the vicinity of Ellensburg. The ditch on the east side of the river, owned by the Ellensburg Water

Company, is 25 miles long, 12 feet wide, and cost, for the 17 miles completed in 1890, \$45,000. The owner of a share in this corporation is entitled to one-half miner's inch of water, this being considered sufficient to irrigate an acre. In 1889 about 2,000 acres were irrigated, the crops consisting of wheat, oats, barley, potatoes, and hay. The capacity of the ditch is reported to be 48 second-feet. The supply of water in the river is very large, but the ditch does not carry an amount sufficient for the demands made upon it. Above and north of this ditch is a large area of land which it is proposed to irrigate by the construction of a much larger canal, taking water from a point higher up the stream. The Westside irrigating canal is about 14 miles long and averages about 12 feet wide. It is estimated to cost when completed \$30,000. At usual stages of the river there is no necessity of a dam for diverting the water. The corporation owning this ditch is composed of irrigators who use its water. Work was begun in June, 1889, and water was first used in 1890.

KLICKITAT COUNTY is in southern Washington, lying in a narrow strip along the Columbia river from the Cascade mountains eastward nearly to the mouth of the Snake river. A great part of the county, especially at the eastern end, consists of high plains similar to those on the opposite side of the river, in Umatilla and Morrow counties, Oregon. These plains are deeply cut by canyons, in which, in the springtime at least, small streams are to be found. The western end of the county is higher, being hilly or even mountainous in character. In nearly all parts of the county crops are raised without irrigation, but especially at the eastern end there are occasional failures, owing to a deficiency of rainfall. If there is a heavy fall of snow during the winter and this melts gradually, saturating the ground, the farmers can depend upon an abundant harvest, but if, on the contrary, the snowfall is light or melts rapidly before the ground thaws, the chances of success are reduced.

Irrigation is practiced on the low grounds along the Columbia river mainly for the purpose of raising fruit, and also in depressions known as swales. The water is obtained in nearly all instances from springs, a small amount being pumped by windmills. In the case of the swales the ground is naturally moist, and the irrigation processes, if they may be so called, consist in regulating the supply of water by means of dams, at one time allowing it to flow freely from the springs or at others draining it off when in excess. The principal crop raised in these localities is for forage. These areas, compared with those irrigated for gardens and orchards, are large and swell the total irrigated in the county. There are very few ditches for irrigation, and of these the Cameron ditch may be given as an example. It takes water from White Salmon river, carrying it out upon the west side for a distance of about 4 miles. The width of the ditch averages 6 feet and the cost was \$3,000. It was begun in 1886 and used to a small extent in 1890. The water is diverted from the river at a point where there are two islands, part of the channel between them being obstructed by a log dam. Its course is mainly through land covered with a poor quality of pine timber, which must be cleared before the ground can be cultivated. The ditch has been built by private parties who have not yet been able to bring it to completion. The water supply is ample.

LINCOLN COUNTY is in eastern Washington, north of Adams county, and forms part of the great plains of the Columbia. It is bounded on the north by the Spokane and Columbia rivers. The drainage systems of the county consist of small creeks, a few of which flow northerly into the Spokane or the Columbia. The greater number, however, run in a general southwesterly course, finally uniting to form Crab creek, a stream flowing in a westerly direction through a series of lakes into Douglas county, where the waters finally disappear by evaporation from the surface of Alkali lake. These streams have cut deeply into the surface of the county and flow in canyons or gorges from 100 to 600 feet deep, or even more.

On the high rolling prairie lands of which the greater part of the county is composed nearly all crops of the temperate zone are successfully raised. The soil is very rich and in many years the yield is exceedingly large. The drought of 1889, so disastrous in other parts of the country, diminished the yield, but did not impoverish the farmers. There is usually a heavy fall of snow in winter, which, melting, saturates the ground to a great depth. Apparently the structure of the soil is such that as the dry season comes on some of this moisture returns toward the surface and reaches the roots of the plants. On the low lands along the streams, as, for example, in the narrow valley or gorge of the Columbia river and of Crab creek, crops usually require irrigation. The soil there is somewhat sandy, not retaining water for any great length of time. Springs issue from the walls of these gorges, usually at a depth of from 100 to 200 feet below the general level of the high prairie, and this water can be easily led out to irrigate the small patches of low ground.

From the character of the country and the fact that crops are successful without irrigation, it appears doubtful whether any large system of water supply will ever be introduced. The greater part of the water flows too far below the surface of the ground to be brought out upon the land, and the country is so rolling and broken by canyons that canal construction would be very expensive. The development of irrigation in a small way, however, will doubtless continue, as the benefits derived from this method of agriculture are such as in some places to warrant the expenditure of considerable sums for watering alfalfa, timothy, and other forage crops, as well as fruits and vegetables. At present a large part of the forage is made by cutting wheat and oats, since without irrigation alfalfa is not uniformly successful and frequently does not thrive through the droughts of summer. The water supply for domestic use is good. Wells usually reach water at a depth of from 10 to 30 feet, although in some places it is necessary to drill or bore to a depth of from 100 to 200 feet. So far as can be ascertained, none of this water rises and overflows.

Spokane county is in eastern Washington, adjoining Kootenai county, Idaho. The principal city, Spokane, is the commercial center for eastern Washington and northern Idaho, and the greater part of the business pertaining to the mining and manufacturing interests, as well as to agriculture, is transacted here. The surface of the country is hilly or consists of high rolling prairie lands with a rich soil, producing wonderful crops of cereals. The county is drained by the tributaries of the Spokane river, the outlet of Lake Cœur d'Alène. These streams have deeply eroded the surface and flow at a depth of from 100 to 400 feet below the level of the rolling prairie lands. Irrigation in this county is exceptional, since the rainfall may be considered as abundant for all crops. The only cases in which it is practiced are those in which a water supply was obtained with more than ordinary facility and utilized by men accustomed to that method of farming. Besides the three instances given, there are other cases in which water has been used in a small way for gardens and fruit trees, but these can scarcely be considered as systematic irrigation.

The majority of farmers in this county do not look upon irrigation as feasible or necessary, but there are a few who recognize that by means of an abundant water supply, even when the annual rainfall is large, the yield per acre can be greatly increased and a second or even a third cutting of forage plants obtained. There has been no year in which the crop failures have been particularly serious, although in 1889 the yield was greatly reduced. During the winter there is usually a heavy snowfall, which, melting, saturates the ground in spring, so that all the cereals except perhaps corn reach maturity, the size of the crop being in a rough way proportional to the depth of snow. The dry season begins usually about the first of June, after which there is little rain until late in the fall. There is an ample water supply for domestic purposes, and good wells are usually obtained, the depths being from 10 to 50 feet, or sometimes more. No flowing wells are reported.

Stevens county is in the northeastern corner of the state, bordering upon British Columbia on the north and Kootenai county, Idaho, on the east. From this latter county Clarke fork flows in a westerly direction into Stevens county, then continues northerly to a point 2 or 3 miles beyond the boundary of the United States, then it turns abruptly to the west again and empties into the Columbia, the junction of the two rivers being almost on the boundary line of the British possessions. The Columbia river, entering Washington, continues in a general southerly direction until it reaches the mouth of the Spokane river, which forms a portion of the southern boundary of Stevens county. It then continues westerly in its course around Douglas county.

The portion of Stevens county west of the Columbia river is included within the Colville Indian reservation. East of the river, however, are many farming areas, the greater part of which have been occupied for only a few years. This nearly triangular area, bounded on the west by the Columbia, on the east by Clarke fork, and on the south by the Spokane river, is known as the Colville region. It differs widely in many of its features from the country to the south, this difference being due largely to the absence of the lava sheets which underlie the greater part of the counties to the south, and give them their peculiar topography. The basaltic rocks do not extend north of the Spokane river, but in their place are rocks related to the granites, and instead of the steep cliffs bordering the streams, as in the case of the basaltic areas to the south, are sandy terraces rising gradually from the river bottoms.

A large amount of detailed information concerning this area is made available by the contoured maps and descriptions of the Colville country, prepared by the northern transcontinental survey and published in 1883. As shown by the agricultural map, the Colville valley, with its rich alluvial soil, extends in a general northerly direction through about the center of this area, being continued on the north by Echo valley to the terrace lands of the Columbia, and on the south to the Spokane river by the sandy plateau and terrace lands of Chamokane creek. Throughout this region, especially on the bottom lands, agriculture is generally successful without the aid of irrigation, although many of the farmers have found it of benefit to divert water from the small streams for gardens and trees upon sandy soils. As a general statement it may be said that grasses, fruit and shade trees, as well as corn and vegetables, grow better if irrigated during the long drought of summer. On the bottom lands along the Colville river redtop and timothy hay are the principal products, wheat and oats being raised on the benches and depending for their moisture upon the rains.

The Colville valley is bounded by mountainous areas, the surface of which is too broken for agriculture. To the east, along Clarke fork, in the vicinity of Calispell and southeasterly from that point, are broad bottom lands usually overflowed each year by the spring freshets, so that, as in the case of other valleys along this stream, drainage is sometimes more necessary than irrigation. If the annual overflow does not occur, however, and the hay lands along the river and creek bottoms are not thoroughly wet, the crop is greatly reduced and is sometimes hardly worth cutting. On the western edge of the Colville region, along the banks of the Columbia, is a succession of low terraces, with rich though sandy soil. Here irrigation is generally necessary, although crops have been raised without it. Water is taken from the small creeks which flow into the Columbia and is used for gardens, orchards, and hay lands. It is possible that a canal may be taken out of the Columbia at some time to cover a portion of these terraced lands.

There are very few ditches of any importance in the county, the greater number being less than a mile in length and conducting water from the little creeks, which are found at intervals of from 8 to 10 miles throughout

this mountainous area. One hindrance to the greater development of irrigation is that many of the settlers are still upon unsurveyed land, so that they do not know whether they are making improvements upon land that will eventually be their own or upon land the title to which will be obtained by some other person.

WALLAWALLA COUNTY is in southeastern Washington, south of the Snake river and east of the Columbia, extending from these streams along the Oregon state line nearly to the summits of the Blue mountains. The Touchet river flows west and south nearly through the center of the county, entering the Wallawalla river, whose course is westerly along the southern boundary. The streams flow in deep gorges hundreds of feet below the general level of the uplands. The principal occupation of the people of this county is wheat raising, large crops being produced each year, and especially when the snowfall of the preceding winter is heavy. It is customary to summer fallow the land every third year, and thus, on an average, two-thirds of the farm land is in crop each season. Occasionally a small amount of corn is raised on this summer fallowed land. Beside wheat some barley, oats, and rye are produced, and occasionally potatoes and other vegetables, although in many parts of the county there is not sufficient moisture to make the yield of the latter profitable.

In the northern end of the county, between the Snake and Touchet rivers and in a general way parallel to them, is the high plateau known as Eureka flat. This is from 30 to 40 miles long and about 6 miles wide. The soil is rich, and enormous quantities of wheat are produced each year. The water supply for this area is, however, greatly deficient. The farmers are compelled to procure water for summer use by saving in cisterns the water from melted snow, by purchasing from the railroad company or by hauling from streams at distances of from 5 to 10 miles by means of wooden tanks mounted on stout wagons. It is reported that in 1889 the water filling a 500-gallon tank cost \$4 and that the same quantity in 1890 cost \$2. One farmer writes that in one year it cost him \$50 for water for household use and to supply 4 horses. Water obtained from the railroad cost \$12.50 for 2,500 gallons, with an additional expense of from \$5 to \$8 to bring it from the railroad station.

Efforts have been made to obtain water by drilling, but it has been found very difficult to penetrate the hard basaltic rock. Small pieces are easily dislodged by the drill and wedge it firmly, so that it becomes very difficult and in some cases impossible to withdraw the drilling tools. Wells have been put down to depths of from 300 to 400 feet without obtaining water, the drill having finally stuck fast. In some parts of the county less difficulty is experienced in obtaining water. One well is reported to be 130 feet deep and with 40 feet of water. Irrigation is carried on along the Snake, Columbia, and Wallawalla rivers, and to a less extent along Touchet river, wherever water can be brought out by small ditches, water wheels, or force pumps. Gardens and fruit trees cultivated in this manner prove highly profitable, as the wheat growers on the higher lands raise very few vegetables or fruits, and thus there is little competition and a large demand for this class of produce.

WHITMAN COUNTY is on the eastern edge of Washington, south of Spokane county and north of the Snake river, and includes the greater part of the high rolling lands traversed by the Palouse river. This stream and its tributaries rise in the mountains of northern Idaho and flow westerly into Whitman county, where the river turns toward the south, and forming the southwestern border of the county flows into the Snake. The surface of the country as a whole falls from the mountainous region on the east, sloping in a general way westerly out toward the great plains of the Columbia. It is broken, however, by innumerable hills, rising gently from heights of from 100 to several hundred feet above the valleys. The drainage channels have been deeply carved into this high rolling country, and the streams for the greater part of their course are in deep gorges.

The eastern half of the county has an abundant rainfall, and the yield of crops can rarely be surpassed by that of any other area. The western half, being out toward the plains of the Columbia, is somewhat dryer, and seasons of deficient rainfall prove more serious. Losses are generally prevented by thorough cultivation. The soil of the county is very rich, consisting largely of a deep black loam, and the yield of most of the cereals is extraordinarily great. No irrigation is required, as there is usually ample moisture to mature the wheat, oats, barley, and other crops. Fruit and shade trees thrive on the higher lands, and rarely is there serious loss through drought.

On the low ground along the Snake river are a few irrigated areas. Here the soil is sandy, and the temperature is higher than on the upper lands, so that crops and fruit trees require the application of water during the summer. These strips of low land are locally known as "bars" or "flats". They are not continuous, but are separated from each other by rocky points which extend down to the river's edge. This is sometimes known as the fruit area of the county, as the greater part of the orchards are to be found here. On the higher grounds some apples and other fruits are produced, and their owners claim that the flavor is better than in the case of fruit from irrigated orchards, but on this point there is difference of opinion.

Water is usually obtained by sinking wells to a depth of from 10 to 50 feet, although in some cases it is necessary to go deeper. At Pullman there are reported to be 8 flowing wells of a depth of from 70 to 180 feet. The cost of these wells ranged from \$3 to \$4 per foot. The wells are from 3 to 6 inches in diameter, and are reported to deliver 800 gallons per minute. There are also 2 flowing wells at Moscow, in Latah county, Idaho, about 10 miles east of Pullman. These wells supply water mainly for domestic purposes, none being used for irrigation.

YAKIMA COUNTY is south of Kittitas and north of Klickitat, these three counties extending from the summits of the Cascade mountains eastward to the Columbia river. The Yakima river rises in the county to the north and flows in a general southeasterly course into Yakima county, where it receives numerous tributaries from the mountains on the west. The agricultural settlements are along these streams, the most prosperous being at places where water can be taken out to cover large areas of the fertile bench and valley lands. As a general rule nothing can be raised without irrigation, although there are a few favored spots where wheat has been successful without the artificial application of water. In the eastern end of the county, toward the plains of the Columbia, there are localities where farming without irrigation is attempted, but the yield is so small as barely to repay the efforts of the cultivator.

The topography of this county is shown by maps made by the northern transcontinental survey in 1883. The area surveyed includes the Kittitas valley and the southern portion of Kittitas county, as well as the greater part of Yakima county. Besides the topography, which is shown by contoured lines, the forest areas have been outlined and the soils studied, the results in each case being shown by colored maps. This area is characterized by ridges running in a general easterly and westerly direction, many of them being cut by the Yakima river. Between these are fertile valleys, the soil of which yields large crops wherever water can be brought upon it.

The first of these valleys is the Kittitas valley, previously mentioned in the description of the county of that name. After leaving this area the river passes through the Beavertail and Umptanum ridges, having cut a picturesque canyon about 15 miles long and from 1,000 to 1,800 feet in depth. It then crosses a valley extending east and west, the portion on the west or right bank of the river being known as the Wenas or Naches valley and on the east the Selah valley. South of these is another ridge of upturned lava known as the Selah ridge, separating these valleys from a similar long, narrow basin on the south. The most notable part of this basin is the Moxee valley, on the east side of the Yakima river. The part of the basin to the west of the river, in which Yakima and North Yakima are situated, is known as Atanam valley. The total length of this basin or valley is from 75 to 80 miles and the width is not greater than 5 or 6 miles. South of the valley the river again cuts through a lava uplift, the Yakima ridge, and enters the large Yakima valley, which extends down toward the Columbia, being 45 miles or more in length and from 10 to 15 miles in width. The Yakima river leaves the valley of that name through a narrow pass and enters the low lands along the Columbia, flowing through these to join that stream. These lands are at an elevation of 100 feet or even less above the Columbia, rising toward the west. They extend from near Wallula for about 50 miles upstream, broadening to a width of 20 miles at points above the mouth of the Yakima river.

The greater portion of the center of the county west of the Yakima river is occupied by the Indian reservation, which thus includes a large part of Yakima prairie. Northeast of this prairie are rolling hills and plateaus, generally covered with nutritious bunch grass valuable for stock raising. The soil is rich, and with an abundant rainfall good crops could be raised. In some localities large areas of government land have been taken up, and settlers have raised from 10 to 20 bushels of wheat to the acre. The majority, however, have not been able to secure a crop, and many homesteads have been abandoned.

The Yakima river and its principal tributary, the Naches, rise among the high peaks of the Cascade range and thus have a large perennial supply of water. Other streams of the county, as, for example, Wenas creek and Atanam river, derive most of their water from spurs of the range, on which, the altitude being less, the snows melt earlier in the spring, giving a diminished summer flow. Along streams of this latter character the area under cultivation has already exceeded the amount which can be irrigated by present means, and as a result there is scarcity of water during the latter part of the crop season, especially among the irrigators on the lower portion of the streams. It is evident that water storage must be utilized to save some of the surplus water of early spring, which usually comes in a flood of duration so short that the irrigators have barely time to give their lands one thorough watering. In many of the streams there are often two decided floods, the earlier resulting from the melting of the snows on the lower foothills, following a warm wind or rain. Later in the spring the snows on the higher mountains begin to melt, sometimes keeping up the height of the water, and at other times giving rise to a second well marked flood. The creeks which do not receive this second supply shrink during June, so that by the first of July there is hardly enough water for gardens and stock. Some of the lower grounds along the creeks receive sufficient moisture by seepage from the streams or from the ditches on the benches to raise crops without the application of water to the surface, but the higher lands must be irrigated, except perhaps in the case of those at an elevation of 2,000 feet or more above sea level.

A large part of the irrigation in this county is carried on by means of ditches built by the farmers, either individually or in partnership. These men, as a rule, have had little money to invest in the development of the water supply, but they have contributed freely of their labor. The short crops of the census year diminished their resources, so that generally they could not unaided undertake larger enterprises, such as the building of long canal systems. In 1889 and the following years outside capital was attracted by the apparent opportunities for profitable investment in works of this character, and corporations began to increase in number. The largest canal thus built is that known as the Sunnyside, built by the Northern Pacific, Yakima, and Kittitas Irrigation

Company, covering lands on the east or northeast side of Yakima river, near Topinish and the new town of Zillah. This canal is on an average 30 feet wide, 6 feet deep, and has a total length of 60 miles. It covers about 240,000 acres of good agricultural lands. Farther down the river, in the vicinity of Prosser and Kiona, are the works of the Columbia and Yakima Irrigation Company and also of the Yakima Irrigating and Improvement Company, all taking water from Yakima river and carrying it to lands in the valleys near the mouth of this stream or northerly along the west side of Columbia river.

In many of the valleys previously mentioned much of the land lies at an elevation too great to be covered by canals from the streams, or if sufficiently low the expense of construction is prohibitory. In the eastern part of the county it is exceedingly difficult to obtain water sufficient even for domestic purposes, much less for irrigation, it being necessary to haul the water for long distances. Great attention, therefore, has been given to the possibilities of obtaining artesian flows. The first attempt to discover artesian water was made at the expense of the state, the well being located on Horse Heaven plateau in section 36, township 8 north, range 26 east. In this excellent grazing region the need of water is very great. This well is 630 feet in depth and is reported to have cost \$3,400, this somewhat large amount being due to the fact that the drill penetrated several hundred feet of basalt, progress through which was extremely slow. Water was struck at a depth of 225 feet, but it did not rise to a higher level. The structure of this area, as described by Mr. Russell, is that of a great block uptilted toward the north, the strata becoming almost horizontal 10 miles to the south of the edge of the fracture and still farther to the south broken again. There is thus nothing of the basin structure essential to the existence of artesian wells.

The successful wells so far discovered are in the Moxee valley, where the somewhat rare combination of conditions resulting in artesian flows has been found to exist. Deep borings have been made by the Yakima Land Company, the Washington Irrigation Company, and others. Well No. 1, of the Yakima Land Company, was the first flowing well in that part of the state. It is located on section 3, township 12 north, range 20 east. The elevation of the ground at the mouth of the well is approximately 1,166 feet above sea level, and when other wells are closed the water rises 26 feet higher, or to an elevation of 1,192 feet. The well is 6 inches in diameter, 314 feet deep, and discharges at the rate of about 0.6 second-feet, the water having a temperature of 75 degrees Fahrenheit. Well No. 2 is located on section 4 of the same township and range, is 8 inches in diameter, and 618 feet deep. The elevation of the ground at the well is 1,206 feet and the water rises in the hole to within 12 feet of the top, or to an elevation of 1,194 feet, or practically the same height as in the case of well No. 1. Well No. 3 is 300 feet from No. 1 and in the same section. The top of the well is at an elevation of 1,154 feet, and when well No. 1 is closed the water rises 35 feet above ground, or to an altitude of 1,189 feet above sea level. Well No. 4, in section 4 of the same township and range, is 583 feet in depth. The top of the well is at 1,266 feet, and water rises only to within 80 feet of the surface, or to an altitude of 1,186 feet. Well No. 5 was drilled in section 25, township 13 north, range 19 east, but was not completed at the time of Mr. Russell's report.

A comparison of the results obtained in each of these wells shows that when not flowing the water would stand at approximately the same level in all, namely, at an altitude above the sea of 1,190 feet, this, as pointed out by Mr. Russell, being the limiting height for this part of the basin. The other conditions, however, which determine the area of a basin and the probability of permanence of supply, are somewhat complicated. Well No. 1, of the Washington Irrigation Company, is located in section 31, township 13 north, range 20 east. The elevation of the surface is approximately 1,085 feet. The discharge is estimated to be 0.3 second-feet. The water has a temperature of 73 degrees Fahrenheit. West of North Yakima, in what is known as Wide Hollow, are two wells, one having a depth of 256 feet. The elevation of the top of the other well is 1,125 feet and its total depth is about 530 feet. Neither of these flows.

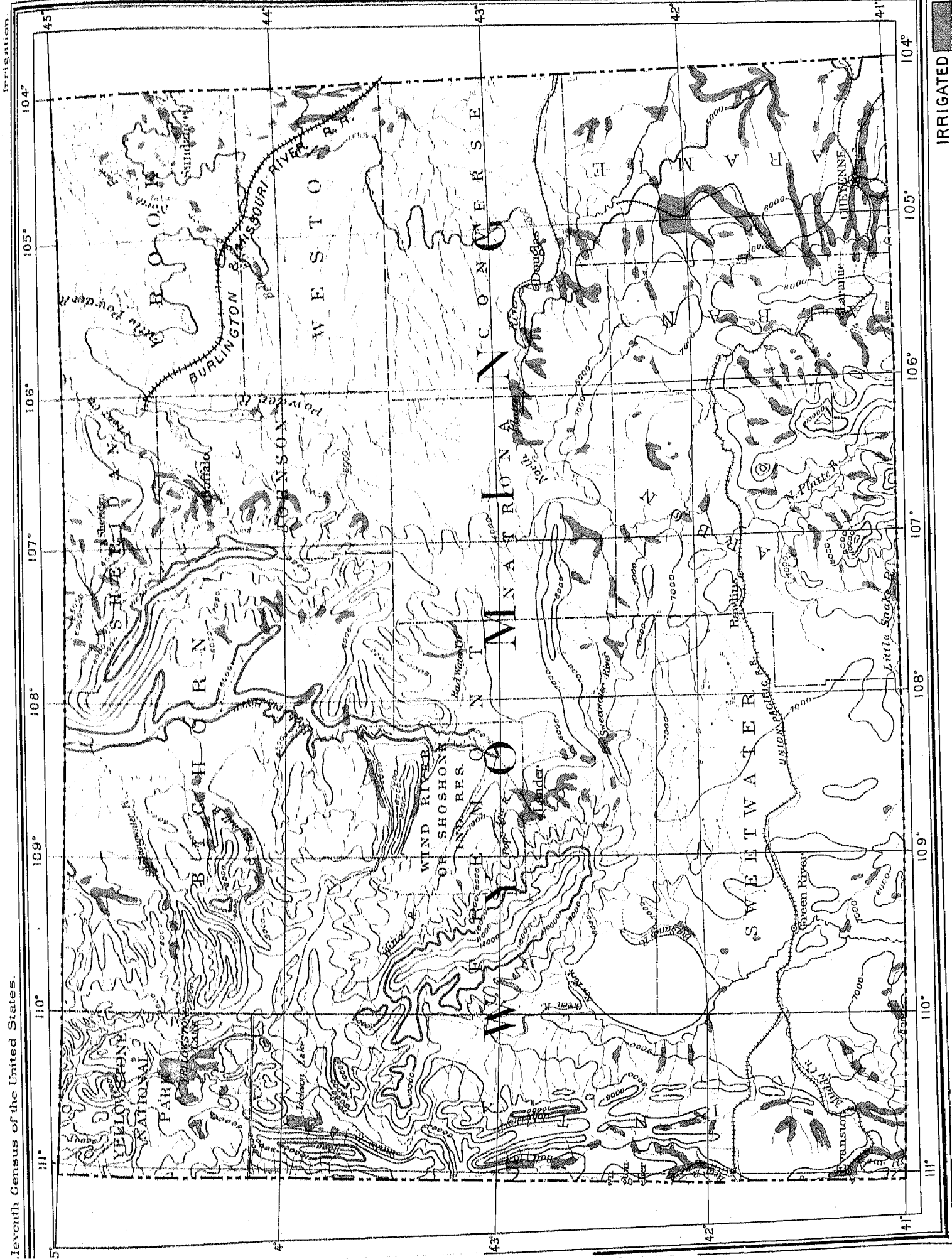
WYOMING.

Total population (average per square mile, 0.62)	60,705
Number of owners of farms (5.15 per cent of population)	3,125
Number of irrigators (61.34 per cent of farm owners and 3.16 per cent of population)	1,917
Area of state, land surface (97,575 square miles)	62,448,000
Area irrigated in census year	229,676
Area of all farms (26.05 per cent improved)	1,830,432
Cereals raised in census year, including 20 acres in buckwheat and 141 acres in rye	21,815
Barley (average production, 24.20 bushels per acre)	486
Corn (average production, 12.73 bushels per acre)	1,977
Oats (average production, 26.60 bushels per acre)	14,607
Wheat (average production, 16.24 bushels per acre)	4,584
Alfalfa	5,270
Total value of all farms, including land, fences, and buildings	\$14,460,880
Estimated total value of the farms irrigated in whole or in part	\$7,212,000
Estimated value of all farm productions (sold, consumed, or on hand) for 1889	\$2,241,590
Estimated value of productions (as above) from farms irrigated in whole or in part	\$1,895,000
Average size of irrigated farms	120
Average size of irrigated farms of 160 acres and upward	494
Per cent of acreage of irrigated farms of 160 acres and upward to total acreage irrigated	65.18
Average size of irrigated farms under 160 acres	50
Average first cost of water right per acre	\$3.62
Average annual cost of water per acre	\$0.44
Average first cost per acre of preparation for cultivation	\$8.23
Average value of irrigated land, including buildings, etc., in June, 1890, per acre	\$31.40
Average annual value of products per acre in 1889	\$8.25

GENERAL DESCRIPTION.

In number of irrigators in the census year Wyoming stood above Arizona, Washington, and Nevada and in area irrigated was near the middle of the list of the 11 states and territories. As a consequence of the large acreage reported as under irrigation, the average size of irrigated farms was necessarily large, 120 acres, in this respect standing second only to Nevada. The principal product on the irrigated land being hay, and much of this from native grasses, the average value of products was very low, \$8.25 per acre. Taking out the large irrigated farms, that is, those of 160 acres and upward, there remained less than 35 per cent of the land in what may be called small irrigated farms, these averaging 50 acres in size. Thus, in respect to proportion of large holdings, this state was far above the average, subdivision of large holdings not having been carried on to a very perceptible degree. The reports as to the first cost of water rights per acre and the average annual cost indicated that these were lower than in any other part of the country, this being apparently due to the many instances where small ditches were constructed by farmers who placed little value on their own labor.

Wyoming lies principally within the northwesterly portion of the Great Plains. The continental divide crosses the state diagonally, running in a general northwest and southeast direction, the southwestern corner of the state containing the headwaters of streams flowing into the great interior basin or southward to the Colorado river. From the continental divide the land as a whole falls gradually to the north and east toward the Yellowstone and the Missouri, the rivers flowing either northward into the Yellowstone or eastward down the slope of the Great Plains. This gentle slope toward the Missouri is interrupted in several instances by mountain ranges, whose course is in general slightly west of north and east of south, the most conspicuous examples being the Bighorn range in the northern part of the state and the Medicine Bow and Laramie ranges in the southern part. These, with the Wind river and Absaroka ranges, induce most of the precipitation of the state, and to their presence is due the greater part of the agricultural possibilities of Wyoming, for from these mountains come the streams most important to agriculture. The continental divide crossing this state is not in all places well marked; in fact, it may be said that the plains sweep over the divide into the head waters of the Colorado. This lofty plain, where unbroken by mountains, does not receive sufficient water to render agriculture possible on a large scale, even if the climate was sufficiently temperate for the ordinary crops.



MAP OF WYOMING SHOWING AREAS IRRIGATED IN 1889.

IRRIGATED

The agricultural land of Wyoming as a whole lies at the greatest altitude of that of any state in the Union, nearly one-half of the total area being above 6,500 feet. The character of the agriculture and that of the products are governed by this fact, and, as is well known, the pastoral industries lead in importance, areas devoted to these practically embracing the greater part of the state. Agriculture proper, the tilling of the soil, is making rapid progress in some portions, especially at the lower altitudes, as, for example, in Johnson and Sheridan counties, along the base of the Bighorn range in the northern part of the state, and also in the more thickly settled parts adjacent to Colorado on the southeast. In the northern counties in the valleys of the Powder, Tongue, and Bighorn rivers, where the altitude is from about 3,500 feet upward, and also to the southeast in Laramie county, nearly all kinds of fruit and vegetables of the temperate region reach maturity, and in all parts of the state grass and the hardier grains flourish, many of the higher plains being too cold for corn. Nothing, however, can be grown without irrigation, with the exception perhaps of a scanty crop in some spot occasionally favored with an unusual summer's rain. No dependence can be placed upon nonirrigated crops and the yield at best hardly repays the trouble. As a result, with a vast area of arable land agricultural development is restrained by the uncertainty of securing water. Irrigation is still in its infancy, and there are few works of notable size, the only exceptions perhaps being in the case of canals in Albany and Laramie counties. There are numerous small ditches leading from the streams out upon the lowest bottom lands, where in most instances a few well located high line canals would serve more land with greater economy. Many of the earlier canals were so faulty in construction and in alignment that the cost of repair has been large, and lack of economy of water has ensued. There is need of systematizing the water diversions from each stream.

WATER SUPPLY.

The water supply of the state as a whole is remarkably good, since there is a large proportion of perennial streams of notable size. The valleys along the Bighorn river and also those to the east of the range of that name receive a large amount of water from the great mountain ranges bordering them. Agricultural development, especially in the north, has been retarded by the lack of transportation facilities, the only railroad until of late years being that crossing the southern part of the state. On the east the tributaries of the Platte have been used nearly to their full capacity for irrigation, the water in the Platte itself being employed to a less extent on account of small slope of the stream and the consequent expense of headworks, irrigation from the tributaries being cheaper. There are many canals, especially along the larger rivers, which receive water only during times of flood. These so-called high water canals are very cheaply built, the headworks, if any, being of temporary character. Water is by this means turned out upon grazing lands, only one thorough watering during the year being secured. In such cases the use of the term "irrigated land" is open to criticism, especially when used in comparisons of statistics from lands where irrigation for grazing is impracticable.

There has been the same complaint in Wyoming as in other states, that with increase of population and pushing of settlement toward the head waters the water is used to a greater extent in the upper valleys, where irrigation is cheaper, but where the climate is less favorable for agriculture, and that by this increased use of the small tributaries the supply of water is diminished in the main stream below to the detriment of prior appropriators. The available supply must be increased by utilizing all the facilities for conserving water, and at the present time steps are being taken in this direction. Some small storage basins are used, but they are insignificant as compared with the untouched facilities. As the matter now stands, the amount of water in the streams depends directly upon the depth of snowfall in the mountains, the rain having comparatively little influence upon the amount available for irrigation. In fact, the irrigator cares little about the quantity or distribution of the rain, his chief concern being the amount of snow in the mountains and the distribution of temperature through the spring and summer, an early warm spring causing the snow to disappear rapidly, while comparatively cool weather in the mountains allows the snow to remain later and keep up the discharge of the streams at the critical time.

The average distribution of the water in the streams in and adjoining Wyoming throughout the year is shown by the following percentages of discharge for each month. As given in the results obtained by the United States Geological Survey, in January the discharge was 3.5 per cent of that of the entire year; February, 4.0; March, 5.0; April, 9.0; May, 25.0; June, 23.0; July, 12.0; August, 5.0; September, 3.5; October, 3.4; November, 3.3; December, 3.3. That is to say, in May, taking the averages of a large number of streams, one-fourth of the amount for the entire year was discharged, or five times the amount discharged in August and over twice that discharged in July. Taking May and June together, nearly one-half the total for the whole year was discharged, or four times that of July, the month in which the crops are in full growth. It is self-evident that by saving a part of this water so plentiful in May and June until July, and especially until August, a far greater acreage can be given a second or third watering. It would be necessary to hold the greater part of this water a very short time, for the culmination of the flood occurs in the latter part of May or the first part of June, while the greatest need is in the latter part of July and in August. The amount of water flowing to waste in winter, although relatively of small significance, would aid in swelling the amount available for storage.

WATER CONTROL.

The legislation recently enacted, approved December 22, 1890, promises a speedy solution of many of the troubles besetting the irrigator, and its practical operations are being watched by the people throughout the arid lands. In preparing these laws advantage has been taken of the experience of other states, and much that is best has been incorporated from the laws of other irrigating countries, especially those of the state of Colorado, where certain of the provisions have been put to practical test. The law is unique in this, that the state does not necessarily wait for controversies and losses to arise, but of its own motion steps in and ascertains how much water is available for irrigation, who are the claimants to this water, and then, knowing these fundamental facts, it gives the use of the water to the proper persons, and employs its own agents to see that the distribution is made.

Under late legislation the state engineer has charge of all the details of water distribution throughout the state, and he, with four superintendents, one from each water division, constitutes a board of control to determine all questions that may arise. Under each superintendent are a number of water commissioners, one for each minor district, whose duties are to enforce the proper distribution and carry out the local regulations. The state engineer is to make measurements of the amount of water in the stream, to determine the most suitable location of irrigation works and lands to be irrigated, and, further, to examine reservoir sites and publish estimates of the cost of storage and distributing systems. The superintendent in each division is to make suitable regulations to secure the fair distribution of water, and by the aid of the water commissioners to keep a record of the amount of water needed, available, or wasted, and if the water is not justly distributed he must enforce division according to his list of priorities. The board of control, of which the state engineer is the head, can appoint a date upon which to examine into the rights of all persons using water from any streams, and knowing the amount of water available, as determined by the state engineer, as well as the area of land irrigated or susceptible of irrigation, it can then make an order determining the rights of each person, giving to no appropriator more water than he can put to beneficial use, the maximum limitation being set at 1 second-foot for 70 acres. Each person is then given a certificate showing the order of priority, the amount of water to which he is entitled, and the number of acres upon which the water is to be used.

No future appropriation of water can be made until the board of control is satisfied that there is unappropriated water, and that its use will not be detrimental to public interests. The second-foot is made the legal unit, thus avoiding the trouble arising from the use of that indefinite quantity, the miner's inch. Each appropriator must maintain head gates by which the water can be turned on or off, and also a flume or weir for measuring the water in his ditch. All dams over 5 feet in height for raising and diverting water must be approved by the state engineer, thus insuring an official inspection of such structures.

From the above abstract it is apparent that the state engineer and board of control hold the most important offices in the state, so far as agricultural interests are concerned, and by a wise and skillful exercise of the functions intrusted to them they can bring about a thorough development of the agricultural resources of the state. With the exception of a part of the head waters of the North Platte and Bear, all the streams rise within the state and are under the control of state officers without hindrance from outside parties. Apparently only such water as Wyoming can not use need be discharged across her borders to Nebraska, the Dakotas, Montana, Idaho, and Utah. She holds the key to the storehouse of agricultural wealth.

WELLS.

In Wyoming a great number of wells have been drilled to depths of from 100 to 1,000 feet or more in the search for petroleum. Usually these pass through strata carrying large amounts of salt water, which, if allowed to do so, rises and overflows at the surface. This water, so far as ordinary uses are concerned, is worthless on account of the large amount of mineral matter which it contains. Occasionally the deep borings have struck fresh water, but these cases are rare and the amount delivered is usually small. There is reported to be a flowing well at Cheyenne; also others south of Laramie, in Albany county, and in the vicinity of Sheridan, in Sheridan county. At this latter locality are two wells, one of which, 500 feet in depth, delivers less than a gallon a minute, and in the other, 452 feet, the water rises only to within 6 feet of the surface.

CONDITION OF IRRIGATION IN EACH COUNTY.

NUMBER OF IRRIGATORS, AREA IRRIGATED, FARMS, AND CROPS IN EACH COUNTY IN WYOMING IN 1889.

COUNTIES.	Number of irrigators.	Area irrigated in acres.	Average size of irrigated farms in acres.	OWNERS OF FARMS. (a)		IRRIGATORS.		Area of counties in acres.	FARM AREA.		Cereals. (Acres.)	Alfalfa. (Acres.)	AREA IRRIGATED.			Average value of products per acre.
				Total number.	Per cent of population.	Per cent of farm owners.	Per cent of population.		Acres.	Per cent improved.			Per cent of area of county.	Per cent of total farm area.	Per cent of land owned by irrigators.	
Total	1,917	229,076	120	3,125	5.15	61.34	3.16	62,448,000	1,830,432	26.05	21,815	5,270	0.37	12.55	15.24	\$8.25
Albany	125	31,522	276	140	1.58	80.29	1.41	2,880,000	214,955	32.19	408	216	1.20	16.06	16.06	0.30
Carbon	272	30,800	147	205	4.30	92.20	3.97	4,932,000	133,241	60.22	1,473	50	0.80	20.02	30.72	6.83
Converse	72	6,800	90	144	5.26	50.00	2.63	4,224,000	45,400	23.91	028	112	0.16	15.16	21.81	6.72
Crook	50	3,027	51	540	23.10	10.93	2.52	3,300,000	127,245	18.88	3,730	46	0.09	2.38	15.02	10.15
Freemont (b)	217	15,512	71	366	14.86	59.29	8.81	15,526,400	96,273	32.54	3,198	1,233	0.10	16.11	23.87	12.25
Johnson	278	28,100	101	307	13.03	90.55	11.79	2,500,000	123,594	46.94	3,570	779	1.10	22.74	24.02	7.97
Laramie	208	33,853	163	405	2.41	51.36	1.24	4,406,000	774,161	15.07	2,164	652	0.75	4.37	5.09	12.44
Natrona	43	5,547	129	105	15.08	26.06	3.03	3,504,000	48,197	28.32	52	135	0.16	11.51	18.46	(c)
Sheridan	294	20,722	101	356	18.05	82.58	14.91	1,776,000	124,749	27.48	5,983	1,144	1.67	23.83	27.14	6.04
Sweetwater	20	1,392	68	23	0.47	86.86	0.40	6,547,200	4,757	30.82	26	23	0.02	28.03	34.39	(c)
Uinta	324	30,918	65	300	4.57	96.00	4.11	9,491,200	130,330	27.77	597	900	0.33	23.72	25.04	6.09
Weston	5	348	70	24	0.90	20.83	0.21	3,091,200	7,470	12.62	40	.....	0.01	4.06	11.44	7.59

a Includes owned and hired farms, assuming one farmer to each.

b Including Bighorn county.

c Returns not complete.

ALBANY COUNTY is in the southeastern part of Wyoming, extending from Colorado northward over a third of the distance across the state. It embraces nearly all the catchment area of the Laramie river, and on the east, beyond the Laramie range, it includes also the sources of the streams flowing easterly or northeasterly into the North Platte river. Within this county are the Laramie plains, which are in general character similar to the Great Plains to the east, but separated from these by the long, narrow Laramie range, a prolongation of the front range of the Rocky mountains. These plains lie at an altitude of about 7,000 feet, and the temperature, while favorable to the growth of forage crops and small grains, is too cold for many fruits and vegetables cultivated further to the east. Nothing grows without irrigation, but with it excellent crops of grass, alfalfa, the hardier cereals, and various vegetables are raised.

The Laramie plains are well watered on the west by the numerous tributaries which flow from the Medicine Bow mountains or Snowy range, and which either sink into the plains or flowing nearly across them unite to form the Laramie river. For a brief period in the spring, during the prevalence of the freshets, there is an ample supply of water, but during the summer there is not enough for all the ditches. Near the foothills on the west side of the plains are many small lakes, some of which are suitable for water storage, and plans have been suggested for constructing suitable regulating works for this purpose, few reservoirs, however, being in actual use. Besides these lakes in Albany county there are many good storage sites on the head waters of the Laramie river in Colorado, south of the county line.

Stock raising is the principal industry, forage forming 98 per cent of the total area of crops irrigated in 1889. As a general rule vegetables and cereals were raised in quantities sufficient merely for local consumption. Besides the crops irrigated there was an acreage of equal amount reported as irrigated for grazing, the total of these two items amounting to a third of the entire area of the farms of the county. The character of the irrigation for grazing is such that one man can apply water to large tracts whenever this is abundant and the cost is therefore very small. On the eastern side of the Laramie range, along the narrow valleys on the head waters of the streams flowing into Laramie county, are large areas of agricultural land. The country is rough and broken, and, as on the Laramie plains, grazing is far more important than tilling the soil. There is a complaint among the smaller farmers that the great corporations engaged in cattle raising interfere with the growth of agriculture by fencing enormous areas within which are lands susceptible of irrigation and legally open to settlement.

CARBON COUNTY is in the southern part of Wyoming, west of Albany county. The North Platte flows from Colorado northerly through this county into Natrona county, where it turns toward the east. The principal agriculture is in the valley of the North Platte, in the southern part of the county, where the river is bordered on the east by the Snowy range and on the west by the Sierra Madre. The ranches are located along the small streams which issue from these mountains, the land under cultivation being near the streams and irrigated by short ditches taken out by the owners of each ranch.

The water in these small streams diminishes rapidly in July, and from then until the middle of August, when the crops are cut, there is often scarcity of water. There is a large volume flowing in the North Platte at all times, and if the river could be diverted in the southern part of the county by large canals running near the foothills on each side of the valley, enormous tracts of fertile land could be utilized. At present the land lying back from the creeks and a little above the level of the bottom lands is of little or no value. The general altitude of the

agricultural land is 7,000 feet. It is undulating and broken, being traversed in places by ranges of hills. The principal industry of the county is grazing, although the climate is favorable to the production of many of the grains. The expense of transportation is so great that nearly all the products are raised for home consumption. The ditches are mostly small, one of 15 feet in width being considered large.

In the southwestern corner of the county is a portion of the head waters of the Snake river, which flows southwesterly into the state of Colorado, finally emptying into the Green river. There are several ranches along this river and its tributaries, the irrigated lands being in the bottoms. The mesa land adjoining these has not as yet been touched on account of the expense of bringing water upon it. Taking the county as a whole, the amount of land taken up is insignificant in comparison with that which remains to be utilized, and there appear to be excellent opportunities for the development of large irrigating systems from the North Platte river and by storage from many of its tributaries.

CONVERSE COUNTY is in the center of the eastern side of the state, lying north of Albany and Laramie counties. The average elevation is approximately 5,000 feet, the greater portion of the county consisting of the debatable ground between the Great Plains region on the east and the Rocky mountain foothills region on the southwest. The Platte river flows across the southwestern corner of the county, receiving many small tributaries from the Laramie range to the south. The county line on the north running east and west lies approximately in the center of the valley of the south fork of the Cheyenne river, the divide between the Cheyenne and Platte being through the center of the county. In many places this is apparently so low that the farmers believe that a canal can be taken from the Platte river in Natrona county and brought out upon or across this divide. There are few ditches, and the area tilled is insignificant in comparison to that used for stock raising.

It is generally impossible to raise any crop without the application of water, although the rainfall is in many seasons almost sufficient to insure success. In the bottom lands, along some of the streams where the land is probably wet by seepage, potatoes and other vegetables have been produced, and in a few localities oats, wheat, and millet have been raised without irrigation, the crops being, however, only about one-half or one-third of those on the irrigated land. Large areas are now under irrigation for grazing, with the intention of bringing the land into condition for raising hay, two or more years of irrigation and grazing being usually considered necessary before a forage crop can be cut. Along the North Platte river several water wheels, carrying upon their rims buckets by which water is raised, are reported to be in use, but with results not always satisfactory. The lower lands along this river are of enormous extent, and with large and comprehensive canal systems, taking water from this river extensive tracts of fertile land can be reclaimed, there being apparently an abundant supply of water. The creeks coming into the North Platte from the south flow in general through narrow valleys, or have cut ravines, rendering it a matter of difficulty to take the waters out upon the higher and better lands. Many of these carry a considerable amount of water throughout the year, but in most instances there is an extent of land far greater than can be brought under irrigation by these streams without storage.

CROOK COUNTY is in the northeastern corner of the state, adjoining Montana on the north and South Dakota on the east. In altitude it is, as a whole, as low as that of any county in the state, the northeastern corner being considerably under 4,000 feet in elevation, while the average for the county is under 5,000 feet. In the eastern part it contains the Bearlodge range, the northwestern prolongation of the Black Hills region. The summits of this range are 6,000 feet or more in altitude, Warrens peak rising to over 6,820 feet. The principal stream of this county is the Belle Fourche or north fork of the Cheyenne river. This stream rises in Weston county, flows northeasterly along the western foot of the Bearlodge range, and shortly before reaching the state line turns abruptly to the southeast, passing around the Black Hills. West of this stream, and separated by a comparatively low divide, are the head waters of the Little Missouri, and beyond this are those of the Little Powder river, the county continuing to the westward and embracing some of the tributaries of the Powder river.

The principal settlements of the county are in the Bearlodge mountains, where there are good ranges for stock, and where agriculture without irrigation is occasionally successful. The streams flowing in all directions from this range and finally uniting in the Belle Fourche furnish opportunities for irrigation on a small scale, and a number of ditches, owned by individuals, have been built, but as a general rule, although there is an ample supply of water at the time of the melting of the snow, yet later in the season, at the time when the waters are needed for maturing the crops, the streams become nearly or quite dry. The principal tributary of the Belle Fourche in this county is the Inyan Kara, which flows in a general northwesterly direction south of Sundance. The banks of this stream are high, and ditches are taken out with difficulty. There is an ample supply of water in the early spring, but the stream has been known to become nearly or quite dry in the fall. The valley of the Belle Fourche itself is narrow and is bounded by high bluffs, the river crossing from side to side, rendering the construction of a comprehensive canal system difficult, if not impossible. The Little Missouri often contains a fair amount of water, but in 1889 and 1890 it was dry in many places, the extraordinary drought of the last two years having its effect upon all these streams as well as upon the crops. The farmers in general state that although they can occasionally raise corn, wheat, oats, and vegetables without irrigation, yet at best the yield is small and they can not be sure of a crop two years in succession.

FREMONT COUNTY, in the western part of Wyoming, comprises a large area extending from the Montana line southward two-thirds across the state, including the Wind river and other head waters of the Bighorn, and extending south over the continental divide, including New Fork and various small tributaries of the Green river. On the southeast are the head waters of the Sweetwater, the county thus including portions of three large drainage basins. The Wind River range, which crosses the county diagonally, lying in a general northwesterly and southeasterly direction, and the southern extension of the Absaroka range on the north are of such a height as to give rise to innumerable streams, so that as a whole the county is well watered. The greater part of the population is in the vicinity of Lander and neighboring towns in the center of the county. Mining is an important industry, although perhaps not as important as stock raising. The Wind River Indian reservation north of Lander occupies a large part of the county, but south of it agriculture has developed along the Popo Agie river and its tributaries, where the water supply in general is remarkably good. In the east of the county, on the Badwater creek, irrigation is less successful, but on the Sweetwater to the south the water supply is reported to be plentiful for the land under irrigation.

There are no large canals in the county, but many small ditches, each taking water to the lands of one or two owners. Owing to lack of transportation facilities there is little or no market for agricultural produce except at the mines. Much of the agricultural land is rough, requiring considerable expenditure to prepare the surface for thorough irrigation. An occasional crop of barley or oats is reported to be successful without the application of water. In the southwestern corner of the county, south of the head waters of the Green river and east of New Fork, is a vast plain lying at an altitude of about 7,000 feet. The elevation of the plain above the channels of the streams is so great, however, that it is doubtful whether water can be brought out upon it. The water supply of that region is good, but compared to the vast area of land suitable for forage crops at least is wholly inadequate. Settlement has been confined to the foothills, where water can be had in abundance.

The north portion of Fremont county is probably the best watered part of the state, for it contains in its western half a part of the Absaroka range, the peaks of which rise to altitudes of from 9,000 to 11,000 feet. Settlement is progressing rapidly on the principal streams which flow from these mountains, and there appears to be no immediate possibility of the water supply being exhausted, at least on the Grey Bull and rivers to the north. On Owl creek, north of the Wind River Indian reservation, some difficulties are reported on account of diversions of water by settlers toward the head waters. In the valley of the Bighorn river is a large amount of good agricultural land and plenty of water, but the banks of the river are high and the fall is so gentle that the expense of taking out canals appears to be large, too great at least for the present settlers to attempt. The lack of a railroad retards development, and the agricultural resources are little known by those outside the county. There are high water ditches, which in times of flood water some of the lower lands in this valley.

JOHNSON COUNTY is in the northern part of Wyoming, separated from Montana only by the comparatively narrow strip of land embraced in Sheridan county. It extends from the summits of the Bighorn mountains eastward toward the Great Plain region, and covers a region most favorable for the development of irrigation, the high mountains on the west contributing a perennial supply of water for the open valleys toward the east. The tilled lands lie in the valleys along the base of the mountain range at altitudes of from 4,000 to 6,000 feet. The streams coming from the Bighorn mountains unite in creeks, which flow in a general northeasterly or northerly direction and finally, after crossing through the foothill and high plain region, empty into the Powder river, the waters of which, flowing northward into Montana, join those of the Yellowstone. The irrigation streams coming from the high mountains fluctuate to a certain extent during the day owing to changes of temperature, the amount of water following a hot summer day being noticeably greater in amount. Within the past few years agriculture has developed to a wonderful extent along the base of the Bighorn range, and there has been brought under cultivation an area of land so extensive that it can not be completely watered by the streams, although their flow is comparatively large and persistent, and the farmers report many acres of crops ruined in 1889 and in 1890 on account of this deficiency of water. In this county the small amount of snow during the winters preceding 1889 and 1890 has had its effect upon the streams in the reduction in their volume.

No crops can be raised with certainty without irrigation, although a few acres of potatoes and vegetables have been reported as successful without the application of water. Some native hay also is thus raised, especially in seasons of unusual rainfall, and many farmers consider this hay better in quality than that raised by irrigation, but the quantity per acre is far less. One cutting of alfalfa is occasionally obtained without the use of water. The ditch system of this county, like that of many other parts of the west, has grown up in a haphazard fashion without definite plan. In most instances the ditches have been built to convey water to a single ranch, and are to a large extent owned by individuals or cattle companies. Consequently the majority of them are small and imperfectly constructed, and the losses that have occasionally resulted have arisen from defects in the ditch rather than from lack of water in the stream, although the water is not in general sufficient for all demands.

In seasons like those of 1889 and 1890 the scarcity in many cases brought about a temporary agreement between various persons claiming water from the same stream, according to which the whole amount of water available was distributed alternately to the different ranches, resulting in economy, and consequently covering a

larger area than before. The over appropriation, however, on Clear creek and on several branches of Crazy Woman creek, has led to vexatious disputes. In many cases where the water can not be had during the crop season it has been found of advantage to apply water later in the season, and late irrigation in general has proved a great benefit. Water storage has been undertaken to a very small extent. One man in particular reports the successful use of a small reservoir in which spring water is held.

LARAMIE COUNTY is in the southeastern corner of Wyoming, east of Albany county, thus including the lands east of the foot of the Laramie range and south of the divide between the North Platte and Cheyenne rivers. The western side of the county is well watered by the many small streams which, rising in the Laramie range in Albany county, flow eastward to join the North Platte river. This river enters the northwestern corner of the county and flows toward the southeast into Nebraska. Its waters are not diverted, except in a small way, upon the bottom lands, as for a great portion of its course through the county the narrow river valley is bounded by bluffs, rendering the expense of canal construction too great for private means.

The eastern side of the county has an altitude of about 5,000 feet, and is in no way different from the Great Plain region of western Nebraska and Kansas. Stock raising is the principal industry, and there are many ranches embracing thousands or even tens of thousands of acres. Dry farming has been attempted, but it is only occasionally that a crop can be raised. Many settlers came into the county during or shortly after 1884, the year of unusual rainfall, expecting that, according to the prevalent ideas, the rainfall would continue to increase. In this they have been bitterly disappointed, and year after year of repeated failures has led them to believe that without irrigation agriculture can not succeed.

On the western side of the county, where the elevation is 6,000 feet and upward, no attempts at dry farming have been made, but the soil wherever tilled is irrigated, except in a few instances among the hills at the southern end, where potatoes, rye, wheat, and oats sometimes do well without irrigation. The waters of the many small creeks have all been appropriated, and as a usual thing the rights to the waters largely exceed the amount available, except in times of unusual floods. In the summer there is scarcity, and losses of crops are reported. There are many storage sites on the heads of these streams, especially in Albany county, and in a few instances small reservoirs have been made and are in successful operation. Nearly all the small tracts along these streams are owned by individuals, but there still remain great areas higher and more remote, to which water can be brought only after a great expenditure for canals and storage works.

The Laramie river, flowing through the range of the same name, joins the North Platte in the northern part of the county, Fort Laramie being placed at the junction of these streams. On the bottom lands along the North Platte river are ditches, which take water whenever the river is high, and thus serve to thoroughly saturate these bottoms during the flood season. At other times of the year, however, these ditches are too high to obtain any water from the streams. These bottom lands are usually sandy, and require more water than do the bluff lands, which are reported to be superior for agricultural purposes, if only the water could be brought upon them. The largest irrigation project in this part of the state is that of the Wyoming Development Company, whose canal takes water from Laramie river, covering land between Sybille and Chugwater creeks. The canal soon after leaving Laramie river passes through a tunnel and discharges its water into a branch of Blue Grass creek, which in turn empties into Sybille creek. Here the water is again diverted into the second portion of the canal, about 35 miles in length and 25 feet wide on bottom. About 12 miles farther down the creek is another branch 20 miles in length and 20 feet wide on bottom. Both of these run in a general northeasterly direction, furnishing water to a number of laterals.

The streams which flow into the North Platte from the northern end of the county drain a low catchment area, and therefore have very little water in comparison to the extent of country drained. Advantage is taken of the spring floods to soak the lands, and all of the water that can be taken from the streams is thus used, in the hope that by the fortunate occurrence of rains the crops may reach maturity. The soil along these creeks is usually too sandy, and the results are not always successful. South of the North Platte river, on the plains forming the divide between Horse creek, a tributary of the North Platte, and Lodge Pole creek, which flows into the South Platte, as well as along these creeks, are many ranches, most of the farming being done, however, on the high lands. Occasionally crops of potatoes, millet, oats, corn fodder, sorghum, and vegetables are raised, and in a few instances windmills are used to pump water for apple trees and various kinds of fruit. Corn is reported as usually unsuccessful, owing to the early frosts. In the lower bottoms, where some water is received by seepage, potatoes and vegetables are more certain of success.

NATRONA COUNTY is east of the center of the state and north of Carbon county, of which it formerly was a part. The North Platte flows across the southeastern corner of the county, and the Sweetwater extends along the southern border to the point where it flows into the North Platte. Neither of these rivers, however, although carrying a large amount of water, is used to any extent for irrigation on account of the difficulty of building canals from them. The agricultural land at present cultivated is along the creeks flowing into these streams from the Laramie or the Rattlesnake range, the water being diverted by various private ditches. Hay is the principal crop, the altitude of the county being about 6,000 feet. Although the tilled land is confined to the valleys along