DISTRIBUTION AND PRODUCTION OF THE SIX PRINCIPAL CEREAL CROPS.

WHEAT.

The acreage and crop of wheat in 1879 amounted to 35,430,052 acres, 459,479,505 bushels, the acreage being 29.7 per cent. of all the land in cereals, and the product about 9.2 bushels per head of total population.

The crop of 1879 is estimated by the United States Department of Agriculture to be, as a whole, about 7 per cent. greater than that of 1878, and 23 per cent. greater than that of 1877. This refers to the aggregate production. The crop was by no means uniformly better even in the regions of its greatest production. In each of the twelve states which together produced over 80 per cent. of the total product there were districts where the crop fell below that of average years, and over large portions of the South the year was not a favorable one for a fair yield. So that while, as a whole, the yield is better, there are many localities where the capacity for wheat production in ordinary years is much better than is indicated in the census tables. The production by states in the order of their production, with data pertaining thereto, is seen in the following table:

TABLE XXVIII.—WHEAT CROP OF 1879 (CENSUS OF 1880).

No.	States.	Acres.	Bushels.	Per cent. of total product.	Cumulative per cent.	No.	States.	Acres.	Bushels.	Per cent. of total product.	Cumulative per cent.
1	Illinois	3,218,542	51,110,502	11.12	11.12	26	Alabama	264,971	1,529,657	0.33	97.95
2	Indiana	2,610,695	47,284,853	10.29	21.41	27	Colorado	64,693	1,425,014	0.31	98.26
3	Ohio	2,556,134	46,014,869	10.01	31.42	28	Arkansas	204,131	1,269,730	0.28	98.54
4	Michigan	1,822,749	35,532,543	7.73	39.15	29	Delaware	87,539	1,175,272	0.26	98.80
5	Minnesota	3,044,670	34,601,030	7.53	46.68	30	Utah	72,542	1,169,199	0.25	99.05
6	Iowa	3,049,288	31,154,205	6.78	53.46	31	South Carolina	170,902	962,358	0.21	99.26
7	California	1,832,429	29,017,707	6.32	59.78	32	New Mexico	51,230	706,641	0.15	99.41
8	Missouri	2,074,304	24,966,627	5.43	65.21	33	Maine	43,829	665,714	0.14	99.55
9	Wisconsin	1,948,160	24,884,689	5.42	70.63	34	Idaho	22,066	540,589	0.12	99.67
10	Pennsylvania	1,445,384	19,462,405	4.24	74.87	35	Montana	17,665	469,688	0.10	99.77
11	Kansas	1,861,402	17,324,141	3.77	78.64	36	Vermont	20,748	337,257	0.07	99.84
12	Nebraska	1,469,865	13,847,007	3.01	81.65	37	Mississippi	43,524	218,890	0.05	99.89
13	New York	736,611	11,587,766	2.52	84.17	38	New Hampshire	11,248	169,316	0.04	99.93
14	Kentucky	1,160,108	11,356,113	2.47	86.64	39	Arizona	9,026	136,427	0.03	99.96
15	Maryland	569,296	8,004,864	1.74	88.38	40	Nevada	3,674	69,298	0.02	99.98
16	Virginia	900,807	7,822,504	1.70	90.08	41	Connecticut	2,198	38,742		
17	Oregon	445,977	7,480,010	1.63	91.71	42	Massachusetts	963	15,768		
18	Tennessee	1,196,563	7,331,353	1.60	93.31	43	District of Columbia	284	6,402		
19	West Virginia	393,068	4,001,711	0.87	94.18	44	Louisiana	1,501	5,034	0.02	....
20	North Carolina	646,829	3,397,393	0.74	94.92	45	Wyoming	241	4,674		
21	Georgia	475,684	3,159,771	0.69	95.61	46	Florida	81	422		
22	Dakota	265,298	2,830,289	0.62	96.23	47	Rhode Island	17	240		
23	Texas	373,612	2,567,760	0.56	96.79						
24	Washington	81,554	1,921,322	0.42	97.21		Total	35,430,052	459,479,505		
25	New Jersey	149,760	1,901,739	0.41	97.62						

It will be seen, from this table, that in the first ten states on the list (all of them large and populous), which together produce about three-fourths of the entire crop, the yield per head of population in each one is over ten bushels. This production relative to population is much exceeded in some of the newer states, having a smaller total production, which consequently stands lower in a table of this arrangement.

The production of wheat, both absolute and per head of population, at previous decades, is given in the following table:

TABLE XXIX.—WHEAT-PRODUCTION PER HEAD.

Crop year.	Bushels.	Bushels per head of population.
1879	459,479,505	9.2
1869	287,745,626	7.5
1859	173,104,924	5.6
1849	100,485,944	4.3
1839	84,823,272	5.0


MAP OF THE
UNITED STATES
SHOWING THE RELATION BETWEEN THE
PRODUCTION OF WHEAT
IN BUSHELS AND THE TOTAL AREA IN ACRES
Compiled from the Returns of Agriculture at the Tenth Census.
1880.
LEGEND
I Less than ½ bushel per acre of total area
II ½ to 1
III 1 to 5
IV above 5
NOTE
The absence of color indicates a population of less than 2 to a square mile being practically an absence of settlement
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
DAKOTA
NEBRASKA
KANSAS
COLORADO
UTAH
ARIZONA
NEW MEXICO
TEXAS
INDIAN TERRITORY
ARKANSAS
MISSOURI
IOWA
MINNESOTA
WISCONSIN
ILLINOIS
OHIO
PENNSYLVANIA
VIRGINIA
KENTUCKY
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
MISSISSIPPI
PUBLIC LANDS
LAKE SUPERIOR
LAKE ONTARIO
LAKE ERIE
LOWER CALIFORNIA

The remarkable fact here seen is not the great increase in the production, but the increase per capita of population, notwithstanding that during this period the country gained in population as no country ever did before.

In any country or district the production of wheat in quantities more than sufficient for the population and as a successful commercial product is regulated and controlled by a complicated variety of conditions, each one of which differs in force in the different districts or countries, and also varies in different years. The districts differ among themselves in the fertility of their soil, the ease with which they are tilled, adaptability to the use of labor-saving machines, markets, facilities for transportation, suitability of climate, reliability of crop, prevailing diseases, insect enemies, systems of land tenure, local traditions, and customs and sentiments of the people. Some of these local differences are permanent, others change slowly; still others change rapidly but continuously in one direction, and still others are very inconstant, and fluctuate this way or that way from year to year. For example, the different seasons are unlike; the ravages of insects are not the same in different years; diseases are more apt to prevail some years than others; the market price, which is determined by the magnitude of the crop in those places which stand in competition, varies greatly. These and other conditions more or less favorable are all of them factors in a very complicated problem. But in this country, and under our system of land-tenure, the immediate commercial importance of the wheat crop is practically controlled by comparatively few conditions. Over most of the American wheat-growing region the climate is reasonably certain, and the total area is so large that droughts or other climatic mishaps, materially injuring the crop in one district, never extend to the whole country, so that we may say that our controlling conditions are, in addition to a suitable climate, land of easy tillage, admitting the use of labor-saving machines and facilities for transporting the crop. We have a great variety of soil sufficiently fertile for good crops, so far as mere chemical fertility is concerned, and over much of the country a climate favorable for the production of grain of a good quality where yet comparatively little wheat is grown. This is partly because of unsolved problems in transportation, partly due to distance of markets, partly to differences in ease of cultivation, and partly to the production of other and locally more profitable crops. The element of cheap land is not so important in practice as is popularly supposed. In the ten states producing three-fourths of the crop the average value of wheat lands, as returned in the answers to the special schedule, is over $30 per acre, much of it $50, $60, or $70 per acre, many grain farms reaching $100 or more per acre. The aggregate quantity of wheat grown on the new cheap lands is comparatively small compared with the whole production of the country.

There is but little wheat land east of the Hudson river, and although New York and Pennsylvania produce considerable wheat, the great bulk of the wheat country lies west of those states, beyond the 77th meridian and the Appalachian chain of mountains and north of the Ohio river. It is a region possessing a fertile soil, but the physical character of the soil is more characteristic than its chemical composition. The most of it is easily tilled; it is not obstructed with loose rocks or stones; is comparatively level or but gently rolling; is possessed of a climate which in average years has sufficient rain during the growing season for the crop, and is hot and dry during the season of ripening and of harvesting; so that, if the crop is actually grown, it is rare that it cannot be harvested in good condition.

The estimates of acreage and of total production of wheat by the United States Department of Agriculture, for the years since the previous national census enumeration, are as follows:

TABLE XXX.—ESTIMATED CROPS.

Crop.	Acres.	Bushels.	Crop.	Acres.	Bushels.
Total crop of 1880	36, 037, 050	480, 849, 723	Total crop of 1874	24, 967, 027	308, 102, 700
Total crop of 1879	32, 545, 950	448, 756, 630	Total crop of 1873	22, 171, 676	281, 254, 700
Total crop of 1878	32, 108, 560	420, 122, 400	Total crop of 1872	20, 858, 359	249, 997, 100
Total crop of 1877	26, 193, 407	365, 094, 800	Total crop of 1871	19, 943, 893	230, 722, 400
Total crop of 1876	27, 627, 021	289, 356, 500	Total crop of 1870	18, 992, 591	235, 884, 700
Total crop of 1875	26, 381, 512	292, 136, 000			

The general progress in wheat production which has accompanied the modern methods of culture, the use of modern machinery and improved means of transportation, is seen in the following tables of the twelve states leading in total production at each of the decades at which the cereals were enumerated:

TABLE XXXI.—WHEAT CROP OF 1839 (CENSUS OF 1840).

No.	State.	Amount of crop.	Per cent. of total production.	Cumulative per cent.	No.	State.	Amount of crop.	Per cent. of total production.	Cumulative per cent.
		Bushels.					*Bushels.*		
1	Ohio	16, 571, 661	20	20	7	Indiana	4, 049, 375	5	78
2	Pennsylvania	13, 213, 077	16	36	8	Maryland	3, 345, 783	4	82
3	New York	12, 286, 418	14	50	9	Illinois	3, 335, 393	4	86
4	Virginia	10, 109, 716	12	62	10	Michigan	2, 157, 108	3	89
5	Kentucky	4, 803, 152	6	68	11	North Carolina	1, 960, 855	2	91
6	Tennessee	4, 569, 692	5	73	12	Georgia	1, 801, 830	2	93

TABLE XXXII.—WHEAT CROP OF 1849 (CENSUS OF 1850).

No.	State.	Amount of crop.	Per cent. of total production.	Cumulative per cent.	No.	State.	Amount of crop.	Per cent. of total production.	Cumulative per cent.
		Bushels.					*Bushels.*		
1	Pennsylvania	15, 367, 691	15	15	7	Michigan	4, 495, 889	4	72
2	Ohio	14, 487, 351	14	29	8	Maryland	4, 494, 680	4	76
3	New York	13, 121, 498	13	42	9	Wisconsin	4, 286, 131	4	80
4	Virginia	11, 212, 616	11	53	10	Missouri	2, 981, 652	3	83
5	Illinois	9, 414, 575	9	62	11	Kentucky	2, 142, 822	2	85
6	Indiana	6, 214, 458	6	68	12	North Carolina	2, 130, 102	2	87

TABLE XXXIII.—WHEAT CROP OF 1859 (CENSUS OF 1860).

No.	State.	Amount of crop.	Per cent. of total production.	Cumulative per cent.	No.	State.	Amount of crop.	Per cent. of total production.	Cumulative per cent.
		Bushels.					*Bushels.*		
1	Illinois	23, 837, 023	14	14	7	New York	8, 681, 105	5	63
2	Indiana	16, 848, 267	10	24	8	Iowa	8, 449, 403	5	68
3	Wisconsin	15, 657, 458	9	33	9	Michigan	8, 336, 368	5	73
4	Ohio	15, 119, 047	9	42	10	Kentucky	7, 394, 809	4	77
5	Virginia	13, 130, 977	8	50	11	Maryland	6, 103, 480	4	81
6	Pennsylvania	13, 042, 165	8	58	12	California	5, 928, 470	3	84

TABLE XXXIV.—WHEAT CROP OF 1869 (CENSUS OF 1870).

No.	State.	Amount of crop.	Per cent. of total production.	Cumulative per cent.	No.	State.	Amount of crop.	Per cent. of total production.	Cumulative per cent.
		Bushels.					*Bushels.*		
1	Illinois	30, 128, 405	10	10	7	Minnesota	18, 866, 073	7	63
2	Iowa	29, 435, 692	10	20	8	California	16, 676, 702	6	69
3	Ohio	27, 882, 159	10	30	9	Michigan	16, 265, 773	6	75
4	Indiana	27, 747, 222	10	40	10	Missouri	14, 315, 926	5	80
5	Wisconsin	25, 606, 344	9	49	11	New York	12, 178, 462	4	84
6	Pennsylvania	19, 672, 967	7	56	12	Virginia	7, 398, 787	3	87

The distribution by latitude shows that 58.2 per cent. is grown between the thirty-eighth and forty-second degrees of latitude, and 83.1 per cent. of the whole production, or about five-sixths, between the thirty-seventh and the forty-fourth, the principal wheat-fields above 44° being the Red River region, in Dakota, in a portion of Oregon, and in Washington, while the portion below the thirty-eighth degree embraces an important share of the wheat of Missouri, Kansas, and notably of California, and a somewhat considerable amount is found scattered over the states east of the Mississippi river and south of the same parallel. The distribution by topographical divisions (Table XVI, p. 11) shows that 125,501,556 bushels, or 27.3 per cent., is produced in what is called the prairie region. Next follows the central region, producing 79,899,788 bushels more, or 17.4 per cent., and next the upper Mississippi belt, producing 43,983,600 bushels, or 9.6 per cent.; these three topographical divisions producing 54.3 per cent. of the whole crop.

The tables of distribution according to drainage basins (Table XVII, pp. 12, 13) show, of course, that the great wheat-fields of the continent are drained by the Mississippi, the separate basins of which are best seen by the tables themselves.

The table of distribution by elevation (Table XVIII, p. 13) shows that 239,999,748 bushels, or 52.2 per cent. of the crop, grow between 500 and 1,000 feet above the sea level, 118,059,847 bushels, or 25.7 per cent., between 1,000 and 1,500 feet, and 53,211,980 bushels, or 11.6 per cent., between 100 and 500 feet; that is, about 93.8 per cent. of the whole crop is produced at elevations below 1,500 feet. The most notable wheat region lying on the upper verge of this or above it is that found on the plateau of eastern Oregon and Washington territory.

While the successful cultivation of wheat in a commercial sense is determined by a complicated set of conditions, in an agricultural sense the matter is very much simpler. The yield and quality of the crop practically depend upon but five conditions: the climate, the soil, the variety cultivated, the method of cultivation, and the liability to destruction by insects. Even under poor cultivation and exemption from insect depredations, if the other three conditions are favorable good crops of wheat of good quality may be very often grown, and in a good climate, and with a good variety of wheat, an excellent quality may be grown even where the soil is comparatively poor. The yield may be small, but the grain itself will be good.

As regards soils, we may say in a general way that light clays and heavy loams are the best for wheat. On the one hand very heavy clays often produce good crops, both as to yield and as to quality; and on the other hand the lighter soils may yield a good quality; it is simply smaller in quantity. The best crops, however, come from moderately stiff soils, but any fertile soil will produce good wheat if all the other conditions are favorable.

Geologically considered, the most of the wheat grown in the United States is over the region of drift, but much of the wheat soil has been so modified by other geological influences that the geological factor is not an important one, the essential character which gives it its value being as largely physical as chemical. Good wheat lands agree in this: that they are sufficiently rolling for natural drainage, are at the same time level enough to admit of the use of field machinery, and are easily tilled, admitting the use of light field implements in their tillage, and thus allowing of a very large production of grain in proportion to the amount of human labor employed. The facility of putting in the crop and harvesting it is really the controlling condition in many localities; so much so that very important wheat regions, where some of the most speculative farming of the United States is practiced, is in regions where the climatic conditions are such that the average yield, one year with another, may be as low as ten bushels per acre. In such cases this low average is usually due to climatic reasons rather than to a lack of fertility in the soil, and in favorable years the yield may be very much larger. The ease of cultivation, the facilities of gathering the crop, and its good qualities in favorable years, incite to the hope that all years will be favorable, and in good years the profits are large. In color, in the amount of clay contained, in physical and in chemical characters, there is much difference in the different soils of the country. Some contain much vegetable matter, others but little. We may say that the soils of all the more important wheat regions (so far as we have chemical analyses) are rich in lime as well as in those other elements of fertility, such as potash and phosphoric acid, which are necessary for a good crop and a good quality of grain.

For commercial as well as for agricultural success climate is an all-controlling condition. Wheat is normally a winter annual. For a good crop the seed must germinate and the young plant grow during the cool and moist part of the year, which season determines the ultimate density of growth on the ground, and consequently mostly determines the yield. It ripens in the warmer and drier parts of the year, which season more largely determines the quality, plumpness, and color of the grain. In climates with winters so cold that all vegetable growth is suspended we have two distinct classes of varieties, known, respectively, as spring and winter wheats. Throughout all the northern states, from ocean to ocean, and to some extent in those southern states which lie east of the great plains, these two classes of varieties are very distinct as regards their cultivation, and to some extent also as regards their characters. In California and in similar climates, as in Egypt, this distinction does not exist in respect to their cultivation, although the varieties partake more of the character of winter wheats than of spring, both in their mode of growth and in the character of the flour made from them.

But in all climates and whatever variety may be grown, the crop must be sown and have its early growth in a cool part of the year. Wheat branches only at the ground and produces no more heads than stalks, and it only sends out these branches early in its growth or during cool weather, and when the growth is comparatively slow. The branching of wheat (called "tillering" in the Old World, and "stocking", "stooling," and "tillering" in different sections of this) must take place before the plant attains any considerable height or it does not occur at all. Hence, in climates like those of the northern and eastern states this takes place mostly in the spring, and a cool, prolonged, and rather wet spring is therefore best for the ultimate yield of the crop; the grain then stands heavier on the ground. On the contrary, a warm, rather dry, rapidly growing and early spring in those parts of the country diminishes the yield of wheat, because of this habit of growth; there are then fewer stalks, and the heads are fewer. Consequently, when from the nature of the season or the general climate of the region there is an undue tendency for the wheat to shoot up without sufficient branching, it is common to check the growth by pasturing off the grain in the early spring, as is a common practice in many of the southern states.

In a country of cold winters, for good crops it is better that the ground be continuously covered with snow. Bare ground, freezing and thawing, now exposed to cold and dry winds and now to warm sunshine, is exceedingly destructive to wheat. It "winter-kills" in two ways: it may be frozen to death by cold, dry winds, or, as is more often the case, particularly on soils rich in vegetable matter, it "heaves out", and by the alternate freezing and thawing of the surface-soil the roots are lifted out of the soil and the young plant perishes. The means of guarding against this or of lessening the danger will be spoken of later.

After the wheat comes in head more sun is needed and less rain. Too much rain, particularly if accompanied with heat, induces rust, mildew, and other diseases, and, on the other hand, too dry winds shrink the grain.

The ideal climate for wheat is one with a long and rather wet winter, with but little or no frost, prolonged into a cool and rather wet spring, which gradually fades into a warmer summer, the weather growing gradually drier as it grows warmer, with only comparatively light rains after the blossoming of the crop, just enough to bring the grain to maturity, with abundant sunshine and rather dry air toward the harvest, but without dry and scorching winds until the grain is fully ripe, and then hot, dry, rainless weather until the harvest is gathered. This ideal is nearer realized in the better years in California than in any other part of the United States, and it is there, in such years, that we find the greatest yields known to the country.

The quality of the grain is largely determined by the climate, a hot, dry, and sunny harvest-time being best for wheat of the first grade. The berry is then brighter, and millers say the quality is better if the climate has been reasonably hot and dry before harvest. The wheat of sunny climates, those of California, Egypt, northern Africa, and similar countries, has always ranked high for quality, and the statement is often made that the wheat of such climates is also richer in gluten—that is, makes stronger flour—than the wheat of cooler climates. Of this latter assertion I find no proof from the modern and fuller chemical analyses. The chemical composition depends more upon the variety cultivated than upon either soil or climate. The spring wheat of Dakota and Minnesota produces as strong flour as grain from a sunnier climate. It is true that certain varieties of very hard wheats only grow in hot, dry climates. Such is said to be the case with the best macaroni wheats, and it is claimed that the macaroni wheats of California are equal to the best of northern Africa or of southern Europe, and that the macaroni made from it in San Francisco is equal to the best Italian. But while, as a whole, the quantity of gluten and the strength of the flour is determined more by the variety of wheat than by the climate or the soil, yet both of the latter have their influence on chemical composition. Although direct chemical evidence is lacking, derived from a large number of chemical analyses from samples chosen with this especial object in view, it is claimed that abundance of phosphates in the soil increases the quantity of gluten in the crop. The millers of western New York say that the flour has grown stronger with the increase in the use of superphosphates in growing wheat in that region, and the same has often been stated as a fact in English experience.

The particularly bright character of American grain, however, depends upon the climate, rather than upon the soil. The sunny climate of the whole United States south and west of New England is favorable for this, and from the time of the first settlement of the colonies the bright color of American grain, as compared with that of northern Europe, particularly that of Great Britain, has been remarked.

The table of distribution according to annual temperature (Table XIX, p. 14) shows that the greatest production is where the mean annual temperature is between 50° and 55°; 173,895,149 bushels, or 37.8 per cent., being grown in this belt, and 136,401,822, or 29.7 per cent., where the mean annual temperature is between 45° and 50°. Adding these two, we see that 310,296,971 bushels, or 67.5 per cent., is grown where the mean annual temperature is between 45° and 55°. Considered in respect to the midsummer or July temperature (Table XX, p. 14), which has much to do with the ripening of the grain, our figures are of less interest in this crop, because over considerable regions of the country the crop is already ripe before July begins, notably in California. But we find that 223,852,371 bushels, or 48.7 per cent., grows where the mean temperature of July is between 70° and 75°, and 178,530,037 bushels, or 38.9 per cent., where the midsummer temperature is between 75° and 80°, or an aggregate of 87.6 per cent. where the July temperature is between 70° and 80°, and 97.3 per cent. where it is between 65° and 85°. While the ideal climate for wheat is one of mild winters, and some of the most noted wheat regions of the world are where snow and frozen ground are unknown or very rare (as in Egypt, India, and California), nevertheless, most of the wheat of the world grows in regions of cold winters.

The table of distribution according to mean winter temperature (Table XXI, p. 15) shows that in this country 46.6 per cent. grows where the mean January temperature is between 20° and 30°; 68.9 per cent. where it is below 30°; and it is safe to say that 70 per cent. of the wheat crop of the country is grown where the average January temperature is below the freezing point. This same condition marks most of the great wheat regions of the world.

The wheat countries (which are also the countries of oats, barley, and rye) are where the summer season only is the growing season, and the comforts of winter must be provided for by forethought and labor, and hence they are also the countries of labor, industry, and enterprise, and where the highest civilization has been developed, the result being correlated to these climatic conditions.

The table of distribution according to rainfall (Table XXII, p. 16) shows that 132,152,234 bushels, or 28.8 per cent. of the crop, grows with an annual rainfall of between 40 and 45 inches; 62.7 per cent. where it is between 35 and 50 inches; and 92.4 per cent. where the annual rainfall is above 25 inches; although some important wheat regions, notably those of California, are where the mean annual rainfall is less than 25 inches. We have an explanation of this in the seasons at which the rains fall. The table of distribution according to the rainfall of the growing season (Table XXIII, p. 16) shows that 220,656,637 bushels, or 48 per cent. of the crop, grows where from 20 to 25 inches of rain falls during this season, and 366,381,658 bushels, or 79.7 per cent., where the rainfall during the growing season is from 15 to 25 inches; 6.4 per cent. where it is below 15 inches, and only 1 per cent. where it is less than 10 inches—a fact of much significance for great tracts of our country.

HISTORY OF WHEAT.

Wheat has been known as the choicest and most desirable of bread-plants from the very earliest times. We are alike ignorant of its origin and of its native country. It was known in ancient Egypt and Assyria, and is often mentioned in the Old Testament. Egyptologists tell us that three thousand years before Christ (and some say more), at the very beginning of definite history, wheat was the most important of the cereals there cultivated. Numerous pictures show us the methods and implements of cultivation and gathering. It was sown by hand, The quality of the grain is largely determined by the climate, a hot, dry, and sunny harvest-time being best for wheat of the first grade. The berry is then brighter, and millers say the quality is better if the climate has been reasonably hot and dry before harvest. The wheat of sunny climates, those of California, Egypt, northern Africa, and similar countries, has always ranked high for quality, and the statement is often made that the wheat of such climates is also richer in gluten—that is, makes stronger flour—than the wheat of cooler climates. Of this latter assertion I find no proof from the modern and fuller chemical analyses. The chemical composition depends more upon the variety cultivated than upon either soil or climate. The spring wheat of Dakota and Minnesota produces as strong flour as grain from a sunnier climate. It is true that certain varieties of very hard wheats only grow in hot, dry climates. Such is said to be the case with the best macaroni wheats, and it is claimed that the macaroni wheats of California are equal to the best of northern Africa or of southern Europe, and that the macaroni made from it in San Francisco is equal to the best Italian. But while, as a whole, the quantity of gluten and the strength of the flour is determined more by the variety of wheat than by the climate or the soil, yet both of the latter have their influence on chemical composition. Although direct chemical evidence is lacking, derived from a large number of chemical analyses from samples chosen with this especial object in view, it is claimed that abundance of phosphates in the soil increases the quantity of gluten in the crop. The millers of western New York say that the flour has grown stronger with the increase in the use of superphosphates in growing wheat in that region, and the same has often been stated as a fact in English experience.

The particularly bright character of American grain, however, depends upon the climate, rather than upon the soil. The sunny climate of the whole United States south and west of New England is favorable for this, and from the time of the first settlement of the colonies the bright color of American grain, as compared with that of northern Europe, particularly that of Great Britain, has been remarked.

The table of distribution according to annual temperature (Table XIX, p. 14) shows that the greatest production is where the mean annual temperature is between 50° and 55°; 173,895,149 bushels, or 37.8 per cent., being grown in this belt, and 136,401,822, or 29.7 per cent., where the mean annual temperature is between 45° and 50°. Adding these two, we see that 310,296,971 bushels, or 67.5 per cent., is grown where the mean annual temperature is between 45° and 55°. Considered in respect to the midsummer or July temperature (Table XX, p. 14), which has much to do with the ripening of the grain, our figures are of less interest in this crop, because over considerable regions of the country the crop is already ripe before July begins, notably in California. But we find that 223,852,371 bushels, or 48.7 per cent., grows where the mean temperature of July is between 70° and 75°, and 178,530,037 bushels, or 38.9 per cent., where the midsummer temperature is between 75° and 80°, or an aggregate of 87.6 per cent. where the July temperature is between 70° and 80°, and 97.3 per cent. where it is between 65° and 85°. While the ideal climate for wheat is one of mild winters, and some of the most noted wheat regions of the world are where snow and frozen ground are unknown or very rare (as in Egypt, India, and California), nevertheless, most of the wheat of the world grows in regions of cold winters.

The table of distribution according to mean winter temperature (Table XXI, p. 15) shows that in this country 46.6 per cent. grows where the mean January temperature is between 20° and 30°; 68.9 per cent. where it is below 30°; and it is safe to say that 70 per cent. of the wheat crop of the country is grown where the average January temperature is below the freezing point. This same condition marks most of the great wheat regions of the world.

The wheat countries (which are also the countries of oats, barley, and rye) are where the summer season only is the growing season, and the comforts of winter must be provided for by forethought and labor, and hence they are also the countries of labor, industry, and enterprise, and where the highest civilization has been developed, the result being correlated to these climatic conditions.

The table of distribution according to rainfall (Table XXII, p. 16) shows that 132,152,234 bushels, or 28.8 per cent. of the crop, grows with an annual rainfall of between 40 and 45 inches; 62.7 per cent. where it is between 35 and 50 inches; and 92.4 per cent. where the annual rainfall is above 25 inches; although some important wheat regions, notably those of California, are where the mean annual rainfall is less than 25 inches. We have an explanation of this in the seasons at which the rains fall. The table of distribution according to the rainfall of the growing season (Table XXIII, p. 16) shows that 220,656,637 bushels, or 48 per cent. of the crop, grows where from 20 to 25 inches of rain falls during this season, and 366,381,658 bushels, or 79.7 per cent., where the rainfall during the growing season is from 15 to 25 inches; 6.4 per cent. where it is below 15 inches, and only 1 per cent. where it is less than 10 inches—a fact of much significance for great tracts of our country.

HISTORY OF WHEAT.

Wheat has been known as the choicest and most desirable of bread-plants from the very earliest times. We are alike ignorant of its origin and of its native country. It was known in ancient Egypt and Assyria, and is often mentioned in the Old Testament. Egyptologists tell us that three thousand years before Christ (and some say more), at the very beginning of definite history, wheat was the most important of the cereals there cultivated. Numerous pictures show us the methods and implements of cultivation and gathering. It was sown by hand,


MAP OF THE
UNITED STATES
SHOWING THE RELATION BETWEEN THE
PRODUCTION OF WHEAT
IN BUSHELS AND THE AREA OF IMPROVED LAND IN ACRES
Compiled from the Returns of Agriculture at the Tenth Census.
1880.
LEGEND
I Less than ½ bushel per acre of total area
II ½ to 1
III 1 to 5
IV above 5
NOTE
The absence of color indicates a population of less than 2 to a square mile being practically an absence of settlement.

reaped with a sickle, bound into sheaves, thrashed by the tramping of animals, and winnowed with a hand-fan or shovel, as wheat continued to be treated in other countries down to the last part of the last century. It was essentially winter wheat, being sown in autumn, and, so far as specimens have come down to us along with mummies and other objects of antiquity, it appears to have existed in several varieties, and was equal in character to the wheat of to-day. On this cereal was founded the wealth and power of the ancient Egyptians, and more land was devoted to it than to any other. The ease with which it was cultivated on the rich alluvial soil, the abundant harvests of grain and straw, the nutritious character of the grain itself, the many ways in which it was eaten, and finally, the wide commerce of wheat from the several ports on the Mediterranean, from one port on the Red Sea, and by land over the isthmus, brought merchandise and money back, making it, perhaps, the principal commercial product of the Nile valley which brought the Egyptians in contact with other people. The description of the culture of wheat among the ancient Hebrews corresponds rather closely with that of the Egyptians. That they cut it high, leaving much of the straw as stubble (the Hebrews in bondage had to gather stubble for straw); that it was generally formed into sheaves, and thrashed with animals, are all shown in numerous passages in the Old Testament. Wheat was also an important crop in ancient Assyria; and in those sunny climates the grain produced is still of excellent quality, resembling that grown in California.

From those early days in the world's history the methods of wheat culture made no very considerable progress until the middle or last part of the last century. In this age wheat has greatly supplanted the other bread grains of previous ages. Rye, buckwheat, barley, and oats have largely lost their place as bread grains among people of our civilization, and the change is rapidly going on in other countries. It is, perhaps, about complete here and in Great Britain.

With present methods of production and transportation wheat travels much more than half way around the world, and the farmers of the upper Columbia, California, Dakota, Illinois, Russia, and India compete in the same markets. The English laborer, who, thirty years ago, ate rye bread, now buys his wheaten loaf, the grain for which may have been grown in either of these widely distant regions.

VARIETIES OF WHEAT.

Wheat exists in countless varieties. During all the long history of its cultivation, under the influences already detailed, when speaking of varieties in general, new kinds have been forming, until now these are numberless, differing so widely from each other that botanists and farmers alike are not agreed as to what were originally different species to begin with and what were varieties induced by man's cultivation.

All the many varieties of wheat, as well as those of spelt, belong to the genus *Triticum*, some botanists believing that both wheat and spelt constitute but one species; others, two (the wheat varieties constituting one and the spelt the other); while still other writers have made three, four, five, seven, or even more species. It has been lately advocated that wheat originated in a plant still found growing wild on the shores of the Mediterranean sea, the *Ægilops ovata*, and certain experiments in France appear to countenance this belief; but the matter is by no means demonstrated, and it probably will always remain an unsolved problem.

Varieties of wheat are now practically innumerable. How many there are is not known, and probably never will be, because there is no standard of agreement as to the amount of difference necessary to constitute a variety. There are several collections numbering some hundreds of varieties each.

The extreme forms are very unlike; they differ in the size and shape and physical character of the grain. Some are long, some are short; some have thick bran and some thin; they are brown, red, amber, and white; some soft and starchy, others hard and flinty; some are sown in the fall, some in the spring; most of them have simple heads, but some have branched heads; they differ in their chemical composition, some containing more starch and others more gluten; some are hardier than others, and so on through all of their essential characters, and, as with the other cereals, new varieties are continually originating and old varieties passing out of use. In the Old World some varieties are grown only for straw for the making of hats and other plaited goods.

The whole profit of wheat-growing in any region depends upon the variety cultivated (there is no locality, no matter how favorable, that will profitably grow all), and yet from the very nature of the case the whole nomenclature of varieties is very vague, and, except in a comparatively few cases, a name for a kind of wheat has but very little value. Because of the importance of this it is the subject of continual experiment among practical farmers in each and every wheat-growing region of the world, and every agricultural college and experimental farm or other public institution having for its object the furtherance of agriculture, if situated in a wheat-growing region, devotes more or less study and care to this subject. But experiments made in one place have little immediate value in another, although a number of series in the United States have especial value upon the subject at large, notably those made at the agricultural college in Michigan and on the farms of the state universities of Ohio, Minnesota, Wisconsin, Missouri, and California. Extended tables have been published, and the literature of the subject of varieties in the agricultural journals is very large. In answer to questions 18 and 19 in the special schedule ("What varieties of winter and spring wheat are most commonly grown"?) the answers were sufficiently numerous but exceedingly vague. There were 153 names of varieties of winter wheat and 74 varieties of spring wheat returned, and it is known that a number of popular varieties did not occur in this list. Moreover, the same variety is often returned under several names, and several varieties under the same name. Each investigation, wherever made, shows essentially this same fact: the nomenclature of varieties of wheat cannot be depended upon; all is confusion. A new variety is often well marked, but, as its cultivation spreads, changes occur in it in different localities. Soon prominent cultivators here and there add popular descriptive adjectives to the name; others mistake the variety, or through ignorance distribute it under other names, until any and every variety that is widely cultivated comes soon to be known under many names, and a number of the varieties under the same name. The Fultz and Clawson varieties are reasonably well known and characterized, and yet each is known under a variety of names. Fife may have once been, but now we have so many Fifes that it hardly means anything. We have the simple Fife, and Hard Fife, and Red Fife, and Scotch Fife, and White Fife, and Siberian Fife, and Minnesota Fife, and Canada Fife, and so on through a long list of Fifes returned in the schedule. So, too, we have Club; but also Big Club, Little Club, Chili Club, Canada Club, Sonora Club, Oregon Club, and so of any variety, like White Flint, which may have once had a definite meaning it has not now. The same may be said of Mediterranean, Black Sea, Odessa, and other popular well-known names used at the present time; they really have ceased to mean definite varieties, but rather a group or class of varieties.

Yet in practice the whole profit of wheat-growing in any locality depends upon the variety cultivated. The various agricultural colleges, in the experiments alluded to, have done what they could to bring order out of this confusion of names, and have been of much use in identifying such varieties as are locally cultivated, and classifying them and giving much information regarding their relative value where the special experiments are made. They have also a general value because of the light they throw upon principles involved, but they bring out in a very strong light the fact that no empirical rules can be laid down as to the comparative excellence of varieties far away from the locality where the experiments are made. The principles already stated regarding varieties of all cereals must be remembered. In wheat, as in the rest, no general rule can be given which will apply to all varieties as to either their value or their endurance. Some are exceedingly enduring; others change easily with time or with change of culture. Some varieties remain popular in the same region through many years; others are very profitable at first, but soon cease to be; and whether a variety is to be enduring and long continue to be a profitable one in any locality depends entirely upon the variety itself. There is no general law of endurance of character or excellence; the economic value of each one in each place can only be determined by the experiment of actual use. Varieties that do well for a time and then do poorly must be discontinued, or again improved by special cultivation.

The change in varieties, it must be remembered, occurs from a variety of causes. It may come because of a change in the conditions of the soil or in cultivation. Fashions change, the demands of market change, and other conditions change. Insects sometimes attack one variety more than another, and thus they increase where that variety is much grown, or diseases or mishaps of one kind and another may come and attack an old variety and demand that a new one be brought in its stead.

There is much discussion as to whether varieties of wheat tend to deteriorate or wear out naturally, and this has been the subject of much study and experiment. The best indications of science are, that they need not wear out or change materially if the same conditions which made them excellent are kept up. Varieties taken to a new place may not be enduring in that place, but in some locality each variety may be maintained. In practice this is generally not done in the regions of the largest production, and where wheat-growing is conducted on the largest scale. The preservation of the excellence of varieties turns mostly on the proper selection and preparation of the seed and on careful cultivation, and neither of these is usually so carefully conducted on those farms where a large breadth is sown as on smaller farms. On farms of moderate size seed-wheat is more often extra cleaned, sometimes hand-sifted, that all the smaller and imperfect grains may be taken out. It may undergo treatment to insure that only the proper kind of seed is sown, but where the cultivation is carried on on a large scale it almost always happens that such care is not extended, and then, from the very nature of the case, the variety deteriorates, or at least the quality of the grain produced deteriorates. This happens in several ways. In the first place, less care in the selection and cleaning of seed is taken, and shriveled, shrunken, and imperfect as well as good grains are sown. It is like the stock-breeder breeding from the good and poor animals of his flock indiscriminately; the breed is bred down. Again, the crop itself is not so carefully tended where the fields are very large. Weeds increase, and their seeds get mixed with the grain and injure its appearance and its grade. Moreover, different varieties of wheat are often mixed together, and the result of all this is that the grade of wheat produced under such circumstances lowers year by year. This is the story in any new wheat region; first, pure wheat is sown, and the quality and grade are most excellent, but deterioration comes on almost inevitably. I have made special investigations on this point, and the testimony is almost universal among millers, chambers of commerce, produce exchanges, and similar organizations that such deterioration has taken place largely because of the carelessness of cultivation. In California there is still another cause, the volunteer or self-sown crop, the grade of which deteriorates.

While popularly any deterioration is often attributed to the exhaustion of the soil, in this country I think that it has been more often actually due to the carelessness of cultivation and carelessness in the selection and preparation of the seed than to soil exhaustion. It must be remembered that improved varieties are very artificial productions.

There is nothing like them in nature. They have been produced by man's labor and care, by long-continued selection of seed or by special care of some kind, and they can only be maintained by similar care. When this is relaxed, then the variety is not sustained; and if the conditions which produce it are not maintained, then the character and excellence of the variety cannot be. Special varieties will be mentioned in connection with special wheat-growing districts.

The nutritious character of flour depends upon its chemical composition, but its market value depends as much upon its appearance as upon its nutritive qualities. In the classification of varieties they are sometimes classified as bald or bearded; sometimes as hard or soft, or as red and white, or as winter and spring. There is no essential difference in the quality of bald and bearded wheats, but bearded varieties are considered, as a whole, more hardy, and some bald varieties become bearded by continued cultivation on a poorer soil or under poorer conditions. As the quality deteriorates the beard increases. The white or red or brown or amber color of the grain is no index of the color of the bread produced from its flour. Color is given to bread largely from the germ and from certain cells lying just within the epidermis. The outer bran may be removed from wheat and the flour be of tolerably good color, and still the bread made from it be very dark if it contain any considerable portion of this coloring matter, which generally, under the old style of milling, passes into the middlings.

Under the old systems of milling, when rarely more than two grades of flour were made from the same grinding, and often but one was made, beside the middlings and the bran, soft wheats, as they were called, were more popular, but with the new processes of milling, largely brought into use in this country within the last dozen years, this has entirely changed. The so-called "patent flour"—flour produced by rollers, by gradual reduction, by high grinding, etc.—has materially changed the relative value of the different varieties of wheat. In Dakota and in northern Minnesota winter wheat is scarcely grown, the product being practically all spring wheat. A few years ago this ranked from 10 to 40 cents per bushel less than winter wheat, but under these new processes of milling, by which millers are enabled to separate the coloring material from the nitrogenous portion, or gluten, as it is properly called, a flour of good color and great strength can be produced from it, and at the present time good spring wheat ranks in value higher than the softer winter wheats. The reason for this will be shown in the special report on Milling, and need not be followed further here.

The number of "grades" differs according to local conditions. In some places, as in San Francisco, where only winter wheat is in the market and most of the sales are in specific lots, there may be but three, or at most four, grades officially recognized; but in eastern markets, where both winter and spring wheats, with red and white wheats of each, are sold, there are more, it may be but six or eight, or there may be a dozen "grades", beside the "ungraded". Local rules vary, but year by year the methods of commerce bring the different places into more and more uniformity of practice.

There is a considerable difference in the weight of wheat per bushel, the actual weights ranging from 54 or 55 pounds to 64 or 65 pounds, but the weight everywhere recognized as a bushel in this country is 60 pounds, both by law and by custom. When the wheat falls below 57 pounds the quality is decidedly inferior, and when above 61 it is considered exceptionally good. It is in only very rare cases that it rises to above 63 pounds.

The bushel in common use in the United States is the Winchester bushel, containing 2,150.42 cubic inches. The imperial bushel of the United Kingdom contains 2,218.192 cubic inches, or about one thirty-second more; therefore wheat weighing 60 pounds per Winchester bushel weighs 61.89 pounds per imperial bushel. This is the reason why the weight of English wheat, as given in ordinary works and reports, appears so much greater than American.

The size and plumpness, and consequently the average weight of wheat kernels vary very much between the different varieties and with the same variety in different years. I have calculated the number per pound and per bushel of several samples, by weighing small portions on a chemical balance and carefully counting the grains, as a basis for computing the number per pound avoirdupois and per bushel. The following table gives the results. In numbers 1 and 2 the grains are very long; in 9, 10, and 11, round and plump. None of them are badly shrunken, and several are of the samples analyzed:

TABLE XXXV.—SHOWING NUMBER OF GRAINS OF WHEAT PER POUND AVOIRDUPOIS AND PER BUSHEL OF 60 POUNDS.

	Variety.	State.	Grains per pound.	Grains per bushel.
1	Macaroni wheat	California	7,443	446,580
2	Macaroni wheat	...do	8,822	529,320
3	Australian winter (very plump)	Oregon	9,450	567,000
4	Little Club (very plump)	...do	10,188	611,280
5	White Australian spring	...do	11,214	674,040
6	White Sonora spring	...do	11,330	679,800
7	White winter	New York	12,236	734,160
8	Amber bearded spring	Maine	13,743	824,580
9	Red winter, No. 2		14,227	853,620
10	Milwaukee Club		15,165	909,900
11	Red winter	New York	16,199	971,940

It will be noticed from the tables of analysis of whole wheat ("wheat in the kernel") that there is considerable difference of composition between the different varieties and between specimens in the same variety. The so-called strength of wheat, that upon which the lightness of bread depends, is related to what is called the gluten, which in the tables of chemical analyses is included in the "albuminoids", and in the 57 samples of winter wheat analyzed this varied from 8.4 to 14.5 per cent. The amount varies in the same variety of wheats, as noticed in the large number of analyses of Clawson wheat from Michigan, which vary among themselves from 10.9 per cent. to 12.4 per cent. of albuminoids. So, too, of Diehl, the albuminoids (which we may take as representing gluten) varying in four samples from 11.8 per cent. to 13.8 per cent. So, too, of Fultz, from three or four states the albuminoids in the four analyses varying between 11.1 and 14.5 per cent. The average of all the analyses of winter wheat and all the spring wheats show that the spring wheats average about 1.3 per cent. more albuminoids than the winter wheats, and this is why, with modern milling processes, they make the stronger flour. The range is also greater than among winter wheats, the poorer spring wheats having but 8.1 and the best 15.5 per cent. albuminoids.

The chemical composition of the grain and its value as a bread-plant not only vary greatly in the different varieties, but also in the same variety from year to year and on different soils, and also vary with the effect of manures. In the extensive series of analyses that have been made by Messrs. Lawes and Gilbert, at Rothamsted, in England, we will merely cite the results of a series of tables showing the amount of albuminoids in wheat grown on unmanured and manured land for a series of years continuously. Several analyses of each crop were made, but only the means are cited. The following table gives the results; the first represents the extreme and the mean of the ten successive harvests from unmanured land; the second, from ten harvests of land manured with ammoniacal salts only; the third represents nine successive harvests grown on soils manured with ammoniacal salts and various mineral manures. The figures given as maximum and minimum do not mean the least and the greatest amount found in any single sample, but the mean of the harvest of that year, and represent the mean of the three, four, or five analyses, according to the number made of that variety:

TABLE XXXVI.—ALBUMINOIDS IN THE DRY MATTER OF WHEAT (KERNEL) GROWN AT ROTHAMSTED FOR TEN SUCCESSIVE YEARS ON THE SAME PLATS OF GROUND.

Fertilizers used.	Minimum in ten years.	Maximum in ten years.	Average of ten years.
Unmanured	11.25	14.63	13.29
Manured with ammoniacal salts only	12.19	15.50	14.14
Manured with ammoniacal salts and mineral manure	12.37	15.06	13.75

These averages illustrate several important items: the first is, that the same variety under the same treatment varies much in different years; second, that the manured average richer than the unmanured; and, third, the greater difference comes from the use of nitrogenous manures.

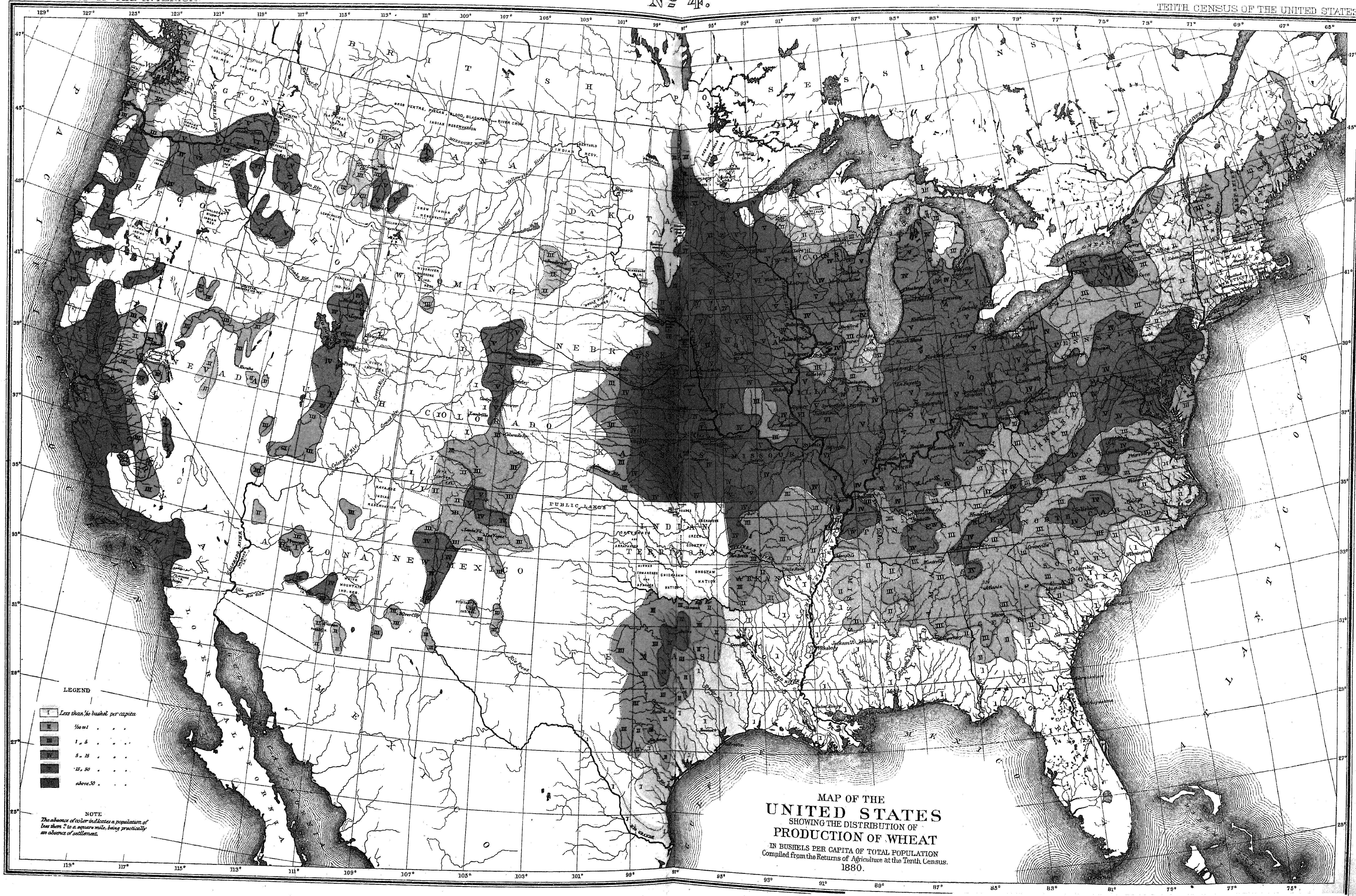
Many years ago Davy found the wheat of Sicily richer in gluten than that of England, and this appears to have led to a hasty generalization, that the wheat of warm climates was stronger than that of cooler ones. It has been claimed that the wheat of northern Africa was stronger, that is, contained more gluten, than that of northern Europe. So far as our analyses of American wheats show, this is not proved to be the case here. Undoubtedly climate as well as soil affect the amount of albuminoids, but we have no evidence that the California wheats are, as a class, richer than those of the other regions, or the wheats of the southern states richer than those of the northern.

There are differences naturally existing in the composition of wheat flour similar to the differences existing in the grain. Of the 49 analyses given in our tables, and representing the labor of various analysts, the average amount of albuminoids is somewhat less than the average amount in all of the wheats, but there is a similarly large range, some sinking as low as 8.6, and others running as high as 13.6, the starch and the albuminoids standing in opposite relations to each other. The flours rich in gluten are what are technically called "strong" flours, while those rich in starch do not easily make so light a bread, but are more especially "pastry flours".

Under the modern systems of milling already alluded to the amount of flour made from a given amount of wheat is not only greater, but the number of kinds or brands of flour has also greatly increased, each with its special characteristics and special properties.

Tables of chemical composition of the wheat grain and the wheat flour show why wheat bread is, on the whole, the most nutritious of breads, in that it is richer in albuminoids. The special excellence of wheat bread, however, is largely due to the fact that the gluten itself has other properties than the albuminoids found in other cereals, which make it more digestible and susceptible of making a lighter bread. An oat meal having a nutritive value equal to wheat flour will not make a light bread. The albuminoids of the different cereals are similar in chemical composition, but unlike in their properties, and those found in wheat, called "*gluten*", have an especial character, known as paniferous qualities, in a much greater degree than the albuminoids of any other grain.

Wheat contains less oil than corn, and this is probably one reason why wheat flour is more easily preserved than corn meal. In the grain of wheat there is more oil in the germ than in the body of the grain, and modern


MAP OF THE
UNITED STATES
SHOWING THE DISTRIBUTION OF
PRODUCTION OF WHEAT
IN BUSHELS PER CAPITA OF TOTAL POPULATION
Compiled from the Returns of Agriculture at the Tenth Census.
1880.
LEGEND
I Less than 1/10 bushel per capita
II 1/10 to 1 " " "
III 1 " 5 " " "
IV 5 " 15 " " "
V 15 " 50 " " "
VI above 50 " " "
NOTE
The absence of color indicates a population of less than 2 to a square mile, being practically an absence of settlement.

methods of milling, which remove the germ (because it somewhat discolors the flour and bread made from it), and deprive it of a slightly larger proportion of oil than did the old-fashioned methods. In the analyses of flours given in the tables of chemical composition the average amount of oil in five "straight" flours is 1.38 per cent., while in eight "patent" flours it is 1.24 per cent.

The thickness of the bran is represented in the analyses by "fiber", and in some varieties we find the amount to be about twice as great as in others, ranging from a trifle less than 1.2 to 2.3 per cent. As a general rule, the bran is thinner on upland wheat than on lowland, and on white wheat than on red. Its thickness also depends somewhat on the time of cutting, as is shown in Dr. Kedzie's analyses illustrating the time of cutting wheat. There is a popular belief among millers that most of the oil contained in wheat is found in the germ, and that by the removal of the germ the oil is removed. The analyses of flours, however, do not bear out this supposition. The average quantity of oil in the flour is somewhat less than in the whole grain, but the amount is nevertheless quite notable. The claim of the greatly superior character of Graham flour, because of its being richer in albuminoids, is not borne out by these analyses. The average of the few Graham flours examined was a little higher than the average of all the other flours in gluten; but it must be remembered that this flour is generally made from wheat of a quality that is rich in albuminoids, while for special purposes many of the whiter flours, notably the pastry flours, are poor in them, and their analyses bring down the general average in the total flour analyses. Two flours (Nos. 100 and 120 in the tables of analyses), called "flour from the entire wheat", are not coarse Graham, but fine flours, made from grain from which merely the outer cuticle has been removed. They are richer in albuminoids than the average analysis of fine flours, and make a very light and sweet bread, although dark in color, and probably have all of the advantages claimed for Graham flour, without its disadvantages. It is well known that the cuticle of wheat is comparatively indigestible, and if coarse Graham flour is superior to fine wheat flour as human food, it is chiefly on physiological rather than on chemical grounds. It is possible that its coarseness has physiological effects, but chemically it is not materially superior to modern new-process flour, except that it is richer in mineral ingredients.

Over most of the United States deep plowing is preferred in theory, although the most of the ground is plowed less than six inches deep, and much of it less than five. The cost and the rapidity of plowing have already been discussed.

On fallowed land, and where the ground is sufficiently smooth, the grain is usually sown directly on the furrows; if the ground is rough, it is harrowed before sowing. There is much difference in local customs in this matter, many preferring to sow directly on the furrows, unless the ground be very rough. Difference of soils and mere local fashions in part explain the preferences.

There are in this country two radically different methods of sowing (or planting) wheat: broadcast and in drills. In the first, the grain is scattered irregularly, and is covered irregularly as to depth with harrow, plow, or cultivator, as the case may be; in the second, it is left in rows or drills, usually 8 (7 to 9) inches apart, at a reasonably uniform depth below the surface. Broadcast sowing may be performed by hand or by machine; drilling only by machine. In the old countries another method, known as "dibbling", was formerly much practiced, and possibly may be yet; but it requires so much hand labor that it is no longer profitable, except under circumstances where competition is, for any reason, very restricted, and it was never practiced to any considerable extent in this country.

The advantages of broadcast sowing are, that if done by hand there is no need of the expense of a machine, and if done by machine it can be more rapidly done, some broadcast sowers sowing 50 or more acres per day. The advantages of sowing by drill are several, and are more especially applicable to winter wheat.

Under right conditions of climate and soil wheat that germinates at an inch or a little less below the surface is under the most favorable conditions for future growth; but if the ground is rather wet, by frequent freezing and thawing in the winter a portion of the surface is raised on small columns of ice and the fibrous roots are drawn upward, and when the ground thaws, and this is repeated, the roots are drawn out of the soil and exposed to the winds and the sun, and the plant is either killed outright or is very much injured in its growth. Where wheat is drilled-in, the operation of the drill leaves the seed deposited at a uniform depth and in the bottom of a slight furrow, and the same operation of freezing and thawing which tends to dislodge the wheat also tends to level down the ridges between these furrows, the soil falling over the roots and partially covering them. For this reason wheat that has been drilled-in "winter-kills" less than where it has been sown broadcast.

If we were sure of just the right amount of moisture in the soil at just the right time, and this moisture continued during the growth of the crop, then grain sown at a depth of less than an inch would be under the best conditions for future growth. The plumule would then easily and quickly reach the surface, and the nutriment stored in the grain would be sufficient for the formation of the first two or more vigorous green leaves, and also for the first roots. In germination the plumule rises as a single stalk from the crown of the roots, which grows at the point when the radicle and plumule emerge from the seed. This is the spot where the wheat-plant branches or "tillers". At the crown of the numerous fibrous roots new shoots form, each throwing out its own set of roots, so that they may be separated into independent plants, if that were an object. How many stalks and ultimate heads are produced from one seed depends upon the soil, the climate, and the variety. Theoretically, the limit is very high, quite often ten or fifteen heads being produced on a single plant, and in experimental cultivation a much larger number is often produced.

This very shallow planting of less than an inch is only best when all the conditions are right, but in practice this is seldom the case; so that the actual depth at which wheat is sown varies with the year and with the circumstances, ranging from 1 to 5 inches. When the seed is planted two or more inches deep, the germination takes place precisely as with shallower planting, but the greater the depth and the smaller the original seed the weaker the plumule is when it reaches the surface. Once above the surface, and with green leaves to absorb the nourishment from the air, a small enlargement grows on the plumule an inch or less from the surface of the ground. At this point a new crown of roots is produced, and for a time the plant grows with two masses of fibrous roots, one by the original seed and the other near the surface, the two connected by a portion of stalk of greater or less length, according to the depth at which the seed was originally planted. Both of these sets of roots for a time nourish the plant. On ground where wheat is liable to winter-kill it is customary to plant the grain more deeply than ordinary (either by drilling or by plowing it in to the depth of three or four inches) to insure this double set of roots, and thus to diminish the liability of winter-killing, the lower set acting as a sort of anchor and hindering the "heaving", and also to provide a double set of roots to preserve the life of the plant if the upper set be killed. Deep sowing is practiced also in times of great drought, where it is feared that the grain will either not start, or, if it starts, that it may perish in the dried surface soil.

In all of these cases the lower set of roots die at a comparatively early stage in the growth of the plant, and then the later and principal growth is nourished by the upper set alone, and at this point all of the tillering takes place. Of course, if there is no special end to be gained, it is better that the extra amount of vital energy required to produce this extra set of roots should not be expended, and deep covering is therefore only to be practiced where the gain on average years is greater than the loss sustained through this slight waste of vital energy.

In the older states, New York, Pennsylvania, and Ohio, more wheat is drilled-in than sown broadcast, but in regions of spring wheat, and where winter wheat is grown on a very large scale, if there is little or no danger of winter-killing, as in California, broadcast sowing is much more largely practiced. Done on a large scale, broadcast sowing with machines and covering with harrows is cheaper than sowing by drills, but on smaller farms, and in mixed farming, authorities differ as to the relative cheapness between broadcast sowing by hand and drilling by machine. Where drilled-in, from 15 to 30 pounds of seed less is generally used than where sown broadcast, but custom is not uniform in this respect.

As to quantities sown broadcast, in the middle states 7 to 9 pecks are common; in the West, 6 to 8 pecks; in California, 3 to 8 pecks, the smaller amount in the drier regions. Some varieties have to be sown thicker than others.

Everywhere east of the great plains the last few days of August or the first three weeks of September are preferred for the sowing of wheat. North of the Ohio river the last days of August or the first week in September is preferred, unless there are special reasons for sowing later.

Between sowing and harvesting wheat in this country receives practically no cultivation. Here and there it may be harrowed in the early spring, and on the black soils of the prairie region it is common to pass a roller over it. Sometimes on smaller farms it is weeded by hand, but I cannot find that anywhere wheat receives any spring or summer cultivation other than that mentioned.

THE TIME OF CUTTING WHEAT.

Numerous experiments have been made to determine the best time to cut wheat, and the average result of many trials, some of which were made long ago, has been that it is best to cut before the grain is dead ripe; that the quality of the grain is better, the yield larger, and that the flour made from such earlier cut wheat is better and whiter and the proportion of bran is less. The rule usually followed is to cut when the straw is already yellow below the head but more or less green in other places, when the kernel is past the milk and in the dough, soft enough to be easily indented with the thumb-nail, and hard enough not to be easily crushed between the fingers. The result of practical experiments in the flouring-mill has been that wheat cut at this stage will yield more flour with a smaller percentage of bran, and it has been claimed that wheat thus cut contains relatively more starch and less gluten, and is, practically, a "softer" wheat. It has also been frequently stated that the starch develops in the grain relatively earlier than the gluten, and that by letting the wheat stand until fully ripe the relative proportion of the latter is increased, and certain microscopic investigations apparently bear out this view.

In the summer of 1879 Professor R. C. Kedzie, of the agricultural college of Michigan, carried out at Lansing a most important series of experiments directly bearing upon this point, the results of which he has described in detail. The investigation extended to two varieties of wheat, the Clawson and Schumacher, specimens of which were cut on twenty-one successive days at the same hour in the day, and the grain from each of these, after drying, was subjected to chemical analysis. The method employed may be summarized as follows:

A field of Clawson wheat, which appeared to be very uniform in its growth and in the quality of the soil, was selected for one set of experiments, and another similar field of Schumacher wheat for a parallel set. Specimens were gathered of each at nine o'clock in the morning, beginning with June 29, 1879, and continuing for twenty-one successive days—a period embracing the progressive changes of the kernel from its early stage, and before the contents were milky in color, up to the time of dead ripeness. The Schumacher variety, however, was somewhat in advance of the Clawson, apparently about five days, through the whole series, and the kernel was in the milk at the first cutting. A sheaf of the cut grain, carefully labeled, was placed to ripen and dry in an airy room, and every sheaf was subjected to the same treatment throughout. When fully dry, the grain was beaten out by hand, winnowed, and preserved in glass jars for chemical analysis. The grain thus ripened on the stalk was slowly dried in a sheltered room under somewhat different conditions from what it would have been if thrashed out as soon as cut or if it had been dried in the sun and in the field; but the conditions were the same for all, and the grain, thus matured, would represent the results secured by ripening under the most favorable conditions of harvesting at the several periods of cutting. Observations were daily made on the weather during this period, and the following diary will give some idea of the condition and development of the berry and the ripening of the stalk at the successive periods of cutting. I also include a brief statement of the condition of the weather, which may assist in explaining the rapid changes which took place at certain stages of growth. In the central and western states the word "berry" is the common term for kernel of wheat, and I have retained it as originally written in the diary:

STATE OF WEATHER AND OF THE DEVELOPMENT OF THE GRAIN.

No. of cutting.	Mean daily temperature.	Degree of ripeness of stalk and berry of Clawson wheat at the several periods of cutting.	Degree of ripeness of stalk and berry of Schumacher wheat at the several periods of cutting.
1	77⅔°.—Cloudy	Stalk green; berry watery and immature; a little milky	Stalks green; berry milky, easily crushed by fingers; sweet.
2	75°.—Rain	Stalk green, and leaves rusted slightly; berry very immature; somewhat milky.	Stalk green; berry easily crushed by fingers; milky and sweet.
3	62⅓°.—Rainy	Berry milky and sweetish; color of berry, green	Berry more milky, but greenish; can be crushed by fingers; sweet.
4	68°.—Cloudy	Berry milky and sweet; still green in color	Berry yellowish, milky-dough; fingers stained by milk when being crushed.
5	70½°.—Clear	Berry milky, sweet, green; no dough	Straw becoming yellow; berry in milky-dough condition.
6	72⅔°.—Clear	Straw still green; berry milky, sweet, greenish in color; no dough	Berry in the dough; crushed between thumb-nails, stains them.
7	77⅓.—Cloudy and raining	Stalk green, but leaves yellow; berry more milky, sweet, yellow-green.	Straw purplish, but leaves green; berry in the dough and becoming yellow.
8	79°.—Hot and close, cloudy	Straw green, heads yellowish; berry yellow-green, thick milk, sweet.	Head brown; berry deep yellow, stiff dough; can be crushed by thumb-nails.
9	66⅔°.—Cooler and cloudy	Stalks and heads turning yellow; berry milky-dough, sweet	Berry brown, hard; difficult to crush between thumb-nails.
10	71⅔°.—Clear	Stalks and heads yellowish-green; berry less sweet and more doughy.	Berry crushes dry; grain harvested to-day.
11	78°.—Rain in night	Stalks yellowish; heads begin to bend; berry thin dough, a little sweet.	Straw purplish-red and fully ripe.
12	73°.—Rainy	Straw yellow; heads bend more; berry in the dough, only a little sweet.	Heads bend over; stalks becoming brown and leaves dry.
13	75⅔°.—Cloudy	Heads bend over; berry stiff dough	Ripe and over-ripe.
14	74°.—Clear	Berry crushes dry between thumb-nails; harvested to-day	Do.
15	70°.—Rain in night	Berry nearly dry and becoming hard; straw entirely ripe	Do.
16	75°.—Cloudy	Berry dry and hard; stalks a full yellow	Do.
17	73⅓°.—Clear	Stalks over-ripe; berry shells on handling sheaf	Do.
18	79°.—Clear	Stalks becoming brittle	Do.
19	81°.—Clear	Stalks becoming brown and brittle	Do.
20	85⅓°.—Cloudy	Manifestly dead-ripe	Do.
21	78°.—Cloudy	do	Do.

RELATIVE YIELD OF WHEAT AT EACH CUTTING.

To determine the relative yield, each sheaf was carefully thrashed and the broken kernels and foreign substances of every kind were removed, but no grains were removed in consequence of imperfect development. Ten grams of this were weighed, and the number of grains of wheat in that weight were carefully counted. This was repeated ten times for each specimen. The average was then taken, as representing the number of grains of wheat per ten grams' weight, and it was assumed that the gross product of grain at the several times of cutting would be directly as the average weight of the kernels and inversely as the number of kernels required to produce a given weight. Table XXXVII (page 72) shows the relative estimated yield in bushels per acre at the different periods of cutting, on the assumed estimate that each variety of wheat produced 30 bushels to the acre as its maximum. It will be seen that the Schumacher is a few days in advance of the Clawson, and that the growth of each variety proceeds by a somewhat irregular progression, the increase of growth bearing some relation to the temperature of the preceding day. No explanation is offered for the falling off in the seventh and twelfth cuttings of the Clawson and the eleventh and fifteenth cuttings of the Schumacher. It will be noticed that after the full ripening of the grain there is a slight but sensible decrease, showing that the common impression among farmers that there is diminished production when the harvest is delayed too long is well founded, and in this case this loss is not from careless handling of the grain or from the over-ripened grain being drier. The loss, though small, is a real one.

RELATIVE CHEMICAL COMPOSITION OF WHEAT.

The grain of each cutting was subjected to chemical analysis, the process being the same as that used in the analyses performed by the Census Bureau, except that the amount of water was determined by prolonged heating and drying at 100 degrees C. (212 F.), and then cooling in a desiccator, instead of 110 C. (230 F.), as in the other cases.

TABLE XXXVII.—YIELD AND COMPOSITION.

Number of cutting.	CLAWSON.		SCHUMACHER.		CLAWSON.			SCHUMACHER.		
	Number grains for 10 grams.	Bushels to acre.	Number grains for 10 grams.	Bushels to acre.	Albuminoids.	Fiber.	Ash.	Albuminoids.	Fiber.	Ash.
1	704	11.23	484	16.11	16.77	4.03	2.72	17.40	3.40	2.20
2	592	13.34	447	17.44	15.10	4.05	2.48	17.41	3.42	2.21
3	531	14.91	455	17.13	15.16	3.55	2.30	17.60	3.31	2.19
4	471	16.81	383	20.37	13.37	3.47	2.24	16.19	2.90	2.18
5	454	17.44	365	23.00	13.05	3.29	2.04	16.06	2.86	2.05
6	362	21.87	332	23.49	12.67	3.16	1.97	15.49	2.88	2.00
7	384	20.62	320	24.37	12.41	3.18	1.96	15.23	2.85	1.97
8	327	24.23	308	25.32	12.54	3.08	1.90	15.68	2.80	1.98
9	316	25.03	304	25.66	12.16	2.80	1.80	15.42	2.83	1.96
10	290	27.31	260	30.00	12.09	2.80	1.81	14.55	2.76	1.94
11	276	28.69	267	29.21	12.54	2.79	1.91	15.17	2.74	1.92
12	282	28.08	260	30.00	12.80	2.40	1.94	15.10	2.68	1.96
13	267	29.66	261	29.88	12.67	2.25	1.91	15.29	2.45	1.91
14	272	29.12	262	29.77	12.28	2.20	1.89	15.29	2.31	1.93
15	264	30.00	266	29.36	12.28	2.26	1.87	15.17	2.26	1.90
16	272	29.12	263	29.65	11.90	2.15	1.82	15.29	2.21	1.86
17	270	29.27	260	30.00	12.80	2.26	1.86	15.10	2.24	1.87
18	277	28.69	260	30.00	12.41	2.36	1.88	14.52	2.29	1.86
19	268	29.55	262	29.96	12.41	2.40	1.77	14.40	2.33	1.85
20	272	29.12	272	28.67	12.41	2.38	1.79	14.20	2.37	1.84
21	268	29.55	276	28.26	12.28	2.30	1.78	14.14	2.36	1.86

The "fiber" of these analyses is in the bran, and in ordinary wheats is from one and two-tenths to two and four-tenths per cent., or an average of about one and sixty-five hundredths per cent. In these samples it diminished from the earliest cutting, when it amounted to four per cent., to a minimum of about two per cent., and then rose as the grain became riper, showing that there is an increase of bran with over-ripening. The larger amount in the first cutting of the Clawson than that of the Schumacher is because of its more immature condition. A reference to the table will show that the highest percentage of albuminoids was found in the earlier stages of growth, and that it falls off regularly to the complete ripening of the seed, at which time the grain contains a smaller percentage of albuminoids than at any time before. The claim that gluten increases near the close of the process of ripening, and that the dead-ripe wheat is richer in gluten than wheat harvested somewhat earlier, is not supported by these analyses. The hard and flinty kernel secured by over-ripening is no richer in gluten, so far as these analyses show, than the softer kernel secured by earlier harvesting.

This refers to the percentage composition, and not to the aggregate production per acre; for while the albuminoids in the early stages of the growth constitute a larger proportion of the grain, as the crop develops all the constituents of the grain increase in quantity, but the starchy constituents increase relatively faster; so that there is an actual increase of albuminoids per acre, although there is a relative decrease per bushel. If the dead-ripe wheat is better for the miller than wheat cut earlier, it is in consequence of certain physical properties of the harder kernel, rather than from any increase in its percentage of gluten, or, as many express it, in its nutritive value.

One significant fact in the process of ripening is the rapid development of starch, both actual and relative. While the albuminoids increased in actual amount, the increase of the carbhydrates was so much more rapid that the percentage of the albuminoids fell off continually up to the period of ripening, and when this storing up of starch was completed the ripening of the grain was also complete. In this investigation no effort was made to determine the value of the straw of these different cuttings. Grain so far outranks the straw in money value

MAP OF THE
UNITED STATES
SHOWING
THE AVERAGE YIELD OF
WHEAT PER ACRE
Compiled from the Returns of Agriculture at the Tenth Census.
1880.

that the western farmer is willing to sacrifice the straw if thereby he may increase the yield or improve the quality of the grain. But every farmer is familiar with the rapid deterioration of the quality of the straw for forage by allowing it to stand until the grain is dead ripe; and where the straw is used for feed, even if there be no deterioration of the grain by over-ripening, the greater value of the straw is an incentive to early cutting. These results, which have been furnished by Professor Kedzie in advance, will be published more in detail elsewhere (*a*).

The wheat harvest of 1879 in the United States began in Texas about the 1st of May, and ended in the early part of September in Dakota, Wisconsin, and Washington territory. As regards the greater grain-producing states, in California the harvest began about the 1st of June, and the most of the wheat was cut between the 15th of June and the 1st of August, but the harvest extended until in September. In Illinois, Indiana, and Ohio the most of the wheat is cut during the last half of June and the first half of July. Everywhere east of the great plains wheat is cut as soon as it is ripe, or a little before, and the harvest seldom extends on any one farm longer than two or three weeks, the wheat being cut as fast as it is ripe. In California, where there is no danger from storms, the harvest extends for many weeks after the wheat is ripe, some of it standing six, eight, and it may be even ten weeks after it is ripe enough to cut.

The replies to question 44, "What proportion was cut by hand, and what by machine?" show that in the prairie regions of the West it is practically all cut by machine. Here and there 5, 10, or in places 15 per cent. of the crop is cut by hand, owing to some local condition, but in most places it is all cut by machine. In the regions of smaller farms, and on rougher land, especially south and east, a larger proportion is cut by hand. It is probable that four-fifths of all the wheat grown in the United States is cut by machine. Everywhere east of the great plains it is practically all bound into sheaves, the exceptions to this being too small to make note of here. This arises from the nature of the climate; the wheat needs to be cured before thrashing. The whole of this part of the country is subject to showers and rains during the harvest season, and against this the farmer provides by binding the wheat into sheaves and curing in shock. In California, where there is no danger from this source, the most of the grain is headed, and is not bound into sheaves.

To question 48, "If cut by machine, what is an average day's work for one man, team, and machine?" the most common answer from Illinois, Indiana, and similar states is 10 acres, the great majority of the answers being from 8 to 12 acres. In California, however, where larger machines are used, from 10 to 20 acres are more often returned; by hand, from 1 to 2 acres.

In answer to question 47, "What wages were paid harvest hands in 1879?" in the great grain-growing states of the Mississippi valley, as in Illinois, Indiana, Iowa, Minnesota, and Michigan, the wages ranged from $1 25 to $2 50 per day, the most common prices over the whole of this region being $1 50, $1 75, and $2. In Missouri and in Iowa the wages ranked a little lower than in Ohio, Indiana, and Illinois. In New York the prices ranged from $1 to $2, $1 50 being the most common price, the harvest hand generally receiving his board. In California the most common price was $2, varying somewhat, special men, with thrashing-machines, however (as engineers and machine men, and sometimes the feeders), receiving higher wages.

As already stated in speaking of thrashing in general, the most of the wheat crop is stacked or put into barns before thrashing in the principal wheat-growing regions, and is then thrashed by steam-power, the most of the machines being custom machines, traveling from farm to farm.

In answer to question 54, "What is the usual price per bushel for thrashing wheat? At this rate, does the grower furnish: (*a*) board of thrasher's men? (*b*) What number of additional hands, if any?" and to question 55, "What do you consider a good day's work for a steam-thrasher under good conditions?" we find that in the group of great wheat-growing states, extending from Ohio to Missouri and from Dakota to Tennessee, the most of the grain is thrashed by custom machines, traveling from farm to farm, the farmer employing them furnishing from four to twelve additional hands, according to special contract—generally about eight—and boarding the thrashers and their teams, the price ranging from 3½ to 5½ cents per bushel, 4 to 5 cents being the most common price. Where the board and extra hands are not furnished, the cost is generally from 10 to 12 cents per bushel. Similar prices obtain through the middle states, but the range is perhaps a little greater, from 3 to 6 cents, depending upon the size of the crop, it costing more per bushel to thrash out a crop of but 300 or 400 bushels than a crop of twice that amount. In New Jersey, Pennsylvania, and Virginia, and so on southward, many custom machines thrash for a portion of the crop, this portion varying from one twenty-fifth to one-eighth, the usual amounts given being from one-twentieth to one-twelfth. As regards what is a good day's work for a steam-thrasher through the western states already alluded to, the usual answers are rarely below 600 or above 1,000 bushels. In the middle states and similar regions, where large grain farms are more rare, 400 to 700 bushels are more often returned. In California the quantities are often much larger. The grain being headed, there is less straw to pass through the machine; it is usually drier, and the amounts grown by individual farmers are very large. A single custom machine will thrash from 40,000 to 100,000 bushels in a "season" of three months. Two thousand bushels per day are often thrashed.

As will be seen from the maps and from the tables, the most of the wheat in the country is grown in the region lying north of the Ohio river, and between the eighty-first and the ninety-seventh meridians and north of the thirty-seventh

a The full paper was read before the American Association for the Advancement of Agricultural Science at Cincinnati in August, 1881, and published later in the year, with tables and diagrams, in the *American Agricultural Association Journal*, I, Part 2, p. 123.

parallel of latitude. Over most of this region the wheat is grown on farms practicing mixed agriculture. Local practices vary, and the wheat production in any one locality varies from year to year very considerably. In all of these states, except the northernmost, it is grown on the same farms with corn and other cereals, corn really being the leading cereal as to quantity. The general methods of cultivation have been so often described that it seems scarcely necessary in this place to note them save where they are exceptional. In portions of this region the average yield seems small when compared with the great amount of product; but it must be remembered that in many districts there are as yet no incentives to a very intense farming, and not unfrequently a production which runs under 15 bushels per acre may at the same time be a profitable one. For the distribution, both actual and relative, of the separate grains over this especial grain-growing region we must refer to the maps.

Throughout the southern states considerable wheat is grown, and, although the average yield seems small, it probably will continue to be grown. The most of the wheat grown in those states is not on the best soils, and is in a style of farming which is the reverse of intense. The principles involved in this have been so fully discussed elsewhere that they need not be more than alluded to here.

The following table, from the twenty-third annual report of the secretary of the board of trade of Chicago, gives the wheat receipts at Chicago in such shape as to show the movement there by crops, but little new wheat reaching that point before August 1, and but little of the previous year's harvest probably being delayed beyond July:

TABLE XXXVIII.—WHEAT RECEIPTS AT CHICAGO.

Received from—	Amount.	Received from—	Amount.	Total amount.	Year harvested.
	Bushels.		*Bushels.*	*Bushels.*	
Aug. 1 to Dec. 31, 1860.	12, 066, 354	Jan. 1 to July 31, 1861.	5, 820, 345	17, 886, 699	1860
Do..........1861.	11, 364, 657	......do ....1862.	6, 416, 802	17, 781, 459	1861
Do..........1862.	7, 311, 314	......do ....1863.	7, 520, 615	14, 831, 929	1862
Do..........1863.	7, 110, 041	......do 1864	6, 770, 187	13, 880, 228	1863
Do..........1864.	5, 317, 790	......do ....1865.	4, 348, 414	9, 666, 204	1864
Do..........1865.	4, 892, 996	......do ....1866.	3, 613, 962	8, 506, 958	1865
Do..........1866.	8, 667, 786	......do ....1867.	2, 037, 087	10, 704, 873	1866
Do..........1867	11, 275, 162	......do ....1868.	3, 511, 699	14, 786, 861	1867
Do..........1868.	11, 245, 395	......do ....1869.	7, 610, 926	18, 856, 321	1868
Do..........1869.	9, 265, 834	......do ....1870.	7, 185, 365	16, 451, 199	1869
Do..........1870.	10, 209, 044	......do ....1871.	5, 286, 041	15, 495, 085	1870
Do..........1871.	9, 153, 615	......do ....1872.	2, 533, 706	11, 687, 321	1871
Do..........1872.	10, 190, 435	......do ....1873.	7, 338, 150	17, 528, 585	1872
Do..........1873.	18, 928, 412	......do ....1874.	16, 210, 067	35, 138, 497	1873
Do..........1874.	13, 554, 555	......do ....1875.	12, 206, 732	25, 761, 287	1874
Do..........1875.	11, 999, 638	......do ....1876.	8, 355, 710	20, 355, 348	1875
Do..........1876.	8, 218, 348	......do ....1877.	1, 921, 017	10, 139, 365	1876
Do..........1877.	12, 243, 498	......do ....1878.	11, 584, 302	23, 827, 800	1877
Do..........1878.	18, 129, 275	......do 1879	13, 575, 041	31, 704, 316	1878
Do..........1879.	20, 531, 068	......do ....1880.	9, 002, 765	29, 533, 833	1879
Do..........1880.	14, 538, 842				

THE RED RIVER REGION.

A region which has recently been brought prominently into notice as a wheat-growing region, lying partly in Minnesota and partly in Dakota, is known as the Red River region. The most notable portion of this is the flat region extending on both sides of the Red river from lake Travers northward, wider upon the western than upon the eastern side of the river. This level portion, known to geologists as lake Agassiz, is composed of black sedimentary soil, exceedingly fine in texture, and occupies what was apparently once a fresh-water lake, extending from lake Travers northward far into British America. The soil is deep, very black, containing some very fine sand, which, under the microscope, shows that it is sedimentary sand. A sample taken on the Cheney farm, at Dalrymple, contained 4.82 per cent. of organic matter in the dried soil. The soils evidently contain a considerable quantity of lime, the amount apparently increasing as we go westward to the Missouri river.

The famous Dalrymple farms, so prominently before the public, are an example of wheat cultivation on a large scale. About 75,000 acres, belonging to several owners, are under the management of Mr. Oliver Dalrymple. They had in crop in 1880 about 25,000 acres, conducted in farms of about 6,000 acres each of plowed land. To each of these farms there is a superintendent. These farms are again divided into divisions of about 2,000 acres each of plowed land, and each subdivision has its own farm buildings, boarding-houses, stables, blacksmith-shop, and so on, this size being considered there the most convenient, and as large enough for systematic management, while, if larger, the men might have to travel too far to and from their work. This region has only been in cultivation six years, the most of the land less; so, as yet, there is absolutely no system of culture or cropping. The land is simply put into wheat. Summer fallowing will soon be resorted to, but has not been as yet.

This management owns about 500 head of working animals, horses and mules. The first breaking is by single plow. After this the plowing is done by gang sulky-plows, two plows to the gang, each drawn by four horses, and averaging about 5 acres per day per man and four horses. Two hundred pairs of harrows (Scotch, 72 teeth) and one hundred and twenty-five seeders (broadcast sowers) are used. They have one hundred and fifty-five self-binding reapers, some binding with twine and some with wire. These have 6½-foot cutting-bar; are used with three animals to the machine, each machine cutting and binding about 14 acres per day. They work in gangs of twelve machines or upward, with an overseer (equivalent to the California riding boss) to each gang, a wagon following with water, twine, and other articles, and with a gang of shockers to set up the grain. They have twenty-six steam thrashing-machines, each thrashing from 800 to 1,200 bushels per day, according to the condition of the grain, 900 bushels being considered a fair average. Twenty-five men and twenty horses will run a thrasher from the shock and haul the grain to the railroad station, two or three miles distant. In this region the grain has to be cured in the shock; it cannot be thrashed directly from the reaper or harvester, as in California.

The fresh prairie is broken in the spring, and the sod rots much quicker than the prairie sod farther south does. If plowed the second time the first year, say six months or more after the first plowing, this second plowing is called backsetting.

There are many wheat farms in this region, the product rapidly increasing. The first breaking, if by contract, costs from $2 50 to $3 per acre; breaking and backsetting about $4 per acre. After the first year the plowing is, of course, cheaper. The cost of growing wheat per acre in this region was variously figured up at from $11 to $13 per acre, exclusive of hauling to the railroad. The yield in 1879 was about 20 bushels per acre.

OREGON AND WASHINGTON.

The conditions of grain production in Oregon and Washington are very unlike those of California, and also unlike those of the eastern states. With a milder climate in winter, the summer climate is also unlike. On the western side of the Cascade mountains the condition of grain-growing in Oregon is more like that found in the eastern states. The wheat produced is of excellent quality, and oats and barley are exceedingly heavy. Over a large region east of the Cascade mountains, on the volcanic plateau lying on both sides of the Columbia and the Snake rivers, settlements and wheat-growing are rapidly extending, and the region possesses a peculiar interest, inasmuch as wheat is grown there probably cheaper than in any other place in the United States, and is transported farther than any other wheat grown in the world. This region extends 500 miles back from the Pacific to the borders of Idaho. The soil is derived from the decomposition of volcanic rocks, is very fine in texture, dark in color, of great fertility, and will probably prove very enduring. Samples of virgin soil taken by me from an elevation of perhaps 2,000 feet, between the Snake and the Pelouze rivers (between Lewiston and Union Flat), show by microscopic examination the volcanic origin of the soil. The dried soil contained 6.4 per cent. of vegetable matter; another sample, near Walla Walla, 4.8 per cent. In 1879 and 1880 the principal drawback to this region was the distance from market and the difficulties of getting the grain to the seaboard. As in all wheat-growing regions, the estimated cost of growing the wheat varied very greatly. The cost of plowing was generally given at $1 to $2 per acre; heading, about $1 50 per acre. This puts the wheat in the stack, but does not include the feeding of the hands, which is estimated at 50 per cent. more. Thrashing is generally done at about 5 cents per bushel.

The crops are large, 30 bushels per acre being common, and a larger yield is not rare. One farmer visited figured up the cost of production at 27 cents per bushel, including sacks. He claimed that in some places in Walla Walla county it could be raised for 23 cents per bushel. Various persons put the cost of production between 30 and 45 cents per bushel, the most of the testimony being that it could be grown at an expense of less than 35 cents per bushel, including interest on the land. A few, however, did not believe that this would cover the expenses on average years.

This wheat plateau is entirely treeless, and the most of it lies at an elevation of over 1,000 feet above the level of the sea, some of it being elevated 1,500 feet. The wheat grown is mostly spring wheat; it is sown in April or as late as May, and harvested in August or September. The best wheat regions lie in valleys or on the successive terraces of this plateau.

The wheat is heavy; the local millers say 61 or 62 pounds is common. It is apparently rich in gluten, and the flour made from it is very strong, but is somewhat yellow. In the Californian and eastern markets this yellow color affects the price unfavorably, but its strength gives it a popularity with those who know it, and in the English markets the color is less objectionable.

As transportation facilities existed in 1880, the transportation of wheat from Dayton or Waitesburg to Astoria or Portland, where it might be shipped, involved from ten to fourteen handlings, according to the way in which it was shipped, and the freights were from $11 to $14 per ton of 2,000 pounds. The cost from Walla Walla to Portland was $8 per ton, the many handlings making it expensive and causing much waste. At Portland or Astoria wheat may be shipped directly to Europe, but previous to 1880 it was mostly shipped to San Francisco, and reshipped thence. The present year (1881) a large portion is shipped direct. Some wheat is sent down from near 500 miles distance from Astoria. This wheat, if carried to Europe by the ordinary routes, travels more than 15,000 miles to reach the consumer, the actual distance often being considerably greater. The rapid extension of railroads has already much diminished the handling, and soon the grain will go through direct.

The wheat of western Oregon in some years will be mostly winter wheat of excellent quality; in others spring wheat, the fashion changing. In either case the wheat is very heavy, 62 and 63 pounds per bushel being not uncommon weights, and the flour made from it is without the yellowish tinge of that made from the wheat east of the mountains. The crop is not subject to rust or blight, but is liable to smut, unless the seed wheat is blue-stoned.

A reference to the tables will show in some of the counties an enormously high production per capita.

CALIFORNIA.

Wheat production in California has increased so largely of late years, and the methods and processes are so unlike those of the other states, that they need special mention and treatment. The crop of wheat in California in 1879 amounted to 1,832,429 acres, producing 29,017,707 bushels. The average production per acre is small (16.1 bushels per acre), but the aggregate production is large, and over portions of the state, where the yield is small, the cost of production is light and the method exceptional; so that comparisons of profit from these figures, drawn from statistics of yield elsewhere, may be misleading. The production of wheat per head in some of the counties is enormous, being above 100 bushels in a number of counties, rising to a maximum of about 346 bushels per head in Colusa county.

The wheat is grown entirely in the valleys or upon a few of the foot-hills, the major portion being in the great central valley. The climate over the whole wheat region is one in which the ground is rarely, if ever, frozen in the winter, and almost the entire rainfall is during the interval between the 1st of November and the 1st of May. The growing season of the crop is therefore the time of year when in the other wheat regions of the United States it is winter. None of this region was originally forest-clad. It more resembled the prairie region of the West, except that the native vegetation is mostly of annual species. The soil is exceedingly rich in all that pertains to the mineral constituents of fertility, but does not contain so much vegetable matter as the soils of equal fertility in colder climates.

In Los Angeles county, where the wheat is liable to suffer for lack of rain, but where, nevertheless, its culture is on the increase in the valleys, the San Francisco ranch may be taken as a sample. The ground is plowed by gang-plows and sown broadcast at the rate of 45 pounds per acre. It is claimed by some of the largest wheat-growers that this amount is better than more; that in the drier years there is not moisture enough in the soil to bring a larger amount to maturity. The wheat is extra-cleaned before sowing, and all treated with sulphate of copper (blue-stone), at the rate of 3 pounds of the crystals per ton of wheat. It is preferable to sow just after the earliest rains have begun; but if they are long delayed, then the grain is sown on the dry ground. That sown after the 1st of December is usually plowed in; that sown before is harrowed in, the earlier being considered better as a whole. The sowing of wheat may be said to extend from the middle of November to the 1st of February, and of barley from the same time in the fall until the middle of February or the 1st of March. The harvesting is done entirely by headers, the harvest men being employed for the time being, and living in camps in the fields. The grain is either thrashed as it is cut or first stacked and then thrashed, according to the convenience of the operator. Twelve-foot headers are used, six horses or mules to each header, one such header cutting from 15 to 25 acres per day. Three header-wagons are usually used for each header, each drawn by two horses (or mules), or four if the ground is soft or hilly, one driver managing them. The number of men in a crew varies with the local conditions. The header-wagons are unloaded at the stack by horse-power. A netting of peculiar arrangement is laid in the box of the header-wagon before loading, and by a suitable arrangement of ropes and derrick the whole load is lifted bodily by horse-power and swung on the stack (or to the feeder if at the thrasher).

On this ranch the following crew was at work at the time of visit:

TABLE XXXIX.—HARVESTING CREW.

Machinery.	Number hands employed.	Number animals employed.
4 headers	4 drivers	24
	4 loaders	
12 header-wagons	12 drivers	24
	2 stackers	
	1 derrick man	
	1 driver (to unload)	2
	1 overseer	1
Total	25 men	51

The animals are either horses or mules. This crew was cutting and stacking from 90 to 120 acres per day, according to the grain and the ground.

Thrashing is done by the steam-thrasher ("straw-burners"), in which a gang of seventeen men and twelve horses is used, as follows: One engineer, one fireman, one oiler, two feeders, two forkmen (to handle the grain to the feeder), two drivers (to work the horse forks), one sackman, one sack-tender, one water-carrier, one straw-buck (who hauls the straw to the engine), two laborers (to help fill sacks and do odd jobs). Twelve horses are used, six to the water wagon, four to the forks, which bring the grain to the machine, and two to the straw-buck, which hauls the straw to the engine. The amount thrashed varies entirely according to the yield of straw in the particular year.

The Odessa wheat is the variety most cultivated in the southern portion of California, although numerous varieties are found. In the San Fernando valley, where wheat-growing is rapidly increasing, plowing is done with gang-plows, six or eight plows in a gang, drawn by eight to ten horses, according to the soil, with one man acting as driver, plowing 3 or 4 inches deep, and averaging about 9 acres per day per gang, although 10 acres is considered a fair day's work under good conditions. In this valley about the same rules pertain as to harvesting and heading, 30 acres per day with a 12-foot header and six horses being considered a good day's work, but the average for the season is perhaps not much above 20 acres. With steam-thrashers, 40-inch cylinder, 1,000 to 1,200 sacks of 2¼ bushels each per day are thrashed; the average, however, for the season would not be above 750 or 800 sacks per day.

In the Kern Valley region, Mussel Slough region, and some other places, considerable wheat is grown by irrigation. The crops are very large, and the quality is exceedingly good; but the process is in the experimental stage, and individual views concerning the best methods are so conflicting that any statement of processes, unless given in great detail, would be of comparatively little value.

In Colusa county the production of wheat per head of population rises perhaps higher than in any other part of the world, amounting to 345.8 bushels per inhabitant; but the figures are somewhat misleading, from the fact that many of the men employed in harvesting do not form a permanent portion of the population.

Dr. Glenn, of this county, is reputed to be the largest wheat-grower in the state, and the processes and methods used on his ranch illustrate the system. Club is the favorite variety of wheat on this ranch. It is the most popular, because it does not shell out with dry winds if not cut as soon as ripe. A portion of the land is summer fallowed, and in that case the ground is broken at any time during the wet season, from autumn until June. If plowed before April, it is replowed before the next sowing. If summer fallow is not plowed for its first plowing until after the rains have ceased or about ceased, it is not replowed in the fall. The most of the plowing is done with a gang sulky-plow, two plows in the gang, and 4 acres per day are plowed on the average, 8 inches deep, with one man and eight horses. They begin to sow on the dry soil in September if entirely ready, and continue sowing up to February 10, if practicable, preferring to sow after the first showers, say during the first half of November. Because of the greater rapidity of work, they use entirely a broadcast sower. Two men with one sower will sow 100 acres per day, which will be harrowed-in by seven harrows (one hundred teeth each), each drawn by eight mules. The ground is usually harrowed once before sowing and once after sowing, but the first harrowing is omitted if it is in especially good order. All of the seed is treated with sulphate of copper (blue-stone), at the rate of 3 or 4 pounds of blue-stone per ton of seed. The seed-wheat is run through a cleaner for extra cleaning, and then the blue-stone is applied by sprinkling the strong solution over the grain. It is dry enough to sow in twenty-four hours. Ninety pounds of seed per acre on summer fallow for the earlier sown, or 100 pounds for that sown as late as February, is the rule. All the cutting is done with headers. Sixteen-foot headers are used, six mules each, and three header-wagons per header if nets are used for unloading. The grain is all thrashed as it is headed, unless it may be that small portions are weedy and the weeds need curing. The average for each 16-foot header is about 30 acres per day. With 44-inch cylinder and 26 horse-power engine from five to seven headers are used; with the 40-inch cylinder, four to six headers. With 44-inch machine, 26 horse-power engine, the ordinary crew is—

(1.) Seven headers, with 42 animals and 14 men.

(2.) Twenty-one header-wagons, 42 animals and 21 men.

(3.) At the machine, sixteen pitchers, one separator man, one oiler, one engineer, one fireman, one derrick man with two horses, one man to handle the hooks, two straw-bucks with four horses, two sack-sewers, two sack-fillers, two sack-buckers, one riding boss with one horse, and one water-cart with four horses.

The engineer and the separator tender have each a riding horse. The total gang, therefore, would consist of 32 men and 11 horses at the machine and 35 men and 84 horses at the headers; total, 67 men and 95 animals. The average of this machine last year with such a gang was 1,700 sacks, about 3,800 bushels, per day for the season; the average for one 40-inch cylinder was 1,200 sacks. I have made many inquiries regarding the maximum amount of thrashing performed by any machine under the most favorable conditions in this country, and have no doubt but that the maximum has been reached on this ranch. It was with a machine especially constructed to order that Mr. Hoag, on July 16, 1879, thrashed 2,748 sacks, called 6,183 bushels. The machine was a 48-inch machine, and the grain was headed, thrashed, sacked, and 1,600 sacks hauled to the river and banked. The crew used was an extra large one, but it is impossible now to ascertain the precise number.

The grain is hauled to the Sacramento river and piled upon the bank. This is locally known as "banking". The banking crew is of fourteen teams of four mules and two wagons each, fourteen drivers, and a riding boss. From the machines, which are 7 miles from the river, this crew makes two trips, and haul 1,680 sacks for a day's work. From a nearer ranch, where the average distance is about 4 miles, three trips per day are made, and 2,520 sacks is the amount for the crew. From the river bank the sacks are taken on barges down the river. The average yield in 1879 was about 19 bushels per acre, that much being saved; for 1880 it was a little better.

It must have been a bold man who first proposed using straw for fuel under the boilers in the dry climate and the winds of the great valleys of central California, but it is a great success, and its users claim that it is the safest fuel where the stubble and dry grass are like tinder.

The dry climate of this state in the summer season makes the crops very liable to be destroyed by fire, and within the last few years grain insurance has been practiced in many parts of the state. In some regions one-half or two-thirds of the crop is now insured against fire. The system is a somewhat complicated one. The agents of the insurance companies estimate what the crop will probably yield and what it will be worth on the ground where grown, the cost of cutting, etc., being taken into account. The practice is on the increase at the present time, while as to its ultimate effects there is a considerable difference of opinion. Rates vary somewhat in different parts of the state, being more where grain crops are very abundant and cover large regions than where they are more sparse. The insurance is usually for a specific time if the grain is in the field, either standing or in shock.

As stated in another connection, the climate and the soil of California are peculiarly adapted to wheat-growing, and the crops produced on the best soils and in the best years have, many of them, been marvelously large. Several cases have been reported to me, seemingly well authenticated, of more than 70 bushels to the acre. I have personally seen crops reputed to be heavier than that, and there are various accounts of much larger crops. How large crops have actually been produced and well authenticated I cannot say, but Hon. John Bidwell, one of the best known farmers of the state, at Chico, when premiums were offered by the State Agricultural Society, harvested upward of 73 bushels per acre on 10 acres, measured, thrashed, and so on, in the presence of witnesses, and with the proper certifications as to authenticity. There is no California farmer but believes that larger crops than even this have been grown.

Combined harvesters and thrashers are coming into successful use in the great central valley. Many experiments have been made to this end in various grain-growing countries, without much success heretofore attending the efforts. The special conditions of topography, soil, and climate in California make their use practicable, and they have there been brought to a successful development. Their use is so exceptional, their operations are so striking, and their promise is so great, that a more special description here is justified. Comparatively few of these machines were in use in 1880, but I understand that sixteen to twenty were made in Stockton, where the patents are held, during the present year (1881). The machines, from their size, have to be put together on the ranches where used. C. H. Huffman, esq., a successful farmer of Merced, has had much to do with bringing them into successful working, and those in use on his ranch in 1880 were specially examined and may be used for description.

The machine is a header, with 18-foot cutting-bar, cutting while in actual use a full 17½-foot swath. The cut grain falls backward on an endless apron, and by suitable devices is carried to the thrasher and separator, which stands upon a platform back of the cutting-bar, and parallel with it. The thrasher has a 32-inch cylinder, which stands at the right-hand side of the platform, and the thrashed material is carried to the left and toward the standing grain; the chaff and straw are sent downward into the tall stubble, and the clean grain is delivered into sacks, which are sewed up by hand and thrown off on the stubble. A man follows with a wagon and gathers the sacks into larger piles, from which they are hauled to the warehouse at the railroad.

The power is furnished by twenty large mules, working ten abreast in two ranks. On another ranch I found a machine at work using but sixteen mules, but the power was too light for the work. On another, with eighteen mules, the success was better; but on Mr. Huffman's ranch, with twenty mules, the success was complete, and the operation satisfactory.

Four men only are required for the whole work of the machine. First, a machine man, whose place is on the platform in front of the thrasher and back of the apron, whose business it is to raise or lower the cutting-bar when inequalities of the ground or of the grain require it, and to look after the working of the machine in general. The second man is the steersman, and he sits perched high above all the rest on the top of the separator, and steers with a horizontal wheel, which, by means of tiller-chains, is connected with a pilot-wheel at the extreme hinder end of the machine. The third man is on the platform behind the separator, with a pile of sacks beside him and threaded needles ready for use. He fastens the sacks in place, opens the spout, and they are quickly filled; withdraws them, quickly sews them up, rolls them on a slide, and they glide away to the right, out upon the stubble, entirely beyond the reach of the machine. Where the grain is heavy this man's work is arduous. The fourth man is the driver, who is seated at the extreme rear and over the pilot-wheel, and either keeps that place or walks to one side or the other on the great whiffletree, to which the rear row of mules is attached. An impression of the gigantic size of the machine is gained from these whiffletrees, which are 22 feet long, 9½ inches wide, and 3½ inches thick, and play on a "tongue", or "pole" (if such it may be called, by which the whole machine is pushed), which is of oak, and nearly 9 inches square. The iron pilot-wheel, at the rear of this tongue, has a V-shaped face, which cuts into the soil, and, being on a swivel, guides the machine. The large platform on which the thrasher is placed travels on two great iron driving-wheels with broad faces, placed 14 or 15 feet apart, the right-hand one of which drives the cylinder and the left-hand one the separator and its appliances. The outside dimensions of this machine must be very great to accommodate all the parts, and the great platform which carries the separator must be high enough to accommodate the driving-wheels beneath. The whole weight is estimated at 8,000 pounds. With a power of twenty mules, the motion of the cylinder is as steady and uniform as with the ordinary stationary horse-power or steam-thrasher.

The machine, when seen at work in a field of some thousands of acres, and under the conditions of California topography, which admit of such wide and distant views, presents a striking aspect. The enormous size of the machine, its length and breadth and height looming up over the plain; the great breadth and impressive character of the team itself, twenty large mules driven in two ranks ten abreast, the separator towering high above the standing grain; the loud hum of the monster as it steadily and majestically sweeps over the plain; the cloud of dust that marks its progress floating away on the breeze; the broad swath, more than a rod wide, which steadily goes down before it, and the sacks of grain, cleaned for the market, rapidly gliding from its side and strewed along the way, make it, all in all, the most impressive piece of machinery I have ever seen at work.

The persons using it stated that under favorable circumstances the machine cuts 40 acres of wheat per day, and, judging from its rate as I saw it at work, I estimate that it was doing at least that. Mr. Huffman states that the average work last year (1880) was 36 acres per day. I was informed by the workmen attending it that four men were thus capable of cutting, thrashing, cleaning ready for market, and sacking from 800 to 1,400 bushels of grain per day, according to the yield of the crop and the condition of the land. It is only fair to say that the actual work of the machine is much greater in bushels than might be inferred from the average yield of grain in the state, Mr. Huffman's wheat going much above the average yield.

The advantages of such a machine are manifold, prominently the small amount of human labor as compared with the amount of grain harvested; the diminution of risk from fire, which in that state is considerable; and the rapidity with which the grain may be marketed, it sometimes happening that grain standing in the field in the morning is shipped and the warehouse bills received from tide-water the same night. It is eminently probable, therefore, that their use will extend in that state.

DISEASES OF WHEAT.

The diseases of wheat most common, not only in this but in other countries, are classed, respectively, under the head of smuts and rusts or mildews.

RUST OR MILDEW.

This disease is produced by a parasitic fungus attacking the stalk and the leaves. There are several species which effect this, but so far as investigated the principal damage in this country is done by a minute parasitic fungus known to botanists as *Puccinia graminis*. In this country, owing to its reddish or russet-brown color, the disease is more commonly known as "*rust*", but in England it is more commonly known by the very loose term "mildew" (from the German *mehl-thau*, "meal-dew"). What in England is called "rust" is a disease of less importance, caused by another genus of fungi (*Trichobasis*), one not troublesome in this country.

In all countries some varieties are more susceptible to the disease than others. As a whole, those which have soft stalks are more liable to it than the harder stalked kinds, and wheat growing on low grounds with much vegetable mold is more liable to be damaged than that on upland. The climate, however, is the important element in the development of this disease. Hot, muggy, damp weather, occurring after the blossoming but before the ripening of the grain, is the most unfavorable. The damage is most liable to occur after the grain is partially formed, and is in the milk or in the dough, as the case may be.

Upon no fact in agriculture has there been more persistent variety of opinion than in regard to the nature and origin of rust or mildew. The parasitic fungus is microscopic, and is produced from spores which have been produced by previous plants. These spores obtain access to the wheat-plant (but precisely how this takes place in nature is not as well determined as we could wish) and germinate in the juices beneath the epidermis. The rust-spores commence their life there in little colonies, which cause, in the first place, a brown swelling beneath the epidermis, which soon splits at this point. The edges are then rolled back, and the growing fungus protrudes its heads and stalks to the open air, where it fruits, producing spores. The vegetative portion of this fungus (the *mycelium*) grows within the tissues of the wheat-plant, and ramifies among the living cells as the roots of an ordinary plant ramify in the soil. It not only absorbs the juices of the wheat by its growth, but it also, to a greater or less extent, kills the living cells with which it comes in contact. The branches of *mycelium* which push out through the ruptured epidermis fruit, each bearing a small spore-case, or head, as we may call it, and these spore-cases produce two minute spores, each so exceedingly small that, once in the plant, they can circulate in the sap. These fungi are so small that their nature can only be discovered by the microscope, and before the investigations of science mildew and rust were popularly believed to be due to the bursting of the sap-vessels by a superabundance of sap, the rusty spot which appears upon the outside of the stalk being considered merely the dried sap. Very many farmers still hold to this theory, although the true nature of the disease has long been known.

In the first book ever published on the microscope (*Micrographia*, by R. Hooke, London, 1665, p. 121) he describes as a minute vegetation the blight on rose-leaves and some other leaves, and gives pictures of them; and although the absolute proof that they were the cause and not the result of disease was not proved until the present century, it is enough in this place to say that numerous investigations have demonstrated beyond any doubt whatever that the disease is due to the parasite, and not the parasite due to the disease.

It flourishes best on some soils simply because on such soils the growth of wheat is more rank and succulent and the conditions are more favorable for the parasite to get a foothold and live. It also has a better chance to gain access to the plant in damp weather. Bright sunshine and dry air are unfavorable to its development.

Up to the present time there is no remedy known. It is well proven that some varieties are much more liable to be attacked than others. A variety may for a time be partially exempt and then be attacked. Moreover, a region may become infected. In new countries the wheat often escapes the rust for some considerable time, and then the disease begins and continues. In any such region the difference between different varieties is at first very marked as to their liability to this disease. In California, in Oregon, and in similar regions, the testimony is well-nigh universal that different varieties are very unlike in their tendency to this disease, while in the older states, like New York, Ohio, and even Illinois, the testimony is by no means so uniform, large numbers assuming that there is absolutely no difference.

In answer to question 63 in the special schedule, "Did some varieties of wheat suffer more than others (from rust or mildew); and if so, which suffered most, and which least?" in some regions the testimony was almost universally "Yes", but the number of persons in some grain-growing regions who stated that all varieties were attacked alike was very large. In New York, in Pennsylvania, and in Indiana a large number answered "No". It would seem that a region may become so infected with the spores that all varieties may suffer from the disease; yet I think it proved that there is a difference in varieties as regards liability to rust, and there is much effort to find some that are "rust-proof". As yet this has not been successful. A variety may be sometimes found which for a while is nearly rust-proof, but with cultivation, in a region where rust prevails, it gradually becomes less so. Others, without ever being rust-proof, are nevertheless less liable to rust than their neighbors.

All of the very numerous experiments that have been made on experimental farms, at agricultural colleges, and by individual farmers in the region east of the great plains have settled nothing of general application. They show that in particular localities some varieties rust more than others, but the variety which rusts in one locality very badly may enjoy comparative immunity in another.

From a very early date it has been believed that an application of lime or of salt to the soil diminishes the liability to rust. We have no specific, but any treatment of soil which tends to harden the stalk diminishes the liability to rust.

The effect upon the crop is, that it causes the kernel to shrivel. If the disease is severe, and begins sufficiently early, the crop may be very small indeed, the grain very shrunken, the amount of starch in it very small, and the flour made from it of poor quality. If the disease strikes the crop late in its growth, the general experience has been that the best thing to do is to cut the crop as soon as possible, no matter how green. We lack experiments scientifically exact in this connection, but it is a popular belief, and many farm experiments apparently confirm it, that wheat cut so soon as rust strikes it, supposing the grain is then well in the milk or dough, does not shrink any more; that all of the grain formed up to that date is retained; whereas, if it is allowed to stand, it becomes more shrunken, the parasite removing by its further growth a portion of the contents of the grain already formed.

There is a curious history connected with the belief that rust in wheat may be in some way related to the presence of barberry bushes, or rather to their flowers. This widespread belief among farmers has been the subject of numerous statutory enactments against these bushes, both in the Old World and the New.

Scientists for a long time denied this inference *in toto;* they could see no possible connection between the blossoms of a bush and the blasting of wheat. An investigation a few years ago by one of the most eminent fungologists of the world proved that the farmers were right and the theorists wrong; that the special fungus which constituted the rust of wheat could exist also on barberry flowers, but in that place was so disguised in form that its nature had not been recognized, and that this form produced spores, which, in turn, could infect wheat. How liable wheat is to this form of infection is the subject of a fresh scientific investigation now in progress.

A disease of wheat, known in certain places in the southern hemisphere as "take all", is believed to be caused by a parasitic fungus which preys upon the roots, as rust and mildew prey upon the leaves and stalk. We know of no development of that disease in this country.

It is proper here to say that, so far as science has yet been able to discover, *all* of the rusts, mildews, rots, and some of the blights of plants, are occasioned by parasitic fungi attacking the living host and injuring it or destroying it by feeding on its juices, changing their chemical character and inducing death or decay in the tissues. All of these fungi live only on some other living creature. They elaborate no sap of their own from soil and air, but live only on that elaborated by the higher order of plants. Their general mode of growth may be described thus:

A spore differs from a true seed by physiological differences which we need not here discuss. As higher plants are produced from seeds, these are produced from spores, the spore being much simpler in its structure than the seed, very much smaller, and in many respects resembling the pollen grain of the higher plants. The vegetative portion of these fungi, that which corresponds to root, branch, and stem of the higher orders, we call the spawn, or *mycelium.* This constitutes nearly the whole plant, and is the portion which does the damage. The spores are merely the reproductive organs or seeds, and in some classes exist of several kinds. Of late years the study of this class of plants has excited very much attention, and there are various works treating of them which are accessible to the farmer; but from the exceeding difficulty attending their study, the many forms which some of them assume, the smallness of their parts, and the patience required to observe and investigate them, it is not likely that the farmer can ever devote much study to them. He will have to accept the conclusions of the scientific men, and profit by them so far as is possible.

SMUT.

The general name *smut* is used in this country to designate a class of diseases which attack the seed, known in other countries under various names, "bunt," "charbon," "coal," etc. The effects are seen in the grain, which is entirely changed in its character where the disease has been complete, and in the case of wheat the kernel is changed somewhat in its appearance—is shorter, plumper, and slightly darker in color, and when opened the interior is found to be entirely filled with a black or very dark-brown powder, fine as lampblack, and somewhat greasy to the feel. The starch and gluten of the interior of the grain have been entirely consumed by this parasite, and its place is occupied by the spores and *mycelium* of the fungus, which together form the black powder spoken of, only the bran of the original grain remaining.

We have more definite knowledge of this disease than of rust, and the whole life history of the plant is reasonably well known. It was long ago known that sowing smutty seed produced smutted grain. Hartlieb, in his *Legacy of Husbandry* (London, 1665), called attention (page 10) to the fact, and further says that according to Helmont it was not known in France until about 1530.

Modern experiment has proved that the disease is ordinarily communicated through the seed. Wheat moistened and rolled in smut before sowing may be so completely infected that nearly every grain of the next harvest will be diseased. All the smuts belong to the genus *Ustilago;* wheat smut to the *U. segetum.* Its spores are rough, sticky, as if greasy, and only one twenty-eight hundredth of an inch in diameter—a minuteness one finds it difficult to appreciate. Eight millions of such spores can stand on a square inch of surface. When smutted wheat is threshed the grains burst, and these spores adhere to the sound grain; and when this is sown as seed, they enter the young plant and develop within during the growth of the wheat, and, like a poison, circulate with its juices, and ultimately fix themselves in the kernel, which they change in nature and fill with the black powder already spoken of, consisting mostly of spores ready to produce a new generation. The ordinary farmer first sees symptoms of this disease in the ripening grain, but the experienced observer can find its traces long before, particularly in the flower, where the *mycelium*, like minute spiders' webs, entangle the stamens and pistil. The immature seed also changes in shape, and is shorter and bluer at the base; the parasite, however, comes to maturity with the maturity of the grain.

The remedies which are efficacious are applied to the seed grain, and, fortunately, for this disease we have several complete remedies. They all consist in soaking the seed in some solution which will kill the spore without injuring the vitality of the seed itself. Many methods have been used from time to time, but two are so much superior to all others thus far devised that there are scarcely any others now used, at least in this country. Both are effective. The most common is to wet the seed-wheat before sowing in a solution of copper sulphate (called also sulphate of copper, blue vitriol, and blue-stone), using at the rate of two to four ounces of the sulphate per bushel of seed-wheat. Three ounces per bushel is the common amount, a few using as low as two, and many as high as four ounces. There are several ways of applying it. Sometimes the sulphate is dissolved in water to a saturated solution. This is then diluted with an equal volume of water and sprinkled over the wheat in a pile, which is stirred and shoveled until all the grain is moistened. This is the least effective way of doing it. In one or two cases I have known a small stream of such solution to be run in a trough along which wheat was moved by an endless screw, which stirred it up. Another method, particularly where wheat is grown on a large scale, is to have the solution in large quantity, of about the strength of half saturation, in a large tub, say a hogshead sawed in two. The wheat, in sacks or in a basket, is lowered into this solution until entirely wet. It is then removed, the surplus allowed to drain off, and the grain thrown in a pile or left standing in the sack until the next day before sowing, this last being simply that the grain may be in a better condition to sow.

The second process, also practically effectual, is to use a solution of strong brine, instead of sulphate of copper. This method has been known for centuries, and is said to have been discovered by sowing wheat for seed which had been accidentally wet in salt water by the sinking of a vessel. To be effective, the brine needs to be strong and the grain thoroughly saturated with it. Where this process is used, it is quite common that the brined wheat be thrown out upon a floor and carefully limed by sifting slaked lime over it. The process is undoubtedly a good one for the crop, but, so far as the smut is concerned, the lime is unnecessary.

The following experiment, which is taken as one of many which have been placed on record in agricultural publications, illustrates this:

On a given farm (in Virginia) 120 acres of land were sown to wheat. The seed used on 40 acres was soaked in strong brine and sown without lime. At the next harvest this was almost free from smut. The seed for the second 40 acres was soaked in a weaker brine and was then limed before sowing. On this the ensuing crop was somewhat smutted. On the remaining 40 acres the seed-wheat was first soaked in water and then limed. On this portion the crop was badly smutted. The use of lime on wheat at the time of sowing in this way undoubtedly strengthens the young plant, and has been recommended for a variety of reasons. It is popularly believed that it hardens the stalk and makes it less liable to damage from even rust and insects; but if these effects follow, they are the indirect result, caused by the good effects of lime on the wheat-plant, rather than the direct specific action of the lime on the fungus itself.

In former times grain that was badly smutted was frequently the cause of disease when made into bread; but in modern milling its effects are completely removed, so that the loss and damage is only that which falls upon the farmer.

No general rule can be given as to whether uplands or lowlands are most affected by smut. Undoubtedly the wheat on lowlands is more liable to rust and mildew, but it is not, as a whole, more liable to smut. The driest hill land is frequently that which is most badly smutted. Farmers in one region believe that uplands are more liable to smut than lowlands; in other regions, the reverse.

The other mishaps to which wheat is subject are so various, and usually so far beyond the ordinary care of the farmer, that they need not be discussed in any detail, the most common one being too great drought during some period of growth. There have been a few cases where injury has been done locally by very late frosts after the wheat was in flower.

WEEDS INJURIOUS TO WHEAT.

The weeds which infest the wheat crop may be divided into three classes: those which choke the crop, and thus rob it of a portion of its nutriment; those which interfere with the harvesting and curing; and those whose seeds, mingling with the grain, injure its grade.

Regarding the first and second, only general rules can be given for their management; that is, better cultivation. Weeds which infest and choke the crop in one place are not those which infest it in another, and each has its own method of treatment. There are scarcely half a dozen weeds that seriously affect the quality of the grain by mingling their seeds with the wheat:

First, the wild garlic (*Allium vineale*), occasionally found in the eastern portions of the United States, affecting the grain by imparting a peculiar flavor to the flour. Weeding by hand and sowing clean seed are the usual methods of eradicating the weed from the fields, and summer fallow helps the process.

Second. Cockle (*Lychnis Githago*). This is sown with the wheat, grows along with it, but its hard, black seeds injure the looks of the grain and of the flour. Various machines are devised for removing the seed from seed-wheat, and the plant is so unlike wheat during its growth that it may be pulled by hand. Two methods are resorted to: a careful screening of the grain and the weeding of the crop during growth. The seeds are hard and peculiarly tenacious of life, and may lie dormant in the soil for many years; so that when once in the land it requires many years of faithful and persistent warfare to eradicate it, but it can be done.

Third. Chess, or "cheat" (*Bromus secalinus*). There has been more discussion over this weed than over any other in existence as regards the permanency of species. It is a kind of grass growing with the wheat, looking so like it during its growth that the most experienced farmer can see no difference. It occurs so extensively, and its powers of reproduction are so much greater than wheat, that there has been for a long time a widespread belief that under certain circumstances wheat will turn to chess. The literature of this subject is a curiosity in its way, and is very extensive. It is enough here to say that no scientific man in the world believes such a transmutation ever takes place, and those farmers who hold to the same idea have been most successful in its eradication. The only way of exterminating it, when once in the land and in the crop, is a persistent warfare against it and the sowing only of clean seed. A portion may be screened from the seed-wheat, the seeds being smaller than the grains of wheat, but not quite all is removed in that way. One of the advantages of carefully brining wheat at the time of sowing is that if the wheat is allowed slowly and carefully to run into the strong brine the chess floats and may be skimmed off; and this process is sometimes pursued by careful farmers, who secure the double or treble advantage by this process of an antidote for smut, the removal of the chess from the seed, and the removal of such other light or imperfect grains as would float on the strong brine.

In California another species, belonging to an entirely different genus (*Lolium temulentum*), is known as chess; and, curiously enough, the same arguments are there used to prove that wheat will turn to that chess that in other places are used to prove that wheat turns to the other chess.

Both of these species, especially the true chess (*Bromus*), are much more prolific than wheat. Individual examples are not uncommon where several thousand seeds have been produced by a single plant. In one which I examined personally about 3,000 grains were matured from a single plant, which is about one hundred and fifty or two hundred times as prolific as the average wheat crop.

Owing to the reasons already mentioned, the crop of a new region is more exempt from weeds than one longer in cultivation. Then, as a result of carelessness in sowing, the weeds in time increase, and the usual history is then a fiercer struggle with them for a time, followed by a diminution of foul stuff in the grain.

INSECTS INJURIOUS TO WHEAT.

The following memoranda pertaining to insects injurious to wheat in this country are from Professor C. V. Riley, of the United States Department of Agriculture:

THE HESSIAN FLY (*Cecidomyia destructor*, Say).—Order: DIPTERA; family: CECIDOMYIDÆ.

This celebrated pest was first known as doing serious damage about the year 1779 in the vicinity of New York. The question as to its importation is at present a disputed one. To-day its injuries are most marked in the grain-raising areas of the middle and northwestern states and the adjoining regions of Canada. It is found, however, all through New England, as far south as Texas, and as far west as western Kansas.

The eggs are laid in winter wheat about the middle of October in the northern states (this period, as well as the following ones, varying, of course, according to latitude) on the leaves at the base of the plant. In from one to two weeks the larva hatches and works its way to the nearest joint, where it fixes itself and remains till full-grown. The full-grown larva is whitish in color, oval-cylindrical in form, and measures about 4^{mm} (0.15 inch) in length. It assumes what is called the "flaxseed" form about December. The larval skin hardens and turns brown, and within it the larva transforms to a pupa after several weeks, the fly—a small, dusky midge—appearing in April or May. The flies issuing at this time pair and lay their eggs both in spring and in winter wheat, their offspring assuming the flaxseed state in June or July, and the adults again appearing in September or October. Two parasites (*Semiotellus destructor*, Say, and *Platygaster error*, Fitch) infest the Hessian-fly larvæ.

Remedies.—Burn stubble immediately after harvest. Sow as late as possible in the fall. Sow a strip of wheat around the borders of the field in early fall, planting the remainder late and plowing under the first sown strip in November.

See Fitch, N. Y. State Agr. Soc. Rep., 1862 (7th), p. 819; Harris, Ins. Inj. to Veg., p. 568; Packard, Bull. U. S. Ent. Com., No. 4 (Dept. Interior, 1880).

THE WHEAT MIDGE (*Diplosis tritici*, Kirby).—Order: LEPIDOPTERA; family: CECIDOMYIDÆ.

The wheat midge was first known in this country between the years 1820 and 1830, when it was imported from Europe, where it had long been known. It is closely allied to the Hessian fly, with which it was formerly considered congeneric. It is single-brooded, the eggs being laid in June in the blossom of the wheat. The larva feeds upon the forming grain until it reaches full growth, at which time it is about 3^{mm} (0.1 inch) long; it is reddish in color. Before harvest the larva drops from the wheat head to the ground, which it enters to the depth of an inch or so to transform, spinning first a delicate silken cocoon, to which are attached many particles of earth, rendering it very difficult to find. In this cocoon it remains unchanged until the following spring, at which time it transforms to the pupa state, and gives out the fly soon after.

Of late years the damage from this insect has not been at all great, but formerly the midge was considered as by far the most prominent of the wheat enemies. For instance, in 1854 the damage to the crop in New York state alone amounted to $15,000,000. Three European parasites of the midge have been described, but none are known with certainty to infest wheat in this country.

Remedies.—Deep plowing in the fall or spring. Sow wheat as late as possible in spring.

See Fitch, Trans. N. Y. State Agr. Soc., 1861, p. 745; Harris, Ins. Inj. Veg., p. 591.

THE JOINT-WORM (*Isosoma hordei*, Harris).—Order: HYMENOPTERA; family: CHALCIDIDÆ.

The joint-worm, in spite of its position in a parasitic family, has been quite satisfactorily proven to cause occasional great damage to wheat, barley, and rye. Fitch described the insects infesting these three crops as distinct species, but Walsh afterward proved them to be identical.

The adult insect lays its eggs in May or June in the stalks, usually just above the first or second joint from the ground. The larva, hatching, works in the internal substance of the stalk, forming a little swelling, deforming the stalk, and destroying its vitality. When full-grown, it presents the appearance of a rather stout yellowish-white maggot, 3^{mm} (0.12 inch) long. The great majority of the larvæ remain in this state through the ensuing winter, but a few transform and issue as flies the same fall. The pupa is at first light colored, but becomes black as it advances in age. Walsh has described a parasite (*Semiotellus chalcidiphagus*) which issues from the swellings of the joint-worm in June, and two other undescribed parasites have been mentioned.

Remedy.—Burn all stubble and refuse straw during the fall or winter.

See Harris, Ins. Inj. to Veg., p. 550; Fitch, Trans. N. Y. State Agr. Soc., 1862, p. 830; Walsh, American Entomologist, vol. I, 1869, p. 149; Packard, Rept. U. S. Geol. and Geog. Surv., 1875, p. 693.

THE CHINCH-BUG (*Blissus leucopterus*, Say).—Order: HEMIPTERA; family: LYGÆIDÆ.

The chinch-bug made its first appearance as a destructive insect almost simultaneously with the Hessian fly, with which for a long time it was confused. It is an indigenous insect, and is now found in all parts of the United States east of Colorado, its injuries being more marked in the older western states. Its eggs are laid in spring, in clusters, either above ground, on the blades of grasses and grains, or (normally) underground, on the roots of the infested plants. The egg hatches in two weeks, and the bug occupies six weeks in attaining full growth. When young, it is bright red and wingless; when full grown, blackish, with white wing-covers, each with an oval blackish spot on the lateral middle. During the whole course of its growth it is an active feeder, sucking the juices of the plant and causing it to wither. There are two broods a year in the more northern states, and probably three in the southern, the first brood maturing ordinarily soon after the maturing of spring wheat.

The adult insects of the second brood hibernate under dead leaves, sticks, stones, in bunches of dead grass or weeds or straw, and often in corn-stalks and stubble. Heavy rains are destructive to the bugs, and their injuries are always more marked on dry, loose soil. It injures only grasses and cereals.

Remedies.—Burning of rubbish and clean cultivation in general; early sowing (winter wheat is less subject to attacks than spring). Migration from one field to another can be prevented by a line of coal-tar kept moist by frequent application, or by a plow-furrow, in which straw should be burned as the bugs accumulate.

See Harris, Ins. Inj. Veg., 198; Fitch, Trans. N. Y. State Agr. Soc., 1855, p. 509; Riley, 2d Ann. Rept. on Nox. Ins. of Mo., p. 15, 1870; 7th Rept., p. 19, 1875; Le Baron, 2d Ann. Rept. Nox. Ins., Ill., p. 142, 1872; Thomas, Bull. 5, U. S. Ent. Comm. (Interior Dept., 1880).

THE ARMY-WORM (*Leucania unipuncta*, Haworth).—Order: LEPIDOPTERA: family: NOCTUIDÆ.

The "army-worm" is a name applied indiscriminately by agriculturists to several distinct species north and south, but the use of the title among entomologists is restricted to the "northern army-worm", sometimes so called, which does its principal damage among the cereals in the states north of Tennessee. The eggs are laid in the spring in the folded basal leaves of grasses and grains; they are white in color, almost spherical in form, and 0.6^{mm} (0.02 inch) in diameter. The worm, hatching, feeds upon the leaves of the plant, and reaches its full size in from two to four weeks. At full growth it is 38^{mm} (1.5 inch) long, and is striped with black, yellow, and green, in varying proportions. It goes into the ground to transform to a dark brown pupa, issuing as a moth in from one to three weeks. The moth is stout-bodied, dull brown in color, with a white dot in the center of each fore wing, and measures about 45^{mm} (1.75 inch) in wing expanse.

The name of "army-worm" is applied from the fact of the frequent appearance of these larvæ in great numbers, when they march from a devastated field in immense armies. The number of broods in a year is at present undecided. There are certainly at least two broods in the more northern states, and three or four farther south, varying with the length of the season. The injurious brood is not necessarily the first, but may be the second or the third. The question of hibernation is also still a mooted one, but it seems probable, from latest developments, that the insect may, and does, winter in all three stages of larva, pupa, and moth.

The parasites of the army-worm are very numerous and important, but we must refer to the bibliographical list for their discussion, and also for the discussion of the theory of climatic influences.

Remedies.—Confine the worms to fields in which they first appear by ditches or plow-furrows, in which straw should be burned as the worms accumulate. In fields upon which there is no hope of saving the crop the worms should be destroyed by burning over, by poisoning with Paris green or London purple, or by rolling with heavy rollers.

See Fitch, Trans. N. Y. State Agr. Soc., 1861, p. 855; Riley, 2d Ann. Rept. on Nox. Ins. of Mo., p. 37; also 8th do., pp. 22 and 182, and Proc. Am. Ass. Adv. Sc., 1878 and 1880; also Walker prize essay, Boston Soc. Nat. Hist.; Packard, 9th Ann. Rept. U. S. Geol. and Geog. Surv. Terr., 1875, p. 699; Comstock, Dept. Agr. Rept., 1879, p. 187; Flint, ed. Harris Ins. Inj. Veg., Appendix; Thomas, 6th Report State Entomologist, Illinois, p. 56; also 7th *ibid.*, pp. 33, 107, 119; also 10th *ibid.*, p. .

THE FALL ARMY-WORM (*Laphygma frugiperda*, Sm. and Abb.).—Order: LEPIDOPTERA; family: NOCTUIDÆ.

This insect, also known as the "grass-worm" and "southern army-worm", is a very general feeder, and is only occasionally injurious to wheat. Only the southernmost portion of the wheat-growing area is subject to injury. The eggs are deposited in small clusters, covered with downy hair, upon the leaves of grasses, grains, vegetables, or fruit trees. The larva is much like the true army-worm, but differs in that it does not become quite so large, and that it is furnished with a few sparse, stiff hairs; it is variable in color. When full grown, the larva enters the earth to transform. The moth has an expanse of wings of about an inch and a half; the fore wings are dark slate color, with lighter markings (very variable), and the hind wings are white. There are several broods in the course of the season, and the insect probably winters in the pupa state. The same remedies may be used as for the true army-worm.

See Riley, 3d Mo. Rept., p. 109, under the name of *Prodenia autumnalis*, n. sp.; also 8th Rept., p. 48; Glover, Agr. Rept., 1867, p. 59; French, 7th Report State Entomologist, Illinois, p. 49; Phares, Dr. D. L., Rural Carolinian, Aug., 1870.

THE WHEAT-HEAD ARMY-WORM (*Leucania albilinea*, Guenée).—Order: LEPIDOPTERA; family: NOCTUIDÆ.

This worm seems never to have been particularly injurious before 1872, but in that year, and in the few years following, it did considerable damage to wheat, oats, barley, and timothy in Maryland and Pennsylvania, and also in 1876 in Kansas. The slate-colored eggs are laid in rows between the sheath and stalk of some grass or grain, and the newly-hatched larva feeds at first upon the leaves. After it is half grown, however, it feeds almost exclusively upon the heads; hence its popular name. The full-grown worm is an inch and a quarter long, and is striped longitudinally with sulphur and straw yellow, light and dark brown. It pupates under ground. The moth has pale straw-colored front wings, with an indefinite white line running from the middle to the outer third. There are two broods a year in Kansas, the insects hibernating both as pupæ and as adults. There are several parasites.

Remedy.—Late fall plowing and harrowing.

See Riley, 9th Missouri Report, p. 50; Packard, 9th Ann. Rept. U. S. Geol. and Geog. Surv., p. 712; French, G. H., 7th Report State Entomologist, Illinois, p. 223.

THE ROCKY MOUNTAIN LOCUST (*Caloptenus spretus*, Uhl).—Order: ORTHOPTERA; family: ACRIDIDÆ.

A discussion of the habits of the Rocky Mountain locust, or "western grasshopper", as it is frequently called, and of the remedies for its ravages, would be out of place here, in consideration of the Missouri reports on the subject and Riley's *Locust Plague in the United States*, and especially of the two extensive volumes recently published by the government, and which are now being distributed (*a*); so we shall content ourselves by referring all interested to those publications. See first and second reports United States Entomological Commission on the Rocky Mountain Locust: Department of the Interior, Washington, 1878 and 1880.

THE STALK-BORER (*Gortyna nitela*, Guenée).—Order: LEPIDOPTERA; family: NOCTUIDÆ.

The stalk-borer larva, when full grown, is 37mm (1½ inches) long, and thick in proportion, and could not, consequently, attain its full growth in a stalk of wheat. Hence we find that while it occasionally does considerable damage in the wheat-field, the larvæ, when half grown, leave the stalks to finish their growth in some one of their numerous other food-plants—corn, potatoes, tomatoes, cocklebur, rag-weed, and various plants cultivated in flower gardens. The color of the borers when young is livid, with light longitudinal stripes. When full grown, they become lighter and the longitudinal stripes broader. They normally enter the ground to pupate, but occasionally remain in the stalks. There is but one brood a year, and the moths hibernate. The moth is of a mouse-gray color, with an arcuated pale line running across the outer third of the fore wings.

Remedy.—The only remedy yet suggested (cutting the borers out by hand) is, of course, utterly useless so far as wheat is concerned.

See Riley, 1st Rept. Nox. Ins. Mo., p. 92; also Bulletin 6, U. S. Ent. Com.; Le Baron, 2d Rept. Nox. Ins. Ills., p. 141; Smith, 7th Rept. State Entomologist Ills., p. 112.

The following species are of minor importance, and never affect the crop so seriously as the preceding:

DIPLOSIS CALLIPTERA, Fitch.—Essay on the wheat fly. Am. Quart. Journ. Agr. and Sci., 1845, II, No. 2.
DIPLOSIS GRAMINIS, Fitch.—New York State Entomological Reports, VI, p. 90.
DIPLOSIS INIMICA, Fitch.—New York State Entomological Reports, VI, p. 88.
HYLEMYIA DECEPTIVA, Fitch.—New York State Entomological Reports, II, p. 301.
HYLEMYIA SIMILIS, Fitch.—New York State Entomological Reports, II, p. 301.
OSCINIS COXENDIX, Fitch.—New York State Entomological Reports, II, p. 301.
OSCINIS CRASSIFEMORIS, Fitch.—New York State Entomological Reports, II, p. 301.
MEROMYZA AMERICANA, Fitch.—New York State Entomological Reports, II, p. 299; Riley, First Report Nox. Ins. Missouri, p. 159.
SIPHONELLA OBESA, Fitch.—New York State Entomological Reports, II, p. 299.
CHLOROPS ANTENNALIS, Fitch.—New York State Entomological Reports, II, p. 300.
CHLOROPS PROXIMA, Say.—Journ. Acad. Phila., VI, 187; Ed. LeC., II, 370; Report Dept. Agric., 1879, p. 257.
CHLOROPS TIBIALIS (*Oscinis*), Fitch.—New York State Entomological Reports, II, p. 300.
SAPROMYZA VULGARIS (*Chlorops*), Fitch.—New York State Entomological Reports, II, p. 300.
AGROMYZA TRITICI, Fitch.—New York State Entomological Reports, II, p. 303.
THE GRAIN PLANT-LOUSE (*Siphonophora avenae*), Fabr.

The grain plant-lice during the early part of the season feed singly upon the leaves and stalks of grains and grasses, and are greenish in color. As soon as the grain heads are protruded from their sheaths the lice congregate upon them and change to an orange color. They hibernate in a wingless state upon the roots, and there is probably also a winter egg. It is an European species, but whether imported into this country or not is undecided.

See Fitch, New York State Entomological Reports, VI, p. 91; Curtis, Farm Insects, p. 290; Thomas, 8th Rept. State Ent., Ills., p. 51; Buckton, Monogr. Brit. Aphides, I, p. 117.

SPHENOPHORUS SCULPTILIS, Uhler.—See Corn Insects.
THE DESTRUCTIVE LEAF-HOPPER (*Cicadula exitiosa*), Uhler.—See Uhler, Riley in American Entomologist, III, p. 78; Comstock, Rept. Dept. Agr., 1879, p. 191.
DIEDROCEPHALA FLAVICEPS, Riley.—American Entomologist, III, p. 78.
THRIPS TRITICI, Fitch.—New York State Entomological Report, II, p. 304.
COLEOTHRIPS TRIFASCIATA, Fitch.—New York State Entomological Report, II, p. 304.
CUT WORMS.—See Corn Insects.
WIRE-WORMS.—See Corn Insects.
LOCUSTS OTHER THAN ROCKY MOUNTAIN (*Caloptenus femur-rubrum*, *C. atlanis*, *C. differentialis*, *Acridium americanum*, *Oedipoda atrox*, *Tragocephala viridifasciata*, *Caloptenus bivittatus*).—See 1st Report United States Entomological Commission, 1878. For locusts in California, see second report of same, 1880.
THE WESTERN CRICKETS (*Anabrus simplex* and *purpurascens*).—See 2d Report United States Entomological Commission, 1880, p. 163.
MORMIDEA (OEBALUS) TYPHEA.—See Glover, Report Department Agriculture, 1867, p. 71.
HARPALUS CALIGINOSUS (found occasionally to feed upon wheat, although normally a carnivorous and predatory beetle).—See Glover, Report Department of Agriculture, 1868, p. 80; Riley, American Entomologist, III, and American Naturalist, April, 1881.

INSECTS INJURING STORED WHEAT.

THE ANGOUMOIS GRAIN MOTH (*Gelechia cerealella*, Oliv.). This is quite a celebrated European pest, but was many years ago brought to this country, and has become thoroughly naturalized in the more southern states. The

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larva is very small, and white in color. It attains its growth within the grain, and also transforms to pupa within it, first, however, cutting a hole through the hull to enable the future moth to make its exit. The moth is small and delicate, and is of a uniform dull yellowish brown, with a satiny gloss. See Fitch, Trans. N. Y. State Agr. Soc., 1861, p. 813.

THE LITTLE GRAIN MOTH (*Tinea granella*, L.).—See Harris, Ins. Inj. Veg., 1st ed., p. 496; Glover Agric. Rept., 1855, p. 98; 1864, p. 556.

Besides these moths there is a large number of beetles injurious to stored grain, prominent among which are *Calandra oryzæ*, *C. granaria* and *C. remote-punctata*, *Sylvanus surinamensis* and *S. quadricollis*, *Sitodrepa panicea*, and many other *Ptinids*, *Tenebrionids*, and *Curculionids*, which it would be a waste of time to specify. See Curtis, Farm Insects; Glover on the Food and Habits of Beetles, Agric. Report, 1868.

EXPORTS OF WHEAT.

Before the American Revolution the exports from the colonies consisted almost entirely of the products of the soil and of the fisheries. Of the former, wheat and wheat flour were the most important, although there were sometimes considerable exports of Indian corn and corn meal. In those days northern Europe bought practically no breadstuffs from us. Our exported grain and flour went to southern Europe—Portugal, Spain, and the ports of the Mediterranean—and to the West Indies, and a considerable amount went to supply the European fishing-vessels along the American coast. Philadelphia was the place of largest export, "the capital of the corn country," as it was described in those times. The following scattering figures, mostly taken from *Observations on the Commerce of the United States*, London, 1783, illustrate some of the colonial grain exports. It is practically impossible to make complete tables for colonial days. The tables from particular ports and in particular years, however, are reasonably complete. The amount of flour exported from New Jersey in 1751 was 6,424 barrels. There was exported from Philadelphia and New York as follows:

TABLE XL.—EXPORT OF FLOUR FROM PHILADELPHIA AND NEW YORK.

From Philadelphia.	Wheat.	Flour.	Bread.	From New York.	Wheat.	Flour.	Bread.
	Bushels.	*Barrels.*	*Barrels.*		*Bushels.*	*Barrels.*	*Barrels.*
April 5, 1765, to April 5, 1766	367, 522	148, 887	34, 736	July 5, 1765, to July 5, 1766	109, 666	70, 664	17, 060
January 5, 1771, to January 5, 1772	51, 699	252, 744	38, 320	During year 1774	350, 000	115, 635	....
January 5, 1772, to January 5, 1773	92, 012	284, 872	50, 504	During year 1775	700, 089	104, 857	....
January 5, 1773, to January 5, 1774	182, 391	265, 967	48, 183				

Virginia wheat had a high reputation, and for some time preceding the American Revolution it is stated that 800,000 bushels were annually exported. The work previously cited states that winter wheat was not cultivated in Canada during its possession by the French; that its cultivation began in 1763, and increased rapidly, so that—

> In 1774 vast quantities of both winter and summer wheat were exported, not less than 500,000 bushels, with which above a hundred vessels were loaded for Europe, besides what was sent in flour and biscuit to the West Indies, and 100,000 bushels were left in hand for want of ships to export them (*Observations on the Commerce of the American Colonies*, London, 1783, page 45).

The early years of American independence were years of very great depression. At first the country was flooded with European goods, and the political disturbances in the Old World, with various other causes, made hard times in America. The tables of exports (Tables V to XIV, pages 4 to 9) of this report show the exports of wheat from 1790 to the present time minus a very few years. It will be noticed from those tables that the exports of grain and flour fluctuated enormously from year to year during the whole of the first half century of the republic, and that they were very small compared with modern figures. For example, the exports of wheat and corn in the year 1790 amounted to 3,226,595 bushels, and of wheat flour and corn meal to 824,596 barrels—that is, three and a quarter millions of bushels of grain, with flour enough to make fully as much more—while in 1798 and 1799 the exports were only 15,000 and 10,000 bushels of wheat, respectively, and much smaller shipments of corn than were exported on the first date; and similar fluctuations mark the whole of the period named.

The exports of wheat and wheat flour, by decades, is given in the following table (compiled from the tables just cited), with values since 1820. It will be noticed that for the first half century of our national existence the aggregate amounts exported each ten years did not materially increase. This was partly due to the condition of the markets in the Old World, the existence of the corn laws in Great Britain, etc., but more largely to the methods of production and transportation then existing, as is sufficiently discussed in another connection.

TABLE XLI.—EXPORTS OF WHEAT AND WHEAT FLOUR SINCE 1790 (BY DECADES).

Year.	Wheat.	Wheat flour.	Total value.	Year.	Wheat.	Wheat flour.	Total value.
	Bushels.	*Barrels.*			*Bushels.*	*Barrels.*	
1790 to 1799	5, 357, 190	7, 085, 090	....	1840 to 1849	14, 243, 705	19, 071, 576	$120, 110, 558
1800 to 1809	3, 119, 670	8, 953, 721	....	1850 to 1859	51, 709, 036	27, 701, 638	243, 389, 450
1810 to 1819	1, 390, 359	7, 447, 057	....	1860 to 1869	187, 086, 309	30, 300, 781	472, 550, 840
1820 to 1829	175, 272	9, 052, 926	$48, 405, 959	1870 to 1879	550, 707, 121	37, 117, 241	923, 134, 355
1830 to 1839	781, 415	8, 664, 829	52, 986, 995	1880	153, 252, 795	6, 011, 419	225, 879, 502

BRITISH WHEAT PRODUCTION.

As our wheat export is so intimately connected with that of the production and wants of Great Britain, the three following tables, compiled from those in the *Journal of the Statistical Society* for December, 1880, pp. 643, 670, will be of interest to the American farmer. Only those figures of more immediate interest in this special connection are here given, but we will say, in the way of general explanation, that the tables cited show that England produces about 90 per cent. of all the wheat grown in the United Kingdom, and that Scotland, Wales, Ireland, the Channel Islands, and the Isle of Man altogether produce only 10 per cent. England also produces about 70 per cent. of the barley, but only 38 per cent. of the oats, Scotland producing vastly more oats, relatively, than of the other cereals. The grain production of Ireland is comparatively small, and from year to year fluctuates more than does that of Great Britain.

The following table shows the acreage of the three principal cereals, along with a few of the other crops and groups of crops, for the years 1879 and 1880, for England, for the island of Great Britain, and for the United Kingdom (the latter term including Great Britain, Ireland, the Channel Islands, and the Isle of Man). It is understood that the "total area" (in the upper line) means the area of land, including mountains, woods, roads, etc., and the term "under crops, fallow, and grass," very nearly, although not exactly, corresponds to our term "improved land":

TABLE XLII.—TOTAL AREA AND ACREAGE UNDER CROP IN ENGLAND, GREAT BRITAIN, AND THE UNITED KINGDOM FOR 1880 AND 1879.

	England.		Great Britain.		United Kingdom.	
	1880.	1879.	1880.	1879.	1880.	1879.
Total area	32, 597, 000	32, 597, 000	56, 815, 000	56, 815, 000	77, 829, 000	77, 829, 000
Total acreage under crops, fallow, and grass	24, 596, 000	24, 504, 000	32, 102, 000	31, 976, 000	47, 587, 000	47, 437, 000
Wheat	2, 746, 000	2, 719, 000	2, 909, 000	2, 890, 000	3, 066, 000	3, 056, 000
Barley	2, 061, 000	2, 236, 000	2, 467, 000	2, 667, 000	2, 695, 000	2, 932, 000
Oats	1, 520, 000	1, 425, 000	2, 797, 000	2, 657, 000	4, 192, 000	3, 998, 000
Total "corn" crops, including beans and pease	6, 994, 000	7, 114, 000	8, 875, 000	8, 985, 000	10, 672, 000	10, 777, 000
Total green crops (potatoes, roots, cabbage, rape, etc.)	2, 659, 000	2, 737, 000	3, 477, 000	3, 554, 000	4, 745, 000	4, 872, 000
Clover, grass, and sainfoin under rotation	2, 646, 000	2, 675, 000	4, 434, 000	4, 473, 000	6, 380, 000	6, 451, 000
Permanent pastures (not including heath or mountain land)	11, 462, 000	11, 234, 000	14, 427, 000	14, 167, 000	24, 717, 000	24, 396, 000
Flax, hops, and bare fallow	836, 000	746, 000	889, 000	796, 000	1, 063, 000	941, 000

In the above table the "corn crops" include wheat, oats, rye, beans, and pease; the green crops potatoes, turnips, swedes, carrots, cabbage, kohl-rabi, rape, vetches, and other green crops, except clover and grass; and the permanent pastures mean those not broken up in rotation, and not including heath or mountain land.

Under the pressure of American competition, combined with bad harvests for a few years past, notwithstanding the increased demand for home consumption a marked decrease in the acreage sown to cereals has taken place, and along with it a more than corresponding increase in permanent pasture lands, the reclaimed land going largely into that class. In Great Britain, as everywhere else, railroads have changed the character of local competition as much as they have the foreign competition. British breeds of sheep for mutton and cattle for beef have been especially noted for excellence for the last hundred years, yet the true management of live-stock was an art confined to a few localities until railroads equalized the price of meat throughout the island. The pressure of American competition was felt in cereal production before it was in meat production, and the attention of British farmers was turned, therefore, in the direction of increased pasturage and increased live-stock production. It is probable that this change will continue to go on, as both the climate and the soil of Great Britain are particularly favorable to the production of meat. The grain competition of the western states produces precisely similar changes in the eastern states to those produced in Great Britain; there is a relative increase in the permanent pastures. In England the cultivation of barley increases with the diminution in wheat production, and the same thing occurs in the middle states. If the Hessian fly and other insects ravage the wheat crops beyond certain limits, then barley and pastures take its place.

For some years past the commercial department of the board of trade has submitted "tables of agricultural returns" for the year, the data for which are obtained through the officers of the inland revenue department. These are collected on the 4th day of June.

The following table gives the acreage of the three principal cereals in Great Britain (not for the whole United Kingdom) from 1871 to 1880, inclusive, arranged from the more detailed tables previously cited:

TABLE XLIII.—TOTAL ACREAGE UNDER WHEAT, BARLEY, AND OATS IN GREAT BRITAIN FROM 1871 TO 1880, INCLUSIVE.

Year.	Wheat.	Barley.	Oats.	Year.	Wheat.	Barley.	Oats.
	Acres.	*Acres.*	*Acres.*		*Acres.*	*Acres.*	*Acres.*
1871	3, 571, 894	2, 385, 783	2, 715, 707	1876	2, 995, 957	2, 533, 100	2, 798, 430
1872	3, 598, 957	2, 316, 332	2, 705, 837	1877	3, 168, 540	2, 417, 588	2, 754, 179
1873	3, 490, 380	2, 335, 913	2, 676, 227	1878	3, 218, 417	2, 469, 052	2, 698, 907
1874	3, 630, 300	2, 287, 987	2, 596, 384	1879	2, 890, 244	2, 667, 176	2, 656, 028
1875	3, 342, 481	2, 509, 701	2, 664, 009	1880	2, 909, 438	2, 467, 441	2, 706, 905

The estimated acreage, yield, and product of the whole United Kingdom available for bread for a series of years are given in the following table to illustrate the relation between production and consumption, since that country has been so large a consumer of American grain. The larger quantities are given (as in the original tables) in "*imperial quarters*" of eight "imperial" bushels, this quarter being 495 pounds. These estimates are given from 1866, since which time the agricultural returns have yearly given the number of acres sown. The estimated home produce available for home consumption is the estimated amount produced minus the amount required for seed:

TABLE XLIV.—ACREAGE UNDER WHEAT IN THE UNITED KINGDOM, YIELD, PRODUCTION AVAILABLE FOR BREAD, AND IMPORTS.

Year.	Acres.	Estimated yield per acre.	Estimated home produce available for home consumption.	Imports of wheat and flour, deducting exports.	Year.	Acres.	Estimated yield per acre.	Estimated home produce available for home consumption.	Imports of wheat and flour, deducting exports.
1866	3, 661, 000	27	11, 440, 000	7, 600, 000	1874	3, 833, 000	31	13, 700, 000	11, 040, 000
1867	3, 640, 000	25	10, 390, 000	9, 010, 000	1875	3, 514, 000	23	9, 124, 000	13, 940, 000
1868	3, 951, 000	34	15, 790, 000	7, 880, 000	1876	3, 124, 000	27	9, 665, 000	12, 150, 000
1869	3, 982, 000	27	12, 400, 000	9, 580, 000	1877	3, 321, 000	22	9, 432, 000	14, 503, 000
1870	3, 773, 000	32	14, 100, 000	7, 050, 000	1878	3, 382, 000	30	11, 825, 000	14, 417, 000
1871	3, 831, 000	27	11, 070, 000	9, 320, 000	1879	3, 056, 000	18	5, 990, 000	16, 400, 000
1872	3, 840, 000	23	10, 110, 000	11, 720, 000	1880	3, 066, 000	26	5, 114, 000	15, 000, 000
1873	3, 670, 000	25	10, 550, 000	11, 230, 000					

The average amount produced for the first five years of the above table, available for home consumption, amounted to 12,842,000 quarters (102,736,000 bushels), the imports amounting to only about two-thirds as much, while for the last six years the average production amounted to only 9,192,000 quarters (73,536,000 bushels), and the average importations to about 14,500,000 quarters (116,000,000 bushels). For the very last years the available production amounted to only about one-fourth of the total consumption.

The amount used for bread is somewhat differently estimated by different persons. Mr. Lawes estimates it at 5⅝ bushels per capita of population, but most writers place it at 5½ bushels. The amount, however, has doubtless increased of late years, as the coarser grains are used less and less for bread.

WHEAT PRODUCTION OF THE WORLD.

Since the great movement of grain by steam, estimates of the wheat production of other countries have become one of the necessities of trade and commerce. Before that a short crop in any country meant short bread in that country, it might be famine; now it means imports from some other country so soon as the prices will warrant it and commerce wishes to be prepared for such contingencies. As a result, the demands of trade have obtained what science and philanthropy failed to do, and estimates are carefully prepared of the production of breadstuffs in all lands. The occasional census enumerations, and the records of exports and imports, etc., are checks on the yearly estimates and give the data for revision. Thirty years ago English statesmen regretted that there was absolutely no means of knowing the amount of breadstuff produced in the kingdom nearer than a wild guess, but the wants of commerce led to the gathering of "agricultural returns" each year. These took a practical shape about 1865 or 1866, and have been improved since. At first they were the estimates of various officials scattered throughout the kingdom, aided by the estimates of private individuals. Now, the agricultural returns are in part estimates, and are in part based on the actual statements of the amount of land under the various crops, and almost approach actual statistics in accuracy. Estimates are now prepared in every civilized country by one or another kind of organization; sometimes by governments, as is the case with our Agricultural Department, and at other times by commercial or trade organizations. For obvious reasons these estimates, founded so largely upon human judgment, must be somewhat indefinite and vary according as made by this or that statistician.

The following table gives two estimates of wheat production in the principal wheat-growing countries of the world. The first and third columns were the estimates of 1878, published in the *Quarterly Report of the Chief of the Bureau of Statistics, Treasury Department*, for the three months ending September 30, 1879, page 118, from the French journal, *Bulletin des Halles*. The second and fourth columns are estimates published in the *Bulletin des Halles et Marches*, November 9, 1879, copied in turn by the *Journal of the Statistical Society of Paris*, January, 1880, and the *Quarterly Report of the Chief of the Bureau of Statistics, Treasury Department*, for the three months ending December 31, 1879, page 226. The bushels, in even thousands, are calculated from the hektoliters of the original tables. The two columns of estimates of average years are given to illustrate both the differences and the agreement of such estimates:

TABLE XLV.—ESTIMATED WHEAT PRODUCTION OF VARIOUS COUNTRIES.

European countries.	Estimated average crops.	Estimated average crops.	Estimated crop of 1878.	Estimated crop of 1879.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*
Austria-Hungary	101, 750, 000	105, 000, 000	110, 000, 000	79, 450, 000
Belgium	23, 375, 000	24, 121, 000	23, 375, 000	18, 440, 000
Denmark	2, 750, 000	2, 830, 000	2, 750, 000	2, 838, 000
France	281, 325, 000	290, 317, 000	226, 875, 000	217, 093, 000
Germany	121, 000, 000	124, 864, 000	123, 750, 000	113, 513, 000
Great Britain	101, 750, 000	105, 000, 000	101, 750, 000	59, 504, 000
Greece	4, 950, 000	5, 108, 000	4, 812, 000	4, 257, 000
Italy	107, 250, 000	110, 675, 000	104, 500, 000	85, 135, 000
Netherlands	....	5, 250, 000	....	4, 257, 000
Norway	270, 000	283, 000	270, 000	283, 000
Portugal	8, 250, 000	8, 513, 000	8, 250, 000	7, 094, 000
Roumania	33, 000, 000	34, 054, 000	37, 950, 000	28, 378, 000
Russia	220, 000, 000	227, 026, 000	214, 500, 000	198, 647, 000
Servia	4, 125, 000	4, 257, 000	3, 850, 000	3, 547, 000
Spain	115, 500, 000	119, 188, 000	110, 000, 000	90, 324, 000
Sweden	2, 337, 000	2, 412, 000	2, 337, 000	2, 421, 000

European countries.	Estimated average crops.	Estimated average crops.	Estimated crop of 1878.	Estimated crop of 1879.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*
Switzerland	2, 337, 000	2, 412, 000	1, 870, 000	1, 845, 000
Turkey in Europe	41, 250, 000	42, 567, 000	38, 500, 000	30, 802, 000
Other countries (Europe)	540, 000	568, 000	540, 000	568, 000
Total Europe	1, 171, 759, 000	1, 214, 445, 000	1, 115, 879, 000	963, 591, 000
Other countries:				
Australia	16, 500, 000	17, 027, 000	16, 500, 000	18, 446, 000
Algeria	24, 700, 000	25, 540, 000	21, 625, 000	21, 284, 000
Canada	16, 500, 000	17, 027, 000	16, 500, 000	17, 027, 000
Egypt	16, 500, 000	17, 027, 000	11, 000, 000	14, 189, 000
United States	302, 500, 000	425, 673, 000	330, 000, 000	425, 673, 000
Other countries	8, 250, 000	8, 513, 000	8, 250, 000	8, 513, 000
Total outside of Europe	384, 950, 000	510, 807, 000	403, 875, 000	505, 132, 000
Grand total	1, 556, 709, 000	1, 725, 252, 000	1, 519, 754, 000	1, 468, 723, 000

The following tables, from the same source as the preceding, show the principal exporting and importing countries. It must be understood that many countries which one year import, may another year export wheat. Thus, France, Germany, and Spain produce sufficient wheat for their consumption on average years. When the crops are exceptionally good, they export; when very short and prices rise, they import.

In addition to the countries of the tables, India has of late grown considerable wheat, some of which is exported.

TABLE XLVI.—PRINCIPAL WHEAT-EXPORTING COUNTRIES.

Countries.	Bushels exported on average years.
United States	85, 000, 000 to 170, 000, 000
Russia	43, 000, 000 to 57, 000, 000
Turkey in Europe and Roumania	14, 000, 000 to 20, 000, 000
Austria-Hungary	14, 000, 000 to 17, 000, 000
Australia	3, 000, 000 to 6, 000, 000
Canada	3, 000, 000 to 6, 000, 000
Algeria	2, 000, 000 to 3, 000, 000
Egypt	2, 000, 000 to 3, 000, 000

TABLE XLVII.—PRINCIPAL WHEAT-IMPORTING COUNTRIES.

Countries.	Bushels imported on average years.
Great Britain	100, 000, 000 to 130, 000, 000
Switzerland	8, 000, 000 to 11, 000, 000
Italy	8, 000, 000 to 11, 000, 000
Belgium	8, 000, 000 to 11, 000, 000
Netherlands	3, 000, 000 to 6, 000, 000