THE
COMMERCE OF AGRICULTURE

A Survey of Agricultural Resources

BY

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TO

THE STUDENTS IN AGRICULTURAL ADMINISTRATION

WHOSE INTEREST INSPIRED THE AUTHOR

TO PREPARE THE PRESENT WORK

THIS BOOK IS

AFFECTIONATELY DEDICATED

PREFACE

THE purpose of this book is to present to the student of agricultural economics, both in and out of college, a broad world picture of present-day agriculture. For the college student in particular, it is designed to lay the foundation for the more specialized courses, both technological and economic, which properly come later in the college curriculum.

The book is the result of five years of classroom instruction, during which time the presentation of the work has been considerably handicapped because of the absence of a suitable text. The immediate and increasing interest of the underclassmen (for whom the course is primarily intended), during this period, has encouraged the author to prepare the present text.

The book naturally falls into four parts:

Population pressure, in relation to agricultural resources and land utilization, is first shown, in order to focus attention upon the underlying force which is impelling us to a more and more careful utilization of our land resources.

The physical bases of agricultural production, such as climate, soil, and topography, are then treated from a world standpoint, which enables the student to anticipate the distribution of agricultural crops and livestock throughout the world.

Next, the world distribution of commercial crop and animal products is taken up, and their broad economic significance is briefly outlined.

Finally, it is shown how territorial specialization in agricultural production inevitably leads to domestic and foreign trade. It is also pointed out that the tendency toward agricultural specialization continually progresses as a result of the "principle of comparative advantage." The problem of marketing the surplus product in the various specialized areas thus grows more complicated, because of the difficulty of fitting production to consumptive demand. This situation naturally suggests the problem of agricultural organization, which has in view a better adjustment of production as well as more systematic marketing.

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Much of the material in the book has been drawn from publications of the Federal Government at Washington, especially those of the Departments of Agriculture and Commerce, and to these sources hearty acknowledgment is given.

This fact is of particular interest to the teacher of the subject, who will have no difficulty in obtaining material for further study, as these Government publications may be obtained without cost through members of Congress, or at a nominal charge from the Superintendent of Documents at Washington. An inadequate general library, other than these Government publications, therefore offers a relatively slight handicap to the teacher presenting this subject. It follows that the text can be readily adapted to a one- or two-semester course of three or four hours a week, depending upon the time which can be given to more extensive study of the subjects outlined in the text. It is believed that the book itself contains more material than can be absorbed by the average underclassman in a three- or four-hour course during a single semester. It is therefore suggested that Parts I and IV be touched upon more lightly if time is limited, and that the intensive study be made of Parts II and III.

The principal contribution of the book is believed by the author to lie in the fact, first, that it presents the agricultural industry in world perspective, showing the interrelations of the various parts within the industry itself and the place of the industry within the economic system as a whole; and second, that it points out to the student in a broad way the great technological and economic problems of agriculture, thus enabling him to arrive at an intelligent judgment concerning the phase of the industry to which he will devote his major attention in the subsequent years of his college course. That the average college freshman is able accurately to sense these things, if not fully to appreciate them, has been amply demonstrated by the experience of the author and his colleagues during the past five years.

F. A. Buechel.

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INTRODUCTION

"No previous age has had such large opportunities as the present for applying material resources in the elevation of human life. The forces of Nature are being turned back upon her to compel her to render ever larger returns to man's efforts in every branch of industry; any resistance that she may offer to the agriculturist and the miner being quickly reduced by the incessant development of fresh sources of rich supply, and by easy and rapid communication between distant places."

—MARSHALL.

"The production of wealth is but a means to the sustenance of man; and to the development of his activities, physical, mental, and moral. But man himself is the chief means of the production of that wealth of which he is the ultimate aim.

"The study of the growth of population is often spoken of as though it were a modern one. But in a more or less vague form it has occupied the attention of thoughtful men in all ages of the world. To its influence, often unavowed, sometimes not even clearly recognized, we can trace a great part of the rules, customs, and ceremonies that have been enjoined in the Eastern and Western world by law givers, by moralists, and those nameless thinkers whose far-seeing wisdom has left its impress on national habits. Among vigorous races, and in times of great military conflict, they aimed at increasing the supply of males capable of bearing arms; and in the higher stages of progress they have inculcated a great respect for the sanctity of human life; but in the lower stages, they have encouraged and even compelled the ruthless slaughter of the infirm and the aged, and sometimes of a certain proportion of the female children."

—MARSHALL.

AGRICULTURAL RESOURCES

CHAPTER I

LAND SUPPLY IN RELATION TO POPULATION PRESSURE

Introductory.—Down through the ages, mankind has ever been confronted with the problem of maintaining an adequate and dependable food supply. Paleolithic man seems to have been mainly a food-gatherer, a collector of foods from wild plants and a hunter of wild beasts. In Central Europe, by the advent of Neolithic times, man had domesticated such animals as cattle, hogs, sheep, and probably the horse, and was cultivating such plants as wheat, barley, and oats. It seems very probable that the domestication of plants and of animals in the various parts of the world was brought about through a need for a larger and a more dependable food supply, a need intensified by a growing population and the destructive exploitation of the free goods provided by nature.

Plant and animal domestication, which was accomplished by prehistoric man, constituted the beginning of agriculture and so provided a means for increases in population. For many centuries population growth was very gradual although, in general, it was a steady increase, and such population problems as were recognized were mainly local in character.

In recent centuries, and especially during the past century, the population of the world has increased rapidly. The question of sustenance for the multiplied millions has been taken care of by migrations to less densely populated countries, principally the Americas, and by importation from foreign lands of plenty. By this process the unoccupied arable land of the world has been gradually reduced in extent, until to-day very little remains in regions with healthful climates. North America now leads in the production of many food crops; yet, but yesterday, as world history goes, it supplied food for only a handful of the Red Men of the forest. To-day the United States, with only about 5 per cent of the world's population, produces about one-seventh of its cattle, one-fifth of its wheat, one-fourth of its oats, one-third of its hogs, three-fourths of its corn, and three-fifths of its cotton.

It is true that our production could be greatly increased by the utilization of all available resources, such as irrigation in the West, and intensive culture, comparable to that practiced in the older and more densely populated countries, in the East. It has been estimated that we could feed between three and four hundred millions of people; but with the millions knocking at our door for admission, and our own natural increase in population, it is easy to vision the time, especially with unrestricted immigration, when this country itself would have to look elsewhere for food. The Americas and interior Africa constitute the world's last food frontier. When they shall have reached their maximum production, if populations continue to increase as in the recent past, a serious situation as to food will probably arise.

In the United States, up to the present time, as population has increased, the problem of food has been met by extending agriculture from the original narrow strip along the Atlantic seaboard farther and farther westward into virgin and fertile soils. We now have occupied all of these, however, and further increases must be obtained either by more intensive cultivation, including fertilization and reclamation of relatively less productive lands, or by irrigation in the semi-arid West and through better farm organization. Any of these methods will present problems far more difficult than our former methods of expansion has required.

Increasing Recognition of Importance of Soil Resources.—That the soil constitutes our greatest natural resource, perhaps no one will deny. But the significance of soils in relation to world problems has been almost entirely neglected. Modern soil science had its beginning in the studies of soils on the plains of Russia. Two great pioneers in blazing a trail through these problems are Professor Ramann of Germany and Dr. Marbut of our Federal Bureau of Soils. Ramann has pointed out that there is at least a coincidence between the distribution of the Brown Earth soils and the historical development of independent peoples. To suggest that there is a causal connection between these factors may be stretching the point; but it is well known that it requires much more care and training to farm successfully the light-colored forest soils usually occupying areas of uneven topography than the more productive lands originally supporting tall grasses. The former may and usually do present on the same farm, a variety of problems in regard to the best crops suited to the various soil types, the ways and means of fertilization, the methods of preventing or checking erosion, and the working out of an effective rotation, thereby greatly limiting the area that can be efficiently cultivated by the individual farm family.

The Doctrine of Malthus.—Another and somewhat different problem will be discussed here. The world has long had population problems; but little systematic discussion of them was to be found in literature until Malthus put forward his famous essay at the close of the eighteenth century. In this work Malthus pointed out the possibilities of population growth, and at the same time stated his doctrine of the arithmetical rate of food-supply increase. The latter was only his way of expressing the Law of Diminishing Returns, which had not then been stated as such.

The doctrine of Malthusianism, local though it was in its inception, has a general application and, "it may be regarded as a desperate cry arising from man's attempt to adjust himself to relatively shrinking soil resources while population was increasing." Malthus did not mention the soil as such, but the doctrine was based upon man's inability to increase the food supply as fast as population tended to increase. The doctrine as originally stated was based on the agricultural situation in western Europe; and the agriculture and soils of western Europe were all that were known to the people of that section of the world. The soils of western Europe originally were low in capacity for production, and the era of mineral fertilizers had not opened when Malthus was living. Agricultural methods had been practically stationary for hundreds of years. Grain yields were low and always had been low. His attempt to increase such yields brought man into sharp conflict with the operation of the Law of Diminishing Returns. Some additions were possible through increases in the production of livestock; but such an expansion meant an increase in the land used for growing forage for the animals, and often this meant a decrease in the land available for grain production.

The Industrial Revolution in its Relation to Increase in Population and Food Supply.—Then came the Industrial Revolution. This gave man engines of transportation as well as large-scale machinery for agricultural purposes. It released men from the bondage of food production, enabling an increasing proportion to work in factories or in connection with means of transportation, and thus provided a market for the surplus products made possible by the use of agricultural machinery. Along with these changes came developments in the science of plant physiology as applied to crop production. This led to an appreciation of the importance of fertilizers as means of increasing crop yields. The practical significance of this was greatly augmented by discoveries of deposits of mineral fertilizer materials. While these developments were occurring, population was expanding beyond the poorer, light-colored soils of western Europe and the eastern United States into the darker-colored soils of the interiors of the continents. This expansion first made its way into the prairies of the central United States, then into the Black Earth of Russia, later into the Pampas of Argentina and the dark-colored soils of southeastern Australia. The present generation seems destined to observe a similar expansion into central Africa. These achievements were made possible through the results of the Industrial Revolution. With them came marked changes in agricultural systems. Specialization received a new impetus, and this has progressively increased down to the present time. In some regions extensive agriculture with large yields per man was the significant thing. In consequence of the foregoing conditions there occurred in west central Europe an Agricultural Revolution scarcely less profound in its significance than the Industrial Revolution. New agricultural methods were introduced, and the quantity of production was revolutionized. Soils were fertilized, better methods of tillage were introduced, more and better livestock were kept, commercial dairying was begun, and new systems of rotation were put into practice. At the same time the great surplus-grain-producing areas of the world were coming into their own. These were the dark-colored grassland soils in the interiors of the continents. From these circumstances arose the transportation of vast quantities of grain to the great manufacturing centers. It is impossible in this place to go much farther into the situation. Briefly, however, it may be stated that the light-colored forest soils of western Europe and the eastern United States are far less productive than the granular dark-colored soils of the interiors of the continents. It should be remembered also that the latter soils did not become important until about half a century ago.

LATE UTILIZATION OF DARK-COLORED SOILS[1]

Opening Up Interior of Continents Permitted Increase in Population and Increase in Per Capita Food Supply.—Until man had developed the modern engines of Civilization, especially modern facilities of transportation and communication, it was necessary for him to live in a region that supplied him with a large part of his necessities. He had to supply himself not only with food, but with water, building material, and fuel from his immediate environment. The black lands of the world are treeless, they are streamless for a considerable part of the year over

[1] Marbut, C. F., The Rise, Decline, and Revival of Malthusianism in Relation to Geography and Character of Soils. Annals of the Association of American Geographers, Volume XV, March, 1925.

large areas, and the ground-water supply lies deep. Each settler must provide himself with all the different kinds of food necessary for maintaining life and health. The black lands are predominantly adapted to grain production and not to a wide range of products. Another reason for their late development lies in the fact that because of the nature of the soil and of the topography, they are predominantly adapted to mass or large-scale production. Their development came only after large-scale development had been made possible through the invention of agricultural machinery.

This Agricultural Revolution and the bringing under cultivation of the dark-colored soils of the interiors of the continents brought about great increases in food production in the western world, and associated with this was a great increase in the population of this part of the world. But the expansion into these productive lands has almost reached its limits. There now exist no virgin areas of productive grassland soils to be exploited, outside of central Africa. Of course, more effective utilization can and will be made of those black-soil areas already under cultivation. The effects of the Agricultural Revolution have not been felt in full in many parts of the world. But just as there exists a physical limit to the area of these regions, so on the other hand there exists the iron-bound law of diminishing returns which progressively constitutes just as inexorable a limit as do area and natural productivity.

The Revival of Malthusianism.[2]—Standing where we stand and looking back over the revolution in production taking place during the last century; realizing that Malthus and his predecessors as well as his contemporaries lived near the close, but still within the Middle Ages so far as food production is concerned, we cannot wonder that this theory suffered an eclipse through the greater part of the latter half of the nineteenth century. When one examines the arguments against it by its opponents, however, he is struck for the most part by their failure to see the true state of affairs. While no classification of these arguments has been attempted (here), a casual perusal seems to indicate that most of them failed to see the relation of increased production per unit of area. They failed to recognize that the final test of the theory hangs on the possibility of an indefinite increase in production per *unit area* and that the increase per man may be a source of evil to the majority of mankind rather than of good. If the law of diminishing returns be an inexorable one, it seems merely a matter of time when the law of material limitation of population will operate much more mercilessly than at any time in the past; for it is evident that the future contains lurking within it no possibility of such an increase in production as has taken place during the last half century through the utilization on a large scale, for the first time in the history of the world, of the black soils of the world. In view of the events of the past fifty years, it may seem surprising to many of us that there should

[2] *Ibid.*

have been in the last few years a revival of the interest in the Malthusian doctrine.

With the increase of economic pressure and the consequent need for the more efficient utilization of the world's natural resources, it will be necessary to know better the limits and the extent of the available resources of the various portions of the earth. In regard to the soils and climatic factors of the United States or of the world, this will mean that they must be known in so far as their characteristics are significant to efficient crop production. This will require a thorough study of the soil characteristics and their distribution, and the manner in which these characteristics influence plant growth and development. It will mean a much closer study of the means of maintaining soil productivity, of the use of fertilizers, and of the means of preventing and reducing erosion. These latter will be considered in some detail in a subsequent chapter

SUMMARY OF THE LAND RESOURCES OF THE WORLD

The land area of the world that is suitable for agricultural production is almost entirely determined by climatic conditions. Also, the limitations of the type and intensity of the production of agricultural commodities are closely related to the features of the climate of the area involved. It has long been known that the climate of a region dominates the broader aspects of the types of native vegetation of that region; it has only recently been shown beyond doubt that climatic conditions in coöperation with the native vegetation determine the broader aspects of the characteristics of the soils of the region. These factors make it necessary to point out here the broader relations of climates to the agricultural resources of the world.

Most of the lands suitable for plant and animal production lie in the tropical and northern mid-latitude belts. If the tropics be defined as that belt lying between the Tropic of Capricorn and the Tropic of Cancer, they include about 40 per cent of the total surface of the globe. In this belt there are about 17 million square miles of land area, which amounts to approximately one-third of the total land area of the earth; but this land area includes only about one-fifth of the total area embraced in the tropics. The southern portions of the Sahara and Arabian deserts and the northern section of the "Dead Heart of Australia" lie in the tropics, but most of the remainder of this relatively vast land area has rainfall sufficient for crop production throughout the year or during some part of it. The mid-latitudes, or so-called Temperate Zones, include almost 53 per cent of the earth's surface. In the southern mid-latitudes, however, there are but 4 million square miles of land area (one and one-third times as large as the United States) and a large share of this has not sufficient moisture for crop production. It has been estimated that the population of this zone is only about one-fifth that of the United States. The northern mid-latitudes contain approximately 26 million square miles of land area and about the same amount of water surface. Because of the surface configuration and the compact shape of the land masses in this zone, a large share of it is semi-arid to desert in character. The humid and sub-humid lands of this belt, however, even though characterized often by extremes in weather conditions, support about two-thirds of the total population of the world, and have long been important regions for agricultural production.

The foregoing summary of the land areas in the different zones is designed to be merely suggestive of the land resources of the world viewed from the standpoint of area. No adequate classification of the world's land resources has yet been made. In the more detailed discussion of climate, soil, and topography, however, which will appear in subsequent chapters, a more complete picture of the land resources of the world may be obtained. We shall now turn our attention to a very general classification of the land resources of the United States.

GENERAL SURVEY OF THE LAND RESOURCES OF THE UNITED STATES

The total land area of the United States is estimated at 1,903,000,000 acres. This may be put into two classes as follows.

1. Lands that will not be used for crop production—930 million acres.
    - *a.* Arid grazing....................468 million acres.
    - *b.* Forest only....................262 million acres.
    - *c.* Pasture or forest.................. 66 million acres.
    - *d.* Cities, roads, farmsteads, etc........ 67 million acres.
    - *e.* Waste—desert, rock............... 67 million acres.
2. Lands physically fit for crop production—973 million acres
    - *a.* Improved
        - (1) Land in crops...............365 million acres.
        - (2) Improved land not in crops....100 million acres.
    - *b.* Unimproved
        - (1) Humid lands that do not require drainage, now mainly in pasture and forest..................235 million acres.

(2) Humid lands—mostly in pasture 52 million acres.
(3) Semi-arid—mostly in pasture..116 million acres.
(4) Lands requiring drainage...... 75 million acres.
(5) Irrigable lands........ ..... 30 million acres.

The foregoing figures show that about half of the land area of the country is physically fit for crop production. This, then, constitutes our potential land supply. Only one-third of this potential crop area is now in crops; about one-half is improved; the remainder is in forest. grass, swamp, and desert. Our *reserve* of potential crop land amounts to 500 million acres, which might appear, upon casual observation, to be ample for all future needs. But the character of this reserve should be carefully noted. It will be seen to include forest and cut-over lands which frequently entail considerable expense to bring into use and are often lacking in fertility for crop purposes. Another portion of the reserve consists of sub-humid land, the use of which for crop purposes involves the hazard of protracted droughts. Again, the reserve is made up of semi-desert and swampy lands, which often require great initial expense before they can be used for crops, and also require the greatest vigilance on the part of the farmers in preventing deterioration after the drainage or irrigation project has been installed.

All this suggests that the additions which we shall make to our crop-land area must come from a reserve, the constituent parts of which are in the main of much lower quality than the lands already in use. In other words, the returns which a given amount of effort applied on these new lands will bring forth become progressively less and less as these new increments of poorer land are brought into use. If we turn to the other possible alternative and expend more effort upon the land which is already in use and which is in the main of higher quality, we are confronted with the unalterable "law of diminishing returns." As a consequence of this law, it becomes uneconomical to expend more labor and capital upon a piece of land after a certain point has been reached. Therefore, whether we attempt to provide more food and fiber by reaching out and bringing new lands into cultivation, or whether we attempt to do it by cultivating the old lands more intensively, we are confronted with the problem of increasing costs.

What, then, is the force which is creating the dilemma in which we in this country are beginning to find ourselves? We shall try to answer this question briefly in the next paragraph.

SIGNIFICANCE OF A GROWING POPULATION

Cultivated Land is Increasing Slowly; Population, Rapidly.—From the beginning of the nineteenth century to the present time, the population of this country has grown from 5 millions to 115 millions. In Europe the increase has been from 150 millions to 450 millions during the same period. Not only has the population of this country increased more than twenty-fold in a century, but the per capita consumption has vastly increased. At the present rate of increase, our country would have at the end of a century a population equal to that of China. While it is not likely that this rate of increase will be maintained, conservative estimates place our probable population at the end of the present century at approximately 200 millions. Twenty-five years from now, it is estimated, our population will be 150 millions. Not until recent years have we been obliged to give serious thought to land in its relation to population increase. It seemed that our land supply was practically unlimited. Even now, many people think of land in terms of area instead of quality, and thus are unable to visualize the problems which are arising because of a relatively fixed land supply in comparison with a rapidly increasing population.

Analogy between a Shrinking Earth and a Growing Population.[3]—If the world were gradually growing smaller and population remaining constant, the effect upon human beings would be very like that produced by the growth of population in a world which remains the same size. It has been estimated that if the population of the world continued to increase at the rate at which it was growing between 1906 and 1911, it would double in sixty years. Let us imagine, therefore, that the world is shrinking at such a rate that it will be half its present size in sixty years. The suggestion seems rather an alarming one as it stands, but to make the analogy more accurate we must assume that the shrinkage is all taking place in the food-producing areas. We should rightly regard such a state of things as more serious than that which actually faces us. For, in the first place, the growth of population carries with it an opportunity for increased efficiency in production, which must be set off against the increased demand for food. Other things being equal, a thousand million people on half the earth would not, therefore, be so well off as two thousand millions on the whole earth. In the second place, we know from experience that, unless some new discovery enables us to produce food more easily, the population will not, in fact, continue to increase at its present rate.

Though the analogy is not complete, however, it may serve to bring out a few points which would otherwise remain somewhat obscure. It illustrates the Law of Diminishing Returns. If the returns to agriculture remained constant, we should have no economic reason for alarm at the

[3] Wright, H., Population, pp. 59–61.

shrinking of the earth. The same quantity of capital and labor would be available and would yield the same amount of food when it was applied to a smaller quantity of land. Even a single field would then suffice to maintain the whole population at their present standard of living. Such a supposition is obviously absurd; but it is no more absurd than it would be to deny the tendency to diminishing returns. Recognizing, then, as we should, that the shrinking earth would yield a smaller return of food to each successive dose of capital and labor applied to it, we should be forced to tackle the problem of maintaining the population on the food produced from a smaller acreage. The price of food would rise. *Increasing quantities of capital and labor would be transferred* from the production of other articles, such as clothes and houses, to the production of food. Some land, which is now more profitably used for other purposes, would also be ploughed up and put under cultivation. Thus, by a considerable transference of resources from the production of less essential commodities, the primary need of human beings for food would be supplied and the whole population might continue to exist on a lower standard of comfort and well-being.

In all probability no actual famine would result from such a decrease in the size of the earth as we have supposed; no one need die of starvation; it is possible that no one need eat less food than before; but food would be dearer and many other things would also be dearer and scarcer, because capital and labor would be diverted from making them in order to keep up the food supply. A unit of labor applied in industry would consequently yield a purchasing power over a smaller quantity of commodities of all kinds.—Reprinted by permission from Population by Wright. Published by Harcourt, Brace & Company.

The Economic Advantages of a Growing Population.[4]—In comparing the growth of population with a shrinkage of the earth, it was remarked that the former would be less alarming than the latter, because an increase in population carries with it an opportunity for increased efficiency in production. It will be worth while to examine that statement more closely.

The raw materials of manufactures are all either agricultural or mineral products, and the Law of Diminishing Returns applies to these as well as to food. The cost of raw materials, however, is often a very small part of the total cost of production in manufactures, and all the other costs tend to decrease as the amount of production increases. Manufactures are much more susceptible than agriculture to improvements in mechanical skill. Mass production enables very great economies to be made, and facilitates that world-wide division of labor which has contributed so enormously to the general wealth. In manufactures, therefore, the causes which tend to diminish costs as the amount produced increases have generally preponderated greatly over the tendency of the raw materials to increase in costs, and it is probable that in most industries the balance will remain tilted in a favorable direction for a long time to come. Moreover, the growth of population has facilitated that development of the means of transport both by land and sea, which, as we have seen, enables the products of distant

[4] Wright, H., Population, pp. 66–70.

lands to be exchanged at trifling costs. The actual proximity of large numbers of human beings to one another, objectionable as it may be to those who love solitude and country scenes, enables great economies to be made in the distribution of goods, and renders possible some amenities of civilization such as picture-palaces and picture-galleries, which could not be provided in a sparsely populated world. This gathering together of multitudes also has some effect in counteracting the tendency to diminishing returns in agriculture, by introducing an economy in the distribution of food. It is clear that British agriculture could not be profitably carried on so much more intensively than that of Canada unless proximity to the consumers exercised a powerful influence on costs. It is equally clear that if much smaller quantities of Canadian wheat were required in this country, the cost of bringing them to market would be increased.

Taking all these factors together, it will be seen that the growth of population may under certain circumstances actually increase the amount of wealth per head, even though food may be getting dearer. Diminishing returns to agriculture and the diversion of an ever-increasing proportion of the total supply of capital and labor into production of food and raw materials may be outweighed by the increasing returns obtained in manufactures. A smaller proportion of the total population employed in manufacturing industries may thus supply the aggregate wants of the community more fully than before. Houses and clothing may be so plentiful as to more than compensate for the comparative scarcity of food.

To put the same point in another way, let us assume that owing to improved machinery and business organization the Lancashire cotton industry is yielding increasing returns, in spite of some increase in the price of raw cotton. The wages of the cotton operative will tend to rise and the price of cotton goods to fall. He may therefore be able to buy as much food as before at a higher price and still have more money to spend on other things. Boots and gramaphones and rides on motor-coaches may also be getting cheaper through economies obtained in their production on a large scale. His real income may thus be considerably increased.

It would be very interesting if we could distinguish between those economies in production which depend upon an increase in numbers and those which would take place if the population remained stationary. Unfortunately they are inextricably mixed together. Many discoveries and inventions which depend upon the brain-work of a few men working in seclusion would certainly be made in any civilized society, whether the population was increasing or not. Some of these could be profitably applied under any circumstances. Others, however, like the discovery of steam and electricity, require a dense population if their potentialities are to be fully developed in such enterprises as railways and telegraphs. Probably an increasing population was necessary to call forth the capital for the great railway systems which were created throughout the world towards the end of last century. Manufacturers, again, certainly require a considerable density of population in order to obtain those economies of mass production and the division of labor which lead to such astonishing supplies of cheap and sometimes nasty goods. It is true that many people would rather have one suit of hand-made cloth than twenty suits of the stuff which is turned out by machinery, but it is clear, at any rate, that much larger quantities of clothing, per head, are available in a densely populated world than could be produced by a scattered community. Finally, as we have already seen, there are economies in distribution which depend entirely upon a large population being congregated in a relatively small area, and many developments of civilization, some wholly good and others of more questionable intrinsic value, but all sought after by the modern town-dweller, which could not have been introduced into a less populous world.

It is not possible, then, to say with any precision how far the progress of civilization and the accumulation of wealth depend upon an increasing population. Up to a point, the growth of numbers has certainly contributed largely to the growth of wealth. There are indications, however, that the most sweeping economies which result from increasing numbers have already been secured in the industrial areas of Europe and the United States. It is probable that the wealth of civilized countries was still growing faster than the population, that the wealth per head was still increasing in the years immediately preceding the war. But it is probable also that the wealth per head would have been increasing faster still, if the population had not been growing so rapidly. From the economic point of view, at all events, there seems no reason to bemoan that slowing down of the rate of growth of the population of the Western world which has alarmed some English bishops and French patriots in recent years.

Taking a somewhat longer view, we may indeed see good reason to strengthen this tentative opinion. For if it appears to be somewhat undesirable for numbers to continue to multiply rapidly when we are considering the immediate effect upon the welfare of the people, it will appear much less desirable when we look to the future.

The main raw materials of European industry are either imported from other continents or raised from mines. Those which are imported are chiefly agricultural products, like cotton and wool, which are subject to the Law of Diminishing Returns.

SOIL IN COMPARISON WITH OTHER NATURAL RESOURCES

The soil differs from such natural resources as iron, coal, and petroleum in that, if properly taken care of, it may be used indefinitely without impairment of fertility, while mineral deposits once removed can never be restored by Nature. Yet soils have in the past been ruined almost beyond recovery, and this process is still going on in many parts of the world. In parts of Europe and the Orient, however, soils have been maintained in their original state of fertility for centuries through careful management and the intelligent use of fertilizers.

Much of American agricultural history, on the other hand, has been characterized by the exploitation of the soil through continuous cropping and consequent soil exhaustion. Practically every part of the country has at one time or another experienced this type of agriculture. In most parts of the United States this process is still going on to a greater or less extent. There are, however, notable exceptions to this, as for example Lancaster County, Pennsylvania, which has reached the settled maturity that characterizes the Old World.

In all parts of this country there are increasing numbers of farmers who are giving greater attention to good husbandry. The principle of alternating, upon tbe soil, crops that produce nitrogen and organic matter with those that consume these substances, and crops that are deep-rooted with those that are shallow-rooted, is being more and more generally observed.

By thus systematically alternating grains, grasses, legumes, and tilled crops, the soil will be maintained in good tilth, weeds kept under control, a basis for animal industries established, and a continuous income throughout the year maintained for the farm family. As these practices become more and more universal, fertility of the soil as a permanent resource will be assured.

It is perhaps not unreasonable to hope that the "shrinking earth" due to an increasing population upon a fixed land area may be indefinitely counteracted by progressive improvement in the care of the soil, and careful planning for the best utilization of land resources.

Professor Frederick J. Turner sounds an optimistic note in reply to those who see in the "shrinking earth" a grave menace, in these words:

> For myself, I doubt the rate at which the catastrophe prophesied by these authorities approaches. But in history a few centuries are not determinative. I do not doubt the trend, and to me who have spent much of my life in the study of the movement of peoples into the vacant spaces of the United States, it is a dramatic outcome of a process that began with the first wanderings of the cave man. But I prefer to believe that man is greater than the dangers that menace him; that education and science are powerful forces to change these tendencies and to produce a rational solution of the problems of life on the shrinking planet. I place my trust in the mind of man seeking solutions by intellectual toil rather than by drift and by habit, bold to find new ways of adjustment, and strong in the leadership that spreads new ideas among the common people of the world; committed to faith in peace on earth, and ready to use the means of preserving it.

THE NEED OF A NATIONAL LAND POLICY

It seems certain that the time is here when a definite national land policy needs to be worked out for the proper utilization of our land resources, not only for unimproved land but for lands already in cultivation. Such questions as the extent to which our agricultural industries should be protected by means of tariffs; the rapidity with which reclamation, by drainage, irrigation, or otherwise, should be fostered by the Government; and the relative amount of our lands which should be used for crops, forests, and grazing, must be studied with the greatest care. In the words of O. E. Baker:

> Whether it is desirable to afford protection to our agriculture in order to promote its expansion involves many questions of policy both economic and social. If after mature discussion it appears advisable to embark upon a policy of protection for our agricultural industries, it is important that the expansion of the agricultural area be promoted in accordance with broad plans of national scope, based on the principle of national welfare. The obstacles to be overcome in the reclamation by drainage, irrigation, or otherwise of the lands that remain unused will increase in difficulty and magnitude as the more feasible projects are completed, and will inevitably require in increasing extent the resources and credit of the Government.
>
> Before such costly public works are undertaken, it is important that the rate, the time, and the direction of expansion of our arable area be carefully studied. The rate of expansion should depend upon the rate of increase of population and the trend of per-capita consumption, of per-acre production, and of exports and imports. The time for expansion should be determined with reference to construction costs and the financial situation. The direction of expansion should involve thorough investigation of soil and climate, with especial reference to crop adaptation and farm organization. A classification of the land of the United States, with reference both to physical character and to economic use, is basic to an orderly expansion of our arable area. Classification with reference to physical character is being well made by the Soil Survey; but classification with reference to economic use has been made only for small areas and usually incidental to other objects. A *survey of the present and potential use of the land is one of our greatest national needs.* This survey must include a study of the agricultural resources of foreign countries also, especially of the tropics, whose products are likely to invade our markets in increasing amounts unless excluded by tariff barriers.[5]

In conclusion, it appears appropriate to note again that, although the land resources of the United States make it possible to feed and clothe 400 million people in a manner that will not seriously impair their health and activity, it will probably require a larger proportion of the national effort to do so than is required at present, and there will be less of other commodities, especially the luxuries, available per individual for consumption. The production per capita of agricultural products apparently reached its crest about 1906–07 and is now diminishing. The production per capita of manufactured products is probably still

[5] See L. C. Gray: Helping Landless Farmers to Own Farms, Yearbook, Department of Agriculture, for 1920, pp. 271–288.

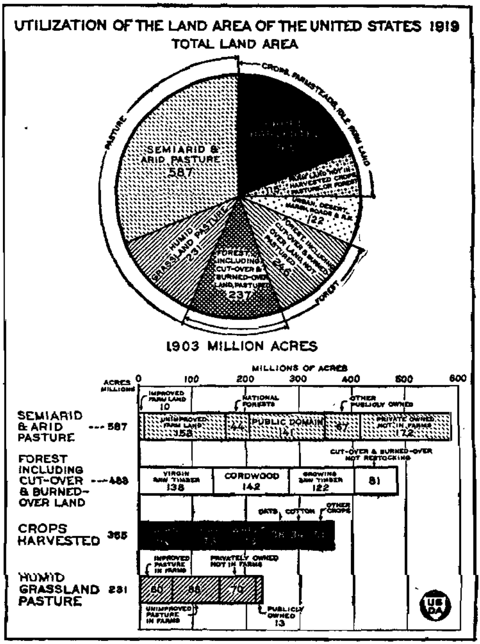

FIG. 1.—Crops harvested in 1919 occupied 19 per cent of the land area of the United States. Pasture (excluding both temporary crop pasture and forest land used incidentally for pasture) occupied 43 per cent, and forest and cut-over land about 25 per cent of the total area. However, the fifth of the land area in crops yielded a vastly greater annual product measured by value than the two-thirds in pasture and forest. The remaining 13 per cent of the land area was almost equally divided between land in farms not used for crops, pasture, or forest (mostly crop land lying idle, crop failure farmsteads, lanes, and waste areas), and nonagricultural land outside farms (mostly urban land, absolute desert, rocky areas, and land used for roads and railroads). Many of the figures in the graph are estimates.

Agriculture Yearbook, 1923, p. 416.

increasing; but, as manufacturing is dependent largely for its raw materials upon agriculture and forestry, manufactured products must soon show also a diminishing production per capita unless there be extensive importation of food and raw materials from abroad. In other words, our nation is probably near, possibly past, the crest of greatest average income per capita; and every increment in population is likely to increase the complaint of the high cost of living.

SUGGESTIONS FOR FURTHER STUDY

The article on the utilization of our lands for crops, pasture, and forests in the Agriculture Yearbook, 1923, gives an analysis of present and potential uses of the lands of the United States for agricultural purposes. The following exercises are based upon this article.

1. In what section or sections of the United States do each of the following types of land utilization predominate?

   a. Semi-arid and pasture.
   b. Forest, including cut-over and burned-over land.
   c. Crops harvested. (For the various crops, see especially Fig. 20, Agricultural Regions.)
   d. Humid grassland pasture.

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THE PHYSICAL ENVIRONMENT OF AGRICULTURE

" The first [inquiry] is an investigation into the potential agricultural resources of the world. There have been more than one elaborate examination of the coal supplies; we have estimates of the total stock of coal down to various depths in Britain, Germany, America, China and elsewhere; we can form some impression of how long at given rates of consumption each of these stocks will last; we know that *exhaustion is not an issue of this generation or of many generations* to come. There is no corresponding study of agricultural resources; there is not material for even a guess at what proportion of the vast regions—in Canada, South America, Africa, Australia—now used for no productive purpose, could be made productive; at what proportion of all the productive but ill-cultivated land could with varying degrees of trouble be fitted for grain and pasture. Without some estimates on such points, discussion of the problems of world population is mere groping in the dark. The inquiry itself is one that by an adequate combination of experts in geographic, agricultural and economic science—not by a commission gathering opinions, or by an office gathering statistical returns—it should not be difficult to make."

—Sir William Beveridge (1919).

CHAPTER II

CLIMATES OF THE WORLD

Introductory.—The problem of modern agriculture is that of the icient and profitable use of the various agricultural lands of the earth · the production of those commodities for which the area is best suited ysically; provided that the degree and kind of utilization are adjusted the immediate demand, and that the system of production is such will insure at least the maintenance, if not also the building up, of e productive capacities of the soils of the areas involved.

The increasing economic pressure upon the limited agricultural sources of the world will make for a closer and more efficient use of ese resources; a more efficient use requires a careful inquiry into the ysical setting of plant growth and reproduction, and thus of animal oduction. It means also a careful study of the agricultural potenlities of the various portions of the earth.

The following discussion of climates, physiography, and soils and eir interactions aims to point out in a broad way the physical environnts of agriculture and to interpret the significant interrelations of e elements in this environment. It must be emphasized that a entific inquiry, in order to be of most value in the efficient use of ids, requires an interpretation of the genetic relationships of the varis physical elements involved: climates and native vegetation; surface tures, underlying rocks and their structural arrangement; and the ysical, chemical, and biological characteristics of soils in their relation all the foregoing physical features.

CLIMATES OF THE WORLD

Significance of Climate in Agriculture.—An examination of the clites of the world reveals the fact that agricultural production is cluded from certain large sections of the continents because of the favorable combinations of climatic factors in those regions. The imiting factors are mainly low temperatures and scanty amounts moisture. Large areas of the polar lands, such as the Tundras with ir very short and cool growing seasons, their cold and wet soils (in summer) and consequent slow plant growth, can never be used for cereal production. They will produce only certain kinds of forage and animals, and these to a very limited extent when compared with total world production. The same thing is true, although in less degree, of the poleward portions of the vast northern coniferous forests in which the timber growth is slow and the stand scattering, and which is composed for the most part of trees too small for lumber purposes. Also, the cold and treeless summit areas of the higher mountain systems of the world are limited by similar conditions.

In addition to the large areas too cold for agriculture, at least 25 per cent of the land area of the earth is too dry for profitable use in plant or animal production. These dry regions are the deserts, which include the sub-tropical or trade-wind deserts such as the Sahara, most of the Arabian Peninsula, and the "Dead Heart" of Australia; the interior deserts of the middle latitudes, such as central Asia and sections of southwestern North America; and also the coastal deserts, such as the coastal lands of Peru and northern Chile and the area along the southwest coast of Africa, north of Cape Town.

These cold or dry sections include most of the areas in which plant and animal production is precluded. We have now to turn briefly to the lands climatically suitable for economical plant production and hence suitable for certain types of animal production. These are the lands where the combinations of temperature and moisture conditions are favorable for certain types of plants at the different stages of their growth and development. Because the combinations of these two fundamental climatic factors vary for different regions of the earth and vary also in the different seasons of the year in the same region, there results a differentiation of sections based on climatic conditions, and thus the various regions and areas are best suited climatically for certain types of plant production and also for special kinds of animal production. It is these factors that differentiate the agriculture of the lowlands of the tropics from that of the mid-latitude zones. It is these factors also that give the broader differentiation of productive regions in both the tropics and the middle latitudes, e.g., the grazing sections, the forest lands, and the farming regions such as the wheat belts, the corn areas, and the pasture, forage, and dairy regions.

The Weather Elements and Agriculture.—In addition to the regular course of climatic events, which results in the subdivision of the earth into climatic regions, there occur, especially in the middle latitudes, certain irregular variations which can be designated as "spells of weather," such as dry spells, rainy spells, cold waves, hot winds, and the frost hazard. Any of these variations may be very significant in agricultural production, and may be important in the storage or transfer of these products in the processes of marketing.

Other Relationships.—The climatic relationships already mentioned will be treated in detail in the succeeding pages. There remain, however, to be pointed out here, other relationships which later will be more fully developed. These include, first, the adjustments of the native vegetation of an area to the climatic conditions, the native vegetation serving as an indicator of the types of economic plants best suited to the section; and second, the soils, the physical and chemical characteristics of which represent the result of the processes of soil formation as they become adjusted to the climatic conditions of the area.

The Climatic Elements.—By weather is meant the condition of the atmosphere at any place for any given time, with respect to temperature conditions, precipitation, atmospheric pressure, humidity, cloudiness, the direction and intensity of air movements, and the intensity of sunshine. Combinations of these conditions over an area give types of weather, the more marked being designated often as "spells of weather."

It is the succession of these types of weather through the seasons that gives to a place, an area, or a region, its climate; and it is the seasonal aspects of weather and of climate that are of such great significance in agriculture.

Temperature and Sunlight: Basic Considerations.—Temperature means simply the hotness or coldness of an object, and thus represents an effect of heat energy. The source of practically all the heat energy on the earth's surface is the sun; and the main facts regarding the unequal distribution of radiant energy on the earth are connected with the results of a rotating, atmosphere-covered globe which is inclined at an angle of $23\frac{1}{2}°$ and revolves about the sun. These conditions result in the division of the earth into the major climatic zones, the frigid, the temperate or middle latitudes, and the tropics, and cause the occurrence of the seasons in the different climatic zones.

The same conditions result in the unequal distribution of light on the earth, but this is considerably modified in many sections by the degree of cloudiness.

Temperature and Life.—Through the ages, the various forms of life, both plant and animal, have become in one manner or another adjusted to a range of temperature conditions; and while heat energy is essential to the existence and development of any form of life, there exist temperature limits, heat maxima and minima, for the different groups of plants and animals, beyond which it is impossible to go without resulting in injury or death to the plant or animal which may be involved.

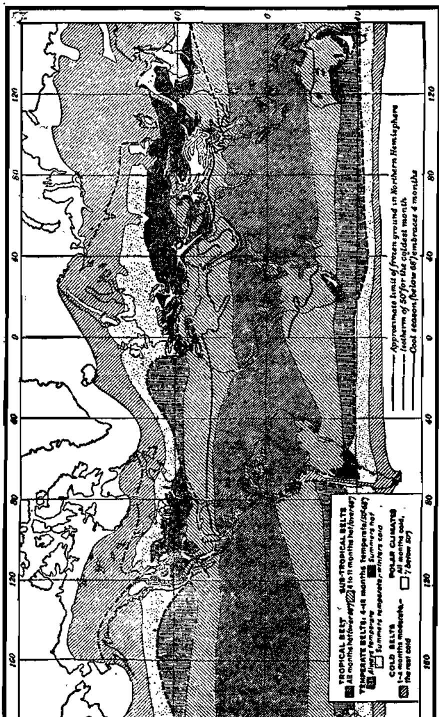


Fig. 2.—Temperature Zones, after Köppen (from Ward, p. 27).

These temperature limits and the ranges, annual and seasonal, to which plants and animals in their long course of development have come to be adjusted, cause the major climatic zones to become in a broad way great life zones. As is to be expected, the types and forms of life in one zone differ markedly from those in another.

Use of Significant Temperature Data.—In the tropics, especially in the rainy lowlands, the monthly temperatures vary so little from month to month and year to year that averages extending over a long series of years are not required in order to get a general idea of the temperature conditions.

The intermediate zones, located as they are in the middle latitudes, are characterized by tropical aspects over large areas in summer and by polar aspects in winter. In addition there occur the changeable effects connected with the passage of cyclones and anticyclones, and thus monthly temperatures extending through but a year may give very erroneous ideas concerning the average temperature conditions and the ranges of temperature in those regions.

Hence, in the middle latitudes it is customary to secure data through a period of twenty years or more, and for agricultural purposes the following have been found to be very significant:

1. Absolute maximum for each month.
2. Average maximum for each month.
3. Absolute minimum for each month.
4. Average minimum for each month.
5. Mean temperature for each month (average of average minima and maxima).
6. Average range for each month.
7. Average dates of the frost-free season.

Relations of Light to Plant Growth.—Light is essential to the process of photosynthesis whereby (simple) carbohydrates are manufactured in the green leaves of plants. The significance of this work of the plant in utilizing light energy is aptly illustrated by the following quotation from Stiles.[1]

The processes taking place in the green leaf, which involve the absorption of carbon dioxide from the air (in the presence of light) and the manufacture of carbohydrates from it and the water supplied by the soil, have for a long time proved the most attractive of all the problems of plant physiology, and are among the very few problems of botany which have attracted the attention of workers in other fields. The interest is undoubtedly justified, for it is upon these processes

[1] Photosynthesis, p. 1.

which take place in the green leaf that in the first place practically all life depends. The green plant manufactures in its leaves the materials which, apart from water, form the basis of the whole plant body, and on which the vast majority of non-green plants and practically all animals are ultimately nourished. The manufacture of carbohydrates in the green leaf may be regarded as the central fact of life on this planet. Also our present civilization is directly traceable to these same processes. The substances manufactured in the leaf are substances of higher energy content than those raw materials of air and soil out of which they are built, and it is this energy stored up in this way in plants of bygone ages, and which remain to us in the form of coal, that rendered possible the industrial developments of the past century.—Reprinted by permission, from Photosynthesis by Walter Stiles. Published by Longmans, Green & Company.

The duration and the quality of light, apart from the temperature relations connected with it, have certain definite effects upon various plants, as, for instance, the effects of duration of light upon the soybean plant, illustrated in Fig. 3.

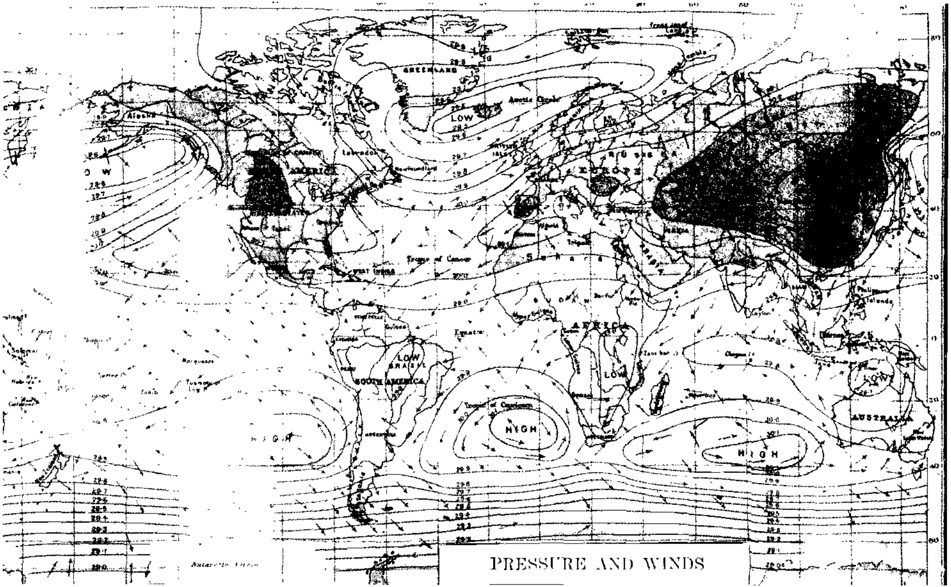
Basic Considerations.—The areal distribution of moisture is controlled by air movements, both horizontal and vertical. Movements of the air are, in turn, caused by inequalities of pressure (at the same level) and these differences are usually closely associated with great inequalities of temperature on the earth's surface.

Relations of Temperature to Moisture.—Not only is the capacity of the atmosphere to contain water vapor limited by its temperature, but the process of evaporation, whereby water vapor gets into the atmosphere, is largely controlled by temperature conditions. In addition, the transfer of water vapor on the earth's surface is brought about by winds, and these moving masses of air are caused indirectly, as has been stated, by inequalities of temperature. Air, when forced to ascend sufficiently, is cooled; and cooling reduces its capacity to retain water vapor and consequently results in condensation, cloudiness, and precipitation.

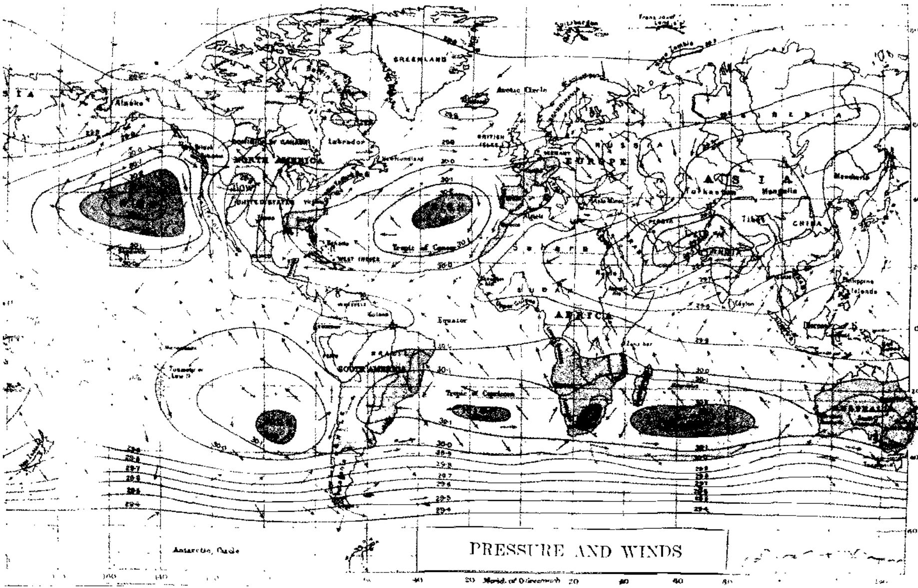
" Centers of Action."—Of major significance in the control of moisture distribution are the " centers of action," those permanent or seasonally developed areas of marked high pressure or of low pressure, which control largely the prevailing winds, annual or seasonal. These " centers of action " include, in the lower latitudes, first, the Equatorial Low, often called the doldrums, or the zone of calms, which occupies the zone immediately dominated by the heat equator; second, the Subtropical Highs, whose location varies somewhat with the seasons but which, especially in the southern hemisphere, are located in the belt crossed by the tropics. These belts of high pressure in the southern

FIG. 6.—Biloxi soy bean. Plants in box on left exposed to the lig[illegible] ours daily. Those in box on right kept out of doors throughout the experiment. When photographed August 15, 1919, the plants on left contained fully matured seed pods and leaves were yellowing, while plants on right had not blossomed.

Smithsonian Report, 1920—Garner and Allard



PRESSURE AND WINDS



PRESSURE AND WINDS

hemisphere are, in July (winter), characterized by the larger area covered and a more intensive pressure, whereas in January (summer) they are interrupted by the southward extension of the continents. Between these sub-tropical belts of high pressure and the Equatorial Low, are the trade-wind belts.

In the northern hemisphere, owing to the greater extent of the continental areas, the seasonal conditions of pressure are much more complex than they are south of the equator.

In July a vast and intensive Low is developed in interior Asia, and a lesser one in North America; whereas, at the same time, the Azores High and the North Pacific High constitute the only areas of high pressure north of the equator. These centers of action indicate the general direction of winds in the northern middle latitudes, which, with the topographic features involved, together with the distance from the water bodies, determine the main features of rainfall distribution.

In January, the continental interiors are areas of high pressure, owing to the collection of masses of cold and heavy air over these cold land areas. These vast continental highs are connected across the Atlantic by the so-called Azores Bridge, a high-pressure belt lying over the Tropic of Cancer. At this season, a vast low, centering about Iceland, is located in the North Atlantic, and another in the North Pacific. The prevailing winds thus indicated are in general outward from the continents during January, and are thus in marked contrast to the summer winds which flow mainly into the land masses of the northern hemisphere. These inflowing winds obviously are significant in their effects upon rainfall conditions, including the amount of rainfall and its areal distribution.

Moisture and Life.—Water, like heat energy, is essential to all forms of life. As in the case of the adjustment of life to temperature conditions, so through the ages plants and animals have become adjusted to certain definite ranges and limits of moisture conditions. In the case of plants, this adjustment is so significant as to become a basis for a major grouping of all plants:

1. *Xerophytes.*—Those plants able to adjust themselves, through structure or function or both, to dry conditions of both soil and atmosphere during the growing season.

2. *Hydrophytes.*—Those able to make adjustments to moist conditions of both the air and the soil.

3. *Mesophytes.*—Those better suited to medium moisture conditions in soil and atmosphere during the growing season. Most of the agricultural plants of the world are mesophytes, rice being an out-

standing exception. Mesophytes include a great variety of plants adapted to a wide range of conditions, such as corn in the Corn Belt, Cotton in the Cotton Belt, or wheat in both Spring and Winter Wheat regions. Many gradations in these groupings are to be expected, including those plants which do well under irrigation conditions in regions of dry atmosphere. These include such crop plants as alfalfa, the date palm, citrus fruits, and some of the deciduous fruits.

The range of moisture conditions, of both soil and atmosphere, is very significant for the various crops. Take wheat, for example, which throughout its vegetative season does best under mesophytic conditions of both soil and atmosphere, whereas during the maturing season it should have a moderately moist soil but dry and warm atmospheric conditions. In the United States, the forested and tall-grass lands are typically mesophytic, and the short-grass country less so. As has long been recognized, a forest climate possesses a warm growing season, a continuously moist sub-surface, and damp air; whereas a typical grassland climate possesses moderately warm summers, with frequent rains, even if the rainfall is small in amount. This is especially true through the earlier part of the growing season, thus insuring for that period a moderately moist soil. The vegetation of the deserts includes typical xerophytic plants, which Shantz has classified as follows:

First, drought-evading plants, such as the desert annuals which spring up when moisture and temperature conditions are favorable;

Second, drought-enduring plants, such as the desert shrubs and perennial grasses, which are dormant except when moisture and temperature conditions are favorable; and

Third, drought-resistant plants, well represented by the cactus which is able to make vegetative growth during the dry months even though its total weight may be decreasing at this period through loss of water from the plant.

Moisture Data.—As in the case of temperature, moisture data by months, for places in the middle latitudes, should extend through a series of at least twenty years.

In addition to the average rainfall and its distribution through the year, it is necessary to know also the type of precipitation; that is to say, whether it comes in rains of the slow, steady type, or of the hard-beating kind, in the cloudbursts which are likely to occur in desert or semi-desert regions, as snow, or in other forms.

Cloudiness.—The degree of cloudiness of the atmosphere, itself related to temperature and humidity, is of great importance to plant

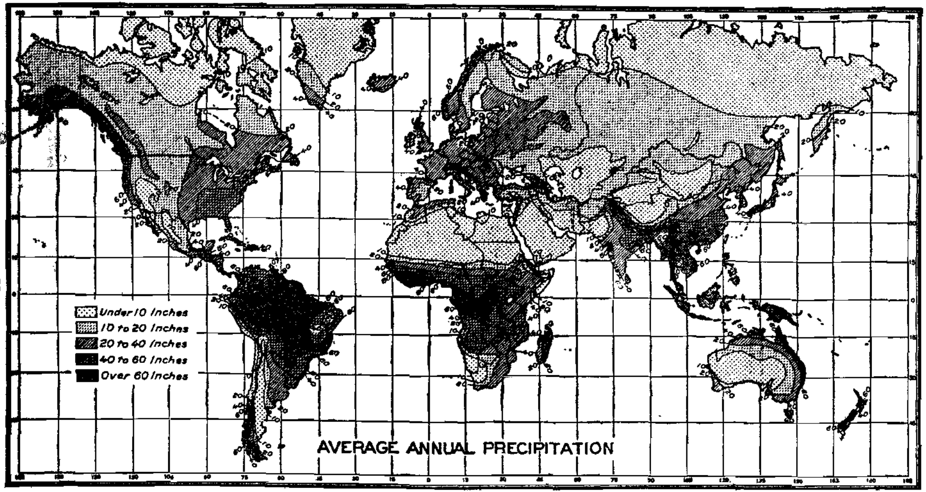


FIG. 6.—This map shows in a very generalized way the world distribution of annual precipitation which correlates broadly with natural vegetation. In general, there are deserts where the precipitation is less than 10 inches and primarily grasslands where it is between 10 and 20 inches. Most of the important cereal-producing areas have between 20 and 40 inches.

Agriculture Yearbook, 1924, p. 465.

growth and development. The dry deserts are proverbially sunny. (The Arbas have a saying that the date palm grows with its feet in water and its head in "heaven.") The sub-tropical lands and the interior continental areas are noted for their sunny summers, whereas the rainy west coasts of the higher latitudes are distinguished for their cloudiness. The tropics are, except during the rainy season, characterized by intense sunlight.

Evaporation.—It is by the process of evaporation that water vapor gets into the atmosphere and thus is the source of rainfall; but, aside from this important process, evaporation is of great significance to agriculture in other ways. Evaporation represents an integration of several very significant conditions, such as the temperature, both of the atmosphere and of the soil, the water content of the soil, the relative humidity of the air, and air movement; all of which play a large part in agricultural production.

In order to illustrate a striking result of evaporation differences and their influence, conditions in the various sections of the Great Plains in North America may be cited. The Edwards Plateau section in Texas has a rainfall of 20 to 25 inches; its native vegetation is mainly mesquite and desert-grass savanna and the main industry is grazing. The High Plains country of the Panhandle has a rainfall of 15 to 23 inches; but the native vegetation is short grass, chiefly buffalo and grama, and the main industry is grazing with dry farming. Farther northward, where evaporation is less, as in eastern Montana, a rainfall of 10 to 15 inches produces a typical short-grass vegetation. Still farther north, in Canada, 10 to 15 inches of rainfall gives a zone of tall grasses and dark-colored soils, this belt being the center of wheat production in western Canada. Beyond the tall-grass region, to the north, with a rainfall of only 10 to 12 inches, is the zone of coniferous forest which, taken as a whole, is a non-agricultural region owing to its climate, topography, and soils.

Climatic Controls.—Climatic controls are those physical factors which determine the distribution of the climatic elements upon the surface of the earth.

The major control is that of length of day and degree of directness of the sun's rays; that is to say, the factors determining the intensity and amount of sunshine. These bring about that unequal distribution of solar energy which results in the division of the earth into the great climatic zones—the Frigid, the middle latitudes (the co-called Temperate Zones), and the Torrid Zone. These zones are based primarily on temperature relations, as is also the division of the year into seasons.

To a large degree, the daily changes in temperature conditions are likewise based upon these factors.

The climate which a place has owing to the solar energy it receives by virtue of its latitude is called solar climate. The climate of a place is a complex consisting of the varying features of solar climate modified by various earth conditions. Chief among these modifying factors are the following:

First, the size and shape of the land masses, and the consequent *distance of interior lands from water bodies.* These conditions are further modified through the action of air movements.

The influence of latitude may be wholly overcome by the effects of land and water. Land and water are fundamentally different in their behavior regarding absorption and radiation. Land areas, and the air over them, warm and cool readily and to a considerable degree; water areas, and the air over them, warm and cool slowly and relatively little. In the same latitudes, disregarding possible permanent differences in cloudiness, the insolation (solar energy) received at the surface on land and water surfaces is much the same. The differences in absorptive power, of disturbance or quiescence, may be quite noticeable. However, the absorbed heat penetrates to but slight depths in the case of land surfaces, and because of the low specific heat of earth materials, especially when dry, the surface temperature of land areas increases greatly under insolation. Since the coefficient of radiation is comparable with that of absorption, the loss of temperature under cooling conditions is considerable. In contrast to this, the heat absorbed by water surfaces may penetrate to considerable depths, a fact which, coupled with the very high specific heat of water, causes but slight change of temperature under either heating or cooling conditions.

The larger continental areas of the middle and higher latitudes therefore have great seasonal fluctuations in temperature. They are distinctly radical in their tendencies. They absorb much heat, but part with it readily. The oceans, on the other hand, are conservative. They warm but little during the day and in summer. They cool but little during the night and in winter. They take in little heat, and part with it reluctantly. Conservatism in temperature is a distinctive feature of marine climates. Another essential difference between oceans and continents is that the waters of the oceans are almost constantly in motion, whereas the lands are stationary. The temperatures of the oceans in higher and in lower latitudes thus tend to become equalized. This process results in keeping the waters near the equator from becoming as warm, and those away from the equator from becoming as cold, as they otherwise would be. The land masses, on the other hand, have to take the temperature appropriate to their latitude and season.[2]

Second, the topographic features of the lands, particularly: (*a*) the height, extent, and direction of trend of the major mountain systems;

[2] Reprinted by permission from "The Climates of the United States," by R. De C. Ward. Published by G. P. Putnam's Sons.

(*b*) the extension and position of plains and lowlands in their relationships to winds; and (*c*) the altitudinal effects associated with mountains and uplands in decreased temperatures.

Third, the size, position, and temperature of ocean currents. This may be regarded as a corollary under the first set of modifying factors previously mentioned.

Fourth, seasonal winds and the influence of passing whirls in the air —cyclones and anticyclones—especially in the middle latitudes.

The cyclone, or low, progresses across the country at an average rate of about 25 miles per hour in winter and somewhat less in summer. The direction of movement varies with the season, but in general, these disturbances gain distance toward the pole when over oceans and the eastern part of continents. Those approaching the North American Continent in winter move at first in a southeasterly direction until they reach either of two regions, first, the Columbian Northwest or, specifically, the Province of Alberta, and second, the Pacific off the coast of Washington and Oregon. A very small number may reach the coast south of the mouth of the Columbia River. The course followed after reaching the two principal points above mentioned is not absolute and fixed, but is conditioned very largely upon the distribution of atmospheric pressure over the continental interior at the moment; and since the latter changes from day to day the path taken by the cyclones which arrive at the northeastern frontier is likewise changeable.

To summarize: The characteristics of the cyclone, or low, are southerly winds, warm and moist air, much cloudiness, and rain or snow. The anticyclone, on the contrary, is characterized by northerly winds, cold dry air, clear skies, and as a rule no precipitation.

Obviously, then, the character of the weather for any given region depends largely upon the frequency with which that region is visited by cyclones and anticyclones and the sequence in which they occur.[3]

If it were possible for an observer to visualize either hemisphere from a great elevation, he would see in winter great cyclonic cloud sheets circling around the pole in mid-latitudes. As winter merges into spring and spring into summer, these sheets, which form an almost continuous procession in winter, would gradually thin out until in summer they would appear in the form of discontinuous patches. The patchy character of the cloud sheets on both sides of the Equator in the warm season would also be in evidence, the patch frequently being the locus of thunder storms and showers.

Occasionally there would come into view over the tropical seas, about 10° to the north and south of the Equator, a very extensive layer of thin white clouds radiating from a center 500 to 1000 miles distant. As this central area approaches a land observer the cloud sheet becomes much denser and the lower and intermediate clouds are seen to be in violent commotion, sometimes being punctured here and there by vivid electrical displays, and thus is indicated the approach of a tropical

[3] Agriculture Yearbook, 1924, p. 460.

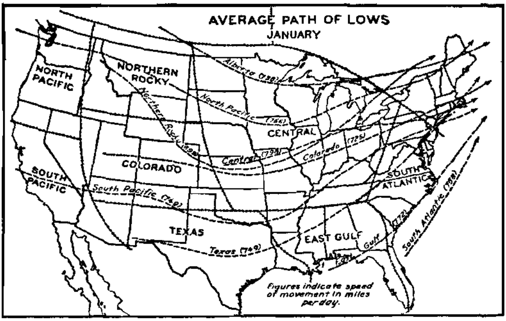


Fig. 7.

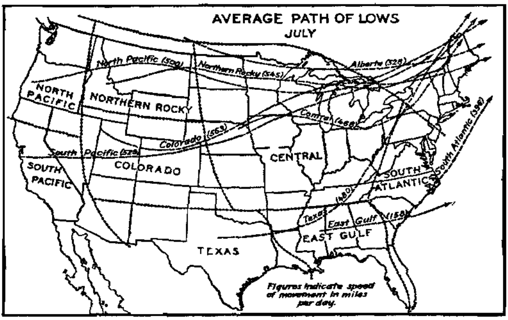


Fig. 8.

Figs. 7 and 8.—Average path of cyclones (lows), (top), January; (bottom) July. Cyclones are classed according to the geographical district in which they are first noted on the daily weather charts, thus "Alberta" signifies that all of the cyclones that followed the path so indicated were first noted in the Province of Alberta, Canada, although their actual point of origin may have been over the Pacific far to the northwest. The average width of cyclones is close to 500 miles; their speed of movement is shown in miles per day by the figures on the several paths.

Agriculture Yearbook, 1924, p. 481.

cyclone—the hurricane of the West Indies, the typhoon of the China Sea, both of which, though bearing different names, are one and the same phenomenon. Destructive storms of this nature sometimes pass inland over the United States from the Gulf of Mexico or the waters to the southeast of the continent, but their destructive character rapidly diminishes after they leave the ocean.

In what has preceded, the reader will find a suggestion as to the cause of the warm winds that spring up in the winter, late fall, and early spring, prevail for a day or so, and then quickly shift to northerly. In many cases these winds do not greatly disturb the regular diurnal and seasonal change in temperature, but a season rarely passes in which one or two thrusts of northerly winds do not carry freezing temperature to the Gulf Coast and Florida.[4]

Climatic Provinces.—Climatic provinces result from those combinations of common climatic elements brought about by various climatic controls so as to give various sections of the earth a common set of climatic features throughout, and thus to mark off these regions from adjacent regions.

Because of various factors, regions far separated by distance may have common climatic characteristics; and thus an interpretation of the type of climate prevailing in one region will apply with certain modifications to other regions with a similar combination of climatic elements.

In the differentiation of climatic regions, the formations of the native vegetation, if properly interpreted, serve as one of the best indicators of the integration of all the climatic factors, annual as well as seasonal, and thus a map of the vegetation formations may be used as a map of climatic regions. Such a map possesses an added interest in that one of the most efficient indicators of the agricultural use of lands is the native vegetation of the area involved.

THE LOW LATITUDES

The low latitudes comprise the so-called tropical zone. If bounded by latitudinal limits (the Tropics of Cancer and of Capricorn), the tropics comprise about 40 per cent of the earth's area. The ratio of land to water in the low latitudes is 1 to 4, and the area of the land surface is about 17,000,000 square miles, comprising about one-third of the land area of the globe.

In this zone the lengths of days and nights vary little, and the zone is marked by receiving the maximum amount of the sun's vertical rays. These conditions of intense and uniform insolation from day to day throughout the year, combined with the relatively low ratio of land to water area and the effect of the position and the size of the tropical

[4] Agriculture Yearbook, 1924, p. 461–462.

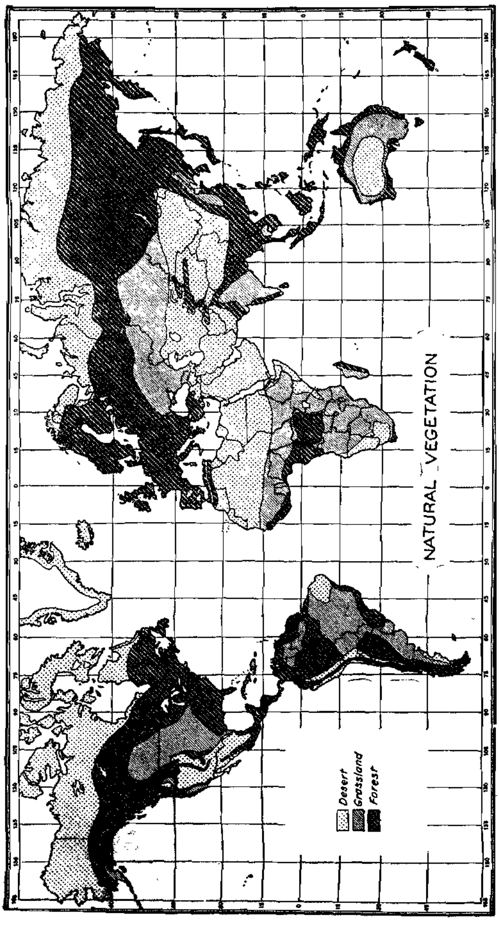


FIG. 9.—A very generalized map of the natural vegetation of the world showing its broader relations to climate. Only three major divisions of vegetation have been attempted, including forests of all kinds, grasslands, and deserts. The principal forests are found in the well-watered areas, the grasslands in regions of scanty precipitation, and deserts where rainfall is very light or the *temperature* too low for vegetative growth.

zone (which is such that masses of cold air from the poleward regions seldom reach it) produce marked uniformity of temperature conditions, with the result that weather is almost synonymous with climate. Except toward the margins (the desert areas) and on highlands, the temperatures never go below 68° F. The seasonal range is small, often as low as 2° F. and seldom more than 20° F., and is less than 10° over the majority of the zone. The mean daily range, associated with the results of day insolation and nocturnal radiation, is, however, often greater than the mean annual range, and night is often termed "the winter of the tropics."

Areas Continually Humid—or the Rainy Low Latitudes.—Those sections of the tropics that are continually humid may be grouped for convenience under two heads: central regions and marginal areas.

Distribution.—The central areas comprise the interior Amazon Basin, the northern section of the Lower Congo with the Guinea coastal section, and the islands of the East Indies. The first two regions are under the influence of the doldrums, or the zone of calms, throughout the greater part of the year, and thus are areas of continuous and heavy precipitation, owing to the convectional rising and consequent cooling of the air brought in by the moisture-laden trade winds.

Rainfall.—In the Guinea lands the rainfall is by far the most important climatic factor. The year is divided into two seasons, the rainy and the dry. The heaviest rainfall occurs just to the south of the trough of low pressure, and so there tends to be a well-marked double rainfall maximum in the course of the summer, one as the low-pressure trough passes north, the other as it returns south. However, during the whole season of southwest winds there is considerable rainfall.

The rains are a time of intense life for the plant world. For the European settler it is the most unhealthy part of the year. Fever is rife; activity is almost impossible in the sweltering steamy heat. Unfortunately the district most visited by Europeans is the coast, precisely the region with the longest and heaviest rains, the pernicious effects of which are exaggerated by the foul odours that arise from the rotting vegetation and slimy ooze of the mangrove swamps. Especially Sierra Leone and the Niger delta have earned and fully deserved the reputation of possessing one of the most unhealthful climates in the world. Sierra Leone is known as the "white man's gave," but the interior of that colony, especially the higher parts (and much of the interior is mountainous) is far less unhealthful than the coast, where the wide expanses of mangrove swamp and the insanitary settlements provide ideal breeding-places for the mosquitoes which carry malaria. The application of scientific methods has already done much to diminish the unhealthfulness, and we may expect still greater success in the future, But a country with a mean annual temperature of 80°, with only 4° difference between the temperatures of the warmest and the coolest months, and an annual rainfall of over 175 inches, never can become an ideal residence for Europeans.

The following description given by Borius of a day during the rainy season in Senegambia presents a vivid picture of the conditions that prevail over the whole of the Guinea lands.

" The sun rises out of clouds which soon melt away under its rays. The air is fresh and pleasant, with a few puffs of wind from the southwest. Light white clouds spread fanwise from the horizon and cross the valley, slowly changing form. Soon after sunrise the shade temperature is 80°. The calm air gets hotter and hotter, and by 9 A.M. it is unpleasant to walk abroad, even with a sunshade. The wet ground reflects the bright sunshine, and this fact combines with the high temperature, the moisture-laden air, and the fever germs to make the sunshine at this season so dangerous.

"About 10 A.M., in spite of an increase in temperature of perhaps 3°, the heat is still bearable and admits of a little activity. The southwest breeze is beginning but is irregular and seems to be on the point of dying away at any moment. At midday the thermometer is still rising, and by 1 P.M. it stands at 86°; the sun is hidden at times as a few cumulus clouds cross the sky from south to north; the surface wind oscillates between west and southwest, but is still very weak. By 4 P.M. the temperature is 88°; the sky is three-fourths clouded, and masses of cloud are piling up on the horizon; the wind often drops altogether. The heat now feels excessive, and though after 4 P.M. the thermometer hardly rises a degree, yet the heat seems to be increasing considerably, and we are astonished that the thermometer does not show a greater rise. We perspire profusely on the slightest exertion.

"At 6 P.M. the sun disappears in thick clouds, which it colours a brilliant copper. It falls calm except for a few puffs from the south and southwest which bring no life and fail to reach the inside of the house. We have to go out on the roof to try to get a breath of cooler air. A little black cloud passes overhead from the southwest, and a few drops of rain fall from it, but not enough to wet the ground. We go in again, but the heat indoors is overwhelming and we long desperately for a breeze. The water, which is kept in porous vessels, and which seemed cool in the morning, is now lukewarm. There is no need for a hygrometer to show that the air is saturated with moisture. The vapour pressure is 23 mm., and it is this high humidity that makes the heat so overpowering, although the actual temperature is not excessive.

" Nothing can be compared with the feeling of utter prostration that overcomes a European. Though he sits motionless in an armchair he perspires as after violent toil; his fatigue is not like what is felt after work, but rather a weakness in the limbs, and especially in the bones—an indescribable feeling of discomfort, which precludes all movement, all bodily or mental work, but yet forbids sleep. Clouds of mosquitoes swarm round him and he feels suffocated.

"At 10 P.M. it has fallen dead calm. The temperature still continues high and our discomfort becomes more depressing than ever. We can neither read nor work; to do so would require an effort of the will which we are incapable of making; our mental energy is sapped even more than our physical strength. Night drags on in its painful way unless a thunderstorm bursts, with heavy rain, in which case the temperature falls and we feel a salutary freshness in the air. We may form some idea of the painful conditions of life on the Senegal during the rains if we think of the discomfort sometimes felt in Europe just before a summer thunderstorm, and imagine that discomfort increased ten-fold." [5]—Reprinted by permission from The Climates of the Continents. Published by The Clarendon Press, Oxford.

The islands of the East Indies lie in the great monsoon region of adjoining southeastern Asia and their position is such that they are continuously under the influence of moisture-laden winds from the ocean, hence, their heavy rainfall. (See Figs. 4 and 5.)

Owing to the topographic features of these islands, certain areas are in the lees of mountains during portions of the year, a fact that expresses itself in differences in the native vegetation and in the desirability of irrigation in the various sections of the islands.

In addition to these three great central regions lying in the equatorial belt, there are certain windward slopes in the trade-wind belts which, because of their topographic relations to trade winds from off the ocean, have fairly heavy and continuous rainfall. Among these marginal areas should be included: the windward slopes of the lands of the Caribbean section, the islands of the West Indies, the eastern coastal portions of Central America and southern Mexico, and the coastal uplands of northern South America; the windward slopes of the Hawaiian Islands; the eastern sections of Madagascar; and the lowlands and coastal slopes of eastern Brazil.

Native Vegetation.—All of these lands with a heavy rainfall and without a marked dry season are continuously moist. They support a heavy and dense forest growth, most of which is evergreen.

Because the soils are continuously moist and high temperatures obtain throughout the year, there is but slight seasonal interruption to plant growth such as is found in all other portions of the world, and thus there is to be expected a dense and luxuriant growth of tree and vine, producing in the forest canopy a veritable tangle which practically shuts off the sunlight from the forest floor.

Typical of the plants native to these lands, especially to the Amazon and Congo sections, are the cacao tree, the Brazil nut, rubber trees, such as *Heavea brasiliensis*, the African oil palm (*Elaeis guineensis*, Jacg) and (probably) the banana.

The agricultural potentialities of these lands are significant, but up to the present very little agriculture has been developed in them, except in the marginal or more sub-tropical regions, as in the Hawaiian Islands

[5] Kendrew, W. G., The Climates of the Continents, pp. 30–32.

or the islands of the West Indies. Their vast potentialities may be indicated by the present conditions in Java, an area a little larger than New York State, only 80 per cent of which is cultivated and which supports a population of more than 35 millions of people. Dr. Shantz says of the Tropical Rain-Forest area of Africa, "as shown by the actual production by natives and Europeans, almost any tropical, and many temperate crops may be grown on land characterized by this forest; Cacao, rubber (both Cearot and Para), sugar cane, vanilla, ginger, rice, manioc, yams, sweet potatoes, potatoes, bananas, coconut (near the coast), coffee, arrow root, indigo, maize, sorghum, pennisetum, eleusine, cotton (where rainfall is not too continuous), peanuts, voandzeia, sesame, oil palm, pineapple, papaya, anona, jack fruit, and other tropical fruits and vegetables may be grown."

Regions Periodically Moist.—These lands, in general, lying on either side of the equatorial rain-forest regions and extending through 8° to 10° of latitude, are distinguished by having a marked dry season which progressively increases in length as distance from the equator becomes greater. In Africa these belts merge into the dry deserts. These moist regions with a dry season are divided into two groups, the savanna and the monsoon.

The Savanna Type.—The savannas are tropical grasslands which represent a form of vegetative adjustment to the climatic conditions involved; that is, their period of vegetative activity is during the rains, whereas the dry part of the year is the maturing period and the dormant season.

The savannas may be subdivided broadly into tall-grass and short-grass lands. Belts of tall grasses with scattering trees occur on lands adjacent to the equatorial rain forests where the precipitation is heavier and the dry season less pronounced. The native grasses are coarse as a rule, and the lands, though agriculturally undeveloped, have great potentialities for such crops as rice, sugar cane, manioc, maize, sorghum, cotton, tobacco, tropical fruits, and vegetables. These tall-grass belts on their outer edges merge into the short-grass zones, which are marked by less rainfall and a longer dry season and by greater ranges of temperature. In the drier portions, grazing constitutes the main industry, with limited possibilities for growing drought-tolerant crops such as the sorghums.

Distribution.—Typical savanna lands are the Sudan of Africa, the lower portions of the Plateau of East Africa, the wide area south of the tropical rain forests of the lower Congo, and in South America the llanos of the Middle Orinoco Valley and the campos of southern Brazil. These extensive lands can provide much forage, which may be utilized for stock rearing. At the present time the agriculture of these regions is of little importance to the outside world; but with an increased demand for agricultural products they can be made of vast significance, first in extensive agriculture centered about grazing, and later in the production of farm crops, especially in the areas with heavier rainfall.

The Monsoon Type.—The term monsoon, an Arabic word denoting 'season,' is applied to the type of climate dominant in southeast Asia, with its distinct wet and dry seasons, all under the control of the monsoon winds.

That there should be many variations in temperature, as well as in amount and annual distribution of rainfall, is to be expected in an area as large, and having such marked differences in surface features, as this section of the earth.

The general features of pressure, winds, and rainfall distribution are to be noted in Figs. 4, 5, and 6.

The monsoon rains are the result of the rising of the moisture-laden masses of air that flow in from the ocean. The general distribution of these rains is governed by the height to which the air masses are forced to ascend, the distance from the sea, and the effects produced by mountain barriers. The variability in amount and in areal distribution of the rainfall from year to year has been attended with different results. Deficiencies may occur in the cool season, especially in northwest India, thus influencing the wheat crop. The summer rainfall of India is least variable in the areas of heaviest precipitation; hence in such cases rainfall variation is of lesser importance. It is most variable over the drier portions of western India, which obviously are not so significant to agriculture. The intermediate areas where population is relatively dense are most affected by deficient rainfall, because here the normal rainfall is only sufficient for the crops necessary to support the population. Over large areas, as along the Malabar Coast, the lower and middle Ganges plain and the lower Brahmaputra basin, and the southern slopes of the Himalayas, the rainfall is heavy. These areas are covered, or probably were covered originally, by monsoon forests, a type of deciduous forest in which a majority of the leaves are shed during the dry season, but which in the rainy seasons resembles the tropical rain forest. In the interior of peninsular India, the upper Ganges and the upper Indus Valleys are regions with much less rainfall, whereas the lower Indus and the Thar have little or no rain, and present typical desert landscapes. The weather conditions in the Punjab (Northwest India) have been graphically described by a resident of the province:

Like the rest of India, the Punjab has really but three seasons: the summer or hot season, the rains, and the winter, which, in India, we speak of simply as the cold season. The hot season begins in April, but in March it is already so warm that barley and wheat ripen and are harvested. From April to June, as a rule, there is no rain. The west wind holds sway, and blowing from the sandy wastes of the Indus region, is a veritable hot wind. A denizen of the Temperate Zone can hardly realize the desiccating, truly scorching heat of the wind.

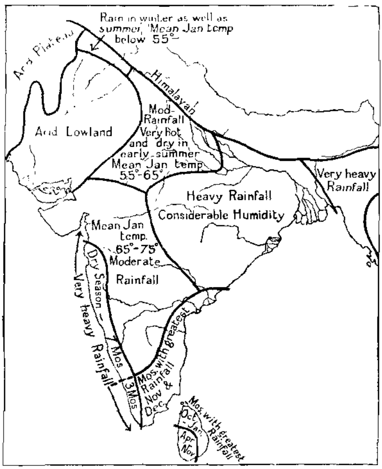


Fig. 10.—Climatic areas of India.

When exposed to it, one may imagine he is facing an open furnace. The thermometer rises in the shade to over 120°. In order to enjoy fresh air at this season one must take exercise in the early dawn, between 4 and 5 in the morning; for no sooner has the sun risen than the heat sets in again. After 7 A.M., save of necessity, no European leaves his house, and should business oblige him to do so, he must protect himself from the sun with a sunshade and a thick head-covering . . . At sunrise, or soon after 5 A.M., houses must be closed, only a small door being left open for communication with the outside world. Thus the house of a European is more like a gloomy prison than an ordinary dwelling house. So long as the hot winds blow strongly and steadily, rooms may still be kept in some measure cool by means of "tatties" or grass screens set up in front of the doorway, and continually sprinkled with water, or by the fan vanes of the so-called "thermantidote," which a servant keeps revolving and sprinkles with water; and at night the punkah is worked. Whoever cannot provide himself with these artificial cooling appliances must suffer the daily torment of insupportable and exhausting heat. Man and beast languish and gasp for air, while even in the house, the thermometer stands day and night between 95° and 115°. Little by little the European loses appetite and sleep; all power and energy forsake him. Vegetation suffers equally; almost all green things wither; the grass seems burnt up to the roots; bushes and trees seem moribund; the earth is as hard as a paved highway; the ground is seamed with cracks; and the whole landscape wears an aspect of barrenness and sadness. At length, in June, the hot winds cease to blow, and are followed by a calm; and now indeed the heat is truly fearful; grass screens and thermantidotes avail naught; all things pine for the rains; but no rain, not even a shower, can one hope for, till the south and east winds shall have set in. And even then, the rains do not extend to the whole of the Punjab; Lahore has but little rain, Mooltan scarcely any; and the peasant of the Western Punjab is dependent entirely on artificial irrigation for the watering of his crops.

The southerly and easterly winds bring first clouds and violent storms with heavy rain showers, which are repeated daily, or, at all events, every two or three days, and, finally, the rains, which, in the Himalayas, set in at the beginning of July and cease at the end of August or in the middle of September. In July the trees begin a second time to burst into leaf; grass springs up once more, and soon a vegetation is developed that, fostered by warmth and moisture, is scarce to be kept within bounds. The peasant now works hard at ploughing, sowing, and weeding his fields. Rice is sown in June, during the great heat. In September it is reaped, and within two months, maize is sown and harvested. . . .

After from four to six weeks of heavy rain, often falling uninterruptedly for two or three days in succession, it clears up, and sometimes some weeks pass without further rain; after which, a week or two more of rainy weather brings the season to a close. Grateful as is the coolness brought by these showers, the more oppressively hot and sultry it is when the rain ceases and holds off, if only for half a day. The atmosphere weighs on one like a heavy coverlet; and then comes the daily and nightly plague of mosquitoes. Insect and reptilian life is now active; of evenings it hums and buzzes and croaks all around; frogs make their way into the house, and with them more serious and unwelcome visitors, scorpions, and snakes; for which reason it is unwise, at this time of the year, to go about in the dark.

One can hardly picture to oneself in our European climate how serious and disagreeable are the effects of excessive moisture, as experienced towards the end of the rains. Woodwork swells, and doors and windows can be fastened only with much difficulty. Shoes and all articles of leather become thickly coated with fungus, books become mouldy and worm-eaten, paper perishes, linen becomes damp in the presses, and despite the oppressive heat, one must often light a fire on the hearth, only to neutralize in some degree the influence of the damp.

The period which immediately follows the rains up to October is the most unhealthful season in the year. Decaying vegetation under an ardent sun generates miasma, the consequences being fever, dysentery, and not infrequently cholera. Towards the end of the rains, one rejoices indeed to see the heavy dark clouds disappear, but the heat soon becomes once more so great that one longs for the cold season, and more than ever turns an anxious eye to the wind vane, watching for some sign of the cool westerly and northerly winds. With the beginning of October these winds set in steadily, clearing the skies, and now the blue firmament appears in all its splendor, so glorious in the Torrid Zone. . . . From October to Christmas, as a rule, the weather is clear and fine, the air is pure and most delicious, and one can hardly imagine a more charming climate; but it must never be forgotten that an Indian sun shines overhead, and that even in the cold season one must never expose the unprotected head to its rays. The European now once more breathes freely, and it is a delight, with the head well covered, to move about in the open air. For five or six weeks white men can work vigorously and with pleasure.

In December and January, the fire burns all day long on the hearth, and in the morning and evening is especially grateful. The nights are positively cold; even on the plains, ice and hoar frost form, and near the ground the thermometer sometimes sinks to 23°. During the second half of the cold season we have in the Punjab a good deal of rain, without which indeed the barley and wheat harvest is poor; the pulses also require the winter rains. In February we have a short spring; many trees unfold their leaves, and every bush furnishes its quota of flowery adornment. But this spring is of short duration, and in March it is already warm on the plains and the hot summer is at hand; an occasional dust-storm is indeed in itself unpleasant, the air being so charged with dust as to bring an Egyptian darkness, no matter what may be the hour of the day.[6]

Southern Burma, Siam, and French Indo-China have heavy rainfall, are to a great extent covered with forest, and are marked by their present production and potentialities in the way of rice production and of other tropical products requiring high amounts of rainfall. The agricultural potentialities of the monsoon regions (as well as those of all the tropics, except the highlands) bear a direct relation to the soil moisture available. In India proper (excluding Burma) the agricultural use of the land has become fairly well stabilized, and probably nowhere else in the world can be found such well-definied agricultural adjustments to available soil moisture as in India. Unless the relations of available moisture to crop production are considered, it is impossible

[6] Quoted by Kendrew in "The Climates of the Continents," pp. 127–129.

to interpret the distribution in India of such crops as jute, rice, sugar cane, cotton, grain sorghums, or wheat.

Desert and Semi-desert Areas.—These are the lands mainly under the influence of the trade winds throughout the year. In Africa, for example, where the low-latitude climates are strikingly developed, the tropical rain-forest area, with its continually humid climate and wet to moist soils, is a center about which the climatic zones of the continent are grouped. This center, with its heavier rains and without a season of drought, is surrounded on the land by savanna belts, which are intermediate between the rain forest and the desert, and which are alternately under the influence of the doldrums and of the trade winds. In the Sahara in the north, and the Kalahari in the south, are the dry lands of the continent. Their rainfall is very small in amount and very irregular in its distribution in time as well as in area.

The following is a description of typical weather conditions in these deserts:

Suddenly, almost without a period of twilight, the sun rises into the clear sky. In this dry atmosphere its rays are already scorching in the early morning, and under the influence of the reflection from stone and sand the layer of air next the ground is warmed rapidly. There is no active evaporation to moderate the rising temperature. After 9 o'clock the heat is great and goes on increasing till 3 or 4 in the afternoon, when the quivering mirage is sometimes seen, produced by the vibration of the air, warmed as in an oven. The heat becomes slowly less towards evening. The sun, just before it sets, suffuses the sky, which is still cloudless, with a glow of color. In the transparent night the rocks and sand lose their heat almost as rapidly as they acquire it, and the calmness of the atmosphere, which is so still that a flame burns without a tremor, also favors the cooling of the air. We shiver with cold and it is no uncommon thing in winter to find water on the surface of the ground frozen in the morning. (Schirmer, Le Sahara.)

To sum up the main reasons for the dryness of the air in the Sahara, the north-east trades, which sweep the desert, originate as currents of air settling downwards from the upper atmosphere in the sub-tropical high pressures. In descending, the air is warmed by compression as it reaches denser strata, and consequently, since it is not receiving any moisture, its relative humidity decreases. Thus in their origin the trades are dry winds, and as they blow towards the south they become warmer and warmer and hence the relative humidity is still further decreased. In lands which have a plant covering, much moisture is transpired into the air by the leaves. This source is lacking in the Sahara, for there is no vegetation. The climate is too dry to support plant life, and owing to the lack of vegetation the air remains dry. At In-salah the mean relative humidity is 56 per cent in winter, 36 per cent in spring, 25 per cent in summer, 39 per cent in autumn.[7]

[7] Kendrew, Climates of the Continents, pp. 26–27.

The semi-arid areas are used for grazing to only a limited extent, and the deserts, except for the oases, are bare of vegetation. Oasis agriculture is of little importance to the world in general, but historically it is of great significance. The Nile valley is a type of oasis, as is also Mesopotamia. The agriculture of the oases of the Sahara centers about the production of the date palm and vegetables, together with a few cereals. In addition to the interior sub-tropical deserts, there are tropical coastal deserts such as the west coast of South Africa and the coastal areas of Peru. In these cases, winds from the sea cross cold ocean currents, thus precipitating a large share of the water vapor which they carry. Consequently these winds reach the coast devoid of a large percentage of their moisture.

The Highlands of the Low Latitudes.—In the tropics the horizontal zonation is based largely on rainfall variations, such as differences in amount of precipitation and in the time of the year and the regularity of its occurrence. But, owing to effects of elevation and consequent cooling, the highlands of the Torrid Zone are marked by vertical zones based primarily on differences of temperature.

In the Andes (of South America) the usual division is into the following climate and vegetation zones: *tierra caliente,* from sea level to 3000 feet with a mean annual temperature of 83° to 75° F., and luxuriant tropical vegetation; *tierra templada,* from 3000 to 6000 feet, temperature 75° to 65°, a belt suitable for maize and coffee; *tierra fria,* 6000 to 10,000 feet, temperature 65° to 54°, where wheat and temperate fruits flourish; *paramos,* from 10,000 to 13,000 feet, too cold for trees and cultivation, temperature 54° to 43°; above 13,000 feet there is perpetual snow. Bogota, 8730 feet above the sea, is in the *tierra fria,* with a mean annual temperature of 58°; the annual range is less than 2°.[8]

Kenya Colony and Protectorate.—The following quotation is descriptive of typical conditions in tropical highlands:

This (Kenya) is probably the best-known Colony of all East Africa and one of the most difficult to generalize, because great variations in temperature and rainfall, the result of topographic diversities, occur within a few miles. The highlands are separated by the great Rift Valley, and the areas of warm and hot country often lie but a few miles apart. Of the agriculture of Kenya we have a clearer picture than of any other Central African Colony except Uganda, due to the agricultural census which has been compiled regularly for the last few years by the Agricultural Department. If this could be supplemented with accurate distribution maps, the picture would take on much more definite form.

[8] Kendrew, Climates of the Continents, p. 324.

Grazing Land Only.—Kenya has a very large area of semi-arid or desert land. The estimates based on vegetation distribution would show 152 thousand square miles of this type. Much of the land is very sparsely inhabited and part, at least, carries very few domestic grazing animals. This is probably partly due to the immense herds of herbivora and their associated carnivora which occupy this area. To introduce cattle would require the destruction of the larger carnivora and possibly ultimately the wild herbivora. Country of this type would make excellent reserves for wild game, but comparatively little of the desert land has been reserved. Ample reserves have been secured in the more fertile Althi plain. About 3 million cattle could be grazed on this desert area, if it ever becomes necessary or desirable to replace the wild herds with domestic animals. These herds of wild animals are one of the important assets of the Colony, since hunters from all parts of the world flock to this region and contribute large sums in license fees and duties.

In parts of this area, and in fact over much of it, there are nomadic pastoral people who live with their herds of cattle, goats, sheep, and camels, and represent in a primitive way the best type of agriculture possible on land of this kind.

Land Suitable for Warm-Climate Crops.—Much of the low, hot country in Kenya is suitable for grazing only. There are, however, large areas of land with rainfall adequate to crop production and with climate warm enough for such crops as cotton, sorghum, peanut, sweet potato, and cassava. Within this belt, along the coast, the coconut is of the greatest importance. Here maize and cassava are the best planted crops and contribute much of the food supply and something for export. Farther inland, maize is still the most important crop, although, from the native point of view, sorghum, peanuts, and cassava are of equal or even greater value in places. Cotton can be grown on much of this area, and with time and favorable prices Kenya could develop probably a million and a half acres of cotton without interfering with the food crops. In this area, where water is sufficient, there is excellent chance of producing sugar cane, and here also sisal is a present reality and future potentiality. At the present time much of this land is occupied by the Masai and other Native Reserves.

Land Suitable for Temperate-climate Crops.—The highlands of Kenya have a climate adapted to some extent to temperate and tropical plants alike. The lands are frost-free, and such diverse crops as wheat and flax, bananas and Arabian coffee, do exceptionally well. Here are areas suitable to intensive production, and over much of the area at the present time crops of value for export are grown. The total area, roughly estimated, of this type of country is 17 thousand square miles, and the density of population over much of it is as great as is usually found in East Africa. The native tribes in this section do not produce coffee, but maize and some of the other food crops are sold. European plantations in this area produce chiefly coffee, wheat, maize, flax, and sisal. Here the Natives have developed an intensive type of agriculture. On the rich sides of the hills and mountains they plant such crops as eleusine, pennisetum, sorghum, maize, bananas and yams; and on the alluvial bottoms sugar cane. Native agriculture is dependent entirely on the hoe, and this enables the natives to occupy the fertile mountain sides, where the land is often far more productive than on the more level areas.

In Kenya about 4 million acres have been bought by the white man, and some of it is in large holdings. Much of this is in the highland areas and here European agriculture has advanced farther than in any other portion of East Africa. Ignoring for the present the native reserve and the acreage of European occupation, there are probably over 3 million acres of this type of country which can be placed in crops by European methods, and under native methods, where hillsides offer no disadvantage, a much larger acreage.

Forest Lands.—Probably about 6 to 7 per cent of the area of Kenya was covered originally with dense forest growth. Around the higher land masses the forests have been destroyed to produce farm lands for the native people. If one considers the possible potential development of this Colony and the difficulty of reestablishing some of the forest types, such as the cedar forests, it would seem unsafe to export extensively until thoroughly adequate plans of reforestation have been perfected. Nowhere in all East Africa are there extensive areas of true forest, most of the tree growth being open and scattered, valuable as woodland and for small timbers, but not strictly of the saw-timber type. It is possible, however, on much of the area to produce excellent forests, and the Department of Forestry has already many acres of excellent young timber.[9]

Typical tropical highlands include those of the Caribbean region—southern Mexico, Central America, northern South America, and the islands of the West Indies, those of the upland zone of East Africa continuing from Ethiopia (Abyssinia) to Rhodesia, and those of southeastern Asia together with the adjoining islands.

The significance of these uplands is that, in addition to their remarkable potentialities for certain tropical crops such as coffee, tea, bananas, and others, they inject a " white man's climate " into the low latitudes —a condition which will become increasingly important.

THE MIDDLE LATITUDES, OR INTERMEDIATE ZONES

These zones, if bounded by the tropics respectively on the one hand and the polar circles on the other, contain almost 53 per cent of the earth's surface. Owing to variations in the controls involved, both in regard to area and the season of the year, the climatic features of the various portions of these zones are marked by great diversities and irregularities of temperature and moisture conditions, and hence, by great variations in possibilities for the production of economic plants.

[9] Shantz, H. L., Agriculture in East Africa.

The middle latitudes of the Southern Hemisphere contain only about 4 million square miles of land (one and one-third times greater than the area of the United States), the ratio of land to water being 1 to 12. Because of other controls, the maritime influences fail to express themselves markedly over large areas, such as the dry desert or semi-desert areas of South Africa and interior western Australia. The climates of deserts are usually regarded as the climax of continental climatic conditions. In the mid-latitudes of the northern hemisphere, one-half of the whole area, or 26 million square miles, is land; under such conditions there is to be expected a marked expression of the features of a continental climate with its tendency toward extremes of temperature and of moisture conditions, as well as variable weather conditions.

Weather and Agriculture.—The middle latitudes, especially in the northern hemisphere, are marked by irregularities of weather conditions, such as unexpected frosts, droughts, hot spells, and rainy periods, all conditions very closely associated with the passing of cyclones and anti-cyclones across the lands. That these variable conditions are in a marked degree significant to agriculture is obvious.

West Coastal Areas of the Middle Latitudes.—Climatically, these areas may be divided into two general groups: the coastal areas of the lower middle latitudes, extending approximately from the 28th to the 40th parallel on either side of the equator; and those of the higher middle latitudes, lying beyond the 40th parallel. The coastal areas of the lower middle latitudes are marginal to the sub-tropical regions, and have the type of climate known as the Mediterranean. The area characterized by Mediterranean climate includes, in the Old World, the dissected and broken coastal lands bordering the larger part of the Mediterranean Sea, whence its name.

Characteristics of the Mediterranean Climate.—By virtue of their position, these areas are transitional between the climate of the subtropics, on the one hand, and that of the cooler middle latitudes on the other.

Moisture.—Most of the rainfall comes during the winter half-year, and the summer is characterized by dryness, the small amount of summer rainfall usually occurring as light local showers. The condition of winter rainfall and summer drought, especially in relation to plant growth, may be regarded as the outstanding feature of this type of climate.

Temperature.—Transitional in position, not only latitudinally but also with respect to the location and seasonal changes of the great pressure areas involved, these lands have a climate partaking in summer, of the nature of the sub-tropical deserts, and in winter, of the marine climates of coastal areas of the higher middle latitudes. The higher temperatures of summer serve to increase evaporation and thus accentuate the conditions of summer drought. These regions are generally marked, however, by the absence of extremes in temperature. The winters are noted not only for their raininess but also for their mildness, the coldest month having a mean temperature above 40° F., and heavy frosts seldom occur. Owing to these conditions, it is to be expected that the equatorward areas of these regions are warmer and have longer summers, less rainfall, and more evaporation, and hence are more desert-like in aspect than the areas on the poleward margins. There are, however, throughout the Mediterranean regions, many local conditions, brought about by the variable nature of the topography and peculiarities of the winds, which modify or accentuate this generalization. The summers are warm to hot, and are further characterized by low relative humidity.

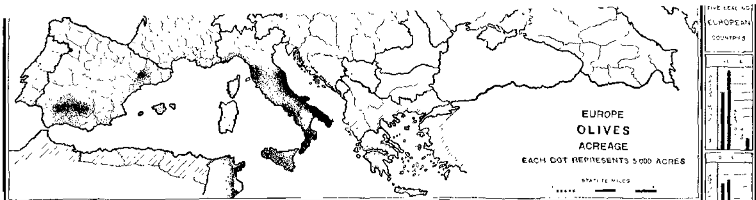
Sunshine.—These areas are noted for their bright sunny weather during the summer half-year, and their winters are far less cloudy than those of the coastal lands in the higher middle latitudes. The clear skies, low relative humidity, and high temperatures all combine to increase evaporation and thus to accentuate the dry conditions of summer.

Distribution of the Mediterranean Types of Climate.—The larger share of the lands adjacent to the Mediterranean Sea have this type of climate. Important exceptions include the coastal lowlands of the eastern half of northern Africa (desert), much of north-eastern Italy, including most of the Po Basin (modified continental), and most of eastern Spain (semi-arid). The extent, in the Old World, of the area characterized by Mediterranean climate is perhaps best indicated by the distribution of the olive-tree, a plant particularly well adjusted to the conditions of this type of climate.

Although the Mediterranean climate here extends far inland, both summer and winter weather is greatly modified by the waters of the Mediterranean Sea. Very significant also is the presence, to the north, of almost continuous mountain ranges which very efficiently serve as barriers to prevent cold masses of air from the interior of Europe from flowing southward. Local winds, such as the *mistral* and the *bora*, descending in winter from these mountain highlands, often cause much damage because of their great force and low temperatures.

Because of the marked significance of the summer climate, a graphic description, by Phillippson, of typical summer weather in Greece is quoted:

Day after day the sun pours down its fierce rays on the thirsty earth



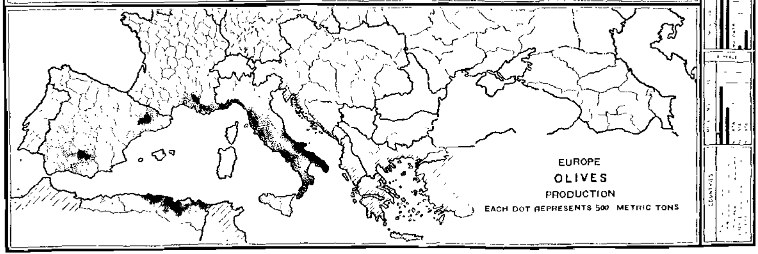


FIG. 11.—Olive acreage in Europe. The olive acreage is densest in Andalusia, Sicily, Calabria, and along the Adriatic Coast of Italy. As in the case of citrus fruits the greater density of the acreage than of the production in parts of Italy is due to the custom of intermingling other crops with olive trees, and of planting extensively orchards which receive little care, like the typical farmers' apple orchards in the United States.

FIG. 12.—Production of olives in Europe and Algeria. The yield varies greatly from year to year, that of Spain and Corsica for 1912 being very low. Spain is normally the greatest producer of olives and of oil (see graph on the side of the map, which shows the average production of 1910–1912).

from a deep-blue sky, in which only occasionally is a little white cloud seen. Very rarely there is a passing shower of rain which evaporates at once. The direct rays of the sun are very powerful, and objects exposed to them are heated to an astonishing degree. In the shade the air temperature reaches 105° at times, but the temperature of the sand on the dunes of Phalerum may rise to 160°. When it is calm the heated air vibrates over the parched land; at other times the north wind carries thick clouds of dust over the plains in great whirls. Distant islands and promontories appear to float high above the surface of the sea in mirages. Most rivers and streams dry up, and grasses and herbs wither; the harvest is gathered early in the season. The ground cracks and lies naked under the heat of the sun. The landscape, which in spring was gay with waving fields of corn or with the green shimmer of sprouting vegetation, now shows the harsh colors of the desert, and the vineyards and maize fields and irrigated gardens alone preserve their bright verdure. In the midday hours all life seems to stop, men and animals drag themselves to shady places to rest, and only the shrill monotonous noise of the cicada fills the air, like the sound of a gigantic rattle. However, the dryness of the air, and the resulting rapid evaporation, make the heat bearable, provided that there is protection from the direct rays of the sun. The heat is intense, but not sultry. Moreover, the air is almost constantly in rapid movement owing to the Etesian winds or the sea-breeze. The heat is far more oppressive in the sheltered valleys and the basins of the interior, or in moist, artificially irrigated agricultural districts, than on the coasts; though even the interior, at any rate at the foot of the higher mountains, is not without a regular air movement. By day the air blows up the mountains, but hardly has the sun set before one feels the first puffs of the cool wind which descends from the heights, so that in the neighborhood of mountains some protection against the cold is necessary in the evenings. At night there is everywhere rapid radiation, but nevertheless it is always quite warm, and dew is rare. Nothing is more magnificent than a summer night on the coast of Greece, when the land breeze wafts down cool fragrant air, and the stars sparkle with a fire never seen in our latitudes. The natives sleep in the open in order to avoid the musty air and the insects of their houses. Summer is also the time of the brightest light, and the most glorious play of colour, especially in the evenings. Every line in the landscape, even at an astonishing distance, is sharply cut, and every tint in the ground shows up brightly since there is little vegetation to hide it.[10]

Coastal Areas of Southern California.—This is a section of varied topography consisting of many parallel well-dissected mountain ranges with numerous intermountain depressions and stream valleys. The southern half of the Great Valley of California has many of the characteristics of the Mediterranean climate but is to be classed as Continental. (This area was formerly covered by Pacific bunch grass.)

[10] Quoted by Kendrew, in "Climates of the Continents."

Middle Chile.—Middle Chile, lying between 30° and 37°, and thus comprising the Vale of Chile, a valley somewhat comparable to the Great Valley of California, has this type of climate. This condition serves to set it off in marked contrast to the deserts of North Chile and the rainy, cool, rough, and forested lands of the southern third of that country.

Cape Town Area.—The southwestern tip area of Africa, including Cape Town, is one of the smaller areas possessing this sort of climate.

Southwestern Australia.—The southwestern portions of the eastern and western halves of Australia possess a Mediterranean type of climate, a condition reflected in the agriculture of that continent.

Native Vegetation.—The native vegetation, as is to be expected, has become adjusted to the climatic conditions of these various lands; and so strikingly is this true that the general aspects of the vegetative covering in these widely separated regions are very similar throughout. This adjustment and its expression in the forms of vegetation are all the more striking when it is learned that different species of plants are represented in each region.

The plant formation is a sparse woodland rather than a forest. The trees, mostly evergreen with small, thick, leathery leaves, and thick bark (for example, cork oak), are spaced far apart and are dwarfed in height. Other vegetation includes thick shrubby growths (the chaparral of California) and many bulbous and tuberous plants with a sprinkling of xerophytic grasses. In the Mediterranean region of Europe especially, these shrubby thickets are associated with rocky areas whose soil cover is thin. The plants commonly are deep rooted, thus making it possible for them to secure moisture at great depth; there is also the rather common lateral rooting system (such as the cactus possesses) by which a network of roots immediately under the surface of the soil enables the plant to take advantage of light showers. In addition to their smallness, the leaves are usually thick and leathery, which with other devices reduces transpiration. The evergreen leaves allow the plants to take advantage of rainfall at any time during the year; and, on the equatorward sections of these climates, the winter temperatures are never low enough to prevent growth, summer being the period of dormancy (except under irrigation). These conditions are well described in a passage quoted by Kendrew:

> At the end of April rain showers become rarer and rarer, the sun pours down its fiery rays more and more vertically, the ground becomes dry and hard, and cracks open, or the soil powders to dust. Plants die away, and grey and yellow tints take the place of the glorious blooms, which are now dried up and fallen to dust on the ground.

August and September are the months with fewest flowers; the landscape is parched and lifeless, only the cicada is heard among the grey olive trees. The land, which in December gloried in a green carpet of wheat fields, now reminds one of a desolate sun-burnt steppe over which hangs the calina, the peculiar heat haze of the south. So Nature continues to sleep till the rains of autumn rouse her to new life, and the seeds spring up, which were scattered by the short-lived annuals, grasses, and shrubs, before they died. The woody brushes put forth new shoots, and the sap begins to circulate in the tubers and bulbs, which have been protected in the hot ground by their numerous coats.

Agriculture.—In the agriculture of these various regions, fruit growing is an important industry and the making of wine is generally significant. Among the more important fruits are the vine (the Mediterranean grapes, *Vitis vinifera*), the olive, and, under irrigation, the citrus fruits. Among the winter crops, wheat and barley are important, and the Old World Mediterranean has long been noted for the leguminous vegetables grown. The live-stock industry has been developed only in a small way, because of the lack of pasturage and forage in the summer. Most lands with this type of climate are adjacent to highlands which introduce modifications of the climate, with cooler and more moist conditions. These forested uplands may be used as pasturage and browse, especially for sheep and goats, these animals being very prominent in the Mediterranean world.

West Coast Areas of the Higher Middle Latitudes.—These areas, owing to their being under the influences of winds from off the oceans (throughout the year) are characterized by their rainy but mild winters and warm but moist summers. These conditions serve effectually to set such lands off from the Mediterranean climates. The annual range in temperature is low, and the percentage of cloudiness is very high. These areas present the typical marine climates of the mid-latitudes. Landward, the climates grade into the continental types, but this gradation is markedly influenced by surface features: in west central Europe, with its plains and lowlands, not only is the transition very gradual, but also marine influences are carried far inland; in the northwestern United States, the windward slopes of the Coast Ranges are dominated by marine conditions. The Puget Sound basin, however, which lies to the leeward of the Coast Range and consequently has much less rainfall, is more continental; while the western slopes of the Cascades (which are higher than the western Coast Range), as indicated by their heavy growth of timber, have much more precipitation than the nearly enclosed Puget Sound basin lying westward whereas, in southern Chile the wet, damp coastal slopes merge eastward with the heavily forested highlands of the Andes.

In general, these lands lie beyond the 40th parallel and include the previously mentioned sections and the western portions of the southern island of New Zealand.

Native Vegetation.—The native vegetation in these continuously moist, rainy regions (rainfall may be 80 to 100 inches) and mild winters is or has been, with few exceptions, a heavy forest. The magnificent evergreen forest, composed mainly of Douglas Fir, centering about Puget Sound in the Pacific Northwest, is one of the most luxuriant forests in the world. The stand is dense, the trees tall—200 to 250 feet—with trunks often 10 to 15 feet in diameter. These are the forests of the Olympic Peninsula and the western slope of the Cascades, which extend southward through western Oregon into California. Southward from Oregon in the more protected and fog-laden coastal valleys, a form of this forest, growing progressively narrower and composed of the giant Redwoods, extends unbroken almost to San Francisco. In the southwestern portion of British Columbia this same forest formation comprises approximately 60 per cent of the total merchantable timber of that province.

Agriculture.—The mild winters, cool summers, continuously moist soils, and humid atmosphere, so suitable to luxuriant forest growth, are just as well suited (when the land is cleared) to the production of economic plants requiring conditions for vegetative growth only; on the other hand, these conditions are detrimental to the maturing and harvesting of cereal crops. Consequently, where these lands have been brought under cultivation, they are used chiefly for the production of forage plants, and thus provide a basis for the livestock industry. In west central Europe, and to a less extent in the Pacific Northwest, these lands are used for dairying. Areas where the climates are more rigorous or less moist are often reflected in the type of land utilization. Thus, northern Scotland, high, rugged, and cool, is a land of heath vegetation unsuited even for good pasturage, whereas the Willamette Valley of western Oregon, gently rolling, but lying in the rain shadow of the Coast Range, is a region of general farming with dairying and fruit production gaining in importance.

Owing to the rough and mountainous topography, a large share of the lands with these climates can be utilized most efficiently by being kept in forest.

Continental Climates.—A very large share of the land of the globe has a continental climate. The west coasts in the higher mid-latitudes are dominantly influenced by marine conditions, and in the equatorial lands the trade winds may carry marine influences far to the interior. In the mid-latitudes the continental interiors present the greater extremes in climatic conditions, whereas the eastern portions of these zones have a continental climate considerably modified by oceanic influences. The dry deserts represent the climax of the continental types of climate.

Marine climate is equable; continental, is severe. The annual temperature ranges increase, as a whole, with increasing distance from the ocean; the regular diurnal ranges are also large, reaching 35° or 40°, and even more, as for example, in the arid continental interiors.

The coldest and warmest months are usually January and July, respectively.

The greater seasonal contrasts in temperature over the continents than over the oceans are increased by the less cloudiness over the former. The clearer continental skies of high latitudes favor a lowering of the winter temperatures, but a slight rise of the summer temperatures; while in lower latitudes the clearer summer skies favor a higher mean annual temperature. Daily and annual changes of nearly all the elements of climate are greater over continents than over oceans.

Owing to the distance from the chief source of supply of water-vapour—the oceans—the air over the larger land areas is naturally drier and dustier than that over the oceans. Yet even in the arid continental interiors in summer, the absolute vapour content is surprisingly large, although the air is still far from being saturated. In the hottest months the percentages of relative humidity may reach 20 per cent or 30 per cent. At the low temperatures which prevail in the winter of the higher latitudes, the absolute humidity is very low, but owing to the cold, the air is often damp. Cloudiness as a rule, decreases inland, reaching its minimum in deserts. And with this lower relative humidity, more abundant sunshine, and higher temperature, the evaporating power of a continental climate is much greater than that of the more humid, cloudier, and cooler marine climate. Actual evaporation is, however, under these conditions, usually much less than the possible evaporation which would take place were there more water present to be evaporated. Both amount and frequency of rainfall, as a rule, decrease inland, but the conditions are very largely controlled by local topography and by the prevailing winds. The decreased frequency of rainfall on the lowlands is especially marked in winter. Winds average somewhat lower in velocity, and calms are more frequent, over continents than over oceans. The seasonal changes of pressure over the former give rise to systems of inflowing and outflowing, so-called continental winds, sometimes so well developed as to become true monsoons. Usually, however, the changes in direction and the development are not very marked.

In winter, clear, crisp days, which are followed by cold, calm nights, and interrupted from to time by spells of cloudy, windy weather, with or without light precipitation; in summer, clear, calm nights, followed by hot days with increasing wind velocity and heavy clouds towards noon, and often by thunderstorms later in the afternoon—these are typical weather conditions of continental interiors in the higher latitudes; and they are of much interest to man. The extreme temperature changes which occur over the continents are the more easily borne because of the dryness of the air; because the minimum temperatures of winter occur when there is little or no wind, and because, during the warmer hours of the summer, there is the most air movement.[11]

Humid Lowlands with Continental Climates in the Mid-latitudes.—These lands are humid and have no pronounced regular dry seasons during the summer (although droughts may occur). They comprise the eastern United States and southeastern Canada, the interior portion of west central Europe, eastern Asia, east central Argentina, and southeastern Australia; that is, lands relatively near water bodies. In these areas the sub-surface materials are always moist and the soils are usually moist also. Such moisture conditions, combined with the associated temperature features, make forests possible, and over most of these areas the native vegetation was made up of forests. Associated with these climatic and vegetation conditions are, as a rule, the light-colored forest soils which prevail over the well-drained lands of these humid portions of the continents. These humid areas may be differentiated climatically on the basis of the length and temperature of the growing season, which factors are also very significant in determining the type of vegetation formation, the soil groups, and, as is to be expected, the types of agriculture of the various sub-regions.

Humid Continental Climates with a Short Growing Season.—This subdivision includes especially those sections of northern North America and of northern Eurasia covered with evergreen forests. The growing season of three to four months is mild but too short to permit any extensive vegetative growth, whereas the winters are long, cold, and noted for their heavy snows. The rainfall, which is uniformly distributed throughout the year, varies from 10 inches or even less in the interior to more than 40 inches near the coasts; but throughout the entire region the soils are moist, owing to the lower evaporation. As a rule, the relative humidity is high, and intensely cloudy weather is a marked factor in these lands. All these factors favor the rapid vegetative growth of annuals during the short growing season. The forests are made up of evergreens, but because of various local conditions these forests are subdivided into several associations. These local conditions are closely related to drainage features and to the underlying geological materials. Throughout most of this climatic region, on the better-drained lands, the characteristics of the soil have been so remark-

[11] Ward, R. De C., "Climate," pp. 38–42.

ably influenced by the climate and the associated native vegetation as to result in a special soil group to be more fully considered in the chapter on soils.

Humid Continental Climates with a Moderately Long and Warm Growing Season.—These climates comprise the east central United States, interior west central Europe, northeastern China, the eastern slopes of southeastern Australia, and the eastern Pampas of Argentina. In general, as far as is known, these regions were covered with a good growth of deciduous hardwood forest, significant exceptions being the eastern Pampas and the eastern portions of the Prairies of the United States, the latter being less humid and subject to longer periods of drought and warm summers than the forested lands to the east. In United States, this climatic region is a section with hot summers and a growing season five to eight months in duration. It is also distinguished for its shorter but generally cold winters with some snow, the winter period being the season with less precipitation. The rainfall averages from 40 to 45 inches and decreases toward the northwest.

Humid Continental Climates with a Long Growing Season.—These comprise the southeastern United States, thus including much of the so-called Cotton Belt and the Gulf coastal lands, southern China, and some of northern Argentina. The winter or cool season is short, the summers hot and long but with sufficient moisture to provide a native vegetation of forests. The rainfall varies from 60 to 40 inches, and it is a rainfall line—that of 10 to 11 inches during the fall months —which marks the southern boundary of the Cotton Belt. In both this climate and humid continental climates with moderately long and warm growing seasons, the summer rainfall is characterized by local and general thunderstorms between which occur periods of bright and intense sunshine. These factors, combined with the high temperatures, aid in projecting truly tropical conditions into the summers of the mid-latitudes, thus providing environments which are significant to the agricultural production of both these subdivisions. That the heavier rainfall, the warm summer temperatures, the short winter season, and the short period during which the ground is frozen should all have their influence on native vegetation and on soils and consequently upon agriculture, seems obvious. The native vegetation in sections with heavier soils is generally hardwoods; but on the lighter-textured upland soils of the southeastern United States, with their high content of sand and generally intensively leached conditions, are the southern evergreen forests.

Periodically Moist and Dry Climates of the Plains of the Continental Interiors.—These include the continental interior lowlands in the middle latitudes. Owing to their distance from the oceans, their rainfall is relatively low, droughts are characteristic, and much of the precipitation occurs irregularly in showers with occasionally heavy downpours, in which case there is a high percentage of runoff. Owing to these conditions the sub-surface is permanently dry, and during the summer period the soils may become dry, a condition which precludes the development of forests. These areas are the climatic grasslands of these latitudes, and the type of grassland—tall grasses, short grasses, or mixed, varying with the relative soil-moisture content—is determined by the amount of moisture entering the soil together with its retention and availability in the soil. These lands include the Great Plains of North America, the middle and western Pampas, the steppes of Russia, the Puztas of Hungary, the Veldt of South Africa, and the Downs in southern and eastern Australia. Closely associated with the total amount of precipitation, its type and distribution through the year, are the soil characteristics involved, together with the degree of evaporation. In Russia, for example, the zones of temperature and of precipitation are fairly parallel with each other, whereas on the Great Plains of North America the temperature zones have an east-west trend whilst the precipitation zones extend in a north-south direction. In this case, it is obvious that evaporation should play a very prominent part in influencing the conditions of the plant habitat, a condition already described (see page 33), and one which is highly significant to the class of soils and consequently to the type of agriculture prevailing in these regions. In the Great Plains of North America occur two weather types very significant to the agriculture of the areas involved. In the northwest, particularly in the mountain valleys and eastward from the front ranges of the Rocky Mountains of Montana and British Columbia, occur the chinook winds. These warm and dry winds, descending from the mountains, burst upon the lower lands in winter, sending the mercury rapidly upward and melting the snow so quickly that the Indians designated them as "snow eaters." The rising temperature and the consequent melting of the snow, exposing the cured grasses of the Plains, are obviously very important to the livestock industry in these areas.

In the southern Great Plains, centering about the Panhandle, is a large section of country subject in summer to hot winds. These lands, naturally hot and dry in summer, have such conditions accentuated by the hot and exceedingly dry winds, which increase transpiration so rapidly that vegetation withers at once, and, if prolonged, cause complete cessation of growth. The grasses of the range become dry and brown; crops are damaged and may be totally ruined. Especially is this true for corn. In recent years, drought-tolerant grain sorghums have been introduced into these areas. Owing to their peculiar quality of drought-resistance and their power to commence growth with the coming of rains, these crops have become very important in the Southwest, subject as it is to droughts and hot winds.

Lying east of the climatic grasslands in the United States are the Prairies, originally covered with tall grasses; and in the eastern Pampas there appears a condition somewhat similar. The Prairies of the United States, especially the western areas, are subject to longer and more intense droughts than the forested country eastward, as well as to higher summer temperatures. The sub-surface is moist, however, and forests were to be found in varying local habitats in both the western and the eastern portions of the Prairies. In the west, the trees were found along the stream courses, there presumably because of the greater and more uniform moisture supply; and in the east, also along the stream courses, here, in part at least, because these constituted the better-drained lands in contrast to the flattish, poorly drained, upland areas often covered with a rich growth of very tall "slough grasses."

Climates of Mountain Ranges and Associated Highlands in the Mid-latitudes.—The climates of these lands are patchy in distribution owing to the influences of the broken topography. The chief factors determining the climate and weather in such lands are latitude, altitude, exposure to sunshine and to winds, and the degree of rain-shadow effects. The following general statements serve to give an idea of the principal climatic features of these areas: *First*, with increasing altitude, there is a corresponding decrease in temperature. *Second*, the windward slopes of mountains (and of uplands) are generally rainy, the degree of raininess varying with the types of exposure and the water-vapor content of the winds. These *rainy slopes are forested*, oftentimes supporting a very luxuriant tree growth. *Third*, leeward slopes are less rainy but may be moist enough to support forest growth, as, for example, the eastern slopes of the Sierra Nevadas. *Fourth*, highlands and plateaus lying in the rain-shadow, that is, to the leeward of mountain ranges, are much less rainy and may be desert-like. In these areas, much of the rainfall may occur sporadically as in cloudbursts. In the United States, the less elevated portions of the Great Basin and of the Columbia Plateau, both covered with sage-brush, are typical of partially enclosed uplands with a semi-desert climate; whereas in the Southwest, under a combination of pressure conditions, winds, *rain-shadow effects, and high sunshine, a truly desert climate prevails*, typified by cacti and associated xerophytes.

Typical cases of mountain and upland regions of the middle latitudes are those of the Rocky Mountain system of the western United States and Canada, the Andean lands of southern South America, the Alpine section of Europe, and the broken highland country of the "Heart of Asia," itself made up of a series of plateaus buttressed in by mountain ranges.

"The Heart of Asia."—With a width of about 500 miles, narrower or wider as the enclosing mountains approach more or less closely, a vast arid tract extends for some 2000 miles from the Pamirs, ENE. to the Khingan Mountains. It is really a great basin, or rather a series of basins, since it is enclosed on all sides, especially the west, by much higher ground; but the average elevation above the sea is about 3000 feet, so that the term plateau is not inapplicable, especially as numerous mountain ranges intersect the region. The tops only of the ranges now project above the deserts of gravel and sand, the products of subaerial denudation which bury the lower parts of the mountains from which they were derived.

Central Asia is often classed as a continuation of the deserts of North Africa and Arabia. Though it resembles those regions in aridity, there are such great differences in the temperature conditions and also in the general causes underlying the climatic peculiarities that they ought to be considered separately.

In winter the heart of Asia is under the influence of the great cushion of dense air that collects over the cold continent, giving the highest atmospheric pressure (reduced to sea level) on the earth's surface. Calm and gently outflowing winds are the result in the central parts of the high-pressure region, and there can be no, or very little, precipitation. In spring the heated land throws off its burden of air, and the change to the low-pressure conditions of summer is a period of violent winds. In eastern Mongolia the northwest winds descend over China in great storms which carry much dust. In summer the low pressures draw in air from all sides, and under more advantageous conditions of relief a certain amount of rain would probably have been received, despite the fact that the sea is a thousand miles distant. But the deserts are surrounded by mountains, notably the Takla Makan, southwest of which tower some of the highest ranges on the globe. The Indian monsoon current is for the most part stopped by the wall of the Himalayas, a barrier 5 miles high. In the east a small portion of the monsoon makes its way into Tibet, but it must still cross the 700 miles of plateau, elevated 3 miles above the sea level and ribbed by numerous ranges, before reaching the Takla Makan. Probably we may safely assert that none of the monsoon current reaches so far north as to make the descent into this inland basin, and even if it succeeded in doing so it would be so warmed by compression as to be a very dry wind. Similarly on the north and west the mountain barrier, though lower, suffices to ward off the winds from those quarters. Only in the east do moist winds penetrate, and we find a belt of good steppe land some 70 miles wide along the southeast border of the Gobi. The sea is only 350 miles away, and the southeast monsoon, when it crosses the Khingan, still contains enough moisture to make agriculture possible with the help of irrigation from the streams. The northern edge of Mongolia also is by no means desert, the rainfall being sufficient to maintain abundant grass in places. Urga has 7 inches of rain per year.

A very important factor in the meteorology is the high latitude. Central Asia lies between 37° and 50° N., and therefore there is a great seasonal change in the insolation. The annual range of temperature throughout these deserts is very great indeed.

It is instructive to recall for comparison the conditions of the Sahara. There the desert, far from being confined to the interior of the continent, reaches the sea on the west, north, and east, and mountains are of but minor importance in causing the lack of rain. Owing to the low latitude there is no excessive cold in winter, for even the north of the Sahara has a mean January temperature of 60°. As in almost all deserts the range of temperature is considerable, but not nearly so great as in Central Asia.

The rainfall is probably less than 2 inches a year in the deserts in the heart of Asia; in the east, as we have pointed out, the rainfall is somewhat greater and may amount to almost 10 inches in favoured localities. But even 2 inches must not be expected in the deserts every year. Many years have far less, and the balance is restored by a violent cloudburst at long intervals. Traces of the overwhelming floods that result may be seen in the deep channels, now dry, which the torrents excavated. There are no long series of records, but the available data show that the total precipitation is made up of winter snow as well as summer rain. The mean annual precipitation at Kashgar is 3.5 inches, of which over two-thirds fall in the summer half-year. At Yarkand half an inch was recorded in the single year a gauge was maintained. A traveller who stayed at Lukchun near Turfan for ten months reports that it rained five or six times, and snowed three times, the snow disappearing the day after it fell. Urga has a mean annual total of 7 inches. No records of the amount of rain are available from eastern Mongolia, but the number of rainy days has been counted at Hakiao (Lat. 41° N., Long. 111° E.) for a few years, and the average found to be 59, 35 being in the summer half-year. This station, lying well to the north and west of the In-Shan and Khingan Mountains, is evidently reached by the southeast monsoon of China.

The air is dry. Sven Hedin recorded a mean relative humidity of 28 per cent in the Takla Makan in May, 69 per cent in December. The mean summer humidity at Lukchun at 1 P.M. was 20 per cent. The sky seems to be somewhat more cloudy than in the Sahara.

The summers are very hot, with the sun glaring down during the long days through the dry air.

In summer the temperature of Central Asia is not very different from that of the Sahara, but in winter there is a great contrast. Frost is indeed by no means unknown throughout the Sahara on winter nights, but the mean January temperature is everywhere above 50° F. In the deserts of Central Asia, the mean for the same months is considerably below freezing-point. Standing water and small rivers are frozen right across throughout the winter months and the natives bring home their water supply in the form of blocks of ice. It is rare for the thermometer to rise above freezing-point even at midday; at Tarim Jangiköl, 2890 feet above the sea, Sven Hedin found that the average maximum daily temperature during January was 9°, and the lowest reading he recorded during his winter's stay was −14°.[12]

These mountainous areas, where rainfall is sufficient, are suitable for forest production or for grazing purposes; the less rainy regions may be utilized to some degree for grazing, but the drier lands seem destined to remain as economic deserts. Because of the broken topography and the sporadic rainfall, these lands are subject to very destructive erosion where a cover of vegetation is absent.

THE POLAR LANDS

The polar zones comprise but 8 per cent of the surface of the earth, the prevailing opinion that they are larger being traceable mainly to the type of map projection usually used in representing these regions. These lands are always cold; the southern portions of the polar lands of the northern hemisphere may warm up somewhat during the short, cool summer. The precipitation is low, but the temperatures are also low. The sub-surface is permanently frozen, but the surface of the Tundra thaws to a depth of a few feet during the short summer. These barren wastes (for the Tundras are cool and water-logged in summer, subject to strong and cold winds in winter, and possess but a short and cool growing season) can never be utilized to any great extent for productive purposes. The arctic vegetation is used to a limited extent for pasturage for herds of reindeer, but its slow growth and limited area appear to preclude any marked utilization in this direction.

[12] Kendrew, W. G., "Climates of the Continents," pp. 154–158.

CHAPTER III

PHYSIOGRAPHIC DIVISIONS OF THE CONTINENTS

Major Relief Features of the Continents.—In order to appraise the physical potentialities of the various lands of the world in regard to their efficient use for the production of economic plants (and livestock), it is advantageous to see in perspective the main features of the surface, size, shape, and relative position of the various continents.

Asia.—Asia, the largest of the grand divisions, and comprising one-third of the land of the world, has an area of 17½ million square miles, and is larger than the combined areas of North and South America. *It is 4½ times the size of Europe and 5½ times that of the United States.*

Although it lies entirely in the northern hemisphere, its latitudinal width is such that it extends from within a few miles of the equator northward to some 10° beyond the Arctic circle. Owing to the great latitudinal range, a wide variety of climatic types result, their characteristics being accentuated by the form and the relief of this vast land mass.

In shape, Asia is roughly a quadrilateral with various projecting peninsulas. The heart of the continent is composed of a series of vast highlands more or less enclosed by mountain systems. Its great plains are marginal in location and, excepting the vast lowland of western and northern Siberia, are for the most part alluvial-filled basins. Among these latter, the following are of particular significance: the Indo-Gangetic Plain; the Plains of North China (alluvial deposits mainly of the Hoang-ho); the basins of the Yang-tse-Kiang; the lowlands of Siam, French Indo-China, and Burma; and the basin of the Tigris-Euphrates river system.

North America.—North America, with an area of 7 million square miles, less than half the size of Asia, is to be contrasted with that continent also in regard to shape. It is roughly triangular and much less compact than Asia. It reaches well into the tropics but is widest at the north, where, as in northern Asia, are vast stretches of " Barren Lands," the Tundra. Along the west coast from the Arctic Ocean to Panama, extends a great mountain system with many ranges, chiefly of north-south trend, and the associated highlands and plateaus. To the east of this system in the United States and Canada, lie the Interior Lowlands, comprising the Great Plains and the Central Lowland. Eastward from the Great Plains of Canada are the Laurentian Uplands, and east of the Central Lowland of the United States lies the Appalachian System. This system is made up of the Appalachian Plateau, together with the newer and the older Appalachian Mountains, the latter including the Blue Ridge and the Piedmont. East of the Piedmont lies the Atlantic Coastal Plain. This plain is continuous with the Gulf Coastal Plain of the southeastern United States and northeastern Mexico.

The dominance, in area, of lowland sections in North America is indicated by the fact that nearly one-third of the continent has an altitude of less than 600 feet, and two-thirds of it is less than 1500 feet; whereas less than one-fourth of Asia has an altitude of less than 600 feet, and almost three-fifths of that continent is above 1500 feet elevation.

South America.—South America is a little larger than North America and, like that continent, is triangular in shape. As it is widest at the north, the larger share of it lies in the tropics. Topographic conditions are comparable to those of western North America, in that the Andean System extends the full length of the west coast, whilst to the east lie the wide level Pampas in the middle latitudes and the vast Amazon Basin in the tropics. These lowlands make up a significant part of the whole area of South America. Two-thirds of the continent has an altitude of less than 1500 feet, and two-fifths of it has an elevation of less than 600 feet.

Europe.—Europe, the smallest of the continents except Australia, lies entirely north of the 35th parallel north latitude. Its widest extent is at the south where its width is three times that adjacent to the polar seas. Europe, which is made up of many peninsulas, is itself a vast peninsula of Asia. It comprises a great central plain, with the Alps and associated valleys and highlands at the south and the uplands of the northern British Isles and of the Scandinavian Peninsula at the northwest. Owing to the great irregularities of its coastline, arms of the ocean extend far inland, thus modifying and tempering the climate of the interior.

Africa.—Africa is next to Asia in size, and, unlike any of the other continents, is cut in twain by the equator. Two-thirds of its area lies in the tropics. One-third of the continent is desert, and in addition large areas are semi-arid. In relief it is a vast highland, the heart of which may be regarded as the plateau of eastern Africa. This plateau extends from the Ethiopian Highlands at the north to the

Drakensberg Mountains at the south. Africa, long known as the "Dark Continent," is coming to be recognized as a land of opportunity as its vast potentialities are made better known.

Australia.—Australia, the smallest of the continents, is the only one lying entirely south of the equator, and is almost equally divided by the Tropic of Capricorn. As in the case of Europe and the Americas, the great plains are in the interior. Owing, however, to its position, shape, size, and relief, a large share of the continent is arid to semi-arid, and this vast "dead heart of Australia" can promise little in the way of production of food and raw materials for the growing demands of the world's increasing population.

SIGNIFICANCE OF TOPOGRAPHIC CONDITIONS FOR AGRICULTURE

Surface features are very significant, in a direct way, for agricultural production: the use of large-scale labor-saving machinery is precluded on a considerable portion of the lands of the globe because the topography is too rough and dissected. Such lands, on account of climatic conditions, often may be best used for pasture or for forest production. However, in regions where agricultural practices are "relieved from the tyranny of the plow," rougher lands may be cultivated; and in areas where population pressure is great enough, the topography may be modified to some extent, as by terracing, thus enabling cultivation to proceed on slopes otherwise too steep for ordinary crop production.

Those plains of the world that occur in regions where climatic conditions are favorable, constitute most of the land suitable for cultivation; and it is on such plains that a large share of the world's agricultural produce is grown.

As will be discussed later, topographic features, together with conditions of the underlying rocks, are of great importance through their interrelationships with climatic conditions, soil charactertistics, vegetation aspects, and in their bearing upon problems connected with irrigation, drainage, and erosion. Also, as has been shown, mountain systems that lie athwart permanent or seasonal wind belts are often characterized by heavy precipitation on their windward slopes, whereas areas to the leeward may be very dry owing to the rain shadow effect of the topographic barrier.

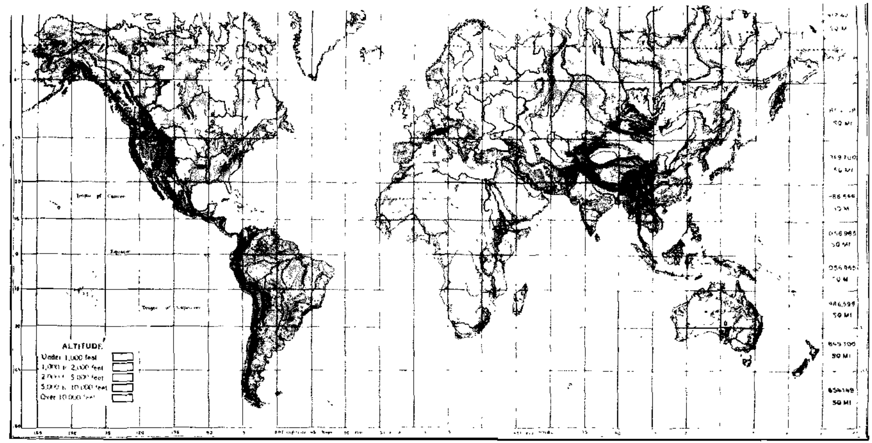


Fig. 13.—Land relief, adapted from Physical Maps of the Continents, by J. Paul Goode, Chicago, 1913–1915. Most of the important agricultural regions of the world lie below 2000-feet elevation, and practically all below 5000 feet. The lands lying above 5000 feet are mostly too arid and frosty for extensive agricultural development, hence are used principally for grazing live stock. The Mercator projection used for this map seriously exaggerates the areas toward the poles. The extent of this exaggeration is indicated by the figures along the right-hand margin of the map, which give the area in square miles in each 15° quadrilateral of latitude and longitude. A square mile at the latitude of Petrograd, Russia, 60° N., for instance, covers four times as much space on the map as a square mile at the equator.

Taken from Finch and Baker, Geography of the World's Agriculture.

CLASSIFICATION OF SURFACE FEATURES

The topographic characteristics of the different continents may be classified broadly into plains, plateaus and highlands, and mountain ranges.

Plains.—The plains of the world, principally lowlands, are dominantly flattish, having little relief, and are formed mainly by the accumulation of sediments—marine, lake, or river—which may or may not be consolidated. The main topographic feature of plains is their undulating to slightly rolling surface, the lack of strong relief being associated with their slight elevation. Relatively slight topographic irregularities have been formed by erosive action or by deposition, as for example, in some glacial deposits. The more noticeable of these irregularities include: first, the river channels and closely associated features, including the "breaks" or the dissected uplands bordering the streams; and second, the hilly, rolling country with many lakes and swamps, characteristic of lands covered by the latest of the great ice sheets. While these irregularities are very significant in regard to the best uses of the lands involved, another set of surface features, far less obvious but very significant, include a more or less regularly developed series of topographic forms. These include broad and often scarcely noticeable lowland depressions developed by the cutting away of the less resistant and nearly horizontal strata (usually limestone or shale) and lie between escarpments or ridges. These ridges of resistant strata, often sandstone, usually have a rugged topography caused by dissection of more resistant layers of rock.

Examples of these depressions of less relief and associated escarpments with greater relief have been developed over portions of the Gulf Coastal Plain and sections of the Interior Plains of North America, producing a belted arrangement of topography very important in interpreting the agricultural utilization of these lands.

The rocks underlying plains are commonly sedimentary. They may be limestones, for example in the Blue Grass basin, the Black Belt of Alabama, or the Black-waxy Belt of Texas. They may be sandstones, such as portions of the Coastal Plain; or shales, such as sections of the Great Plains, as in western South Dakota; or they may be unconsolidated deposits, which include the following types:

First, river alluvium of flood plains and deltas, such as the Nile, the Mississippi, Ganges, Indus, Yang-tse-Kiang, Hoang-ho and many others.

Second, glacial deposits, which are prevalent over northern Europe and the northern portions of the interior lowlands of North America. Glacial deposits may include a variety of component materials such as (*a*) the sandy materials of the plains of North Germany, of Denmark, of central Wisconsin, and of the northern portion of the southern peninsula of Michigan; (*b*) limestone materials, such as are to be found over much of northern Indiana, and southern Michigan.

Third, another type of unconsolidated materials is represented by recent marine deposits such as those of eastern Texas and southern Louisiana.

The plains of the world that possess suitable combinations of temperature and moisture are the crop-producing regions, present or potential, and here are found the great centers of population at the present time. Typically, the great plains, as has been shown, are the vast interior plains of North and South America, of Europe and Asiatic Russia, and of Australia; and the marginal plains, such as the coastal plains of North America, the eastern Pampas of South America, and the great river-basin plains of southern and eastern Asia.

It is of importance to note that the interior plains of the continents are generally characterized by a rather low precipitation and the occurrence of droughts during the summer. These are the world's grasslands with dark-colored soils. The marginal plains, on the other hand, are humid, and in some cases very rainy. They are characterized as a rule by a forest vegetation, the density and luxuriance of which are associated with the combination of moisture and temperature features and soil conditions.

Plateaus and Highlands.—These include those high lands with considerable summit areas, which usually are adjacent to lands of higher elevation. The skyline of these land forms is fairly uniform and horizontal, but the topography, when examined in detail, is rough, owing to the degree of dissection. Plateaus and highlands are underlain by the various kinds of sedimentary, igneous, and metamorphic rocks, or by the complex crystalline rocks.

Some typical examples are the following: the Colorado Plateau, underlain by sedimentary rocks, and characterized by the dissection produced by the Colorado and its tributaries; the Columbia Plateau and the Deccan, both underlain by layers of igneous rock, and both of which have been subject to intense dissection by stream action.

Types of these land forms underlain by complex crystallines include such agricultural areas as the Piedmont, the Coastal Hilly Belt of New England, southeastern Brazil, and such non-agricultural lands as the Laurentian Upland, the uplands of Fenno-Scandia (Norway, Sweden, Finland), and the New England uplands. Associated with these highlands are numerous depressions which in many instances are weak-rock lowlands and may be partially filled with deposits of unconsolidated materials. Such lowlands may be very important agriculturally. They include, for example, the better farming sections of southern and central Sweden, the Connecticut Valley Lowland of southern New England, and the St. Lawrence Lowland in eastern Canada.

PHYSIOGRAPHIC DIVISIONS OF NORTH AMERICA

North America, like other continents, is differentiated by climatic subdivisions into broad and extensive regions, particularly where the topography is flattish, less rugged, or non-mountainous. The divisions of the land masses into plains, plateaus, and mountains present likewise generalized topographic features in broad outline. Associated with these broader topographic groups are numerous minor features which produce local variations, often wide in extent and very significant from the standpoint of efficient utilization of the lands. These local variations, associated with differences in the underlying rocks and with inequalities in the action of dissecting agents, manifest themselves in local climatic features, in soil differences, and in variation in regard to agricultural potentialities.

Because of the significance of surface features in their relation to the agriculture of regions and areas, the following outline of the physiography of North America is introduced.

North America, roughly triangular in shape, is dominated by three great topographic features. Stretching along the Pacific Coast from Behring Strait to Panama is the great western mountain system, with its high ranges and associated highlands and plateaus subdividing it into numerous smaller topographic units. The northeastern section of the continent is made up mainly of the Laurentian Upland, a vast rolling area, recently glaciated, with many local irregularities of surface (bare rock areas, lakes, swamps, bogs, and muskegs), but without any marked mountainous regions. Extending southward from the northeastern part of the continent is the Appalachian System. Lying between the Rocky Mountain System and the uplands of the north and the east, are the vast rolling interior plains of the continent which at the south merge into the coastal plains.

The Laurentian Upland.—This "old land" region, underlain by complex crystalline rock, is characterized over large areas by the remarkable evenness of its skyline. The area has been recently glaciated, which accounts for many of the local variations in its physical landscape. It is a region characterized by its many lakes and swamps; large portions of the better-drained areas are covered with morainal deposits, often hummocky in appearance, and having large areas of bare rock exposed, as a result of glacial scouring.

It is a region noted for its large percentage of undrained lands and likewise for its large areas of bare rock surface. Much of the rest of the country is somewhat rugged and underlain by coarse glacial materials. There occur rather level areas, such as the Clay Belt of Ontario, underlain by fine sediments which contain at slight depths considerable amounts of lime. At the southeast, the Laurentian Upland suddenly gives way to the St. Lawrence Lowland, an area underlain by fine-textured water-deposited materials.

New England.—In the extreme northeastern United States lies the New England province, from which a similar type of topography extends into the Province of New Brunswick, Canada.

Like the Laurentian Upland, New England is immediately underlain mainly by complex crystalline rocks—granites, gneisses, and schists—and it too has been recently glaciated.

New England presents different types of topography in its various sections, all of which must be taken into account in planning for the best utilization of the lands. Northward are the more rugged and mountainous areas, including the Green and the White Mountains. A large portion of central New England includes the so-called eastern and western uplands, which lie on either side of the Connecticut Valley Lowland. These uplands, which have a rather even skyline, are interrupted locally by many irregularities resulting from the uneven surface of the underlying rocks and from glacial deposits, most of which are bowldery and mainly made of other coarse materials.

Immediately interior from the coast of New England is a more dissected and hilly belt, lower in elevation, and likewise with many surface irregularities associated with glacial deposition. In south central New England and extending across Massachusetts and Connecticut, is the Connecticut Valley Lowland—a lower area developed on rocks (sedimentaries) that are less resistant than the complex crystalline of the uplands. This area during glacial times was filled in with water-borne glacial materials. These materials include sands and clays and give to the lowland a physical appearance quite in contrast with most of the rest of New England. These deposits have since been much modified by stream action, forming the classic terraces of gravels, sands, and clays, so significant in past and present-day agriculture of the lowland. There are, however, in other portions of the province, locally flattish areas underlain by water-deposited sediments, such as those in eastern Massachusetts underlain by glacially derived sands and gravels; a few marine deposits (coastal plain) such as in the lower valley of the Saco; lake deposits, as along Lake Champlain; river terraces, such as those of the Connecticut (already mentioned) and of the Merrimac, and the poorly drained lowland areas along streams and the filled-in swamps and bogs so common in recently glaciated lands.

It is needless to emphasize the fact that these varying types of topographic features have been and are very significant in the past and present use of lands in this region.

The Coastal Plain.—Extending southward from the vicinity of New York City, to and including the Yucatan Peninsula, is a low-lying but by no means featureless plain of varying width. It is underlain by recently uplifted marine sediments comprising strata of limestones, shales and clays, sands and sandstones.

The surface of much of the plain lying next the coast is characterized by its extreme flatness and consequent poor drainage, the latter being accentuated in some sections, as in east Texas, by the impervious nature of the tough, intractable geological clay deposits.

In contrast with the generally flattish country along the coast are the interior portions of the plain, which show a greater degree of dissection. The forces of stream erosion, acting upon the outcrops of the various strata—each stratum characterized by differences in degree of resistance—have produced in various sections a belted arrangement of topography made up of coastward-sloping structural plains formed on less resistant strata and lying between ridges formed from the more resistant strata. Some sections are characterized by interstream flats wholly or nearly untouched by dissection. It is this dissected portion which contains the 15 or 20 per cent of the Coastal Plain which is too rough for cultivation under present conditions.

Typical Examples from Alabama of a Section of Coastal Plains

In order to appreciate better the topographic variations of the Coastal Plain, the following examples are introduced. In Alabama there is no flat coastal section such as, for example. the extensive Coastal Prairies in the vicinity of Houston, Texas.

Pine Hills Section.—Just behind a very narrow coastal strip of fairly well-stabilized sand dunes, lies a belt of hilly country mainly underlain by sands. This undulating country produced by dissection is in the main an area of gentle slopes, is well drained, and extends westward into Mississippi and eastward into Florida. However, on interstream areas occur flattish lands practically unmodified by erosive agencies.

Lime Hills Section.—Between the Pine Hills escarpment and the Southern Red Hills is a lowland formed on limestones. Differential erosion has resulted in a country of rounded hills, grading at the southeast into a flattish country, the Lime Sink Region, which continues into Florida.

Southern Red Hills Section.—This is a zone of moderately hilly country extending uninterruptedly from South Carolina through Georgia, Alabama, and Mississippi, and into west Tennessee. The underlying geological materials are mainly sands, although limestones occur locally.

The Post-Oak Flatwoods.—In west central Alabama, lying between the Southern Red Hills and the Chennunnuggee Ridge and extending into Mississippi, is a narrow belt of flat land formed on the so-called Flatwoods clay, and called the Post-Oak Flatwoods on account of the characteristic topography and its associated vegetation.

The Chennunnuggee Ridge.—This includes a northward-facing escarpment, lying next the Black Belt, and a hilly region to the south. Toward the east it widens considerably, and there its topography is less rugged. This belt is underlain by marls and sands.

The Black Belt.—This well-known area, once known as the canebrake or prairie country, is a slightly undulating lowland with a few hills formed on the Selma chalk, a soft, gray, argillaceous limestone. This lowland plain, sloping southward, is flattish in the main and often poorly drained, though, as is to be expected, it is more dissected along the margins.

The Central Pine Belt.—The Central Pine Belt is the interior zone of the Coastal Plain. This is a dissected area formed mainly from sandstones.

River Features Associated with the Coastal Plain

Many rivers, with flood-plains of varying width, extend across the Coastal Plain throughout its full length. The most significant of these is the Mississippi River, whose flood-plain, 50 to 75 miles in width, extends from Cairo, Illinois, to the Gulf of Mexico. A large share of its alluvial deposits has been carried from the Great Plains country. The flood-plain of the Mississippi includes the low and poorly drained portions of southeast Missouri and northeast Arkansas (the St. Francis Basin); the Yazoo Basin in Mississippi and the low, poorly drained areas of eastern Louisiana which merge with the Delta of the Mississippi. The general features of this great alluvial plain are the higher, better drained ridges paralleling the stream; from these the land slopes on either side to the swamps and bayous so characteristic of this area. Being higher and better drained, these natural levees, as they are called, are of great significance to the use of these lands. Eastward from this alluvial lowland, extend the Mississippi bluffs, marking the height of the lands to the east. This dissected bluff zone and the area eastward have been covered with loess deposits (wind-blown materials carried by the storm winds from the west). Some of these silty materials have, no doubt, been picked up from dry mud-flats along the Mississippi.

Central Plains.—This area, occupying most of the section south of the Great Lakes to the Gulf Coastal Plain, grades into the Great Plains on the west and into the Appalachian Plateau on the east. It is distinguished generally by conditions of slight relief; it is underlain by sedimentary rocks, chiefly limestones, and all practically horizontal in attitude. It may be subdivided into three sections as follows:

First, the northern portion, whose rolling to hilly surface is characteristic of areas covered with deposits left by the recent ice-sheets. As is to be expected, it is not well drained, being marked by numerous bogs, swamps, and lakes. It is a section characterized by rough and bowldery glacial moraines, by outwash areas made up of sands and silts, together with typical basins poorly drained.

Second, the middle section, with a surface more flattish and often almost level, and consequently including much land that is poorly drained. (The draining of a large percentage of these lands by means of tile was necessary before they could be cultivated after being occupied by farmers.) This section was covered by the earlier ice-sheets, but its pre-glacial surface was probably not greatly dissected and the covering of glacial materials was less deep than in the section to the northward.

Third, the southern section includes the territory drained mostly by the southern tributaries of the Ohio and the Missouri Rivers, which was never glaciated. Its surface is generally rolling to rough, owing to stream dissection, although gently undulating to slightly rolling areas are to be found, as in the Blue Grass district of Kentucky.

Special Areas of the Central Plains

River Flood-Plains.—In the central and southern sections of this topographic province, the rivers charactertistically have rather narrow flood-plains, many of which are poorly drained. In the northern section the drainage lines are poorly developed and the flood-plains, if present, are usually narrow and often filled with glacial outwash.

The Blue Grass Region.—This slightly undulating to gently rolling country of northeastern Kentucky extends across the Ohio River into southwestern Ohio. It has been sculptured out by stream erosion and is underlain mainly by limestones with a high content of phosphates. The slightly rolling topography of this district, which centers about Lexington, is in marked contrast to the surrounding lands which have a greater relief and often are covered with stones.

The Nashville Basin.—Similar in many aspects to the Blue Grass is the Nashville Basin of central Tennessee, a slightly rolling country developed in the basin of the Cumberland River.

Lake Plains.—The district drained by the Maumee River in northeastern Ohio is a flattish, poorly drained country underlain by fine sediments—the floor of the glacial Lake Maumee, a former extension of what is now Lake Erie. A continuation of this lowland extends eastward in a narrow belt between the southern shore of Lake Erie and the rugged, dissected, northward-facing upland, the latter being a northern terminus of the Alleghany Plateau. In western New York this lowland widens and becomes more complex. There it comprises a series of dissected limestone escarpments with intervening longitudinal lowlands covered over with deposits of sands, silts, and clays.

In central Wisconsin is an area formerly occupied by Glacial Lake Wisconsin and underlain mainly by sterile sands. It is similar, in many respects, to the northern portions of the Plains of North Germany. Centering around Lake Winnipeg in central Manitoba and extending southward into the United States, including eastern North Dakota and western Minnesota, is a very flat and generally poorly drained area which has long been noted for its great agricultural productivity. It is the floor of Glacial Lake Agassiz and is underlain by fine silty materials. This very important farming region, much of which is as flat as the floor, embraces an area of approximately 110,000 square miles.

The Plains of Southern Ontario.—This is an area underlain by a series of sedimentary rocks which dip southward. It is a country of rolling topography and comprises a series of east-west, fairly wide, lowland areas which lie between northward-facing and somewhat dissected limestone escarpments. These slightly rolling lowland depressions with numerous lakes are covered with a variety of deposits consisting mainly of sands and silts. Eastward, this region merges into the flat and often poorly drained St. Lawrence Lowland, which is largely underlain by lake silts and clays.

The Driftless Area.—This area of 8000 to 10,000 square miles of dissected and glacially unmodified country, mainly in southwestern Wisconsin, but including some lands of northwestern Illinois, northeastern Iowa, and southeastern Minnesota, has long been known because of the contrast it offers to the surface of the surrounding country.

The Ozark and Adjacent Uplands.—This is a highland region, large in area, and lies between the Central Plains and the Gulf Coastal Plains. It includes a large share of southern Missouri and northern Arkansas portions of eastern Oklahoma. The Ozark Region, covering most of Missouri south of the Missouri River, is a dissected plateau, underlain mainly by cherty limestones which dip westward from the St. Francis Mountains, the latter a series of granite knolls in the eastern portion. The Plateau consists of winding river valleys with narrow flood-plains (river bottoms), belts of dissected, hilly country extending from the bottom lands to the rolling interstream ridges or the undissected interstream flats. The latter indicate the existence of a flattish upland, formerly more extensive over this region. This type of topographic development continues southward into Arkansas to the northern edge of the Boston Mountains. These mountains, together with the Ouachitas in west central Arkansas and east central Oklahoma, are made of folded strata, in which dissection has produced a ridge-and-valley topography not unlike that of the folded Appalachian section, in the eastern United States. Between these two mountain groups is the Arkansas River valley with its flood-plain and the broken country parallel to the stream.

The Appalachian System.—Between the Central Plains and the Atlantic Coastal Plain lies the Appalachian System, which is made up of three rather distinct sections.

The Central Plains grade almost imperceptibly into the dissected country of the Appalachian Plateau, whose eastern edge descends suddenly by way of an escarpment into the ridge-and-valley country of the Folded Appalachians.

The Appalachian Plateau, well dissected by the headwaters of the Ohio River, is underlain by sedimentary strata of shales, sandstones, and coarser materials, which dip slightly westward. Between the eastward-facing escarpment of the Appalachian Plateau on the west and the Older Appalachians on the east, is the ridge-and-valley belt of the Folded Appalachians. In this zone of folded sandstone and limestone strata, stream erosion has produced a generally rough topography of hills and ridges where the more resistant materials persist, whereas the intervening limestone country has been worn down to a series of rolling lowlands. The most significant of these lowlands is the Great Valley, which extends uninterruptedly from northern Alabama (Coosa Valley) to the Hudson Lowland; thence, by way of the Champlain Valley, it connects with the St. Lawrence Lowland. Important sections of the Great Valley include the following valleys: Coosa Valley of East Tennessee, Shenandoah, Hagerstown.

To the east of the Great Valley are the Older Appalachians, underlain by complex crystallines. The western portion consists of a well-developed ridge or series of ridges extending from near Harrisburg, Pennsylvania, southward almost to Atlanta, Georgia. A large share of this elevated country is known as the Blue Ridge, while at the south it merges into a complex series of ridges and hills, locally known as mountains. The eastern portion of this crystalline area is known as the Piedmont. This is a generally rolling country, somewhat dissected and well drained by numerous streams. The Piedmont grades almost imperceptibly into the Coastal Plain at the east and south.

The Great Plains.—This vast province, extending from the MacKenzie Valley at the north to and including the Edwards Plateau at the south, is bordered by the Rocky Mountains on the west; at the east it grades into the Central Plains of the United States, and in Canada it grades into the western section of the Laurentian Upland through a zone characterized by swamps and large lakes. At the southeast, it is sharply marked off from the Gulf Coastal Plain by the dissected hilly front of the Balcones Escarpment. This province in the United States and in Canada is underlain by horizontal sedimentary strata of shales, limestones, and sandstones. Only the portion north of the Missouri River has been glaciated. In general, there is a gradual rise of elevation westward, as shown by the river systems and the relief map. The surface features result mainly from the effects of stream dissection and of glacial deposition on the horizontal sedimentaries. The central portion of the Great Plains (in the United States) is a flattish country called the High Plains. Westward, between the High Plains and the Rocky Mountain front, is an eroded lowland, hilly and rolling. In Colorado this lowland is known as the Colorado Piedmont, and at the southwest it is the valley of the Pecos River. South of the Canadian River is a very flattish portion of the Great Plains known as the Llano Estacado (or staked plains) which southward merges into the dissected upland of the Edwards Plateau. Eastward from the High Plains, in a region of higher rainfall, the headwaters of numerous rivers have produced a dissected and hilly transition zone between the undissected flat lands (High Plains) at the west and the Central Plains to the east.

In the northern portion of the Great Plains in the United States is a vast area which has been post-maturely dissected and which is drained by the Missouri River and its tributaries. The section north of the Missouri River was covered by the most recent of the ice-sheets. This country is characterized by a rough to rolling topography. It includes such diverse surface features as the rough and broken la ds bordering the Missouri River in portions of Montana, the Big Bad Lands of western South Dakota, such isolated mountain areas as the Black Hills, the Little Rocky Mountains, and even fairly level lands such as the Judith Basin and the Milk River valley.

The southern portion of the Canadian Great Plains constitutes the great wheat-producing region of Canada. The elevation descends rather gradually from the Rocky Mountains eastward to Lake Winnipeg, as is indicated by the drainage lines. The Manitoba lowland, an area of about 67,000 square miles, comprises the country surrounding Lake Winnipeg. It is almost as level as a floor, and is underlain by lake-deposited silts. This flat area, much of it poorly drained, is terminated at the west by a dissected escarpment, over which the elevation rises to the so-called second " prairie steppe." This section is of moderate relief, contains river valleys with narrow flood-plains and broken country adjacent to the stream courses. The upland country is fairly undulating to gently rolling, and over it is spread a mantle of glacial materials. Swampy conditions in this zone still further reduce the amount of land available for profitable cultivation. Westward in Alberta the country has more relief; much of the land, especially near the mountains, is too rough for profitable cultivation. Throughout the western portions of these Prairie Provinces, occur sandy bowldery areas, the result of glacial deposits, where the agriculture is less profitable.

Typical Cases of Topography of the Great Plains.—A cross-section of the Great Plains through the state of Kansas may be regarded as typical. Lying, as it does, in the interior of the continent, and underlain by nearly horizontal strata of sedimentary rocks, this region has, as its characteristic topographic features, slightness of relief and general simplicity of aspect. Larger subdivisions of this plain, as has been stated, include the undissected High Plains and such topographic irregularities as have been produced on either side of this zone by intensified erosion. The effect of this erosion has been modified by structural conditions of alternating layers of resistant and less resistant rocks of varying thickness, differing in composition and almost horizontal in arrangement. Westward from the St. Francis Mountain area—a very rough and broken country covered with granite bowlders—are a series of more or less belted plains or platforms lying between hilly and dissected escarpments. These intervening belts in Missouri are themselves dissected and broken, and covered with flint bowlders. This hilly Ozark region is formed mainly by the differential erosion of a series of westward-dipping cherty limestone strata, varying in degree of resistance, and extending just into southeastern Kansas. Between the Ozark country and the Flint Hills, an outlier of the Great Plains, lies a lowland belt, the eastern portion of which, lying on weak shales and sandstones, has been described by Marbut as follows:

> The surface of the lowlands is gently undulating, with water-courses flowing in wide flat-bottomed valleys bordered by low gentle slopes. Toward the west side of the valley, outliers of the escarpments bordering the northwest side relieve the general monotony of the landscape. The whole area is practically down to grade. It is really a lowland of denudation. It has long since passed through its stage of most pronounced relief and is now gradually wiping out the varieties of its surface.

The western and much broader portion of this lowland consists of a succession of hilly ridges with intervening valleys which have been sculptured by the action of erosion upon a series of stratified and westward-dipping shales, sandstones, and limestones of varying thickness and resistance. This gives a surface of moderate relief, somewhat rugged and well drained. Westward from this lowland belt is the Flint Hills Upland, an irregular zone of country extending from north to south across the state. It is underlain by cherty limestone strata, the eastern portion of which has been severely dissected. Only one stream, the Kansas River, crosses this topographic area, the surface of which is generally rugged in appearance.

> The name Flint Hills is derived from the large amount of flint which is found over the surface. Nearly all the limestone composing them contain some flint and a few of them carry heavy beds of it. The weathering of the limestones has left the enclosed masses of flint which are strewn over the surface in such profusion as to seriously interfere with travel.

Between the Flint Hills and the High Plains, in Kansas, lie several dissected areas, very irregular in outline. This section is crossed by the Arkansas River, which flows through a broad lowland developed on strata of shales. In north central Kansas is a somewhat dissected area from which have been removed the layers of sands and gravels so characteristic of the High Plains to the west. The underlying materials consist of limestone and shale, and here and there above the general surface rise isolated buttes or hills which are remnants of a more resistant layer, most of which has been eroded away.

Western Kansas is on the High Plains, whose practically level surface represents a great constructional plain composed of sands and gravels spread out eastward like great fans from the Rocky Mountains. These deposits formerly extended farther eastward, the irregular escarpment at the eastern edge of the High Plains marking the westward limit of the dissecting action of erosion agencies in a region of greater rainfall.

The High Plains, made up of unconsolidated material, standing above grade, and exposed to a considerable precipitation, are held by their sod. The great plateau surfaces of the High Plains show no systems of drainage, because presumably, from the commencement of the present erosive stage, they have been sod-covered as at present. In other words the High Plains have endured as alluvial plateaus since Tertiary times or at least since the opening of the Pleistocene. While degradation is at a standstill upon the plateau surfaces, the topographic belt which they constitute has, however, been appreciably narrowed within a corresponding climatic belt by marginal recession. The limiting bluff, especially that which faces eastward, is carried backward by sapping on the part of small streams or by the feeble beginnings of streams originating in springs and "seeps" at the bluff foot.

The High Plains cover eastern Colorado but do not extend to the mountains. Just eastward from the mountain front, the greater erosive energy of streams originating in the mountains has produced a dissected belt, the so-called Colorado Piedmont. Northward from Kansas is a zone of country exceedingly interesting topographically. It is in the main the drainage basin of the Platte. South of this river, with its fairly wide flood-plain, is a dissected plains country partially covered with loess deposits. In north central Nebraska and north of the Platte, is the Sand Hills Country, an area of billowy topography covering one-fourth of the state. The rounded hills, with moderate slope and irregularly placed, are interspersed with rounded or oblong depressions, some of which are lakes or ponds. The surface material of fine-grained sand is underlain by fairly impermeable clays and shales which help to retain the water that so quickly percolates through the porous sands. The surface of these sandy lands is stabilized fairly effectively by the sand-binding qualities of the roots of the vegetation (bunch grass); and when the latter is disturbed by fires, by overgrazing, or otherwise, wind erosion results in the formation of "blow-outs" and consequently of moving dunes.

The Western Section of the Continent.—From the Behring Sea at the north to the Panama Canal at the south, extends a series of mountain ranges, with lowlands and associated highlands and plateaus, which in general comprise the part of the continent lying between the Great Plains (Coastal Plain in Mexico and Central America) and the Pacific Ocean.

In general, this vast system is made up of a main (eastern) axis and ranges of lesser height and extent lying along the coast, between which are the wide plateaus, such as the Northern Interior Plateau of Canada; the Columbia Plateau, the Great Basin, and the Colorado Plateau in the United States; and the Mexican Plateau of northern Mexico.

The Rocky Mountain System.—This great series of mountain chains extends from Sante Fé, New Mexico, northward into Alaska. It is made up of parallel ridges and intervening depressions. It is a region representing a maximum of dissection, characterized by rough and typically mountainous topography, crossed in part by a few streams, and partially or wholly enclosing flattish to rolling valleys or lowlands such as the Wyoming Basin and numerous others of lesser importance. The enclosed and intermountain plateaus, already named, show in the main a more subdued skyline but, because of dissection, present such spectacles as the Grand Canyon of the Colorado, the Snake River Canyon in Idaho, and the Grand Coulee in Washington.

The Columbia Plateau is a basin partly filled by lava flows. Some portions present a flattish surface, but others, as is characteristically true of the Palouse country of eastern Washington, northwestern Idaho, and northeastern Oregon, are rolling to rugged in appearance.

The Great Basin, lying between the Sierra Nevada at the west and the Wasatch Mountains and the Colorado Plateau at the east, is characterized by a great number of north-south trending mountain ranges between which are depressions covered over with alluvial or wind-blown materials. The mountain system west of the intermountain plateaus presents varied characteristics. In general, it is made up of a series of coastal ranges between which lie flattish lowlands, such as the Puget Sound Valley, the Willamette Valley, and the Great Valley of California.

These elongated north-south depressions, hemmed in by mountain ranges on either side, have been filled with alluvial materials brought by streams from the adjacent mountains. These valleys present a rolling to flattish surface, except along the base of the surrounding mountain ranges where numerous and typical fan-like deposits of silts, sands, or coarser materials have been formed by streams descending from the elevated areas.

CHAPTER IV

SOILS

Introductory.—That the soils constitute the fundamental agricultural resource of any country has long been recognized. The conception, however, of soils as a natural body, continuously under change and differing in different areas both in characteristics and in soil-making processes, is not so well recognized, and its significance has hardly been touched.

Soils may be thought of as either naturally unproductive or productive. Certain non-productive soils may be so ameliorated by man—through drainage, irrigation, fertilization, or liming, or by certain other practices such as dry farming, or addition of organic matter—as to be made productive. Other non-productive soils, such as those of the polar regions and most of the dry desert lands, cannot economically be modified, hence they will remain practically unproductive.

Soils that are naturally productive vary not only in their degree of productivity for the same plant, but also in their relative productivity for different plants, and in their power of retaining productivity under cultivation. It is because of these fundamental differences in the soils of the world, in their relation to agriculture, that the following classification of soils is introduced. But in order to appreciate the significance of a classification of soils, it is necessary to get at the main facts of soil formation.

The Formation of Soils.—The principles of soil formation may be summarized as follows: The soils (not the geological parent materials) of any section of the earth's surface represent the results of the climatic forces acting through and with the native vegetation upon the parent geological materials involved. The result of this is the soil covering, which may include soils ranging from extreme youthfulness through maturity to old age, these representing stages in development. Glinka has stated, "All soil researches made in the field have taught us that the chief properties of soils arise in the actual process of their formation, for during this process, they receive an imprint that cannot be effaced by mineralogical, mechanical, or even chemical differences, in the parent rock."

The chief climatic factors involved in the processes of soil development are temperature, moisture, and evaporation, which, strikingly enough, are the main factors affecting not only the type and growth of native vegetation but also the growth and development of cultivated or other economic plants as well.

These factors permit the action of, or set in action, forces which, operating with the native vegetation, result in the formation of the great climatic soil groups. The characteristics and properties which determine any one soil group and differentiate it from others are characteristics and properties of the soils themselves. These qualities and properties are not determined by the underlying geological materials or by any other single phenomenon. There is, however, a marked relationship between climatic regions, vegetation formations, and the larger soil groups.

In order to illustrate the principles involved in the formation of soils in a local area, the following cases are cited.

PLANT SUCCESSION FROM THE BARE ROCK SURFACE TO THE CLIMAX VEGETATION

Islands in Lake Superior.—In the western portion of Lake Superior are granitic islands recently upraised above the lake level. Careful studies of the development of native vegetation on these islands have shown in the following stages:

First, in the initial stage, the rocks are bare, and rock fragments resulting from mechanical weathering are mainly removed by erosion. The bare rock surface is subject to great extremes of temperature and moisture conditions, especially during the growing season. The rock surfaces exposed to the sun become highly warmed during the day and cool rapidly at night, such conditions being conducive to mechanical weathering. Such rocks are wet only when rain is falling or during cloudy weather.

Second, certain lowly organized plants, called pioneers, make their appearance in time. Clinging to, or even burrowing into, the rocks are the crustose lichen associations, which prepare the way for the next stage and for their own destruction (through shading by the next lichen stage). The foliose lichen in turn paves the way for the next higher forms of plants, which may be the fructicose lichen association (such as the reindeer lichen), and incidentally prepare for their own destruction. By the time this latter stage is reached, a marked change in the habitat of these plants has occurred. The presence of the plant covering, by reducing erosion and by the decay of plant materials, has resulted in the accumulation of a mantle of loose materials. This accumulation acts as a sponge to retain the rain water, thus resulting in a greater uniformity of moisture conditions. With the formation of a covering on the bare rock, and thus with the more uniform moisture supply, the daily variations of temperature are very much reduced.

Third, the more uniform climatic conditions of the habitat thus provided make it possible for higher plants to become established. In fact, the deeper accumulations develop first in the crevices, and here shrubs early may be found. Owing to the moist conditions prevailing, with the deeper accumulation of loose mantle material, trees and shrubs may establish themselves, wherever these accumulations may form. The vegetative cover with its interlacing roots reduces erosion, thus stabilizing the topography. Also it aids in a deeper accumulation of the loose mantle materials, because it helps to retain substances brought in by the agencies of wind or water.

This progressive succession of plant life from the lower forms to the forest tree association (the climax in this climate), together with the progressive development from very changeable conditions (but mainly dry) towards uniformity of available moisture for plant growth, is termed a xerarch succession. It is thus a succession from conditions of a habitat suitable to xerophytes only to one suitable for mesophytes; the significance of available moisture to plant succession is obvious in this connection.

PLANT SUCCESSION FROM POND TO CLIMAX VEGETATION COVER

Another type of plant succession, very marked in the undrained low areas, particularly in the recently glaciated portion of humid North America (or of Europe), is the hydrach succession, that is, from a hydrophytic habitat to one of mesophytic conditions.

On the borders of many lakes may be observed various zones of vegetation. Farthest out may be seen submerged plants, then zones of partially submerged plants, and on the shores, plants such as rushes or cat-tails growing under very moist conditions. Then, owing to the processes of lake filling (by sediments which are carried in by erosion agencies, and with which organic matter may later be incorporated), basins in various stages of extinction are numerous. As they are filled in, there is a progressive change in the vegetation from hydrophytic to more and more mesophytic; and in time the cover is an association in the climax vegetation formation of that region.

The principles of habitat changes, and the progression in the plant cover which goes hand in hand with these changes, whether from hydrophytic to mesophytic or from xerophytic to mesophytic, hold in general throughout all the lands of the middle latitudes except the drier sections of the deserts. The type of climax vegetation that is possible is in every case determined by the climatic conditions involved. Owing to various factors, however, such as variations in topography, differences in the parent geological materials, or in the possibilities for plants to migrate into the area, these progressive changes in different areas take place at very different rates.

The progressive changes outlined occur only if disturbances by outside agencies are prevented. When, for example, the native vegetation is disturbed by fires, by cutting, by overgrazing, or otherwise, there is a possibility, especially on the more sloping lands, for retrogression, through the action of erosion. In this process the mantle materials may be carried away, resulting not only in gullying but also in carrying the habitat conditions back to the initial stages.

Processes of Soil Development.—The conditions just outlined, the weathering of rocks by physical and chemical means, the mixing of organic matter with these materials, and the tendency toward physiographic stabilization through the development of a plant covering, are processes having to do primarily with the formation of a covering of the loose mantle materials, but not necessarily with soil formation. In reality, they but pave the way for soil formation as that process is now understood by soil scientists.

When relative stabilization has taken place, then soil-making forces, as such, can produce results. These forces, essentially climatic, acting with the native vegetation upon the more or less weathered geological parent materials, result in the formation of distinct layers in the soil. These layers, or horizons, are distinguished from each other because of the characteristics of the materials that make them up. The important features of the materials of each horizon are: (*a*) the color and the amount of organic matter present, (*b*) the texture (size of the particles), (*c*) the structure (arrangement of the particles, granular or non-granular), (*d*) other physical properties including water relations, (*e*) the chemical composition.

The special activities of soil-making processes in the loose mantle accumulation are: (*a*) incorporation of organic matter by physical or chemical means in the horizons, or the accumulation of plant residues on the surface, (*b*) the carrying down, from the top layers, of materials, in solution or by mechanical means, (*c*) the deposition or precipitation of some or all of these materials in some of the lower layers (in humid lands soluble compounds are continuously being carried away by the drainage waters), (*d*) the carrying up, from the lower layers, by the movements of soil water, of materials in solution and the possible precipitation of these in the upper layers of the soil.

That these soil-making forces and the rate at which they act will vary considerably with the climatic conditions of the atmosphere is obvious; that the final result is limited by the climatic conditions of the region has been demonstrated; and further, it has been demonstrated that topographic conditions are much more significant as a whole than are the parent geological materials (except in the youthful stage of development) in determining the characteristics of the layers of soil.

The Soil Horizons.—Soils, when looked upon as natural bodies representing stages in a series of developments, are produced by climatic forces acting with the native vegetation, the rate of development being modified by the different climatic and weather conditions, by variations in topography, and by inequalities in the parent materials. Thus, soils may be classified as young, mature, and old, these divisions representing the various stages in development. A recent deposit of alluvium on a flood-plain, if regarded as soil at all (in the modern sense), is in an infantile stage of development. On areas where intense erosion is continuous, mature soils cannot develop. Where the topography has been stabilized (by vegetation or through the results of geological processes) for a sufficient time, a mature soil will be formed; a mature soil is made up of two distinct horizons and rests upon the geological parent material, the latter designated in soil literature as the *C* horizon.

In general, for a mature soil, the upper, or *A*, horizon consists of a zone or layer in which organic matter accumulates, where weathering is most active, and from which materials (such as the finer particles) are carried downward, in solution or by physical means, by the percolation of soil water. A large share of these finer soil particles and some or all of the materials in solution are added to the lower soil horizon, thus increasing the clay content of the *B* horizon (the layer underneath the *A* horizon). A typical case illustrating these different horizons may be taken from any climatic region in the country. A section through a virgin soil, mature in development and covered with forest (hardwoods), in eastern Pennsylvania is typically as follows: There is a layer of leaf mold some 2 to 4 inches deep on the surface. The *A* horizon proper consists of a dark brown layer 4 to 6 inches in thickness. This horizon is typically a loam, made up of sands and finer mineral materials with which is incorporated organic matter. The *B* horizon, characterized by a yellowish brown to a reddish color, contains much more clay and consequently has a much finer texture than the *A* horizon. The *B* horizon grades into the less well-oxidized *C* horizon, mainly an accumulated mass of geological materials.

A typical section in the southeastern part of the United States shows a much thinner layer of organic matter on the surface, an *A* horizon much thicker, with much less organic matter, often almost entirely composed of sands. The *B* horizon, with much less sand and a higher percentage of clay, is a layer of reddish materials (on slopes), and of yellowish ones on flatter areas.

On flat areas where there is not the continual action of surface erosion, an old soil may develop. In such cases, the continuous addition of clayey materials to the *B* horizon results in the formation of a tough, tenacious layer which interferes with circulation of soil water. This impervious layer is known as "hardpan." That these various soil horizons, differing locally in their physical and chemical characteristics throughout the same soil group, and varying widely in different regions, should be of vast significance to the development and the feeding processes of plant roots is obvious. It is only necessary here to summarize by saying that the physical potentialities of lands for the production of economic plants are determined very largely, as well as best indicated, by the properties and characteristics of the different soil horizons of the area or region.

CLIMATIC SOIL GROUPS

The soils of the world can be grouped into two large divisions: first, those in which the carbonate content (chiefly $CaCO_3$) is being constantly increased, in either the *A* or *B* horizons or both, that is, the unleached soils; and second, those in which the carbonate content is being decreased. The latter constitute the leached soils of the world.

Soils with a Constantly Increasing Content of Carbonates.—Where these soils are found, the rainfall is usually less than the possible evaporation, and the soil moisture is removed by evaporation and by transpiration, so as to result in an agriculturally dry soil during the dry season of the summer. In these areas, the water table is deep below the surface of the ground; and between the geological ground water and the alternately wet and dry soil, there is a zone of variable width which is permanently dry. This, in addition to the alternate moistening and drying out of the soil, precludes the growth of trees in such lands. These are the climatic grasslands and the dry deserts.

The Climatic Grassland Soils in the Middle Latitudes.—These soils, although not so extensive as the forest soils of the world, are of vast significance. They may be subdivided on the basis of color, which is closely associated with their content of organic matter, into Black soils (Black Earth), Chestnut Brown soils, and Brown soils.

In general, the zones with a greater soil-moisture content were originally covered with tall grasses. This resulted in the addition of a higher content of organic matter to the soils; hence their dark color. In this group are included the Black Earth lands. On the other hand, those with a lesser amount of soil moisture, with a native vegetation of mixed tall and short grasses, and with less organic matter, comprise the Chestnut Brown soils. The drier lands with short grasses are the light brown grassland soils. All these soils are characterized by a high content of carbonates, particularly calcium carbonate. The latter appears as a distinct layer (sometimes indurated to limestone) in these soils.

GENERAL CHARACTERISTICS OF GRASSLAND SOILS

Texture.—In general, the texture is fine, and in many cases the parent geological materials are partly composed of wind-blown matter (loess).

Structure.—The soils of grasslands, especially in the tall-grass regions, are characterized by a granular structure, which appears to be associated genetically with the high content of calcium carbonate and of organic matter.

Workability.—The workability of these darker-colored grassland soils is high. In general, they are well drained, while in addition the humus content and the structure make for conditions of good tilth.

Differentiation of Climatic Grassland Soils.—The zones of these soils may be differentiated mainly on the basis of color, as has been stated. However, other characteristics, usually closely related to color, are very important in this regard. Among these are included the water content of the soils, the content of lime and other mineral compounds, as well as the depth of the layer of lime accumulation. In general, for the climatic grasslands, the greater the amount of available soil water, the taller the grasses, the greater the content of organic matter incorporated into the soil, and the deeper the zone of accumulation of the calcium carbonate; the latter, as a rule, marks the lower limits of root penetration. Considered as a whole, the less the rainfall, the greater is the accumulation of soluble mineral compounds in the soil horizons. A marked accumulation of these compounds may result in alkaline soils.

Productive Capacity.—The high productive power of these soils is definitely correlated with the amount of available soil moisture present during the growing season. This in turn is associated with the amount of rain water entering the soils, and its retention and availability in the soil. These conditions are closely related to the humus content, texture, and structure, and the amount of water transpired by plants or lost through evaporation. Associated with the high initial capacity of the darker grassland soils for production, is their power of retaining this property through a long period of cultivation.

General Location of these Soils in the Middle Latitudes.—The climatic grasslands, that is to say, the lands without under-drainage and, in general, with a rainfall less than the possible evaporation, are located in the interiors of the continents. They occupy a country whose topography as a rule is flattish to gently rolling. The rainfall comes, in most cases, during the summer, and generally during the earlier part of the growing season. The location of many of these areas to the leeward of drier regions no doubt accounts for the loess materials scattered over many sections of these lands.

General Significance of the Darker Soils of this Division.—Until recently, up to the seventies and eighties in the United States and Russia, and later in Argentina and Australia, these lands were used for grazing purposes only. They have been brought into use as an integral part of the Agricultural Revolution, which must be recognized as the agricultural counterpart of the Industrial Revolution.

A greatly increased city and factory population created a demand for agricultural products. The development of transportation facilities made it possible to bring the continental interiors into connection with the world markets. The use of large-scale labor-saving machinery on these wide areas of flattish lands, with granular dark-colored soils of high productive capacity, made it possible for these regions to become great surplus-producing regions for certain agricultural products, particularly wheat. This type of use of land was and is greatly facilitated by the general homogeneity of all physical factors in these areas, a quality which is in marked contrast to the heterogeneity of physical conditions in areas with broken topography.

Special Problems Connected with These Soils.—These soils, as has been stated, not only have a high initial productivity in the more moist sections, but they retain this condition well through extended cultivation. These conditions represent an adjustment of soil formation to the physical environment involved, and make the problem of application of mineral fertilizers a minor one. In order to maintain the optimum physical conditions, it will probably be necessary to work out an efficient means of adding organic matter to these soils. Owing to the continual accumulation of certain mineral compounds, certain disadvantages result, such as tough subsoils in some of the semi-arid sections, and alkalinity, especially in the drier portions where poor drainage conditions exist.

SOILS OF THE DRY DESERTS

In the semi-arid sections of the western United States, where the native vegetation consists of sparse stands made up of woody shrubs and grasses stunted by adverse climatic conditions, the soils are very light in color. In these regions, however, true profiles have been formed, except where prevented by erosion of the surface materials. These soils are of little use for crop production, except where irrigated. When irrigated, as is to be expected, these lands are exceedingly productive. Their productivity, however, may be entirely destroyed by the accumulation of alkali if the drainage is not capable of removing the excess soluble compounds which otherwise tend to accumulate in the soil.

SOILS IN WHICH THE CARBONATE CONTENT IS CONSTANTLY DECREASING

This great group of soils comprises areas with a humid climate, and in which the excess soil water drains through the sub-surface and thus carries away in solution various soluble compounds; in other words, these are soils that are subjected to continous leaching, and in which there is a constant accumulation of the less soluble materials. Owing to the permanent supply of available moisture, especially at sub-surface depths, forest growth is possible over most of the lands involved; in fact, as a whole this group includes the forested lands of the world.

Light-colored Forest Soils.—These are the soils formed on fairly well-drained uplands (as distinguished from river bottoms and other low, poorly drained areas), and were originally covered with forests. Because of their color, these soils have long been known as the light-colored forest soils, and, as can be seen from the forested area of the world (Fig. 14), they cover a very large percentage of the land area of the globe.

Color.—The light color is associated with the low content of organic matter incorporated into the soil body. It is common for a rather deep accumulation of leaves and decaying organic matter—the so-called forest sponge—to form on the "forest-floor" in timbered lands, but this material soon oxidizes or is eroded when the forest is removed. In addition to this, the deep rooting system of trees extends the organic matter derived from root decay even into the *C* horizon. Also the lack of lime in both the *A* and *B* horizons removes a condition which, if present, would help to incorporate organic matter into the soil body (the amount varying with the temperature and moisture conditions involved) and bring about a deeper accumulation of organic materials on the forest floor, especially in the cool, moist areas such as is characteristic for example in eastern Canada. These conditions are in marked contrast to those obtaining in the wetter portions of the grassland soils.

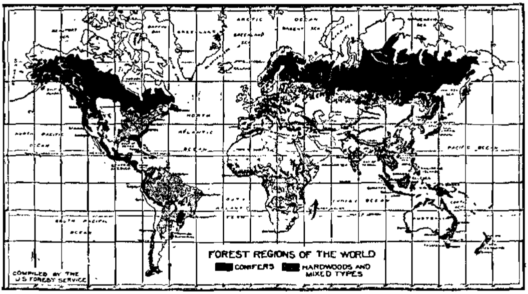


FIG. 14.—Map from "Forest Resources of the World," by Zon Sparhawk, McGraw-Hill Book Co., 1923.[1]

Structure.—The structure of soils refers to the size of aggregates of the soil particles. The structure may be (*a*) granular, as in the *A* horizon of the Black Earth; (*b*) nut-like, as in certain forest soils rather fine in texture (this structure is generally lost when the soils are brought under cultivation); or (*c*) single-grained, a structure which is common in forest soils of coarser texture, and usually in forest soils of finer texture if they have been cultivated for a considerable period.

The structure of soils is associated with the relationships concerned in their formation. The humus content of the light-colored forest soils is low, the soluble compounds, especially lime, are continually being leached away; and, in addition, there is in mature soils a remarkable concentration of clay materials in the *B* horizon (which is greatly accen-

[1] Reprinted by permission from Forest Resources of the World, by Zon and Sparhawk. Published by McGraw-Hill Book Company.

tuated in old soils). In general, the structure tends more and more toward the single-grained type with progressive cultivation.

Workability.—In general, the finer-textured forest soils are more or less intractable. This characteristic is accentuated with cultivation, unless extraordinary means are taken to improve the physical fitness of the soil. In many cases, removal of the forest and subsequent cultivation, associated with the broken topography and heavy rainfall, have resulted in the erosion of the surface horizons, thus leaving bare the *B* horizon characterized by its greater clay content. Examples of this effect are to be seen especially in the exposures of red clays throughout the southeastern United States. In many sections where the parent geological materials contained a rather high amount of sand, the resulting sandiness of the *A* horizon produces friable conditions. These features obviously are significant in the use of such lands. In general the "upland" soils of the southeastern United States are remarkably sandy. Not only is this condition associated with a rather high amount of sand in the original geological materials, but there is also an accumulation of sand as a natural result of soil-forming processes. In these processes soluble compounds and finer materials are removed from the surface horizons, leaving the sands. A great part of the soluble compounds has been carried away in the drainage waters, and the finer materials have accumulated in the *B* horizon, thus forming the so-called clayey "subsoils" so common in the southeastern United States.

Classes of Forest Soils.—The different grades of color of the forest soils serve as indicators of the kind and degree of leaching, of the incorporation of organic materials into the soils, and, in general, of the results of weathering, all of which are related, directly or indirectly, to the climatic features of the regions involved. There are three main classes of forest soils.

The Gray Forest Soils.—The gray forest soils are those of cool, moist regions, especially those of the northern evergreen forests. The better-drained areas are covered with a rather thick accumulation of partially decayed materials derived from coniferous vegetation. Immediately beneath this dark-colored peat-like organic material is a layer of varying thickness composed of fine grayish materials with a floury feel and containing no organic matter. The *B* horizon immediately beneath usually has a brown color, with some organic matter, and has a fairly large clay content. At the base, the *B* horizon grades into the mottled or bluish, poorly oxidized geological materials, the *C* horizon. The gray forest soils are not important in agricultural production. The long winters and deep snows, combined with the cool, moist, and short growing season, have not only produced this group of soils, but serve also as limiting factors for cereal production on a large scale. It must be remembered, moreover, that large areas in the regions possessing these soils are characterized by surfaces of bare rock, and that others are poorly drained lowlands (for example, muskegs). In the better areas, especially where there is a rather high lime content in the parent materials, various forage crops and some vegetables make remarkably rapid growth during the short and rather cool growing season. This soil group not only prevails throughout the northern coniferous belt of North America, but is found also in the corresponding coniferous forest belt of northern Eurasia.

The Brown Forest Soils.—These occupy the humid sections of the middle latitudes with a moderately long growing season and with winters cold enough to freeze the ground, thus checking the processes of weathering, leaching, and erosion during that period. These are the regions, in west central Europe and in the east central United States (in which sections this soil has been best studied), formerly occupied by deciduous hardwood forests. A maturely developed soil in a typical hardwood forest is characterized by a darker-colored, coarser-grained, fairly friable *A* horizon, ranging from 5 to 8 inches in thickness. This is covered over by a forest mulch of leaves and decaying organic matter, the lower portion of which grades into the top of the *A* horizon. Below the coarser-grained *A* horizon is the brownish-colored, finer-textured, heavier *B* horizon, which has a thickness of 8 to 10 inches, and which throughout the whole region is distinguished by its high clay content. Below this is the *C* horizon, in most cases made up of the slightly oxidized disintegrated parent rock materials.

The brown forest soils comprise the best of the upland forest soils of the world. They are as a rule less leached, and contain much more organic matter, than the soils of humid areas nearer the equator where the temperatures during winter are higher or the winter is entirely lacking. In western Europe these soils have been of immense importance from the Middle Ages down to the present. In the east central United States these soils, derived from parent materials somewhat coarser and lighter in texture than in corresponding sections of Europe, have been nevertheless of vast significance in our agriculture. In eastern China this same group of soils is found. In the plains of that country they have been derived from alluvial materials, however, and have supported, with careful utilization, a dense population for thousands of years. A large proportion of the lands of the world in which this soil group is found has a rolling to hilly topography, a condition which accentuates erosion once the native vegetation is disturbed.

The Yellow Forest Soils.—This group of soils contains less organic matter and is more intensively leached than either of the preceding. The climate of the lands occupied by these soils is distinguished by its long and warm growing season and its short, mild winter, or (as in the tropics) by the total absence of a cool season. These conditions, combined with the generally heavy rainfall, cause chemical weathering to be intensive, and consequently leaching goes on at its maximum rate. These soils, especially the "upland" soils of the southeastern United States, are marked by their low content of organic matter and by the coarse-textured sandy nature of the *A* horizon. The *B* horizon contains a large amount of clay, but this material, even on the flattish areas (except in a few cases), has not developed into an intractable hardpan. This horizon with its yellowish color is associated with the type of oxidation of the contained iron compounds. On sloping areas, however, where soil drainage is better developed, aëration is more perfect and a reddish horizon prevails. The large amount of sand mainly comprising the *A* horizon in the southeastern United States seems to be associated directly with the high sand content of the parent materials from which the finer material and the soluble compounds have been removed, leaving the sand accumulation. By way of comparison, the following interpretation of related soils of the Amazon Basin is quoted from Dr. Marbut:

With the exception of the very small portions on steep hillsides the upland soils of the central Amazon Basin are well developed and, when well drained, light in color. They contain a low percentage of organic matter and therefore of nitrogen. In this respect they are comparable to the uncultivated soils in forest-covered lands throughout the warm temperate and tropical regions of the world. The percentage of organic matter in the soils is somewhat higher than in southeastern United States, for example; but this seems to be due principally to their heavier texture and in part to the greater activity of insects, especially ants in the Amazon region, by mixing the surface organic matter with the upper layers of the soil, for chemical analyses of the forested soils of the Amazon uplands show a content of organic matter in the upper 8 inches no higher than 3 per cent, while a grass land loam in the United States will average perhaps twice that amount. The timber-land soils throughout the world are known to lose organic matter at a rapid rate when placed under cultivation unless special effort is made to maintain it by constant additions. It is believed those of the Amazon Basin will not, when cultivated, be an exception to this rule.

Besides the low percentage of organic matter in the soil, the layer of vegetable debris on the surface is thin when compared with the luxuriance of the forest growth. This consists of a layer of loose leaves, with some twigs, of a very few inches in thickness, and usually much less of partially decomposed and finely divided organic matter still retaining its brown color. Enough organic matter is supplied to the surface of the land by the forest cover to fill the soil if nature provided any means of incorporating it therein. This she fails to do except to a very slight extent by action of insects and worms. The work of these, though large in the aggregate, is wholly inadequate to incorporate and maintain a supply of organic matter as compared with that supplied by the growtb of grass.

Color of the Upland Soils.—The different horizons of the virgin soil of the uplands show the following colors: (*a*) surface soil, brown; (*b*) soil next below surface, generally yellow, but sometimes this layer is very thin; (*c*) below yellow horizon, a layer of deep red to yellowish red—replaces (*b*) when latter is absent; (*d*) mottled clay below red horizon; the soil is clay or sandy clay, gray-blue or white in color, with spots of brown or reddish iron oxide.

(*a*) *Brown horizon.*—The surface virgin soil, usually varying from 6 to 8 inches in thickness, has a darkish brown color, due to the organic matter it contains.

(*b*) *Yellow horizon.*—Varies in depth from a mere film to one of great thickness. If the soil contains a high percentage of sand, rapid weathering is greatly favored and the layer is thick. If, on the other hand, there is present a high percentage of clay, the layer may be thin or absent.

(*c*) *Red horizon.*—Lies beneath the yellow horizon. Generally the material of this red horizon is heavier than that of the surface. When the yellow horizon is very thin, the red layer may reach a maximum thickness of 10 feet.

(*d*) *Mottled clay horizon.*—Usually several feet in thickness, often more than 25, and sometimes extending to the water table in river bluffs that exceed 50 feet in height. It is a clay or sandy clay, gray-blue or white in color, with spots of brown or reddish-brown iron oxide, hence the name. The iron oxide is probably due to segregation and oxidation of the iron that was formerly present in the unchanged parent rock in some other form than oxide. At the top of this clay horizon, mottled red material predominates.

Structure and Consistency.—The term " structure " refers mainly to the size of the aggregate of soil particles, resulting in a coarse-grained or fine-grained crumb structure or the absence of it. In a region with high rainfall, such as the central Amazon Basin, there is either an absence of any aggregation of soil particles, known as single-grain structure, or an aggregation into large granules or " crumbs," known as nut structure. In size they are as large as hazelnuts or peas, but are always irregular in shape and of uneven surface. Nut structure occurs only in soils made up of relatively fine-grained material; it is not a characteristic of very sandy soils.

In the Amazon region single-grain structure does not seem to be of common occurrence. This is in part due to the fact that the soils are practically all virgin or uncultivated, and such soils the world over are rarely characterized by single-grain structure. It is well known, however, that all soils developed under the influences of a heavy rainfall and an arboreal vegetation tend to take on this structure soon after their cultivation has been begun unless the farmer keeps his soil well supplied with organic matter. It is the presence of a granular structure of some kind and the absence of a single-grain structure that gives a soil what it generally known as good tilth.

Closely associated with structure in soils and often confused with it is a condition designated "consistency," which may be described as the "feel" of the soil, that is, whether it is friable, tough, plastic, loose, or compact. The soils of the central Amazon Basin are predominantly friable and moderately loose down to the mottled-clay horizon. The thickness of this friable layer ranges from a few inches to 6 or 8 feet, being in the mature soil usually about 5 to 6 feet. No soils were found which were difficult for the soil auger to penetrate; neither was there occurrence of a well-defined hardpan nor large areas of soils with plastic, tough, or hard clays.

Thickness and Texture.—The *loam soil in the uplands attains a* maximum thickness of about 10 feet and an average of 7 to 8 feet. This figure refers to the combined thickness of the brown, yellow, and red horizons as they have been described above, and does not include any part of the horizon with segregated iron. It is the zone of complete oxidation and aëration. This weathered zone (not merely the affected zone) in the central Amazon Basin is thicker than that of soils in the warm temperate portions of the United Ststes.

The prevailing texture is a loam, with silt loam and very fine sandy loam as important occurrences. Sands were encountered in very few places. The region differs widely in this respect from that of the southeastern Cotton Belt of the United States, where a surface soil of sand is present over large areas and the predominant texture is not heavier than a light sandy loam.[2]

GRASSLAND SOILS WITH A HUMID CONTINENTAL CLIMATE

In this soil group are included the dark-colored grassland soils of the Prairies, in interior North America, and the eastern portion of the Pampas of east central South America. The reasons why the Prairies were covered with grasses need not concern us here, but instead the emphasis will be placed upon the physical conditions of these lands in so far as such conditions are significant to crop production.

The region as a whole is flattish, and in the east with its higher precipitation, the flat interstream areas were originally poorly drained, often forming, during the spring of the year, large shallow ponds, which later in the summer were covered with a dense growth of tall slough grasses. In the western portions of the Prairies, as has been stated, the summers are hotter, dry spells are longer and more frequent, and the precipitation less. Obviously, this is a transition zone between the humid country and the periodically moist and dry interior, the latter

[2] Trade promotion series No. 23—Department of Commerce, pp. 57–59.

being climatic grasslands. The flattish uplands were covered with tall grasses, and as a rule the soils are dark in color, thus indicating a high content of organic matter. Owing to the heavier rainfall, the sub-surface is always moist although, especially towards the west, the surface may dry out during the summer. The condition of the permanently moist sub-surface means that leaching through the circulation of soil water proceeds almost continuously, even though slowly. In mature development, the *A* horizon consists typically of 10 to 15 inches of dark-colored fine-textured materials interwoven with the roots of the tall grasses. The dark color becomes lighter as depth increases, until it grades into the brown *B* horizon, with a texture that is finer than that of the horizon lying above. The brown horizon may extend to a depth of 3 to 4 feet where it merges into the slightly oxidized materials of the *C* horizon. Through the Prairie region, the broken lands along the streams were originally covered with timber. In these narrow belts has developed a typical brown forest soil, especially marked along the Mississippi, the Missouri and the Illinois Rivers, where these streams pass through the Prairie country. Over a large portion of the eastern Pampas, a somewhat similar soil group occurs. These areas are poorly drained, lake-dotted, and originally covered with tall grasses.

GENERAL RELATIONS OF LIGHT-COLORED FOREST SOILS TO AGRICULTURAL PRODUCTION

The large areas of the globe covered by these soils makes them of tremendous importance to agriculture. Because they are continuously being leached and also because much of the organic matter is accumulated on their surface, they are inherently much less productive than the dark-colored soils of the tall-grass lands. Being leached of carbonates, they tend to be acid or sour. The deficiency of lime in these soils, together with the low amount of their organic matter, results in a structure naturally less desirable for cultivation. Erosion often is very intense; consequently, over large areas much of the *A* horizon with its better structure and greater content of organic matter has been carried away. Owing to these conditions, the structure of uncultivated soils of this class is as a rule much less desirable than that of the dark-colored soils of the world. Moreover, what is perhaps more important, the structure becomes progressively undesirable with continued cultivation unless special means are employed to maintain or build up the physical condition. Another aspect to be considered is the numerous local variations in these soils, associated not only with the broken topography as such, but also with the great variation in the kinds of geological materials thus provided as soil materials.

All of these conditions pertaining to the physical and chemical characteristics of the light-colored forest soils of the world require the development of very carefully-worked-out systems of soil utilization, including the amelioration of the undesirable characteristics of these soils. Another aspect of the utilization of these classes of soils consists in the substitution of crop plants, usually with rather shallow root systems and fairly small feeding areas, in contrast to the deep-rooted trees, with extensive feeding areas, typical of the native vegetation.

In the use of these soils in western Europe and eastern China, where such soils have been longest under intense cultivation, different means of utilization have been worked out. In China, manures and plant residues are used very intensively to maintain production; but it must be remembered also that a large share of the agricultural lands of China, particularly the Plains of North China and the lowlands of the Yang-tse Basin, consist mainly of alluvium, that of the Plains of North China being derived from loessial materials. In west central Europe, the present high productivity is maintained by a careful system of soil utilization, including the use of manures, plant residues, lime, and mineral fertilizers, together with a carefully-worked-out system of crop rotation. In the eastern United States where the soils are, perhaps, somewhat lighter in texture than in west central Europe, and have not been cultivated as long as the latter, a less well-developed system of soil utilization has been worked out.

The Fertilizer Problem.—The Greeks and Romans were familiar with the use of leguminous crops and manures in soil improvement, a practice probably borrowed from interior Asia. The use of mineral fertilizers awaited the rise of agricultural chemistry, which received its first great impetus about the middle of the nineteenth century, the groundwork having been laid by the investigations of De Saussere, Boussingault, and Liebig. Later still, the work accomplished by these investigators was further extended, particularly at the Rothmansted Experiment Station in England under the direction of Lawes and Gilbert. The effectiveness of mineral fertilizers, in increasing the productivity of these leached and light-colored forest soils with less desirable physical conditions, was proved, no matter whether the benefits derived from their application are due to the addition of certain plant food materials—such as nitrogen, phosphorus, or potash—to the soil, or to the bringing about of certain desirable physical changes whereby the growth conditions of the plant are accentuated, or to a combination of these conditions.

By the first quarter of the nineteenth century the Industrial Revolution was making greater demands upon the soil for increased crop production, a condition which has increased progressively up to the present time. The only lands then directly available were these forest soils, and their productivity was, to say the least, difficult to maintain. Just then came another great impetus in the form of increased knowledge of how plants feed and grow; another significant development was the discovery and opening up of geological deposits rich in these mineral fertilizers.

Nitrates.—The only known geological deposit of nitrates of any size occurs in the desert section of northern Chile. In 1830 nearly a thousand tons of nitrates were exported from Chile; and in the years immediately preceding the World War this export had reached nearly 3 million tons annually. Nitrate compounds may also be added to the soil by certain plants, particularly legumes; and recent developments in applied chemistry have resulted in fairly efficient methods of nitrogen-fixation, through combining atmospheric nitrogen into certain chemical compounds.

Phosphates.—Before the discovery of geological deposits containing phosphates, the bones of animals constituted the main source of supply. Geological deposits were first opened in South Carolina and later in Florida, Tennessee, and Arkansas. The reserves, however, in the southeastern United States, are small. Large reserves (proportionately very much larger than the nitrate reserves of Chile, that is, in regard to reserves in relation to rate of use), but of somewhat lower grade than those in the southeast, occur in Wyoming, Montana, Idaho, and Utah. Other reserves occur in North Africa, in Tunis and Algeria, as well as in Egypt, in Russia, in Belgium and northern France, and in some of the islands in the Indian and the South Pacific Oceans.

Potash.—About 1845 the potash deposits of the Stassfurt district in Germany were opened. Protected as a government monopoly and advertised widely, the export of potash became very important to Germany. Later, large deposits were discovered in Alsace, which are now under French control. There are other sources of potash, but the reserves of Germany and France seem sufficient for a long time hence.

Use of Fertilizers in the United States.—The large expenditure for mineral fertilizers and the areas where most are applied are indicated in Fig. 15. Almost all the expenditure for fertilizers in 1919 occurred in the Coastal Plain and Piedmont sections in the eastern United States, and about half the total in the Coastal Plain and Piedmont areas of Virginia, the Carolinas, and Georgia. These are the lands with light-colored forest soils, with a coarse or sandy texture, in a region of heavy rainfall and almost continuous leaching due to the very short and mild winters. The use of fertilizers for various crops is indicated markedly in the cotton areas on maturely developed soils in the middle Coastal Plain of the Carolinas and Georgia, and of the southern Piedmont in Georgia and South Carolina. Other areas of extensive use of fertilizers include lands of the Coastal Plain in the Carolinas;

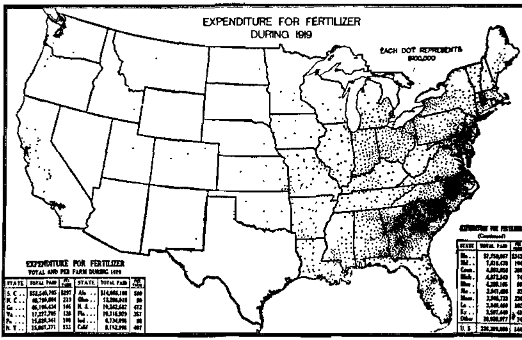


FIG. 15.—Fertilizer is used at present principally on the more intensively cultivated crops, particularly cotton, tobacco, fruit, and truck, including potatoes; and almost wholly as yet in the Eastern States, where the rainfall is heavier and the soils more leached. About half of the expenditure in 1919 was in the Coastal Plain and Piedmont portions of Georgia, the Carolinas, and Virginia. Minor areas are the trucking districts of New Jersey and Long Island, the tobacco-onion district of the Connecticut Valley, the Aroostook potato district in Maine, and the fruit-trucking district in southern California. Especially significant and prophetic is the considerable expenditure shown in Ohio and Indiana and even in Illinois and Iowa.

Agriculture Yearbook, 1921, p. 496.

the sandy soils of trucking and gardening sections about Chesapeake Bay, Long Island, the lowland belt of central New Jersey; and certain areas with specialized crops, such as the tobacco lands in the middle Connecticut Lowland and the potato-producing district in Aroostook County, Maine, both of which are areas of sandy soils.

Soil Erosion.—The mineral fertilizer problem is confined almost entirely to the light-colored forest soils of the world. While better systems of soil utilization, especially those which will maintain or build up the physical conditions, are desirable for the dark-colored grassland soils of the world, the use of mineral fertilizers on these soils is not a profitable practice under their present conditions of productiveness and the present pressure of economic demand. The problem of soil erosion is not confined, however, to the light-colored forest soils with their characteristically broken topography and heavy rainfall, but is very significant also in the semi-arid and arid portions of the world, especially where the native vegetation has been destroyed by over-grazing, by cultivation, or by fire. The southeastern United States, with its rolling topography, deep and light-textured soils, heavy rainfall, and often less careful soil utilization, is a section wherein erosional activity has been especially disastrous, rendering large areas of land impossible of cultivation for years to come. Another portion of the United States where results have been relatively as disastrous are the range lands of the mountainous country, in the West. Here the disturbance of the grass cover, by over-grazing combined with steep slopes and heavy rains occurring sporadically, has resulted in a retrogression such that years would be required, under the best system of range management, to bring the land back to its former undisturbed condition. The cutting of forests in the western mountains has often extended the area of this eroded section. In the arid regions, wind action has always been a very important erosion agent.

While the special devices for controlling or reducing erosion vary with the region as well as with the type of land utilization involved, the general principle is that, when once the processes have been brought under control, a vegetative covering must be secured. This covering may consist of forests or grasses, and must be as nearly closed as possible. Many of these lands, especially those with very broken surface features and heavy rainfall, can best be utilized, under present economic conditions, for forest production with some grazing. Others can be utilized very profitably for forage crops and pastures, which, if the market conditions are suitable, may become the basis for the dairy industry, this industry being one of the most desirable for these types of soils. The better lands, especially the less hilly and rolling, with heavier-textured soils, covering as they do such a large portion of the continents, with more careful management and the more efficient use of fertilizers, manures, plant residues, and soil amendments, will continue to be significant producers of food crops, of forage resources, of livestock, of fibers, and of fruits and vegetables.

SOIL AREAS WITHIN A CLIMATIC SOIL GROUP

The soil group, like the climatic region and the native vegetation formation, extends, as a rule, over a fairly large area of country, typical cases being the grasslands of the Great Plains of North America and the steppes of Russia. These have a periodically moist and dry interior continental climate, without marked local variations, chiefly because of the general flatness of the topography. The belts of these two regions having the higher effective rainfall produce tall grasses and have dark soils. These are the "Black Earth" districts, whereas with less moisture in the soils the vegetation consists of short grasses and the soils are lighter in color. Over these areas, soils and native vegetation, like the climate and topography, are fairly uniform. However, with variations in the combinations of rainfall and temperatures, with variations in the topography or in the structure, attitude, or composition of the underlying geological materials, or with any other factor or group of factors affecting particularly the relations of the soil water (and such variations do occur in spite of the general homogeneity of these regions) it is to be expected that marked modifications of the soils will occur. The areas with soils different from those common to the region, are generally of great significance either positively or negatively, not only to the native vegetation but to the agriculture of the area, the type of soil common to the region being determined chiefly by the climatic conditions, whereas that of the exceptional areas is determined mainly by local or edaphic conditions. In humid regions with more broken topography, it is to be expected that many more local variations in the soils will occur, and such edaphic conditions are often of major significance in determining certain types of land utilization in the region. These local variations, in which the soils do not possess the characteristics common to the soil group of that region, are associated closely with other physical features of the area, including surface features, the underlying geological materials, the native vegetation, and especially the ground-water conditions of the particular area involved.

Stages in the Formation as Illustrating Variations of Soils.—In order to appreciate better these local variations, it is necessary to review certain features of soil succession. The soil, with its horizons and their physical and chemical characteristics, is a natural body formed by natural forces acting upon earth materials. The soil body, through the development of its profiles together with the physical and chemical changes taking place in these profiles, passes through an orderly series of stages or successions. These stages are as marked as the stages in the characteristic development of the vegetation of an area from its initial stages to the climax. The climax vegetation is, by definition, determined by the climatic features of the area. Not only do the soils and the vegetation of an area pass through an orderly series of stages in development but, in addition, the stages in soil development are very closely related to those in the development of the native vegetation. If the whole group of soil-making forces and the parent materials upon which they act are similar throughout the region, it is to be expected that the various stages of soil formation will, at any given time, present similar characteristics throughout the entire region. On the other hand, variations in the soil-making forces or in the parent materials, or in both, will necessarily produce different characteristics in the soils at any given time. Since the main soil-making forces of any area are the climatic features involved, the succession of soil development in a climatic region is toward the climatic climax; but, owing to local variations, various areas in the same climatic region present at any given time different stages of development. In accordance with these varying characteristics, the soils of the different parts of a climatic region may be classed as infantile, youthful, mature, or in old age. The infantile soils represent little more than accumulations of disintegrated parent soil materials. The mature soils are those in which the characteristics of the parent materials have been largely obliterated by the action of soil-making forces. The charactertistics of mature soils represent a complete adjustment to the climatic conditions of the regions. In soils of old age—post-climax soils—the soil-making forces, acting in combination with a physiographically stable, flat surface, produce at the base of the *B* horizon a tough, impervious, clayey layer known as hardpan. The stable physiographic conditions simply allow the soil-making forces to continue undisturbed to bring down from the *A* horizon the finer particles. These finer particles are left in the *B* horizon, forming the hardpan layer. It is obvious that such a condition must influence markedly the soil-moisture relations, resulting in poor drainage in wet weather, and in very dry soil conditions during the drier part of the summer. Such water relations must have very significant effects upon the native vegetation as well as upon the agriculture of the area. In addition, the physiographic stability of these flat lands in humid climates permits leaching to continue until old soils in humid regions are characteristically marked by, first, the grayish color of the $A^{\bullet}$ horizon—that is, besides the lime and other bases the iron compounds have been leached away—and second, by the brownish or yellowish heavier-textured *B* horizon whose base, mottled with blue clay (thus indicating poor aëration and consequent inadequate oxidation), grades into the hardpan layer.

Special Types of Soil Areas.—The soil group, such as the Black Earth or the Brown Forest soil, represents the mature development of fairly well-drained to well-drained soils, on surfaces relatively stable physiographically. Hence, such soils occur as a rule on the upland sections, as distinguished from the lowland areas such as river flood-plains or recently filled-in swamps or lakes.

Many portions of upland regions may have such recent geologic deposits (for instance, certain loess materials along the bluff lands of the Missouri and Mississippi Rivers or areas covered by the Wisconsin ice-sheet) or may possess a topography so broken that continuous surface erosion prevents the formation of a maturely developed soil. Hence it is to be expected that mature soils in any given region will be found in those well-drained uplands which are relatively stable physiographically, and thus have not been subject to severe surface erosion.

Areas that are unstable physiographically, with recent geologic deposits, whether on uplands or in flood-plains, deltas, or filled-in swamps and lakes, usually present marked examples of infantile or youthful soils, whereas flattish areas which have been physiographically stable for some time are very likely to present soils in old age, that is, with a well-defined hardpan.

SUMMARY OF THE SOILS OF THE UNITED STATES

The humid eastern United States presents two soil groups: (*a*) *The Gray Forest Soils.* These are in the earlier stages of development except on the higher sections, as, for example, in the White Mountains where true podsols (soils with a characteristic whitish layer just underneath the vegetable-mold accumulation) occur. These occupy the northern belt of the northeastern United States and extend pretty generally over eastern Canada; their present extent is fairly well indicated hy the distribution of the spruce-fir forest in Canada and the northeastern United States. These soils are developed on certain lands covered by the Wisconsin ice-sheet, which was the last of the great glacial invasions into the lowlands of the middle latitudes; and thus much of the region, especially in Canada, is very poorly drained. The Gray Forest soils are developed only on the less poorly drained uplands, whereas the swamps (muskegs) occupying depressions are still in the process of being filled in and hence are progressively changing toward better drainage conditions. These bogs are dominated by black spruce and tamarack; the heavier-textured gray soils support a good growth of white spruce, balsam fir, and the paper birch, whereas the finer-textured soils are likely to be dominated by the white pine and the jack pine.

(*b*) *The Brown Forest Soils.* In general, this group occupies the central United States east of the Prairies. The northern portion of the region occupied by these soils was covered by the Wisconsin ice-sheet; south of this belt is a zone covered by pre-Wisconsin ice-sheets; while the southern portions, never glaciated, have a rolling to rough surface due to the work of stream erosion. In spite of these diversities of the physiographic history, the well-drained upland soils throughout the entire region have many very similar characteristics and almost all of the region was covered by an excellent growth of deciduous hardwoods, originally one of the most magnificent hardwood forests in the world. Associated with differences in underlying geologic materials and the topographic irregularities, together with the differences in temperature and rainfall conditions to be expected in a region of this size, there occur numerous soil areas which are of great significance in interpreting the efficient use of these lands. These include (1) flood-plain deposits and terrace remnants; (2) areas formerly occupied by lakes or swamps; (3) more recent loess deposits on the bluff-lands and adjacent areas along the Missouri and Mississippi Rivers; (4) topographic basins, such as the Blue Grass, the Nashville Basin and the Great Valley; (5) dissected plateaus, such as the Ozark country and the Appalachian Plateau; (6) recent marine deposits.

Flood-plain Lands.—The materials of flood-plains are, in general, silty, and may have been carried in from a region whose climate is very different from that where they are deposited, this being particularly significant for those brought in by rivers that have crossed the Great Plains. Flood-plain deposits, even in the humid sections of the central United States, are often non-acid owing to their lime content—a fact very significant in their utilization. As a rule, they are rather high in organic matter. They occupy areas that are physiographically unstable and are continuously modified by river erosion or by additional deposition. A large percentage of these areas is poorly drained owing to their flattish surface and their slight elevation above the stream level. In flood-plains, the recent deposits and those surface materials that occur in places where the ground water rises nearly to the surface may be regarded as infantile soils. Relatively better-drained areas may present soils in a youthful stage of development; and in sections that have been topographically stable for some time—thus allowing the continuous activity of the soil-making forces—soils in early maturity are sometimes formed. River flood-plains have been proverbially known as productive areas, but it is obvious that their productivity varies greatly, owing to the differences in their soil characteristics.

Areas Formerly Occupied by Lakes and Swamps.—In this group are included thousands of filled-in areas, which were left as depressions with the recession of the Wisconsin ice-sheet; it includes also certain areas formerly covered by glacial lakes, such as Glacial Lake Chicago, Glacial Lake Maumee and others. In the case of filled-in depressions there occur usually large amounts of organic matter which may or may not be mixed with lime or marly materials; the organic content may be so high as to form accumulations of muck or peat. In the materials may be (1) heavy silts, as in the bed of Lake Maumee in northwestern Ohio, (2) sands with some lime, as in the bed of Lake Chicago at the southern end of Lake Michigan, or (3) sterile sands, as in central Wisconsin.

Loess Deposits.—The more recent loess deposits are very important agriculturally, as on certain bluff lands and adjacent areas along the Missouri and Mississippi Rivers. The deeper deposits of these windblown materials usually occur along the broken and hilly bluff-lands bordering the flood-plains; under these conditions it is to be expected that erosion is common. Such physiographic instability as a rule precludes the development of mature soils in these locations. Adjacent to the dissected bluff-land areas may occur thinner deposits of loess which, owing to the physiographic stability, often have developed the profile features of a mature soil. Furthermore, on flat areas, especially farther inland, old soils may be formed. Old soils, wherever formed, are usually less desirable agriculturally because of the disturbed circulation of moisture in the soil, owing to the impervious nature of the hardpan layer.

Topographic Basins.—Typical topographic basins include the Blue Grass region, the Nashville Basin, and the Great Valley Lowland of the Appalachian System. The Blue Grass region and the Nashville Basin have been developed on limestone strata by the action of erosion. The limestone rocks, which are the source materials for the soils of these areas, have a high phosphate content. The topography is subdued and the surface undulating to gently rolling. These lands, with gentle slopes and fairly heavy soils, are very similar in topographic and soil conditions to the Great Valley, which also was produced by the erosion of limestone strata.

Dissected Plateaus.—Illustrations of dissected plateau areas include the Ozark region and the Appalachian Plateau. The lands with higher elevation and underlain by nearly horizontal sedimentary rocks have been so dissected as to produce a prevailingly rugged surface. In general, the flood-plains formed by the winding streams are narrow. In the sections between the streams may occur slightly rolling to flat surfaces, marking a former elevation of a more extensive upland; the more level areas often have remained stable physiographically for a time sufficient for the formation of soils. The grayish surface layers of these old soils grade into the yellowish *B* horizon, the lower portion of which consists of a heavy-textured mottled layer which may merge into a hardpan.

The broken areas lying between the ridges or the undissected flats are unstable physiographically; this prevents the formation of old soils, but may accentuate erosion when such lands are cleared and brought under cultivation. The topography allows better drainage and consequently more complete aëration, and the *B* horizon of such sloping lands is usually reddish.

Recent Marine Deposits.—Some recent marine deposits occur along the east coast; and the heavy, silty materials of the flattish and poorly drained St. Lawrence Lowlands were deposited when this section was an arm of the sea, soon after the recession of the Wisconsin ice-sheet. An arm of Brown Earth soil extends through southern Ontario alongside of these heavier materials of the St. Lawrence Lowlands, and it is of value to note that this was originally occupied by a splendid growth of hardwoods.

SOIL AREAS IN THE SOUTHEASTERN UNITED STATES

The soil group with yellowish to reddish *B* horizons lies south of the Brown Forest soils and east of the dark-colored grassland soils of middle Texas. As a whole, the upland soils—those areas that are relatively stable physiographically are distinguished by the sandiness of the *A* horizon and by the fairly tight clay of the *B* horizon.

Because of such varying factors as topography, character of underlying geologic materials, drainage conditions, and, for those sections near the coast, recency of uplift above the sea, many soil areas exist in this group. Some of the more important ones, from the agricultural point of view, are as follows: (1) the Coastal Flatwoods areas, (2) the Middle Coastal Plain, (3) the Upper Coastal Plain, (4) the Interior Flatwoods, (5) the Piedmont, (6) the southern portion of the Great Valley, (7) the Black Prairies of Alabama and eastern Mississippi, (8) the Uplands east of the Mississippi River.

The Coastal Flatwoods Areas.—These lowlands, often poorly drained, extend from the coastal section of Virginia southward in a strip averaging 25 to 50 miles in width. They comprise much of central Florida, where they constitute the main area of citrus fruit production in that state. The underlying materials consist of recently uplifted sediments. In this area the soils differ mainly with variations in the drainage conditions; the flood-plains of the streams are usually rather narrow but subject to overflow and often poorly drained; the sloping lands bordering the stream courses are much better drained;

whereas most of the area is made up of the flat interstream lands, undissected because of the recency of uplift and the low elevation above sea level, and thus are poorly drained. As a rule, throughout this soil group of the southeastern United States there are very few sections where old soils with their characteristic tough and intractable hardpans prevail. They are found, however, in the Interior Flatwoods areas and in a few of the Coastal Flatwoods areas, as in central Florida. Here the surface is level; the *A* horizon consists of light-colored sands, and below this is the heavier *B* horizon, the lower part of which forms the hardpan. Such a condition obviously interferes with the movement of moisture in the soils.

The Middle Coastal Plain.—This area of gently rolling topography extends across the Carolinas and Georgia into western Florida. The light-colored sandy *A* horizon is underlain by a yellowish *B* horizon made up of clays mixed with sands.

The Upper Coastal Plains.—This belt of land, with a rolling topography produced by more intense dissection, makes up a large share of the inner Coastal Plains lands in the Carolinas, Georgia, and Mississippi. Another very similar area includes the rolling country of northeast Texas, northwest Louisiana, and southwest Arkansas. The elevation in both of these sections varies from 50 to 500 feet above sea level. The *A* horizon is prevailingly light in color (gray to brown) and fairly sandy in nature; the *B* horizon is composed of a sandy clay, yellowish to reddish in color.

The Interior Flatwoods.—These lands of flattish aspect are, as a rule, slightly undulating owing to dissection developing at their borders. They are so flat, however, as to have much poorly drained land, and over much of the country an old soil has developed. The largest area lies in southeast Texas just north of the Coastal Prairies. This area extends into Louisiana. Another area includes the very flat and narrow crescent-shaped belt lying along the western and southern side of the Black Belt of Alabama and eastern Mississippi. The *A* horizon is prevailingly grayish in color and composed of sandy silts or even clay materials. The *B* horizon is a heavier clay, yellowish to reddish in color. It is to be noted, however, that where a very compact layer has been formed at the base of this horizon, the lack of uniform oxidation has given it a mottled appearance.

The Piedmont. This is an area underlain by complex crystalline rocks; its surface is rolling to hilly and its elevation ranges from 100 to 1500 feet. The *A* horizon is light in color and sandy, as a rule. The *B* horizon is reddish to yellowish in color and consists of fairly heavy clays. Owing to surface erosion, however, the exposure of the reddish

B horizon largely dominates the landscape. Lying between the Piedmont and the Upper Coastal Plain is a narrow belt of sand hills, apparently representing an *A* horizon made up almost entirely of sands to a depth of 3 feet or more. As is to be expected, such lands are very poor agriculturally in contrast to those areas where the clayey *B* horizon, though similar, lies nearer the surface.

The Southern Portion of the Great Valley.—This area, with a topography ranging from undulating to slightly rolling, is underlain by limestones. As in the Middle and Interior Coastal Plain areas, the drainage is good as a rule. The *A* horizon is heavier than most of the soils in this group; it is made up of silts and loams, brown to grayish in color and sometime cherty (that is, containing fragments of flint). The *B* horizon is a yellowish to reddish clay which is fairly friable.

The Black Prairies.—This crescent-shaped belt, some 30 miles in width, extends through central Alabama into eastern Mississippi. The surface generally is undulating to gently rolling and is underlain by a light-colored chalky limestone. The major portion of this area was originally covered with tall grasses. This condition, combined with that of a high lime content in the soil materials, has resulted in the accumulation of a large amount of organic matter; hence, the dark color of the soils. The *A* horizon has a dark brown color, whereas the heavier-textured or clayey *B* horizon is lighter in color.

The Uplands East of the Mississippi River.—East of the bluff country bordering the Mississippi Lowlands is a zone of undulating to flattish lands underlain by loess materials. This section is one of the important cotton-producing areas of the South. Some of the undulating lands are badly gullied, while in the flattish areas old soils have developed. Nearer the bluff lands, the loessial areas are more dissected and the loess deposits deeper; the *A* horizon of the section is brown in color and somewhat silty in nature; the *B* horizon is heavier in texture, but friable. In the eastern portion, however, the lands are more level, the loess materials shallower, the *A* horizon much lighter in color; the *B* horizon is yellowish to yellowish-brown in color and often mottled because of the poor oxidation; the base of this horizon is usually a hardpan so impervious as to interfere seriously with the movement of water in the soil.

The Mississippi Bottom Lands.—These flattish lands of low elevation are often poorly drained, and a large share of the area is subject to overflow. Like the materials in the loessial uplands, the parent materials of the Mississippi Bottoms were brought in from other climatic regions, some of which are very unlike those in which they are at present. For example, much of the material has been brought in from the Great Plains and consequently is less leached when deposited as alluvium. In sections that have been stable physiographically for some time, the development of soils has proceeded with direct relation to drainage conditions; the flattish lands, poorly drained, are practically the same as when deposited, whereas the sloping lands along drainage lines have developed a true soil profile with a brown *A* horizon and a heavier *B* layer.

THE PRAIRIE SOILS

As the term is here used, the Prairies include those sections originally covered by tall grasses in the humid middle latitudes. Climatically they are potential tree-growing lands. Because of their heavier rainfall, leaching is taking place, often slowly; but the grassland vegetation has caused the accumulation of a higher content of organic matter; hence their dark color and usually better tilth as compared with the Brown Forest soils.

The topography of these lands is undulating to slightly rolling; the lack of strong relief, combined with simplicity of geological structure (gently dipping strata), allows a rather uniform development of soil conditions throughout the entire area. Some differences of climate, however, do exist. These, associated with variations in surface features and degree of physiographic stability, have brought about the development of significant soil areas in this very important soil group. In the United States these include (1) the flattish and poorly drained areas in the eastern portion of the Prairies, (2) the old soils of south central Illinois, (3) the old soils of south central Iowa and north central Missouri, (4) the eastern portion of the Black Waxy Belt of Texas, (5) the Coastal Prairies, especially of east Texas, (6) the Black Prairies of Alabama and Mississippi, already treated (p. 111).

The Poorly Drained Areas of the Eastern Prairies.—These lands include those left with a flattish surface at the recession of the ice-sheet and those filled-in lake and swamp basins which, at the time of their occupation by the white man, were covered with tall grasses. There were large areas in which the drainage was so poor as to preclude intensive farming until they had been drained by man. When drained they are, as a rule, highly productive.

The Old Soils in Southern Illinois.—This subdivision includes an area which has been stable physiographically since the recession of one of the earlier ice-sheets. The surface is gently undulating to flattish; the *A* horizon of the soils is light in color and less tractable than grass land soils usually are. The *B* horizon is a heavy clay of mottled appearance, its lower layer being a compact and impervious hardpan. So much does this hardpan accumulation interfere with the moisture relations of these soils that their low productivity is reflected in their low crop yields and the system of farming here employed, is, of necessity, very unlike that used on the darker-colored soils on more rolling topography at the north.

Other Old Soils.—The areas of old soils in south central Iowa and north central Missouri are similar in some respects to those of southern Illinois, but apparently have not advanced as far beyond maturity as the latter.

The Eastern Portion of the Black Waxy Belt of Texas.—The Black Waxy Belt of Texas is an area of undulating to gently rolling topography underlain by chalky limestones. The eastern portion of this belt has a sufficient rainfall to allow leaching. This prevents the accumulation of carbonates in the soil, and thus serves to distinguish this area from the central and western portions of the Black Waxy Belt in which there is a constantly increasing content of carbonates, chiefly lime in the soil, although the parent materials throughout the Black Waxy Belt are very similar in character and composition.

The Coastal Prairies, Especially of East Texas.—These level areas have emerged but recently; they are formed on a heavy, tough, and compact marine clay, only the upper portion of which has been modified by the soil-making processes and the accumulation of organic matter. Thus these youthful soils consist of a rather compact but dark-colored *A* horizon, out of which the carbonates have been pretty thoroughly leached. The *B* horizon, imperfectly developed, is mottled and heavy, and grades into the light-colored compact parent clays at a depth of about 12 to 14 inches.

CHAPTER V

CENTERS OF PRODUCTION

A treatment of the physical bases of agriculture finds its most significant application in the interpretation of the physical potentialities of regions and areas for the production of agricultural commodities. A region or area whose interrelated physical conditions give it certain marked advantages in the production of an agricultural commodity or group of commodities may be called a center of production. The physical characteristics that differentiate a center of production from adjacent lands constitute an interrelated complex of climatic, topographic, soil, and native vegetation conditions, all of which in conjunction produce a complex habitat in which plant associations develop. Man's relation to an agricultural center of production consists in his attempt to establish on the lands involved an association of plants (crop, pasture, or forest) for the purpose of producing a desired quality and quantity of certain plant materials. In so doing, advantage is taken of the enormous plasticity inherently possessed by most plants, and attempts are made to bring about closer adjustments between the plants and the complex conditions of the physical environment of the area. The cultivated plant is only a modified wild plant; and a field (crops, pasture) is a man-made or man-modified association of plants which should be in adjustment with the man-modified habitat in the area involved.

In the past, both the selection of the plants and the adaptation of the plant to the habitat have been accomplished mainly by hit-or-miss methods; and when by this process a successful means was developed it was, and is, oftentimes thought that this result would be attained equally well in areas possessing a very different environment. Scientific developments in more recent years, however, have made it possible to establish methods of plant selection and breeding by which much closer adjustments can be made to the physical environment of the areas involved.

These developments include: (1) a better understanding of the inherent growth habits of plants; (2) a more thorough comprehension of the interrelated physical environment of plants—(*a*) climate and weather, (*b*) topography and underlying rocks (*c*) soils, their areal distribution and their characteristics; (3) a keener discernment of the relations between the inherent growth conditions of plants and the annual or seasonable aspects of their habitat. Various aspects of the physical bases of plant production have been pointed out in preceding chapters; the study of the fundamentals of plant life belongs more properly to botany, and only certain phases will be outlined here. The broader relations between plant life and its habitat conditions will be outlined in the present chapter and more fully pointed out in the chapters on crop production.

FUNDAMENTAL CONSIDERATIONS OF PLANT GROWTH IN RELATION TO THE HABITAT CONDITIONS OF AREAS

A plant is a mechanism which takes certain inorganic materials from the soil and from the atmosphere and combines these into certain organic compounds; in a state of nature, it usually reëstablishes itself continually by means of types of vegetative growth (e.g., such as root stocks and tubers) or through the production of seeds or spores.

In annuals and biennials, seasonal vegetative growth occurs largely prior to seed growth and maturity; and in perennials, some years of vegetative growth usually take place before the plant reaches the fruit or seed-bearing stage. During the period of vegetative growth, the plant adds much to itself in the way of what in analysis is termed dry matter, but in annuals this addition generally is materially checked with the inception of flowering and seed formation in the plant. It is to be expected that the complex of physical conditions best suited to vegetative growth in plants may be very different from what is best during the seed-forming phase of plant development. Also, may it not be that, through the centuries, plant-growth characteristics, both vegetative and reproductive, have become rather closely adjusted to the annual and seasonal environmental conditions in which the plants have grown? May it not be, too, that what are termed inherent qualities in a plant, are results of natural selection whereby certain structures or functions have survived which help to bring the plant into closer adjustment to its environment?

The growth of a plant, whether vegetative or reproductive, may be regarded as a dynamic balance between the inherent qualities of the plant itself and the sum total of its environment. There is abundant experimental evidence to show that the relations of a growing plant to its environment are very complex. For example, Kraus and Kraybill have shown that the tomato may be made non-vegetative and non-fruitful, very vegetative and non-fruitful, or moderately vegetative and fruitful, by varying the carbohydrate-nitrogen ratio in the plant. If the plant is non-vegetative and non-fruitful because of a lack of carbohydrate in relation to its nitrogen content, the addition of carbohydrates allows it to become very vegetative but non-fruitful (all goes to stem, as the old saying has it); if the carbohydrate content in relation to the nitrogen content is further increased the plant becomes moderately vegetative and fruitful (this being a condition desirable commercially for grain, fruits, etc.); if the content of carbohydrate is then further increased, the plant becomes both non-vegetative and non-fruitful, a condition undesirable commercially. When the plant has been brought to this stage, further increases in the carbohydrate content result in injury or in death. On the other hand, if a plant is non-fruitful and non-vegetative because of a too low nitrogen content in relation to the carbohydrate content, repeated additions to the nitrogen content of the plant allow it to change successively from the non-vegetative and non-fruitful phase to the one of moderate vegetative growth and of fruitfulness; to the very vegetative and non-fruitful stage; to the non-vegetative and non-fruitful stage, and beyond to injury or death of the plant. These results not only illustrate the enormous plasticity of the growing plant, but also suggest a means whereby this plasticity can be so controlled as to produce what is most desirable commercially, whether that product be the grain of the cereals, the fruits of temperate or tropical plants, such varied types of vegetative growth as hays or pasture plants, or such vegetables as lettuce, asparagus, or celery.

The far-reaching results of these researches in the control of the growth of economic plants are emphasized in that the quantity of water available to the plant has many effects similar to that of applications of nitrogen. Garner and Allard, in their investigations on the effects of the relative length of day and night on the growth and reproduction of plants, have shown that the growth of plants, whether vegetative or reproductive, can be modified by regulating the daily period during which the plant is exposed to light, some plants require a long day to enable them to produce flowers, whereas others flower only if the daily period of exposure to light is short. Whatever the cause of these reactions, whether or not it is associated with an carbohydrate-nitrogen ratio (as has been suggested by some), it is the illustration of another means of control of the inherent plasticity of plants; a means of control by which many growth conditions of plants, in the middle latitudes and in the tropics, can be better interpreted.

Gericke's researches on the significance of the presence or absence of certain plant nutrients, after a certain amount of vegetative growth has been made in complete nutrient solutions, have shown that the yield of certain annuals is decidedly improved if they can make the latter part of their growth in conditions where certain of the so-called essential nutrients are lacking. For instance, when certain annuals were removed after four weeks from a complete nutrient solution, a greater growth of total dry matter and a greater yield of grain were obtained when they were transferred to solutions devoid of phosphorus and magnesia; when the plants were transferred at the age of six weeks to solutions deficient in certain nutrients, the greatest growth was obtained from solutions devoid of potash and sulphur; and in these and other experiments, it was found that the elements required for the longest time were calcium and iron. From these and other experiments Gericke reaches the conclusion that plant production in nature is a function of the rate of depletion (and of rendering unavailable), during the season, of certain essential nutrients; that is, that plant production for certain annuals is materially increased if the soil is depleted of certain available nutrients during the growing season.

It is possible that these conditions may be correlated with Stewart's investigations in which it was shown, for example, that when a large crop of barley was obtained, the crop rapidly depleted the soil of nitrogen. The purpose of reviewing here the results of these investigations is to illustrate some of the ways that man has learned to take advantage of the inherent potentialities of plants and thus better to control the amount and kind of production. Upon the application of these principles depend such practices as the use of fertilizers, irrigation, tillage, dry-farming methods, and the like, whereby the habitat conditions are controlled or modified with a view of increasing crop production. It can not be emphasized too much that these practices must be varied not only with reference to the kind of plant grown, but also in regard to the complex of physical conditions of the area involved. This brings the discussion to the topic that gives this chapter its title:

CENTERS OF PRODUCTION

In considering the physical potentialities of a region or area for agricultural production, it is necessary to synthesize as much as possible the physical characteristics of that region or area. The results of years of research work have shown that the soil characteristics, if properly interpreted, constitute the best working synthesis of the conditions that are important in plant production throughout an area. In the morphology of the soil, its horizons and their characteristics, are integrated the action and interaction of climatic factors, topographic features, parent geological materials, ground-water and drainage conditions, and the effects of the vegetative cover as these are combined throughout regions and areas. When the morphology of the soils of a region has been properly studied and the relationships of the soil horizons to plant associations have been interpreted in a general way, it is then possible to apply more and more, throughout the whole region, the results of the researches of the plant physiologist, of the plant breeder, and of the soil physicist. The way is thus pointed toward more refined and effective methods of controlling the quantity and quality of agricultural products, that is to say, of providing for more efficient land utilization for the various portions of the earth.

To sum up, the meaning and significance of production to agriculture involves: first, an integration of those physical conditions which are common throughout a region or area and which are of importance to agricultural production, serving not only to distinguish regions or areas with certain common physical characteristics but also to differentiate such regions or areas from adjacent lands; second, a general interpretation of the native plant associations of the area as these are related to other prevailing physical conditions; third, a general interpretation of the man-made or man-modified plant association involved —crops, pasture, or forest—as these are related to other conditions of the physical environment throughout the area. This includes several features such as (*a*) the selection and breeding of such desirable plants as are better adjusted to the habitat conditions of the area, including general features and seasonal changes; (*b*) amelioration of the habitat, so as further to increase the yield and to better the qualities of the desired products. Amelioration of the habitat includes such practices as will modify the physical and chemical conditions so as to promote better plant growth. These practices include cultivation (breaking up the soil, destruction of weeds, forming a soil mulch in humid regions, providing for better aëration), addition of mineral fertilizers, barnyard manures, lime, crop residues, irrigation, drainage, and so on. The practices employed will necessarily differ in the various areas involved; this is another reason for emphasizing the concept of centers of production.

CENTERS OF ORIGIN OF OUR CULTIVATED PLANTS

It has often been pointed out that there are three great centers of origin of our cultivated plants, that is, sections where wild plants were brought under domestication by man.[1] These centers include: 1. South-

[1] For example, see Brunhes, Human Geography, p. 250; Cowles and Parker, A Book about Plants; De Candolle, Origin of Cultivated Plants.

western Asia and the Mediterranean Lands; 2. India and southeastern Asia; 3. Tropical America. It may be pointed out that each of these centers includes regions which were the seats of ancient civilizations.

The significance of knowing the conditions under which our domestic plants were developed lies in the possibility of the introduction and growth of these plants in the different agricultural regions of the world. In the long period of time during which corn, wheat, cotton, and most other agricultural plants grew in their respective original habitats, each of these plants acquired a *growth-rhythm* by which it became adjusted to the conditions of its environment, especially to the features of the climatic rhythm which obtains in that region. When plants are introduced into regions, they hold over many of the characteristics that they possessed in their original homes; therefore, in adapting plants to different environments or in ameliorating the habitat conditions, it is of great value to know their growth habits in relation to their native habitats. To illustrate these features, it is only necessary to examine the agricultural history of corn, wheat, cotton, grain sorghums, sugar cane, or the rubber tree; in fact, the large majority of our economic plants illustrate these principles, the proper consideration of which will enable man more and more to abandon " hit-or-miss " methods and to appreciate better the possibilities of a scientific basis for plant production.

The Mediterranean Lands and the Levant.—These lands surrounding the Mediterranean Sea comprise areas possessing marked physical diversities. In ancient times this portion of the earth was at the crossroads of the Old World. It became the seat of a civilization from which our own is largely derived. Its location was such that it could borrow and gather in from adjacent deserts, grasslands, and forests. Plants, no doubt, were borrowed by these lands also, but from this region has come a large number of our most important economic plants. These include such cereals as wheat, oats, and barley, each probably being developed in different areas of the region; in fact, it is very probable that there were multiple lines of development, and in the case of oats this may be regarded as proved. For example, Trabut, working in north Africa, found three ancestral varieties of our present cultivated oat, one of which is adapted to a cool climate, another to a warm climate, while a third is drought-tolerant. The Mediterranean gave us also such fruits as the apple, pear, palm, cherry, the olive and fig, and the European grape. It gave us such vegetables as the beet (garden, sugar, and mangel), lettuce, the onion, the carrot, and the parsnip. One great forage plant, alfalfa, came from Persia. It is believed that flax may have been developed in the Mediterranean region. In addition to the preceding list, the Mediterranean lands contributed such nut trees as the English walnut and the almond as well as many other plants of lesser significance.

India and Southeastern Asia.—Another very rich region in its contribution to crops of modern agriculture is southeastern Asia, India, and the adjacent islands. Historically, these regions have long been occupied by man. They have developed rice, one of the three great cereals of present-day agriculture, and a crop peculiarly adjusted to the climatic and other physical conditions which obtain in those monsoon lands. These lands have contributed sugar cane, the citrus fruits, most of the spices, one of the original ancestors of cotton, jute, such vegetables as the yam (not the sweet potato), the dasheen, the eggplant, and the cucumber. Among the forage plants contributed to the western world, the cowpea, Bermuda grass, and probably some of the grain sorghums were developed in India. The original home of tea probably was the mountainous country lying between India and southern China.

Tropical America.—A third great region whose plants have enormously enriched world agriculture includes the tropical sections of the Americas. It is of more than passing interest that each of these three great centers of origin of economic plants, all three of which were great centers of ancient civilization and all of which are or were regions of relatively dense population, has contributed an important cereal to the modern world; wheat from the Mediterranean, rice from the monsoon lands, and corn from tropical America. Tropical America as a source of economic plants has been recognized far less than its importance deserves. It is, in importance, probably second only to the Mediterranean. Besides corn, which seems to have been developed on the plateau lands of tropical America, this region has given us such vegetables as the New World beans (for example, the lima bean from the vicinity of Lima, Peru), the tomato from the same area as the lima bean, the sweet potato, pumpkins, and squashes. The peanut comes from Brazil, cacao from northern South America; and it seems probable that in this area the coconut was developed also. Cassava or manioc is indigenous to the Amazon Basin country, and probably tobacco also. Cotton is native to the New World (plateau of Mexico) as well as to the Old World (India). Another fiber from this region is an agave from which sisal is obtained and which is native to Yucatan, its present chief center of production. The Amazon Basin is the home of the "Para" rubber tree (*Hevea brasiliensis*), this species being now the basis of the plantation rubber industry of the Far East. In spices, it has contributed allspice (from the West Indies), vanilla (from an orchid native to the vicinity of Tampico, Mexico), and red pepper.

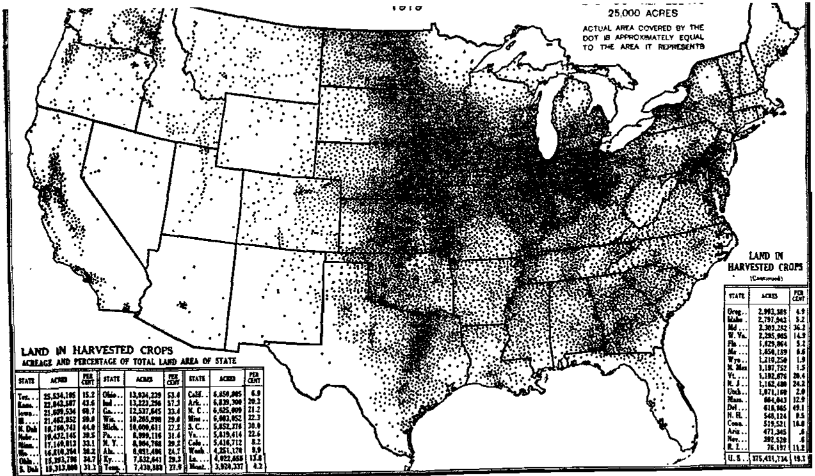
Other Sources of Origin.—From the three regions previously discussed have come a large share of our most important cultivated plants. Other sections of the world, however, have made important contributions to our cultivated plants, giving us such plants as rye, turnips, cabbage, cauliflower, carrots and parsnips, red clover, timothy, blue grass, and red top from central and west central Europe; the soybean and kaoliang (a grain sorghum) from eastern China; the date palm from the Sahara; the watermelon, the grain and forage sorghums (Sudan and Johnson grass) and coffee (Abyssinian highlands) from interior Africa; and the common white potato from Chile.

In summing up these general facts in regard to the centers of origin of our cultivated plants, it must be emphasized that variations in human conditions associated with differences in areal characteristics, combined with certain inherent features of the plants themselves, have produced widely different types of plants. These can be grouped into three great divisions: plants requiring continuous or nearly continuous high temperatures such as the truly equatorial, the tropical and subtropical categories; those requiring a long and warm growing season such as cotton and corn; and those requiring a cool and shorter growing season such as many of the vegetables and forage plants.

Typical Examples of Centers of Production

In the United States.—Several of the great crop regions of the United States illustrate excellently the principal features of centers of production. Only a few more of the outstanding ones will be treated in this chapter.

The map of land in harvested crops in the United States in 1919 is shown in Fig. 16. When the whole nation is considered, almost all the crop land lies in the sub-humid interior and the humid East. The zone of densest acreage is a roughly triangular one. The base of the triangle is the zone of Black Earth and Chestnut Brown soils in the interior of the continent. The remainder of the triangle comprises the dark-colored Prairie soils to the eastward, which, in Indiana and Ohio, grade into the Brown Forest soil group which there includes many dark-colored areas, the result of poor drainage conditions. This triangular section in the heart of the United States includes within it the Corn Belt, the Spring and Winter Wheat Belts, the largest cotton-producing area in the country (the Black Waxy Belt of Texas), and, in addition, it produces a vast amount of hay. Although this section covers but



LAND IN HARVESTED CROPS
ACREAGE AND PERCENTAGE OF TOTAL LAND AREA OF STATE

STATE	ACRES	PER CENT	STATE	ACRES	PER CENT	STATE	ACRES	PER CENT
Tex. . .	25,534,106	15.2	Ohio . .	13,934,239	53.0	Calif. .	6,050,005	6.0
Kans. .	22,043,587	43.6	Ind. . . .	13,223,256	57.3	Ark. . .	6,839,300	20.3
Iowa . .	21,699,534	60.7	Ga. . . .	12,537,645	33.4	N. C. . .	6,625,009	21.2
Ill. . . .	21,462,852	60.0	Wis. . .	10,265,990	29.6	Miss. . .	6,003,052	22.3
N. Dak.	18,700,741	44.0	Mich. .	10,000,611	27.2	S. C. . .	5,852,376	30.0
Nebr. . .	19,432,145	39.5	Pa. . . .	8,999,116	31.4	Va. . . .	5,819,414	22.6
Minn. .	17,140,813	33.1	N. Y. . .	8,904,708	29.2	Colo. . .	5,416,712	8.2
Mo. . . .	16,810,394	38.2	Ala. . . .	8,051,400	24.7	Wash. .	4,251,170	9.9
Okla. . .	15,393,796	34.7	Ky. . . .	7,632,641	29.3	La. . . .	4,022,655	13.8
S. Dak.	15,313,000	31.1	Tenn. .	7,430,383	27.9	Mont. .	3,924,337	4.2

LAND IN HARVESTED CROPS
(Continued)

STATE	ACRES	PER CENT
Oreg. . .	2,993,185	4.9
Idaho .	2,797,942	5.2
Md. . . .	2,303,282	36.2
W. Va.	2,295,905	14.9
Fla. . . .	1,829,864	5.2
Me. . . .	1,850,159	8.6
Wyo. . .	1,210,250	1.9
N. Mex.	1,197,752	1.5
Vt. . . .	1,192,676	20.4
N. J. . .	1,162,400	24.2
Utah . .	1,071,160	2.0
Mass. .	664,043	12.9
Del. . . .	618,865	49.1
N. H. .	548,124	9.5
Conn. .	519,521	16.8
Ariz. . .	471,345	.6
Nev. . .	392,520	.6
R. I. . .	76,197	11.2
U. S. . .	375,431,734	19.1

FIG. 16.—Over five-sixths of the crop land is in the humid eastern half of the United States, and nearly two-thirds is concentrated in the triangular-shaped area described under Fig. 9. In this area, which includes only about one-fourth of the land of the United States, are produced four-fifths of the corn, three-fourths of the wheat and oats, and three-fifths of the hay crop of the nation. No region in the world of equal size affords so favorable natural conditions for the growth of corn, and few regions possess so favorable conditions for the culture of the small grain and hay crops.

Agriculture Yearbook 1921, p. 181

one-fourth of the total land area of the United States, it includes about three-fifths of the total improved land in the country ("in this area 60 per cent of the land area is improved farm land, whereas in the United States outside this area only 15 per cent is improved"); and in 1919 it produced four-fifths of the corn, three-fourths of the wheat and oats, and three-fifths of the hay crop of the country. Some of the more significant phases of the types of land utilization in relation to the physical bases of agriculture in this area will be presented in the following pages.

The Corn Belt.—The Corn Belt is well called the heart of American agriculture.

> Into it flow the stocker and feeder cattle from the West for fattening, to supplement its home-grown stock, and out of it flow more than two-thirds of the beef and pork consumed in the eastern, northern, and to a lesser extent, in the southeastern sections of the country. It supplies, moreover, most of the large exports of pork and lard; and, in addition, ships corn and hay in vast quantities to the eastern and southern markets. Although the Corn Belt includes only 8 per cent of the land area of the United States, it produced over 50 per cent of the Nation's corn crop in 1919, and possessed more than 20 per cent of the cattle, 25 per cent of the horses, and 41 per cent of the hogs of the Nation.[2]

Why is this relatively small area so important in production, and what are its potentialities in regard to future production?

The northern and western limits of corn growing in the United States are climatic ones. Corn is grown over most of the South but there the acreage is less and the acre yields much lower. The real Corn Belt, where more than half the total acreage is given to corn and where the acre yields are uniformly high, is an area extending from west central Ohio westward through central Indiana, most of the northern two-thirds of Illinois, through eastern and central Iowa to western Iowa, eastern Nebraska, the southeastern corner of South Dakota and northeastern Kansas. This zone, some 900 miles long and averaging about 200 miles in width, is the center of corn production. Marginal areas of denser production do appear; for example, the 1909 map shows relatively dense areas in eastern Kansas, in central Kansas extending southward through central Oklahoma, in the Black Waxy Belt of Texas, and elsewhere.

While the outer limits of corn production at the north and the east are climatic ones, the areas of greatest production can be closely correlated with certain soil characteristics. In all cases, the soils are dark in color, and in most cases they were originally covered with a rather

[2] Agriculture Yearbook, 1923, p. 328.

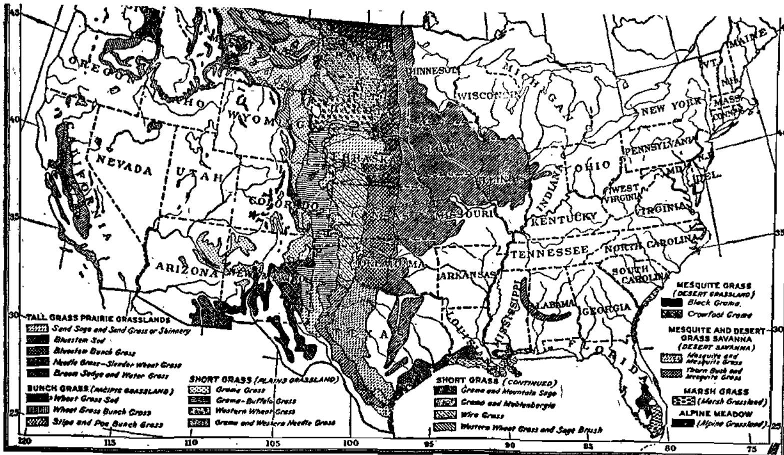


FIG. 17.—Each of the five main grassland divisions, (1) the tall grass (prairie grassland), (2) the short grass (plains grassland), (3) the bunch grass (Pacific grassland), (4) the mesquite grass (desert grassland), and (5) the mesquite and desert-grass savanna (desert savanna), occupy large areas of land and consequently show many variations. The tall-grass vegetation may be subdivided on the basis of the dominant species into a number of types, the approximate distribution of which is shown on the map. The short-grass vegetation is similarly subdivided into types, eight of which are indicated on the map. In the bunch-grass vegetation three divisions are shown, two divisions in the mesquite grass, also two divisions in the mesquite and desert-grass savanna. The subdivisions not shown occupy small or restricted areas scattered throughout the main divisions, and the distribution can not be shown on a small-scale

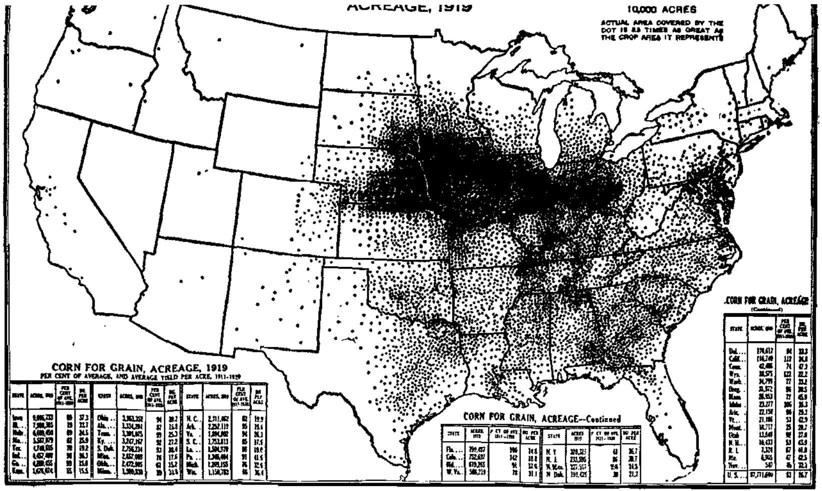


FIG. 18.—Over two-thirds of the corn acreage of the world is in the United States, nearly all east of the line of 8 inches mean summer rainfall and south of the line of 66° mean summer temperature. Nearly 90 per cent of the acreage of corn for grain in the United States is in the Corn Belt, the Corn and Winter Wheat Region, and the Cotton Belt. In these three regions corn constitutes about one-third of the acreage of all crops. In the Corn Belt it is dominant, contributing nearly two-fifths of the acreage and half of the value of all crops. Hay, associated with spring oats in the northern portion and with winter wheat in the southern portion, is the other important crop in

dense growth of tall grasses. The topography of the corn-producing lands is undulating to gently rolling. Much of the land in the eastern portions was naturally so poorly drained as to necessitate artificial drainage. The surface of corn lands should be flattish, owing to the necessity of cultivation and the consequent dangers from erosion. The climate during the summer is tropical in many of its aspects. The growing season is moderately long, the days are hot, the nights warm and often hot; the rainfall, especially toward the west, has a summer maximum and falls in thunder showers; between the periods of showers are the periods of intense sunshine during the exceptionally long days. These are the conditions which appear to be best suited to corn production.

This crop of tropical origin, which has its world center of production in the heart of a region possessing tropical climatic conditions during a moderately long summer, reaches its maximum production in those areas of this region where certain favorable soil conditions are found. Natural forces, through their silent and continuous action, have produced here a set of soil conditions which do not exist over so large an area anywhere else in the world. Climate and physiography, native vegetation, and ground water, acting upon and interacting with parent geologic materials (which here are chiefly different forms of limestone with which is mixed some loess) form the so-called Prairie group of soils. These soils have throughout the area certain common morphological features. That is to say, the characteristics of their profiles distinguish them from adjacent soil groups. The general soil morphology of this region consists of three horizons: The brown or dark brown, rather fine-textured loam of the *A* horizon is mellow, as a rule, and therefore tractable, and extends to a depth of 12 to 15 inches; in its initial condition this layer was filled with a network of grass roots. The *B* horizon usually consists of an upper portion, some 5 to 15 inches in thickness, less dark in color than the *A* horizon, but containing more clay; and a lower portion, which is a heavier clay some 15 to 20 inches thick, and yellowish or sometimes mottled in color. The *B* horizon grades into the *C* horizon, which is made up of partially oxidized parent materials of limestones, shales, or glacial drift.

As is to be expected, there are many local or even wider variations of conditions which have their influence upon the morphology of this group of soils. For example, the lands at the east are poorly drained, whereas those at the west have less rainfall and actually grade into the eastern extension of the true Black Earth. Many topographic variations occur, each of which registers itself upon the characteristics of the soil profile. Because of these variations, differences occurred in the kind of tall grass which originally was the vegetative cover. But, in spite of these local variations, the morphological features are so common over the entire area occupied by the soil group that it is easily set off from adjacent soil groups.

As has been suggested, the Corn Belt extends into the eastern edge of the Black Earth in Nebraska and to some extent into Kansas, but in that section the Black Earth exhibits many characteristics common to the Prairie soils. At the east, in Indiana and Ohio, the Corn Belt seemingly extends into the Brown Forest soil group; but what actually occurs is that the more important corn-producing areas in these states occupy dark-colored soils, those formed in isolated prairie sections, such as the rather large one just west of Columbus, Ohio, or the dark soils developed in poorly drained areas, such as filled-in swamps or basins or on the heavier silt materials as in northwestern Ohio.

What, it may be asked, are the properties of these Prairie soils, or of those soils closely resembling them, which make them so markedly important in corn production? The corn plant makes fairly rapid growth, which, for the best results, must be continuous. Unlike the grain sorghums, corn can not make a successful second growth, once its development has been arrested by drought. Not only is it necessary that conditions be suitable for continuous and fairly rapid growth, but the requirements for a large plant and a heavy yield with this rapid growth are an indication that corn will do best in a highly fertile soil, well supplied with moisture. Being a "gross" feeder, it requires a fertile soil; its necessity for continuous growth requires a continuously available supply of moisture in the soil. Both of these conditions are adequately met by these soils in conjunction with the climatic features of the region. The Prairie soils are medium to high in their content of plant nutrients, although they are being slowly leached of their more soluble compounds; their fine silt-like texture and generally favorable structure are suitable to intense cultivation; their high content of organic matter, their rather fine-textured *A* horizon and heavier, clayey *B* horizon, are significant in retaining large amounts of available soil water. Moreover, the *B* horizons are not so compact as to interfere with the free circulation of this water. The undulating to slightly rolling topography, in general, reduces the amount of erosion. These are the physical features upon which corn production in the Corn Belt is based. These same conditions also determine, to a great extent, what types of farming will in the long run be most profitable and contribute most to the well-being of the people of the United States who are directly and indirectly concerned with the Corn Belt. As is well known, the Corn Belt is also the swine belt as well as the beef-fattening center of the United States.

Soil Limitations in Areas Adjacent to the Corn Belt.—At the north of the eastern and central portions of the Corn Belt are the less productive, light-colored forest soils derived mainly from drift materials left by the Wisconsin ice-sheet. Here corn is usually put on the better soils; and, although climatic conditions are less suitable, it appears that the actual northern extent of denser corn acreage in that section is determined by soil conditions. To the east of this denser zone, "islands" of denser corn production occur in areas possessing darker-colored and heavier-textured soils, surrounded by the lighter-colored forest soils of lower productivity and with less desirable physical characteristics. Corn is grown throughout most of the southeastern United States, but nowhere with dense acreage or high acre yields except in certain local areas with darker-colored soils, such as certain river flood-plains. Throughout the sandy upland soils of the southeastern United States, more corn might be grown with the use of fertilizers, a practice which is not at the present time a profitable one for corn production.

The southern part of Illinois is not an important corn-producing area, most of it being included in the rather flattish lands in which a very compact and tough hardpan has been formed in the *B* horizon; the *A* horizon is light in color and the general productivity of the whole section is low. In south central Missouri the broken Ozark country with its light-colored forest soils is low in total amount of corn produced. In the flatter lands of north central Missouri and south central Iowa, although these lands were originally covered with tall grasses, there has developed a rather compact layer in the *B* horizon at a depth of some 15 to 20 inches. The *A* horizon is less dark in color than the Prairie soils as a group; its physical conditions are less desirable; and the compact layer in the *B* horizon so interferes with the circulation of soil water as to reduce materially the producing capacities of these lands. This condition is reflected in the less dense corn acreage in these areas. In western Missouri the lands are more rolling and the soils dark, and their higher productivity is indicated by the corn production. The production, however, is much less than in the darker soils, with more desirable physical conditions, which prevail over western Iowa and eastern Nebraska.

Eastern China

Eastern China may be used to represent types of intensive land utilization in the Orient. The important producing areas are the alluvial plains, including the Plains of North China, those of the Yang-tse basin in Middle China, and the lowlands and delta of the West River in southern China. These areas are naturally very fertile, the alluvial materials having been carried from the interior and drier regions of central Asia. Although the plains lands constitute but a small portion of the territory of China, they support a very large share of the population of that densely peopled country.

. Eastern China is humid; the rains come mainly during the summer season, as a result of the inflowing monsoon winds. In general, rainfall is sufficient for crop production over most of eastern China; the lightest precipitation occurs at the north where there is less evaporation, and, as is to be expected, rainfall not only decreases toward the interior, but also is less dependable there. It is to be expected that marked differences in the length and temperature of the warm season will occur in a country which extends through a north-south distance of 20 degrees or 1200 miles.

The differences in temperature relationships and variations in the rainfall are reflected particularly well in this part of the world, because of the intensity of the pressure of a vast population upon the relatively restricted areas of high-grade arable lands. These conditions are effectively shown by adjustments made through cropping systems in the various centers of production in China. Rice is grown wherever possible. Where the growing season is long enough, two crops of this high-yielding warm-season cereal are produced, and as a rule these same lands during the winter are kept in such cool-season crops as wheat or barley, potatoes, legumes, and other vegetables. In Middle China the deep fertile soils of the Yang-tse lowlands produce regularly two crops annually: The cool-season crops previously mentioned occupy the lands during the winter portion of the year. These are generally planted in rows or hills and intertillage is practiced generally. Legume crops are often planted between the rows after the cool-season crop has made its vegetative growth. These in turn are followed by a warm-season crop—rice or cotton—planted in mid-summer. Rice, throughout the Orient, is usually transplanted, a practice reflecting intense utilization of labor and lands. The seedlings can be better cared for in nursery plots, and when transplanted they can be uniformly spaced. Although transplanting requires much extra labor, the increased yield more than compensates for this in these densely populated lands. Moreover, the farmer has the use of rice lands for a longer time for the growing of cool-season crops.

In north China the cool-season crops are regularly produced in spite of the long winters. For the summer, warm-season crops with a growing period shorter than that of rice or cotton are required; typical of these are the soy bean and various millets and sorghums.

Rice and the millets are the great staple food cereals of China. Both of these are warm-weather crops and each is adapted admirably to the conditions of the region in which it is produced. Each reflects forcibly the remarkable significance of moisture conditions to crop production. The selection of millets as the staple crop where rainfall is less, or is irregular in distribution through the summer, is comparable in many respcts to the production of grain sorghums in the southern Great Plains of the United States. The millets, like the grain sorghums thrive in the hot summers; they are able to survive when the available soil moisture is reduced to a low content, and they are able to make rapid growth when the rains do come after the drought.

The intense pressure of population upon land supply is well illustrated by the intensity of cropping and cultivation. In addition, manures and crop residues are conserved and applied with a degree of care not dreamed of in the Western nations, and that, in spite of the great inherent fertility and high degree of workability of these deep alluvial soils. The sloping lands of the hilly country in the interior are carefully utilized so as to yield the largest returns of such crops as tea and the mulberry, and at the same time to reduce the runoff and control erosion. Livestock are reduced to a minimum; cattle in the drier sections and the water buffalo in the wetter regions are the draught animals; but more important in these lands are the large numbers of pigs and poultry—those wonderfully efficient transformers of otherwise waste materials into high-grade edible products. Thus have these "farmers of forty centuries" in a pre-scientific and pre-commercial age developed by empirical methods an efficient system of land utilization whereby high agricultural production has been made permanent.

The Amazon Basin

In striking contrast to the intensive utilization of agricultural resources in China is the Amazon Basin, vast in extent but practically undeveloped. This region, comprising an area of about 2¼ million square miles (that is, about three-fourths of the size of the United States) has a population of only about 1½ millions. Topographically, it is a shallow trough of wide expanse and extends from the base of the Andes, where it is broadest, eastward to the Atlantic. This low plains country is intersected by numerous streams, forming the extensive Amazon drainage system. These streams provide one of the most thorough systems of inland waterways to be found anywhere in the world, and are of vast importance in this country where other means of commercial transportation are absent and can be established only with great difficulty.

Climate.—The climatic conditions throughout the entire basin are characteristically those of an equatorial rainy climate. The temperatures are continuously warm, but not extraordinarily high even for short periods. In the lower Amazon Basin, temperatures seldom rise above 93° F., are never known to reach 105° F., and have an annual mean of 85° F. The effects of this monotonous temperature are modified considerably by the circulation of the atmosphere. The rainfall, although great, can not be considered heavy in comparison with that of other equatorial rainy regions. The rainfall, as contrasted with the temperature, is much less uniform in distribution through the year, and over most of the region a distinct dry season occurs. As is to be expected, the prevailing type of native vegetation is the equatorial rain forest, characterized by its rapid growth and dense stands. Although common forest features prevail and dominate the vegetative aspects of the entire basin, many variations occur as a result of differences in the topography and of the underlying geologic materials.

Topography.—Two important types of surface features dominate the landscape; the alluvial lowlands and the somewhat dissected intervening uplands. The alluvial lowlands in general are subject to overflow and, while extensive in area, are not as large as is commonly believed. The alluvial lands along the Amazon are, as a rule, not wide; and, as is typical of flood-plains, are characterized by the presence of natural levees, adjacent to the streams and thus in contrast to the lower and often poorly drained lands back of them. The upland interstream areas, as a rule, change from undulating or slightly rolling to more broken conditions as distances from the streams increase.

Soils.—The soils of the Amazon Basin are discussed elsewhere (pp. 96–98). As a rule, the soils are light in color, as is characteristic of forested regions everywhere. Variations in soil characteristics are associated here as elsewhere with differences in topography, drainage, and parent materials. The materials of the alluvial lowlands are deposits of light-colored silts and fine sands derived from the forested uplands. After deposition, these materials, where physiographically stable, have been slightly altered, as a result of the vegetative growth and by the deoxidation of the lower layers, which is due to the high water table. The soils of the uplands vary considerably with the degree of dissection of the topography and the relative fineness or coarseness of the parent geologic material. In general, the top soil is brown, fairly low in organic matter, and underlain by horizons which are yellowish to reddish, the colors varying with the degree of weathering.

As a rule, the texture of the *B* horizon is heavy enough to be very significant in retaining soil moisture to be utilized by the vegetation. Where sandy areas prevail, as in the northern portion of the lower Amazon valley, the effects of the dry season upon the vegetation are very noticeable; and in other areas, especially some of the more level uplands, an incipient hardpan has begun to develop and is clearly reflected in the characteristics of the native vegetation.

Agriculture and Forest Production.—Although undeveloped at present, this vast region, three-fourths the size of the United States and possessing the climatic conditions and soil resources previously discussed, seems destined to become a great agricultural empire. It seems unreasonable to doubt that its progress in agricultural development will be increased considerably by the growing demand of the peoples of the middle latitudes for those commodities which the tropics are best suited to produce. As an illustration of this force, the recent interest in the possibilities of the Amazon Basin for rubber production is illuminating. Large areas exist, particularly south of the Amazon, where the physical conditions are highly suitable for the production of rubber on a large scale. The main handicap at the present time, in the development of the plantation rubber industry, is the lack of laborers. The physical possibilities for the production of crops other than rubber are indeed significant. Crops successfully grown at the present time include sugar cane, mandioca, corn, tobacco, cotton, cacao, forage grasses, and, in small quantities, rice. The present development of cropping systems adapted to the physical and economic conditions and the production of cattle throughout the region serve as indicators of the vast agricultural potentialities possessed by this almost untouched empire.

THE RANGE COUNTRY OF THE WESTERN UNITED STATES

Because of physical conditions, a large proportion of the western United States can not be used profitably except for grazing or for forests. The limiting physical conditions are mainly those of climate, topography, and native vegetation. Probably the best indicator of the climatic conditions prevailing generally over the West is the distribution of native vegetation (see map, Fig. 22). The possibilities for use in grazing, especially in its seasonal aspects, are fairly well indicated in Fig. 19.

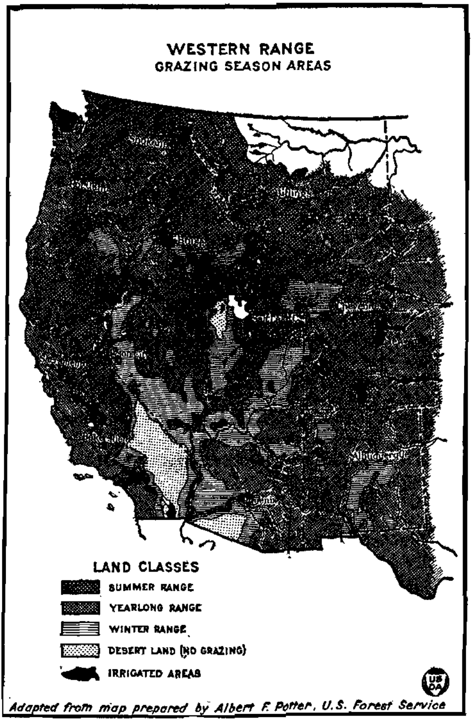


FIG. 19.—The great variety of climatic and soil conditions existing in the Western States results in very decided differences in the possible grazing seasons as well as the character and value of the herbage. The higher mountains furnish from three to six months of excellent grazing in summer (when the ground is free from snow). Although the foothills and plateau areas are available for grazing most of the year, the extent of the range is not sufficient generally to carry the animals grazing upon these areas for more than six to eight months without a change of pasture, except on the southern range. The desert or winter ranges, because of lack of water, are available to livestock, principally sheep, only during the winter months. Some of the Arizona-California desert region is, because of a lack of water, practically unusable for livestock. Much of the range livestock is now fed in irrigated valleys during the winter. *Agriculture Yearbook, 1923, p. 392.*

THE WESTERN RANGE REGION [3]

The western range region embraces practically all of that part of the country west of the 98th meridian, except the humid belt along the North Pacific Coast. In the eastern part of this region lie the semi-arid Great Plains, a vast expanse of grassland. Along the eastern edge of the plains, tall prairie grasses prevail, but the greater part of the area is covered with short grasses, notably grama grass in the northern part, buffalo grass in the central plains, and mesquite grass south of the Red River. In the Rocky Mountains and other high mountain areas, where there is adequate moisture, forests and woodlands occupy much of the land. Scattered throughout these forests are numerous parks or open places, which are covered with grasses and other herbaceous plants that furnish excellent summer grazing.

Between the Rocky and Cascade Mountains is an arid intermountain region consisting mostly of high plateaus and basins, both cut through by narrow river valleys. Sagebrush is the characteristic vegetation of the northern and central portions of this intermountain region, and creosote bush and cacti of the southern portion. The Blue Mountains of eastern Oregon nearly cut off the Columbia Basin from the Great Basin to the south. On the higher plateaus of the Columbia Basin and on the foothills of the mountains to the north, east, and west of the Great Basin, the pasturage is largely bunch wheat grass. On the plateaus of western New Mexico and northern Arizona, short-grass vegetation prevails, mostly grama in the northern and mesquite grass in the southern portions.

The valleys of California, like the moister portions of the Columbia Basin, were originally covered with a bunch-grass vegetation. These native grasses were early over-grazed and largely destroyed. They have been replaced by annual grasses and other plants introduced from Europe, especially from the Mediterranean region. In the Cascade and Nevada Mountains, the highlands are covered with timber, with numerous grassy parks intervening and alpine meadows above timber line. In the north, the eastern foothills of these mountains are covered largely with the bunch wheat grasses, but in the south both slopes at the lower levels are for the most part covered with thickets of woody shrubs, called chaparral.

The Grazing Season.—In the greater part of this region the livestock are grazed for as much of the year as possible, and the animals may travel many miles in going from one grazing ground to another.

[3] Agriculture Yearbook, 1923, pp. 390–402.

During the summer months many of the livestock are grazed in the mountains; the spring and fall months will find them in the foothills and higher plateau areas; and in winter many of them will be on the desert or semi-desert lands, in the irrigated districts, and on the stubble fields of the dry-farming areas. In areas where there is insufficient winter range, the animals are often fed for a period of from three to five months.

The time of the year that a given range area is grazed depends largely on when it is available for use, and partly on the general system of livestock production followed. In general, the western range country may be subdivided according to the season of its availability as (1) summer range; (2) yearlong range, and (3) winter range.

Summer Range.—The summer ranges are mostly in the mountains and, because of the shortness of the growing season, are available only during the warmer months. The grazing season varies from approximately three months in some of the higher altitudes in the northern range states to about six months in the mountains of the Southwest. Most of these lands are in the national forests, although some summer grazing is obtained in forest areas belonging to lumber companies and others.

Yearlong Range.—The "yearlong ranges" are those areas where grazing can be carried on during practically the entire year. Most of the yearlong ranges are covered with grass, and in the northern range states are fairly free from trees and brush. A large portion of the less rolling yearlong range in the northern Great Plains and Columbia Basin, where there is sufficient rainfall for the growing of crops, has in recent years been converted into farms.

In the semi-arid Great Plains region the grazing season is now largely dependent on the farm practice. Formerly, yearlong grazing prevailed throughout the region. The rapid settlement of much of this region in recent years has so greatly reduced the area available for pasture that it has generally become necessary to shorten the pasture season and resort to winter feeding. A ranchman who is primarily engaged in the production of livestock and who has extensive pasture lands will graze his animals throughout the greater part of the year and, except in unusually severe winters, will give them comparatively little supplemental feed. Under such circumstances the range is frequently divided into summer and winter pastures. On the other hand, a small farmer with a limited acreage and with only a small number of animals seldom has sufficient pasturage to last longer than six to eight months.

In the northern portion of the Great Basin, the range, although it can generally be grazed throughout the greater part of the year, is now so restricted in area that it will carry only a part of the total livestock. For this reason it is generally reserved for spring and fall grazing and serves to a large extent as an intermediate range for animals traveling between the summer range and the winter range or feed lots.

In the southern range states, where conditions are generally too arid for farming, there are still large areas of yearlong range. Here, however, it is often customary to use the higher levels during the warmer season, and the lower levels in winter. The distance traveled from one to the other is comparatively short, frequently being only a few miles.

Winter Range.—The winter ranges are restricted mostly to the valleys and basins of the intermountain and southern range states, where the rainfall is light and where water or snow is available for livestock only during the winter months. The vegetation in such areas consists largely of shrubs and weedy annuals, many of which are not relished by cattle but are readily grazed by sheep. In the more northern desert areas the winter ranges are available for a four- or five-months' period, whereas in the Mohave-Gila desert the grazing period is usually restricted to a few weeks in the late winter and early spring. In case the spring rains fail, these latter areas are usually unavailable.

In the irrigated and dry-farming districts, much late fall and early winter grazing is obtained by giving the animals the run of stubble fields, the aftermath of hay fields, especially alfalfa, and by pasturing them on marshy lands. In fact, in California many of the sheep get their entire winter subsistence by grazing on crop lands after harvest, or in orchards and vineyards.

Carrying Capacity.—Owing to the very diverse moisture and temperature conditions, the carrying capacity varies widely in different parts of the range region. It is shown in a general way in Fig. 41, and is summarized for some of the more important grazing districts in Table I. This table also indicates briefly the character of the pasture and the duration of the grazing season.

IMPROVEMENT OF METHODS IN THE WESTERN RANGE REGION

While the western range lands include over half of the grazing lands of the United States, they support at present only about one-third of the total livestock carried on pasture. This is largely the result of the prevailing arid conditions, but is also due in part to the fact that the range land has been over-grazed and its carrying capacity greatly reduced. The experience of numerous ranchmen and the work of State and Federal investigators prove that these lands can be restored

TABLE I

Character of Forage and Estimated Capacity of the Western Grazing Areas of the United States

Agriculture Yearbook, 1923, p. 396.

Areas	Chief Forages	Length of Season	Area to Support a Cow
		Months	*Acres*
Northern Great Plains	Grama, buffalo, needle, and wheat grasses	5 to 10	10 to 30
Southern Great Plains	Grama, buffalo, bluestem, beard, and mesquite grasses; scrub oaks.	8 to 12	15 to 35
Black Hills	Grama, buffalo, and bluestem grasses	3 to 5	25 to 30
Central Rocky Mountains	Blue, fescue, wheat, brome, and redtop grasses; Baltic rush; and "weeds." *	3 to 6	15 to 25
New Mexico-Arizona mountains	Grama, fescue, beard, and wheat grasses; scrub oak, mountain mahogany.	5 to 8	12 to 25
West-central Montana foothills and high plains.	Fescue, wheat, blue June, porcupine, brome, and grama grasses.	5 to 7	15 to 30
Northern Rocky Mountains	Pine, wheat, blue, brome, and fescue grasses	3 to 6	20 to 150
Central Idaho	Pine, wheat, brome, fescue, and blue grasses	3 to 7	25 to 30
Wasatch, Uinta, and Wyoming Mountains	Wheat, porcupine, fescue, and blue grasses; bluebells and other "weeds"; * browse.	3 to 7	8 to 25
Northeastern Nevada, southern Idaho, and central Oregon.	Wheat, blue, and fescue grasses; sagebrush, shadscale, greasewood	4 to 8	35 to 40
East-central Nevada mountains.	Wheat, blue, and fescue grasses; browse	4 to 6	25 to 50
Wyoming semi-deserts	Salt grasses; sagebrush, shadscale, greasewood.	2 to 6	35 to 100
Utah, Nevada, Arizona deserts.	Salt, grama, three-awn, and annual grasses; annual "weeds"; * sagebrush, winter fat, greasewood, shadscale, mesquite, palo verde, cacti.	2 to 5	50 to 150
New Mexico-Arizona foothills and basins.	Grama, tobosa, galleta, three-awn, muhlenbergia, and salt grasses; sagebrush, shinnery, other browse.	4 to 12	15 to 75
San Luis Valley of Colorado	Blue, salt, and fescue grasses; Baltic rush; sagebrush.	7 to 9	30 to 40
Utah foothills and valleys	Wheat, porcupine, and June grasses; sagebrush	5 to 7	20 to 30
Nevada semi-deserts	Salt, and lyme grasses; greasewood, shadscale, sagebrush.	1 to 4	75 to 150
Southeastern Oregon and Snake River plains.	Fescue, wheat, and lyme grasses; sagebrush	2 to 5	50 to 100
Columbia River Basin	Blue, fescue, wheat, lyme, and salt grasses; sagebrush, greasewood.	7 to 9	10 to 50
Eastern California mountains	Short, blue, wheat, needle, oat, and brome grasses; deerbrush and other browse.	3 to 6	15 to 35
Western Oregon mountains	Fescue, brome, wheat, pine, and bent grasses; deerbrush and other browse.	3 to 7	30 to 100
Southwestern California mountains.	Deerbrush and other browse	6 to 12	40 to 60
California and southwestern Oregon foothills and valleys.	Browse; "weeds"; * annuals, including wild oat, rye, brome, barley, and fescue grasses; bur and wild clovers; alfilaria.	6 to 8	15 to 50

* On the range "weeds" refers to miscellaneous herbaceous plants.

to their original carrying capacity and be thus maintained. The methods that have proved most effective deserve mention.

Avoidance of Premature Grazing.—The keeping of livestock from the range until the grass has had a chance to get a fair growth will tend to increase its total carrying capacity. On the national forests, the prevention of premature grazing has had much to do with range improvement.

Prevention of Over-grazing.—Not only is too close grazing harmful to the range, but it is usually reflected in the lack of gains made by the animals. However, a pasture on which stock cattle are run can be slightly over-grazed without causing any appreciable effect on the animals. Whether a range is being over-grazed can generally be determined by watching the gradual disappearance of the grasses and their replacement by less desirable vegetation. Recent experiments with range pastures at Mandan, North Dakota, composed largely of grama grasses and needle grasses, lead to the conclusion that from 15 to 25 per cent of the foliage covering should remain on this type of pasture at the close of the season, if over-grazing is to be prevented. This conclusion applies also to ranges farther west covered with perennial bunch grasses.

Deferred Grazing.—On some types of grasslands, notably in the mountains, the use of deferred grazing methods has resulted in great improvement. The plan is to permit the desirable grasses on a portion of the range to mature seed before grazing is commenced. Thus, quantities of seed are scattered and to some extent trampled into the soil.

Rotation Grazing.—In the improvement of ranges it is a desirable practice to graze a series of pastures in a regular succession, leaving each year one field for deferred grazing. This method gives the grasses and other forage plants a better chance to reëstablish themselves. Usually it is only necessary to defer the grazing on any particular area once in three years in order to maintain the stand of desirable plants. Sometimes it is desirable to use the same field for deferred grazing two years in succession.

Grazing with Two or More Kinds of Animals.—Two or more kinds of animals are often used on the same range, either at the same time or in succession. In Texas it has been found on many ranches that a certain number of sheep and goats can be run, in addition to the cattle, without decreasing the number of cattle; in fact, in some instances the carrying capacity for the cattle has been slightly increased. On such ranges the sheep prefer the weedy plants that the cattle do not care for and thus prevent these plants from encroaching on the grasses. On some of the Texas ranges where there is much browse which neither sheep nor cattle relish, the addition of goats has been helpful in keeping the oaks and mesquite from crowding out the grasses.

Improved Methods of Grazing Sheep.—An important step in improving ranges where sheep are run is to avoid having the animals "bed down" in the same place for more than two or three nights in succession. The constant traveling between the bed grounds and the grazing areas results in the destruction of much vegetation through trampling. It has also been found that sheep do much better, and that less damage is done to the vegetation where, instead of being "close herded," they are allowed to scatter while grazing. In Texas it has been found that nearly twice as many sheep can be carried on the same area when they are allowed to run loose in fenced pastures than under the herding system.

Development of Watering Places.—The development of well-located and adequate watering places is important. Without plenty of water within a reasonable distance animals can not make satisfactory gains. The watering places should be so distributed, if possible, that cattle do not travel much over 2 miles in going to water, and in a very rough country not much over half a mile. Frequent watering places aid also in preventing the formation of trails, which in time form rain channels and may lead to erosion. Well-located watering places are helpful also in opening up areas that were formerly but little grazed.

Proper Distribution of Salt.—On cattle ranges, much can be done in equalizing the grazing by placing salt at suitable distances from the watering places and in such localities as to draw the cattle away from the heavily grazed areas to those only lightly grazed. Systems of salting have been found to be an excellent means of regulating grazing on unfenced ranges.

Building Trails.—The grazing capacity of many ranges can be increased by building trails in rough country or through timber, to open up numerous small areas which, because of their inaccessibility, are little grazed. Many stockmen have found that it is profitable to build trails, which save the energy of the animals and prevent trampling of the vegetation.

The Importance of Introduced Range Plants.—The idea has often been expressed that better pasture plants can be found that will thrive in the different sections of the western range country. Judging from what has happened in other parts of the country, there are reasons for the belief that properly chosen introduced plants will greatly increase the carrying capacity of the range lands. In the northeast quarter of the United States, the pastures are entirely made up of introduced grasses—blue grass, white clover, redtop, timothy, etc.—all from Europe and all so aggressive that the native vegetation can not compete with them. In the South, Bermuda grass, carpet grass, lespedeza, Johnson grass, Dallis grass, and others have been of similar importance. In California, 80 per cent of the lowland forage is now produced by introduced plants, mainly from the Mediterranean region, such as wild oats, bur clover, wild barleys, alfilaria, and many others, all introduced by chance. Many of these plants are now spreading in the Columbia River Basin. It is true that some of the plants introduced by chance in each region are undesirable. However, if proper precautions are used, it is not likely that undesirable plants will be introduced.

Important results may be obtained in the range region, by introducing desirable plants from regions with similar climatic conditions. For the most of our range lands the source is central Asia, whence came alfalfa and sweet clover, the two most valuable forage plants of the West; also Russian thistle, rosy saltbrush, and tumbling mustard, which have spread of their own accord over large areas of the ranges in less than ten years. These last three plants are not particularly desirable, but there can be little question that excellent forage plants, which will spread with comparable vigor, can be found by intelligent search. There is every reason to expect that desirable wild range plants from central Asia will add as much wealth to the West as did alfalfa, the great cultivated forage from the same region. One of these plants, crested wheat grass, is already giving very promising results.

Seeding with Tame-pasture Plants.—The cultivated grasses and legumes now in use in this country are not adapted to the greater portion of the western range country. Excepting in the more humid areas, most of the seeding experiments have yielded poor results. The cheapest and apparently the best method of reseeding native grasses is that of deferred grazing. In many of the mountain meadows, however, the conditions are very favorable for such plants as blue grass, redtop, the fescues, and white clover, and it is highly probable that these plants will eventually become important in such areas.

Elimination of Rodents.—In increasing the carrying capacity of the range, much can be accomplished by the destruction of the various rodents, particularly the prairie dogs, ground squirrels, jack rabbits, pocket gophers, and mice. Prairie dogs and ground squirrels select the richer valley and bench lands, and are direct competitors with livestock for the use of the more palatable and nutritious forage. Prairie dogs often destroy the grass roots and denude the lands, rendering them barren wastes occupied only by plants of little or no forage value, and subjecting them to permanent damage by erosion. The constant migrations of these animals into new feeding grounds result in the establishment of new towns and the extension of their devastation. Ground squirrels, because of their greater numbers and more general distribution, consume even larger quantities of grass.

Jack rabbits, which inhabit most of the range country, also subsist largely on the grasses. Their numbers, and consequently the amount of damage caused by them, fluctuate greatly from time to time. Meadow mice and pocket gophers also destroy grass, and, when numerous, the gopher burrows interfere seriously with handling the livestock.

Effective and economical methods for poisoning and otherwise destroying these pests have been worked out, and extensive poisoning campaigns have been inaugurated in recent years in nearly all of the range States. These campaigns are conducted by the United States Department of Agriculture (Biological Survey) in coöperation with the various State agencies and organizations of stockmen and farmers. Several million acres of grazing land have been freed of rodents, and a marked increase in forage production has resulted. In Arizona a three-year united effort on the part of more than 800 stockmen, coöperating with the Biological Survey to exterminate prairie dogs, was entirely successful, an area 120 miles long and from 10 to 20 miles wide having been freed of this pest.

The Elimination of Predatory Animals and Wild Horses.—It is estimated that predatory animals, until recent years, took an annual toll of $20,000,000 to $30,000,000 worth of livestock on the western ranges. The Department of Agriculture (Biological Survey) is now coöperating with state and county officials and livestock associations in the destruction of these wild animals, approximately 500,000 having been destroyed since 1915. The destruction of the large numbers of wild and practically worthless horses, which on some areas number thousands, would also increase the capacity of the range in many districts. Their presence not only decreases the number of valuable livestock, but they are an actual source of injury to the range. In many instances they are so wild, and the country is so rough, that it is impossible to round them up or remove them. Even if rounded up they have no commercial value, except for fertilizer or for poultry feed.

The Elimination and Avoidance of Poisonous Plants.—Poisonous plants cause heavy loss among western livestock, especially sheep and cattle. These losses are much more prevalent on the western ranges than on eastern pastures, because the animals graze in large herds and the plants sometimes grow in dense masses. It is important that livestock producers be able to recognize the poisonous plants, in order that, so far as possible, they may prevent their animals from grazing upon them. The most important are the death camases, milkweeds, *larkspurs and locoes.*

Some of the milkweeds, which are rather widely distributed, are exceedingly poisonous. They kill not only sheep, but also many cattle and some horses. Larkspurs, which grow on all of the mountain ranges of the West, as well as in some of the Eastern States, are the most dreaded by cattlemen of all of the poison plants. There are several kinds, but apparently all are poisonous. As cattle must eat about 3 per cent of their weight in order to be poisoned by these plants, scattered patches of larkspur do little harm. The plants sometimes grow in canyons in thick masses, and it is when hungry cattle drift into these places that heavy losses occur. The destruction of these large patches helps greatly to lessen losses. The saving of cattle resulting from the destruction of large patches of these plants in the national forests has *much more than paid for the work involved. It is not feasible* wholly to exterminate larkspur, but the danger from it can be greatly lessened. As horses and sheep are not poisoned by larkspur, some of the infested ranges can be used by these animal

The locoes, which have perhaps caused more losses than all the other poisonous plants combined, are widely scattered throughout the Great Plains country. Of the several different species, the white loco or rattle weed, the purple or woolly loco, and the blue loco are the most important. Much of the area where these plants occur has been taken up for farming purposes within the last few years, and the losses, though still large, are much smaller than formerly. It has been shown to be profitable to dig out the loco plants in inclosed pastures, but there is no feasible method of controlling loco trouble on the open range.

Not only is it important to know which plants are *poisonous*, but *it* must also be borne in mind that, generally speaking, the greatest losses usually occur at times of feed shortage. Losses seldom occur when the animals have sufficient good pasturage.

SUGGESTIONS FOR FURTHER STUDY

The article on weather and agriculture in the Agriculture Yearbook for 1924 contains a summary of the main relationships of weather to agriculture in the United States. The following map, showing the agricultural regions of the United States, represents the main aspects of climate and agriculture in this country.

This shows also the areas of beef production in the United States.

In addition this article contains many suggestions as to reasons for the distribution of agricultural regions and the kinds of agricultural production in those regions.

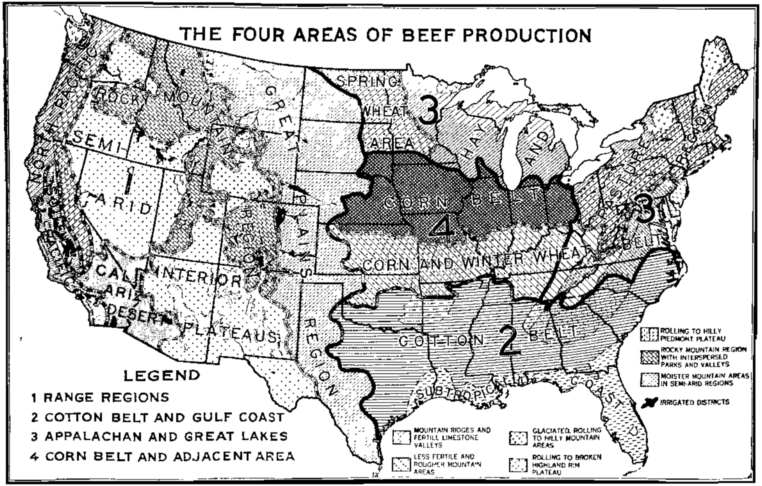
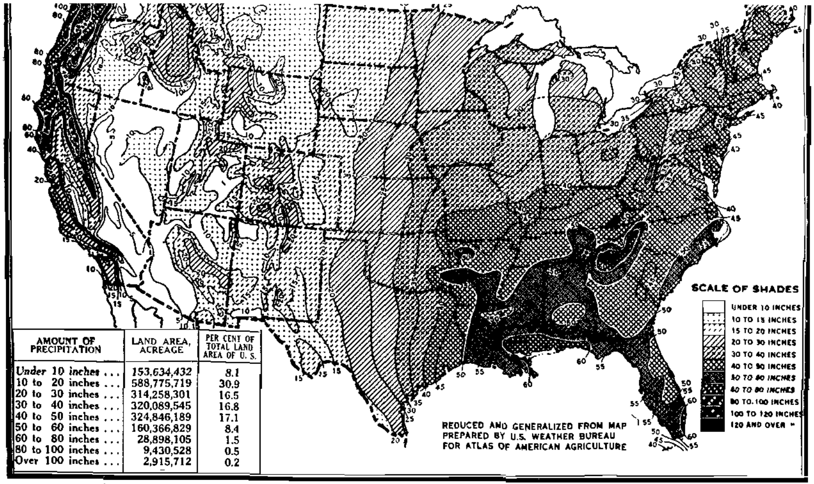


FIG. 20.—The Western Range, being mostly semi-arid, is devoted largely to grazing cattle. In the Cotton Belt cattle are raised chiefly on wooded and other untilled land. Along the Subtropical Coast, largely cut-over pine land and prairies, many cattle are raised in large herds under almost range conditions. In the Appalachian and Great Lakes region cattle are raised in small herds, the cows being kept for milk as well as for their calves. In this region many cattle are fattened on grass alone. The Corn Belt is the principal region for the fattening of cattle. Large numbers are



AMOUNT OF PRECIPITATION	LAND AREA, ACREAGE	PER CENT OF TOTAL LAND AREA OF U. S.
Under 10 inches ...	153,634,432	8.1
10 to 20 inches ...	588,775,719	30.9
20 to 30 inches ...	314,258,301	16.5
30 to 40 inches ...	320,089,545	16.8
40 to 50 inches ...	324,846,189	17.1
50 to 60 inches ...	160,366,829	8.4
60 to 80 inches ...	28,898,105	1.5
80 to 100 inches ...	9,430,528	0.5
Over 100 inches ...	2,915,712	0.2

FIG. 21.—Precipitation includes rain, melted snow, sleet, and hail. The map is much reduced and generalized from a map prepared by the Weather Bureau and published in the Precipitation and Humidity section of the Atlas of American Agriculture. The map suggests why the United States should be divided agriculturally into an eastern and a western half.

Agriculture Yearbook, 1921, p 418.

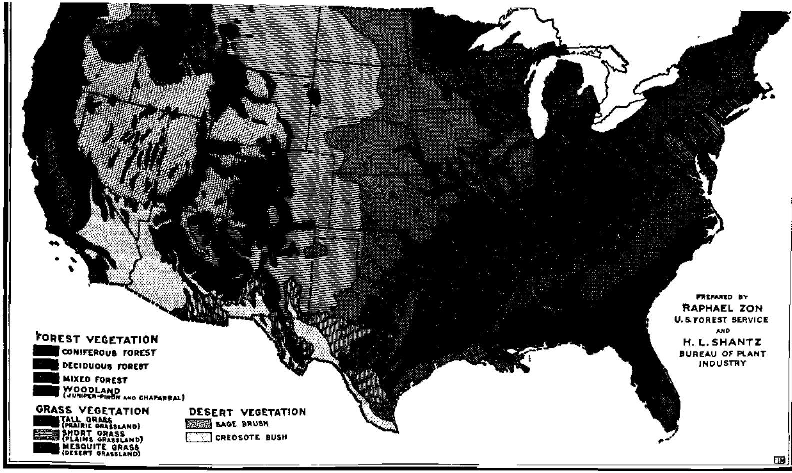


FIG. 22.—Forests, including semi-arid woodland (pinon-juniper, chaparral, etc.), originally covered about 900 million acres in the United States. About 350 million acres have been cleared for agriculture, and as many more have been cut-over or devastated. About 600 million acres were clothed originally with grass, interspersed commonly with various herbaceous plants. Some 200 million acres of this grassland have been plowed up and used for crops, or for pasture in rotation with crops, including about 7 milllion acres irrigated. Desert vegetation characterized 400 million acres, of which about 12 million acres have been reclaimed by irrigation. Half of the remaining forest and woodland is pastured, practically all of the grassland, and

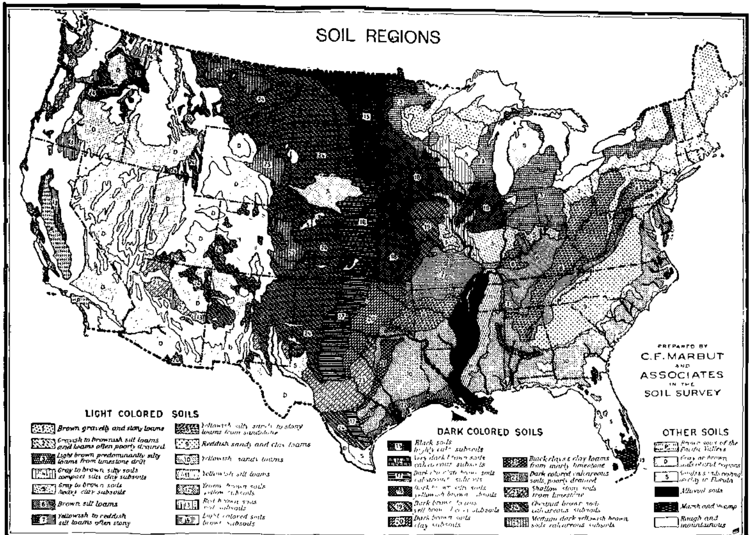


FIG. 23.—Soils originally or at present covered with forest are normally light colored, and are likely to be less fertile than soils in regions of lower rainfall. Grassland soils, in general, are dark colored, the humid prairie soils being commonly almost black and highly fertile—the subhumid prairie soils, blackest of all—while the semi-arid short-grass plains soils are dark brown or chocolate colored, the color gradually fading to medium brown in regions of lesser rainfall, and to light brown or even ashy gray in desert areas. The light-colored forest soils in the United States total about 800 million acres, the dark-colored grassland soils about 600 million acres, and the light-colored arid soils about 500 million acres.

PROBLEM

What are the climatic conditions which prevail in the Hay and Pasture Region, and how do these conditions affect the agriculture of the section? Apply a similar analysis to the other agricultural regions.

The map of average annual precipitation of the United States illustrates the influence of winds, topography, and distance from the sea upon the areal distribution of rainfall. These climatic conditions are reflected in the map of native vegetation of the United States, which represents an integration of most of the climatic factors. Thus the distribution of native vegetation is closely related to the great soil groups.

The soil map, except for the Prairies and the Great Plains, does not show the great climatic soil groups, but represents mainly the influences of physiography upon the soils.

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PART III

FOOD, FIBER AND FOREST RESOURCES OF THE WORLD

PRESENT-DAY PROBLEMS IN AGRICULTURAL PRODUCTION

Four closely interlocking agencies—the plant, the climate, the soil, and the animal—each of which is variable within certain limits, play a very prominent part in the problems which confront the investigator in the production of agricultural commodities.

Added to these is a fifth—that of markets—which also must be continuously considered in the agricultural industry. In the investigation of problems dealing with agricultural production, two methods of procedure are open: the empirical and the scientific; it is also possible to follow a method which is a combination of the two. These problems relate especially to alterations in the plant itself and to the means employed to ameliorate the physical environment, such as modifying the soil moisture supply and applying fertilizers so as better to adapt the supply of available plant nutrients to the growth periods of the plant.

Scientific studies of the problems of plant production enable man to understand better and to appreciate more keenly the wonderful wheel of life in which the plant takes up simple substances and in some mysterious way fashions them into food for men and animals, packing them with energy drawn out of the sunlight—energy which enables us to move and work and to drive the engines of power upon which our complex civilization so largely rests.

Adapted from Sir E. John Russell.

CHAPTER VI

CEREALS AND FORAGE CROPS

WHEAT

Introductory and Historical

Antiquity.—Wheat was one of the first bread crops known to man. At the dawn of history in the Mediterranean world, it was already playing an important part in the dietary of the patriarchal family, as is shown by references to it in the chronicles of the times. The Old Testament, for example, makes frequent allusions to wheat in a manner which testifies to its importance in that era of human civilization. Throughout ancient, medieval, and modern times, wheat has been almost indispensable to the peoples of the western world.

Wheat Growing in America

Soon after the settlement of Jamestown, wheat was brought over from the Old World to be planted first along the Atlantic seaboard and then to begin its slow but persistent march westward into the present-day centers of production of the continent. This westward migration of wheat furnishes one of the most romantic episodes in American history, for closely connected with it is the conquest of the American continent. This westward movement of wheat occurred in a series of great sweeps. The first great westward shift occurred during the period immediately following the American Revolution, from 1783 to 1840. This was the period of internal improvements—the building of turnpikes, bridges, and canals. The implements of production were crude and consisted of the sickle and cradle for harvesting and the flail for threshing.

Between 1840 and 1860, the center of wheat production shifted from the Middle Atlantic and the upper Ohio River States to Wisconsin, Illinois, and Indiana. In addition to the turnpikes, canals, and rivers, which furnished the facilities for transportation during the first period, there was added, during the second period, the railroad, which served as a great boon to the pioneer wheat growers of the then Far West. The reaper had displaced the sickle and cradle; and a power-driven threshing machine, the flail. Along with these improvements occurred a tremendous increase in the acreage and production of wheat. During this period, too, Texas and California appeared as wheat-producing states.

From 1860 to 1900 occurred the great shift which, with slight modifications, has clearly delineated the permanent wheat-producing areas of the country. These areas are the level and fertile dark-soil lands in the interior of the continent, which originally supported a dense growth of tall grasses. During this period railroads were greatly improved and extended, and steamships were introduced for ocean transportation. The self-binder and the steam-driven separator completed the equipment for the most perfect system of wheat production the world has ever known. No such epoch-making developments in wheat production have occurred either before or since this period. During the period, similar changes were taking place in other lands, and especially in those regions of the southern hemisphere which are similarly adapted to wheat production and in which there were great areas of undeveloped lands.

Present Importance of Wheat in the United States.—Wheat is an important crop in this country to-day for the following reasons: *First*, it is grown by a great many farmers. In some areas in the United States wheat is almost the only source of income. About one-third or approximately 2 million farmers of the United States produce wheat.

Second, a large acreage of land is annually devoted to it. In 1921, 62 million acres were devoted to wheat, or an area equal to one-sixth of all the crop land of the country.

Third, it constitutes a large part of our domestic commerce. Normally it is fourth in value among our crops, being outranked only by corn, hay, and cotton.

Fourth, it contributes a large part of the value of the exports of the nation; and of the crops it stands second only to cotton.

Fifth, it is the national bread crop. During the War we became keenly conscious of how intimately our welfare and happiness are related to wheat. Normally our supply of wheat is so plentiful that we are almost unconscious of our dependence upon it.

Physical and Biological Factors Affecting Wheat Production

Climate.—Because of the temperature requirements of the wheat plant, the wheat-producing regions of the world are confined to the middle latitudes. For its best development, wheat needs a cool,

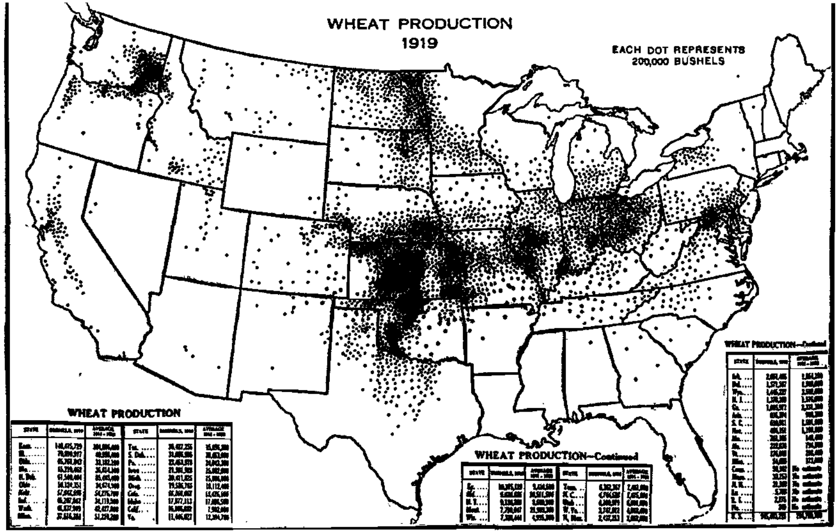


Fig. 24.—The United States produces about one-fifth of the world's wheat, as compared with three-fifths of the world's corn and cotton. The wheat crop of the United States, measured in bushels, is usually from one-fourth to one-third of the corn crop. Half of the wheat crop was grown in six states in 1919. Kansas was the leading state, as usual, but North Dakota, which has often ranked first and is usually second, had a very poor crop in 1919. On the other hand, both acreage and production were unusually large that year in the southern portion of the Corn Belt and northern portion of the Corn and Winter Wheat Region.

Agriculture Yearbook, 1921, p. 440.

moist vegetative period during which tillering and most of its growth occurs. The maturing period, on the other hand, should be warm and dry; during this time moisture must be supplied from the soil if a large yield of high quality is to be secured. If the weather during the maturing season is warm and moist, fungous diseases develop; this results in decreased yields and a poor quality of grain. In general, the climatic conditions of the maturing period determine the quality of the wheat. In areas with a relatively humid maturing season, a soft wheat, high in starch and yielding a "weak" flour, is produced; whereas the hard wheat, high in protein and growing a "strong" flour, is produced in areas where the maturing period is warm and dry.

Topography.—It is desirable that the topography be level enough to permit the use of large-scale labor-saving machinery in the preparation of the seed bed, for seeding, and for harvesting. In general, the wheat-producing lands of North America are fairly level. The Palouse region of the Northwest, however, is a section of very rolling topography.

Soils.—The dark-colored soils of the grasslands in the middle latitudes are the best for wheat production. These soils are well drained, contain a large amount of organic matter and a relatively high lime content, are granular in structure, and are fine in texture. These qualties not only make them retentive of moisture but also render them highly efficient in yielding this moisture to the growing plant. The nitrate content is relatively high, and that of phosphates and potash medium to high. Forest soils are less desirable. They give lower yields unless fertilized, and, because of the climate, produce only soft wheats. The periodic recurrence of droughts over much of the wheat area causes wide variation in the yield of wheat from year to year. This situation might be much more serious than it is, were it not for the fact that wheat production is carried on over widely scattered areas the world over, and a shortage in one part of the country or the world is usually offset by bountiful crops elsewhere. Other climatic menaces to the wheat crop are hail, hot winds, storms, and freezing temperatures.

The best wheat-producing areas are those upon which the native vegetation was originally tall grass and the color of the soils black or dark brown. Therefore, the characteristics of the native vegetation and the soil conditions of a given area constitute reliable indicators of the physical potentialities of these lands for wheat production.

Insects.—Insects cause severe losses in the wheat crop each year. The most destructive insects are the Hessian fly, chinch bug, joint worm, grasshopper, and green bug. The average losses from these pests have been estimated to be 2 per cent of the crop, or from 15 to 18 million bushels annually for this country alone.

Diseases.—Wheat is subject to many fungous diseases, chief among which are rust, smut, and scab. The loss in the United States, caused by stem rust alone, in 1916, has been estimated at 160 million bushels. The average annual loss in the wheat crop of the United States, from the various diseases mentioned, is estimated at upward of 75 million bushels annually.

Areal Distribution and Production of Wheat

The great wheat-producing regions of the world, as already indicated, are closely related to the tall-native-grass and dark-soil areas of the middle latitudes. In the United States, for example, the largest wheat-growing areas are found in the tier of states extending from Texas to Canada.

Distribution.—Here are found the mild, moist growing season and the dry, hot maturing season so admirably suited to wheat production. Similar conditions are found in the wheat belts of Argentina, Australia, Russia, and Canada.

Surplus Production.—The United States contains three important surplus-wheat-producing regions. The first of these extends from northern Texas through the western portion of Oklahoma, almost the whole of Kansas, and portions of western Missouri until it finally yields to the Corn Belt in southern Nebraska. The second region begins in Minnesota and South Dakota and extends into southwestern Canada. The third area, limited in size, but extremely productive, is found in the western portions of Washington and Oregon. Why is wheat grown in these regions? Obviously, the nature of the soil, together with the climatic factors already mentioned, has a tremendous influence. But other forces must be taken into account.

The wheat-consuming powers of the United States may have some influence, but it must be remembered that an enormous export crop is also produced. The only remaining explanation lies in the possibility of comparatively low cost of production, and an examination of this last possibility leads us into various and complicated problems.

In the first place, land in the wheat belts under consideration is comparatively cheap. Here is an advantage, but it is at least partially offset by the fact that labor costs in America are higher than in any other part of the world. The wheat farmer can escape this difficulty only by doing without labor; and, strangely enough, this is precisely the solution that has been worked out by American producers and those of the newer surplus-producing regions. By the use of machinery and by cultivating on an enormously extensive scale, the producer has

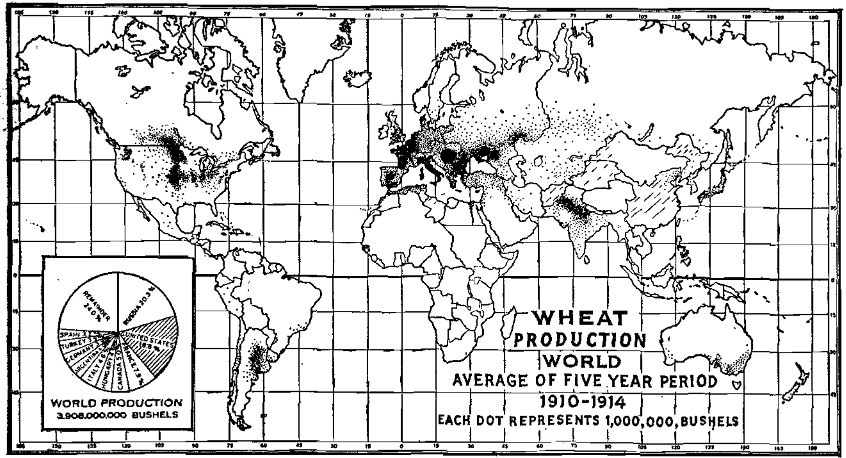


FIG. 25.—World wheat production before the War. Russia was then the greatest producer in the world and the United States was second. No satisfactory statistics of production since the War are available from some important producing countries. The North Temperate Zone produces most of the world wheat.

Agriculture Yearbook, 1921, p. 82.

literally done away with a large part of the human labor formerly required.

Only a century ago, wheat was cultivated in substantially the same way that was common in Biblical times. The scythe had replaced the sickle and had in turn given way to the cradle reaper; but sowing and reaping depended upon the labor of man. The great fields of the mid-western United States would never have been possible with this primitive technique.

The first improvement was the mowing machine, which was not entirely successful for the cutting of wheat; then in rapid succession came the power thresher, reapers which automatically bound the wheat into bundles, headers which cut only the heads and left the straw in the field, and finally the marvelous combination which cuts, threshes, and sacks the grain at one operation.[1] In the meantime gang plows drawn by power tractors came into use, and these same tractors were utilized for the operation of harrows, discs, and seeders.

The amount of human labor was reduced to a minimum, and wheat fields began to spread into the vast unused semi-arid regions. The yield per acre was comparatively low, but land was cheap and when machinery was used it cost but little more to double the acreage.

But North America still remained in an apparently disadvantageous position in so far as transportation was concerned. Surplus wheat could only be disposed of in Europe; therefore the producers were some 5000 miles from at least a part of their market. But the difficulty of reaching the European market was more apparent than real. The primary problem was to get the wheat from the fields to the American terminal markets.

The wheat industry of the United States and Canada depended largely, of course, upon the development of railroads. As the railroads moved westward, the wheat belt moved also. Many problems of railway transportation appeared and were solved. Country elevators were built to care for the crop until transportation could be provided. Concentration points were furnished with adequate storage facilities. And when problems of transportation within the continent were solved, the export difficulty disappeared.

Transportation of wheat by water is comparatively simple. With the use of machinery, wheat can be handled in bulk quite easily; and as water transportation is comparatively cheap, wheat can be sent to Europe almost as easily as it can be transported to many parts of the

[1] The use of this machine is possible only in regions where the matured heads are dry enough for immediate threshing. Most wheat requires a ripening period in the shock.

United States. Rail transportation is necessary in the case of practically all wheat grown in the United States, but a considerable amount of wheat is produced on lands in close proximity to the sea ports. The exportable surplus grain of Washington and Oregon is shipped through the ports of Puget Sound; the Great Lakes furnish an outlet for the northern United States and the Prairie Provinces of Canada; and much Texas and Oklahoma wheat finds its way to the Gulf ports.

TABLE II

WHEAT STATISTICS FOR IMPORTANT COUNTRIES

Country	Average Acreage 1909–1913 (1000 Acres)	Per Cent of World Total	Production, (1000 Bu.)	Per Cent of World Total	Yield, per Acre (Bu.)	Export, 1910–1914 (1000 Bu.)	Per Cent of Crop Exported	Imported, 1910–1914 (1000 Bu.)
Russia	57,420	21.12	607,828	16.15	10.6	164,862	27.12	556
United States *	47,097	17.32	690,108	18.34	14.7	104,967	15.21	1,808
British Indies	29,224	*10.75*	*351,841*	9.35	*12.0*	49,889	14.18	208
Russia (Asiatic)	16,789	6.17	151,113	4.01	9.0			
France	16,500	6.07	325,644	8.65	19.7	1,230	.38	44,081
Argentina	16,051	5.91	147,059	3.91	9.2	95,243	64.77	3
Italy †	11,793	4.34	184,393	4.90	15.6	3,682	1.20	56,784
Canada (for 1919–23)	9,945	3.66	197,119	5.24	19.8	95,828	48.61	448
Spain	9,547	3.51	130,446	3.46	13.7	70	....	6,262
Roumania	9,515	3.50	158,672	4.22	16.7	54,630	34.43	196
Australia	7,603	2.80	90,497	2.40	11.9	49,732	54.95	7*
Germany	4,029	1.48	131,274	3.50	32.6	23,300	17.75	91,851*
Yugo-Slavia	3,982†	1.47	62,024†	1.65	15.6			
Hungary	3,712†	1.37	71,493†	1.90	19.3	49,116	68.70	7,214
Poland	3,350†	1.23	63,675	1.69	19.0			
United Kingdom	1,899	.70	59,640	1.58	36.1	4,493	7.53	219,474*
Portugal	1,211	.45	11,850	.31	......	219	1.85	2,630
Netherlands	*138*	*.06*	*4,976*	*.13*	*36.1*	....	....	*80,702*
All others	21,98 5	8.09	324,230	8.61	......	44,881	13.84	160,809
World total	271,793	100.00	3,763,882	100.00	......	7,421,142	....	673,033

* Year ended June 30.
† Estimated for present area.

South America and Australia.—Wheat production in South America and Australia may be compared with production in North America. Labor is scarce, and modern farm machinery is utilized in order to compensate for this scarcity. Both countries produce wheat on an extensive scale, the cheapness of the land making profitable the relatively low acre yield. Both countries produce wheat principally for export. It is significant that Argentina, relatively the leading exporter of wheat, has the lowest wheat yield per acre of any country.

Russia and British India.—Russia and British India are the two great surplus-producing regions that remain for consideration, and methods of production practiced in these countries offer a striking contrast to those of the western hemisphere. Labor is cheap, and, as a consequence, labor-saving machinery is not extensively used. In spite of the cheapness of labor, however, acre yields remain at the low level which is characteristic of surplus-producing regions and extensive agriculture.

An enormous quantity of wheat is grown in western Europe, but local production falls far short of supplying the demand. The wheat of this region is grown under conditions of very high costs, due mainly to the limited supply of land and its consequent high value. Of necessity, the production of grain must be carried on intensively, but even the high acre yield alone would not make wheat growing profitable. The sole advantage of the west European grower lies in his nearness to the consuming market and his consequent relief from transportation charges.

Economic Factors in Wheat Production

Since wheat has become a highly specialized crop in regions peculiarly adapted to its production on account of favorable climatic, topographic, and soil factors, it follows that a great surplus has developed in these areas which must be disposed of in distant centers of population. As a result of this, the economics of wheat production, such as the cost of production, the place of wheat in the farm organization, and the marketing of wheat, are now as important as the technological problems of production, such as selection, breeding, and the control of insects and diseases.

Cost of Production.—The price of wheat at any given time is a result of world supply and demand conditions, and the farmer must see to it that his land, labor, and capital costs are less than the market price if he is to receive a profit. With the normal upward price trend of land, equipment, and labor in this country during the past twenty-five years, and with the opening up of virgin wheat lands of high potential productivity in Argentina, Australia, and Russia (including Siberia), the problem of keeping costs of production below the market price of wheat has been an uphill fight for thousands of American farmers, and many have fallen by the wayside. Others have wisely departed from the pioneer practice of extreme specialization and have made wheat but one of the enterprises in the farm organization.

Place in the Cropping System.—Just as wheat migrated westward and in better-adapted areas often became the sole crop, so likewise there has followed not far in its wake a westward migration of diversified farming, in which wheat occupies a position of varying importance depending largely on local conditions. In each section of the country in which wheat was at one time the exclusive crop, it was found that the continuous growing of wheat resulted in a lowered productivity of the soil, increased growth of weeds, accumulation of destructive plant diseases, and consequently a diminished yield and one of poorer quality. All of these factors contributed still more to the rising production costs, while at the same time market prices were declining.

Wheat Marketing.—It will not be possible here to go into all the questions connected with the marketing of wheat. Nevertheless, there are certain fundamental considerations connected with the farmer's disposal of his crop that can not be neglected. It is reasonably safe to say, perhaps, that in the past the farmer has not been directly interested in the marketing process. The price of his product is without doubt his chief concern, but a great many things affect the price which are beyond the farmer's control, and as a consequence he is being forced more and more to look beyond the limits of his individual farm.

The class [2] and quality of wheat are also reflected in the price. The class of wheat grown is determined by the nature of the soil and climatic conditions; hence it is largely beyond the control of the farmer. The same thing is true of the quality of the grain, but proper care will often offset the effects of adverse climatic conditions.

In addition to the division of wheat into classes and sub-classes, a further classification is made on the basis of weight per hushel, moisture content, percentage of damaged kernels, purity, cleanliness, and condition. Five numerical grades are used, and grain failing to meet the specifications of any of these is termed "Sample Grade."

The importance of this grading and classifying is evident. Wheat can be sold by description, a statement of quality is always assured, and trading is greatly facilitated. In addition to these advantages, a premium is placed upon high-grade wheat, and the farmer is encouraged to grow a superior product.

The various other factors that affect the price of wheat are the general level of prices, the cost of transportation, and the relation to the world's supply. Any agency that attempts to predict the price of wheat must collect information which will enable it to anticipate these factors. At the present time this information is collected most accurately by the organized grain exchanges, but there is no reason to believe

[2] Under the official Wheat Standards of the United States, wheat is divided into the following commercial classes: (1) Hard Red Spring, (2) Durum, (3) Hard Red Winter, (4) Soft Red Winter, (5) Common White. The above classes are further divided into various sub-classes.

that other organizations, for example, producers' coöperatives, could not perform this function equally well. Most of the grain that is consumed outside of the country in which it is produced is now marketed through the organized exchanges. Coöperative marketing, however, is increasing in importance, and a complete consideration of marketing would necessarily involve a careful study of this growing institution.

Marketing Problems. International Aspects.—As already indicated, our chief competitors in wheat production are Canada, Argentina, Russia, and Australia. Since the War, Russia has been the unknown factor in the world wheat situation. A most important economic question is how the future demand for our wheat will be affected by the return of Russia to her former place in international trade. Will Russia come back, and how rapidly? The question of how far Canada, Argentina, and Australia can continue to increase their acreage and production is also very important to us.

Exports.—The United States has exported a surplus of wheat in every year of its history except 1836. International trade in wheat on a large scale may be said to have begun in 1850 in which year the repeal of the British Corn Laws went into effect. At this time practically all of the wheat of the United States was produced east of the Mississippi River and there usually was not a large quantity available for export.

The Civil War cut off the southern market for northern wheat and a good demand in Europe at the same time caused a large increase in the exports during those years. Following this war there were a few years of small exports, but by 1869 they had returned to the Civil War level. Exports increased rapidly from 1866 to 1880, after which there was a decline until 1890. This was followed by a period of large exports until 1902. From 1878 to 1902 was the great surplus-producing period of the development of wheat production in the United States. From 1903 to 1913 the exports were much smaller than in the previous decade.

The exports of the recent war period seem very large, but in the percentage of the total of the crops produced they have not been greater than the exports of the period from 1880 to 1900. It is probable, however, that the future will show a continuation of the pre-war trend of the years 1903 to 1913 inclusive.[3]

Tariff.—Since wheat is a surplus crop, it follows that a tariff can benefit the wheat grower to only a limited extent if at all. The Spring wheat growers, however, have long felt that a tariff on Canadian wheat was necessary to their welfare, and as a result such a tariff has existed for a number of years. Space forbids our entrance into a discussion of the interminable tariff controversy, either in the case of wheat or of any other farm product. The tariff problem, however, promises to become of increasing importance to the agricultural industry.

[3] Agriculture Yearbook, 1921.

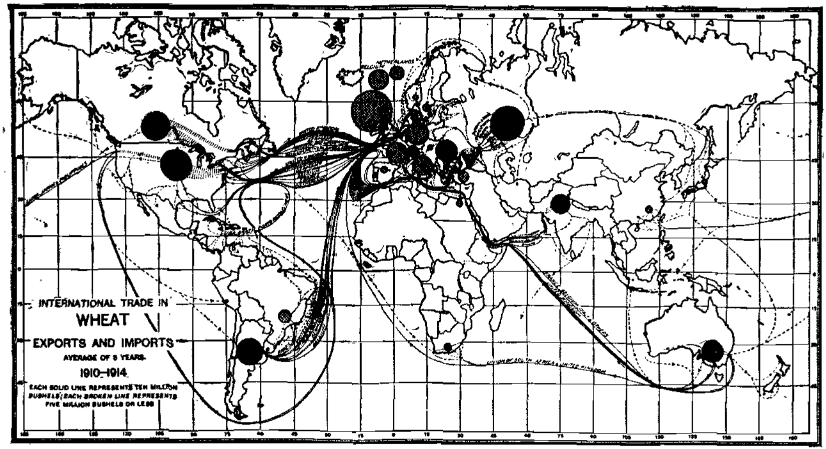


FIG. 26.—International trade in wheat before the World War, showing surplus production, trade routes, and destination. The two hemispheres are fairly well balanced in production. Western Europe is the great purchaser. Exports are represented by solid black circles; imports by shaded circles.

Agriculture Yearbook, 1921, p. 156.

Situation and Outlook.—During the past ten years the wheat growers of the nation have experienced the most extreme vicissitudes of fortune. During the War the Government food-control policy and appeals to patriotism stimulated the farmers to create the greatest wheat acreage in the history of the country. Post-war deflation and the economic paralysis of our greatest customer, Europe, left us with a huge surplus of wheat during the first three years of the present decade, with a consequent abrupt decline in prices. Economic recovery in Europe, combined with rather universal unfavorable climatic conditions during the past two years, has greatly strengthened the wheat market. Just how far the present favorable situation of the wheat grower is attributable to chance, and how far to permanent causes is still a matter of conjecture.

CORN

Introductory.—Unlike wheat, corn has, comparatively speaking, only recently played an important part in the economy of man. Indigenous to the highlands of tropical America, it was the earliest cultivated crop on the American farm. The Indians taught the first white settlers how to raise corn and how to prepare it for consumption. At first the implements and methods of culture used by the settlers were as crude as those of the Indians themselves, but improvements were soon introduced and corn soon became one of the mainstays of the early colonists and of the later pioneers in their conquest of a continent.

There were three reasons for the immediate popularity of corn in colonial days: first, accumulated seed was available; second, corn furnished food for man and for animals; and third, it was the most adaptable and best-yielding crop for newly cleared land.

As the westward migration gained momentum and the Appalachian mountain system was crossed, corn took on new economic importance. It came to be less and less important as a food for direct human consumption and became increasingly important as food for livestock.

Present Importance of Corn.—Although it is the most recently developed of the grain crops, corn is perhaps the most important agricultural crop of the Western hemisphere. Almost unknown in many parts of the world, this grain surpasses all other crops of the United States in both value and acreage. In Mexico, Central America, and a large portion of South America, it is the mainstay of the human diet. Corn is not primarily a commercial crop, and it is of little significance in international trade; but in those countries which devote a large part of their agricultural energy to its production, it is tremendously important.

Except in countries having a relatively low standard of living, corn

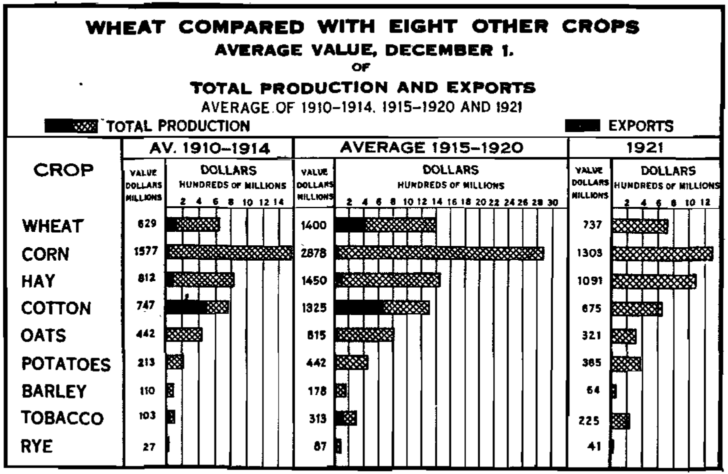


FIG. 27.—Comparative average value of wheat and eight other crops. Wheat ranked fourth in value in the eleven years, 1910 to 1920, and third in 1921, when the value of all crops had shrunken greatly. Wheat ranked second in value of crops exported.

Agriculture Yearbook, 1921, p. 80.

is not to any great extent utilized as human food. This is true largely on account of the fact that light or leavened bread cannot be made from it, and on account of its relative unpalatability, especially when cold. In the United States, for example, 85 per cent of the crop is fed to livestock and only 10 per cent is utilized as human food. In addition to the corn that is used as grain, a great deal of the crop is converted into fodder and silage, and for this reason it is closely related to the production of dairy products as well as to the beef and hog industry.

Physical and Biological Factors Affecting Corn Production

Climatic Factors.—The area of land well suited for corn production is relatively limited. This is due largely to the fact that corn is very sensitive to climatic factors. Of these factors, rainfall and the length and temperature of the growing season are the most important. Corn production on a large scale is excluded from many sections because of the likelihood of protracted droughts, especially during the pollination and maturing period; and from many other sections because of the lack of a sufficiently long and warm frostless period. The former condition limits its successful extension into the West and Southwest; the latter, into the North and Northwest portions of this country.

Soils and Topography.—Somewhat less of a limiting factor, although very important, is the character of the soil and the nature of the topography. The surface of the corn-producing lands should be smooth enough to permit the use of labor-saving machinery and to prevent destructive erosion. For the highest and most profitable yields, corn requires a fertile and well-drained soil containing a high percentage of organic matter. In the United States these conditions are best fulfilled in the dark-colored grassland soils in the central part of the country. These dark-colored Prairie soils constitute the heart of the American Corn Belt. Although corn is grown outside of this region, the percentage of the land used for this crop is less and the acre yields much lower unless fertilizers are extensively used.

Insect Enemies.—Corn is less subject to destruction by insects than are wheat and many other grains; yet the loss from this source, on the average and in the aggregate, is very great. The principal insect enemies of corn in the Corn Belt and the Mississippi Basin States are the chinch bug, the corn ear worm, white grubs, and the corn root aphis. Grasshoppers also sometimes do some damage, and in 1917 the European corn borer was first observed in Massachusetts, where it did considerable damage. This very destructive pest has since migrated as far west as Ohio, and efforts are being made by the Department of Agriculture to prevent it from being carried farther westward.

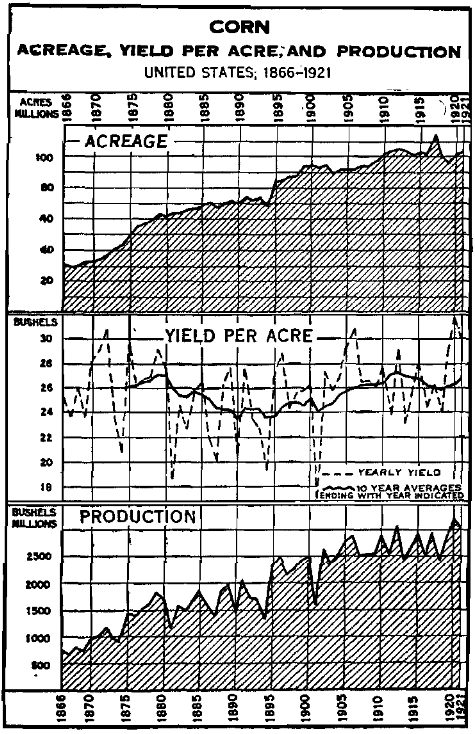


Fig. 28.—Acreage and production of corn have increased rather steadily sinc 1866. Production has fluctuated from year to year much more than acreage, becaus it depends not only on acreage but also on yield per acre, which has fluctuated largel in different years. Upward and downward trends, however, have occurred in yiel

griculture Yearbook, 1921, p. 169.

Disease.—The most destructive and widespread diseases of corn in the United States are common smut and the root, stalk, and ear rots. Of these the common smut, which is carried by a parasitic fungus, produces the heaviest losses. It has been estimated that the annual loss due to smut averages 80 million bushels or nearly 3 per cent of the total crop. No practical method of combating this disease has yet been developed. Development of smut-resistant strains seems to offer the best insurance against losses from this source.

The estimated losses from root, stalk, and ear rots average annually about 125 million bushels. The most effective methods of control for these diseases are seed treatment, crop rotation, and upbuilding of the soil by proper practices, especially by the addition of lime and phosphates where necessary.

Areal Production and Distribution of Corn

Corn can be grown in many parts of the United States; but it has long been realized that the region lying between Ohio and Kansas, bounded on the south by the line of the Ohio River and on the north by South Dakota, Minnesota, and Wisconsin, produces this grain most successfully. This American Corn Belt possesses climatic advantages over perhaps any other producing region, although corn is produced extensively in other parts of the world. The Corn Belt soil is fertile, generally uniform throughout its extent, and free from large stones. For these reasons it is easily tilled. Rainfall is generally adequate and well distributed, but an occasional drought occurs, which greatly diminishes the yield.

Although less than half of the total cultivated land is devoted to corn production, the agriculture of the Corn Belt is built around this grain. Considerable livestock is raised within the Corn Belt and much more shipped in from the West and South for fattening. In this way the grain is utilized most economically, and transportation costs, which are very important on account of the relative bulk of corn, are greatly reduced. The remaining cultivated land is devoted mainly to the production of hay and small grains. These additional crops provide for a rotation scheme, and in addition they help to distribute labor over the entire year.

Most of the corn grown is consumed in the producing area, but surplus-producing areas are found, notable among which are Iowa and northern Illinois. A small amount of corn is shipped to the eastern and southern United States. Practically all districts in the country that lie outside the Corn Belt are deficiency-producing areas.

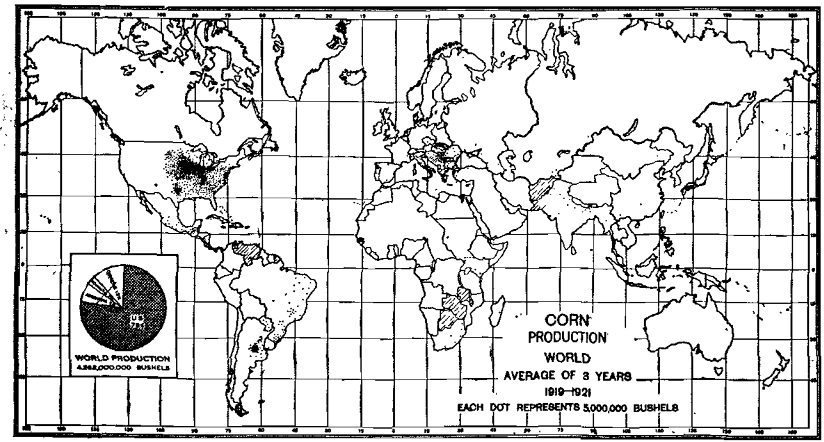


FIG. 29.—The United States produces three-fourths of the corn crop of the world. Corn is an important crop in Argentina, Brazil, Mexico, South Africa, India, and southern Europe. Its northern limits are found between 45° and 50° latitude north, and its southern limits between 30° and 40° latitude south. Quantity and distribution of summer rainfall are important factors in production within these limits.

Agriculture Yearbook, 1921, p. 167.

The only country competing with the United States in corn production is Argentina, which has increased its corn production steadily for the past twenty years. This augmented production is due to the progressively increased use of land suitable for corn production and the increasing tendency toward intensification of agriculture. Mexico and the northern states of South America produce a considerable quantity of corn, but there is little possibility that any of these countries will ever produce for export.

Corn is produced in Argentina by methods similar to those practiced in the Corn Belt of the United States. But in the other South American countries and in Mexico there are no great level expanses of corn land. The fertile valleys are not extensive, and corn is frequently grown in plots only slightly larger than kitchen gardens. However, almost all the corn produced in these countries is utilized for human food and practically none is fed to livestock.

The chief remaining corn-producing regions are found in Italy, the lower Danube Valley, in Russia, Hungary, and the Balkans. This territory does not produce for export, and a large portion of the total crop is consumed as human food. Production is carried on intensively, and a considerable amount of labor is required.

Economic Factors

Cost of Production.—The cost of producing a bushel of corn varies greatly, not only from section to section but from state to state, and even from farm to farm. This may be accounted for by differences in farmers, quality of land, and cost of labor and equipment. During the War the cost factors entering into corn production increased less rapidly than corn prices and consequently corn growers made a profit. The decline in corn prices due to post-war deflation was much greater and more abrupt than was the decline in costs of production. The result was that corn growers have been in a serious plight for a number of years and only recently have conditions shown any material improvement.

Cropping System.—Only limited areas in the Corn Belt are devoted to the production of corn to the exclusion of other crops and livestock enterprises. In the main, good corn-producing areas are associated with small grain crops and tame hay, raised largely for purposes of proper crop rotation and soil improvement. Livestock, especially hogs and beef cattle, occupy a prominent place in the organization of a Corn Belt farm. Intertillage crops, which compete with corn for labor and capital, play an inconspicuous part in the farming of this section of the country.

TABLE III

CORN STATISTICS FOR IMPORTANT COUNTRIES

Countries	Average, 1909-1913 *(1000 Acres)*	Per Cent of World Total	Production, 1909-1913 (1000 Bu.)	Per Cent of World Total	Yield per Acre (Bu.)	Exports, 1910-1914 *(1000 Bu.)*	Per Cent of Crop Exported	Imports, 1910-1914, *(1000 Bu.)*
United States	104,229	64.92	2,712,364	69.63	29.6	41,409*	1.52	2,699*
Roumania	9,644†	6.01	193,209	4.96	20.0	46,998‡§	24.32	364‡§
Argentina	8,710	5.43	191,698	4.92	22.0	115,749†	60.38	2†
Mexico	6,093‖	3.80	133,362	3.42	21.9	7‖	......	1,120
British India	5,898¶	3.67	82,620	2.12	14.0			
Yugo Slavia	4,786†	2.98	111,897	2.87	24.9			
Italy	4,090†	2.55	102,676†	2.64	25.1	268	00.26	14,771
South Africa	2,290‖	1.43	33,517¶	.86	14.6			
Hungary	*2,192†*	*1.37*	*60,813†*	*1.56*	*27.7*			
Russia	2,031†	1.27	36,982†	.93	17.0	28,354	76.66	299
United Kingdom	....	.....	....	.....	.....	115**	.....	80,441
Germany	6†	.....	....	.....	27.7	2*	.....	32,056
Netherlands	....	.....	....	.....	.....	8,641	....	30,377
Belgium	....	.....	....	.....	.....	8,238	...	25,818
Other countries	10,579	6.59	237,017	6.09	......	14,289	......	80,523
World total	160,548	100.00	3,895,565	100.00	......	264,070	......	268,470

* Year ended June 30, from original sources.
† *Estimated for present territory.*
‡ International Institute of Agriculture.
§ Three-year average.
‖ One year only.
¶ Two-year average.
** Year ended December 31.

Marketing.—Although corn is not primarily a commercial crop, a large absolute quantity (which is of course a small percentage of the total crop) enters into foreign and domestic trade. By far the greatest portion of the corn that is produced in the United States, however, is marketed in the form of meat, and we must look to the problems connected with the marketing of meat in order to see the full significance of corn marketing.[4]

Corn is sold almost entirely by grade, six standard numerical grades having been established by the Federal Government. It is obvious that the grades have an influence upon the price. Quality, with particular reference to the moisture content, has an even greater influence, because corn having a high moisture content will undergo considerable shrinkage during storage. This fact accounts in part for the regular seasonal variation in prices. Corn is almost always cheapest at harvest time, and the tendency is toward a gradual increase in price until the begin-

[4] See "Marketing of Hogs."

ning of the next harvest season. Obviously the price of meat, the general level of prices, and the supply of corn are the most important factors affecting the price of corn.

International Trade in Corn.—During the past thirty years the total production of corn in the United States has increased approximately from 2 billion to 3 billion bushels. The percentage of the crop exported, however, has tended to decline on account of the increased consumption of corn by meat animals. Thus 10.3 per cent of the crop was exported in 1899, while by 1907 the figure had dropped to 3 per cent, which has not since been exceeded.[5]

The corn exports of the United States go mainly to Europe. The United Kingdom receives almost one-third of the exports; Germany, one-sixth; and Canada, the Netherlands, Denmark, Belgium, Cuba, and Mexico receive smaller amounts.[6] Except in Cuba and Mexico, this grain is used in the feeding of livestock. A few million bushels of particular grades of corn are imported annually into the United States from Argentina. This grain is utilized mainly for the industries and in the manufacture of poultry feed.

The importance of Argentina in corn production arises from the fact that a large portion of the crop is exported. Between 1910 and 1920 Argentina exported almost twice as much corn as did the United States although production in the latter country was more than thirteen times as great. Most of the South American corn goes to Europe where it enters into competition with grain from the United States. Argentine corn seems to be preferred by European buyers in spite of its slightly higher price.[7]

Outlook.—So far as North America is concerned, increased production of corn is probably dependent upon increased yield per acre. Most of the good corn land is occupied, and although there is much land in the Corn Belt that is devoted to other crops, the whole system of Corn Belt agriculture is dependent upon this arrangement and it is not likely to be disturbed. The incentive for increased production, moreover, must come from an increase in the consumption of meat, and although the total consumption of meat will almost surely increase, there is every reason to believe that this increase will be slower than it has been in the past.

A recent attempt has been made to increase the consumption of corn products in Europe. Naturally this plan has been partially successful during the post-war period of relative poverty; but the food habits of

[5] The Corn Crop, Agriculture Yearbook, 1921.

[6] *Ibid.*

[7] *Ibid.*

a people are remarkably tenacious, and a greatly increased consumption of corn can not be expected from this source.

Argentina is capable of increasing production to some degree, and the increasing labor supply in that country may have a tendency toward increasing the acreage of corn. However, the forces which influence the production and consumption must be evaluated as they occur. Trends in the cost of production, general prosperity, acre yield, and population must all be taken into account by the producer who would adjust his production to the probable consumption. And the prosperity of the corn producer is largely dependent upon such an adjustment.

RICE

General Considerations.—Probably more important than either wheat or corn, in the number of people who depend upon it for food, is rice. Since the dawn of history, rice has been the principal food of millions of Oriental peoples, and a failure of the crop generally means starvation to large numbers of them.

Rice is particularly important from the standpoint of land utilization, for, without this crop which thrives only in regions of excessive rainfall, great areas of fertile land would be useless for grain production. It is well known that wheat requires a dry summer, and that corn does not produce abundantly in a tropical climate; but, fortunately, the best physical environment for rice includes wet summers and general tropical conditions. In addition, the grain, unlike other cereals, is able to withstand warm and humid conditions in which other grains would decay or rot quickly. Of further importance in land utilization is the relatively high yield of rice. In the United States the yield of this grain is more than twice that of wheat, and in a country of dense population this adaptability to intensification is very important indeed.

Although numerous varieties of rice are recognized, the grain may conveniently be divided into two classes; upland rice and swamp rice. The former requires abundant rainfall, but the latter type, which is more extensively grown and yields more than twice as much as upland rice, must literally be grown in the water. Consequently, topography has an important bearing upon the type of grain produced, and in rolling or hilly country swamp rice can not be produced unless there is provided some means, such as terracing, whereby a uniform depth of water can be retained on the fields.

Because of the water requirements, it is desirable that rice fields be underlain by an impervious substratum which retards the free drainage of the irrigation water.

Distribution and Production

China is perhaps the most important rice-producing country of the world, but accurate statistics, either of production or of acreage, are not available. In spite of the large production, however, the exportation of this grain is forbidden by law and very heavy imports are sometimes made necessary by the domestic demand.

Both upland and swamp varieties of rice are produced in China, with the latter type predominating. Along the level coastal country and the river-basin areas of middle and southern China the topography and climate are ideal for the growth of the swamp variety. However, the large and cheap labor supply has made it possible to grow this type of grain far into the interior. Gentle sloping country has been terraced with infinite care, and the side of a hill will often be covered with dozens of tiny fields, separated by the embankments which hold the water supplied by irrigation. The means of supplying irrigation water is generally quite crude, and sometimes water is simply drawn up in buckets from a well or stream and dumped into troughs which carry it to its destination. The small fields are, of course, not adapted to the use of farm machinery, and practically all labor is performed by hand. Only the extreme cheapness of labor, due to the very dense population, makes such methods of production feasible.

India.—The monsoon climate of India, with the accompanying heavy summer rainfall, causes large areas of this country to be well suited for rice production. Although large portions of India are devoted to other crops, rice is by far the most important crop of this densely populated country both in production and in consumption. India, including Burma, produces 70 per cent of the world's rice crop excluding that of China. The population is dependent largely upon rice for its food supply, but in spite of the densely populated territory some rice is exported. In Burma the population is relatively less dense; consequently, more of this cereal is exported from that country.

Rice is produced in India in a manner similar to that practiced by the Chinese. An abundant and cheap labor supply is available, and rice is generally cultivated in small plots and by hand labor. There are a number of rice-producing regions in India, but the most important one is found in the lower valley of the Ganges. Here the land is very fertile and relatively costly on account of the density of population in relation to the limited land supply. Consequently, intensive culture is practiced and a high yield of superior grain is produced.

Java.—Rice is a very important crop in Java, constituting the main food for the millions of people inhabiting this small island.

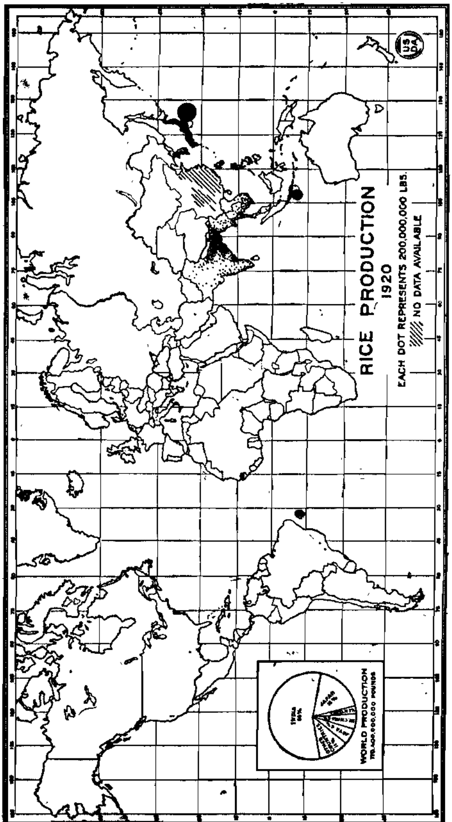


FIG. 30.—Most of the rice crop is grown in the tropical and subtropical countries of the Eastern Hemisphere. The greatest centers of production are in eastern and southeastern Asia and nearby islands, especially Japan and Java. India alone produces over half of the rice of the world, excluding China. The United States has contributed about 1 per cent of the world production since 1918.

Agriculture Yearbook, 1922, p. 513.

TABLE IV

RICE STATISTICS FOR IMPORTANT COUNTRIES *

Countries	Average 1909–1913 Acreage (1000 Acres)	Per Cent of World Total	Production (1000 lbs.)	Per Cent of World Total	Yield per Acre (Bu.)	Export, 1909-1913 (1000 lbs.)	Per Cent of Crop Exported	Imports, 1909-1913, (1000 lbs.)
India	67,004	63.84	64,144,192	58.24	957	5,337,516	8.32	278,272
French Indo-China	8,550	8.15	7,332,350	6.66	858	2,288,040	31.20	41
Japan	7,300	6.95	15,787,020	14.33	2163	61,936	.39	655,676
Java and Madura	5,953	5.67	7,180,998	6.52	1206			
Siam	4,666	4.45	5,447,671	4.95	1168	1,928,507	35.40	
Korea	2,905	2.77	3,292,776	2.99	1133	1,304,446	3.96	17,830
Philippine Islands	2,753	2.62	1,165,293	1.06	423	4		412,718
Madagascar	979	0.93	896,300	0.81	916			
United States	716	0.68	660,272	0.60	922	16,215	2.46	200,814
Ceylon	695	0.66	476,536	0.43	686	....	....	821,654
Italy	358	0.34	646,470†	0.59	1806	142,239	22.00	4,415
All others ‡	3,082	2.94	3,107,878	2.82	....	2,815,942	90.60	9,317,802
World total	104,961	100.00	110,137,756	100.00	.....	12,720,845	.....	11,439,950

* The following are harvested in the southern hemisphere within the calendar year, India, Japan, Java and Madura, Formosa, Dutch Guiana, Spain, and Italy.

† Estimated for present boundaries.

‡ This does not include China, for which statistics are not available.

Siam and Indo-China.—Over large areas in Siam and Indo-China, the character of the land has made possible the extensive production of rice. Because of their relatively less dense population, these countries, like Burma, have large quantities of this cereal available for export.

Japan and the Philippines.—Japan and the Philippines also produce large quantities of rice. Methods of production are similar to those of India, the cheap labor supply, which is characteristic of the Orient, causing an intensity of culture. Land is generally more costly in Japan, and intensification is, therefore, carried to an extreme degree. Rice is also grown in the delta of the Nile, but this crop has made little progress here, on account of the superiority of other crops, and the economic needs of England, which directs the agricultural development of Egypt.

Small quantities of rice are grown in various parts of Europe, but the only important producing region is the upper valley of the Po in Italy. Italy produces almost the same amount of rice as does the United States.

United States.—Although the United States lies wholly within the middle latitudes, rice has been cultivated continuously in this country since the beginning of the eighteenth century. In comparison with the world supply, production in the United States is insignificant, but nevertheless 75 per cent of domestic consumption is grown at home.

Methods of production are in striking contrast to those found in the Orient, for in this country a cheap labor supply is not available, and cultivation must be carried on in such manner as to utilize machinery whenever possible. Power pumps are used for irrigation, and the fields are so arranged that cultivators and other implements can be driven over the low dikes that retain the water supply. Ordinarily, rice is harvested and threshed by machinery similar to that used for wheat, and by these various appliances, unknown in the Orient, the necessity for a large supply of labor is done away with.

There are at present three important rice-producing sections in the United States. The first and oldest of these lies in the tidal delta regions of Georgia and South Carolina. In this district there is an abundance of fresh water available from the sluggish lower portions of the rivers, and topography is so even that no difficulty is experienced in keeping the soil sufficiently moist for successful rice growing. This was for many years the most important rice-producing region of this country, but because large-scale labor-saving machinery can not be used in this section it can not compete with the other rice-producing areas of the country.

In eastern Louisiana, the swampy bottom lands traversed by numerous bayous form the basis of a profitable rice-growing industry. Most of the land is underlain with water, and, although drainage is difficult, the network of streams and drainage canals takes off a large quantity of the surplus water with a minimum of labor.

The most important producing region, and the one most capable of increasing production, is found in the level lands of southwestern Louisiana and eastern Texas. The soil here is excellent for rice growing, as a light top soil is underlain with a clay which holds water admirably. Water is not so easily available as in some other sections, but shallow wells equipped with power pumps make irrigation relatively inexpensive. It is in this territory that machinery is most extensively used, for the ground is generally dry at harvest season, and consequently heavy machinery can be used with ease.

The only other producing areas in the United States are found in eastern Arkansas in a region similar to eastern Louisiana, and in the valley of the Sacramento in California.

Outlook

There is little reason to suppose that the rice acreage of the world will be materially increased in the near future. Most of the land suitable to rice production is now occupied by this crop, and rice can not be grown successfully except under special climatic conditions. On the other hand, there is little chance that the acreage will decline, for the Oriental peoples could hardly substitute another crop that would furnish a sufficient food supply.

Long years of the most intensive cultivation have developed the crop far beyond the point that has been attained by other cereals, and for this reason an increased supply through a larger acre yield is hardly possible. The United States has some land, particularly in the Texas region, that could be utilized for rice growing, but the possible increase in supply from this source is relatively insignificant. Production of rice has probably reached a position more stable than that of any other important grain.

OATS

Introductory.—The United States leads the world in the production of oats, but, prior to the World War, this position was maintained only by virtue of an acreage yield which was higher than that of Russia. The latter country annually planted almost 42 million acres in oats, thus exceeding every other country. At the present time it is almost impossible to estimate Russia's production. The acre yield of practically every important producing country except Russia, however, exceeds that of the United States. This is explained in the case of the European countries by the intensity of culture; but in Argentina, Canada, and other countries of the western hemisphere, a soil suitable for the production of the prolific varieties seems to furnish the explanation.

Regions of Production.—Oats in general require a cool, moist climate for their vegetative development. They will withstand and mature in a more humid atmosphere than will wheat. The oats regions of the United States occupy the territory contained in, or contiguous to, the northern margin of the Corn Belt. Practically all of the oats grown in this country are produced east of the tier of states that contain the Spring Wheat Belt. The two other important oats regions are found in western Europe and in east central Russia. An increasing acreage of this grain is being planted in Argentina.

Importance of Oats.—Oats have many advantages to recommend their culture. In the first place, the grain is traditionally the bone and muscle builder among the feed crops. Work horses and breeding stock seem to thrive better on oats than on corn and other fattening feeds. Then, too, oats under normal conditions yield a large amount of grain per acre. And, what to some types of farm organizations is most important of all, oats require little care or labor in the various phases of pro-

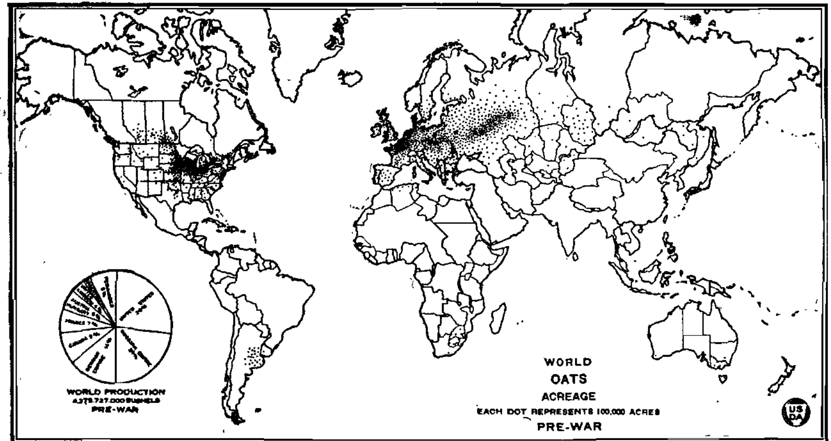


FIG. 31.—Pre-war oat acreage and production of the world. The United States led in acreage then, with Russia a close second. Germany, Canada, France, and Austria-Hungary followed in the order named. Complete postwar statistics are not available from several important producing countries. Like wheat, most of the world oats is produced in the North Temperate Zone.

Agriculture Yearbook, 1922, p. 470.

duction. This fact is important because oats can be used to fill out various crop-rotation schemes, particularly those that are found in the Corn Belt. The rotation plan can be carried out, and a minimum of labor is taken away from the care of the cash crops and animal industries.

TABLE V

OAT STATISTICS FOR IMPORTANT COUNTRIES

Countries	Acreage (1000) Acres)	Per Cent of World Total	Production (1000 Bu.)	Per Cent of World Total	Yield per Acre (Bu.)	Export, 1910-1914 (1000 Bu.)	Per Cent of Crop Exported	Imports, 1910-1914 (1000 Bu.)
United States	37,357	26.25	1,143,407	25.57	30.6	9,655*	0.84	5,352*
Russia †	35,514	24.95	817,231	18.27	23.0	70,466	8.62	1,206
France	10,084	7.09	368,462	8.24	36.5	122*	0.03	29,846*
Canada	9,597	6.74	351,690	7.86	35.6	14,771	04.20	90
Germany	9,529	6.70	527,178	11.79	55.3	33,575*	15.36	37,202*
Russia (Asiatic)	5,742	4.04	107,687	2.41	19.0	‡	......	‡
United Kingdom	4,040	2.84	206,589	4.62	52.1	1,591*	0.78	68,371
Austria	883	0.62	29,030	0.65	23.8	114	0.39	2,295
Netherlands	346	0.24	18,070	0.40	52.2	30,771	......	38,862
Switzerland	81	0.06	4,784	0.11	29.1	13	0.27	12,464
All others	29,131	20.50	898,146	20.08	......	78,096	8.69	36,296
World total	142,304	100.00	4,472,274	100.00	......	239,174	100.00	226,984

* Year ended June 30, from official sources.
† Including Ukraine and Northern Caucasia.
‡ Included in Russia.

Oats are also used in the preparation of human food, and are considered to be as nourishing to growing children as they are to young livestock. In this country about 3 per cent of the total crop, which means an enormous absolute amount, is utilized for human food. In various European countries, particularly in the United Kingdom, the percentage used for human consumption is much greater.

Marketing.—The marketing of oats presents no great problems, for the reason that this grain enters into commerce to a very limited extent. However, the census data indicate that slightly less than one-third of the total crop is sold outside of the territory in which it is grown. The Federal Government has established grades for oats, and all grain that passes through the terminal markets is graded by licensed inspectors. International trade in oats is practically non-existent.

Outlook.—The tendency in the United States is for oat acreage to increase. The same thing is true in Argentina, the greater necessity for rotation schemes being responsible for the trend in both cases. In

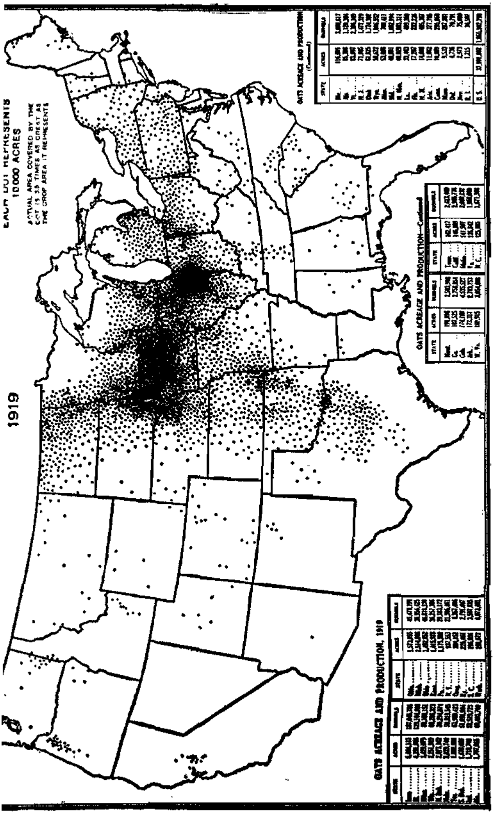


FIG. 32.—The Oat Belt of the United States consists of a crescent-shaped area extending from New England to North Dakota, bounded on the north by the Great Lakes and on the south by the Corn and Winter Wheat Region. An arm extends south-westwardly from this belt across eastern Kansas and Oklahoma to central Texas. Oats prefer a cool, moist climate, and this large acreage in the Corn Belt and southwesterly is owing more to the need of feed for horses, and of a spring grain nurse crop for clover, than to particularly favorable climatic conditions. In the Southern States most of the oats are fall sown, but in the North the oats are sown

Europe the acreage is fairly stable. The production of oats fluctuates very widely on account of the variation in acreage yield from year to year, but there is a tendency toward greater world production due both to increasing acreage and larger yields per acre.

BARLEY

General Considerations.—Barley is a particularly significant grain crop in spite of the fact that it is much less extensively grown than wheat or oats. Its significance lies in the possibility of its successful cultivation in regions where almost none of the other grains will mature. Barley has a comparatively short growing season; for this reason it is grown in high latitudes, and in regions where sufficient rainfall is found during only a few months of the year. This crop thrives on soil too poor for wheat or oats, and for this reason it makes a valuable feed crop for those farmers who are unable to grow other grains.

Uses.—A second important feature in barley production is its use in the preparation of malt and malt extracts. Only special types of this grain are used for this purpose, however, and the total amount used is a small proportion of the world's crop. Barley is also used as human food, and in some countries, notably Algeria and Japan, it furnishes an important part of the total food supply. The most important use, however, is as a feed for livestock, and the trend in total production will probably be dependent upon its increasing or decreasing usefulness for this purpose.

Before the World War, Russia was the greatest barley producer, and normally more than 25 per cent of the crop was exported. As is the case with wheat, the disorganization of that country's agriculture has resulted in uncertainty as to what the world can expect in the future production of barley. With the large amount of land available, however, it is certain that Russia will in the future tend to approach prewar production.

World Production.—The greatest per capita production is found in the north of Africa. This is true because there are only a few months of the year in which the rainfall of this region is sufficient for the growing of crops. Barley is sown in order to utilize this short season. It is also an important crop in Japan and India, where it is grown in the cool season as a supplement to the rice crop. Ordinarily, only a slight surplus, if any, is produced in these countries for export.

In almost every part of Europe some barley is produced, but no European country except Russia has ever been a conspicuous exporter of this grain. England, however, produces a bright barley that is preferred

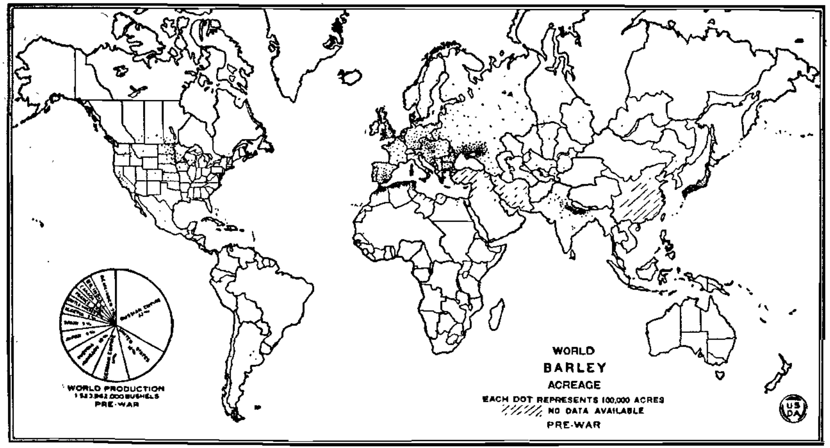


FIG. 33.—World pre-war acreage and world production of barley. No statistics were available for China, Persia, Asia Minor, and part of northern Africa. The four great centers of production are seen to be in southern and western Europe and northern Africa, the United States, British India, and Japan. Complete statistics are not available for many of the large producing countries, notably Russia, since the War.

Agriculture Yearbook, 1922, p. 487.

for malting, and a large quantity of this particular type of grain is utilized by the other countries of Europe.

TABLE VI

BARLEY STATISTICS FOR IMPORTANT COUNTRIES

Countries	Average 1909–1913 Acreage (1000 Acres)	Per Cent of World Total	Average 1909–1913 Production (1000 Bu.)	Per Cent of World Total	Yield per Acre (Bu.)	Export, 1910–1914 (1000 Bu.)	Per Cent of Crop Exported	Imports, 1910–1914 (1000 Bu.)
Russia (Europe)	23,281	28.58	381,235	22.43	16.4	173,240	45.44	124
British India	8,877	10.90	145,496	8.56	16.4			
United States	7,620	9.36	184,812	10.87	24.3	7,896*	4.27	
Spain	3,510	4.31	74,689	4.40	21.3	113	0.15	690
Germany	3,464†	4.25	133,787†	7.87	38.6	136	0.10	148,297*
Algeria	3,395	4.17	45,974	2.70	13.5	5,482	11.92	213
Japan	3,042	3.74	89,531	5.27	29.4	....	......	15
United Kingdom	1,845	2.27	65,341	3.84	38.9	101‡	0.15	48,550*
Hungary	1,322†	1.62	32,369†	1.90	24.5	11,636	35.56	229
Austria	421†	0.52	10,065†	0.60	23.9	8,123	80.70	716
Belgium	88†	0.11	4,446†	0.26	50.5	3,079	69.25	18,351
Netherlands	68	0.09	3,270	0.20	48.1	26,975	......	38,039
Other countries	24,502	30.08	528,612	31.10	..	43,639	8.25	17,745
World total	81,435	100.00	1,699,627	100.00	......	280,020	.....	272,969

* Calender years 1909-1913.
† Estimated for present territory.
‡ Year ending June 30th.

In the United States.—Barley is increasing in importance in the United States, this tendency being the result of more careful land utilization. A considerable amount of land in California, no longer well suited for wheat production, is being planted to barley, and the increasing acre yield has justified the change. Then, too, California produces the bright variety which is sought by brewers, and for this reason the crop is normally marketed without coming into competition with the feed types.

The most important producing region in the United States is found, however, in the Dakotas, Minnesota, and Wisconsin. In this district the grain is produced primarily as a feed crop, and in many cases it is sown only after some other crop has failed. The feeding value of barley is somewhat in dispute among the farmers of this region, but it is significant to notice that an increasing amount of the grain is planted as a first crop. This increase has come about with the realization that all land will not continue to produce the same grain without diminishing

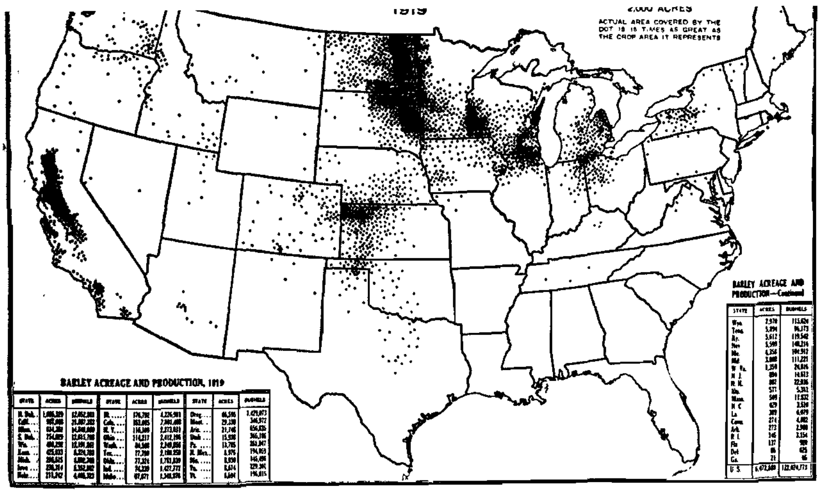


FIG. 34.—It should be noted that a dot on this map represents only one-fifth as much acreage as on the maps of corn, wheat, and oats. Barley is a minor crop in the United States compared with these crops, except in southeastern Wisconsin, southeastern and northwestern Minnesota, the eastern portions of the Dakotas, and the valleys of California. In these five States nearly two-thirds of the Nation's barley acreage is found. Minor centers may be noted on the map in northwestern Kansas, southeastern Michigan, and northwestern New York. These barley districts are characterized by a cool, sunny climate. The crop in California is grown during the winter. Much barley is also sown in California to be cut green for hay.

crop yields. The process has been hastened by the distress that has come to the one-crop wheat farmer.

There are no great problems of marketing to be met by the barley producer. A large part of the crop is utilized at the place of production, and a relatively small amount of the grain enters into commerce. There are no Federal grades for barley, and thus far they have not been found necessary.

It was felt that prohibition in the United States would discourage the barley producer of this country by destroying the market for the finer grades of grain. Up to the present, however, this has not been the case. Manufacturers of near-beer have consumed almost as much grain as did the pre-prohibition brewers. But even aside from this disturbing influence, the place of barley seems to be assured. Its ability to grow to maturity under adverse conditions of soil and climate makes it invaluable in the face of a growing scarcity of agricultural land.

RYE

General Significance.—A second crop of extreme significance from the point of view of land utilization is rye. Hardier than any other grain, so far as low temperature is concerned, it can be grown on a wide variety of soils too wet for other small grains. Little sunshine is required, and although it produces more abundantly upon fertile soil it may be grown successfully on land too poor for wheat culture.

Rye is the second most important bread crop. Its properties are similar to those of wheat, and a leavened bread may be manufactured from rye flour. However, this grain has a distinct flavor, and for this reason the two grains are not interchanged promiscuously. Palates accustomed to wheat flour do not take kindly to the stronger rye flavor, and in most parts of the world wheat bread is preferred. Substitution, however, is possible, as the experience of the American people during the War will testify; but substitution is generally accomplished through a process of mixing the flour of the two grains.

Areal Distribution.—Rye production is insignificant in the United States, as about 96 per cent of the world's crop is produced in Europe. However, it is a valuable crop to have in reserve; and to farmers in the Small Grain Belt, with land too poor, too wet, or too rocky for the successful production of other grains, it is a blessing. The rye-producing regions of the United States lie north of the Winter Wheat Belt in the States of Minnesota, Wisconsin, and Michigan. The presence of large areas of poorly drained lands with acid soils is the main explanation of this distribution of the crop.

In many parts of the country, rye is sown for purposes other than grain production. In the East, the tough rye straw is greatly in demand, and rye is grown with this form of utilization in view. In the South, rye is planted as a winter cover crop, as feed for poultry, or to be cut for hay.

TABLE VII

RYE STATISTICS FOR IMPORTANT COUNTRIES

Countries	Average 1909–1913 Acreage (1000 Acres)	Per Cent of World Total	Average 1909–1913 Production (1000 Bu.)	Per Cent of World Total	Yield per Acre (Bu.)	Export, 1910–1914 (1000 Bu.)	Per Cent of Crop Exported	Imports, 1910–1914 (1000 Bu.)
Russia	61,913	56.55	743,519	42.31	12.0	33,979	4.57	5,381
Germany	12,713*	11.61	368,337†	20.96	29.0	43,936‡	11.93	16,226
United States	2,236	2.04	36,093	2.05	16.1	888‡	2.46	
Austria	1,110*	1.01	23,785†	1.35	21.4	2	....	1,469
Belgium	672*	0.62	23,644†	1.34	35.2	830	3.51	5,755
Canada	117	0.11	2,094	0.12	17.9	58	2.76	68
Argentina	85	0.08	640	0.04	19.3	273	42.65	§
Australia	9	0.01	114‖	0.02	12.7			
All others	30,614	27.97	559,021	31.81	.....	37,383	6.69	57,928
World total	109,469	100.00	1,757,247	100.00	.....	117,349	......	86,827

* Estimated for present territory
† Estimated for present boundaries.
‡ Year ended June 30.
§ Less than 500 (thousands of bushels).
‖ One year only.

Europe.—The most important rye-producing belt in the world is found in Central Europe, in Russia, Germany, Austria, and Hungary. In this region rye flour is greatly prized, and it is often used in preference to the wheat product. At the present time, however, the disorganized condition of this part of the world has been reflected in a marked decrease in the total rye production and for this reason a large portion of the total product of the United States has been exported to Europe. This development has had the effect of greatly increasing the rye acreage in the United States from 1913 to 1920.

The acreage and production of rye in Europe were relatively stable until the years of the War. It is probable that production will tend gradually to approach the pre-war figure, and then remain practically stationary. In the United States, a decrease in production, due to the lessened demand from Europe, may be expected. But, just as in the case of barley, rye cannot be denied a place in a situation of acute scarcity of agricultural land. When it becomes necessary, rye will be grown; and with the increasing demand for wheat, which can only be supplied at higher costs, rye will probably occupy a more important place in the diet of this and other countries.

MILLET

The millets are comparatively unimportant in this country, but in Africa, southern Russia, and northern China, they furnish a supplementary grain crop that is used for human food. In some parts of India, notably in regions in which the grain sorghums will not mature, considerable millet is produced. Ordinarily, millet is utilized only as forage in this country, the smaller seeds of the plant being more difficult to thresh than wheat. Millet is also used as a cover crop, as silage, and as a catch crop after the failure of corn or forage crops.

GRAIN SORGHUMS

General Characteristics.—The grain sorghums are essentially substitute crops, particularly in the United States; but as such they are of tremendous importance. Just as rye is planted in the northern margin of the Wheat Belt on lands too humid for the production of other small grains, so grain sorghums are grown in regions where corn is needed, but cannot be raised on account of the inadequate rainfall. In India and Japan, large quantities of this grain are produced as warm-season crops on land too dry for rice, and it is used to supplement the human food supply. In the United States, it is produced on the semi-arid southwestern borders of the Corn Belt, where its use tends to extend the Corn Belt type of agriculture.

There are many characteristics of grain sorghums which make them less desirable than corn, and therefore the possibility of their encroaching upon the Corn Belt area of the United States is distinctly limited. The first of these disadvantages is found in the extreme difficulty in preserving a pure strain. The various types of this grain will cross at the slightest provocation, and the result is a multiplicity of varieties. This difficulty is, of course, passing away, and experimentation has tended to establish and maintain standard and pure varieties. It must be remembered that, of the countries producing grain sorghums in large quantities, the United States is the only one that has a progressive policy of agricultural experimentation, and that the crop was not established in this country until the last quarter of the nineteenth century.

Another disadvantage is found in the relative difficulty of handling

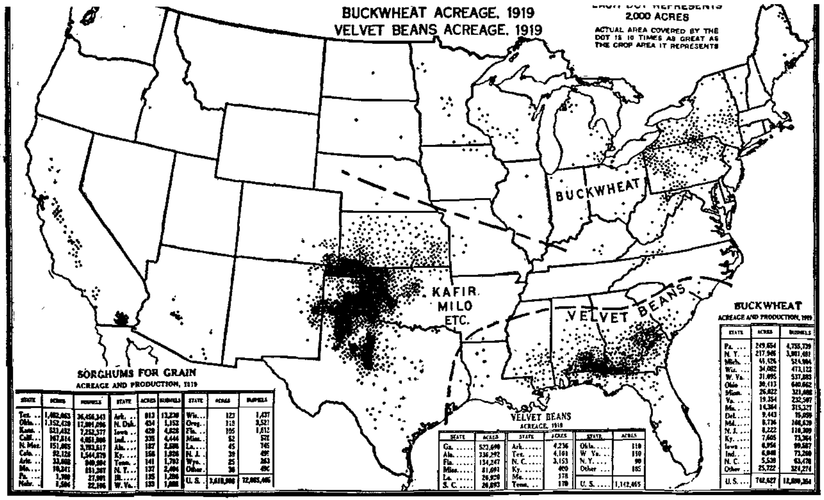


FIG. 37.—The grain sorghums are, perhaps, our most drought-resistant crops. The expansion of acreage during the past two decades in the southern Great Plains area has been extraordinary. From 1899 to 1909 the acreage in the United States increased from 266,000 to 1,635,000, or sixfold, and between 1909 and 1919 it more than doubled. Buckwheat, which is practically confined to the Appalachian area and the Lake States, has increased slightly in acreage since 1909. It is peculiarly adapted to districts having cool, moist summers and sour soils.

grain sorghums. The heads must be thoroughly dried before they can be safely stored, and if the shelled grain is kept in bins it must be clean and free from cracked kernels in order to prevent heating. The heads are not as easily transported as corn, and as a result of all these disadvantages corn is ordinarily preferred.

In the United States, different varieties of grain sorghums were introduced from time to time, but it was not until about 1880 that any success was attained. It was ten years later that the crop was established in Kansas, and from this time on the grain gradually spread until it became important in Oklahoma, Texas, Colorado, and New Mexico. Smaller quantities of the grain sorghums are now produced in California, Missouri, Nebraska, and Iowa. In all these regions they are used as a dry-weather substitute for corn.

Distribution.—The three important producing regions of the Old World are found in Africa, China, and India. In various parts of Africa, grain sorghums are the standard cereal crops, and they have been cultivated more or less diligently by the natives as long as this region has been known to the civilized world. The drier parts of the Nile Valley and the semi-arid edges of the northern desert form one producing region, the next in importance being found in South Africa. But in almost all parts of the continent where any sort of agriculture is carried on, some variety of grain sorghum is to be found.

India, with its dense population, finds it necessary to cultivate all its available lands. For this reason the grain sorghums are invaluable in the regions not suited to the production of rice or wheat. The tremendous importance of the grain is indicated by an annual planting of more than 25 million acres. Every part of the plant is utilized in this country, and the grain itself is used both as human food and as feed for livestock.

Another country that must utilize all of its resources in land is China. In the northern portion of this country and Manchuria, a type of sorghum, known as kaoliang, is produced. The grain is used as human food, but it is also particularly suited for the manufacture of poultry feed. Occasionally, cargoes of this grain arrive at the Pacific Coast ports of the United States, where they enter trade and are used largely in the preparation of poultry and livestock feeds.

Outlook in the United States.—It is probable that in the future the greatest development of grain sorghums will occur in the United States. Their importance to this country lies in the possibility of the intensification of ranching in the eastern portions of the ranching belt. It is well known that the grass ranges of the West are frequently overstocked, and the tendency is toward smaller ranches, and a less complete dependence upon the supply of range grass. The grain sorghums appear to furnish the best solution to the feed problem of this semi-arid country.

FORAGE CORPS

The term " forage crops," used in the broad sense, includes all concentrates such as cereals, provided they are destined to be fed to livestock and not to be used for human consumption, as well as root crops and grasses.

FARM VALUE OF THE CROP PRODUCTS USED AS FEED FOR LIVESTOCK, HUMAN FOOD, FIBER, ETC., AND ACREAGE REQUIRED TO GROW THESE PRODUCTS, UNITED STATES, 1919.

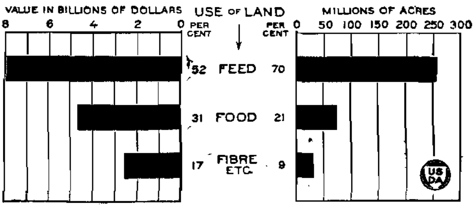


FIG. 38.—The farm value of the crops and crop products used as feed for livestock is less than twice that of the crops and crop products used for human food, although the former requires over three times as much crop land for its production as the latter. To produce the fiber and other nonedible crop products required less than one-seventh as much land as that devoted to producing feed for livestock, but these fiber and other crop products had a farm value one-third that of the feed.

Agriculture Yearbook, 1923, p. 316.

Seven-tenths of the 365 million acres of harvested crop lands of the United States in 1919 were used to produce forage crops; that is to say, 257 million acres were used to produce concentrates and roughage for livestock; about two-tenths, or 76 million acres, produced food for human consumption; and nearly one-tenth, or 32 million acres, were used for other purposes, principally cotton fiber, tobacco, and flax.[8]

In addition, livestock consumed the product of about 60 million acres of humid improved pasture; probably 171 million acres of humid unimproved grassland pasture, over half of which was in farms; about 237

[8] A larger acreage than this was devoted to cotton, tobacco and flax; but, after allowing for the value of cottonseed, most of which is used for stock feed and human food, the amount allowed for cotton fiber, tobacco, and flax is approximately as indicated. Agriculture Yearbook, 1923, p. 311.

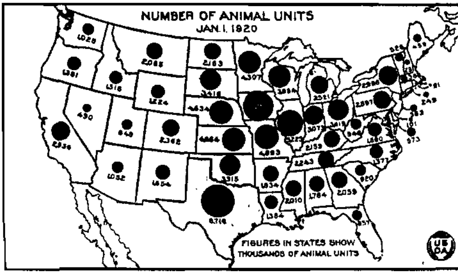


Fig. 39.—Nearly half the animal units in the United States are in the Corn Belt and Great Plains States. Yet even the eastern Corn Belt does not produce enough livestock to supply its needs for meat and other animal products. It will be noted that livestock are most abundant in the regions of heavy crop production rather than in the West, where arid grazing land predominates.

Agriculture Yearbook, 1923, p. 3[illegible]

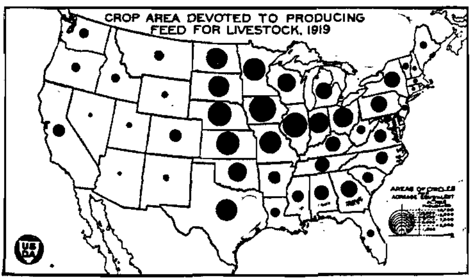


Fig. 40.—A very large proportion of our harvested forage is produced in the eastern or humid part of the United States. In this eastern half crops are much more important than pasture, while in the western half the reverse is true. The Corn Belt and the Great Plains States, it will be noted, are the principal regions of feed production.

Agriculture Yearbook, 1923, p. 314.

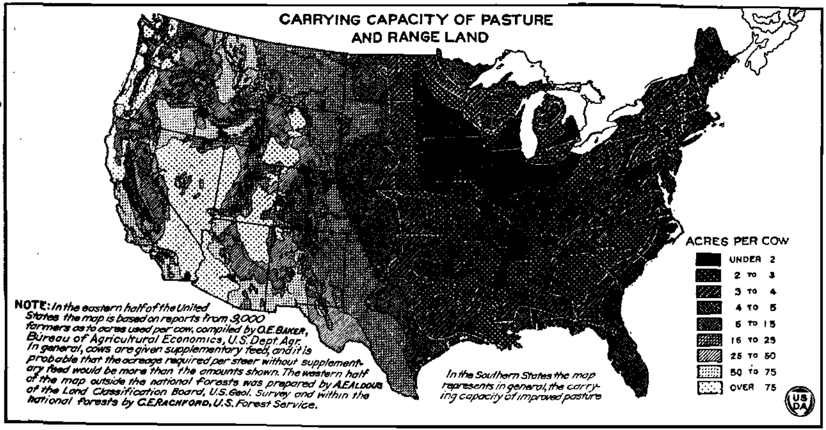


FIG. 41.—In the Corn Belt and in the southwestern portion of the hay and dairying region, where the soil is naturally rich and where there is ample rainfall, most of the pastures will carry an animal unit on 1 to 2 acres. The lowest carrying capacity, over 75 acres per animal unit, *is in the arid interior plateau region and in the dense forests of the North Pacific coast. The areas having the* greatest percentage of tame pastures generally have the highest carrying capacity.

Agriculture Yearbook, 1923, p. 383.

million acres of forest and cut-over pasture land in farms or under other private ownership and in our national forests; besides perhaps 587 million acres of arid or semi-arid grazing land in the West. In other words, 1312 million acres out of a total 1903 million acres of land in the United States, or nearly 60 per cent, is used to produce feed for animals; only 4 per cent is used directly to produce human food; and 2 per cent to produce cotton fiber, tobacco, and flax. The remainder of the land area is used either for roads, urban sites, and farmsteads, or is still either virgin forest or cut-over and burned-over forest, none of which is used for agricultural production.

The cereals have already been considered at some length. It has been noted that not only is the roughage associated with the growth of the cereals used as feed for animals, but the immediate destination of the cereals themselves, in the main, is consumption by livestock, and not by human beings. Thus, our land is used directly to maintain great livestock enterprises, such as the raising of beef cattle, swine, dairy, cattle, poultry, sheep and goats, all of which will be considered at some length in the next chapter, and indirectly through these to sustain a large and growing human population.

One important type of forage crop, however, remains to be considered before passing on to the discussion of the livestock enterprises, viz., hay.

HAY

In many respects, hay is the most important single crop produced in the country. It is made of many varieties of grasses and other plants and is fundamental in the economy of a large percentage of the farms of the country. Rural prosperity, which is largely based on livestock enterprises both in this country and in Europe, is closely associated with hay as an important farm enterprise.

History.—Since the beginning of history, hay has played a very important part in the development of civilization. This is especially true in central Europe, where the conversion of the natural marsh grasslands into well-drained meadows of cultivated hay plants was one of the main factors in social and economic progress. In the Roman Empire, before the beginning of the Christian Era, the making and storing of hay was considered so important that it was regarded as lawful and proper to engage in this work on holidays and days of worship. There were few other activities so highly regarded.

Hay has played no small part in the development of the United States. At first it was produced from the natural meadows and marshes.

But, even as early as Revolutionary times, it became necessary to establish artificial meadows near the towns in order adequately to maintain the growing livestock industry. Fortunately, the early settlers of the northeastern section of the country found the climate well suited to the growth of good hay grasses, and among those first introduced were timothy and clover which continue to this day to be the leading hay grasses in the northeastern part of the country.

Not until after 1825, however, did hay production become an important farm enterprise or hold a prominent place in the cropping system. From then on, up to the present time, it has grown in importance until it now occupies the key position in the farming system of the most populous sections of the country. This is due largely to the growth of cities with the consequent need for hay to feed the draft animals used in the cities and the dairy cattle needed to furnish the growing population with dairy products, especially milk. As the eastern part of the Mississippi Valley and the South become more industrialized and a larger proportion of the people come to live in cities and towns, the need for whole milk will increase, and this will necessitate greater attention to hay crops. Especially is this true of the south, where the percentage of land devoted to hay is very small and where the lack of tame grasses and legumes in the rotation is manifesting itself in a decrease in crop yields.

Distribution of Hay Acreage in the United States.—The distribution of the total hay acreage of the United States in 1919, by sections, is shown in the following table:

New England,	3,400,000 acres, or 20 per cent of the improved farm land.
Middle Atlantic,	8,200,000 acres, or 20 per cent of the improved farm land.
East North Central,	14,200,000 acres, or 12 per cent of the improved farm land.
West North Central,	26,600,000 acres, or 10 per cent of the improved farm land.
South Atlantic,	6,500,000 acres, or 7 per cent of the improved farm land.
East South Atlantic,	5,000,000 acres, or 6 per cent of the improved farm land.
West South Central,	5,600,000 acres, or 3 per cent of the improved farm land.
Mountain,	7,400,000 acres, or 7 per cent of the improved farm land.
Pacific,	4,200,000 acres, or 8 per cent of the improved farm land.

The primacy of the northern and eastern sections of the country in the production of hay may be ascribed to their favorable climate, topography, and market conditions. The grasses from which nine-tenths of the hay of the country is made are timothy, clover, alfalfa, and prairie grass. Timothy and clover abound in the North and East while alfalfa and prairie grass predominate in the North and West. A number of tame grasses, such as red top, orchard grass, Kentucky blue grass, crag grass, Bermuda grass, and Johnson grass furnish almost one-tenth of the hay of the country. These grasses are found principally in the South and Southwest. A substantial addition is made to the hay supply by such plants as cow peas, soy beans, peanuts, field peas and vetch. A great need of Southern agriculture is a legume equal to the clovers or alfalfa as a forage crop and soil builder.

The total hay crop of the nation in 1923 was approximately 100 million tons, or an amount sufficient to supply about one-fourth of the coarse forage requirements. This total was composed of 26 million tons of alfalfa; 23 million tons of timothy; 20 million tons of clover; 17 million tons of prairie grass; and almost 10 million tons of miscellaneous grasses such as Bermuda, Johnson, Sudan, blue grass and the like. In

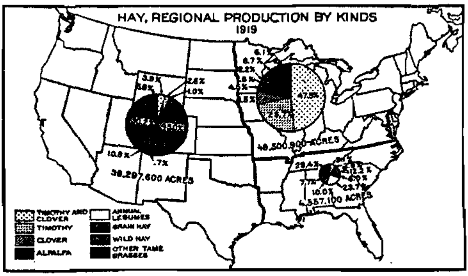
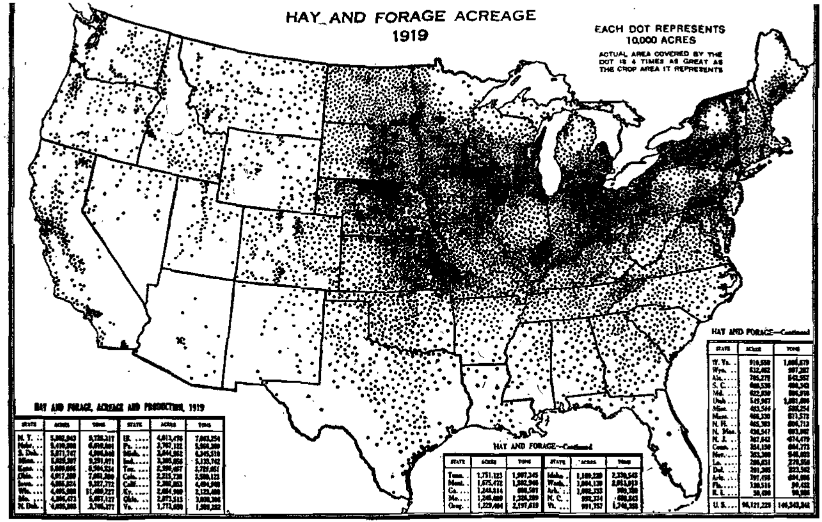


FIG. 42.—In the northeastern humid region (the States north of the Cotton Belt, and east of the Great Plains) timothy constitutes nearly half the acreage of hay, and mixed with clover nearly a quarter more. In the Southeastern States the census group known as "other tame and cultivated grasses" (in this region largely Bermuda and Johnson grass) and the annual legumes are the most important hay crops, constituting each about one-quarter of the acreage. In the Western States alfalfa is the dominant hay crop, with wild hay second in importance.

Agriculture Yearbook, 1923, p. 338.

addition, several million tons of hay were made from cow peas, soy beans, peanuts, field peas and vetch.

Marketing of Hay.—About one-sixth (16 million tons) of the hay produced in this country enters into commerce. This hay has a farm value of 200 million dollars. Notwithstanding the great volume and value of hay which enters commercial channels, only very recently has substantial progress been made in the establishment of satisfactory grades and standards for the classification of hay by the Federal and State Governments. In order to make the Government grades and standards immediately effective in the hay trade, the Federal Govern-



HAY AND FORAGE, ACREAGE AND PRODUCTION, 1919

STATE	ACRES	TONS	STATE	ACRES	TONS
N. Y.	[illegible]	[illegible]	Ill.	[illegible]	[illegible]
Nebr.	[illegible]	[illegible]	Pa.	3,767,122	[illegible]
S. Dak.	[illegible]	[illegible]	Mich.	[illegible]	[illegible]
Minn.	[illegible]	[illegible]	Ind.	[illegible]	[illegible]
Kans.	[illegible]	[illegible]	Tex.	[illegible]	[illegible]
Ohio	[illegible]	[illegible]	Colo.	[illegible]	[illegible]
Iowa	[illegible]	[illegible]	Calif.	[illegible]	[illegible]
Wis.	[illegible]	[illegible]	Ky.	[illegible]	[illegible]
Mo.	[illegible]	[illegible]	Okla.	[illegible]	[illegible]
N. Dak.	[illegible]	[illegible]	Va.	[illegible]	[illegible]

HAY AND FORAGE—Continued

STATE	ACRES	TONS	STATE	ACRES	TONS
Tenn.	1,751,123	1,907,345	Idaho	[illegible]	[illegible]
Mont.	[illegible]	[illegible]	Wash.	[illegible]	[illegible]
Ga.	[illegible]	[illegible]	Ark.	[illegible]	[illegible]
Me.	[illegible]	[illegible]	N. C.	[illegible]	[illegible]
Oreg.	[illegible]	2,197,619	Vt.	[illegible]	[illegible]

HAY AND FORAGE—Continued

STATE	ACRES	TONS
W. Va.	910,530	[illegible]
Wyo.	[illegible]	[illegible]
Ala.	[illegible]	[illegible]
S. C.	[illegible]	[illegible]
Md.	[illegible]	[illegible]
Utah	[illegible]	[illegible]
Miss.	[illegible]	[illegible]
Mass.	[illegible]	[illegible]
N. H.	[illegible]	[illegible]
N. Mex.	[illegible]	[illegible]
N. J.	[illegible]	[illegible]
Conn.	[illegible]	[illegible]
Nev.	[illegible]	[illegible]
La.	[illegible]	[illegible]
Del.	[illegible]	[illegible]
Ariz.	[illegible]	[illegible]
Fla.	130,516	[illegible]
R. I.	[illegible]	[illegible]
U. S.	[illegible]	[illegible]

FIG. 43.—This map of hay and forage includes not only the hay *crops but also corn* and the *sorghums* cut for silage or fodder and root crops used for forage. The hay and forage acreage, it will be noted, is largely concentrated in the Hay and Pasture Region and around the margin of the Corn Belt, the greatest State acreage being *found in New York and the greatest tonnage production* in Wisconsin. Relative to the acreage in crops, however, hay and forage is most important in the Rocky Mountain Region.

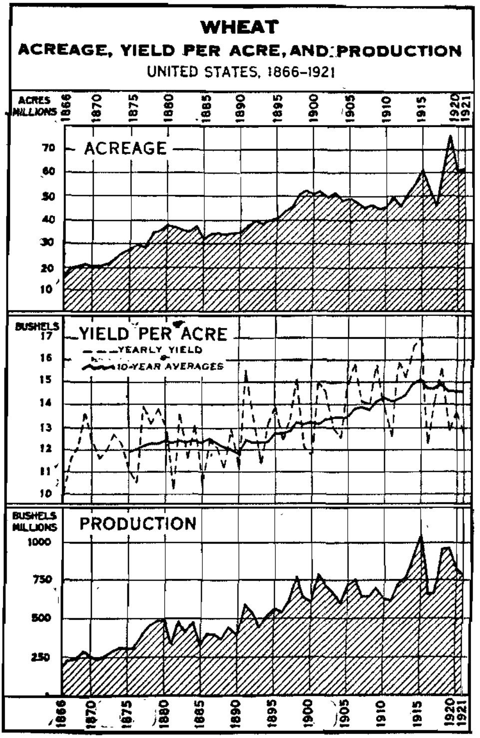


FIG. 44.—Annual acreage, acre yield, and production of wheat in the United States from 1866 to 1921. Estimates of acreage have been revised to accord with census returns. The solid line in yield per acre is a ten-year running average. Note that average yields increased about 3 bushels per acre from 1890 to 1915.

Agriculture Yearbook, 1921, p. 80.

ment has recently fostered *hay schools* for the purpose of training men to become hay inspectors.

The government *hay* standards are based upon class requirements and *grade* requirements. The *class* requirements take into consideration the percentage of mixture allowed for each kind of hay. There are three numerical grades based upon the percentage of green hay and the percentage of foreign matter in the hay.

Federal standards have so far been provided for timothy, clover, prairie hay, alfalfa, and Johnson grass. The standardization of hay will greatly facilitate the marketing of this product and will be beneficial alike to hay growers, the hay trade, and consumers.

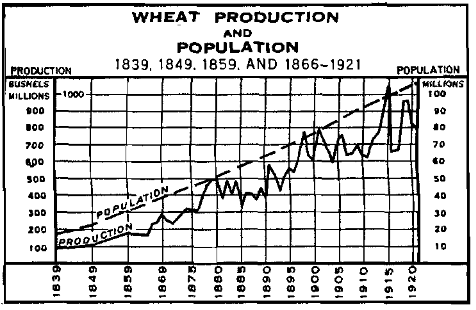


FIG. 45.—Population has increased more rapidly in the United States in the last twenty years than has wheat production, in spite of enormous production during the World War.

Agriculture Yearbook, 1921, p. 158.

SUGGESTIONS FOR FURTHER STUDY

1. Discuss:
   a. The areas in which the acreage of wheat has been increasing from 1866 to 1921. (See Agriculture Yearbook, 1921, article on wheat).
   b. The reasons for the general increase in the yield per acre during this period.
   c. The causes for the fluctuations from year to year in the production of wheat.

2. Show why the various states are respectively in deficit-producing regions or in surplus-producing regions.

3. The suggestions in (1) above may be applied also to corn in connection with the problems of acreage, yields per acre, and total production of corn.

4. Summarize the main physical and economic conditions having to do with the distribution and density of production of the following crops: wheat; corn; rice; barley; oats; rye; grain sorghums; hay and other forage crops.

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CHAPTER VII

ANIMAL FOOD PRODUCTS

BEEF

General.—Beef, the great meat staple of the Western Hemisphere is without doubt one of the most important of the animal food products In the United States the great herds of cattle which roam the western arid belt, the crowded feed lots of the Corn Belt, and the monotonous appearance of beef in the average diet, is sufficient testimony to the importance of this product. The enormous exports of beef to western Europe from South America and Australia indicate a strong demand for beef in the Old World as well. This demand, together with the means of its satisfaction, will bring up, then, problems of production financing, transportation, and consumption. The most important questions which arise, however, center about the possible instability of the demand for beef and about the problem of the future utilization of land.

The great open pastures of the world are diminishing, and under the pressure of population great portions of them have already yielded to crop producers. Considerable cultivated land is now devoted solely to the production of feed for cattle. In other words there is a tendency toward more intensive and less extensive uses of land, as is manifested in the transition from range to crop land wherever practicable. All this means higher prices for beef. On the other hand, improved methods of transportation and preservation have tended to make production more efficient. The two tendencies, together, produce many complex problems, a large proportion of which, perhaps it is at present impossible to solve. They must be borne in mind, however, in any discussion of the beef industry. In the pages that follow there will be found an attempt to indicate some of the most important problems of the industry, and in so far as possible such statistics as seems to be necessary for an understanding of these problems will be presented.

DEVELOPMENT OF THE BEEF INDUSTRY IN THE UNITED STATES

The development of the beef industry in the United States is significant, because, in the first place the United States is one of the most important producers of cattle. In the second place we are able in this country, to observe all of the steps in land utilization from the most extensive to that degree of intensification which has now been attained. At this point we are able to complete our observations of the relation of cattle to crop production and to the food supply, by a consideration of the older countries of the world, which, generally speaking have reached a higher degree of intensification.

TREND IN POPULATION COMPARED WITH TREND IN NUMBER OF CATTLE, SWINE, AND SHEEP, 1850-1922.

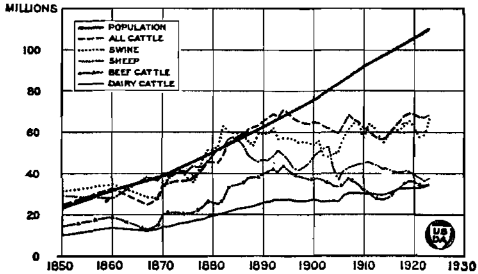


FIG. 46.—The marked divergence in the trends of human and animal population indicates a gradual change in our national diet. The numerical relation between people and livestock continued much the same from 1850 to the decade 1884–1893. The number of sheep show a downward trend since 1884. The number of swine have remained about stationary since the eighties. The number of beef cattle have decreased 22 per cent since 1894, whereas the human population has increased 62 per cent. Dairy cattle are the only kind of livestock (other than poultry) to show a consistent increase in numbers throughout the entire period represented on the chart. From 1890 to 1920 the number of dairy cattle, however, increased only 27 per cent, as compared with 68 per cent increase in population.

Agriculture Yearbook, 1923, p. 818.

Historical.—It is interesting to note that the cattle industry in North America had two distinct beginnings. During the sixteenth and seventeenth centuries cattle were introduced into the southwestern portion of the continent and upon the Atlantic seaboard. The northeastern colonists were agriculturists, and their cattle were a necessary adjunct to the small-scale type of agriculture with which they were familiar. The inhabitants of the Southwest were Spanish adventurers, gentlemen, and *conquistadors* whose only ambition was to make the country yield the greatest amount of gold and silver or their equivalents. It is not surprising, then, that their cattle industry should be characterized by large herds which required a minimum of care, and whose products, in the form of hides and tallow, could be exported to the Old World. The result of the Spanish efforts was the introduction, during the following 250 years, of the half-wild Longhorn cattle into the semi-arid plains of Mexico, Texas, Arizona, and New Mexico. It was only after a union was effected between the eastern and southwestern producing regions that this type began to disappear.

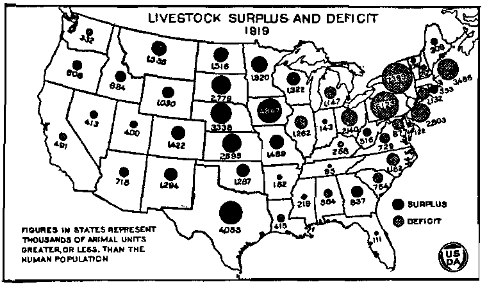


FIG. 47.—In the United States there was approximately one animal unit for each person in 1919. The above map shows for each State the number of animal units in excess or in deficiency of a number equal to the national proportion. Illinois had a deficiency because of the large industrial population of Chicago and vicinity, while Arkansas, Mississippi and Vermont show a surplus chiefly because these states are without any large cities. The Great Plains and the western part of the Corn Belt produce most of the surplus meat which goes to support the manufacturing centers of the East.

Agriculture Yearbook, 1923, p. 320.

In the East it was discovered that the Ohio Valley was admirably suited to the production of corn. Since this product could not be marketed as grain, the practice arose of grazing steers for four or five years and then furnishing them for the eastern market by feeding corn for several months. In the Southwest, marketing began to be effected by driving the cattle overland to the feeding areas of the Ohio Valley. It was partly on account of the necessity for this long drive that the rangy longhorn type tended to persist in the Southwest.

When the railways pushed their way into the Middle West, the production of corn became more important, and Illinois, Iowa, and Missouri fattened a great many locally raised animals as well as Texas grass-fed steers. Texas cattle were now driven almost due north to the railway towns of Kansas. By 1860 the greatest concentration of cattle was found in Texas and the Corn Belt.

When the railroads were extended into the West and Southwest, the distribution of cattle production gradually fell into the general form that exists to-day. The plains of the West and Southwest were able to support large numbers of grass-fed animals. These cattle were then shipped to the Corn Belt where they were either slaughtered at once or fattened for a short time on corn. The Corn Belt itself raised many cattle which were marketed after a few months on corn.

The latest development was the increase of the cattle industry in all of the western and semi-arid states. Following the laying of the Pacific railroads, beef cattle were introduced upon the far western ranges until by 1900 practically all available pasture was stocked to capacity.

Distribution.—Cattle are distributed over practically the whole of the middle latitudes, the greatest concentration occurring in India, western Europe, the United States, and southeastern South America. However, the mere statement of this distribution falls far short of presenting an adequate picture of the situation in the beef industry. India, for example, with its enormous number of cattle, is of no importance as a producer of beef. Indian cattle are used only for draft purposes, and because a large portion of the population are restrained by religious motives from eating beef, even slaughter for domestic use is practically neglible. On the other hand, a large proportion of the cattle of Argentina and the United States is produced for slaughter.

The absolute number of cattle in the world has declined during the last few years, and this tendency is reflected even more in the per capita decline in cattle production. Population has almost universally increased during the period of declining cattle production, and, indeed, it is probable that increased population has had something to do with this decline.

In the old agricultural countries of Europe, a striking uniformity in the number of cattle per capita from 1890 to 1914 will be noticed (see Table VIII). That is to say, in these countries a stabilized adjustment in land has been reached. All of the land that can possibly be cultivated is cultivated. There is some land that apparently can never be used for crop production, and this constant quantity remains as pasture. In these countries only enough cattle will be raised to occupy the permanent pasture and to utilize the by-products of crop production, such as waste or stunted grain and crops planted mainly for their effect upon the soil. The consumers of agricultural products are willing to pay such a high price for these products that land has become too costly for the produc-

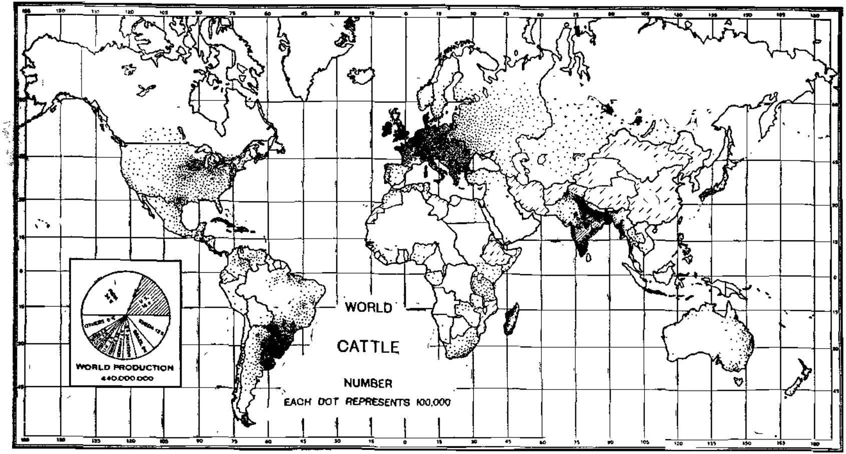


FIG. 48.—The centers of world cattle production are Europe, India, the United States, and southeastern South America, particularly the La Plata River-Basin of Argentina, Uruguay, and southern Brazil. No figures are available for China and several areas in Africa. The large population of western Europe requires importation of beef in addition to the home supply. Most of these imports come from South America, North America producing now little more than enough for its own needs. India exports practically no beef.

Agriculture Yearbook, 1921, p. 231.

tion of cattle. It is obvious that no one can realize a net return by pasturing cattle on land worth, say, $200 per acre.

In the newer countries of the Western World, we have a different situation. Population is increasing very rapidly, and this increased population means an increased demand for agricultural products. Consequently, an increasing amount of land is gradually being diverted from pasture to crop production. Then again, this larger population furnishes the additional labor which crop production demands. In the Old World, then, this process has simply been carried to its logical conclusion, and all of the pasture land that can be cultivated has been absorbed by crop producers. In the western hemisphere, especially in the United States, the same condition is being rapidly approached.

Does this tendency mean that the beef industry is doomed? Most certainly not; but it does seem to indicate that there is a possibility of a marked decline in beef production. More *efficient* production, however, will have the effect of making this decline more gradual than it would otherwise be. It will be well, then, to look into the various methods of production, preservation, and transportation in order to illuminate this side of the question. A consideration of the growth of the beef industry in the United States will be very valuable in this connection, because this country is now experiencing a stage in the adjustment of the industry which has already taken place in Europe and which has not yet occurred in some other parts of the world.

TABLE VIII

NUMBER OF CATTLE PER CAPITA IN SELECTED COUNTRIES

Country	Cattle per Capita			
	1890	1900	1910	1914
United States	0.82	0.89	0.71	0.57
Argentina	5.90	5.90	4.70	3.60
Australia	3.30	2.20	2.70	2.40
Belgium	0.26	0.25	0.25	0.25
Brazil	....	....	1.11	1.23
France	0.35	0.38	0.36	0.37
Paraguay	....	3.61	4.38	
Uruguay	....	7.50	7.90	
Russia	0.32	....	....	0.25
United Kingdom	0.30	0.28	0.26	0.26
Germany	0.35	0.33	0.32	0.31

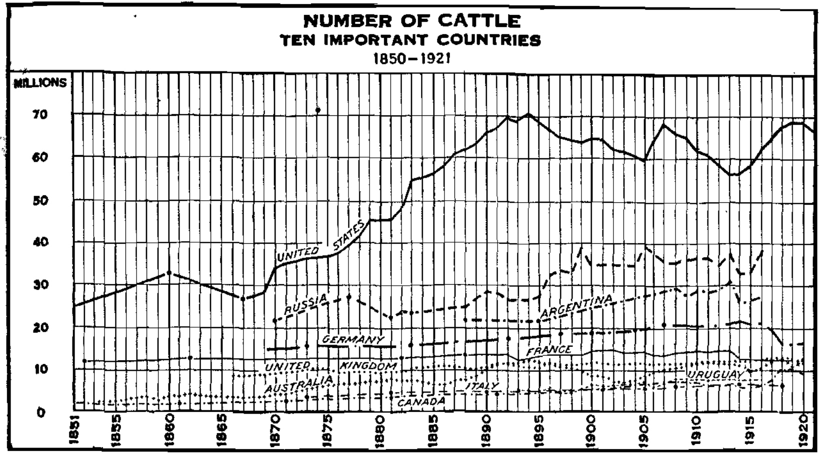


FIG. 49.—*The number of cattle* in *France* has remained almost stationary for seventy years; in Germany the number increased until 1907, in Argentina till 1913, in Russia up to 1899, and in the United States there was a rapid rise to 1894, since which year the number has remained more or less constant, except for wide periodic fluctuations. In the other countries shown the number of cattle slowly increased up to 1918. The increase in the United States from 1867 to 1894 was *about equal to* the total number of cattle in the United Kingdom, France, Italy, Australia, and Canada to-day.

Agriculture Yearbook, 1921, p. 230.

Methods of Production

Argentina.—Argentina is primarily an agricultural and stock-raising country, and it ranks among the leading countries in the production and exportation of beef. The principal stock-raising sections resemble very closely the level corn and alfalfa regions of Kansas and Nebraska, but the climate is as mild as that of our Southern States. The resulting year-round pasturage gives a particular advantage to stock raisers. Large amounts of alfalfa are also raised, and steers are ordinarily fattened by being turned into alfalfa pastures. There is practically no necessity for auxiliary winter feeding; and the corn-feeding, finishing period, which is so familiar in this country, is virtually unknown.

In general, the cattle of Argentina are of a fairly good grade, and pure-bred bulls, generally Shorthorns, are found in practically all of the large herds. There is a tendency, however, to develop a type of animal more rangy than the smooth, compact pure-breds of this country. The reason for this situation may be found, perhaps, in the fact that in Argentina large numbers of cattle must still be driven long distances before they are marketed. A considerable number of breeding animals are imported into the country, but only stock of a very superior sort, and of the particular type desired, find any market there.

Argentina is ideally suited to the production of livestock. This fact is due principally to the relative cheapness of good pasture land. Land that is quite fertile and receives adequate rainfall is retained as pasture, while in the more thickly settled countries the same sort of land is utilized for crop production. For this reason, Argentina has a beef-producing advantage over, perhaps, all other countries. The advantage is partially offset, however, by the distance of the consumers' market, which becomes particularly important when the sale of by-products is considered.

Uruguay.—In Uruguay, with its gently rolling topography, its mild climate, and its large extent of grass-covered lands, livestock production is the only important industry. Very few hogs are raised, and sheep and cattle are generally found together on the range. The grass remains green the year round, and, as in Argentina, winter feeding is almost never necessary. The cattle of Uruguay are of good grade, Herefords predominating, and an important part of the cattle industry is the sale of breeding stock to Brazilian producers.

Beef production, however, is carried on in the face of some important difficulties. Hoof-and-mouth disease is prevalent, and tick fever helps to make the industry precarious. Then, too, the distance to a consumers' market makes the economical utilization of by-products quite difficult, and, as in Argentina, stock must often be driven long distances to the slaughtering centers.

Brazil.—Brazil has possibilities of an increasing beef industry, but the presence of disease is a serious limiting factor. The nature of the country is inimical to effective disease control, and various proposals to eliminate the fever tick have been declared impracticable. Nevertheless, the rolling Campos country of eastern and southern Brazil is admirably suited to cattle raising, and a gradual development of the beef industry may reasonably be expected.

Australia.—The plains and rolling highlands of Australia are devoted very largely to the grazing of livestock, the rainfall over large areas being insufficient for crop production. Except in seasons of great drought, the native grasses are abundant and nutritious, which makes the country almost ideal for pasturage. The mild climate insures grass the year round, and ordinarily no winter feeding is necessary. There are, however, a few serious limitations upon the cattle industry.

Australia is very poorly supplied with natural streams, and in dry seasons many cattle, particularly young animals, perish from lack of water. Then, in the interior there are practically no railroads, and cattle sometimes have to be driven as much as 1000 miles to the market. Most of the common cattle diseases seem to have been introduced into the country with the cattle, but apparently losses from diseases are only slightly higher than in the United States.

The grade of Australian cattle is being constantly improved by the importation of English breeding stock. It is quite possible that continued improvement in grade, together with the provision of artificial water holes, will enable Australia greatly to increase her beef production. Increased production, however, will depend largely upon advancing prices for meat.

United States.—The United States may conveniently be divided into four areas of beef production, each district being characterized by its distinct methods. In the first of these regions, the western range, grass-fed animals are produced. The herds roam the great private and public pasture ranges, and they are expected to shift for themselves during a great part of the year. With the exception of the southwestern areas, however, winter feeding is found necessary throughout the region. Some of these western cattle are slaughtered as they come from the range, but a great many of them are fattened in the feed lots of the Corn Belt before being marketed.

The southern region, or the Cotton Belt, produces large numbers of beef cattle; and although production is ordinarily not on a large scale, this district is quite important. Cattle are grazed on farms and on the

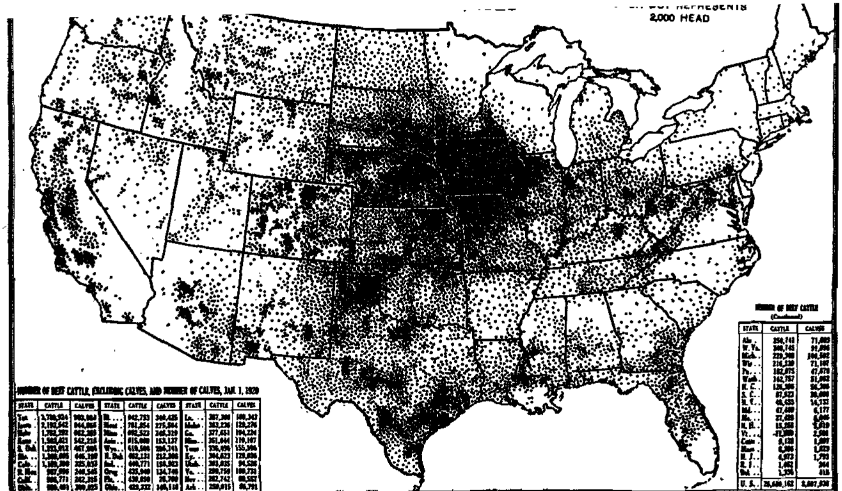


FIG. 50.—Beef cattle constitute slightly over half the total number of cattle in the United States, but slightly less than half the value. Over 8 million beef cattle (including calves) are in the Corn Belt, and as many more in the Great Plains Region, these two regions having nearly half the beef cattle in the country. A large number of beef cattle will also be noted in the Subtropical Coast and southern portion of the Cotton Belt, in the Appalachian valleys, in eastern Kansas, in the mountain parks and valleys of Colorado, Utah, and Idaho, on the plateaus of southwestern New Mexico and southeastern Arizona, and in California. Over 40 per cent of the beef cattle are in the

great areas of cut-over timber land that are found from North Carolina to eastern Texas. The cattle of this region are not of a very high grade, but considerable improvement is possible through the introduction of more pure-bred beef bulls. Southern cattle are commonly fattened for the market by the feeding of cottonseed cake or meal, alfalfa, grain sorghums, velvet-bean hay, silage, and blackstrap molasses.

In the Appalachian and Great Lakes region a few beef cattle are produced on farms in order to make use of land not suitable for crop production. Supplementary feeding is always necessary in winter, but the cattle are generally finished off on grass and marketed in the East as grass-fed animals. The grade of the cattle found in this region is ordinarily quite high.

The Corn Belt is primarily a fattening area, but even on the level prairies there is some land that can be used more economically for pasture than for crops; and consequently, some cattle are raised and wintered on corn and hay. But the greatest part of the Corn Belt cattle come from the western range as yearlings or two-year-olds. They are carried through the winter on hay or other home-grown feeds, fattened on corn, and marketed in the spring before the grass-fed steers from the Southwest begin to arrive. In this region about 25 per cent of the corn crop is fed to cattle.

Europe.—Cattle in Europe are generally raised under conditions of fairly high costs, this being possible on account of the advantages local producers have in transportation charges. There is some land, however, that can be utilized most economically in pasture. The beef cattle industry in southern Germany, France, and Spain is due to the existence of land of this character. In England it is often possible to raise breeding stock on land that is quite fertile and expensive. This is due, of course, to the high prices commanded by English breeding stock in South America and Australia. In northwestern Europe very few beef cattle are raised, and dairy animals have a tendency to occupy all available pasture land.

Transportation and Preservation

Without the modern improvements in the transportation and preservation of beef, the situation of the beef industry would be entirely different. The production of beef makes for a comparatively extensive use of the land, and in the thickly settled parts of the world it is not economically possible to raise many cattle. Consequently the people of these regions must import meat or do without. On the other hand, a surplus of beef will not be produced in a region admirably suited to its production unless the surplus can be disposed of.

Transportation.—Until the last half of the nineteenth century transportation was slow, and the preservation of meat, except by salting or drying, was impossible; and, as a consequence, beef was transported alive whenever conditions permitted. The transportation of live animals under the existing circumstances was not economical, for sometimes a month elapsed between the departure of a herd of cattle from the plains of Texas and their arrival at the slaughtering plants. During this time they necessarily lost considerable weight and finish. In Mexico, Argentina, and Australia, it was practically impossible to export meat, and animals were often slaughtered for their hides and tallow.

Refrigeration.—With the more rapid and efficient land and water transportation brought by steamships and railways, the trade in live animals quickened, but still the practice was quite uneconomical. The final and most important impetus to the industry was given by artificial refrigeration. When beef carcasses could be frozen and kept indefinitely, many of the old problems of transportation disappeared.

One of the first results of artificial refrigeration in the United States was the moving of the slaughtering centers from the consuming districts to points near the center of production. The economies which followed this shift are easily seen. Since only about 50 per cent of the weight of the live steer can be used for meat, it is clearly not desirable to ship the whole animal. It is also much easier to ship meat than live animals. Then, too, there are certain advantages of large-scale production, one of the most important of which is the utilization of by-products.

Marketing Beef Cattle

Extension of the Market.—The development of refrigeration has made a world market for beef possible. Beef from the United States, Argentina, Australia, and South Africa can be disposed of all over the world. This development has had the double effect of greatly increasing the numbers of consumers of meat and of linking up the producing regions with these prospective buyers. And, in the beef industry at least, some progress has been made in wiping out the seasonal glutting of the markets. Generally speaking, the packers take all the animals that are offered, and, as the carcasses may be kept indefinitely, seasonal fluctuations in prices are not nearly so pronounced as was once the case.

Before the advent of artificial refrigeration the cattle markets were necessarily found near the centers of population; but during the last half of the nineteenth century the central markets moved steadily westward until at the present time the largest of them are located in or

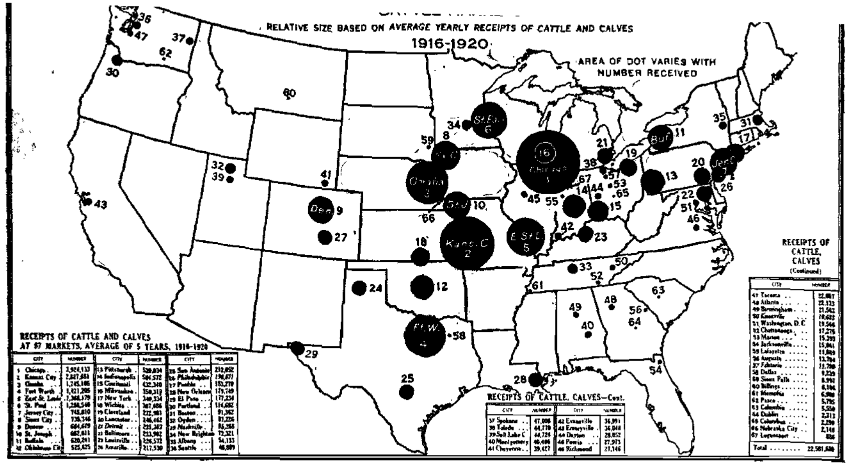


FIG. 51.—Over 55 per cent of the receipts of cattle and calves at the 67 public stockyards in the United States during the years 1916 to 1920 were at points in the Corn Belt. Other important yards are located at Fort Worth, St. Paul, Jersey City, Denver, Buffalo, Oklahoma City, Pittsburgh, and Indianapolis. The annual receipts at Chicago have been greater than any other market since the founding of the present yards in 1865. Kansas City ranks second and Omaha third. Most of the cattle received at these yards are sold to packers for slaughter, but large numbers are also sold to farmers for stockers and feeders.

Agriculture Yearbook, 1921, p. 281.

adjacent to the Corn Belt. As between 50 and 75 per cent of all cattle slaughtered in this country pass through the central markets, these markets are seen to be quite important.

Centralization.—This centralization of the markets has been partly responsible for the concentration of the packing industry in the hands of a few great corporations. Although this system may not be ideal, it certainly has tremendous advantages. These advantages have been mentioned before and consequently they will not be discussed here. But there has been a feeling among producers and consumers that this concentration is not consistent with their own best interests. For this reason, both of these groups have attempted to discover means of bargaining with packers and large buyers upon a substantially equal basis. The producers have begun to develop cooperative marketing as a possible solution to this problem, particularly as it is related to the large buying and commission corporations. That this movement is not entirely in the contemplative stage is evidenced by the fact that in 1920 about one-fourth of the livestock of Iowa and two-thirds of that of Wisconsin were marketed through cooperative organizations.

Government Inspection.—The consumers look to the Government to protect their interests. The Federal Government maintains a very strict meat-inspection service, and there is no doubt that the quality of meat products manufactured in this country is very high indeed. The Packers and Stockyards Act gives the Government additional regulatory powers with particular reference to the supervision of competition. There have been a great many demands for the Government to take more drastic steps, and price regulation has even been suggested. The packers, however, have thus far been successful in averting this development.

Some of the same problems of centralization are found in the other surplus-producing regions of the world; indeed, American packers are established in Argentina, Uruguay, and Australia. But in Europe no such situation prevails. Slaughtering is carried on locally, and the phenomenon of the central market, with its attending problems, does not exist.

Trends in the Beef Industry

Obviously, there is a possibility that any one of several factors may limit the development of the beef industry. For example, without efficient means of transportation between surplus and deficiency-producing areas, the industry will be severely hampered. Just now, however, the most pressing of the general problems of transportation and preservation seem to be solved, or at least solved to the extent that transportation is not a limiting factor. Another possibility is that the scarcity of land for pasture, or for the production of feed, will become so acute that the development of the industry will be checked. This situation is perhaps nearer to realization, and it will be necessary to look at it a little more closely.

Decrease in Pasture Land.—The ranges of the United States are almost completely stocked with cattle, and a great many of them, both publicly and privately owned, are dangerously overstocked. In addition to this fact, the tendency is to divert land, whenever possible, from pasture to crop uses. In view of this situation, it is not reasonable to suppose that the beef industry in this country will expand to any considerable extent. A consideration of the production figures given at the beginning of this chapter will clarify this proposition. While the adoption of more intensive methods have made possible an increase in the absolute production of beef, it is clearly seen that the per capita production has steadily decreased. In other words, the peak of *surplus* production has been passed.

The situation in Europe is so obvious that a bare mention will dispose of it. The per capita production of beef has been almost constant for many years. That is, Europe has attained equilibrium in the utilization of land, and if her demand for meat increases, she will be forced to import this new supply in addition to the amount that is already being imported. There is little opportunity for expansion of production.

But in the great surplus-producing countries, quite different conditions exist. In Argentina, Brazil, Uruguay, and Australia the number of cattle may be materially increased. It is true that even here there is some competition for the land. For example, in Australia there is a tendency for sheep to displace cattle, and in Argentina pasture is constantly being turned into crop land. *If necessary*, however, all of these countries can increase their production of beef enormously; but when and under what conditions will this increase be necessary? Here we have what is perhaps the heart of the whole problem.

The obvious answer to the question is that increased production of beef will be necessary when there is an increased demand for beef. But demand is likely to be an empty phrase. It is much too commonly used, and too often it is something which we simply assume without making any attempt to explain. In this case the demand for beef is simply the consumption of beef, and we must scrutinize closely the consumption habits of the population if we are to receive any light on our problem.

It has been said that " the abundant use of meat in a national diet reflects in that country either a primitive state of economic development or a comparatively high standard of wealth."[1] This simply means that considerably more land is needed to produce meat than is necessary for the production of the same amount of food in other forms. In China, for example, the population is so dense that if enough food is to be produced for all, the land must be utilized for the production of food that can be consumed directly by man. The same thing is true in England, but England is wealthy enough to be able to buy her meat from other countries.

Meat is palatable; it is concentrated; and a minimum of skill is required for its preparation. Consequently, it is highly prized, and the general assumption is that meat is an essential among civilized peoples. But a great many cattle raisers in the United States were ruined during the past war period by placing their faith in this simple proposition. The truth is that people can and will reduce materially their consumption of meat. The French look with horror upon the predominance of roast beef in the diet of the " barbarous " English; and, in the case of the French at least, it seems evident that skill in cookery has gone a long way toward the replacement of meat by vegetable products. The importance of meat in the world's food supply is quite generally exaggerated. It has been estimated, for example, that the food value of the world's annual production of meat is only 15 per cent of that of the yearly wheat crop.

It is quite difficult to obtain exact data showing the per capita consumption of beef, but, since the inauguration of the Federal Inspection Service in the United States, fairly reliable figures may be secured for this country. From these figures it is estimated that the per capita consumption of beef declined in the United States approximately 20 per cent between 1907 and 1921. As far as can be determined, the same tendency to decline is found in all of the surplus-producing countries. In Europe the consumption per capita was fairly constant until the war period, when it declined very rapidly. A low consumption level has been maintained since the war, largely on account of the lowered buying power of the European countries.

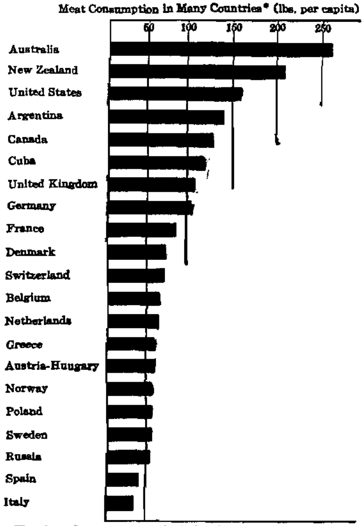
Figure 52 does not show, of course, the tendency in beef production. It is included largely in order to give an idea of the distribution of meat consumption, and to bear out the proposition that a large consumption of meat indicates either considerable wealth or a relatively low stage of economic development.

The evidence which has been presented does not necessarily prove that the relative consumption of beef will decline, but it does indicate

[1] Whitbeck and Finch, Economic Geography, p. 121.

that the consumption of large quantities of beef is not *essential.* In China, in Mexico, and at the present time in Europe, the per capita consumption of meat is very low. This simply means that it is possible to push per capita consumption to a relatively low level. If the price

Meat Consumption in Many Countries* (lbs. per capita)



* The above data are not available for all countries during the same year. The figures include not only beef but lamb and mutton, veal and pork.

Fig. 52

of beef becomes very high, therefore, consumption will probably decline. At the present time, then, consumption seems to be the limiting factor in the expansion of the beef industry. In many parts of the world, production can be greatly increased with a relatively small increase in cost; but this increase will not take place until consumers are willing to pay a slightly higher price for meat. At the present time the tendency is apparently not in this direction.

DAIRYING

General.—No other group of foods, perhaps, has received as much attention during the past few years as have the products of dairying. This phenomenon is due to the ever-increasing necessity for the more economical production of food, to recent discoveries and developments in the science of dietetics, and to the constantly rising standard of living of a large portion of the world's population. Milk is, of course, the most economical human food produced by animals. Dairy cattle will produce about twice the amount of available human food as will beef cattle or sheep, when given the same amount of feed.

But the fact that milk is an economical food does not explain completely its recent rise in importance, for individuals and nations who are wealthy enough do not need to be economical in their selection of food. More effective than considerations of economy are the urgings of dietitians, health institutions, and health officers, who are almost unanimous in their pleas for greater consumption of milk and milk products. Milk contains the mysterious vitamines which are necessary to health and which, on account of food standardization, are likely to be deficient in the average modern diet. Milk is also nearly a perfect food in that it contains most of the essentials of the human diet in almost perfect proportion. For these reasons, and one other important one which will be mentioned later, the consumption of dairy products is constantly increasing.

A rising standard of living is important in promoting an increase in the use of products derived from milk. Butter, fancy cheeses, milk chocolate, condensed milk, ice-cream powders, and other milk products fit into the diversified and bountiful diet which characterizes a relatively high standard of consumption. The existence of this high standard, together with the present active educational campaigns in favor of greater consumption of milk products, makes for at least a superficial feeling of security and optimism in the dairy industry.

In view of the general tendency toward greater intensification and less extension in the production of food products, it will be desirable to inquire into the position of dairying in the process. Dairying lends itself to intensification in two ways. First, the cow is an efficient utilizer of agricultural waste products. In other words, the by-products of the average general farm will supply feed for from one to several cows, and, inasmuch as these products are converted more efficiently than would be possible in the production of beef cattle or sheep, the keeping of milk cows may be said to be more intensive than the production of beef or mutton. The value of the by-products of dairying in the form of fertilizer is certainly not negligible, and the consequent building up of the soil fertility is an integral part of intensification.

Dairying is intensive, however, in still another way. In the most specialized dairying districts, only standing room is occupied by the dairy animals. They are fed almost entirely upon cultivated feeds, and they are pastured on carefully cultivated forage crops. In most cases, however, pasture is utilized to some extent, but the average pasture land per dairy cow is much lower than in the case of beef animals or sheep. Much more capital and labor, and less land, is utilized in dairying than in meat production.

Distribution

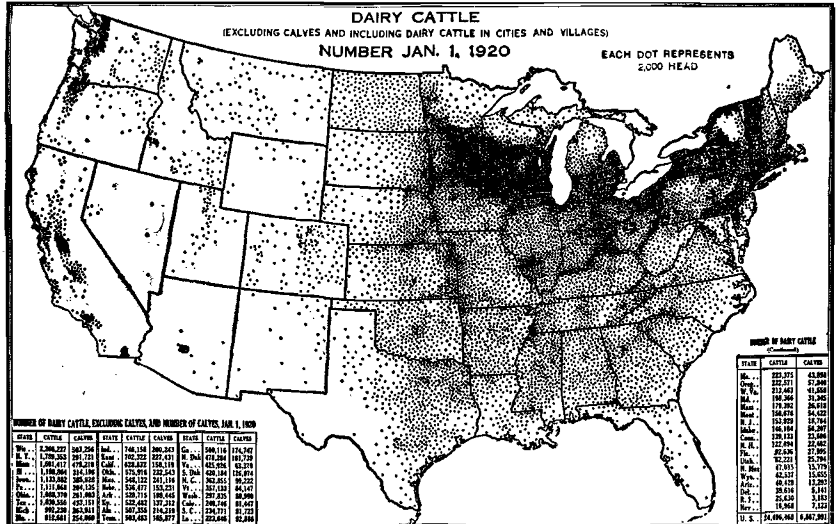
As a general rule, it is safe to say that the cow population tends to follow the human population in the middle latitudes. This is true, of course, on account of the relative perishability of milk products; although there have been many improvements in the transporation and preservation of these products, it is still impossible, in the main, for fresh milk to be consumed very far from the centers of production.

United States.—In the United States the concentration of milk cows is greatest in the so-called Elgin district of northern Illinois and southern Wisconsin; in central New York and northeastern Vermont; and in a narrow strip extending from Baltimore to the lower Hudson Valley. There is also a region of dense cow population in southeastern Canada. These areas of concentration are due largely to the corresponding density of human population, but climatic conditions also play an important part. The ration of the dairy cow should contain large quantities of succulent feeds, and a cool, moist climate is ideal for the production of this class of forage.

Surplus Areas.—The important surplus-producing countries of the world are Denmark, The Netherlands, Switzerland, New Zealand, and Canada, while the United States has some importance in the production of special products, such as condensed and evaporated milk. The outstanding deficiency-producing countries are the United Kingdom and Germany; but butter and cheese from west central Europe are consumed over the entire world.

Production

A discussion of the production of dairy products covers a wide and varied activity. The variety of milk products and the widely different conditions which prevail in the various producing areas make for a



NUMBER OF DAIRY CATTLE, EXCLUDING CALVES, AND NUMBER OF CALVES, JAN. 1, 1920

STATE	CATTLE	CALVES	STATE	CATTLE	CALVES	STATE	CATTLE	CALVES
Wis. . .	2,300,227	503,256	Ind. . .	746,158	200,243	Ga. . .	500,116	174,747
N. Y. .	1,780,353	291,721	Kans. .	702,322	227,431	N. Dak.	478,284	103,739
Minn. .	1,601,417	479,210	Calif. .	628,872	158,110	Va. . .	425,926	63,370
Ill. . .	1,180,864	314,196	Okla. .	575,916	232,543	S. Dak.	420,184	126,074
Iowa. .	1,133,882	385,828	Miss. .	548,122	241,116	N. C. .	362,855	98,222
Pa. . .	1,111,868	294,135	Nebr. .	536,477	153,231	Vt. . .	357,133	44,147
Ohio. .	1,068,370	281,003	Ark. .	528,715	190,445	Wash. .	297,835	80,900
Tex. . .	1,030,556	453,151	Ky. . .	522,482	137,312	Colo. .	240,746	81,447
Mich. .	992,230	263,911	Ala. . .	507,355	214,259	S. C. .	234,771	81,723
Mo. . .	812,661	254,060	Tenn. .	503,483	185,877	La. . .	223,646	82,886

NUMBER OF DAIRY CATTLE (Continued)

STATE	CATTLE	CALVES
Me. . .	223,375	43,858
Oreg. .	222,571	57,340
W. Va.	213,463	41,858
Md. . .	198,366	31,345
Mass. .	179,392	26,618
Mont. .	156,676	54,422
N. J. .	153,929	18,764
Idaho.	146,164	58,207
Conn. .	139,133	23,606
N. H. .	122,894	22,482
Fla. . .	92,636	27,995
Utah. .	82,221	25,794
N. Mex.	47,833	13,779
Wyo. .	42,537	15,655
Ariz. .	40,429	13,293
Del. . .	39,616	8,141
R. I. .	25,630	3,183
Nev. . .	18,968	7,123
U. S. .	24,096,468	6,467,991

Fig. 53.—Nearly half the dairy cattle in the United States are in the Hay and Pasture Region and the adjacent northern and eastern margin of the Corn Belt. Other dense areas will be noted in southeastern Pennsylvania, which is really Corn Belt country, and in the valleys of the North and South Pacific regions. In the Cotton Belt, especially the northern portion, dairy cattle are more numerous than beef cattle, but in the Great Plains, Rocky Mountain, and Arid Intermountain Regions they are much less numerous. Nine-tenths of the dairy cattle are in the East. The dairy cattle in cities and villages ("not on farms and ranges") number 1,220,564, which is less than 4 per cent of all dairy cattle and calves in the United States.

Agriculture Yearbook, 1921, p. 477.

striking lack of uniformity. Rather than general problems of production in the dairy industry, then, we must speak of the problem of milk, cheese, or butter production; and quite often a further classification must be made on the basis of the location of the industry. The most common problem that presents itself, perhaps, concerns the preliminary consideration of the production of dairy cows.

Efficiency of Dairy Cows.—Concerning the enormous difference in the efficiency of dairy cows there can be no doubt. Even in the most uniform herd there will be found a noticeable difference of production between the individual cows; and a comparison between first-class dairy animals and ordinary farm milk cows is as striking as a contrast between different species. This difference in efficiency is particularly important in the dairy industry on account of the comparatively high cost of production of dairy products. Fortunately, however, it is ordinarily quite easy to measure the efficiency of dairy stock. As a rule, the herd is uniformly fed, and if milk records of the individuals are kept an estimate of the efficiency of the animals is easily made.

The ease of estimating the worth of an individual cow has been a powerful impetus to the development of better dairy herds, particularly in specialized dairy regions, where inefficient cows with their offspring are sent without delay to the slaughtering block.

To increase efficiency through the use of a scientifically determined diet is not so easy. The available feed-stuffs must be utilized, and, although experiments seem to indicate that much better results can be obtained through scientific feeding, general conclusions covering all the possible combinations of feeds have not been developed to such an extent as to make them widely acceptable. However, in regions of specialized dairying and fairly uniform conditions, feeding has increased enormously in efficiency.

In the United States the most important production problems have to do with fresh milk, for almost half of the total product is utilized in this form. These problems are most acute in the large cities of the North and Northeast, and methods of production are quite highly developed in the producing regions which supply these cities. Generally, there is a gradual change in production methods which varies directly with the distance from these large cities, and, although there is no definite line between these producing areas, an observer is quick to notice the change.

Types of Dairy Farms.—In the outskirts of cities are to be found highly specialized dairies occupying a relatively small area of land. These dairies operate at fairly high costs because land prices are too high to devote to feed production and practically all feed used must be bought and shipped in. The lower transportation costs, together with highly efficient production, make it possible for these industries to show a profit. Farther out will be found a second type of specialized dairying. Here land is not so costly and it is generally found profitable to raise all or a large part of the feed consumed. This land is built up by the cows which consume its produce, and quite efficient land utilization results. In addition to the land used for feed production, there is commonly a large permanent pasture and often crop land is pastured.

As the extreme regional limits of the milk-producing area are approached, a third type of production is found. This type is the diversified farm with milk as one of the products of diversification. It is here that the idea of agricultural production on small holdings has been put into practice. Cream is shipped and the milk by-products are fed to hogs. The cows consume specially produced feeds, pasture grasses, and the cash crop by-products; and in turn they help build up the soil of the whole farm. It is perhaps to be regretted that there are not more farms of this sort.

As was mentioned before, there is no definite line of demarcation between these types of dairy farms. In any producing region the different types will be found fairly close together, and there is undoubtedly a tendency for them to be distributed about as has been indicated. The nature of the country, particularly with reference to the presence or absence of good pasture land, will sometimes offset the tendency; but distance from the city market has a powerful influence upon the type of milk production that will prevail.

Butter and Cheese Areas.—A somewhat different set of conditions exists in the region westward from Lake Michigan. Although the concentration of the dairy industry here is partly due to the consuming markets of several large cities, the country itself is particularly suited to dairying. The cool, moist summers make for an abundance of high-grade pasture grasses, and much of this land is not suitable for crop production; consequently, it is here that the great surplus-producing region of the United States is found. Two-thirds of the cheese produced in the United States, for example, is manufactured in Wisconsin. Milk products are produced in this region either by the specialized dairy, raising its own feed, or by the diversified farmer. The latter type of production probably predominates. The manufacturing and marketing operations of this cheese and butter region will be taken up in another place.

Although the surplus-producing regions of the country have been described, the largest part of the country still remains. Dairy cows are fairly evenly distributed over the southern and middle western state and in these self-sufficing or deficiency regions milk products are pro duced under widely different conditions. Ordinarily, however, dair cows are kept on farms and fed largely on the native pasture grasse and the by-products of agriculture. Butter is produced for loca consumption, and a small amount of cheese is manufactured in th cooler regions of the south. Cows are commonly of low grade; dairy ing is of secondary importance; and the dairy *industry* can hardl be said to exist.

West Central Europe.—Several factors combine to make west cen tral Europe the greatest dairy region in the world. The populatio is very dense, and the total amount of meat required, therefore, ca not be produced economically. Much of the land is not ideally suite to cereal production because it is either too rough, too marshy, or to humid. On the other hand, the cool, humid climate is ideal for dairy ing, and as a result the prosperity of a few countries and the food suppl of several others of the region are dependent upon the dairy industr The United Kingdom, particularly Ireland, produces large quantitie of milk products, but it can not begin to supply the demand of th great English cities. Consequently, the dairy belt extending fro western France to Denmark, and from Sweden to Russia, has a read market for its surplus. The predominance of this region in the dair industry is indicated by the west central European names which a associated with dairying and dairy products.

The Netherlands.—In the Netherlands dairying is carried on unde extremely intensive conditions. Although most of the marshy reclaime land of the country makes excellent pasture, the cow population so dense that auxiliary feeding is practiced in the midst of the mo abundant pastures. The cows receive the most exacting care, an dairy sanitation has reached a high stage of development. Butt manufactured in the Netherlands is marketed chiefly in England, an occasionally in the United States, but the Dutch are more famous fo their cheeses, which are exported to many parts of the world. Th dairy industry has been the means of utilizing low, poorly draine areas and thus has been responsible for a large part of the land-reclama tion program in the Netherlands.

Denmark.—Denmark also presents a striking example of lan utilization. The soil was originally quite poor, but intensive dairyin has had a powerful effect in increasing its fertility. Indeed, Denmar presents an illustration of efficient dairying to all the world, and th investigators of dairy problems of all kinds find it profitable to stud Danish methods of production and marketing. Denmark does not hav

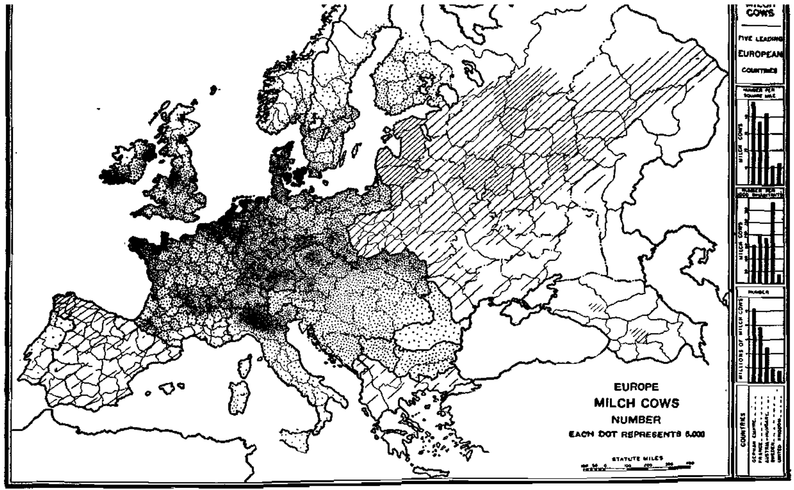


FIG. 54.—Distribution of cows in Europe. Most of the cows in Europe are of the dual-purpose type, but in the northwest the specialized dairy breeds are quite important. The importance of the dairy industry in Great Britain, especially Ireland, is, however, inadequately shown on the map, owing to different statistical classification. As might be expected, the general features of distribution conform closely to those of all cattle. It is interesting to note the greater density of cows along the northwest coast, where climatic conditions favor rich pastures. Pasture and dairying are even more closely connected in Europe than in the United States. The intensive dairy districts in northern Italy and along the northern coast in France, the Netherlands, and Denmark have between two and three times as many cows per square mile as the densest dairy region in the United States.

[1] *Finch and Baker, Geography of the World's Agriculture, p. 185.*

such ideal pasture resources as are found in the Netherlands, but a large part of the land is devoted to the production of feed for cattle, and in addition grain and other concentrates are imported for feed. Two very important developments are to be noted in the Danish dairy industry. First, although crowded conditions make the spread of disease easy, the dreaded tuberculosis has been stamped out among the herds of the country. Second, the Danes have so standardized their products, especially butter, that they are known and prized all over the world. The Danes export butter to England, and the tinned product is shipped to the most remote parts of the world.

Switzerland.—Switzerland and northern Italy are noted throughout the world for their cheese production. Particularly in Switzerland, dairying is almost the sole agricultural industry possible, and the amount and quality of her exports of cheese, condensed milk, and milk chocolate indicate the extent to which she has taken advantage of her possibilities.

Potential Producing Areas

Before the development of artificial refrigeration, the production of even the relatively non-perishable dairy products was limited to cool climates; but at the present time butter and cheese can be manufactured almost anywhere in the middle latitudes. Particularly in the Cotton Belt of the United States is increased production possible. In this region labor is fairly abundant, and the by-products of diversified crop production will feed many dairy cows. Argentina and Australia could, of course, produce enormous quantities of dairy products. It is possible that if the industry were developed, these countries could produce butter and cheese more cheaply than west central Europe. But the point is that the industry is already developed in Europe. The European products are standardized and known all over the world, and the population of the surplus-producing countries have a high degree of skill in the manufacture of dairy products. On account of these facts it is probable that only the local pressure of population or a great increase in consumption of milk products will increase the industry in the present deficiency-producing areas. Nevertheless, in recent years, New Zealand, remote from the great markets, has become a formidable rival of Denmark for the English trade.

Recent Developments in the Industry

Transportation.—One of the most important developments that has occurred in recent years is the tremendous improvement in the methods of transporting fresh milk. The limits of the metropolitan milk areas are sometimes more than a hundred miles from the city itself, and, for the purpose of experimentation, fresh milk has been shipped successfully from Wisconsin to New York. These long shipments are only made possible through the use of special railway-transportation facilities. The common method of transportation is to assemble the large cans of milk at the country railroad stations, and then ship the cans by special refrigerator trains. Commonly, the cans are covered with cakes of ice and in this way low temperatures are maintained throughout the trip.

Refrigeration.—The latest method utilized is to transport milk in specially built tank cars. The tank cars are built in sections and provided with cranes by means of which the sections are loaded or unloaded. Vacuum tanks may be used, but plain glass-lined sections, cooled by a variety of methods, seem to be satisfactory, and they are certainly much cheaper. It is obvious that this method can be commercially used only when large quantities of milk are produced in one district and where the distance to market is very great.

Motor Truck.—As in many other phases of transportation, the motor truck is increasing in importance. Good roads make truck transportation easy, and as the milk must be hauled over the highway at some stage of its journey, it is often economical to haul it all the way rather than to change from truck to train and then back to truck again when it arrives in the city. Experiments seem to indicate that for distances up to 30 miles the truck is cheaper than railroad transportation, and that the truck can compete with the railway for all distances under 60 miles. This tendency toward the use of trucks has progressed so far that certain large railway companies, such as the Pennsylvania Lines, have made truck transportation an important adjunct to their transportation system. Of course, a fairly good road must exist before highway transportation can be undertaken at all. However, hauling by truck has certain disadvantages. There is danger of injury to the milk by the churning process which is imparted by the truck motion, and it is, of course, impossible to carry large quantities of ice. It is claimed that especially constructed tank trucks do away with these objections.

The cities of Cincinnati, Kansas City, Atlanta, Milwaukee, and

Indianapolis receive more than half of their total milk supply by truck, without intermediate railway transportation. The development of highway milk transportation has been of benefit to both producer and consumer of milk. Marketing costs are reduced; cities receive a more plentiful and better supply of milk than ever before; and farmers have a wider market for their product.

Sanitation.—Dairy sanitation has made rapid progress during the present century. The increasing complexity of the marketing of dairy products, the distances over which milk has to be shipped, and the number of handlings fresh milk must undergo have made sanitary methods very necessary. This is particularly true on account of the fact that milk is not only a perfect food for man but for bacteria as well. As long as milk could not be guaranteed free from harmful numbers of bacteria, the situation was unfavorable to both the consumer and producer, for only the absolutely necessary amount of milk would be consumed.

Bacterial Count.—The situation has changed markedly since the first certified milk was produced in 1892. A simple bacteriological technique for discovering and counting bacteria in milk has been perfected, and in most cases the consumer of milk knows just what sort of product he receives. Producers of milk have realized the importance of a pure product in increasing demand, and ordinarily they are willing to take every precaution necessary for the production of sanitary milk. If they are not willing, pressure is brought to bear by the milk-inspection service which is maintained by practically every city.

Pasteurization.—Pure milk is of two sorts. First, milk may be produced and handled with such sanitary conditions that the bacterial count is too small to produce bad effects. Second, milk with a high bacterial count may be pasteurized, or maintained at a temperature of 145° F. for about thirty minutes. For a long time there existed a distinct prejudice against pasteurized milk, but a realization of the importance of a pure product has largely done away with this feeling.

Tuberculosis.—Bovine tuberculosis presents an important public-health problem as well as a problem for the farmer. Fortunately, a diagnostic technique has developed, and it is now possible to determine the presence of tuberculosis in any herd. In 1917 a coöperative tuberculosis-eradication campaign was organized, and this campaign has at the present time made considerable progress. The essential plan is to test all herds, at the owner's invitation, and eliminate all diseased animals. As practically all of the states indemnify owners for cattle reacting to the test, there is little incentive for concealing the disease where it exists. As a result, the percentage of tuberculous cattle has greatly decreased and the future complete eradication of the disease in this country is probable.

Marketing

Coöperation.—One of the most important recent developments in the dairy industry is the increase in the United States of coöperative production and marketing. Coöperative creameries and cheese factories have been operated for many years, particularly in Minnesota, Wisconsin, and Michigan, but the existence of these organizations had little significance from the point of view of marketing.[2] Their main function was to retain the profits of butter and cheese manufacture for farmers, and little or no attempt was made to dispose of the product in any other way than through the regular channels of trade. It is obvious that this plan has a great many advantages to producers. However, it soon became evident that if the producer expected to have sufficient influence in the industry he must particpate in the marketing as well as in the production of his product.

Brands and Trademarks.—The growth of an almost universal demand for greater stability in the quality of foodstuffs brought about the adoption of brands and trademarks in even the staple food products. Consequently, the producers of high-grade goods were able to collect a substantial premium on the market. In a large number of cases at least, it was the coöperative factory, managed by producers with the producer's pride in his own product, which manufactured tbe highest-grade produce and received the premium. For this reason, more than for any other, the coöperative producers began to become interested in the marketing field.

Oregon Cheese Federation.—Several years ago a group of coöperative cheese factories in Oregon formed a federation to dispose of their product under a uniform brand. This organization has apparently been successful, but it is important to notice that it did not succeed simply because it was coöperative. In the first place, production was on a large scale, and once a demand for the particular product was created the supply was always forthcoming. No less important is the fact that the product was of high and uniform quality. In other words, the organization performed a service that was not being performed elsewhere. A coöperative organization deals with the same customers as does any other marketing agency, and it is important to its success that its directors realize this fact at the outset.

Wisconsin Cheese Federation.—In Wisconsin a federation of cheese coöperatives is now operating under a plan similar to the one described

[2] Agriculture Yearbook, 1922: The Dairy Industry.

above, and at present there is a federation composed of several hundred Minnesota coöperative creameries which maintain their own wholesale marketing agencies in New York City. On the west coast, a comparatively small group of butter producers have gone a step farther and are maintaining their own agency in Los Angeles, supplying butter directly to retailers.

Producers of milk for city consumption have also made considerable progress toward marketing their products coöperatively. Producers organizations have existed in this field for several years, but in the beginning they attempted to engage only in collective bargaining with the distributors of milk in order to obtain better prices. More recently, a few organizations have undertaken the retail distribution of their product.

The Dairymen's League, composed of some 72,000 dairymen in the milk district of New York City, is the largest coöperative dairy marketing association in the country. This organization maintains its own wholesale distributing station in New York City, and large consumers are supplied directly. Milk is also sold to wholesale milk dealers, and the surplus is disposed of at various markets where butter, cheese, condensed and evaporated milk, ice cream, and powdered milk are manufactured. A number of other flourishing coöperative milk-marketing associations are in operation in the Middle Atlantic and New England States and also in the North Central States.

Various problems connected with the coöperative marketing of dairy products have presented themselves. Space does not permit consideration of these problems here, and their details can only be taken up in a specific study of marketing. It must suffice to say that difficulties are to be expected in a new undertaking, and that a great many persons are engaged in an attempt to solve the most difficult of the problems connected with coöperative marketing.

Technique

Cream Separation.—Machinery and mechanical appliances of various sorts have been successfully adapted to the dairy industry, but there have been two mechanical inventions of fundamental importance. The first of these was the centrifugal separator used to isolate the cream, or that portion of the whole milk which contains most of the total solid content and all of the fatty solids. The use of this separator is particularly important from the point of view of marketing, because it makes possible a fairly standard product. This machine is supplemented by a second device, the Babcock Tester, which removes all guesswork from the determination of the quality of the milk.

Babcock Tester.—The Babcock Tester is a simple device for measuring the quantity of fat in milk, but, despite its simplicity, it is of permanent importance. With the use of this machine it is possible to classify milk on the basis of fat content, and a standard quality can be made the basis of milk prices. Important as this process of standardizing has proved to be, the Babcock test performs an additional service of immeasurable value. In the breeding of dairy cattle it is desirable to develop those animals which produce a high-quality product. Without the Babcock test only the amount of the product can be measured accurately, and the amount of the product is not always a perfect indication. The Babcock test is cheap, simple, and accurate, and its use enables producers to sell both milk and dairy cows on the basis of quality.

Thermometer Silo and Milking Machine.—Various other mechanical aids have come into use in the dairy industry. With the Babcock test and the centrifugal separator came the wide use of the thermometer. Later the silo, which provided succulent feed in winter for dairy cows, was perfected. The technical improvements in transportation have already been mentioned. Within recent years the milking machine has come to be widely used and the machine process has been adapted to butter and cheese manufacure. The dairy industry, however, is dependent upon a large amount of skilled labor, and, while the mechanical aids are not to be despised, the labor factor must never be forgotten.

Meat Production from Dairy Animals

Meat a By-product.—An extremely important by-product of the dairy industry is the meat obtained from discarded or unfit dairy animals. These animals are of three classes. Cows become unfit for milk production on account of old age, low milk yield, physical defects, and sterility. Bulls are discarded on account of old age, vicious behavior, or unfitness for breeding purposes. The amount of meat obtained from these two classes of animals is certainly not insignificant, for it has been estimated that in the United States dairy animals furnish 23 per cent of the total meat production.[3] Naturally, the quality of meat obtained from dairy stock is very low, but young cows may sometimes be fattened so that they furnish good cow beef. Meat from the older cows and bulls is either sold in the form of cheap cuts or it is utilized by the canners and sausage makers.

Veal.—Veal from discarded calves furnishes the third and most important class of meat obtained from dairy animals. Formerly the

[3] Agriculture Yearbook, 1922, p. 338.

excess male calves from dairy herds were slaughtered at birth in order to conserve the milk supply, but it has been discovered that these animals can be disposed of profitably after a few weeks' feeding of skim milk and other supplementary feeds. For this reason, calves that are not to be added to the herd are disposed of as veal. The quality of this meat is good, and a large portion of the meat supply obtained from dairy animals comes from these calves.

Consumption

The per capita consumption of milk and milk products constantly tends to increase. That there is room for much more development along this line, both in the United States and in many foreign countries, is plainly shown by the following diagram:

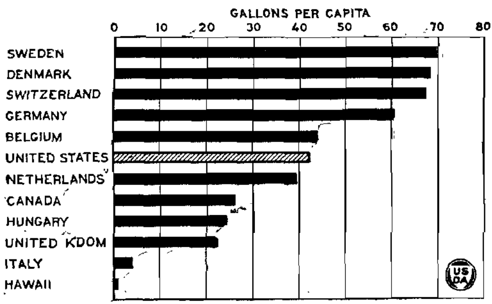


Fig. 55.—The per capita consumption data upon which the above chart is based are those nearest to 1914 that are available. They are not all for the same year. The per capita consumption of milk has increased in the United States from 42 gallons in 1914 to 49 gallons in 1921. The average consumption of milk and cream in cities in the United States was obtained from reports from 300 cities with a total population of 33,676,563, nearly one-third of the population of the United States. On the basis of this survey, the average quantity of whole milk consumed per person in the cities was estimated at 0.668 of a pint daily, and, in addition, the consumption of cream accounted for the utilization of 0.167 of a pint of milk, making a total equivalent to 0.835 of a pint of whole milk. Combining the rural and urban consumption, the average per capita consumption of whole milk as milk and cream for household purposes was 1.06 pints daily. This is equal to 49 gallons of milk annually, which is the largest annual per capita consumption on record in this country.

Agriculture Yearbook, 1922, p. 387.

Perhaps the principal reasons for this tendency toward increased per capita consumption are the improved transportation facilities for these products, the more sanitary conditions of production, and the growing realization of the importance of milk products in the human diet. Dietitians and various health agencies have maintained an active campaign in order to bring about increased consumption of milk, and as a result of all these influences dairying in this country has become widespread.

Increasing Costs.—In the past, dairying has been carried on under conditions of constant or decreasing costs. That is to say, the cost of producing a unit of milk either remained about the same or tended to decrease. But this situation no longer exists, and the costs of producing milk are increasing. Therefore, consumers will have to bid higher for milk products if they are to induce dairymen to continue to produce them.

Substitutes.—The most important and most expensive element in fresh milk is the fat that it contains, and it is for this fat that substitutes are most readily available. Everyone is familiar with the butter substitutes that have appeared; and although few consumers prefer them to the genuine product, it is at least safe to say that some of the disdain with which we entertain thoughts of oleomargarine and similar products is due to our prejudice against all substitutes. Of late a product closely resembling butter has been made from coconut oil, and the purity of most of the new vegetable oils has caused many to adopt them for culinary purposes.

Vegetable oils are more easily preserved than butter, and as a consequence they can be used more satisfactorily in an undeveloped country. They are, of course, much cheaper than butter, and for this reason, if for no other, they will tend to replace it when milk products become very expensive. It is very probable that the consumption of milk will continue to increase; but it is also true that as substitution becomes easier the more highly prized but more expensive butter will tend, to some extent at least, to give way before the cheaper substitutes.

THE TARIFF

Comparatively recently, the American farmer has interested himself in the tariff problem, particularly with regard to the "protection" of farm products. This interest is the result of several factors,[4] the most important of which are the opening up of new agricultural

[4] Holman, The American Farmer and the Tariff. Annals of American Academy of Political Science, January, 1925.

lands in other parts of the world and the adoption of substitutes for staple agricultural products. The producers of dairy products, on account of their relatively strong position, and on account of the possibility of substitution for their product, have been most active in directing attention to the tariff issue.

It is impossible here to go into the consideration of the relative merits of protection and free trade. However, the tariff policy of the United States has been fairly consistent in its adherence to some degree of protection. In the light of this situation, it will be well to inquire into some of the needs, in the matter of tariff, of the American producer of dairy products. In general, American products enter into little competition with the products of west central Europe. However, it is felt that in the absence of tariff regulation America would be the dumping ground for the surplus European stocks. That this dumping is comparatively rare and that it serves only to demoralize domestic prices is held to be sufficient justification for its abolition through the adoption of a high tariff.

More important, perhaps, is the extent to which vegetable oils are substituted for dairy products. Large quantities of these oils are imported into the United States and, granting that protection is desirable, there can be no grounds for denying protection to producers of dairy products. Those who advocate a protective tariff for agricultural products point to the declining curve of agricultural exports, and to the rising curve of manufactured exports. Conditions, they say, have been reversed since the tariff policy of this country became habitual. In other words, manufacturing has been protected during the period of its growth and at the present time it is so developed as to need no protection from without. Agriculture, on the other hand, has declined in relative importance, and newer countries are threatening to flood this country with products at prices which can not be met by domestic producers, since they must carry on their operations with the aid of land that has progressively become more costly.

HOGS

Historical Development in the United States.—Pork production had attained considerable importance even in colonial days. Several of the northern colonies produced a surplus of pork which was exchanged with the West Indies for sugar and rum. The first export statistics were published in 1790, and in that year there were exported from the United States approximately 6 million pounds of pork and pork products. The domestic consumption was many times greater.

After the war of 1812, agriculture developed rapidly in the Ohio Valley. Inasmuch as this region was well adapted to corn production and corn could best be marketed in the form of hogs, the production of hogs received a tremendous impetus. During the early years, hogs were driven to eastern markets such as Philadelphia and Baltimore, and southward to the cotton-producing region. As early as 1820, however, slaughtering of hogs for shipment down the Ohio and Mississippi Rivers began, and Cincinnati soon became a great packing center. With the westward migration of corn production, packing plants were established at many points, and in 1832 one was established at Chicago, which has since become the largest in the world. While hog raising was a great boon to the pioneer farmer west of the Alleghanies, who was thus able to market his corn more economically, it was disastrous to the farmer of the Northeast, who was unable to compete with the western farmer in corn production and consequently in hog production.

With the extension of the canals, and, more especially, of the railroads, a further impetus was given to the hog industry in the West during the 'thirties, 'forties, and 'fifties. The Civil War cut off the southern market for hogs and greatly demoralized the industry.

After the Civil War, vast areas of new free lands, admirably adapted to corn production, were opened up in the Prairie States of Illinois, Iowa, the Dakotas, Minnesota, Nebraska, and Kansas, under the homestead laws. The result was a rapid expansion of the hog industry, and consequent low prices. From 1870 to 1880 our exports of pickled and salted pork increased three-fold; of lard, six-fold; and of ham and bacon, fifteen-fold. This flood of American pork brought a demand for protection from the hog producers of Germany and France. The demand for a protective tariff was made on the pretext that American pork was infested with trichinæ and was thus dangerous to the health of the people. The result of thus reducing the outlet for pork was still further to reduce prices and greatly to retard further expansion of the hog industry.

Since 1890 the most significant change in the distribution of swine is the increase in number of hogs in the western part of the Corn Belt, along the border of the Great Plains and in Iowa, in conformity with the tendency to market the most distant corn in the form of hogs. In the eastern Corn Belt States, the market demand for corn has resulted in the reduction of the number of hogs nearest to corn markets.

Present Importance of Hogs in the United States.—Hogs are produced on 75 per cent of the farms in the United States and represent over 10 per cent of the value of the nation's agricultural production. Nearly two-thirds of the commercial production of pork is carried on in the Corn Belt. Hogs rank second in number and third in value of farm animals. According to the United States Census, the number of hogs in the country has increased from 27 million in 1840 to 62 million in 1920. No substantial increase has occurred, however, since 1890.

World Distribution of Hogs

The centers of densest hog production are the Corn Belt of the United States, where approximately 23 per cent of the world's supply is produced; China, where, it has been estimated, 31 per cent of the world's supply is produced and where hogs are fed largely on waste products and barley; and west central Europe, where hogs are maintained largely on root crops, including potatoes and the by-products of the dairy industry. The corn-growing areas of Hungary, Italy, Argentina, and Brazil are also important in hog production.

Swine are relatively unimportant in the tropics, for various reasons. First, the population in most tropical areas is sparse. Second, vegetable oils which serve as a first-class substitute for animal fats, may be obtained in abundance. Third, hogs suffer more from parasites and diseases in the tropical climates than they do in temperate climates. Fourth, religion practically excludes hogs from India, Turkey, certain other parts of Asia, and parts of Africa.

Economics of Hog Production

Hogs in the Various Farming Systems.—About 75 per cent of the hogs raised in the United States enter commercial channels and are produced under one of three general types of farming systems, viz., the Corn Belt, the Cotton Belt, or the Dairy Belt.

Corn Belt.—By far the largest proportion of commercial hogs are grown in the Corn Belt section of the country. The reasons for this situation have already been indicated. It was seen that hogs fit in well with a good cropping system and with other livestock enterprises, all of which contribute to soil improvement.

Cotton Belt.—The production of hogs on a commercial basis has been greatly retarded in the South on account of the dominating importance of cotton, just as it has been promoted in the Corn Belt by the dominance of corn. Instead of occupying the pivotal position in the farm organization as it does in the Corn Belt, hog production in the South is but an unimportant incident to the main enterprise, viz., cotton production. Under these conditions, relatively little attention is given to scientific feeding and breeding, and a less efficient type of hog is produced.

HOGS IN SELECTED COUNTRIES.

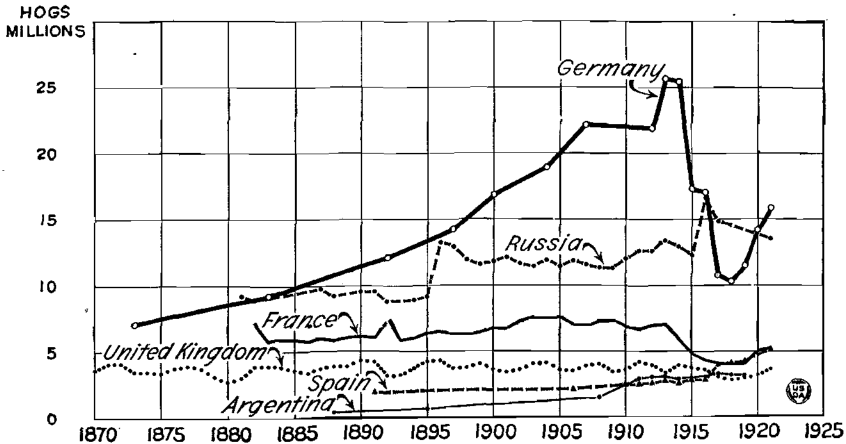


FIG. 56.—In the forty years previous to the World War the number of hogs increased more in Germany than in any other important country for which statistics are available. The War caused a great reduction in the number of hogs in many of the European countries. Spain, however, increased its number of hogs. Argentina has only recently become an important producer. The estimates shown for Russia since 1914 are from the Central Statistical Bureau of Russia.

Agriculture Yearbook, 1922, p. 186.

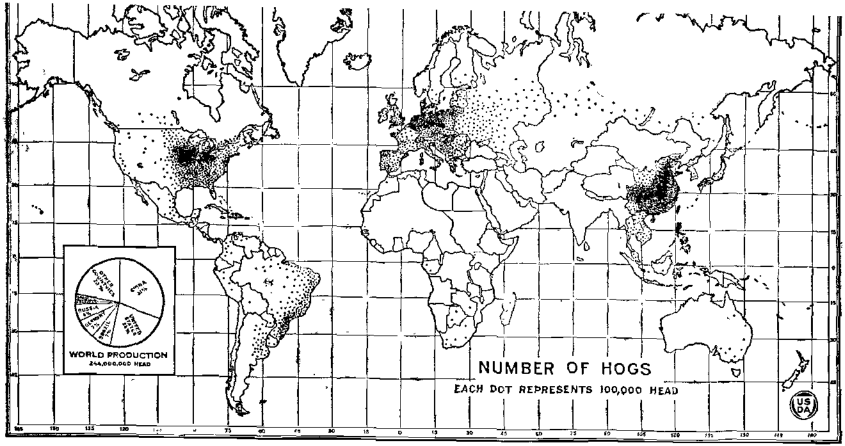


FIG. 57.—The centers of densest hog production are the Corn Belts of the United States and Hungary, the potato and dairying belt of northern Europe, and China, where hogs are fed largely on waste products and barley. Little is known about hog production in China, and the figures used are only estimates. In the corn-growing regions of Argentina and southern Brazil the number of hogs is increasing. Hogs are not numerous in tropical countries, *because such countries, as a rule, are not densely populated* and have available the vegetable oils to supply the needed fats. Moreover, in the tropical and subtropical climates hogs suffer more from parasites and diseases than in temperate climates. Religion practically excludes hogs from India, Turkey, and certain other parts of Asia; also from parts of Africa.

Agriculture Yearbook, 1922, p. 183.

In some parts of the South, however, the production of hogs on a commercial basis is assuming considerable importance as part of a program for diversified farming, soil building, and combating the boll weevil. The cowpea, soybean, peanut, and other leguminous plants are contributing to the economical production of hogs and to other phases of the diversification program.

Dairy Belt.—The northeastern section and the Great Lakes region of the United States are well suited to the growth of tame grasses and other forage crops, and here the dairy industry thrives. The by-products of the dairy industry are ideal feeds for stimulating the growth

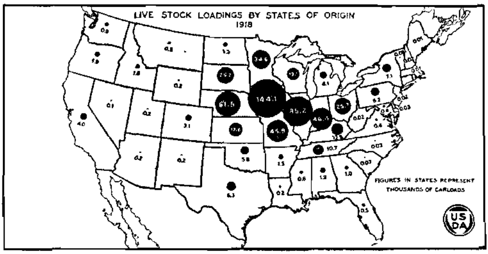


Fig. 58.—In 1918 Iowa led in number of hogs loaded, with 144,105 cars; Illinois was second with 85,164 cars; Nebraska third with 61,489 cars; Indiana fourth with 46,362 cars, and Missouri fifth with 45,860 cars. Iowa loaded more than 25 per cent of all the hogs shipped during that year, whereas Missouri, which was the fifth, loaded 8 per cent of the total.

Agriculture Yearbook, 1922, p. 236.

of young pigs and, as a result, the hog industry fits in well with the major industry, which is dairying. This is far more true of the Great Lakes region than of the Northeast, because in the latter region a large proportion of the milk is consumed by the people as whole milk, while in the Great Lakes region only the cream, in the main, is used for human consumption, the skim milk being left as feed for hogs and other animals. Therefore, in commercial hog production, the northeastern section of the United States, has long since been obliged to give way to the Corn Belt, while in the Lake States, although they are not so well adapted to corn production, the hog industry is able to maintain itself on a fairly large scale. The suitability of the states north of the Corn Belt for the production of barley, and of other feed crops almost equal to corn in feeding value, contributes to the same result, as it tends to make the cost of production in this area no greater than in the Corn Belt.

Hog Diseases and Cost of Production.—The cost of producing hogs is greatly modified by the presence or absence of disease. Among the most serious diseases and ailments afflicting hogs are cholera, tuberculosis, and hog "flu," together with certain parasitic infestations. Of these afflictions, cholera is by far the most virulent and destructive, although since the use of the preventive serum began in 1913 the losses have been greatly reduced. Even now, from 80 to 85 per cent of hog losses are due to cholera.

Tuberculosis is second only to cholera in the losses it occasions among hogs. Hogs become infected with tuberculosis largely as a result of being fed unsterilized milk from tubercular dairy cattle or consuming grain that has passed through tubercular steers. It is believed that tuberculosis among hogs will be greatly reduced when the accredited-herd and accredited-area plans become more generally adopted.

Hog "flu" increases the cost of production of hogs more because of the loss of weight which the animals suffer while they are afflicted with the disease than because of the actual death losses incurred. Hog "flu" is a very contagious disease which spreads rapidly through the herd. The disease is accompanied by symptoms of "difficult, jerky and wavelike respirations with nausea, high temperature, cough and sometimes great prostration." The disease first attracted attention in 1918.

Among the parasitic infestations of hogs, the most destructive are due to trichinæ. These parasites are largely distributed by rats and become embedded in pork products, making these products dangerous for human consumption unless thoroughly cooked. The presence of these parasites in exported pork was used as a pretext by a number of European countries for imposing tariff barriers in the early 'eighties, and impelled the Federal Government to make microscopic inspection of all pork exported to these countries from 1898 to 1906. It was found that one animal out of 71 showed positive infestation with trichinæ.

Breeds of Hogs.—The most popular breeds of hogs in the United States are the Duroc-Jersey, Poland China, and Chester White. These breeds are recognized as distinctively American, having been developed through many years of breeding from foundation stock derived from various parts of the world, but mainly from England.

Some of the qualities sought after by the hog breeder are size, vigor, rustling qualities, early maturity and prolificacy. In recent years another requirement has appeared, viz., that a type of hog be produced in which the percentage of ham and bacon is at a maximum. This can best be realized in breeds that will attain a weight of from 175 to 225 pounds in from six to nine months of judicious feeding. The premium which the consuming public is willing to pay for this class of pork is so great that discerning breeders will give this matter increasing attention in the future.

It will avail the grower of hogs but little, however, to produce the type of pork the consumer wants, and for which he is willing to pay a premium, unless this premium is reflected back in part at least to the farmer. For this reason the problem of marketing hogs is one of growing importance.

Marketing.—The more important present-day methods of marketing are as follows: *first*, producer shipments, (*a*) to central markets, (*b*) direct to packers, (*c*) slaughter and sale of products by farmers; *second*, local sale, (*a*) to the country drover, (*b*) to the packer buyer, (*c*) to the local butcher; *third*, coöperative marketing, (*a*) through shipping associations, (*b*) through auction sales.

It is impossible within the limits allowed for this subject to do more than enumerate the different ways in which the marketing of hogs is now carried on. It may be stated, however, that the coöperative marketing of hogs is growing rapidly in this country and may reasonably be expected to exercise tremendous influence in stabilizing both the production of hogs from year to year and their flow to market from day to day.

Price.—The influence of price in bringing hogs on the market from day to day is very great and should be studied carefully by all students of agricultural economics, including farmers. Efforts should be made to avoid alternate gluts and deficits, with the consequent changes in prices. This can be accomplished by establishing adequate agencies for collecting information concerning prospective shipments from local points, and conveying this information to the farmers throughout the commercial hog-producing area. This can be done most effectively by farmers' organizations.

Again, a general high level of daily prices over several months will tend to stimulate excessive breeding of hogs, and this in turn will bring on a low level of market prices a year or so later. These daily price fluctuations, interrelated with seasonal variations, constitute the greatest obstacle to the stabilization of the hog industry.

Domestic Consumption of Pork and Lard.—Domestic consumption of pork varies greatly, and this adds materially to the hazards of the hog industry. According to the Agriculture Yearbook for 1922, the

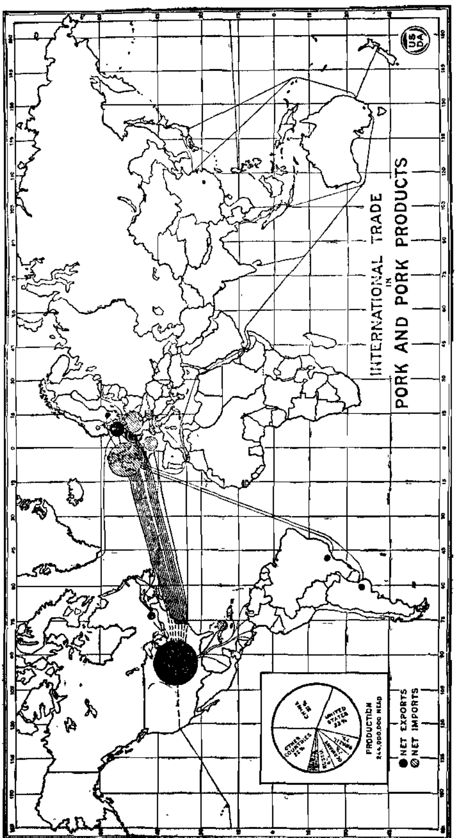


FIG. 59.—The United States is the great surplus pork-producing country of the world and industrial Europe is the great market for the surplus pork. In the bacon market Denmark and Sweden are important competitors. Argentina and Brazil are new competitors. China and Australia export small amounts to their Oriental neighbors.

Agriculture Yearbook, 1922, p. 274.

per capita consumption in this country was greatest in 1908, when it was 85 pounds, and lowest in 1917, at 58 pounds. The total difference in consumption for the country was over 1½ billion pounds, not including lard.

Foreign Consumption.—Fortunately for our hog producers, Europe provides a substantial outlet for our pork and lard. During the war period, over 1½ billion pounds of pork and lard were shipped abroad. Normally, our exports of pork and pork products represent from 10 to 12 per cent of our agricultural exports and from 5 to 6 per cent of our exports of all kinds.

International Trade in Pork and Pork Products.—Our principal competitor in the foreign pork market is Denmark. Other countries that produce a surplus are Canada, the Netherlands, Sweden, Australia, Argentina, and Brazil. The last three have entered the field since the War. Our best customers are the United Kingdom, Germany, Cuba, and Mexico.

Outlook.—The trend of pork production has been only slightly upward during the past twenty years, and the increase has not kept pace with the increase in population.

In 1882 there were 120 hogs per 100 people and now there are only 50 to 100 people. With the declining per capita production of hogs there has been a declining export of pork and pork products. This tendency toward declining exports was interrupted during the War and the period immediately following, but it is probable that the pre-war trend of diminishing exports will be resumed as world readjustment is brought about.

POULTRY AND POULTRY PRODUCTS

Importance of the Industry.—The production and distribution of poultry is one of the most important of all industries. In the United States it yields annually a product worth over one billion dollars, about equal to the value of all oats, rye, barley, and buckwheat grown. The production of the poultry industry in this country exceeds that of any other country, China probably being the nearest competitor.

New York City, because of its importance as a port of shipment and as a center of distribution for a densely populated area of consumption, is the market of primary importance in the egg trade of the United States. The growing importance of this country has made New York one of the most influential egg markets in the world, second only to London.

Domestic Production.—Relative changes in the poultry and egg production of the United States indicate a general tendency to increase. The high value of all grain during the War had a discouraging influence on the poultry raisers, as shown by the low relative increase in the quantity produced from 1909 to 1919.

It has been shown by the history of older civilized nations that, as the population increases, the number of forage animals depending upon pasture decreases and the population depends more upon cereals, animals consuming the cereals, and those easily kept under confinement.

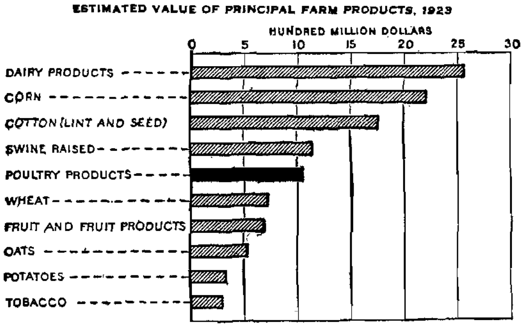


FIG. 60.—Only four farm products exceeded the value of poultry and eggs in 1923, dairy products heading the list. Poultry products were valued at over 1 billion dollars, exceeding wheat by 321 million.

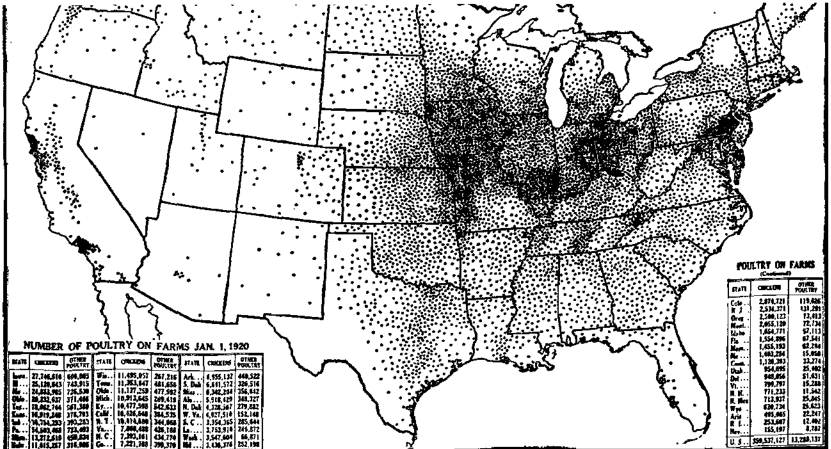
Agriculture Yearbook, 1924, p. 389.

There has been a general tendency in the United States during the past ten years for the poultry industry to progress toward the South, Southwest, West, and Northwest. Only slight development has occurred in the Rocky Mountains, but the Pacific Coast has taken great strides in the development of specialized poultry ranches.

Chief Areas of Production in the United States

Northeastern District.—Most of the markets receiving goods by long shipments from all over the country are located in the northeastern part of the United States. This district includes New England and the Middle Atlantic States.

During the last ten or fifteen years many specialized poultry farms



NUMBER OF POULTRY ON FARMS JAN. 1, 1920

STATE	CHICKENS	OTHER POULTRY	STATE	CHICKENS	OTHER POULTRY	STATE	CHICKENS	OTHER POULTRY
Iowa.	27,746,510	690,085	Wis..	11,495,057	267,216	Ark...	6,955,132	440,522
Ill...	25,120,643	743,915	Tenn.	11,353,047	481,656	S. Dak	6,611,572	326,516
Mo...	24,833,985	726,530	Okla.	11,127,259	477,982	Miss..	6,342,204	356,642
Ohio.	20,232,637	371,466	Mich.	10,913,645	269,430	Ala...	5,910,429	348,327
Tex..	19,062,744	567,380	Ky...	10,477,598	542,633	N. Dak	4,328,547	279,882
Kans.	16,919,248	376,703	Calif.	10,426,640	384,535	W. Va.	4,027,510	152,140
Ind..	16,734,283	393,283	N. Y.	10,414,800	344,068	S. C..	3,954,365	285,644
Pa...	14,603,460	723,402	Va...	7,888,488	426,188	La....	3,753,910	246,872
Minn.	13,272,619	458,524	N. C.	7,393,161	434,774	Wash.	3,547,604	66,871
Nebr.	11,615,287	316,906	Ga...	7,221,788	398,370	Md...	3,436,376	252,198

POULTRY ON FARMS (Continued)

STATE	CHICKENS	OTHER POULTRY
Colo..	2,874,721	119,626
N. J.	2,534,371	131,293
Oreg.	2,500,123	73,413
Mont..	2,055,120	72,734
Idaho	1,654,771	57,113
Fla...	1,554,896	67,541
Mass..	1,455,193	62,284
Me...	1,403,284	15,050
Conn..	1,120,383	33,274
Utah..	954,695	25,402
Del...	948,056	51,431
Vt....	799,707	15,288
N. H..	771,233	11,542
N. Mex	713,937	25,845
Wyo..	630,734	26,623
Ariz..	495,065	22,247
R. I...	251,607	17,402
Nev...	155,197	8,787
U. S..	359,537,127	13,258,137

FIG. 61.—Half of the poultry in the United States are in the Corn Belt and around its margin, where feed is cheap. But the two most notable districts of production are the counties in southeastern Pennsylvania, near Philadelphia, and Sonoma County, Calif., especially the district around Petaluma. Six counties in southeastern Pennsylvania had nearly 5 million poultry on January 1, 1920, or 4000 to the square mile; while in Sonoma County there were over 3 million poultry, with sales of eggs and chickens amounting to over 12 million dollars in 1919. Los Angeles County, Calif., had 1,350,000 poultry. The California cities are supplied largely from these two counties; but the eastern cities draw their supplies from a much wider territory.

Agriculture Yearbook, 1921, p. 487.

have been developed in this district, which now contains several large areas where poultry keeping is almost the only industry followed.

The climatic conditions of these areas seem to be favorable, and markets are easily available. The production of turkeys and geese has been decreasing during recent years in this section, but the production of ducks has increased, principally because of the demand for spring ducklings. Long Island is the center of the duckling industry. The White Pekin duck is commonly bred for the production of spring ducklings. Single-comb White Leghorns are the most important breed for egg production in New York and New Jersey, while the American breeds are popular in New England.

Egg Production.—Perhaps the most important subdivision of the poultry industry is egg production. The following table shows the leading egg-producing states in order of importance for the years 1909 and 1919. It will be observed that the leading states in egg production

TABLE IX

Important Egg States Arranged in Order of 1909 and 1919 Production

1909 Production		1919 Production	
States	Millions of Dozens Produced	States	Millions of Dozens Produced
Missouri	111.8	Iowa	120.7
Iowa	109.8	Missouri	117.2
Ohio	100.0	Illinois	105.8
Illinois	100.1	Ohio	102.4
Kansas	81.7	Indiana	83.1
Indiana	80.8	Kansas	76.1
Texas	77.8	Pennsylvania	76.0
Pennsylvania	74.7	Texas	70.6
New York	72.3	California	64.1
Michigan	59.9	New York	62.2
Minnesota	53.8	Minnesota	60.2
Wisconsin	50.6	Michigan	56.0
Nebraska	46.9	Wisconsin	53.2
Oklahoma	46.0	Nebraska	49.1
Kentucky	44.3	Tennessee	48.7
Tennessee	42.0	Oklahoma	45.4
California	41.0	Kentucky	42.2
Virginia	35.1	Virginia	36.6
Arkansas	27.1	South Dakota	30.4

are not the ones in which the specialized poultry farm predominates; on the contrary, the areas of greatest egg production are characterized by great numbers of small farmyard flocks.

Western District.—The so-called Western area is north of the Ohio River and north of a line extending west of the Ohio to the Rocky Mountains. Most of this territory is in the Corn Belt, where there is plenty of waste grain scattered around the farm buildings and in the fields, so that every farm maintains a flock of 25 to 100 hens. The human population of this district, as compared with the hen population, is low; therefore, a large proportion of the eggs produced in this section are available for shipment to eastern markets. This section of the country therefore is much more important in commercial egg production than would appear from the density of hen population. The products from this district are usually of good quality and, as a rule, constitute a large proportion of the available poultry and eggs on the eastern markets. The industry has developed rapidly in this district, but has not been accompanied by specialization as in the Northeast and Pacific Coast regions.

Southern District.—The development of the poultry industry in the southern territory, which lies south of the Ohio and east of the Mississippi, has recently made rapid strides. The coöperation between the United States Department of Agriculture and the State colleges, in the formation of boys' and girls' clubs, has helped to show the farmers of this section how to take care of their products so as to make them worth much more when marketed. A large proportion of the southern product is consumed locally, most of the surplus being divided between the northeastern consuming centers and the export trade to Cuba and Panama, via New Orleans or Key West. Tennessee and Kentucky have become very important poultry and egg states during the last few years.

Southwestern District.—This area, including that section lying south of the western area and west of the Misisssippi, as far as the Rockies, has probably advanced more rapidly during the last decade than any other section of the United States. This has been due, first, to improved methods of producing and handling poultry products throughout southern Missouri, Kansas, Arkansas, Oklahoma, and Texas; and second, to the fact that these sections are becoming more densely populated, the cattle ranching giving place to crop raising on smaller farms. The oil booms in this area have attracted a great many people, some of whom have settled on the land and began to practice agriculture. The meat packers have established chains of packing houses throughout the district, and these facilities, combined with those provided by the independent buyers, have given this region exceptional markets. The rapid development of such gateway markets as Kansas City and St. Louis is evidence of the growing importance of this district in the market poultry and egg industry.

Pacific Coast District.—The favorable climate on the Pacific Coast has led to a rapid development of specialized egg farms during the last few years. The state of California shipped about a thousand cars of eggs to the eastern markets in 1921; the surplus available for shipment from this state has increased from practically zero to the above amount since 1917. Washington and Oregon are increasing their production in approximately the same way as California.

Many of the egg producers on the Pacific Coast carry specialization so far that if they keep hens for egg production they do no incubation or brooding, but purchase their pullets from other specialists. The poultry industry has been developed as a science, and persons with no knowledge whatever of farming study this business and with a little practical experience are frequently able to engage in it successfully. The success of the poultrymen has caused booms in real estate prices. This condition, with the necessity of importing much of the feed from the Middle Western States, has raised the costs of production in this section to such a point that the prices received by producers are no more than necessary to maintain them in business, and any slight depression in prices seriously menaces the industry.

World Production and Foreign Trade

United States.—The foreign trade in eggs of the United States amounted to practically nothing until the imports from Canada were developed, from about 1890 to 1896. The Canadian eggs were of good quality and they met with high favor in our markets during the seasons of scarcity. These imports were given up under the McKinley and subsequent tariffs. About 1916, when the Underwood tariff, allowing free entry of eggs, was established, some import business was again developed.

Just after the World War, foreign products could be imported at very low costs because of the almost complete collapse of all war-inflated values in Europe, including labor, construction material, and coal; the exchange rates for most of our foreign trade, after the War, also lowered their costs, as expressed in our money. A wave of sentiment for protection in this country then resulted in a limitation of the imports, which materially affected the general trend of commerce; but such conditions probably can not prevent the ultimate increase in our imports of raw materials and exports of finished products.

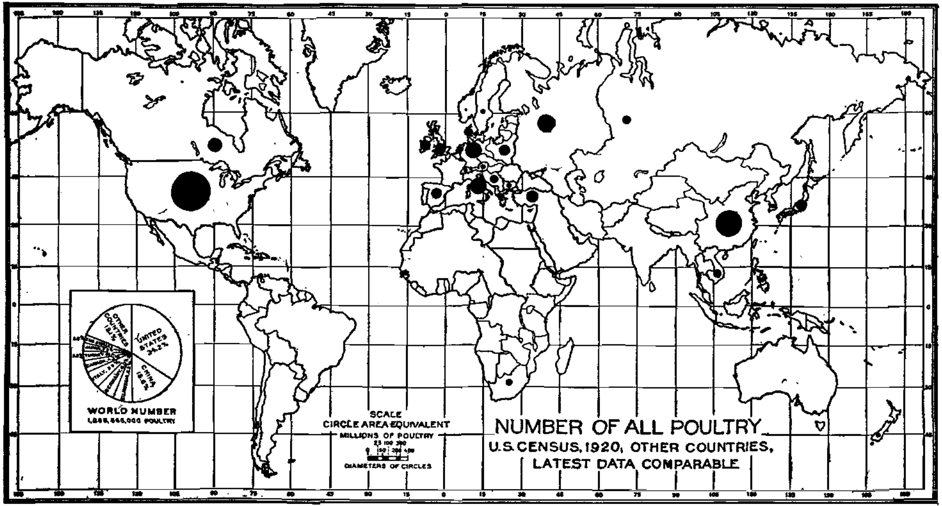


FIG. 62.—The number of poultry is larger in the United States than in any other country of the world. China ranks second.

Agriculture Yearbook, 1924, p. 578.

The principal ports of entry for foreign trade, in the United States, are San Francisco and Seattle for Asiatic shipments; Chicago and Buffalo for Canadian products; and New York, Boston, and Philadelphia for shipments from Continental Europe, Africa, and South America. The principal ports for outgoing traffic are New York, Boston, and Philadelphia for traffic to Great Britain and France; New Orleans and Key West for shipments to Cuba; New Orleans and El Paso for shipments to Mexico, Panama, and Central America; Chicago and Buffalo for shipments to Canada.

The best eggs available are usually needed for the Canadian and European trades, while Mexico, Cuba, and Panama usually take lower qualities. The eggs shipped to these southern countries are quite often of a grade termed "trade eggs." These are small, but clean and of good quality. They are about the same size as the eggs produced in these countries and can be sold to better advantage by the side of the local product than could the larger and more expensive eggs.

Canada.—The 1920 estimate for Canada was a production of 170,000,000 dozen and a consumption of 170,200,000 dozen; this shows a slight balance of imports. Canada imports many more eggs than this, the 1920 estimate being over 7,000,000 dozen from the United States alone. These imported eggs are substituted for the best of the Canadian products, which are shipped to Europe under the national Maple Leaf Brand. The reputation of Canadian eggs in foreign countries is high, because the Canadian Government has established grading rules for all eggs to be exported. While many of the traders in Canada have seriously objected to these rules, their use has served to establish a reputation for the Canadian eggs on the English markets. On Prince Edward Island the poultry industry has been highly developed, largely through the organization of egg circles. Many of the Prince Edward Island eggs find their way into the Boston market and are good enough to meet the demand there. In British Columbia a development of White Leghorn henneries has been started in about the same way as the similar development along the Pacific Coast of the United States. Many of these white eggs go to the New York City market.

Argentina.—This country seems to be the only one in South America that has developed the poultry industry to any appreciable extent. The soils, crops, and climate are well adapted to the industry. The fact that Argentina is located in the southern hemisphere, and that most of the consuming centers are located in the northern hemisphere, makes it possible for this country to put its surplus of eggs into the northern markets during the northern season of scarcity, the flush season in Argentina extending from August until December. Most of the farming in Argentina, at the present time, is done by tenants who move frequently from one ranch to another. This condition does not encourage the production of fine poultry and eggs; but as the agricultural population becomes more stable and the farms are broken up into smaller units, the quality of the poultry products will undoubtedly improve rapidly. The few eggs shipped into the United States from Argentina have shown good original quality and good size, but very careless handling and packing. Argentina has been an importing country for a long time, but during the last few years has begun to export to Great Britain and the United States.

China.—China, with its human population of approximately 400 million, and hen population of about the same number, has a very large potential home demand which has not been developed much up to the present time. When, through the efforts of colleges, experiment stations, missionaries, and foreign exporters, the quality of Chinese eggs is improved, Chinese people themselves will begin to use more of this product as food. This was the experience of our own country when we improved the quality of our market eggs, and has been the experience of many other countries. At the present time the Chinese hens are not well cared for; reports indicate that they are fed only for a short time after hatching, until they are able to pick up their own living as scavengers. Most of the Chinese egg production occurs in southern China, at about the same latitude as the southern and southwestern district of the United States. The hens are small, laying small eggs, and the poor care which they receive undoubtedly causes a lower average egg production than that of the American hen. During hot weather the eggs are of very poor quality, many of them not fit to be marketed; most of the operations of the foreign egg-breaking and exporting plants are carried on during cool weather, on this account.

It is said that values of Chinese eggs in remote rural districts range from 1 to 8 cents per dozen; consular reports indicate that when country prices are more than 9 cents per dozen, the egg-breaking plants can not afford to operate. The loss in handling eggs that are transported for distances of 300 to 500 miles along the rivers, by the poor means of transportation available in South and Central China, must be tremendous; eggs of such slight value are always carelessly handled. The Chinese eggs are probably not worth much more than is paid for them. Better markets for these eggs, however, will increase the prices, gradually increase the care given to the eggs, improve the quality, further increase the prices, and so on; this is the history of the egg industry in all countries.

Exports of eggs from China have been increasing rapidly during the last few years; most of the eggs go to Great Britain, the United States, and France. A few shipments of shell eggs have been made, but the absence of adequate refrigerating facilities on the boats has made it necessary to ship most of the eggs frozen or dried. A few Chinese plants do exporting, but most of the work is done by English, German, Belgian, French, and American industry. The principal ports for exports are Shanghai and Hong Kong, located in two important centers of the industry.

Japan.—The Japanese egg industry is of relatively recent origin. Better methods of handling the flocks and products are used in Japan than in China; many of the breeds in Japan have been imported from those countries which have developed their poultry industries, and are of modern types. The Japanese eggs that came to America in 1921 were of exceptional quality; those reaching New York were about as good as the Pacific Coast whites arriving on the market at the same time.

Australia.—Agricultural experiment stations in Australia have for many years been working on better methods of handling poultry. The Australian eggs are especially large, and some of the biggest egg records known have been made in the Australian egg-laying contests. Australia, like Argentina, has the commercial advantage of being in the southern hemisphere; this means that Australian producers can ship their eggs north during their flush season, to arrive on the markets during the seasons of scarcity. Most of the Australian hens are White Leghorns. Australian eggs shipped to New York in 1921 arrived in very good condition and met a strong demand among the buyers. They compared favorably with the Pacific Coast product.

Austria and Italy.—The farmers of Austria and Italy are not as thrifty as those of Germany, and the eggs are of poorer quality. Great Britain and France receive the bulk of the exports.

Russia.—Russia and Siberia have tremendous possibilities for the production of poultry and eggs. The climate and soil seem to be well adapted to poultry raising, and the large production of cereals is an important factor in the development of the industry. Russia does not have as large a consuming population as China, and the eggs should be of a better initial quality. The farmers are adopting new methods, and it will be easier to establish modern methods of collecting, transporting, and shipping eggs in Russia than in China. Before the World War, Russia was exporting tremendous quantities of eggs to Great Britain, Germany, Austria, Holland, France, and Denmark, named in order of their importance. The eggs were not all of a fancy quality, but were a good edible product.

Germany.—Germany imports more eggs than she exports, but seems to occupy the position of an important exchange center for eggs coming in from Russia, Austria, and Bulgaria, and going out to Great Britain, Holland, and France. Germany undoubtedly exports some of her best eggs and replaces these with lower grades purchased from other countries. Some of the German cities have a preference for white eggs.

France.—The French people show considerable skill in producing and preparing fancy dressed poultry. Paris and similar markets receive some of the best poultry sold anywhere in Continental Europe. It is all dry-picked, air-cooled, and shaped during the cooling process to make it blocky and compact. France imports more poultry products than she exports; her principal export business is to Great Britain, while she imports from a great many countries, including Belgium, Russia, Turkey, Germany, and Austria.

United Kingdom.—The most important markets for poultry and eggs in Great Britain are London and Liverpool. London, particularly, has become a highly developed trading center for eggs from all over the world. Eggs are received from Russia, Denmark, Germany, France, Egypt, Holland, Austria, Italy, Australia, China, South Africa, the United States, Canada, Ireland, Belgium, Turkey, Argentina, and practically every other country doing any exporting. In regard to poultry products, Great Britain is primarily an importing country; the exports consist mostly of frozen and dried eggs, which have been imported from other countries.

The poultry industry of Great Britain is old and has been developed along conservative lines. The British are renowned for their production of fine poultry meat. Most of the eggs produced in England are consumed near the point of production. Practically the entire business of the wholesale dealers in large markets, such as London, is in handling imported eggs; very few local eggs get into the market, and these usually come through roundabout channels and are likely to be of inferior quality.

Ireland.—Coöperative organizations have served to increase the interest in poultry keeping in Ireland, and the English markets have always furnished a convenient and desirable outlet for all the eggs produced. The eggs shipped from Ireland to England are marked "Irish Eggs," and although the quality of the product, as a whole, is variable, the packing and grading have been so standardized in some sections that these eggs have established a fine reputation on the British market.

Denmark.—The development of the poultry industry in Denmark has had much in common with the development of the Danish coöp-

erative associations. Denmark imports some eggs from Russia; she reëxports these or uses them for her own consumption, thus creating a larger surplus for export to the British markets.

Holland.—Holland has always been an importing country, buying eggs especially from Russia and Germany. Some of the German and Russian imports are reëxported to other countries, principally Great Britain, as Holland is a trading country. There have been a few coöperative efforts in Holland, but the poultry industry is not organized there as it is in Ireland and Denmark. However, some of the best eggs received in the London market are from Holland.

Consumption

Eggs are becoming a relatively more important food product. This is not only because they have such high nutritive value but also because chickens are such efficient transformers of raw materials into human food that it becomes good economy to substitute poultry for forage animals.

TABLE X

Marketable Product and Edible Solids Produced per Hundred Pounds of Digestible Organic Matter Consumed in Ration

	Marketable Product, Pounds	Edible Solids, Pounds
Milk	139.0	18.0
Swine	25.0	15.6
Cheese	14.8	9.4
Butter	6.4	5.4
Eggs	19.6	5.1
Fowl, dressed carcass	15.6	4.2
Broilers, dressed carcass	23.8	3.5
Steers	8.3	2.8
Sheep and lambs	7.0	2.6

The population of the seven cities—New York, Chicago, Boston, St. Louis, Cincinnati, San Francisco, and Milwaukee—increased 36 per cent between 1890 and 1900, 30 per cent between 1900 and 1910, and 19.7 per cent between 1910 and 1920; the receipts of eggs in the same seven cities increased 72 per cent between 1891 and 1901, 65 per cent between 1901 and 1911, and 12.3 per cent between 1908 and 1919. The lower receipts in 1918 are due to the lower production resulting from the war conditions, and it is believed that the abnormal movement of working people to the cities for war employment slightly affected the relative "population" and "egg receipts" figures for 1918. The general increase in the importance of eggs as a food product causes the fluctuations of the egg market to follow industrial influences closely.

LAMB AND MUTTON

Sheep are bearers of two products, viz., meat and wool. Each of these is so important, and their importance is so nearly equal, that it is impossible to classify sheep exclusively under either of these two headings. From the standpoint of international trade, however, wool doubtless is of greater importance than mutton owing to the fact that wool, rather than mutton, has made sheep production a pioneer industry, far removed from the centers of population, and capable of utilizing vast areas of otherwise barren wastes. Because of its relative value, wool could be moved great distances economically long before the carcass itself could be so moved; and even to-day, with all the modern improvements in transportation, the wool breeds of sheep predominate in sparsely settled areas such as Australia, South Africa, and Argentina. But the increase and shifting of population, improvements in transportation, and the like constantly bring up the problem in sheep production of striking a proper balance between wool and mutton.

For convenience, therefore, and because of the greater importance of wool in international trade, the sheep industry will be considered primarily under the head of wool rather than of meat.

Consumption.—Lamb and mutton are among the most healthful, nutritious, and palatable of meats. However, the consumption of these meats varies widely in different countries. In the United States the average annual per capita consumption of lamb and mutton for the ten-year period, 1912–1921, was 6.2 pounds; Canada in 1910 averaged 9 pounds; the United Kingdom in the period 1895–1908 averaged 26.7 pounds; France in 1904 consumed 9 pounds per person; and Germany in 1904–1913 only 2.2 pounds per person. Reduced to percentages of total meat consumption in the countries mentioned we have the following: United States, 4.35 per cent; Canada, 5.57 per cent; United Kingdom, 22.25 per cent; France, 11.25 per cent; and Germany, 1.91 per cent.

The consumption of lamb and mutton varies greatly in different sections of the United States in a given year, as well as from year to year. Moreover, the demand for lamb and mutton is very sensitive to general business conditions. This tends to make the price very unstable and undependable.

Consumption of Mutton Compared with Other Meats.—The relative importance of the different meat animals in the family diet in the United States, as well as the trends in the consumption of the different meats may be seen in the following table:

TABLE XI *

ANNUAL PER CAPITA CONSUMPTION OF LAMB AND MUTTON, BEEF, VEAL, PORK, AND LAMB, 1907–1923

Year	Lamb and Mutton	Beef	Veal	Pork, Excluding Lard	Lard	Year	Lamb and Mutton	Beef,	Veal	Pork, Excluding Lard	Lard
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1907	6.4	79.7	7.1	74.1	12.5	1916	6.2	57.3	5.3	73.1	14.4
1908	6.2	72.4	6.8	85.4	14.3	1917	4.6	61.1	6.5	58.5	11.9
1909	6.6	76.2	7.5	68.6	11.6	1918	4.7	65.2	7.4	67.6	13.6
1910	6.5	71.8	7.4	60.3	10.5	1919	5.8	58.0	7.7	68.6	12.8
1911	7.8	68.4	7.0	75.1	11.8	1920	5.0	61.2	7.9	69.0	13.1
1912	8.2	61.7	7.0	70.6	11.4	1921	6.2	57.8	7.0	72.9	11.3
1913	7.6	60.8	5.0	72.5	11.7	1922	5.0	61.4	7.3	76.0	14.1
1914	7.5	59.3	4.4	70.3	12.1	1923	5.2	62.5	7.9	91.4	16.4
1915	6.4	56.0	4.3	70.2	13.2						

* Agriculture Yearbook, separate, 1923, p. 283.

The trend in lamb and mutton consumption and in beef consumption seems to be slightly upward.

Marketing.—The marketing of sheep is complicated not only by the wide variation in the consumptive demand for lamb and mutton, but also by the fact that wool enters strongly into the determination of sheep and lamb prices. Perhaps this commodity is the source of more complications than any other single item. This is due partly to the comparatively wide fluctuations in the price of wool, but more particularly to the extreme variations in the amount of wool, carried by the animal at various seasons of the year. For example, late in the spring an animal may carry from 5 to 8 pounds of wool and at a given time this may represent 25 or 30 per cent of the value of the animal. A sharp decline in the price of wool may, therefore, more than neutralize the gains which the animal may make in the weight of meat.

Again the problem of marketing sheep and lambs in the United States is complicated by the fact that an abnormally large proportion of them are marketed during the three months from August 15 to November 15. Moreover, a large proportion of the lambs marketed during this period are of poor quality and not only bring a low price, but tend to depress the price of good lambs.

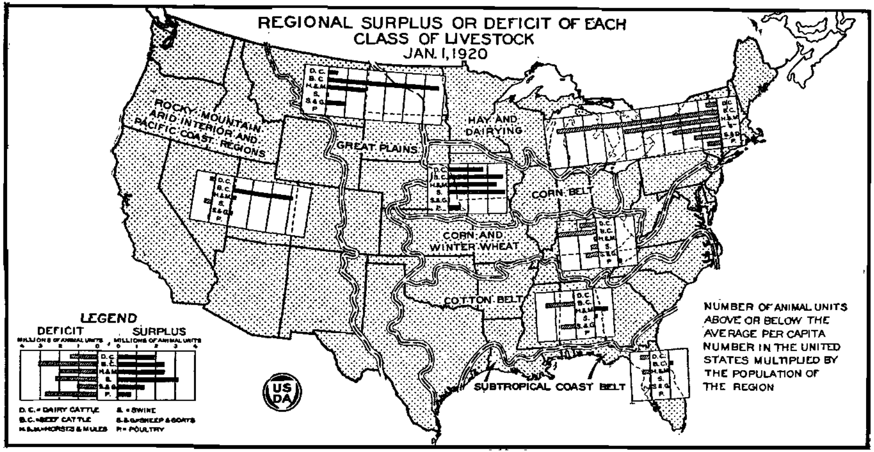


FIG. 63.—The principal regions of surplus livestock production are the Corn Belt and the Great Plains. These two regions produce a surplus of all classes of livestock. The area of greatest deficit is the Hay and Dairying region, where the large urban population has to depend in part upon other portions of the United States for its Animal Foodstuffs, especially for its beef and pork. This region, however, supplies its entire need for dairy products. The Cotton Belt also, and even the corn and winter wheat region, depend on the Corn Belt and Great Plains for a large part of their beef.

Agriculture Yearbook, 1923, p. 384.

Further discussion of the sheep industry will be taken up under the head of wool.

EXERCISES

1. What are the physical and economic conditions in the various agricultural regions which bring about the varying amounts of surplus or deficit production of the different kinds of livestock as shown in Fig. 63?

2. The definition of the term "animal unit" may be found in the Agriculture Yearbook, 1923, page 321. Using the data given in Fig. 63, compute the number of animal units shipped out of each of the surplus-producing regions and the number of the animal units shipped into each of the deficit-producing regions.

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CHAPTER VIII

VEGETABLE OILS

Introductory.—We have only recently become conscious of the potentialities of vegetable oils in general, and of the vegetable oils of the tropics in particular. The rapid increase in the production of these oils is presenting problems to the animal industries, especially to the swine and dairy industry, which promise to become more acute each year. The problem arises out of the fact that animal fats are produced very indirectly: first, by the conversion of solar energy into starch through the intervention of plants; and second by the conversion of starch into fats through the intervention of animals.

The following quotation from Alonzo Taylor is of interest in this connection:

> Starch is first secured in grains and this then converted into fat in cattle and hogs. The solar energy in the tropics is more effective in fat production than is the solar energy in the temperate zone in starch production. In addition, animals are inefficient converters of starch into fat. The maintenance requirements of the animal are a heavy loss. Consider the feed required to bring pigs and steers to growth. From a pig of ten months, 25 per cent of the feed protein may be recovered in the carcass as flesh and 35 per cent of the feed starch as fat. From a steer of eighteen months, 20 per cent of the feed protein may be recovered as flesh and 14 per cent of the carbohydrate as fat. These are top notch figures. The usual returns from feeding operations are much lower. With cattle, returns are often as low as 10 per cent.[1]

The cost of production of fats is least when they are obtained directly from tropical plants, somewhat higher when they are obtained directly from plants of the Temperate Zone, and highest when they are obtained through the intervention of starchy plants and animals in the middle latitudes. The result is that the densely populated areas of the northern hemisphere are becoming more and more eager to tap the great vegetable-oil reservoirs of the tropics. The plantation system furnishes

[1] Wisconsin Extension Circular 150, p. 5.

a means of growing tropical oil plants under large-scale conditions of production. In order to be successful, this implies good management, cheap labor, processing plants in close proximity to the plantation, and improved transportation, together with the natural advantages enjoyed by the tropics in oil production. Such favorable conditions may well cause the hog raiser and the dairyman of the northern hemisphere serious concern.

The uses of fats are stated by Taylor, as follows:

> Fats have four uses: on the dining table; in the kitchen; in the bakery; and in a group of important technical processes. All are important and differ mainly in price levels. Fats are employed in soap making, in the tinning of steel sheet, in the manufacture of yarn and cloth, in the dressing of leather, in the fabrication of linoleum and other coverings, in the preparation of paints, varnishes, waterproofing and ink, in toilet preparations, as lubricants, and to some extent as an illuminant. At every point the competition of tropical fat with fat of domestic production is keenly felt. Every fat is salable on the basis of content of fatty acid and glycerine.[2]

The competition of vegetable oils is not restricted to the fat of slaughtered animals, but also includes the dairy industry and brings up at least two big questions. Does the widespread use of vegetable oils impair health through failing to provide the necessary fat-soluble vitamine? Will the competition of these oils seriously affect the present organization of the American dairy industry? As to the first of these questions, it may be pointed out that a number of experiments, covering a wide range of territory in many countries, prove conclusively that subnutrition inevitably results from an inadequate consumption of whole milk. The answer to the second question must be based upon a consideration of what is likely to be of greatest benefit, in the long run, to consumers and producers.

In order to illustrate the interchangeability of vegetable oils and fats, the demonstrated derivatives may be tabulated.[3] The list includes only the principal oils and fats. The magnitude of the several operations varies widely and fluctuates from season to season. Some of the derivatives proceed from residues or foots, others from unrefined oil or fat. The technical procedures are more or less intricate, with different derivatives, and these difficulties find expression in the price levels necessary to make a particular procedure available or unavailable.

[2] Wisconsin Extension Circular 150, p. 6.
[3] *Ibid.*

Product	Derived from
Lard substitutes	Lard, coconut oil, soya oil, corn oil, cottonseed oil, oleo oil, animal stearin, vegetable stearin, and peanut oil.
Salad and cooking oils	Soya, corn, cottonseed, peanut and olive oils.
Oleomargarine	Neutral lard, oleo oil, animal stearin, cottonseed soil, corn oil, peanut oil and tallow.
Margarine	Soya oil, corn, peanut, cottonseed and coconut oil.
Animal stearin	Tallow and hog fat.
Vegetable stearin	Peanut oil, cottonseed, corn oil and soya oil.
Oleo oil	Tallow, hog fat, soya oil, corn oil and cottonseed oil and peanut oil.
Neutral lard	Hog fat.
Filled milk	Coconut oil.
Soap	Fish oil, hog fat, tallow, soya oil, corn oil, cottonseed soil, peanut oil, olive oil, coconut oil and palm oil.
Fats used in metal industries	Palm oil, palm-kernel oil, soya, cottonseed oil, fish oil.
Fats used as lubricants or quenching materials	Palm, palm kernel, soya oil, fish oil, lard, neutral lard and cottonseed oil.
Fats used in manufacture of inks, paints, rubber substitutes and leathers	Tallow, fish oil, cottonseed oil, soya and olive oil.
Domestic products	Tallow, hog fat, fish oil, soya oil, corn oil, cottonseed oil, peanut oil and olive oil.
Products from island possessions	Coconut oil.
Imported products	Cottonseed oil, soya oil, peanut oil, tallow, coconut oil, palm oil, palm-kernel oil, and olive oil.

LARD AND LARD-SUBSTITUTE PRODUCTION

The magnitude and trend of lard and lard-substitute production are well shown in Table XII. It will be seen that the highest production of lard substitutes occurred in 1917 and this high production was almost maintained during 1918. From 1918 to 1923 there has been a continuous and substantial decline in lard-substitute production in every year except 1921. The cause of the great increase in the use of lard substitutes during the two war years was undoubtedly the relatively high price of lard; and conversely, as lard and lard substitutes attained more nearly to an equality in value, a relative decline in the use of lard substitutes occurred. The figures seem to indicate that people under present conditions will use vegetable oils in place of animal fats if the price of the latter rises above normal; and, on the other hand, that they will return promptly to the customary use of animal fats when the price advantage for the vegetable oils disappears. Heretofore animal fats have enjoyed an advantage upon the American market because of the prejudice of the housewife against the use of substitutes of all kinds. As the good points of vegetable oils become better known and the old-time prejudice against substitutes is broken down, the producers of animal fats will have to bear the full brunt of this new and increasing competition.

TABLE XII

LARD AND LARD-SUBSTITUTE PRODUCTION

Years	Lard,* Pounds	Lard Substitutes, Pounds	Total Lard and Lard Substitutes, *Pounds*	Per Cent of Lard Substitute to Lard and Lard Substitute Production
1922	2,330,000,000	†675,000,000	3,005,000,000	22
1921	2,095,000,000	†950,000,000	3,045,000,000	31
1920	2,095,000,000	†800,000,000	2,822,000,000	28
1919	2,089,000,000	†1,000,000,000	3,089,000,000	32
1918	2,015,000,000	‡1,146,000,000	3,161,000,000	36
1917	1,577,000,000	‡1,173,000,000	2,750,000,000	43
1916	1,973,000,000	‡1,027,000,000	2,000,000,000	34
1914	1,652,000,000	‡1,137,000,000	2,789,000,000	41
1912	1,643,000,000	877,000,000	2,520,000,000	35

* Figures compiled by Bureau of Animal Industry, U. S. Department of Agriculture.
† Estimated.
‡ Supplement to Bulletin 769, U. S. Department of Agriculture.

BUTTER AND BUTTER-SUBSTITUTE PRODUCTION

What has been said above concerning the trend of lard-substitute production, in relation to lard, holds substantially true for butter substitute production in relation to butter. This is well illustrated in Table XIII. Instead of occurring in 1917 as in the case of lard substitutes, the maximum production of butter substitutes did not occur until 1919. This is doubtless due to the fact that war influences did not cause such an abrupt rise in the prices of dairy products as in those of swine products, on account of the greater stability of the dairy industry. After 1920, however, the decline in production of butter substitutes became very abrupt, for reasons analogous to those given in the case of lard substitutes.

TABLE XIII

BUTTER AND BUTTER-SUBSTITUTE PRODUCTION

Years	Butter, Farm and Factory,* Pounds	Butter Substitutes,† Pounds	Total Production of Butter and of Butter Substitutes, Pounds	Per Cent of Butter Substitute to Butter and Substitute Production
1922	1,778,515,000	185,076,000	1,963,591,000	9.4
1921	1,650,000,000	211,867,000	1,861,867,000	11.0
1920	1,442,458,000	370,730,000	1,813,188,000	20.0
1919	1,558,900,000	371,317,000	1,930,217,000	19.0
1918	1,530,700,000	355,536,000	1,886,236,000	18.0
1917	1,568,890,000	290,902,000	1,856,792,000	15.0
1916	1,635,000,000	202,444,000	1,837,444,000	10.0
1914	1,706,000,000	143,900,000	1,849,900,000	7.0
1909	1,621,700,000	110,000,000	1,731,700,000	6.0

* Estimates from the Department of Agriculture.
† Compiled by Bureau of Agricultural Economics.

SOY BEANS

There is a wide and growing belief that the soy bean is destined to become one of the leading farm crops of the United States.

Origin.—The soy bean is native to Eastern Asia, the wild form being known to occur in China, Manchuria, and Korea. Its culture in China and Japan is very ancient, and to-day it is of prime importance in furnishing nitrogenous food and supplying the life-sustaining vitamines in these very densely populated countries.

Uses.—The soy bean has a great many uses. In the Far East it is grown mainly for the seed, which is used for human consumption and for the manufacture of food products. In this country the crop is grown largely for forage and green-manuring purposes, but the production of seed for the soy-bean oil industry is rapidly growing. The Cotton Belt as far west as central Texas, is peculiarly adapted for the production of soy beans for seed, the Corn Belt for seed and forage, and the Dairy Belt for forage and ensilage.

An excellent outline showing the varied uses of this product appears in a recent book, " The Soy Bean," by Piper and Morse, from which the following has been adapted. This shows the uses, both varied and important, to which the plant can be put, and its potentialities for this country in the light of our rapidly increasing population.

TABLE XIV

Showing the Various Ways in which the Plants and Seeds of Soy Beans Are Utilized

- Soy beans
  - Plants
    - Green manure
    - Forage
      - Hay
      - Ensilage
      - Soiling
    - Pasture
  - Seeds
    - Meal
      - Human food
      - Stock feed
      - Fertilizers
    - Oil
      - Glycerin
      - Explosives
      - Enamels
      - Varnish
      - Food products
        - Butter substitute
        - Lard substitute
        - Edible oils
        - Salad oils
      - Waterproof goods
      - Linoleum
      - Paints
      - Soap stock
        - Soft soaps
        - Hard soaps
      - Celluloid
      - Rubber substitute
      - Printing inks
      - Lighting
      - Lubricating
    - Food products
      - Dried beans
        - Soy sauce
        - Boiled beans
        - Baked beans
        - Soups
        - Coffee substitutes
        - Roasted beans
        - Vegetable milk
          - Cheese
            - Fresh
            - Dried
            - Smoked
            - Fermented
          - Condensed milk
          - Fresh milk
          - Confections
          - Casein
        - Breakfast foods
      - Green beans
        - Green vegetables
        - Canned
        - Salads

World Production

Production.—According to Piper and Morse, more soy beans are produced in Manchuria than in all the other countries of the world combined, the production in 1921 being 4,520,000 tons. Other important producing countries are Mongolia, with 431,000 tons, and Japan, with 545,000 tons. The United States produced 68,000 tons, of which 66 per cent was grown in North Carolina.

Trade.—Trade in the soy-bean products prior to 1908 was confined largely to Oriental countries, mainly China, Manchuria, and Japan. In that year trial shipments of the beans were made by Japan to England, meeting with immediate response from English oil mills, with the result that trade was soon extended to other European countries. The War caused a temporary decline in the soy-bean trade, but in all probability it will be resumed and enlarged.

Outlook for the United States.—The soy-bean crop is certain to increase in importance in the United States for a number of reasons: it can be grown profitably over a large area; it yields a large amount of seed per acre; it may be easily grown and harvested; it has many uses as human and animal food; and it will help fill the impending need for more vegetable oils. In the south this crop may prove a great boon when its uses are better understood. In the cropping system it provides a suitable leguminous forage crop, maintains the productivity of the soil, and helps to make livestock enterprises more profitable. By taking an important place in a diversified cropping system it tends also to offset the destructive effect of the boll weevil. In addition, it furnishes the cotton-oil mills another source of raw material for their industry.

OIL PALM

Habitat.—The African oil palm in its natural state is found mainly in West Africa between 16 degrees north and 12 degrees south latitude. In recent years it has been successfully introduced into the more humid regions of southeastern Asia.

Climate.—The tree does best when the maximum temperature does not exceed 95 degrees, the minimum 59 degrees, and the mean 77 degrees. The minimum rainfall should not be less than 40 inches and not more than 250 inches. The best rainfall is from 70 to 100 inches. Moreover, it is desirable that the rainfall alternate with sunshine throughout most of the year. On the whole, it may be said that the climatic requirements are similar to those of the cacao tree

Soil.—Soils must be neutral or alkaline, and therefore not stagnant. The earliest-bearing trees, the largest fruit clusters, and the most pulp are obtained on alluvial soils, provided the soil is kept moist enough. The most favorable soil conditions are realized in the Niger Delta, the Ivory Coast, St. Thomas, and the Lower Congo Basin. Similar conditions seem to exist in eastern Sumatra, on the low-lying parts of the Federated Malay States, Java, Borneo, British Guiana, Brazil, and perhaps also parts of the Philippines.

Fruit.—The fruit is similar in structure to the peach, viz., an outer pulp surrounding a nut which contains the kernel. From the pulp is obtained the palm oil of commerce. The kernel enters commerce as " palm kernel " from whcih the oil also is expressed. Variation in the relative amounts of pulp and kernel is to be found in the fruit from different kinds of trees, and this determines whether the oil is derived mainly from the pulp or from the kernel.

Plantations.—The plantation, together with the " central factory " system as it relates to the oil palm, is in its infancy; but it has already been demonstrated that the cultivated palm yields a much larger crop than the wild tree of West Africa. Moreover, plantation agriculture makes possible much better preparation of the oil. Freshly gathered fruit, brought into the central factory, yields a much better quality of oil than fruit that has been allowed to ferment.

Since the oil palm yields larger financial returns than the coconut palm under similar conditions, it is reasonable to suppose that the industry is destined for relatively rapid expansion once the plantation system gets well under way.

Uses.—Hitherto, palm oil has been used, in Europe and America, chiefly for tin plating, for soap stock, and for candles. It has been found, however, that the oil can be converted into edible fat, and this will tend to widen its market.

Palm and palm-kernel oil are similar to coconut oil. Palm oil is employed largely in tin plating. Just as it replaced tallow in the tin mill, so it is now being threatened by hydrogenated cotton-seed oil. Palm oil is employed largely in soap, shaving cream, margarine, cakes and confectionery.[4]

In 1910 palm oil constituted nearly 34 per cent of all vegetable oils imported into the United States, while in 1922 it had dropped to 9 per cent.

[4] Circular 150, Wisconsin Extension Service College of Agriculture.

OLIVE OIL

From time immemorial the oil of the olive has been intimately identified with the life of the people of Asia Minor, and from there its cultivation and use spread gradually westward throughout the entire Mediterranean country. To-day its culture and the processing of its fruit constitute one of the important industries in Syria, Greece, Italy, southern France and Spain, and all the countries along the southern shore of the Mediterranean Sea with the possible exception of Egypt. The olive was introduced into the United States by the early Mission Fathers and is now cultivated in California and to a less extent in Arizona. In recent years the uses of vegetable oils have come to be so varied that the olive furnishes only about one-half of the consumptive demand for vegetable oils, even in the Mediterranean countries.

Uses.—Olive oil of better grade is used primarily for table and culinary purposes. The lower-grade oil is widely employed in spinning and weaving and in the manufacture of soap.

Types of Olive.—The American olives are not nearly so rich in oil as those grown in Italy. The demand for pickled olives in this country is sufficient to absorb almost the entire American supply at a price which yields the grower a greater profit than could be obtained from the oil-bearing varieties. As a result, selection in this country is in the direction of fruit suitable for picking rather than for oil, and consequently the American fruit yields only 20 per cent of oil whereas the best European varieties yield as high as 60 per cent.

Imports.—In 1922 olive oil constituted about 14 per cent of the total imports of all vegetable oils, of which about 10 per cent was destined for table and culinary use and 4 per cent for industrial uses.

Processing.—The edible oils come mainly from the first two pressings to which the ground olive pulp is subjected in the process of manufacture. The best grade of edible oil is obtained from pulp that has been subjected to relatively light pressure. This pulp is then reground in a little cold water and pressed again. This results in edible oil of inferior grade. A third and sometimes a fourth grinding and pressing in hot water is given to the pulp, resulting in oil which is of still lower quality and, unless chemically refined, is suitable only for soap and other industrial uses. In Europe the final press cake is treated still further, chemically, and the oil is used only for technical purposes.

THE COCONUT

Introductory.—The coconut palm is one of the most important items in the domestic economy of the natives of those islands which extend throughout the tropical zone. Especially is this true of the East Indies and the adjacent coasts of Malaysia. For ages, this plant has furnished these peoples with food and drink, shelter and clothing, weapons and utensils. In more recent years, however, the products of this remarkable tree have come to occupy a very important phase in modern economic life. The dried meat of the nut is used for food; the oil is used for food and in the manufacture of toilet soaps; and the residue, or cake, for cattle feed.

Climate.—The coconut is a tropical plant. It is a light-requiring species, and is intolerant of shade. It requires continuously high temperatures and considerable moisture, 60 to 80 inches, for its best development, although the rainfall required varies with the texture of the soils.

Soil.—The soil best suited to the coconut palm is a deep, fertile, sandy loam, such as is found, for example, in alluvial flats along the sea coast, at the mouths of rivers, or in the lower portions of river valleys. With proper care the tree can be grown on a variety of other soils, as in inland areas. Apparently, the lime content of soils along coastal areas is a factor of importance in making soils better adapted to the growth of the coconut. Heavy soils or soils poorly drained are not suitable for this crop.

Commercial Products.—The principal commercial product of the coconut is copra, the dried meat of the coconut. It has been estimated that 922,000 tons of copra entered world trade in 1922, of which approximately one-fourth was supplied by the Philippine Islands. The rapid expansion of coconut production in these islands is indicated in Table XV.

TABLE XV

AVERAGE ANNUAL EXPORT OF COPRA (AND COCONUT OIL REDUCED TO ITS EQUIVALENT IN COPRA) FROM THE PHILIPPINE ISLANDS*

1900–1903	113,314,610 pounds annually
1904–1908	140,000,310 pounds annually
1909–1913	266,768,848 pounds annually
1914–1918	345,058,130 pounds annually
1919–1923	626,875,920 pounds annually

* Data from Department of Commerce, Washington.

Coconut oil is expressed from the copra. In recent years a large share of the oil has been expressed in the area of production. This is especially true for the Philippine Islands.

Coconut Oil as a Soap Stock.—The chief industrial use of coconut oil is for soap stock, which serves as a basis for a wide variety of soaps.

Coconut oil is unique among the oils and fats of general occurrence (except butter) in that the fatty acids of this oil contain a majority of what are called " low boiling point " fatty acids. Due to this chemical property coconut oil has the following characteristics which make it valuable as a soap stock: (1) it is readily saponifiable; that is, cold-process soaps may be made from this oil; (2) it contains a relatively high percentage of glycerin; (3) it is the only oil that will make a soap which will lather in salt water; (4) it is one of the very few oils which form " soft soaps " with caustic soda. Furthermore, at the moment it is cheap.[5]

Coconut Oil as a Food.—For making soap it generally is not necessary to refine the coconut oil. On the other hand, coconut oil for food purposes is refined through processes which remove the free fatty acids, the color, and the odor. The edible products in which coconut oil is used are mainly margarine and lard compounds. In the United States, however, the coconut constitutes but a very small percentage of the total butter and margarine output—only 3 per cent in 1923. Coconut oil is used in this country to even a smaller extent as a constituent of lard compound. There are two reasons for this: (*a*) coconut oil is generally higher in price than cotton-seed oil; and (*b*) the cotton-seed oil, because of its properties, is more desirable for frying purposes than coconut oil.

In Europe, however, the situation is very different:

In this case we have to deal with a market in which the local production of animal fats is very small. Consequently it has become necessary to European countries that animal and vegetable oils should be imported for food purposes. These edible fats might be divided into three general classes—(*a*) cooking fats, (*b*) butter and butter-substitute fats, and (*c*) salad oils. The first group comprises lard and lard compounds; Europe imports large quantities of lard and manufactures lard compounds from imported oils and oils made from imported oil seeds. The second class comprises butter, coconut oil, peanut oil, sesame-seed oil, and the various other vegetable and animal oils composing margarine. The third class consists mostly of olive, cotton-seed and soya-bean oils. . . . The consumption of margarine as related to the consumption of butter is far greater in western Europe than in the United States, margarine comprising 53 per cent of the combined

[5] Trade in Philippine Copra and Coconut Oil. Trade Promotion Series No. 11, Department of Commerce.

butter-margarine consumption of the United Kingdom in 1923, 52 per cent of Germany's, 41 per cent of France's, 42 per cent of the Netherlands', and 72 per cent of Denmark's, as opposed to 9 per cent for margarine in the United States in that year. This is not due to the fact that Europe does not produce butter. On the contrary, Denmark probably produces more butter per capita than any other country, but regularly exports the bulk of its butter and imports margarine for its own consumption. There are no figures available showing the amount of coconut oil consumed in the manufacture of margarine in these countries. It is probable, however, that in Germany and Denmark a large proportion of the net consumption of coconut oil is in edible products, while in the United Kingdon, France, and the Netherlands more than one-half of the net consumption doubtless goes into technical preparations, especially soap and cosmetics.[6]

PEANUT OIL

It is not known whether the peanut, which is probably a native of Brazil, was used by the aborigines as a source of oil, but certainly in a comparatively short time after the early explorers carried this product of the Western World back to Europe its value as an oil material was realized. Peanut oil may be expressed from any one of the many varieties of peanuts. That this oil is one of the most important of the world's food oils is shown by the fact that annually over 120,000 metric tons of peanuts in the shell, together with about 240,000 metric tons of shelled nuts, are crushed in Marseilles alone, yielding 15,500,000 gallons of edible oils.[7]

Europe.—In Europe the oil is made principally from the shelled nuts. As in the case of the olive, the peanuts are first crushed and then subjected to a series of compressions of increasing intensity, each succeeding compression producing a grade of oil inferior to the preceding one. Only the oil from the first and second pressings is generally used for table and cooking purposes, the inferior grades from subsequent pressings being used in lard substitutes, in margarine, and as a substitute for Spanish olive oil in the woolen industry in this country.

Asia.—Great quantities of peanuts are grown in Asia and are shipped out to be crushed in importing countries.

United States.—The production of peanut oil on a large scale is yet in its infancy in this country, but the cotton-seed oil mills located in the peanut-growing territory, and in charge of men thoroughly acquainted with oil machinery, are rapidly taking up the pressing of peanuts.[8]

[6] Trade Promotion Series No. 11, Department of Commerce.

[7] Agriculture Yearbook, 1916, p. 171.

[8] *Ibid.*, p. 172.

The lack of uniformity in American practice and the use of all sorts of stock, from old, rancid, cull peanuts to prime fresh material, have resulted in the production of oils of varying quality, some of which require refining and bleaching, as do cotton-seed oils, while others are sweet and bright, ready for the table as soon as they have been filtered.

Imports.—In 1919 more than one-sixth of all the vegetable oil imported into the United States was made from peanuts, but in recent years these imports have become negligible.

COTTON-SEED OIL

Cotton-seed oil production in the United States is equal to more than the combined production of all other vegetable oils produced in this country from both imported and domestic-grown raw material. In 1922 the production of crude cotton-seed oil in this country was 935 million pounds, and that of all other vegetable oils 812 million pounds. More than two-thirds of the world supply of cotton-seed oil comes from this country, and the remainder is produced in Great Britain, Germany, France, Smyrna, India, China, and South America. Thus, cotton seed, a commodity which not many years ago was considered a waste product of the cotton industry, has now become the basis of a great independent industry, a source of tremendous wealth to the South and a vast reservoir providing an essential article of human food.

Uses.—Cotton-seed oil is said to serve every conceivable use to which animal fats can be put. It is the base of the older type of oleomargarine.

Processing.—It has been noted that in expressing most edible oils several grades are made by a re-pressing of the same batch of raw material. Cotton seed, however, in the United States, is pressed only once: and when hydraulic presses are used it is always heated or cooked before pressing. The process of expressing the oil and subsequently refining it is very complicated, involving the use of expensive equipment and requiring considerable technical skill. About 20 per cent of the weight of the cotton seed is oil, and the remainder consists of valuable by-products such as cotton-seed meal, cake, and hulls, which are used for stock feed.

EXERCISES

1. On page 765, Agriculture Yearbook, 1924, is a table showing the international trade in cotton-seed oil. List the important importing and exporting countries and explain why each of these countries carried on trade in cotton-seed oil.

2. With an increasing population pressure upon land supply, what animal fats are likely best to meet the increasing competition of vegetable oils? Explain why.

3. Which vegetable oils are likely to increase most rapidly in the near future? Explain why.

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CHAPTER IX

STARCHY FOODS

WHITE POTATOES

There is little doubt that the potato is indigenous to the Andean region of South America and that it was introduced into Europe and North America at about the same time. Unlike two other important crops native to America, the potato has attained far greater importance in ministering to human welfare in Europe than it has in its native environment. So important has the potato become in Ireland, for example, that until recent times there has been a close relationship between a short potato crop and migration from Ireland to America. In a number of other European countries a serious shortage in the potato crop is attended by considerable distress among the lower economic strata of society. While in the United States a shortage in this crop is not normally attended by keen distress for want of food, our attachment to and dependence upon the potato is shown by the high price all classes of the population are willing to pay for it rather than forgo any considerable proportion of their customary consumption.

TABLE XVI

World Production and Distribution of White Potatoes

Average 1909–1913

Country	Acreage, 1000 Acres	Per Cent of World Total	Production, 1000 Bu.	Per Cent of World Total
Germany	6,775	18.0	1,373,609	25.0
Russia	6,763	18.0	704,994	13.0
Poland	5,693	15.2	889,531	16.4
France	4,066	10.8	526,793	9.7
United States	3,677	9.3	357,699	6.6
Czechoslovakia	1,849	4.9	245,210	4.5
All Others	8,749	23.8	1,330,720	24.8
Total	37,572	100.0	5,428,556	100.0

Climate.—The white potato does best in a climate possessing cool and moist weather during the vegetative period of its growth. It is desirable that the maturing and harvesting season be fairly dry and the temperatures warm but not hot. High temperatures and dry weather at this period not only decrease the yields, but reduce the quality as well. Because of their temperature conditions, the northern and western sections of the United States possess marked advantages for potato production. White potatoes are grown in the central and southern states either as an early or a late crop, thus avoiding the unfavorable temperature conditions of the summer weather.

Soils.—Potatoes do best on light-textured well-drained soils. The excellent tilth of such soils is significant for the potato, not only in regard to cultivation and the desirability of loose, mellow conditions for the development of the tubers, but also as an important factor in the digging of the crop. Although the water requirement of the potato is high the plant requires good drainage. It is important that the water supply be uniform. Droughts often reduce materially the production of potatoes in the eastern United States, but in irrigated districts of the West the acre yields are more uniform.

Insects.—The losses in potatoes, caused by insect pests, are small in comparison with those incurred from this source in many other plants. This is due largely to the effective control measures which have been discovered and which can be economically employed in potato culture. Among the most destructive pests, if uncontrolled, are the Colorado potato beetle and the flea beetle. Both may be destroyed by spraying the plants with Paris green or arsenate of lead.

Diseases.—Potato diseases are of two kinds, one group attacking the tubers, the other the vines. The potato scab is a common pitting on the potato. The parasite is able to live many years in the soil, especially if the soil is neutral or alkaline. This disease may be kept in check by planting tubers that are initially free from infection or have been made so by the use of disinfectants, and by a rotation of crops. The disease is much less destructive in acid soils.

Early blight is a fungous disease which attacks the potato leaves and causes the slow drying up of the foliage. It may be controlled by a weekly spraying with Bordeaux mixture, beginning when the plant is 6 to 8 inches high and continuing throughout the season of growth. Crop rotation is also beneficial, since infection takes place from the spores which have overwintered in the soil.

Late blight is the principal vine disease to be contended with. It is caused by a fungus which acts more quickly than early blight and may be controlled in the same manner. The disease does not live over in the soil and may be largely prevented by the planting of disease-free tubers.

Since in potato culture, even more than in most other farm crops, satisfactory profits are usually associated with high acreage yields, it follows that potato growers should give unusual attention to control and preventive measures in combating insects and diseases. Where the plant is maintained in full health and vigor throughout its natural growing period, the yield is much greater than where its life has been cut short by the ravages of insects or disease. In addition, the quality of the tuber is vastly superior and the crop will thus command a premium upon the market.

Distribution of Production.—The world map of potato production, Fig. 64, shows the remarkable concentration of this crop on the mainland of west central Europe, and especially in Germany. In fact, this is the world center of production for the white potato. It is to be noted that no production at all occurs in the tropics, and but very little in the southern middle latitudes. The striking centralization of the potato in west central Europe represents in a peculiar way a method of land utilization in this region of concentrated city population where the potato can be grown so well. In the map of potato production in the United States is to be seen a type of centralization on a smaller scale, and more scattered in distribution. The principles determining this unique distribution are similar in character. Among these factors are the following: First, the physical features, especially the cool, moist growing weather and the well-drained, loose, sandy or sandy loam soils, present suitable conditions for high acre yields of this crop, thus enabling it to fit well into a system of intensive agriculture. In these regions potato production is increased by the use of manures and fertilizers. Second, because the potato is a crop of bulky nature and commands a lower price per unit of weight than most other food crops, a major share of this commodity is produced comparatively near the consuming centers. Third, the potato has a variety of uses.

In most of Europe and the United States, the potato is used more universally as a table food than any other crop except wheat. In the United States it is mainly used in this way. In Europe, while the larger share is used also as human food, it is being increasingly used for other purposes, such as livestock feed and in the manufacture of starch and industrial alcohol.

Areas of Production in the United States.—In the United States the northeastern quarter of the country stands out as the producing section. Throughout this portion of the country, climatic influences are very favorable to potato production; moreover, this is the most

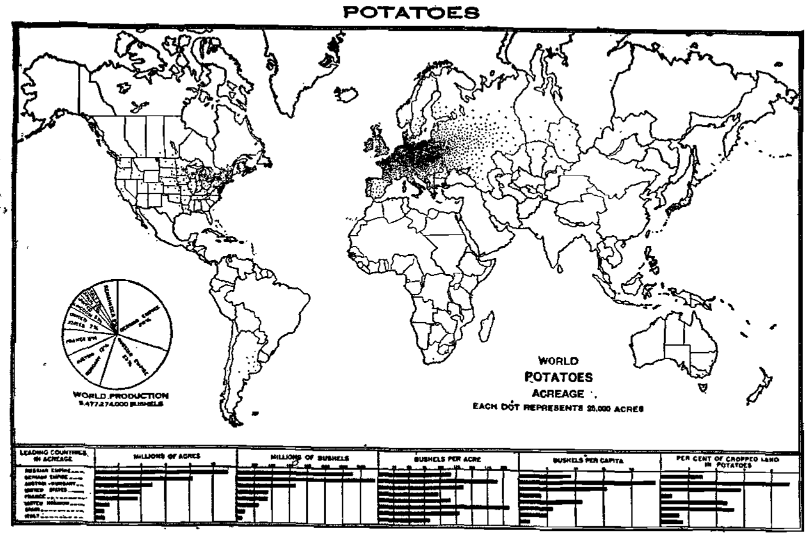


FIG. 64.—World acreage in potatoes. The extent to which this New World plant has been adopted by Europe is strikingly shown. Over 90 per cent of the world's crop is grown in Europe, the potato production of that continent exceeding in volume and almost equaling in value the wheat crop of the world. Germany alone has an average potato acreage twice as great and a production over four times as great as that of the United States. Nearly 14 per cent of the cropped land in Germany is in potatoes, as compared with 1.2 per cent in the United States. Russia and Austria-Hungary also each have a greater acreage and yield of potatoes than the United States. The Southern Hemisphere with sparse population and large areas of unfavorable climate has no important potato-raising centers.

Finch and Baker, Geography of the World's Agriculture, p. 68.

densely populated portion of the United States. Localization, however, allows soil areas particularly favorable to the production of high-class potatoes to be used intensively for this purpose. These areas, usually with sandy soils and generally well drained, include the noted Aroostook County district, in Maine, Long Island, sections of central New Jersey and southeastern Pennsylvania, southern Maryland, western New York, portions of central Michigan, central Wisconsin, and the lands adjacent to St. Paul, Minnesota.

SWEET POTATO

Introductory.—The original home of the sweet potato is believed to be northern South America. When first found by white men, the sweet potato was already an important crop in the West Indies and in Mexico. Its use was begun very early in colonial times in Virginia and the Carolinas. The increase in production in the United States has been rapid, particularly during the past few decades, until at the present time sweet potatoes rank second only to white potatoes as a commercial truck crop.

The sweet potato belongs to the morning glory family and occupies about the same position in the more humid, warm middle-latitude and tropical regions as does the white potato in the humid, cool middle-latitudes.

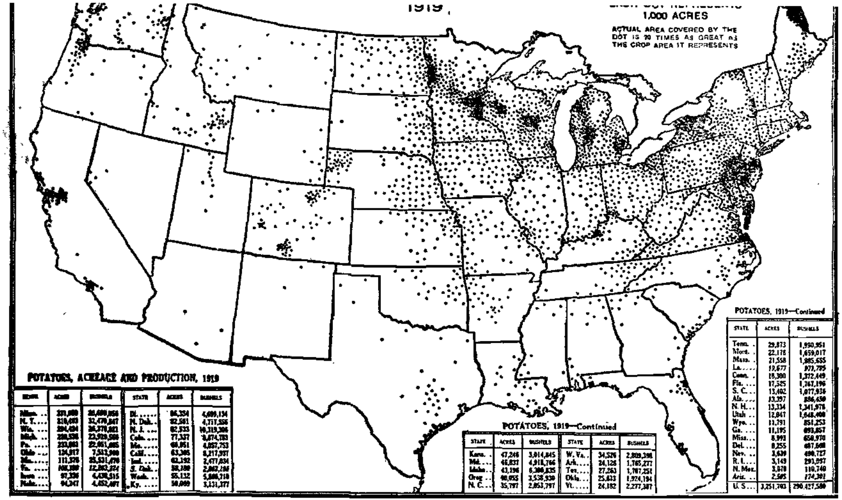
Varieties.—There are several varieties of sweet potatoes of commercial importance. The small quantity from the New Jersey region are dry and mealy and are readily disposed of in the adjacent markets. Most southern varieties are moist-fleshed, a characteristic which seems best to suit the southern consumer.

Soil.—The sweet potato requires even lighter and sandier soil than the white potato, and may, therefore, be successfully grown on the sandy soil of the Coastal Plain in New Jersey, Maryland, and Virginia. Similar sandy spots in Iowa, Illinois, and other north central states make possible the economical growing of sweet potatoes in limited quantities.

Climate.—The climatic requirements of sweet potatoes are a growing period of at least four months with warm days and nights, plenty of sunshine, and moderate rainfall. The largest yields and the best quality are secured when rainfall is abundant in the early part of the growing season and less plentiful during the latter part.

Distribution in the United States.—Five states, Georgia, Alabama, Mississippi, North Carolina, and Texas, produced more than half of the entire crop in 1920.

Production.—Between 1915 and 1919, the average annual produc-



POTATOES, ACREAGE AND PRODUCTION, 1919

STATE	ACRES	BUSHELS	STATE	ACRES	BUSHELS
Minn.	[illegible]	[illegible]	Ill.	86,354	4,499,134
N. Y.	310,000	32,478,847	N. Dak. ..	82,581	4,717,556
Wis.	294,494	26,370,[illegible]	N. J.	82,533	10,319,306
Mich.	280,536	23,929,580	Colo.	77,337	8,874,783
Pa.	233,003	22,051,005	Mo.	66,051	4,057,753
Ohio	124,917	7,513,900	Calif.	63,305	8,217,937
Me.	111,376	25,531,478	Ind.	62,152	2,477,034
Va.	105,100	12,863,324	S. Dak. ..	58,100	2,062,186
Iowa	97,336	4,438,515	Wash. ..	55,132	5,886,718
Nebr.	94,347	4,452,407	Ky.	50,000	3,131,377

POTATOES, 1919—Continued

STATE	ACRES	BUSHELS	STATE	ACRES	BUSHELS
Kans. ..	47,248	3,914,845	W. Va. ..	34,526	2,809,398
Md.	46,837	4,918,766	Ark.	24,126	1,765,277
Idaho ..	43,196	6,300,835	Tex.	27,263	1,707,251
Oreg. ..	40,055	3,538,930	Okla. ...	25,433	1,924,194
N. C. ..	35,797	2,053,797	Vt.	24,182	2,277,387

POTATOES, 1919—Continued

STATE	ACRES	BUSHELS
Tenn. ..	29,873	1,990,951
Mont. ..	22,178	1,659,017
Mass. ..	21,558	1,985,655
La.	19,677	973,795
Conn. ..	18,300	1,372,449
Fla.	17,525	1,767,196
S. C. ...	13,402	1,077,936
Ala.	13,397	886,450
N. H. ...	13,334	1,341,978
Utah ...	12,047	1,648,400
Wyo. ...	11,791	851,253
Ga.	11,195	693,857
Miss. ...	8,993	650,978
Del.	8,255	467,608
Nev. ...	3,630	490,727
R. I.	3,149	293,097
N. Mex.	3,078	110,740
Ariz. ...	2,505	174,302
U. S. ...	3,251,703	290,427,580

FIG. 65.—The regions of heaviest potato production lie to the north of the Corn Belt. This is due partly to the fact that the quality and yield of potatoes are better in regions of cool climate, and partly to the fact that corn, which requires labor at the same time, is very productive and gives a greater return. Many of the large centers of potato production are in regions of *sandy or loamy soils*—Aroostook County (Me.), Long Island, New Jersey, eastern Virginia, western Michigan, central Wisconsin, and Anoka County (Minn.). Many of the minor centers of production are located near large cities, since potatoes are a bulky crop, expensive to trans-

tion of sweet potatoes in the United States was about 83 million bushels, and the average acreage yield was nearly 97 bushels. Approximately 90 per cent of the total production was grown in the southern states.

Uses and Composition.—The chief use of the sweet potato is for human food, but it is also used to some extent for feeding livestock. The crop may be utilized for making starch, sirup, and alcohol. The roots contain about 20 per cent starch and 4 per cent sugar, or a total of 20 per cent of alcohol-producing material. The vines when dried make a medium grade of hay.

It has been seen that the sweet potato crop on the average is nearly one-fourth as great as the white potato crop in the United States, and its importance is rapidly increasing.

SUGAR

Introductory.—Chemically, sugars are carbohydrates, compounds of carbon, hydrogen, and oxygen. From a dietary standpoint, refined sugar is a highly concentrated food, containing practically no waste and consisting exclusively of energy-producing elements.

Although sugar had long been known in the Far East, it had no commercial significance in Europe until after the time of the Crusades and then only to a very limited extent. It was not until the nineteenth century that the per capita consumption of sugar began to assume any considerable importance in Europe and North America. Its present significance in the diet of the population of the United States is indicated diagram on p. 280.

The increasing significance of sugar in the United States is indicated by the fact that the per capita consumption during the past century has increased from less than 10 pounds to more than 100 pounds, while the total consumption has increased from a few thousand tons to more *than 5 million tons in the year 1922–23.*

Practically all of the sugar produced is used for food, either directly or in manufactured food products. In the United States the per capita consumption, as stated above, averages about 100 pounds of sugar a year, which is practically the same as the British consumption before the War.

Cane and Beet Sugar

Historical.—Sugar cane is believed to have originated in India or some other part of eastern tropical Asia. Knowledge of the cane plant was acquired from India by the Chinese, as is shown in Chinese writings of the eighth century B.C. Crystalline sugar was first known in the East about A.D. 600, so far as historical records show. The Arabs probably were responsible for the introduction of cane culture into Egypt and thence into Spain. However, it was not until after the return of the Crusaders from Palestine that trade in sugar began to spread throughout western Europe. Cane culture was introduced into the West Indies from Europe soon after the discovery of the New World.

Cane Sugar.—After centuries of cultivation, cane remains a tropical plant, which is grown commercially no farther north than Louisiana

FUEL VALUE AND COST OF SUGAR IN THE DIET.

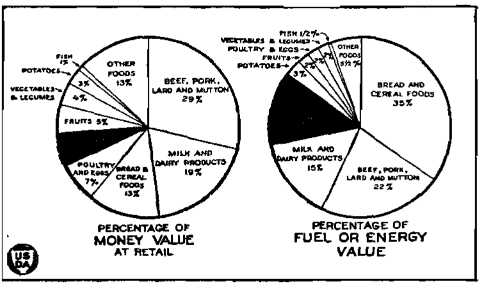


FIG. 66.—Sugar supplies about 13 per cent of the energy or fuel value of the foods consumed in the United States; but its cost at retail, including candy, is only about 6 per cent of the total expenditure for food.

Agriculture Yearbook, 1923, p. 162.

or southern Spain. This is because the cane plant requires a long and warm growing season. It requires, in addition, a fertile, well-drained soil and a considerable amount of moisture during the vegetative season. Less humid conditions are desirable during the maturing and harvesting period for the production of the maximum amount of a high-grade commodity.

The Cane Plant.—The cane plant, a member of the grass family, varies in height from 8 to 24 feet. Although there are numerous varieties, much remains to be done in the development of strains particularly fitted to conditions in the various producing regions. Cane is propagated by cuttings from the stalk. In the tropics the cane plant is a perennial, but as a rule production begins to decline after the third year's growth.

The Development of the Sugar-beet Industry.—Although beet sugar has so recently entered the field, it has proved an important rival of the cane product. The race between the luxuriant perennial cane of the tropics and the carefully cultivated beet of the middle latitudes has been an interesting contest during the past eighty years. The leading place was first won by beet sugar in the season 1882–83. Occasionally, after this, cane-sugar production forged ahead, but did not hold the

WORLD PRODUCTION OF SUGAR, 1853–1922.

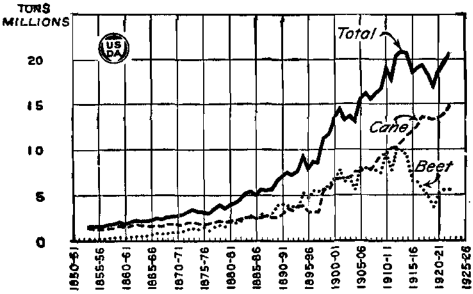


Fig. 67.—The commercial production of sugar first became important in the last half of the nineteenth century. Production increased rapidly until 1914, when it was checked by the World War. Beet-sugar production, at first unimportant, was stimulated by bounties and tariffs and was approximately equal to that of cane sugar from 1884 until 1914. Since 1914 cane-sugar production has continued to increase, while beet sugar has declined in relative importance to less than one-third of the total sugar supply of the world.

Agriculture Yearbook, 1923, p. 218.

lead. The chief European governments used bounties, drawbacks on exports, and other measures to encourage the production of beet sugar, and thus enabled it to supersede cane sugar in the British market. The effect on the West Indian industry was disastrous. Finally the principal western European governments agreed, under the terms of the Brussels Convention of 1902, to do away with the artificial aid to beet production.

The trend of production of cane and beet sugar, as well as the total, is shown in Fig. 67.

The World's Sugar Production

The world's maximum sugar production for which data are available occurred in 1923–24, and it amounted to a little more than 22 million tons. This is about 3 million tons more than the average for 1909 to 1913.

The limit of the world's potentialities for sugar production has not yet been approached. More sugar may be grown by putting additional land under cane or by increasing the yield per acre. Cuba and the Philippines, for example, can extend their cane fields. British India now produces about one ton of sugar to the acre, but by the use of improved methods, the output can readily be raised to two or three times that amount. In the United States, for example, and elsewhere in the middle latitudes, large areas can be devoted to beet culture, whenever the price of sugar makes it profitable in competition with other crops. The supply can thus be increased whenever there is enlarged demand from consumers who are able to buy sugar.

The tremendous growth of the sugar industry during the last half of the nineteenth century is indicated in Fig. 67 and Table XVII. This increase has continued during the first quarter of the present century, which has been particularly marked by a great development of cane-sugar production.

TABLE XVII

Sugar Crops of the World and Percentage of Cane and Beet, *1840, 1901, and 1923*

Year	Total Crop (Tons)	Cane (Tons)	Beet (Tons)	Percentage	
				Cane	Beet
1840	1,150,000	1,100,000	50,000	96	4
1901	8,800,000	2,850,000	5,950,000	32	68
1922	22,009,000	15,537,000	6,472,000	71	29

Labor shortage threatens to become a limiting factor in some localities, but as an offset there is the possibility of more widespread use of machinery. Cane cutting and cultivation of beet fields still requires considerable hand labor, while machinery has been applied to most of the later processes. Mechanical cane cutting seems not impossible, as a number of machines have been designed for that purpose, some of which may eventually prove practicable.

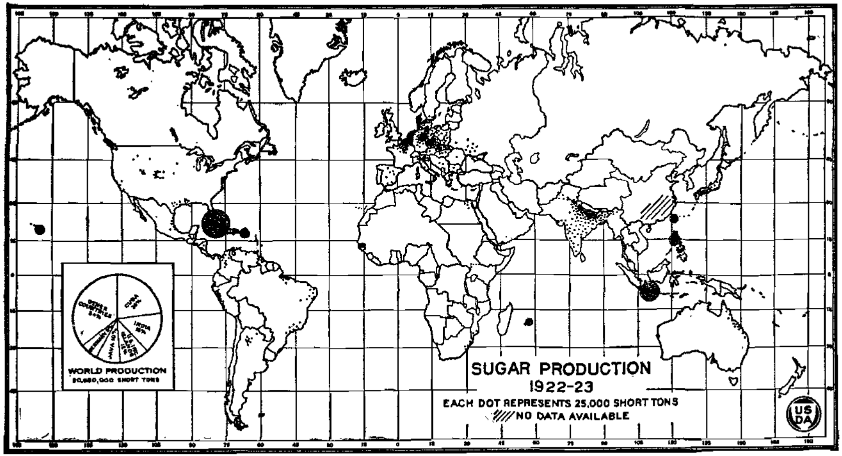


FIG. 68.—The production of sugar is widespread throughout the world. Cane sugar is produced in tropical and subtropical zones and beet sugar in temperate latitudes as far north as Sweden. Since the beginning of the World War sugar production has increased most rapidly in tropical countries, particularly in Cuba. Over one-fifth of the world's sugar is produced in Cuba. The United States and insular territories produce nearly one-seventh.

Agriculture Yearbook, 1923, p. 214.

Cuba.—Cuba is the leading producer and exporter of sugar. After the liberation of the island in 1898, this industry, which is by far the largest in Cuba, was greatly stimulated. The maximum crop under Spanish rule was one million tons (1894) but by 1910 this figure was almost doubled, and in 1924–25 the record crop of 5,175,000 tons was produced. The area of land suitable for cane which was controlled by producers in 1920 was estimated at more than 4 million acres, or about one-seventh of the area of the island. More than half of this acreage is controlled by the "centrals," factories which as a rule are owned by large corporations. The central usually grinds not only the cane produced on its own lands but also some cane purchased from near-by "colonos," who own estates or farms. Of the entire investment in the Cuban sugar industry, estimated at over $950,000,000 in the fall of 1921, two-thirds is believed to be American capital.

A large proportion of the island possesses physical conditions almost ideal for sugar-cane production.

Handling Cane.—Mechanical methods of handling cane and making sugar are highly developed in Cuba and are typical of progressive methods used in other cane-growing countries. Freshly cut cane is hauled immediately to the central where the juice is at once pressed from the stalks by machinery. The cane then enters the mill and is passed between heavy rollers to force out the juice. On an average, from 12 to 16 per cent of the weight of the cane consists of sugar, most of which can be extracted. The richness of the juice varies considerably under the different conditions of growth and with the stage of maturity.

Manufacture.—Cane juice, after having been heated, settled, and filtered, is boiled first in multiple evaporators, and then in vacuum pans, in which it is almost completely crystallized. Most of the mother liquor, or molasses, remaining thereafter is driven off in centrifugal machines revolving at high speed. The product is a hard-grained, yellowish-brown raw sugar, practically dry and possessing good keeping qualities.

Market.—The principal market for Cuban raw sugar is the United States, and refineries at the various ports from Boston to Galveston use this grade. Under the reciprocity treaty between the two countries, the United States grants a reduction of 20 per cent on the duty on all sugar imports from Cuba. The United Kingdom became a large buyer of Cuban sugar during the War, when European beet sugar was cut off. British imports from Cuba in 1918 increased almost four-fold over 1913, but after the war this trade declined, leaving Cuba with greatly increased crops for which purchasers were needed. War-time

SUGAR PRODUCTION IN PRINCIPAL SUGAR-PRODUCING COUNTRIES, 1890–91 TO 1922–23

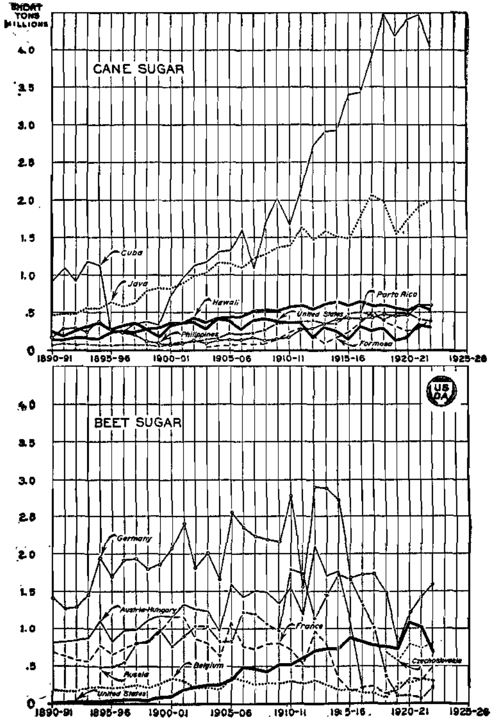


FIG. 69.—The great increase in cane-sugar production in the last twenty-five years has been chiefly in Cuba and Java. The Philippines, Hawaii, Porto Rico, and Formosa have also increased their production. The average production of cane sugar in the United States increased until 1908 and has since declined slightly. The production of beet sugar has either declined in recent years, or advanced but slightly in every country except the United States, which in thirty years has advanced from small beginnings to the third position among the beet-sugar producing countries of the world.

Agriculture Yearbook, 1923, p. 217.

prosperity had led to heavy investments in new and costly installations of equipment at centrals. The close of 1921 found Cuba in a serious financial condition with abnormally large stocks of sugar, almost one-third of the year's crop.

The problem of the surplus at the close of 1921 was largely solved by a tremendous buying movement in the United States and unusual European purchases in the first half of 1922. But the Cuban industry has demonstrated its ability to increase production at a more rapid rate than the normal increase of American consumption. It may eventually become necessary for Cuba to dispose of an increasing proportion of its product outside of the United States. As Continental beet-growing countries will, in all probability, again supply their own needs and in addition may have a surplus for export, Europe is an uncertain market for Cuban sugar. The Orient has been suggested as an outlet; but in this connection a probable increase in production in the tropical areas of Asia, the Philippines, and the Malay Archipelago, together with the very low per capita buying power of these people, is not to be disregarded.

India.—British India falls far short of its potential importance as a sugar producer. With nearly 3 million acres under cane (1920–21) the country does not supply all of its domestic demand and regularly imports additional sugar, mostly from Java and Mauritius. The sugar crop of 2½ million tons or more represents less than the entire cane production, as some cane is used directly for chewing and other purposes. While information on the Indian crop is inexact, owing to the non-commercial character of much of the production, the acre yield is known to be conspicuously low, averaging just over one ton of sugar to the acre. The bulk of the output is a crude raw sugar called "gur," which satisfies the native population. Efforts are under way to improve the methods of cultivation and increase output.

Java.—A remarkable state of development has been reached in the cane-sugar industry of Java. The Dutch Government and the producers themselves have thoroughly utilized scientific methods of culture and extraction, with highly successful results. Abundant and cheap labor has also been an important factor in this success. A crop averaging nearly 2 million tons is produced, and Java is the second largest exporter in the world. "Java white," the characteristic product of the industry, is an incompletely refined sugar especially adapted to the market in British India, where religious prejudice exists against sugars refined with animal charcoal. Other grades made in Java are "browns" and muscovado (raw sugar of a lower grade than centrifugal). British India, Japan, and China take the bulk of Java's exports; but in times of high prices, as in 1920, exports to Europe and America are increased at the expense of the Orient. Whereas in Cuba the limiting factor in cane production is labor, in Java the limiting factor is the lack of available lands. Here the population is very dense and it is necessary to keep the lands suitable for sugar production in rice.

Other Cane-producing Countries.—Cane is grown in many sections of the world other than those mentioned; but on the basis of an annual total cane-sugar production, averaging nearly 15 million tons since the War, the crops of Cuba, India, and Java, amounting to about 4½ million tons, 3 million tons, and 2 million tons respectively, constitute more than 60 per cent of the world's cane-sugar supply. Hawaii furnishes the largest item of the remainder, with Porto Rico and Japan (including Formosa) as close competitors. Several other regions, including Peru, Brazil, the Philippines, Mauritius, Argentina, Australia, and Louisiana, produce considerable quantities. Most of the larger islands of the West Indies grow enough cane to export at least a small quantity of sugar, and in some cases the manufacture of molasses and Jamaica rum adds to the profits of the sugar industry.

Hawaii.—The Hawaiian Islands deserve special attention because of the advanced development of their cane-sugar industry. The highest yield per acre in the world is achieved in these islands, because of a combination of suitable physical conditions, scientific knowledge, and organization. In spite of these favorable conditions, however, Hawaii can put little if any new land into cultivation and will have much to fear from the competition of countries where land is cheaper and wages lower. In fact, in recent years there has been a gradual decrease in acreage because of the keen competition of other crops for the limited supply of arable land. Under present conditions Hawaiian sugar is admitted duty-free into the United States, thus insuring a market preference over all imported sugar, including that from Cuba.

Philippines and Porto Rico.—The Philippines are still far from full development of their sugar industry, and exports remain about the same as under the Spanish régime. Modern factories and equipment have been installed, with the result that centrifugal raw sugar now predominates over muscovado. Exports are divided between the Far East and the United States. In Porto Rico most of the sugar is produced at centrals with modern methods of machinery. Since the island became an American possession, production has risen from an average of less than 100,000 tons (1900–05) to more than 400,000 tons, marketed exclusively in the United States. Philippine and Porto Rican sugars are free of duty.

Louisiana.—Louisiana has produced cane sugar since the French colonial period, before 1800, and Texas produces a small crop. The quantity in the two states is not large enough to affect the world market. Although soil and rainfall are suited to cane culture, the warm growing season is too brief, and the consequent low yields per acre and high labor costs increase the cost of production. The crop averages about 200,000 tons a year, which is refined and used in the United States. Crops of over 300,000 tons are occasionally produced, as in 1911–12 and earlier; but, on the showing of the last fifteen years, Louisiana sugar production is a declining industry. Were it not for the protective tariff it is probable that the Louisiana cane-sugar industry would have declined even more during this period.

Refining generally forms a separate branch of the cane-sugar industry and is carried on mainly at the ports of entry in the importing countries.

The raw sugar used by our eastern refineries comes principally from Cuba, with lesser amounts from Porto Rico and the Philippines, whereas San Francisco handles most of the Hawaiian raw sugar. The British refineries secure their raw cane sugar from all quarters of the world—Cuba, Mauritius, the British West Indies, South America, and Java.

TABLE XVIII

CANE AND BEET-SUGAR PRODUCTION OF THE LEADING SUGAR-PRODUCING COUNTRIES FROM 1909 TO 1914

Country	Cane, 1000 Tons	Per Cent	Country	Beet, 1000 Tons	Per Cent
British India	2,649	25.5	Germany	2,304	26.3
Cuba*	2,287	22.0	Russia†	1,557	17.7
Java	1,485	14.3	Czechoslovakia	1,221	13.9
All others	3,960	38.2	France	808	9.2
			Poland	703	8.0
Total	10,381	100.0	United States	642	7.3
			Belgium	279	3.2
			Netherlands	246	2.8
			Italy	209	2.4
			All others	801	9.2
			Total	8,770	100.0

* Cuba's production is now nearly double this amount.

† Russia's production nearly vanished during the War and post-war period.

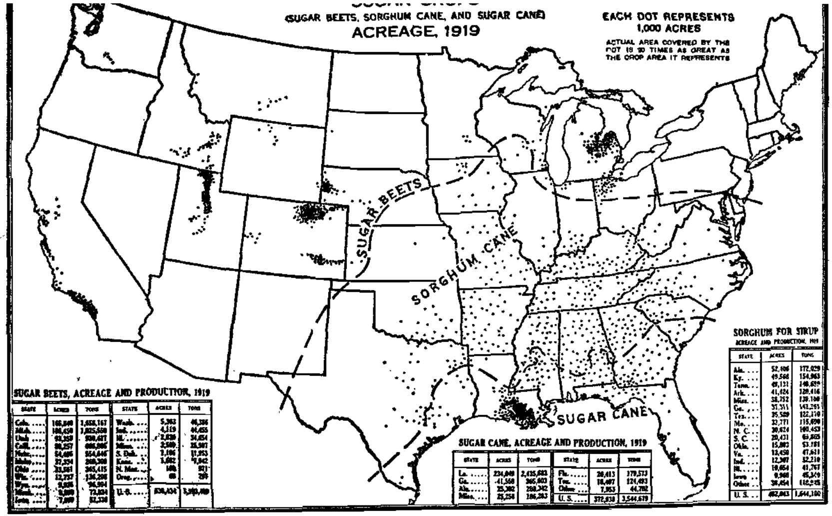


FIG. 70.—The two more important commercial sugar crops are cane and beet. The acreage of sorghum cane is greater than that of sugar cane, but the sirup is mostly made from the sorghum on the farm and does not enter into commerce. Sugar beets do not, in general, show a sufficiently high sugar content to be manufactured profitably where the summer temperature is over 72°, and the beets must also then compete with corn for the farmer's labor. Sugar cane is not grown commercially for sugar outside of the almost frost-free lower Mississippi Delta of Louisiana. The broad belt between the sugar-beet and sugar-cane areas is occupied by a thin and scattered acreage of sorghum cane.

Beet Sugar

The growth of the beet-sugar industry is a striking example of the application of science to agricultural production. A German chemist, Andreas Marggraf, made the discovery about 1750 that beets contain sucrose, a form of sugar. In 1802 one of Marggraf's pupils operated, in Silesia, the first beet-sugar factory in the world. The industry gained a powerful impetus in France when, in 1811, Napoleon found it necessary to foster beet-sugar production in that country, the supply of cane sugar, brought in chiefly from the West Indies, having been cut off by the British blockade. When the blockade was raised after Napoleon's defeat, cane sugar was again available and all European beet-sugar factories suffered temporarily. The new industry revived after a few years, and great progress was made in improving the quality of the root. The maximum sugar content is now between 18 and 21 per cent, whereas originally it was not more than 6 per cent.

Although the sugar beet will grow over large areas in the middle latitudes, its chief centers of production occur in northern France, Belgium, the Netherlands, central Germany, Czechoslovakia, Poland, and southwestern Russia. Beet culture in limited areas extends northward to the Scandinavian countries and southward to Spain and Italy. In the United States, sugar-beet production is largely localized, the areas of production occurring in eastern Michigan, western Nebraska, northeastern Colorado, the oasis of Utah, and the coastal region of southwestern California. In 1919 the largest crops occurred in Colorado and Michigan.

The manufacture of beet sugar is in many respects similar to that of cane sugar. On the other hand, it differs in certain important respects, notably in that the juice is extracted from the thinly sliced beets by the diffusion process. In the United States, most factories carry out all steps from slicing to refining. In Europe, however, many beet-sugar factories turn out raw beet sugar which is later sent to separate refineries or exported. Beet pulp is used for stock feed, and the molasses by-product, like cane molasses, may be reworked for its sugar content, distilled, or used in cattle feed.

Outlook for Cane and Beet-sugar Production in the United States.—In general, the natural conditions of soil and climate in American cane and beet regions can not be considered the factors which limit expansion of the sugar industry. The limiting factors appear to be economic rather than agronomic. Labor supply, market price, crop competition, and assurance of protection are among the important factors which govern the production of sugar in the United States and its insular possessions.[1]

Beet-sugar Production in the United States

The American beet-sugar industry is a much larger contributor to the sugar market than the southern cane industry. Efforts to establish the beet-sugar industry in the United States began in 1830; but the difficulties were so great that by 1890 there were only three beet-sugar factories in the whole country and their combined production was only 10,000 tons per year. There was then a slight increase until 1900, since which time progress has been relatively rapid. In the season 1919–20 there were 106 beet-sugar mills in the United States, including those under construction. In 1920, from an area estimated at about 900,000 acres, a crop just under one million tons was produced. This is far less than the proportionate yield in Europe. Cost of production was high compared with that of Cuban cane sugar. The crop is marketed exclusively in the United States, usually no farther east than Buffalo and Pittsburgh.

Physical Conditions of the Sugar Beet.—The sugar beet is a native of Europe. It requires, for its best development moist and fairly mild conditions with much sunshine for its vegetative period, whereas cooler weather is said to be most suitable for the maturing season. Because of the necessity of a constant moisture supply during the vegetative period, soils of heavier texture, although well drained, are desirable in humid climates. In irrigated regions, however, where the moisture can be supplied as needed, light-textured soils are usually preferred.

International Trade in Sugar

Countries important in the sugar trade may be divided into three groups: first, those that are regularly net exporters; second, those that can not supply their own needs and are therefore net importers; and third, countries that produce sugar primarily for their own use and in addition either export or import as circumstances in their own or in the international market require.

Exports.—Export trade since the War is carried on in large units, principally by the cane-producing countries, Cuba, Java, Mauritius, Hawaii, Peru, Brazil, the Philippines, and the Dominican Republic and Porto Rico. Other West Iudian islands contribute a considerable quantity of sugar. Cuba and Java are the great sources of supply,

[1] Agriculture Yearbook, 1923, p. 228.

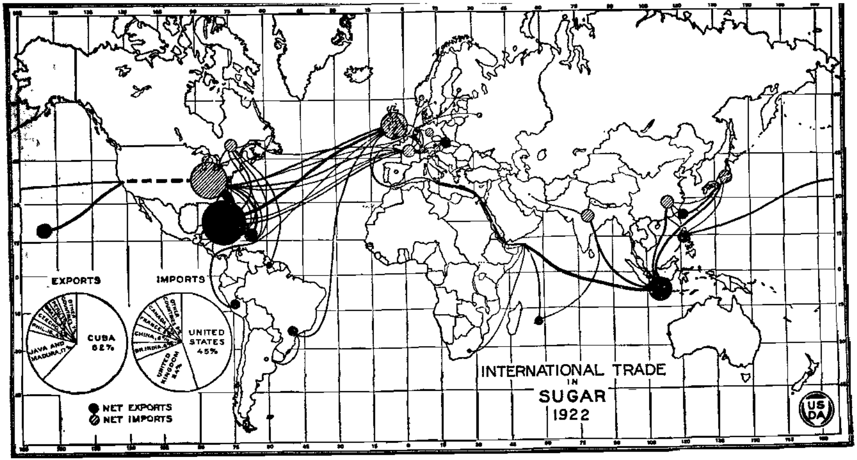


FIG. 71.—The two largest sugar-exporting countries are Cuba and Java, with secondary sources of supply in Hawaii, the Philippines, Porto Rico, Czechoslovakia, Formosa, Brazil, and Peru. The United States and the United Kingdom are the most important sugar-importing countries, followed in importance by British India, China, France, and Canada. The United States imports sugar from Cuba to supplement the domestic supply and shipments from its insular territories, while the United Kingdom and western Europe import more largely from Java and the minor surplus countries.

Agriculture Yearbook, 1923, p. 215.

and their combined crops, which formed about 33 per cent of the world's production in 1920–21, are almost wholly available for export. Hawaii, Porto Rico, the Philippines, and Mauritius regularly devote 80 per cent or more of their output to export trade.

Prior to the War, Germany, Austria-Hungary, the Netherlands, Belgium, and Russia were net exporters of beet sugar. Net exporters of beet sugar in 1920 included Czechoslovakia, Poland, the Netherlands, and Belgium. Germany is nearing the point where export trade can be resumed. The prospects of an exportable surplus from Russia are problematical.

Imports.—The great importing countries are the United States, the United Kingdom, and British India, which rank in the order given. By reason of the large domestic and insular production and the preference granted to Cuban sugar, the American market is not open to the other producers except to a very limited extent. The United Kingdom gives preference to sugar from its own possessions which, however, falls far short of meeting the demand. Competition between selling countries, therefore, centers upon the markets of the United Kingdom and India, and their annual imports of nearly 2 million tons and 600,000 tons, respectively, represent the great prizes in international sugar trade. The import trade of Canada and China is of considerable importance, and Japan imports more than 100,000 tons annually.

In the pre-war period, France was the outstanding representative of the third group. Its best production was practically sufficient to meet domestic requirements. In addition, an extensive refining industry handled raw sugars, permitting considerable exports of the refined product. Exports and imports were in approximate balance, the net movement in either direction being determined by conditions in the internal market. Since the War, France has been a net importer, taking as much as 540,000 tons net imports in one year. This is abnormal and as the domestic crop improves imports are being curtailed. In 1921 the imports were cut down by half and exports were increased.

A general review of the international sugar trade is afforded by Table XIX which shows average production, consumption, and net imports or exports of the principal countries from 1909 to 1913.

Factors Controlling Exports

The direction of exports is determined primarily by location of markets, but may be influenced by political control, tariffs, or trade connections. The fact that Cuba receives tariff preference in the United States makes it advantageous to dispose of as much of the crop as possible in that market. Sugar from British and French West Indian colonies receive preferential tariff treatment from their respective governments. Good keeping qualities and the ease with which sugar can be shipped make the sugar trade very flexible. Philippine sugar bears the cost of shipment to New York and sells in competition with Porto Rican sugar. Java sugar is marketed both in the East and in Europe. South American countries such as Argentine and Peru, in which British capital is invested, pay part of their trade balances in sugar shipped to the United Kingdom.

TABLE XIX

PRODUCTION, CONSUMPTION, AND NET IMPORTS OF SUGAR BY PRINCIPAL COUNTRIES— AVERAGE FOR 1909 TO 1913

Country	Consumption	Production (1000 tons)	Net Imports (1000 tons)	Net Exports
United States	3,391	953	2,083	....
British India	3,339	2,650	689	....
United Kingdom	1,821	....	1,821	....
Germany*	1,534	2,304	....	870
Russia	1,267	1,557	....	290
Austria-Hungary	675	1,520	....	845
France	787	808	....	21
Cuba †	278	2,287	....	2,009
Netherlands	139	246	....	117
Java	76	1,485	....	1,409
Porto Rico	83	363	....	280
Hawaii	83	568	....	485

* For 1912–13 only.

† Cuba since these years has greatly increased its production. In the year 1923–24 it was 4,539,000 short tons.

WORLD PRODUCTION AND MOVEMENT OF SUGAR [2]

The production of sugar forms a part of the agricultural economy of nearly every important country of the world. Since the cane is a tropical plant and the beet is at home in the temperate zones, sugar is produced in commercial quantities in every continent, and from Natal and Argentina in the Southern Hemisphere to Canada and Sweden far to the north.

The reported world production increased very rapidly in the years just before the World War, and in 1912–13 reached 20,700,000 short

[2] Agriculture Yearbook, 1923, p. 213.

tons. In the next seven years, in spite of the War and subsequent unsettled conditions, the minimum production was 17,700,000 short tons in 1919–20, with a maximum of 19,600,000 tons in 1917–18.

In 1921–22, and again in 1922–23, the world sugar output was in round numbers 20,000,000 short tons. But while the total production has remained so remarkably constant, there has been a radical shift in the chief resources of supply. In 1912–13, 9,000,000 tons, or 45 per cent of the world's supply of sugar, was produced in Continental Europe, which not only supplied its own demand and that of Great Britain but exported considerable quantities to the United States and the Near East. Following the War in 1919–20, the European production was less than 3,000,000 tons, or 17 per cent of the world production, and even in 1922–23 Europe has produced only 4,500,000 tons, or 23 per cent of the total. Germany and France are now importing more sugar than they export, and only Czechoslovakia has any considerable surplus for export. The United Kingdom, with its large demand for foreign sugar, has been obliged to turn to Cuba, Java, and other producing centers in the Tropics.

This shift in production has also meant a shift from beet sugar to cane sugar. In the five years just preceding the World War, out of an average world production of 18,400,000 short tons, 8,500,000 tons, or 46 per cent, was beet sugar. In the five years since the close of the War, with an average world production of 18,800,000 short tons, only 4,750,000 tons, or 25 per cent, was produced from beets. This shift may be shown by a comparison of two countries, Germany and Cuba. Germany in *1909–10* to *1913–14* produced an average of 2,296,000 short tons of beet sugar, while in the same years Cuba produced an average of 2,295,000 short tons of cane sugar. In the years 1918–19 to 1922–23 Germany produced an average of 1,220,000 tons, while Cuba produced an average of 4,350,000 tons.

Since Europe had relied so largely upon beet sugar, the sudden change to a cane sugar basis found the importing countries of Europe lacking in adequate cane-sugar refineries. Therefore, much of the cane sugar destined for European consumption has been refined in the United States, and appears in the trade statistics as exported from the United States to Europe. Consequently, the sugar exports of the United States increased from an average of 80,000 tons in the years 1909–1913 to an average of 650,000 tons in the four years 1919–1922 to an average of 650,000 tons in the four years 1919–1922, thereby making the United States in these years not only the largest sugar-importing country, but the third largest sugar-exporting country, exceeded only by Cuba with exports of 4,200,000 tons, and Java with 1,700,000 tons. Next to the United States, the largest sugar-importing countries in the years 1919–1922 were the United Kingdom, France, Canada, British India, and China.

The sources of the net sugar supply of the United States, making allowance for raw sugar imported and later exported as refined sugar, were for the years 1918–1922, inclusive, approximately as follows: Cuba, 50 per cent; domestic beet, 18 per cent; Hawaii, 11.4 per cent; Porto Rico, 8.2 per cent; domestic cane, 4.7 per cent; Philippine

Islands, 2.7 per cent; other sources, 5 per cent (Fig. 48). In the fiscal year ending June 30, 1923, the dutiable imports of sugar in the United States amounted to 3,929,000 short tons, of which 3,865,000 tons came from Cuba. In addition, 277,000 tons were imported without tariff duties from the Philippines; 598,000 tons were brought in from Hawaii; 355,000 tons from Porto Rico; and 5,000 tons from the Virgin Islands. These amounts added to the domestic production of 970,000 tons give a total gross supply for the year of 6,134,000 tons. The exports in the same period were 391,000 tons, leaving 5,743,000 tons for consumption, or 29 per cent of the world's supply.

CASSAVA OR MANIOC

The cassava plant, also known as manioc and mandioca, is a native of Brazil. It is grown in almost every part of the tropics, its tuberous root often forming the chief source of food for the natives.

Tapioca.—The best-known product of manioc in Europe and America has in the past been tapioca; but in recent years the starch obtained from the roots has been utilized industrially as a source of alcohol, glucose, and dextrin, and as a sizing material for yarns and fabrics. The roots and residue are used for stock feed. Two kinds of cassava are cultivated, the bitter cassava and the sweet. The former contains considerable quantities of prussic acid which is disposed of in the process of preparation.

Climate.—The cassava is essentially a tropical plant though it can be grown profitably, in most warm, humid regions that are free from frost for at least eight months in the year. Its growth is stopped by a slight frost or even by continued cold weather. Sweet cassava is the hardier, therefore it is the variety grown in regions farthest from the equator, such as Paraguay and Madagascar. The plant thrives best in those humid tropical regions where the rainfall is comparatively slight; it requires only 14 to 16 inches annually. In regions where rainfall is heavy it is necessary to select light-textured well-drained soils to prevent water-logging which is fatal to the plant. It may be cultivated at an altitude of 2500–3000 feet, but matures earlier and gives heavier yields in the valleys. Sheltered positions should be chosen for the plantation, as the stems are brittle and the plant suffers severely in strong winds.

Soil.—The best soil is a rich, light-textured, sandy loam. Recently cleared forest land is preferred by the natives in most parts of the tropics, since it is rich in plant-food materials and crops can be grown on it for several years with good yields. Many growers prefer soil with hardpan, as the roots will then keep near the surface and thus will be less difficult to dig.

Planting.—The cassava plant is propagated commercially by means of stem cuttings, planted in rows about 4 feet apart. Before planting, the soil should be brought to a fine state of tilth. The use of artificial fertilizer and barnyard manure becomes necessary after the land has been in crop for a few years, and the plantation must be kept free from weeds.

Rotation.—Several crops can be grown in succession on rich, newly cleared land, but the proper system of rotation must be practiced sooner or later to prevent deterioration of the soil. In North Africa the following system is practiced: cassava is followed first by peanuts or some other legume, then by some cereal such as sorghum or maize, and then by cassava again for two or three years. As a variation of this rotation, a crop of beans or sweet potatoes may be interspersed.

Yields.—The yield varies from 2½ to 3 tons on poorer sandy soils, to 15 tons on good soil. The average yield is about 8 tons.

Processing.—To prepare starch and tapioca, the roots are cleaned and grated, and the starch is separated from the fiber and collected in tanks of water. For industrial purposes the starch is then dried; but if tapioca is to be made, the wet starch is placed on hot iron plates, which causes the grains to gelatinize and adhere together in lumps while being stirred. It is then dried, after which it becomes the pearl tapioca of commerce. Flake tapioca is made by placing a thin layer of wet starch on the hot plate and then stirring.

For laundry purposes, cassava starch is inferior to rice starch, but it is said to be much better than either corn starch or potato starch, giving a smoother surface and a finer gloss.

For sizing cotton yarn, it yields a paste of somewhat feeble adhesive qualities and is therefore inferior to other starches. For medium and heavy sizing, it is ordinarily mixed with wheat or corn starch.

It may be said in conclusion that the cultivation of the cassava plant is but one of the many instances, which we shall observe, of the increasing commercial utilization of tropical and sub-tropical resources for the growing food demands of the northern middle latitudes.

THE BANANA

Introductory.—The banana ranks with the potato, sweet potato, and cassava as a starch food and bread equivalent. This plant can be grown throughout the entire tropical belt wherever the rainfall is adequate to produce tropical forests.

The ease with which this nutritious fruit may be grown makes it a staple food throughout the humid tropics. Its place in the diet of equatorial peoples corresponds to that of the potato for the north European peasant and rice for the people of southeastern Asia.

In addition to being indispensable to the life of the natives, the banana has high standing among tropical products entering commercial channels as an article of export. This is due to the fact that the plant is easily grown and gives an early return. It is prolific, and a crop is usually assured. The fruit travels well in cold storage and arrives in presentable form in countries far distant from its place of origin, having been protected from contamination during handling in transit by the tough, though easily removable skin. The banana can be retailed at a low price and, besides being eaten as a raw fruit, it can be employed as a food in many other forms.

Banana Trade.—The first bananas were brought into this country in the late 'sixties and into England about ten years later. The trade did not become important here until the formation of the United Fruit Company in 1899. Since that date the imports have increased rapidly both here and in the United Kingdom, until in 1922 a total of over 45 million bunches entered our ports, more than half of which came from Honduras and Jamaica. In view of the fact that the banana plant can be grown in almost all tropical lands that have adequate rainfall and available labor, it may seem surprising that more bananas do not come from western Africa. This may be due to the fact that, up to the present time at least, the cacao and oil palm have proved to be more profitable in this region, and also perhaps to the distance to market. Rapid transportation and refrigeration, together with more experience in handling the fruit to prevent spoilage, will probably overcome the latter obstacle.

The Banana Plant

Varieties.—There are a number of species of banana plants, but only two of these are of commercial importance. One kind is dominant in Jamaica and the surrounding banana region, and the other in the Canary Islands and adjacent areas. The kind grown in Jamaica and Central America is a rapidly growing herbaceous perennial, the height of which normally ranges from 18 to 25 feet, depending largely upon the soil. It produces very large, rather straggling bunches of pointed fruits which are somewhat coarse as compared with the Canary Island banana. They can, however, withstand a considerable amount of handling without damage, and as they can be exported without crates they are the most popular for market purposes. There is a colored form of this variety—the red or claret banana—the demand for which is relatively small.

The Canary Island banana is said to be indigenous to southeastern China, whence it was introduced into the Canary Islands and other regions of the East. The plant is much smaller in all respects than the one just described, its normal height being only 10 or 12 feet. This tendency toward dwarfness, together with its robust character, renders it more capable of withstanding violent wind storms and hurricanes. The fruit of the Canary Island type is much smaller, both as regards the size of the bunch and the length of the individual fruits, than the Jamaica type. When mature, the fruit of the Canary Island type has a golden yellow flesh, is "melting," aromatic, and of finer flavor and texture than the other; but the skin is more delicate, thus rendering it more liable to injury in transit, and the bunches are always crated before shipment.

The banana plant bears but a single bunch of fruit in its life cycle. In the case of the Jamaica variety, the fruit of a single plant weighs from 50 to 75 pounds; and in that of the Canary Island variety, from 25 to 65 pounds.

The production and distribution of bananas destined for the two principal consuming markets—the United States and the United Kingdom—may be seen from the table given below:

TABLE XX

IMPORTS OF BANANAS, 1922

Into the United States		Into the United Kingdom	
From	Bunches	From	Bunches
Honduras	14,584,674	Colombia	4,163,695
British West Indies (chiefly Jamaica)	10,689,186	Canary Islands	2,645,444
Guatemala	4,498,800	Costa Rica	1,228,059
Costa Rica	3,704,727	Republic of Honduras	1,185,492
Panama	3,665,378	Total, Foreign Countries	9,226,690
Colombia	2,205,538	British West Indies (chiefly Jamaica)	1,804,963
Nicaragua	2,603,491		
Cuba	1,808,872		
Mexico	739,186		
British Honduras	460,825		
Others	134,215		
Total Bunches	*45,093,892*	*Total Bunches*	*11,027,653*

EXERCISES

1. In Table 153, Agriculture Yearbook, 1922, is shown the acreage, production, and farm price of potatoes, annually from 1896 to 1922; note the relationship between acreage, production, and farm price from year to year. Explain the variations in acreage and the more striking variations in annual production. Note the relationships between the total production and farm prices.

2. Explain the high degree of concentration and specialization of the sugar industry in the various sugar-producing areas of the world.

3. Explain the relationship between improved transportation (including refrigeration and specially constructed apparatus) and the rapid increase in the consumption of bananas in the middle latitudes.

4. Explain the relatively slow increase in the consumption of cassava products in the middle latitudes.

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CHAPTER X

FRUITS, NUTS, AND VEGETABLES

DECIDUOUS TREE FRUITS

Apples.—The apple is by far the leading fruit crop in the United States; yet, compared with other staple crops, its place in American agriculture is relatively small. Of the 200 million bushels which constitute the normal yield for the United States and Canada, only about 90 million enter into commercial channels.

Climate and Soil.—Apples do best in cool, moist sections of the middle latitudes. They require fairly fertile soils, well-drained land, mild winters, moderately warm summers, and abundant moisture. They are not usually found where the mean summer temperature exceeds 80 degrees or the mean winter temperature is below 20 degrees, and where not grown under irrigation they require at least 18 inches of rain annually. Within these limits, proximity to markets largely determines production.

Distribution: Europe.—In Europe apple production is largely confined to the western countries. In England, Hereford, Devon, Somerset, and Kent are the chief districts; in France, Normandy and Brittany. Western Germany and northwestern Spain are also important.

Canada and the United States.—In Canada, the Annapolis Valley of Nova Scotia, sections of southern Ontario, and certain valleys in southern British Columbia are some of the principal producing areas. In the United States apple production is particularly localized both in the East and in the West.

United States.—In the East this localization is associated either with proximity to water bodies as in western Michigan, western and southeastern New York, and southern New England, or with rolling topography as, for example, northwestern Missouri, southwestern Missouri and northwestern Arkansas, and districts in Virginia, Maryland, and Pennsylvania. In the West localization is associated with irrigated lands whose temperature conditions are favorable to apple production. These include such areas as the Grand Junction district in Colorado, the Boise district in Idaho, the Yakima and Wenatchee valleys and the Spokane district in Washington, and the Sonoma Valley in California.

Producing areas in the southern hemisphere include the island of Tasmania, sections of Australia, and portions of the southern island of New Zealand.

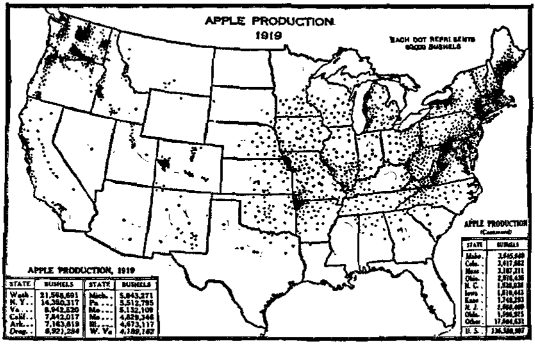

FIG. 72.—The West produced one-third of the apples grown in 1919 despite the fact that it possessed only one-seventh of the acreage of bearing trees. Washington led all States in production, with a total almost equal to that of New York and Virginia combined. The three famous apple districts of Washington—the Yakima Valley, the Wenatchee Valley, and Spokane County—stand out clearly on the map; also the Hood River and Willamette Valleys of Oregon, the Boise, Idaho, district, the Sonoma Valley in California, and the Grand Junction-Delta-Montrose district of Colorado. In the East, the New England area, the two noted New York districts, the Appalachian, the western Michigan, the Ozark, and the northwestern Missouri districts are the most important.

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Pears: Centers of Production in United States.—The important centers of production of pears in the United States are in central California, the Rogue Valley of Oregon, the Yakima Valley of Washington, the southwestern portion of Michigan, the Ontario shore counties in New York, the upper Hudson Valley, eastern Maryland, Delaware, and southern New Jersey.

Peaches.—Because of the fact that peach trees are less hardy and blossom earlier than apples, this fruit is more susceptible to damage by winter-killing and also from spring frost. Consequently, the southern states, with their milder winters, are relatively more important in peach production than the northern states. About 75 per cent of the peach trees of the United States are grown south of the Ohio and Missouri Rivers, and in California; the fruit is not extensively produced in sections where the mean winter temperature is under 25 degrees. The most extensive heavy peach-producing section of the eastern

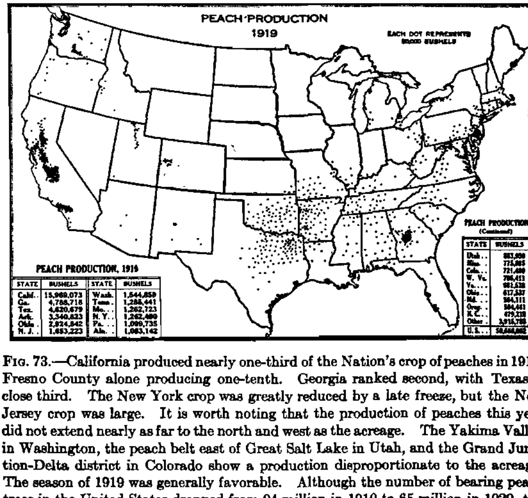

FIG. 73.—California produced nearly one-third of the Nation's crop of peaches in 1919, Fresno County alone producing one-tenth. Georgia ranked second, with Texas a close third. The New York crop was greatly reduced by a late freeze, but the New Jersey crop was large. It is worth noting that the production of peaches this year did not extend nearly as far to the north and west as the acreage. The Yakima Valley in Washington, the peach belt east of Great Salt Lake in Utah, and the Grand Junction-Delta district in Colorado show a production disproportionate to the acreage. The season of 1919 was generally favorable. Although the number of bearing peach trees in the United States dropped from 94 million in 1910 to 65 million in 1920, the production was 40 per cent greater in 1919 than in 1909.

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United States comprises the area from central Oklahoma and northeastern Texas eastward to central Georgia, northwestern South Carolina, and western North Carolina. In the West, peaches are grown in the lower, warmer valleys northward to the Canadian border, but the section around Fresno, California, in the San Joaquin Valley, is the principal producing area.

In the more northern states east of the Rocky Mountains, few peaches can be grown in localities other than on the leeward side of large bodies of water, such as the Great Lakes, where the severity of the winter is tempered by the water influence and where the same influence retards early blooming. The climate of the lake districts of western New York and southwestern Michigan is favorable for the growth of this crop, but the severity of the winters between the western lake region and the Rocky Mountains precludes profitable production. Warm nights, such as favor corn growing, produce the fine-flavored peaches, whereas cool nights favor size and color at the expense of flavor.

Apricots.—Apricots are a yellow fruit grown in the warmer parts of Europe and in the Levant and California. Syria, Asia Minor, and Caucasia export large quantities dried, and California exports both tinned and dried apricots. Mishmish are apricots candied and pressed, the staple form of this type of export from Syria. An oil is extracted from the kernels for an almond-oil substitute.

Cherries.—The climatic requirements of cherries are quite similar to those of apples. Cherries do not thrive well in the warmer climate of the South, the southern limit being somewhat farther north than in the case of apples. East of the Rocky Mountains there are few cherries grown where the mean summer temperature exceeds 77 degrees. The northern limit of culture corresponds very well to that of apples, the limiting line being a mean winter temperature of about 20 degrees. The principal production areas in the West, where the sweet variety is almost exclusively grown, comprises the lower Sacramento Valley in California and the valleys of Washington and Oregon. Sweet cherries are slightly less hardy than sour varieties, the former approaching the hardiness of the peach, and the latter that of the apple. For some unknown reason, sweet cherries do not usually thrive east of the Rocky Mountains.

Prunes.—The prune is a variety of plum which has a high sugar content and can be dried without the removal of the pit. It requires a long season of abundant sunshine and warm weather for proper maturity, with plenty of water during the growing season. As natural weather conditions do not meet these requirements, the principal producing areas comprise those sections where the summers are warm and clear, and where the necessary water can be supplied by irrigation. The most extensive production in the United States is in central California, although a considerable crop is grown in Oregon and a small quantity in Washington.

Prune blossoms are subject to damage by spring frost, but are less liable to harm than most other fruit, as they blossom comparatively late. Early fall rains are harmful, as humid weather greatly interferes with picking and drying operations; consequently, there has been an increasing use of evaporators for artificial drying in recent years in sections where early fall rains are to be expected.

Plums.—The plum, in different varieties, has a wide climatic range, East of the Rocky Mountains this fruit is grown to a greater or less extent in all sections from the northern tier of States to the Gulf Coast area. Plums are somewhat more extensively produced, however, in the interior valley states where intermediate temperature conditions prevail.

SMALL FRUITS

Grapes

The Grape in Europe.—The grape has been known in central and southern Europe since the dawn of history. From the earliest times it has constituted an important food and drink to the people of the Mediterranean lands and the regions immediately adjacent thereto. In its importance to these peoples it is comparable to the olive. In Europe the cultivation of the vine is a distinguishing characteristic of the agriculture in all the land bordering the Mediterranean. These lands constitute the center of grape production in the Old World.

France.—France is the most important grape-producing country in Europe. The more important producing areas are the valley of the Loire, the Bordeaux region of southwestern France, the western slopes of the Saône Valley, and the Midi district of the southeast. Often a number of different wines are produced even within a given district. The Bordeaux district serves as a good example, there being several kinds of Bordeaux wines from that district. The quality of the different wines is apparently closely associated with the physical conditions under which the grapes are produced, but doubtless the processes of manufacture play an important part in determining the characteristics of high-grade wines.

Italy.—Because of the limited supply of arable land in Italy, vine culture is an important agency for profitably utilizing lands too rough for ordinary cultivation. Even on the hillsides, leguminous crops such as peas, beans, and vetches are often grown in the vineyards as winter cover crops. In the lowlands, wherever grapes are grown, they constitute one of the elements of an intensive multiple cropping system.

Spain and Greece.—Raisin grapes are grown extensively in southern Spain and Greece. These grapes contain a smaller quantity of water

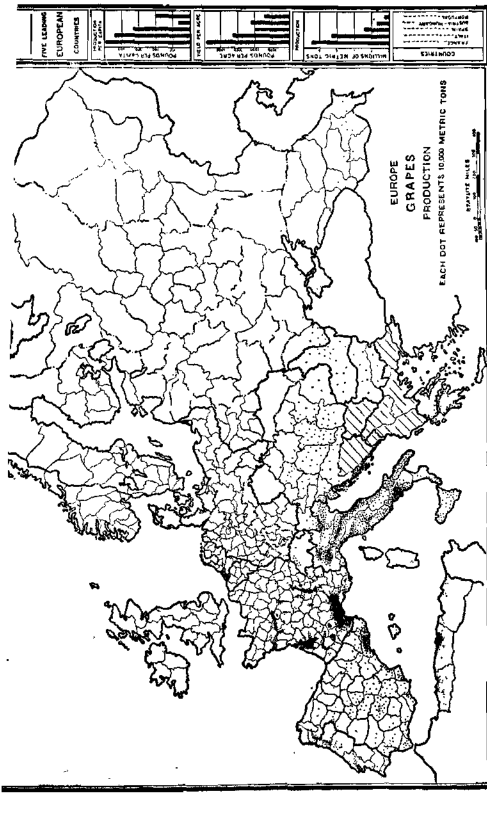

FIG. 74.—Distribution of the products of the vine in Europe and Algeria so far as figures are available. The leading rank of France in grape production will be noted. The greatest production of wine in France is along the Mediterranean coast near Montpellier. The better known wines, however, come from the Bordeaux region on the Garonne River, from the banks of the Rhone, and from the province of Champagne. The principal centers of wine production in Italy are near Naples and along the slopes of the Apennines in northern Italy.

and have a higher sugar content than the wine grapes. These characteristics may be associated with the drier climate of these areas, and the uniform dryness of the summer weather is certainly an important factor in the drying of these grapes.

In the southern hemisphere, where the Mediterranean type of climate is found, as in middle Chile, the Cape Town district of South Africa, and portions of southwestern Australia, grape culture is assum-

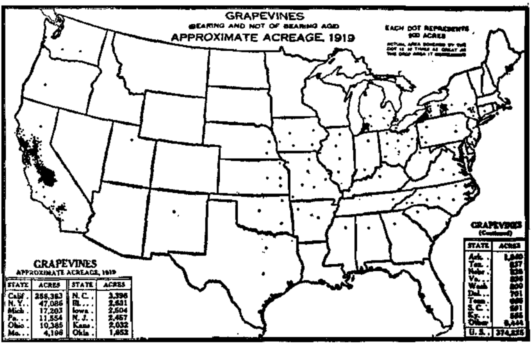

FIG. 75.—Two-thirds of the Nation's acreage of grapes is in California. The raisin district centers around Fresno, where the land is flat and the sunshine almost continuous, while the wine grapes are grown mostly on the slopes of the valleys that open into San Francisco Bay. These wine grapes are now used largely for raisins. A smaller center may be noted in southern California near San Bernardino. In the East the principal grape district extends along the southern shore of Lake Erie from Erie to Buffalo. Minor centers may be seen in the Finger Lakes district of New York, the south shore of Lake Erie in Ohio, and in the southwestern corner of Michigan. These eastern grapes are mostly consumed fresh or made into grape juice.
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ing considerable significance. This is true regardless of the countries from which the inhabitants of these newer lands came.

United States.—Both the *vinefera* (European) and native varieties of grapes are grown in the United States, though the climatic requirements of these two general varieties are quite different. The *vinifera* require the Mediterranean type of climate, with warm, clear, sunny summers, while the native varieties prefer a moist, cool climate, such as is found in the Great Lakes region.

California has about two-thirds of the grape acreage of the United States, practically all *vinifera*, owing to its Mediterranean type of climate. Warm, sunny summers are necessary for the proper maturing of raisin grapes, as a high sugar content is necessary. The San Joaquin Valley of California possesses an ideal climate for growing raisin grapes, and practically all the raisins used in the United States are produced there.

The principal centers of production of native grapes include southwestern Michigan, the southern shore of Lake Erie, the shore of Lake Ontario north of the Niagara escarpment from Hamilton, Ontario, eastward into New York, and the Finger Lakes region of New York. Native grapes are used almost exclusively for table use, the surplus being used for the manufacture of grape juice.

Berries

Cranberries.—Cranberry growing is an American industry, and cranberries are practically unknown in European countries except as the fruit is shipped there from the United States.

Physical Factors.—A climate with moderately cool summers is necessary for the successful growing of cranberries. The cranberry is a member of the heath family and requires an acid peat soil. Hence it grows only in bogs.

For the commercial growing of the cranberry it is necessary that the bogs be drained. A constant and ample water supply, however, is required for irrigation during droughts and for flooding to protect the plants from winter injury, untimely frosts, and injurious insects. When fully established, the cranberry bog produces a crop which ranges from 50 to 100 barrels per acre.

Distribution.—The cranberries that enter into commerce in this country are grown mainly in three districts, viz., Central Wisconsin, and the coastal plains of Massachusetts and New Jersey.

Uses.—The seasons of greatest cranberry consumption are the Thanksgiving and Christmas holidays when the cranberry is quite indispensable as a relish or sauce in connection with the Thanksgiving and Christmas fowl.

Marketing.—A very large proportion of the cranberries of the country are marketed through a central exchange with headquarters at New York. Through skillful advertising a business of considerable magnitude has been developed, and the industry is normally in a fairly prosperous condition.

Blackberries and Dewberries.—Blackberries and dewberries grow wild over much of the United States. They do well on deep sandy loam, the blackberry preferring heavier soil than the dewberry. Blackberries are propagated by sucker and root cuttings, and the dewberry by layering. They are easily reproduced and respond readily to cultivation; and in certain sections of the country, as northeast Texas and the district about Seattle, Washington, they are one of the most profitable horticultural crops grown. They are marketed both fresh and canned.

Gooseberries and Currants.—Gooseberries and currants do well on a variety of soils, but they prefer climates with cool summers.

Currants are usually propagated by cuttings, and gooseberries by layering. There is much variation in the size and appearance of the fruit. Currants may be red, black, white, or purple. Gooseberries vary from a light green to a deep red when ripe. Currants are used mostly for jellies and are usually not picked until ripe. Gooseberries are generally harvested when green and are used mostly for pies and preserves.

Raspberries.—There are two general classes of raspberries, the European and the American. Except in the Hudson River district, practically no European raspberries are grown in the United States. The American raspberry includes the red raspberry and the black-cap variety.

Raspberries do well on a deep sandy loam but require a rather cool, moist climate. They are usually propagated by suckers, root cuttings, or tip layers. Raspberries are usually marketed fresh in pint or quart boxes.

CITRUS FRUITS

The growth of citrus fruits, such as oranges, lemons, grapefruit, and limes, has a very definite climatic limitation. Being of tropical origin, they can be produced only in sections without severe frost. In California and southern Texas they are successfully grown where rather severe frost in winter is not unusual, but artificial protection from low-temperature damage is usually practiced. In the United States, the citrus industry started in Florida, where climatic conditions are quite similar to those of southeastern China, to which the fruit is indigenous. Later, cultivation was begun in California where the bulk of citrus fruit in the United States is now grown. The groves in California are located mostly along the western and southern slopes of the foothills of the Coast Range in the southern portion of the state, but there is also considerable production in the central, and slight production in the northern portions. Frost-protection methods are now widely practiced during the winter months, the Weather Bureau coöperating by conducting temperature surveys to determine the susceptibility of different localities to frost and by providing special warnings of impending harmful temperatures.

Soils.—Citrus fruits, like many other crops, grow under a wide variety of soil conditions. It is necessary, however, that conditions

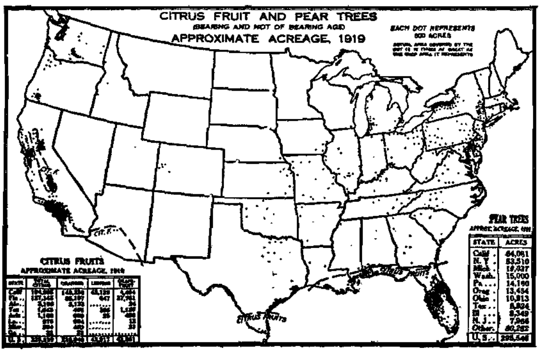

FIG. 76.—Citrus fruits can withstand only a few degrees of frost. About three-fifths of the acreage is in California and nearly two-fifths in Florida. There are a few orchards in the Mississippi Delta in Louisiana, in the Brownsville, Tex., district, and near Phoenix Ariz., and recently hardy Satsuma orange trees have been planted along the Gulf coast in eastern Texas, southern Mississippi and Alabama. Lemons are practically confined to California, grapefruit largely to Florida, while oranges are grown in both states.

The principal pear districts are the Ontario shore counties and the Hudson Valley of New York, southwestern Michigan along the lake, the foothills of central and southern California, western Oregon, and the Yakima Valley of Washington.

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be favorable for a deep and extensive root system. Good underdrainage is essential, as water-logging is disastrous to the trees. Moreover, in irrigated lands, where most of the citrus fruits are grown, poor drainage leads to the development of alkali.

Distribution.—The principal commercial citrus-fruit areas of the world are the United States (southern Florida, southern California, Rio Grande Valley of Texas, Salt River Valley, Arizona), Spain (Valencia region), and Italy (Sicily and Campania). Syria and Algeria also produce citrus fruits on a commercial scale. Large areas in South Africa, Australia, and Argentina are suitable for citrus production; but, as the fruit ripens there largely during the months of July and August, it would have to compete with the various deciduous fruits ripening at that time in America and Europe or be confined to the limited market of the southern hemisphere. For lack of a market, there is little encouragement for expansion.

Importance.—Citrus fruit is especially important to us because of the fact that in our climate most fruits ripen in summer and many kinds can not be carried into the winter season in fresh form. Since most of the citrus fruit ripens in the late fall and during the winter months, its value from the standpoint of health and enjoyment can not easily be exaggerated. While Florida and California still supply the greater portion of the citrus fruit consumed in this country, southern Texas is making rapid strides and surpasses all other regions in the quality of grapefruit produced. Large quantities of these fruits are imported also, grapefruit from the West Indies and lemons from Sicily.

Marketing.—Since citrus-fruit culture is limited to a few favored sections on the southern and southwestern extremities of the country, whereas most of the people live in the North and East, the marketing problem looms up big for the citrus growers. Through coöperative marketing, at least a fair degree of prosperity has been attained by an industry which otherwise could not exist at anything like its present magnitude.

Minor Citrus Fruits.—Tangerines, which are related to the oranges, are somewhat smaller than the Satsuma orange and are grown more for novelty than for commercial purposes.

The kumquat is a low citrus bush, grown extensively in Japan and somewhat in Florida, California, and Texas. The fruit is small and the rind sweet. When used fresh, both rind and pulp are eaten. The fruit is most commonly used in America for preserves. The tree, being small and dense, is used as a potted ornamental; and the fruit, with branches, is employed to some extent for decorative purposes.

DATES

The date palm is a native of northern Africa, which is still the region of most extensive production. The lower portion of the Tigris-Euphrates Valley is also an important center of production, and the date palm has recently been introduced into sections of the southwestern United States. It was one of the earliest plants to be cultivated by man.

Climate and Soil.—The climatic and soil conditions necessary for the best growth of date palms include a dry atmosphere and a high temperature at least during the later stages in the development of the fruit, and an abundance of circulating water at the roots of the trees at all times. Moreover, under natural conditions it can not be too hot for the date palm and the air can not be too dry. The date palm is quite tolerant to alkali water.

Description of Tree.—The date palm reaches a height of 100 feet or more and continues to bear for 100 to 200 years. The trunk is topped with a large crown of long, leather-like leaves and bears six to twenty large clusters of fruit, each cluster weighing from 20 to 40 pounds.

Distribution.—The principal date regions are the oases, or depressions in the desert where the water comes to or near the surface. Most of the dates of commerce come from Mesopotamia, Syria, Algeria, Morocco, and Egypt.

Processing.—Artificially ripened dates are superior to the naturally ripened fruit in keeping quality. This is probably due to the fact that the artificially ripened product is more nearly sterilized by the treatment which it undergoes. The dried, cured date, as ordinarily obtained on the market, contains 1.9 per cent protein, 2.5 per cent fat, and 70.6 per cent sugar. The seed constitutes about 10 per cent of the date by weight, and the remainder is water.

The commercial date industry of the United States is still in the experimental stage. Dates of excellent quality have been produced in Arizona, New Mexico, and California. There is a market in the United States for far more dates than will be produced in the country for many years to come. The United States imports about 25 million pounds of dates annually.

FIGS

Origin.—The fig is probably a native of Turkey and the Mediterranean regions. Although it has a wide range throughout the tropics, it is particularly important in the regions that have a Mediterranean type of climate.

Types.—There are two main types of commercial figs. One type, mainly of the Smyrna variety, furnishes the greater portion of the dried figs of the market. These are grown most successfully in the semi-arid regions of the tropics and sub-tropics. The other type, of which the

Magnolia is an important variety, is used for preserving in a thick sirup. This type is grown on the Gulf Coast, particularly in Texas, and differs biologically from the Smyrna varieties in that it does not require caprification. The trees come into bearing at two years of age. They bear their fruit in the axil of the leaf of the current season's growth. They are, therefore, pruned very heavily each winter.

The potential producing area is very great in Texas, and expansion of the industry is limited only by the market.

PINEAPPLES

The pineapple is a native of tropical America and is now cultivated to some extent in various sections of the tropics, the sub-tropics, and even in Europe (under glass). It is grown on a commercial scale in the West Indies, Porto Rico, Cuba, Florida, Hawaii, the Federated Malay States, Ceylon, Java, and to a lesser extent in Brazil and Madagascar and in other countries.

Climate and Soil.—Pineapples should have a rainfall of at least 50 inches, but they will endure a much greater rainfall if the soil is well drained. The pineapple is a rather anomalous plant in some of its relation with the soil, belonging as it does to a family of plants many of which are air plants. It appears itself to be able to live for considerable periods practically without any contact with the soil. The living roots, however, possess an unusually heavy coating of root hairs near their growing tips, and the physical condition of the soil, with respect to drainage and aëration, appears to be the prime factor in the proper growth of the plant. The pineapple will not endure an excess of either lime or manganese.

Propagation.—The pineapple is propagated by suckers, slips, crowns, or stumps. The suckers are the small plants which develop in the axils of the upper leaves below the fruit stem. Ordinarily propagation is by means of suckers, since plants grown from suckers produce fruit more quickly than those propagated by any other method. If the suckers are taken for planting at the right state of maturity, the resulting plants will come into bearing within fifteen to eighteen months. The plant reaches a height of 2 to 4 feet, developing only a very short stem, which is commonly called the stump.

Characteristics of Fruit.—Unlike most other fruits, the pineapple does not develop its full flavor if picked when green. This is due to the fact that at no stage of its growth, prior to maturity, does the pineapple contain any considerable quantity of starch. On the other hand, the stump and fruit stem contain large quantities of starch. The supply of sugar for the ripening pineapple is, therefore, secured from the starch in the stump. It is evident that when the fully grown pineapple, still green and firm, is cut from the plant, there is no material in the fruit which can be transformed into sugar during the process of ripening. Since the fully ripened fruit will not bear long transportation, the fresh pineapples on the market contain only 4 per cent sugar, whereas the fruit fully ripened on the stump contains from 9 to 14 per cent. Pineapples are not harvested for canning until they are completely ripe, and for this reason the flavor of ordinary canned pineapple is superior to that of the average run of fresh pineapples to be found in the market.

Pineapple-canning Industry.—The business of pineapple canning has undergone quite a phenomenal development in Hawaii. In 1908 the output was about 350,000 cases, while at present it is nearly 2,000,000 cases.

OTHER TROPICAL AND SUB-TROPICAL FRUITS

Guava.—Guava is grown in Florida and the Hawaiian Islands. To the uninitiated, the fruit has a very disagreeable odor, but it is said to be the commercial leader of fruits for the purpose of jelly making. The fruit decays rapidly when ripe, and the jelly factories must therefore be located near the point of production.

Mango.—The mango is a tree grown extensively in the tropics, and to a limited extent in southern Florida and southern California. The fruit is large, kidney-shaped, rather soft, and resinous. The mango tree is an evergreen and is very susceptible to cold, but it is attracting some attention in the southern part of the United States.

Avocado.—The avocado, or alligator pear, is a native of the West Indies and may be found from Mexico to Peru and Brazil. The trees are grown to some extent in southern Florida and southern California. The fruits are pear-shaped, containing a large quantity of yellowish-green, buttery pulp, surrounding a single large seed. The pulp contains a large quantity of oil and is much esteemed as a salad.

Avocadoes were first mentioned in California around 1856 and are now attracting much attention in that state. There are around 150 named varieties now being grown in the United States. This fact throws some light upon the non-commercial character of the business in its present stage of development.

Persimmon.—The persimmon is a native of North America and is found growing wild in most of the central and southern states. It is easily grown from seed but does not grow true to type. It usually bears heavily. Most of the wild fruits are small and filled with seed. While sweet when fully ripe, it is very astringent when green. It is easily grown and has high nutritive value.

Many varieties of Japanese and Chinese persimmons have been introduced into this country. The fruit is generally much larger than that of the native American persimmon, often being as large as a tomato, which it resembles somewhat in shape and color. Most of the Japanese and Chinese persimmons are neither as sweet when ripe nor as astringent when green as the wild persimmons.

Jujube.—The jujube is native to China, but seedling trees of the variety have been grown for forty years or more in America.

About 1915, improved varieties of jujubes were introduced into the United States by the Federal Department of Agriculture. Not only are the trees ornamental, but the fruit, which is about the size of the plum, is assuming considerable importance as fresh fruit and for preserving. Candied jujubes are known as Chinese dates as they resemble the dried date both in appearance and in chemical composition.

The jujube does well over a very wide range of soil and climatic conditions. It will succeed where many other fruits fail, and offers promise both as an ornamental tree and as a fruit for home orchards.

NUTS

PECANS [2]

The pecan is native only to certain sections of the United States and northern and central Mexico. In the United States, the species is indigenous throughout most of the southern portions of the Mississipi Valley, and central and eastern Texas, where its best development occurs on the alluvial soils of the river flood-plains. The greater proportion of native pecan trees are distributed along the streams of Texas.

The cultural range of the pecan, like that of most fruits and nuts, is much larger than its native hahitat. Pecans have been successfully grown in the southeastern portions of the United States and westward across a large proportion of Texas.

Physical Factors.—The length of the growing season varies from a minimum of 170 days in the northern border of the pecan belt to 290 days along the Gulf. Native trees seem to do best where the rainfall is from 20 to 30 inches and the altitude 1000 to 1800 feet.

Outlook.—Pecan culture has grown rapidly during the past ten years, but the industry is yet in its infancy. On account of the large

[2] For the material on the pecan, the author is indebted to "Pecan Growing," by Stuckey and Kyle.

percentage of native pecan trees, it is difficult to form an estimate either of the actual number of trees or of the quantity of nuts. The available statistics are so inaccurate as to be almost worthless except for purposes of comparison. With the increasing attention that is being given to cultural methods and the studies that are being made of markets and marketing methods, the pecan industry promises to become important in the coming decades.

ALMONDS[3]

The almond is supposed to be native to the countries around the Mediterranean, and at present the bulk of the world's supply is produced in that region. The almond resembles the peach somewhat in manner of growth and character of blossoms and leaves; but, whereas the peach is desired for the pulp surrounding the seed, the almond attains its value from the seed kernel.

About 98 per cent of the almonds produced in this country are grown in California. The chief centers of production there are in Contra Costa County and extend up into both the Sacramento and San Joaquin Valleys.

Climate.—The almond is more particular in its physical requirements than most orchard fruits. While the tree itself is as hardy as the peach, the blossom is subject to injury on account of the short period of dormancy which is characteristic of the almond tree. An annual rainfall of 16 inches is sufficient if it is properly distributed and if the soil is deep and in good tilth. Of all the commonly grown horticultural products, the almond withdraws the most mineral matter from the soil. The soil must, therefore, be deep, rich, and well-drained, with plenty of humus, free from alkali, and with a porous rather than a hardpan substratum.

Propagation.—Orchard almond trees are never grown from seed, as they do not reproduce true to type, but are propagated by budding desirable varieties on seedling roots in the manner commonly employed in nursery practice for other stone fruits, like the peach. Every grower must decide, however, on what rootstocks he will plant his trees.

Marketing.—Almond production was almost stationary between 1900 and 1915. At the latter date plantings increased rapidly and, since the trees come into bearing at about four years of age, the production has been increasing rapidly during the past few years and this increase promises to continue. Coincident with this increase in production, however, there has been an increase of about 50 per cent in the price of almonds. The absorption of an increasing supply at an

[3] Bulletin No. 297, California Experiment Station.

increasing price is attributable to the successful operation of the California Almond Growers' Exchange which was launched about ten years ago. This industry furnishes one of many illustrations of how coöperation is adding wealth to the producers and providing utilities to consumers, and thereby making life more complete for all parties.

Filberts and Chestnuts

Filberts.—Filberts grow on a small shrub which is extensively cultivated in Europe and Asia, and to some extent on the Pacific Coast of North America. Under the name of hazel nuts, they grow wild over much of North America. The nuts are much in demand, particularly around the holidays. The plant is very easily grown, and is propagated from suckers or layering as it does not come true from seed. Cultivation is much the same as for other fruits.

Chestnuts.—Chestnuts are native to the mountainous part of the eastern United States and were at one time very common in the forests of the higher and drier locations. In recent years, however, on account of the ravages of the chestnut blight, most of the chestnut trees have disappeared from the eastern forests. Japanese varieties, however, which are immune to the blight, have been introduced and are grown as ornamental trees and for nuts.

Walnuts [4]

The producing areas and the physical and cultural requirements for English walnuts and for almonds practically coincide. Moreover, both types of nuts grown in this country must meet formidable foreign competition, primarily from the Mediterranean countries. At present, well above 50 per cent of both kinds of nuts consumed in this country come from abroad. As the rapidly increasing number of new trees come into bearing, and the market becomes more nearly saturated at the present price level, the nut growers may be expected to request tariff protection, especially since the foreign nuts are produced at a much lower cost than our own.

About 85 per cent of the California crop is sold by the California Walnut Growers' Association, and the price received by the grower is the selling price less the cost of grading, packing, and selling.

VEGETABLE CROPS

In regard to the climatic conditions to which they are best suited, vegetables may be divided into two general classes: the cool-season

[4] Bulletin 379, Agricultural Experiment Station, Berkeley, California.

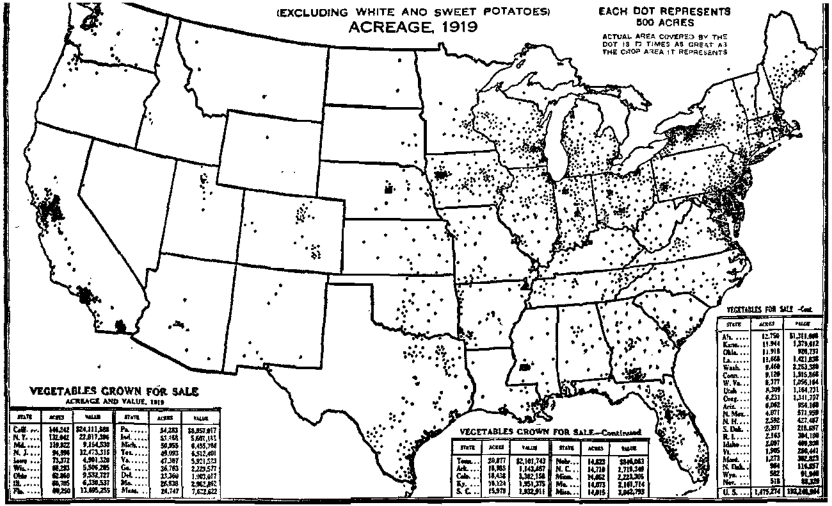
group and the warm-season group. The vegetable of the cool-season group grow best where the growing period is comparatively cool and moist or where they may be grown during the cooler period of the year in warm climates. This group includes such vegetables as lettuce, garden peas, radishes, spinach, white potatoes, turnips, cabbage, celery, and cauliflower. The warm-season group includes cucumbers, melons, squash, pumpkin, sweet corn, string and lima beans, egg-plant, peppers, sweet potatoes, and tomatoes. Intermediate between these two groups in their temperature requirements are beets, carrots, onions, parsley, asparagus, and rhubarb.

Vegetable crops utilize about 2 per cent of the crop land of the United States and they normally constitute about 9 per cent of the crop values. They are grown under three systems of farming: first, home gardening; second, market gardening; third, truck farming.

The second and third systems constitute the commercial vegetable industry and are of comparatively recent origin. Rapid transportation and refrigeration, a large and increasing urban population, and the increased price of meat have all contributed to the rapid development of the commercial vegetable industry. In addition, there has been a rapdily growing recognition of the value of vegetables in the diet.

Market Gardening.—Since the great majority of farmers and villagers produce their own vegetables, it follows that towns and cities constitute the great market for the commercial vegetable industry. Market gardens, therefore, tend to become concentrated near cities because the short haul to market enables the farmer to furnish the consumer with fresh vegetables at low cost. This consideration is of especial importance in the case of the vegetables, as distinguished from most other farm products, because freshness is a quality particularly desired in vegetables by the consumer, and also because fresh vegetables contain a large amount of water in proportion to solid matter and will therefore not bear the cost of transportation over great distances unless the price becomes very high. Proximity to the city also enables the market gardener to utilize the refuse which accumulates in the city and which he makes to serve as cheap but valuable fertilizer for his land. The fluctuating demand for labor, moreover, which is characteristic of market gardening, is more easily met near cities where there is normally a surplus of common labor.

Gardens under Glass.—The season for growing fresh vegetables in the open is relatively short in those sections of this country where population is most concentrated. The problem of providing fresh vegetables during the cold seasons is, therefore, partly met by very intensive vegetable culture under glass. This involves a large invest-



VEGETABLES GROWN FOR SALE

ACREAGE AND VALUE, 1919

STATE	ACRES	VALUE	STATE	ACRES	VALUE
Calif.	146,242	$24,111,888	Pa.	54,283	$8,857,917
N. Y.	132,042	22,817,396	Ind.	53,468	5,687,181
Md.	119,822	9,154,530	Mich.	50,955	6,455,768
N. J.	94,996	12,473,316	Tex.	49,093	6,912,401
Iowa	73,372	4,901,320	Va.	47,387	5,921,523
Wis.	68,283	5,506,285	Ga.	36,763	2,229,577
Ohio	62,860	9,532,727	Del.	33,360	1,903,017
Ill.	60,705	6,330,537	Mo.	26,838	2,962,892
Fla.	60,250	13,095,255	Mass. ...	24,747	7,622,622

VEGETABLES GROWN FOR SALE—Continued

STATE	ACRES	VALUE	STATE	ACRES	VALUE
Tenn. ...	20,877	$2,101,743	Nebr. ...	14,823	$846,083
Ark. ...	18,985	1,142,457	N. C. ..	14,710	2,719,349
Colo. ...	18,438	3,382,158	Minn. ..	14,662	2,223,305
Ky. ...	16,124	1,953,375	Me. ...	14,073	2,101,714
S. C. ..	15,978	1,932,911	Miss. ...	14,015	3,062,793

VEGETABLES FOR SALE—Cont.

STATE	ACRES	VALUE
Ala.	12,750	$1,311,868
Kans. ...	11,944	1,379,612
Okla. ...	11,918	920,731
La.	11,668	1,421,836
Wash. ..	9,460	2,253,380
Conn. ...	9,120	1,815,868
W. Va. ..	8,377	1,056,164
Utah ...	8,309	1,164,731
Oreg. ...	6,231	1,341,707
Ariz. ...	6,062	956,160
N. Mex. .	4,071	571,959
N. H. ...	2,592	427,487
S. Dak. .	2,397	218,657
R. I.	2,163	304,190
Idaho ...	2,097	409,830
Vt.	1,985	290,441
Mont. ..	1,273	302,823
N. Dak. .	984	116,857
Wyo. ...	582	91,940
Nev. ...	518	88,320
U. S. ...	1,475,274	193,240,904

FIG. 77.—The most important area of vegetable production extends from New York City to Norfolk, Va. In this area about one-fifth of the Nation's commercial crop is produced. A second important area extends from Utica, N. Y., west to Buffalo and Erie. Another belt surrounds the southern half of Lake Michigan. Florida and southern Georgia, where perhaps one-third of the winter vegetables are grown, may be said to constitute a fourth area. California possesses three important areas—the Sacramento-Stockton district, the Los Angeles district, and the Imperial Valley. In California also the winter crop is important. Smaller centers of production adjoin most of the large cities. The centers shown in western Iowa and Nebraska represent popcorn.

ment in capital, the most scientific cultural methods, and a rapid succession of crops. Nearly 4000 acres of vegetables and flowers are said to be grown under glass in this country. Only the very high prices for vegetables which prevail during the cold season make this kind of gardening feasible.

Truck Gardening.—Truck gardening differs mainly from what has been designated as market gardening only in the fact that, in the latter, location is the determining factor, and in the former, climate and soil. Moreover, the truck gardener is frequently more of a specialist than the market gardener, confining his activities to a limited number of the more staple vegetable crops. Truck gardening may be carried on at long distances from the market, provided rapid transportation and refrigeration are available. Various sections along the Atlantic and Gulf Coasts from New Jersey to southern Texas have developed important truck-farming areas. The sections most handicapped by distance are most favored by climate, so that, given favorable transportation facilities, the Rio Grande truck farmers are able to place their early crops on the northern market with profit. As the season progresses, the sections nearer the market contribute to the market vegetable supply, each in turn taking advantage of its more favorable climate, as compared with those farther north, and its more favorable location, as compared with those farther south. Finally, the market gardens adjacent to the cities, and the truck farms nearest to them, furnish the consumers with their fresh vegetables during the warm summer months.

EXERCISES

1. Summarize the important physical features of the various (*a*) vegetable, (*b*) citrus fruit, and (*c*) deciduous tree-fruit producing areas in the United States.

2. Contrast the problems to be met in producing and marketing citrus fruits in Florida, in southern Texas, and in California.

3. Contrast the problems to be met in production and marketing in vegetable gardening and in truck farming.

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CHAPTER XI

BEVERAGES, CONDIMENTS, TOBACCO, AND RUBBER

CACAO

The cacao is native to tropical America in the valleys of the Amazon and Orinoco Rivers. When compared with tea and coffee its history as a commercial beverage is relatively short, for it was not used outside of its native habitat until after the discovery of America. It is rapidly growing in commercial importance, however, primarily because of the increasing popularity of chocolate and cocoa, the two trade products derived from cacao.

Climate.—The cacao tree does not thrive where the temperature falls below 60° F., and is limited to a zone about 10 degrees in width of either side of the Equator. On account of the relationship between temperature and altitude, the cacao tree does not do well at an altitude in excess of 1800 feet within the zone mentioned above.

The upper limit of rainfall for optimum growth of the cacao tree is about 200 inches. The lower limit can not be so definitely stated as it depends largely upon the character of the soil, the humidity of the air, and the amount of sunshine. The deeper soils may ameliorate conditions arising from relatively light rainfall, by serving as a sponge and thus retaining a large percentage of the moisture for plant use. High atmospheric humidity may compensate for lack of rainfall, and cloudiness may cut off the direct sunlight, thus conserving soil moisture.

The most efficient culture of the cacao tree usually requires more or less modification of the natural climatic conditions. Windbreaks must be erected, shade provided, soil cultivated, and frequently irrigation and drainage projects created.

Description of Plant.—The cacao tree attains a height of 15 to 40 feet. It bears large pods 6 to 9 inches long, which are attached to the trunk. Each pod contains 20 to 25 large seeds or cacao beans, closely packed in a gelatinous mass.

Propagation and Culture.—The best locations for cacao plantations are openings in the forest or areas protected by windbreaks. The trees are planted in rows and spaced from 10 to 30 feet apart. Permanent shade is successfully provided by the use of such trees as kapok, rubber, and certain leguminous trees. In some places, notably Brazil, Grenada, and St. Thomas, the cacao tree is grown without shade.

The cacao beans are planted either in nurseries or directly in place in the fields. The former practice is recommended, as the young seedling can be better cared for in the nursery during the first year of growth and a more uniform grove is thereby insured.

Picking.—The pods (which cling close to the trunk and limbs of the tree) are removed when ripe, with a knife or hook, leaving a clean wound. The pods are then gathered and opened on the same day or within three days at the most. The contents of the pods—the seeds and gelatinous mass—are removed at once to the fermentation house.

Yield.—The cacao tree begins to bear at three or four years of age, and reaches full bearing at about seven or eight years. At about twelve years the yield is at a maximum. The yield is from 100 to 1000 pounds per acre, 500 pounds per acre being a good return.

Fermentation.—The fresh cacao beans as they are removed from the pod are large, somewhat flattened seeds, about three-quarters of an inch in width, and of an ivory-white or delicate violet color. The beans are placed in boxes 6 to 7 feet in depth, in which they undergo a process of heating and fermentation. After fermentation the beans are dried. The objects of fermentation and drying are: to remove the bitter taste of the fresh bean; to develop the characteristic taste, odor, and color; to make the interior of the bean brittle and to toughen and loosen the skin; to liberate the bromine, the stimulating principle of cacao; to cause the bean to fill out and become thicker; to destroy the pulp covering the seeds. The seeds are dried by spreading in the sun or by the use of artificial driers. The former method takes longer, but under favorable conditions gives a brighter-colored and more uniform product. If sun-dried, the seeds must be protected from the rain. In some places, Ecuador, for example, the beans are not fermented but are dried at once and packed for shipment.

Markets.—Among the most important cacao markets are Hamburg, Havre, London, Amsterdam, Lisbon, and New York. The wholesale Hamburg price normally ranges from 12 to 24 cents per pound for the dried beans.

Producing Areas.—The leading producing areas, in the order named, are: the Gold Coast, Nigeria, and the adjacent island of St. Thomas, Brazil; Ecuador; the West Indian islands (Trinidad, Grenada, Jamaica, and the Dominican Republic); Venezuela; and Ceylon. The total exports of cacao beans from producing countries are about 400,000 tons annually. In territory belonging to the United States, the cacao is grown to a slight extent only in Porto Rico and the Philippines, and experiments have been tried in Hawaii.

Manufacturing.—To convert the dried cacao beans into cocoa and chocolate, they are roasted at a temperature of 250 to 275 degrees for a short time in rotary drums. The beans are then cracked and the skins removed by an air blast, after which the beans are ground into cocoa powder.

Sweet chocolate consists of cocoa powder to which have been added sugar, spices, starch, flavors, and other ingredients. Plain or bitter chocolate is the firm, unmodified mass obtained by grinding the fermented and roasted bean. Chocolate, whether of the sweet or bitter sort, therefore contains all of the cocoa fat originally present in the bean. The cocoa of commerce is the original cocoa powder from which a part of the fat has been removed by pressure.

TEA

Origin.—Tea is an evergreen plant native to the wild, hilly country of interior southeastern Asia. It is not known from what source the Chinese first obtained the plant for cultivation, as the variety now grown in China differs greatly from the indigenous plant discovered in Assam, India, in recent times.

The cultivated Chinese plant has a small leaf and grows naturally as a bushy shrub, whereas the Assam variety has a very large leaf and if allowed to grow naturally develops into a tree which sometimes attains a height of 100 feet.

From time immemorial the natives of these regions have cultivated the tea plant and picked and eaten the leaves. The Chinese were, however, the first to use it as a beverage; in the early years of the Christian era, the Chinese were manufacturing and drinking tea. The Japanese obtained tea seed from China about the tenth century and soon acquired the tea-drinking habit. For centuries, tea drinking was confined to China and Japan.

Spread of Tea Drinking.—The East India Company was the first to introduce tea into Europe on a commercial basis, late in the seventeenth century. Coffee and cocoa were then the recognized beverages, and for many years tea remained an expensive luxury to be indulged in only by the rich. The East India Company retained a monopoly of the tea trade until the early part of the nineteenth century and, by keeping up the price, restricted consumption so that in 1820 the per capita consumption of tea in the United Kingdom was only one pound each year. With the breaking of the monopoly of the East India

Company, the price of tea decreased and the consumption increased. In 1836, however, a high duty was imposed upon tea and this materially checked consumption. Later the duty was lowered, cultivation of tea in British India increased, transportation costs were reduced by the introduction of the steamship and the opening of the Suez Canal, and by 1920 the per capita consumption of tea in the United Kingdom was 9 pounds.

In the United States one pound of tea is consumed per capita each year, compared with 9 pounds of coffee, while the reverse ratio tends to hold true in the United Kingdom. Formerly the green teas from China and Japan were the most popular in this country, but in recent years the black tea from India and Ceylon is making headway.

Tea is now a popular beverage not only in Asia, Europe, and to a lesser extent in the United States, but also in portions of South America, Africa, and Australasia.

Physical factors.—Tea requires a large amount of moisture for its most vigorous growth and thrives best in a rainfall of 90 to 400 inches. The Assam tea makes its greatest growth at low altitudes, while China tea gives satisfactory results at elevations up to 5000 feet. The tea plant requires well-drained soils and does well with little cultivation. Consequently, tea production is a means of utilizing lands of rough topography in the monsoon region of Asia.

Propagation.—Tea is propagated from seed planted either directly in the field or in seed beds from which the seedlings are later transplanted in the field at distances of 4 to 5 feet apart. In commercial plantations, tea is usually prevented from growing more than 5 feet high, by repeated pruning. The first picking takes place about three years from the time of planting the seed, and full bearing begins when the plants are about six years old. The crop of leaves continues unabated for fifty years or more. In fact, by means of severe pruning after a plantation has apparently run out, renewed vigor may be established for a considerably longer period.

Production and Distribution.—The yield of tea ranges from 200 to 1000 pounds of cured leaves per acre, according to the number of flushes, the nature of the soil, the variety of tea, and the locality in which it is grown. In Ceylon there are about 400,000 acres devoted to the production of tea, and the exports from that country amount to 190,000,000 pounds of black tea annually. The total exports of tea from tea-producing countries stand in the following order: British India and Ceylon, China, Dutch East Indies, Formosa and Japan. These countries are also the chief tea producers.

In the equatorial regions tea leaves may be plucked from ten to

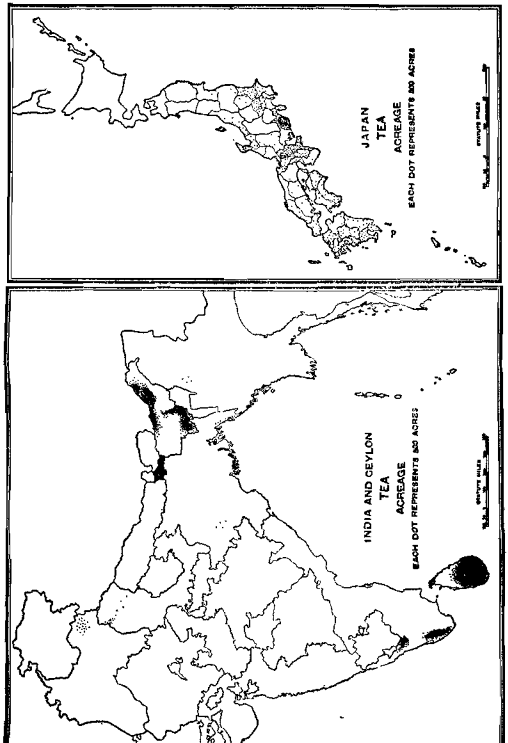

Fig. 78.—Map of Tea Production in Asia.

Finch and Baker, Geography of the World's Agriculture.

twenty-five times a year. But where a marked cool season occurs, as in China, the number of pickings is very much reduced. Tea, like many other tropical plants, shows at intervals an unusually vigorous growth in which fresh leaves are developed very rapidly. These periods of unusually active growth are known as flushes. For the highest grades of tea, only the tip of the actively growing shoot and one or two of the youngest leaves are plucked. A few older and coarser leaves go into the cheaper grades. The tea leaves are brought from the field by pickers, and at once undergo a withering process in the sun, in open sheds, or under the influence of low artificial heat, for a period of two to ten hours. The piles of tea are covered with a clean cloth wrung out in cold water. The appearance of a coppery yellow color in the leaves and the characteristic aroma indicate the time to stop the process of fermentation. The tea then goes at once into the drying or firing machines, where the leaves are completely dried by currents of hot air. The process just described produces black tea.

Fermentation of the leaves is carefully avoided in making green tea. The fresh leaves, on being brought in from the field, are at once heated in a pan or are steamed until they wilt, and are then put immediately into the drier. This process effectively prevents fermentation and consequently prevents the development of the dark color characteristic of black tea. Green teas, however, are not all green in color; in fact, they have no uniform color. They usually show a gray or brown as well as a green color. On account of the lack of uniformity in color of green teas, it was formerly a widely prevalent custom to color them artificially.

China produces both green and black tea, while Ceylon tea is almost all of the black sort. The noted Oolong tea from Formosa is manufactured like green tea, except that it is allowed to ferment only slightly. Oolong tea therefore has the appearance of black tea and the flavor of green tea.

In the list given above, of tea-producing countries mentioned in the order of their importance, only a few countries of the greatest importance as sources of tea were given. Tea is also a commercial product in Natal, the Caucasus, Jamaica, Fiji, Java, the Andamans, Tonquin, and Burma. Since 1901 the importation of tea into the United States has been, with but slight deviation, about 100 million pounds annually. In the amount of their tea imports prior to the War, the first three countries are Great Britain, Russia, and the United States, in the order named.

The United States has taken little part in the business of producing tea. It has been grown experimentally at Pinehurst, South Carolina, and also in Hawaii. It is impossible, however, for us to compete with the cheap and abundant labor of the Orient. While the planting and cultivation of tea requires no more hand labor than is customarily applied to fruit crops, the picking of the leaves is a tedious process which would make the cost of production disproportionately high, except where labor is very cheap.

COFFEE

Coffee was first brought into western Europe from Arabia in 1650 and the habit of drinking coffee spread rapidly in all the towns into which the product was introduced. Until 1690 the world's supply of coffee came from Arabia and Abyssinia, the latter country being the original home of the coffee tree (*Coffea arabica*). At this date it was introduced from Arabia into Java and Ceylon where the coffee industry developed rapidly. In 1875 the prosperous coffee plantations of Ceylon were destroyed by a leaf blight. This disease spread rapidly into adjacent regions and, in conjunction with the work of a borer beetle, completely destroyed coffee production in southern India and Java. The immense areas devoted to coffee were then gradually planted in tea, and this was the beginning of the present huge tea industry of India and Ceylon.

Production.—In 1720 coffee was brought to the West Indies, and in 1770 to Rio de Janeiro. At present the total world area of coffee is 5,000,000 acres, of which Brazil has 3,300,000. The world production is 2,500,000,000 pounds annually, of which Brazil produces 1,750,000,000.

Distribution.—From the standpoint of the amount of coffee exported, coffee-producing countries stand in the following order: Brazil, Venezuela, Colombia, Guatemala, Salvador, Haiti, Mexico, Java, and Porto Rico.

Consumption.—The United States is now the greatest consumer of coffee, the amount consumed being about 40 per cent of the world production. Germany (pre-war) comes next, with a consumption of 17 per cent of the total world production. The per capita consumption is greatest, however, in the Netherlands, followed in order by Sweden, Norway, and Belgium.

Physical Conditions

Coffee production extends through a zone about 25 degrees north and south of the equator and from near sea level to an altitude of 6000 feet. The plant thrives best, however, at altitudes of 500 to 5000 feet.

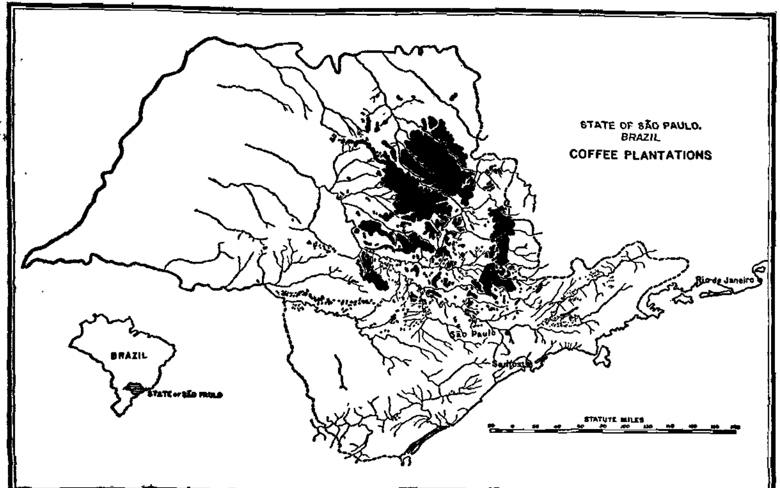

FIG. 79.—In the absence of statistics of acreage or production of coffee in the minor divisions of Brazil, the above map, showing only the general location of the coffee plantations of São Paulo, has been adapted from a map by F. F. Ramos in "The Valorization of Coffee," second edition (Antwerp, 1907). The coffee plantations are located on the slopes and undulating plateaus between the valleys, and not in the lowlands, where air drainage causes injury from chilling temperatures.

From Finch and Baker, Geography of the World's Agriculture, p. 95.

Climate.—Coffee will endure quite a heavy rainfall, but does not thrive satisfactorily where the annual rainfall is less than 50 inches. The extremes of rainfall between which coffee may be said to grow best are 50 to 100 inches. The most favorable temperature is an annual mean of 70 degrees with a mean minimum of 55° F. and an average maximum of 80° F.

Soil.—To obtain the best results, the coffee plant requires a rich, deep, well-drained soil, with plenty of humus. Stagnant water is fatal to it. The most suitable situation for a plantation, therefore, is on gently undulating land possessing a loamy soil overlaying a porous subsoil. Heavy clays, light sands, or very chalky soils should be avoided. On slightly sandy soils good results are obtained, provided the soil is rich in humus so that plenty of moisture is retained, or as long as the rainfall is heavy and fairly evenly distributed throughout the year.

Rocky soils with pockets of rich soil are perhaps the most suitable, since they are generally well drained and cool, and the rocks themselves furnish an almost inexhaustible reserve of food which is continually becoming available to plants by the action of weathering. Some of the best coffee produced in Arabia, Java, India, and elsewhere is grown on soils of this type, but the total quantity produced on such areas is necessarily very small.

Culture.—Coffee is planted either directly in place or in nurseries from which seedlings are later removed for planting. Young seedlings in the nursery bed require some shade for their best development and are usually seasoned by removing to half shade for a short time before planting in the field. More frequently, shade is furnished the young plants in the field until they become thoroughly established. Coffee trees are spaced from 6 to 12 feet apart, according to variety, locality, and the opinions of various planters. When left to themselves, the trees will attain a height of 30 to 40 feet. However, they are usually topped off at about 6 to 15 feet. This operation not only keeps the tree from growing out of reach of the coffee pickers, but seems to have the effect of increasing the bearing of the vigorous lateral branches.

Appearance of the Tree.—The coffee tree is one of the most beautiful of all the agricultural plants. The dark, glossy, green leaves, thickly scattered along the horizontal branches, are always an attractive sight; and when the white flowers appear in great profusion upon the upper surface of these branches, the tree somewhat resembles the holly in a snowstorm. Later, when the red "cherries" appear, the coffee tree is also very attractive. The tree begins bearing at from two to five years. The bearing age occurs somewhat earlier in Asiatic countries than in Brazil. The full mature crop does not occur until about seven to ten years. Under ordinary conditions, the limit of the profitable bearing age of coffee is about thirty years. The yield varies enormously in different countries and in different localities. Under favorable conditions, the yield of dried coffee per acre ranges from 500 to 1200 pounds. It may ordinarily be considered that 1 to 1½ pounds of dry coffee per tree is a satisfactory yield.

Coffee "Valorization" in Brazil[1]

Rapidly increasing world demand, a wonderfully fertile soil, and cheap labor kept the Brazilian coffee industry in a flourishing condition down nearly to the close of the imperial régime in 1889. After the abolition of slavery and the establishment of the Republic, several factors contributed to prolong the prosperity. World demand continued to increase; virgin soil was still available; immigration supplied labor; and Brazilian currency was falling in gold value. The inevitable happened: easy profits led to increased investments and careless methods; little effort was made to cultivate intensively; hand labor in cultivating, picking, washing, drying, hulling, polishing, sorting, packing, and loading, remained in vogue; and planters fell into a luxurious absenteeism in the capital or in Paris.

The time came, about the beginning of the new century, when conditions changed: supply passed demand; formidable surplus stocks began to appear; prices, which had long been declining, fell to or below cost of production; Brazilian exchange reached bottom and began to rise rapidly. The conditions of the 'nineties were reversed, and planters began to turn to the banks for aid. A few far-seeing ones realized that the real remedy lay in the introduction of methods which would reduce the absurdly high cost of production, but they were unable to turn the tide. When bank assistance failed, a demand was made for the improved methods employed by the few saner planters, and the coming to maturity of trees set out during the preceding decade continued to augment the crops.

The three coffee states have long been the chief economic and political centers of Brazil. Especially is this true of São Paulo, which was the chief sufferer in the coffee crisis. Coffee raising was then, as it is to-day, almost the sole industry of this state. Conditions demanded either reform in methods of production, with bankruptcy for the weaker planters, or further Government assistance. The latter was the easier

[1] Adapted from "Coffee 'Valorization' in Brazil," Quarterly Journal of Economics, May, 1909, pp. 528–35.

solution, and it was a political possibility. Soberer views might still have prevailed but for a new danger—the " bumper " crop of 1906–07. Brazilian production had risen slowly from 9,500,000 bags in 1899–1900 to 11,300,000 bags in 1905–06. Then it suddenly jumped to 20,000,000 at a time when there was already a surplus stock of some 4,000,000 bags on the market. Small wonder that the warnings of the wiser minority were unheeded, and that the coffee states, led by São Paulo, launched their valorization plan.

By this plan the states of São Paulo, Minas Geraes, and Rio de Janeiro agreed to purchase and hold for better prices enough coffee to keep out of the market all but a quantity sufficient to supply the world demand, which was estimated at 17 million bags. Feeling that Brazil held a virtual monopoly of the trade, the advocates of the scheme maintained that this withdrawal of excess supply would at once force prices up to the minimum fixed by the Government as the basis for their purchases or subsequent sales. This price was to be from 32 to 35 milreis per bag for Santos grades, in proportion. It was determined by an estimate of " reasonable profit " at existing cost of production.

Funds for the purchase were to be raised by a 15-million pound loan on the credit of the states. Interest, amortization, and other charges were to be provided for by a surtax on coffee exports of 3 francs per bag.

By the end of 1907 São Paulo had borrowed some $88,400,000 and had purchased, at about $1.22 per bag (of 132 pounds) above the market price, 8,357,500 bags of coffee. But prices failed to rise. In fact, they fell slightly. The existence of the huge government stock induced conservatism among dealers. Possibly, too, there were thrown on the market stocks which had been previously hoarded in anticipation of valorization. The proceeds of the surtax were insufficient to provide safely for interest, storage, commissions, and amortization. Attempts to dispose of portions of the government holdings threatened further to demoralize the market. Creditors grew nervous and began to demand their money. São Paulo found itself unable to raise further funds on coffee collateral. Purchases had to be suspended, and valorization may be said to have come to an end by the beginning of 1908.

In summing up the general results of the plan described above (and of similar plans undertaken since), one must bear in mind both the state government and the planters. The credit of the state has suffered severely. No proof of this statement is needed beyond the fact of the extreme difficulty experienced in raising the final loan and the insistence of the financial world that federal guaranty must be secured. Prior to 1906, the ability of São Paulo to meet its obligations seems to have been unquestioned, and it was borrowing freely for many sorts of permanent improvements. The direct financial loss, though extremely difficult to estimate, has in all probability reached a sum of several million dollars.

The whole experience serves to emphasize the dangers of government interference with industry. The state of São Paulo came to the rescue of its planters in a situation which the latter had created by their own shortsightedness. Possibly such action may have been partly justified in view of the vast importance to the state of that particular industry. Possibly, too, it may be said to have been partly successful, provided the problems still remaining be solved without further disaster. Yet, even if partly successful, it has been so only at large direct loss to the state government, and serious impairment of its credit, and has encouraged producers to rely on government aid rather than on their own efforts. It is safe to say that the coffee industry will not resume a normal and thoroughly satisfactory condition until the planters resolve to stand on their own feet. This will involve the introduction of better methods all along the line, the closer watching of the costs of production, willingness to accept low profits compared with those of ten and fifteen years ago, and the elimination of the weaker producers.

SPICES AND FLAVORINGS [2]

Spices played a very important part in the history of Europe during the Middle Ages and up to the sixteenth century. The first knowledge of tropical spices was perhaps brought to Europe by Arab and Jewish traders. These materials brought high prices and were widely sought, especially by the wealthier classes. The existence of spices in far-off, and at that time unknown tropical countries, led to renewed activity in the building of sailing vessels and to the study of navigation. In fact, the whole course of world development has been modified as a result of the struggle for the possession of spices. The search for spice-producing lands evoked an enthusiasm similar to that aroused by the Crusades. When Vasco da Gama rounded the Cape of Good Hope and reached India, the primary result of his expedition was to lay the foundation of a colonial empire for Portugal, giving that country a large supply of spices. Later, the Dutch activities in India and the East Indies led to an attempt to secure a monopoly of the whole spice trade. In this attempt, complete success was attained, as far as cinnamon was concerned, until the year 1833. The success of the Portuguese and Dutch led to great efforts at colonization on the part of the English

[2] Wilcox's "Tropical Agriculture" has been used extensively in the preparation of portions of this section.

and to the establishment of the Straits Settlements and other English Colonies in Asia.

All tropical spice plants of economic importance are native to the Asiatic tropics, with the exception of vanilla, capsicum, and allspice, which come from the American tropics.

Allspice.—Allspice is obtained from the pimento, a tree native to the West Indies and Central America. The tree attains a height of 15 to 40 feet. The leaves contain an essential oil which is used, like that of *Pimenta acris*, in the preparation of bay rum. The flowers of the allspice are small and white, and the tree bears a purple, one-seeded fruit about the size of a pea, which loses much of its aroma on ripening and hence is harvested before it is fully ripe. The fruit is dried for three to twelve days in the sun or in a fruit evaporator, after which the material is ready for market. Allspice is propagated from seed, the trees being spaced about 20 feet apart. The bush begins to bear at about eight years of age and reaches its full bearing at fifteen years. The average yield of mature trees is about 75 pounds of dried fruit per tree per year. At present the world's supply of allspice comes chiefly from Jamaica, which exports about 11 million pounds annually. An oil is extracted from the pimento fruit and is sold under the name of pimento oil. The commercial allspice is not closely related to the other plants that sometimes bear the name of allspice with certain qualifying adjectives.

Cassia Bark.—The cassia tree of southern China is closely related to the cinnamon tree and is said to have been used since 3000 B.C. in China as a substitute for cinnamon. The tree attains a height of 25 to 50 feet and closely resembles in appearance the true cinnamon tree. Cassia bark was used as spice in various countries long before true cinnamon was employed for that purpose. The best grade of Chinese cassia bark, or *Cassia lignea*, is nearly as aromatic as true cinnamon and may be used for the same purpose. Young trees are cut down at the age of six years and the inner bark harvested from the branches. The bark is then dried, baled, and prepared for shipment. All parts of the plant may be used for distillation of cassia oil. The United States imports about 6 million pounds of cassia bark annually.

Cinnamon.—The true cinnamon of Ceylon and India is an evergreen tree attaining a height of 20 to 60 feet. Ceylon cinnamon is commonly considered of finer quality than that from Malabar. In the early days of the cinnamon industry, the bark was collected from wild trees, but now most of the supply comes from plantations. Under cultivation the young trees are spaced from 6 to 12 feet apart, and by skillful pruning they are forced to spread out until the plantation finally becomes a thicket. Most planters consider that some shade for the cinnamon tree is desirable. As a rule, two harvests are made each year by cutting the two- or three-year-old canes at a time when the bark slips readily. The twigs are at once carried to the peeling shed, where they are ringed and split longitudinally, after which the bark is stripped off. These strips of bark are kept moist over night, and the inner bark is then removed. In preparation for market, the bark is dried; during this process it rolls into quills, and these are packed into bales of about 100 pounds each for shipment. About one-third of the cinnamon exported is in the form of chips and broken pieces.

Cinnamon also comes from French Guiana, Brazil, and the Federated Malay States. Ceylon exports about 6,500,000 pounds annually.

Pepper.—The source of the common black and white pepper of commerce is a vine native to Ceylon and southern India. This plant is chiefly cultivated in Penang, Malabar, Sumatra, Ceylon, Java, and the West Indies. The plant is strictly tropical in habitat, being cultivated within about 20 degrees north and south of the equator. It requires a heavy rainfall. The pepper plant is commonly propagated by cuttings from the tips of the bearing vines.

Pepper plants require some support during their growth. Pepper begins bearing at three years of age and reaches full bearing at seven years. The fruiting life of the plant is from seven to fifteen years. If hardwood posts or artificial supports are used, the planting distance may be 7 feet apart. At that rate the yield should be 2000 pounds of pepper per acre. Pepper berries are red when ripe, but turn black in drying.

Black pepper is prepared by grinding the berry without removing the outer covering. When the outer covering is first removed the resulting product, when ground, is white pepper. In other words, white pepper is made from the ripened seeds only.

Cloves.—The search for cloves was one of the important attractive forces which drew the sailing vessels of Portugal, Holland, and other European countries to the Asiatic tropics. Cloves are obtained from bushy trees 12 to 40 feet high, native to the Moluccas or Spice Islands in the East Indies. The tree is now chiefly cultivated in Ceylon, Zanzibar and Pemba, Sumatra, the Spice Islands, and the West Indies. It thrives only near the sea and up to an elevation of nearly 1500 feet. The cloves of commerce are the dried unopened flower buds which are borne at the tips of the twigs in small clusters. About seven-eighths of the world's supply of cloves comes from the islands of Zanzibar and Pemba. Zanzibar alone exports about 9000 tons of cloves annually.

The clove is propagated from seed planted in nurseries under shade.

The seedlings are planted 30 feet apart and the tree begins to bear at four to five years of age. A clove plantation at maturity yields about 10 pounds of dried cloves per tree. In the Molucca Islands two pickings a year are practiced. In harvesting cloves the flower buds are gathered by hand or are knocked off the trees by means of bamboo poles. The buds are then dried for six to eight days in the sun. Care is always taken to prevent dew from forming or rain from falling on them during the drying process, since moisture causes them to turn black. Cloves are used as spice, as a source of clove oil, in perfumery, soaps, toilet articles, and confectionery, and for medicinal purposes. In recent years they are being used to a great extent in the preparation of an artificial vanilla flavor, " vanillin," which at the present time absorbs the great bulk of the Zanzibar clove crop.

Ginger.—The well-known plant which is the source of commercial ginger is native to southern Asia, but ginger is now cultivated throughout the tropics. It is a perennial herb, with leafy stems 18 to 24 inches high. It produces a white, aromatic rootstock from which ginger is prepared. The plant requires an equable, hot, and moist climate, a shaded situation, and a rich, well-tilled loamy soil with a high humus content. In Ceylon it thrives up to an altitude of 3500 feet.

Ginger is propagated only by short cutting of the roots. It is planted in rows 24 inches apart and 14 inches in the row. Chinese ginger is commonly cultivated by a system of raised beds. The roots are harvested about ten months from the time of planting, maturity of the roots being indicated by a withering of the leaves. The range of yield is from 1000 to 2000 pounds of dried ginger per acre, while the average is about 1200 pounds. In drying, the roots lose about 70 per cent of their weight; they then contain about 10 per cent of water. Drying is accomplished in the sun or by the use of artificial heat.

Ginger is an important crop in Malabar, Bombay, Malaya, Sierra Leone, Fiji, and Barbados, but more especially in Jamaica, which exports about 2 million pounds of dried ginger annually. The Jamaica product invariably commands the highest price on the market. The United States imported 3½ million pounds of ginger in 1914. Ginger is used as a spice, confectionery, beverage, curry, medicine, and as preserved ginger. The essential oil called ginger oil, from the rootstocks, is used in preparing the essence of ginger. Experiments have shown that ginger will thrive well and produce an excellent crop in Hawaii, Porto Rico, and the Philippines, but no commercial ginger industry has thus far been developed in these countries.

Nutmeg.—The nutmeg was sought no less eagerly than the clove by the early explorers of the Asiatic tropics. Nutmeg is obtained from a bushy tree native to the Moluccas and Dutch East Indies. The tree attains a height of 25 to 50 feet. The handsome fruit is globular or pear-shaped and is enclosed in a firm, aromatic husk, one-half inch thick, containing the shiny brown seed or nutmeg which is surrounded by a lace-work of tissue, the latter constituting the source of the mace of commerce.

A good grade of nutmeg in the shell measures one inch in diameter. On ripening, the husk splits into halves. The fruit is then picked or allowed to fall, after which the nut is separated from the mace and both products are thoroughly dried. The shell is then removed from the nut. The nutmeg trees are spaced about 25 feet apart; they begin to bear at the age of seven years and reach their full bearing power at about thirty years of age, at which time each tree bears from 2000 to 5000 nuts per year. The tree lives to be 100 years old or more and bears two crops annually. Most of the male trees are cut out so as to leave one male to ten female trees. Some shade is usually provided for the young trees. The yield of mace is generally about one pound per 10 pounds of nutmeg.

Sources of Supply.—The chief supply of nutmeg and mace comes from Banda, Sumatra, Minahassa, Java, Amboyna, Penang, Singapore, and the West Indies. The production of nutmeg is increasing most rapidly in the West Indies. The Penang mace is most highly prized, while Banda mace is also fairly good. Mace from Batavia and Singapore, however, is inferior.

Nutmegs are used in spice, for seasoning sausages, and other meat products, for making nutmeg butter, and as a source of nutmeg oil which is distilled from the nut. Mace is chiefly used as a spice, being far more delicate than nutmeg and much more highly prized.

Vanilla.—This is one of the few important spice plants that are indigenous to tropical America, and the vanilla plant is the only orchid yielding a commercial product. The plant from which practically all of the commercial product is obtained is native to the rainy, tropical lowlands of Mexico and Central America. The plant was first used as a spice by the Aztecs, and is now cultivated throughout the tropics, ranging 20 degrees north and south of the equator. Vanilla requires a hot, moist, climate and much humus in the soil about the roots. Trees, stakes, or trellises for support are required in the cultivation of this plant. Vanilla is propagated only by cuttings about 3 to 4 feet long, which are planted at the base of stakes 9 feet apart both ways, or at the base of nurse trees. The cuttings are first rooted in the nursery.

Vanilla plants may be pruned back at the age of eighteen months in order to induce a habit of branching, or they may be allowed to climb to a height of 10 to 15 feet and to become pendulous from above. Like other orchids, the flowers of the vanilla are naturally fertilized by insects, but the proper insect species are not everywhere present. Vanilla has been introduced into many countries where its natural insect visitors are not to be found. In practical vanilla growing, hand-pollination of the flowers, an art requiring considerable skill, is therefore necessary. One man, after sufficient practice, can fertilize 500 to 2000 flowers per day. The period from fertilization to the maturing of the pods ranges from four to nine months, varying greatly in different countries.

A good vanilla plant at full bearing may put out as many as 200 racemes of flowers, bearing altogether 2000 to 4000 flowers. In practice, it has been found desirable to pollinate not more than six to ten flowers per raceme. The vanilla pods reach a length of 4 to 6 inches and are harvested when the tip begins to turn yellow. The curing of the pods is the most important process in the vanilla industry. The pods are dipped in water at a temperature of 195° F. for fifteen to thirty seconds. They are then put in an oven for fifteen minutes, after which they are exposed to the sun until dried. This process is repeated for six to ten days; at the end of this time the pods become flexible and are of a deep chocolate-brown color. The fermentation process is then considered complete. The subsequent process in curing vanilla consists largely in properly drying the pods. For this purpose the pods are exposed in a ventilated drying room for a period of one to two months. Various other processes have been adopted for sweating and fermenting the vanilla pods to develop the proper aroma.

The vanilla plant flowers once a year and begins to bear at the age of three years. The world's vanilla crop amounts to about 600 tons of pods annually. The main producing countries at present stand in the following order: Tahiti, Mexico, Réunion, Comores, Madagascar, Seychelles, Guadalupe, Mauritius, and Ceylon. Vanilla is used chiefly in flavoring chocolate liqueurs and confectionery. The artificial vanillin has been synthetically made from eugenol, the characteristic principle in the oil of cloves. Artificial vanillin is much cheaper than real vanilla, but has not succeeded in replacing the latter to any great extent.

TOBACCO

Historical and General.—Tobacco is the fourth agricultural product of great commercial importance that is native to America, the other three, as stated in a previous chapter, being corn, cotton, and potatoes. (Cotton is native also to India.)

At the time of the discovery of America, the natives were cultivating tobacco from Canada to southern Brazil. The early records of the aborigines show that they understood the fundamental principles of tobacco culture now practiced, such as proper spacing, topping and suckering the plants, and the distinctive processes of drying now known as *air-curing*, *sun-curing*, and *fire-curing*.

The Spanish settlers began tobacco culture long before the settlement of Jamestown, and the early English colonists had to meet Spanish competition on the European market from the very beginning. In spite of anathemas pronounced against the "vile weed" by James I of England, tobacco at once became a leading article of exchange with the mother country; and in the colonies it served the varied purposes of comforting the lonely settler, of paying the transportation cost of wives to help make the early colonial homes, of serving as a medium of exchange for the simple commercial transactions of the time, and even of paying the preacher's salary when other forms of currency were lacking. Thus tobacco was interwoven with every phase of early early colonial life, and history credits it with having more than once saved the struggling colonies from utter destruction by serving as the one available product for which there was a universal demand.

Because of the great importance of tobacco in colonial economy, there was a constant tendency to overdo its production, and, throughout the history of the colonies, vain efforts were made by their legislatures to control the output. By 1664 the exports of tobacco amounted to 24 million pounds, and at the outbreak of the Revolution to 100 million pounds annually. The exportation of tobacco was checked during the half century following the Revolution on account of the trade disturbances following that conflict and the Napoleonic wars which occurred during the first quarter of the nineteenth century. During this period, however, the tobacco area was extended over the mountains into Ohio, Kentucky, and Tennessee.

While tobacco culture is carried on to-day in 42 states and in 1694 counties of the United States, nearly two-thirds of the output of the country in 1919 was produced in Virginia, Kentucky, and North Carolina, and one-third of the total output was produced in Kentucky.

Types of Tobacco.—The history of tobacco production in the United States has not been one of simple expansion; there has been throughout a tendency toward increased specialization. The use of tobacco for chewing and pipe smoking and in the forms of snuff, cigarettes, and cigars was prevalent among the natives when Columbus first visited America; but it is not clear whether these people recognized the special adaptability of different tobaccos for use in these different

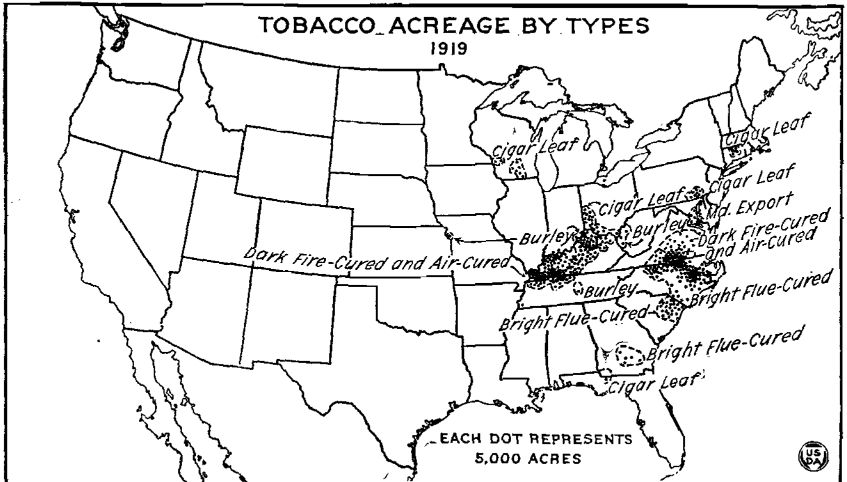

FIG. 80.—Each distinctive type of tobacco has its special requirements as to soil and climate and the present localization of production of the various types is the result of a long process of evolution and specialization.

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forms At any rate, the early settlers in Virginia produced at first but a single fundamental type of tobacco for export to Europe, although this product soon came to be recognized as differing in its qualities from the tobaccos produced in the West Indies and South America by Spanish settlers.

As tobacco culture was carried from the first settlement at Jamestown into new territory, it was seen that the changes in soil and climate resulted in important differences in the character of the tobacco produced. It gradually became more and more apparent also that these differences in the properties of the tobacco leaf, due to soil and climatic influences, greatly affected its adaptability for use in different forms; the product of one section, for example, was especially suitable for making smoking or chewing tobacco, but perhaps did not produce so acceptable a cigar as that of another section. It was learned, moreover that desirable charactertistics of the tobacco leaf resulting from local soil and climatic influences could be further accentuated by modifying the methods of growing and curing. Thus, through a process of gradual evolution, tobacco culture has become highly specialized, each producing district furnishing a distinctive type of leaf especially adapted for certain uses, based ultimately on the tastes and preferences of the consumer. It is the accumulated experience of three centuries of tobacco culture that each of these types can be produced only under certain conditions of soil and climate, by using certain varieties of seed, and by employing special methods in growing and handling the crop.

Dark Fire-cured and Air-cured Types.—The dark, fire-cured types of to-day are funamentally the same as the original Jamestown tobacco. The Indians taught the first settlers the use of open fires and smoke in curing the green tobacco leaves, and this method of curing, together with certain distinctive cultural practices adopted in the earliest days, is still followed. As tobacco culture was extended farther inland, the modifications in character of leaf produced by the heavier, more clayey soils of the Piedmont region proved to be desirable, and as a consequence the culture decreased and was finally abandoned on the lowlands of the tidewater region originally employed. Thus the culture of this type was transferred to the uplands of the Piedmont section of Virginia. Fire-curing was also practiced in southern Maryland in the earliest days, but later the process of air-curing without the use of artificial heat was substituted there as well as in the upper counties of Virginia. The production of these fire-cured and air-cured types was extended across the Appalachians into eastern and southern Ohio, across Kentucky and northern Tennessee, and even beyond the Mississippi into Missouri, by pioneer settlers from Virginia and Maryland.

From the beginning, the dark, fire-cured types have been distinctively export tobaccos, about 80 per cent of the total production going to foreign markets. The remander is used mainly for snuff and for plug chewing. The dark, air-cured types also have always been exported in large quantities, but most of these types are far more important in the domestic manufacture of chewing tobaccos than are the fire-cured types.

Bright Flue-cured Tobacco.—As the early colonists pushed tobacco culture into the central border counties connecting Virginia and North Carolina, it was found that the light gray, comparatively infertile lands of that section produced a light-colored, sweet leaf, which soon became popular as a chewing tobacco. After the War of 1812, an active foreign demand for mild spangled tobacco stimulated the production of this new type. Less heat and smoke were required for this tobacco than for the darker, stronger types, and about 1825 charcoal began to be used in place of open wood fires, in order to secure lighter colors. Soon after the Civil War, the use of flues in curing was adopted, thereby further increasing the demand for this type in the manufacture of chewing and smoking tobaccos and causing rapid expansion in production in southern Virginia and the north central portion of North Carolina. Beginning about 1890, there was very rapid development in the culture of bright, flue-cured tobacco in the so-called " new belt " section of eastern North Carolina and South Carolina. During the past fifteen years there has been further marked expansion in the production of bright, flue-cured tobacco, and its culture has now been extended into southern Georgia. This type is chiefly used for the manufacture of chewing plug, granulated smoking mixtures and cigarettes, and for export.

Cigar Leaf.—In 1810 the manufacture of cigars from tobacco imported from Cuba and Brazil began in a small way in Hartford County, Connecticut, and about 1825 it began to be recognized that the local conditions of soil and climate were adapted to the growing of cigar leaf. In 1833 the Maryland Broadleaf variety of tobacco was introduced, and this marked the beginning of the extensive Broadleaf or Seedleaf tobacco industry, which expanded rapidly about the middle of the last century, not only in the Connecticut Valley, but also in Pennsylvania and in the Miami Valley of Ohio as well. Soon after the close of the Civil War the culture of cigar leaf rapidly developed in Wisconsin. About 1870 the so-called Havana Seed type of cigar leaf, obtained from Cuba, was introduced into the Connecticut Valley, the Miami Valley of Ohio, and southern Wisconsin, and its culture developed rapidly in the next decade. During the past two decades there has been extensive development of the growing of cigar-wrapper leaf under artificial shade in the Connecticut Valley and in the Quincy, Florida, district.

White Burley.—The extensive Burley industry owes its existence to the discovery of a new, distinctive variety of tobacco in Brown County, Ohio, in 1864. The great success of this variety in displacing the dark tobaccos, which were grown at that time in north central Kentucky and in counties of adjoining states along the Ohio River, was due primarily to its special fitness for the manufacture of heavily sweetened plug for chewing. In recent years this type has found extensive use in the manufacture of cigarettes and smoking mixtures, and this has resulted in wider culture of the sub-variety known as Stand-up Burley.

Physical and Biological Factors Affecting Tobacco Production

Soil.—Soil, as previously stated, is an important factor in bringing about the high degree of specialization which is met with in the tobacco industry. The variety of types of tobacco is largely dependent upon soil characteristics. The small tobacco leaf of dark color, heavy body, and strong aroma is closely related to the heavy, clayey soils, and the resulting product is used for plug chewing tobacco. The lighter soils are associated with a thin leaf of relatively large size, light color, fine texture, and weak aroma, from which cigar wrappers and granulated tobacco suitable for cigarettes are made. Again, the characteristics of the soil contribute to variations in the flavor of tobacco, which plays such a lart part in satisfying the varying whims of tobacco users.

Climate.—The tobacco plant thrives best in localities where the soil has sufficient moisture and the air also is humid during the growing season. Thus tobacco culture is not an important industry in the arid and semi-arid regions under irrigation.

Tobacco is successfully grown under a wide variation of mean annual temperature conditions, as, for example, from Florida to Wisconsin and Connecticut.

Insect Pests.—The horn worm is by far the most serious insect pest of tobacco. It feeds voraciously on growing tobacco leaves and grows to a large size. The horn worm may be controlled by dusting with powdered arsenate of lead.

The tobacco bud worm is of primary importance to the shade-grown tobacco of Georgia and Florida. The eggs are deposited in the buds of the plant and a single larva may eat through several leaves, rendering them unfit for use as wrappers. A mixture of arsenate of lead and corn meal in the ratio of 1 to 75, applied to the buds twice a week until the plant is topped, is the most effective method of control.

Another pest is the tobacco flea beetle, which may be controlled by the application of arsenate of lead or Paris green.

Other insects that injure tobacco are cut worms, split worms, tobacco thrips, several species of grasshoppers, and other minor pests.

Diseases.—Among the most common diseases of tobacco in this country are root rot and wilt diseases. The best method of control so far discovered is crop rotation.

Tobacco is subject to a number of leaf-spot diseases, and recently the one known as wild fire has given considerable concern. While the virulence of the disease is largely dependent upon weather conditions, it appears to originate in the seed bed, and the transplanting of infected plants should therefore be carefully avoided.

Areal Production and Distribution

Tobacco is grown in considerable quantity in various parts of the world. As far as statistics are available, the eleven countries producing upward of 50 million pounds annually during the pre-war period, 1909 to 1913, are, in order of quantity produced: the United States, British India, Russia, Hungary, the Dutch East Indies, Japan, Germany, the Philippine Islands, Brazil, Cuba, and northern Caucasia. The production of China undoubtedly is very large in the aggregate, but for that country only fragmentary stastistics are available. It is estimated that world production for the period 1909 to 1913 averaged approximately 2,800,000,000 pounds, of which the United States furnished 35 per cent.

It is apparent that the tobacco crop of the world is produced under widely contrasted climatic conditions and on very diverse types of soil. The tobaccos thus produced differ greatly as to the properties that determine their usefulness for different forms of manufacture, and consequently there are wide differences in the commercial value of these tobaccos. Most countries can readily produce large quantities of tobacco, but only of a relatively inferior grade, while only a few countries possess areas having the necessary soil and climatic conditions for growing tobacco of superior merit. So important are the effects of soil and climate on the quality of the tobacco produced that even in those countries which, as a whole, grow a product of relatively low grade, tobacco culture is more or less definitely localized.

Economic Factors

Tobacco in the Farming System.—As a rule, the acreage of tobacco planted constitutes but a small proportion of the total crop acrea of

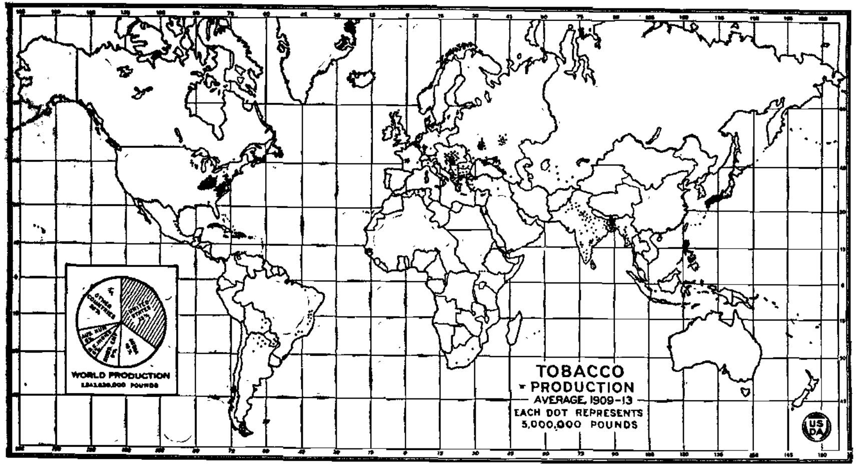

FIG. 81.—Tobacco may be grown successfully under a wide range of conditions of soil and climate, as shown by the fact that this crop is an important one in many parts of the world. The commercial value of the product, however, is influenced to an extraordinary degree by soil and climate so that the product of different countries varies greatly in market value.

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the farm. There are, however, restricted areas, as, for example, the Connecticut Valley, where this is not the case. Here very intensive methods, including a large application of commercial fertilizer, are used, with respect to both capital and labor employed, and the same land is used for tobacco year after year. In recent years the acre yield has declined, owing in part at least to the appearance of root diseases, although the yield still remains high.

In Lancaster County, Pennsylvania, tobacco occupies a totally different place in the farming system. Here only a small proportion of the crop land of the farm is devoted to tobacco, and the high yields are maintained by means of a complete system of crop rotation accompanied by livestock enterprises which makes possible a liberal application of barnyard manure. High yields are thus maintained with a minimum of expense for artificial fertilizer. This system prevails in modified form in the tobacco regions of Kentucky, Tennessee, Ohio, and Wisconsin. In some sections, notably Virginia, Maryland, and North Carolina, relatively low yields are obtained on account of the inferior soil, and formerly the practice prevailed of growing two or more crops of tobacco with a minimum application of manure or fertilizer. The land was allowed to lie fallow for a few years until it recovered some of its fertility, when tobacco was again planted upon it. In recent years, resting the land has proved to be insufficient to restore its productiveness, and the tendency is to make more liberal applications of artificial fertilizer.

Cost of Production.—From 75 to 90 per cent of the cost of tobacco production is attributable to man and horse labor, land, and the maintenance of tobacco barns.

Relation to Yield.—Costs vary not only on different tobacco farms for a particular season, but also on the same farm from year to year. Such variations may be due to unfavorable weather, to diseases, to insect pests, or to the management of the operator. Variations in the cost of producing a pound of tobacco are due to variations in the cost expended per acre and in the yield obtained. A grouping of the tobacco records according to an increase in yield per acre showed that the cost per acre increased with yield, and the cost per pound decreased. It was found, for example, that in the Kentucky Burley area, for 1919, the farms producing from 600 to 1000 pounds per acre had an average cost of $237 per acre and 30 cents per pound; while those that yielded over 1500 pounds per acre (averaging 1580 pounds) produced at a cost of $330 per acre and 24 cents per pound. In the Kentucky dark, fire-cured area, costs increased from $118 per acre for the farms having an average yield of 393 pounds to $136 for the farms averaging 1306 pounds per acre; but the cost per pound for the low-yielding group was 30 cents as compared to 10.5 cents for the high-yielding group. It must be remembered, however, that a rank, coarse growth is quite often associated with poor quality and low returns per pound. Therefore, a reduction in cost per pound through larger yields should not be encouraged to the extent of sacrificing the quality.

Marketing Tobacco

Auction System.—Tobacco that is destined to be sold at auction is first brought into a soft, pliable condition and assorted according to quality, color, length, and other factors. Except for a general knowledge of the qualities of tobacco, farmers have no guide in this assorting process. In most cases they separate their tobacco into lots of similar character, without knowing to what grades the tobacco belongs or for what use the tobacco is suited. This being true, the farmer is at a loss to know the market value of his tobacco even after carefully assorting it. The principal reason for this condition is that there are no generally recognized standard grades for tobacco.

Tobacco is sold at auction in three ways: by publicly selling loose or unpacked tobacco to the highest bidder; by publicly selling in packed form to the highest bidder; and by closed-bid auction of packed tobacco. Most of the tobacco is sold by the first method.

The different lots of tobacco, as brought in by the farmer, are weighed, properly tagged, and arranged in piles on the warehouse floor according to grade. At the appointed hour the piles are auctioned off in rapid succession. The warehouseman, after deducting certain fees, pays to the farmer the net proceeds and collects this amount from the buyer.

Farm Selling.—The next most common method is that in which the farmer sells the tobacco to a local buyer or representative of a manufacturer. The farmer usually makes no attempt to assort his tobacco with reference to quality. Sometimes the buyer visits the place to inspect the tobacco, but very often it is bought at a general price without being examined. The tobacco is generally sold by the dealers according to the quality of each lot, whereas the farmer sells the tobacco unassorted for a general average price. In all sections in which farm selling is practiced, the farmers have practically no conception of tobacco grades and very few realize the wide variation in the prices of tobacco of different qualities. Their main source of information as to the value of tobacco is the price received by neighbors, which is usually a flat price of so many cents per pound for all qualities of tobacco.

The farmer who sells his tobacco at an average of 30 cents has very little idea what proportion of it has a market value of from 3 to 5 cents per pound. This is due to the fact that there are no standard grades by which the farmers can be governed. With tobacco varying from 1 cent to $2 per pound, it is not possible for a farmer to estimate with any degree of accuracy the market value of his tobacco without the use of some uniform system of grades. Neither is it possible for market quotations to be of much value without standard grades.

Coöperative Marketing.—In recent years an increasing proportion of the tobacco is packed, pooled, and sold by the farmers themselves through their coöperative associations. Under this plan the tobacco is assorted and tied into appropriate bundles by the individual farmer, and delivered to the receiving warehouses of the association, where it is weighed, placed in baskets, and tagged in the same manner as in the case of the auction system; but, instead of being sold at auction, the baskets are graded by expert graders who are employed by the association. Each farmer is given a statement showing the grades of the tobacco delivered to the association with the weight of each grade. At the same time an advance payment is made on the tobacco delivered. The amount of this advance is governed by the association and proportioned according to the particular quantity of each grade delivered to the association.

The association has full jurisdiction over the tobacco after it has been received, and may condition, warehouse, or sell it at will. A certain percentage of the tobacco, as a rule, is sold directly to dealers and manufacturers from the loose-leaf receiving floors of the association. The remainder of the tobacco is shipped by the association to conditioning plants where it is conditioned and packed into hogsheads or cases for storage. As the tobacco is packed, it is inspected, regraded, sampled, and weighed by competent and reliable persons, many of whom are licensed for the purpose under the United States warehouse act. It is then delivered to public storage houses, many of which are also licensed under the same law.

Prices of Tobacco.—The practice of paying farmers a general price for tobacco under the ordinary marketing system has already been mentioned. Only a few additional data need to be presented in order to show how slipshod and unbusinesslike this practice is, and how it invariably penalizes the farmer who attempts to produce a high quality product, and places a premium upon the inferior product. If tobacco is grouped into four classes, viz., (1) cigar type, (2) Burley type, (3) flue-cured type, and (4) dark, fire-cured and air-cured types, it has been found that the variation in price per pound of the first type is from 3 cents to $4; of the second, from 1½ cents to $1; of the third, 1½ cents to $1.25 per pound; and of the fourth, from 1 cent to 65 cents per pound. It is apparent from these facts that exact grades and standards should be established and that the price paid to the farmer should be based upon these grades. Coöperative marketing associations have this object in view.

Financing the Marketing of Tobacco.—Before tobacco may be used for manufacturing purposes, it must have passed through an "aging" process which requires from one to three years with an average of about eighteen months. Where the tobacco is marketed through

TREND IN CONSUMPTION OF LEAF TOBACCO: CIGARS, CIGARETTES, TOBACCO, AND SNUFF, 1897–1921.

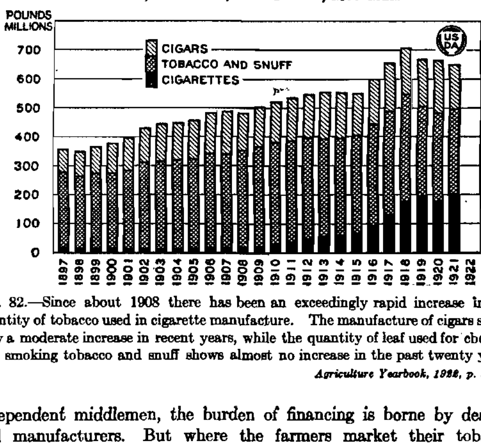

Fig. 82.—Since about 1908 there has been an exceedingly rapid increase in the quantity of tobacco used in cigarette manufacture. The manufacture of cigars shows only a moderate increase in recent years, while the quantity of leaf used for chewing and smoking tobacco and snuff shows almost no increase in the past twenty years.

Agriculture Yearbook, 1922, p. 452.

independent middlemen, the burden of financing is borne by dealers and manufacturers. But where the farmers market their tobacco coöperatively, the advances to the farmers and the costs of carriage are provided for by borrowings by the association from local banks, city banks, and the federal intermediate credit banks. The collateral for these loans is the tobacco itself, represented by warehouse receipts.

Consumption.—Of the 1,362,000,000 pounds of tobacco which constituted the average production of the United States from 1917 to 1921, domestic consumption absorbed 65.5 per cent and the remainder was exported. During the past century the proportion of our tobacco crop consumed at home increased three-fold. The per capita consumption increased from less than 4 pounds prior to the Civil War, to almost 9 pounds in 1920. The rapid growth in tobacco consumption in recent years comes mainly from the vast increase in the use of cigarettes, the consumption of tobacco for this use alone having increased from about 75 million pounds in 1915 to 200 million pounds in 1921. The quantity used for chewing and smoking tobacco and snuff shows almost no increase in the last twenty years.

International Trade in Tobacco

Exports.—Including those countries for which statistics are available, the average yearly exports of tobacco for the period 1909 to 1923 amounted to 929 million pounds. The United States leads in these exports, furnishing 41 per cent of the total. The Dutch East Indies contributed 18 per cent; Brazil, 6.5 per cent; Cuba, 4 per cent; British India and the Philippine Islands, each 3 per cent. Turkish exports are also important and probably rank with those of Brazil.

Imports.—Of the total imports in world trade during this period, Germany received 20 per cent; the United Kingdom, 14 per cent; France, 7½ per cent; the Netherlands, 7 per cent; the United States, Spain, and Austria Hungary, each 6 per cent; and Belgium, 2½ per cent.

Import Duties.—From the very beginning of our Government, import duties have been levied upon tobacco. The two objects of revenue for the Government and protection for the tobacco industry have been present in varying proportions, depending largely upon the political party in power. During the past fifty years, a total of $800,000,000 has been collected by the Federal Government from this source.

Internal Revenue.—A much more important source of Government revenue, however, is the internal tax placed upon tobacco products. In 1920 the revenue derived by the Government from this source amounted to nearly $300,000,000.

Outlook

The greatest problem of the tobacco grower, from colonial days to the present time, has been the recurring menace of over-production. In most of the tobacco regions, only a relatively small percentage of the available land is used for tobacco. Since the cash returns per acre for tobacco are large compared with those for other staple crops, it requires only a slight increase per pound above the normal price to stimulate *a material increase in acreage, which results in over-production.* It is to be hoped that tobacco growers may be able to stabilize their acreage and thereby, in part at least, their production, and that by this means, in conjunction with more orderly marketing, they may obviate the vicissitudes of fortune to which in the past they have been subjected.

RUBBER

General.—Rubber is another significant contribution made by tropical America to the agricultural resources of the world. However, the methods by which crude rubber is converted from an unstable, sticky material to the familiar vulcanized product were not discovered until the nineteenth century. About 1780, Joseph Priestly, an English chemist, found that the new material would rub out pencil marks, and this property gave it its English name. In 1832, Ludusdorf found that sulphur added to crude rubber in turpentine rendered it non-adhesive. In 1839, Charles Goodyear discovered accidentally that when heated to a high temperature such a solution attained the characteristics which we have since associated with the rubber goods of daily use. These discoveries multiplied the uses to which rubber was put; but the really great impetus to the consumption of rubber came with the advent of motor transportation, which required pneumatic tires and tubes made largely of rubber. This new demand has also revolutionized the manner in which raw rubber is produced. Until this demand appeared, crude rubber was obtained from wild sources located mainly in South and Central America and Africa. Since then the proportion of crude rubber supplied by cultivated plantations has increased from about 5 per cent in 1909 to 92 per cent in 1921. The following table shows some significant facts concerning the growth of rubber consumption and plantation sources:

The plantation rubber industry in the Far East originated from the seeds of *Hevea brasiliensis*, commonly known as Para rubber. These seeds, collected in Brazil by Henry Wickham in 1876, were taken to England, germinated in the Kew Gardens, London, and the seedlings sent from there to Ceylon. The Ceylon plantations constituted the source of the rubber plantations in the other sections of the Far East.

Not only has the development of rubber plantations since 1909 been stimulated by the demands of the automotive trade, but planters of coffee, sugar, and other tropical products, who were meeting with disappointing prices for these products, were eager to replace these crops with rubber, for which the price at that time was very high.

TABLE XXI

World Production, Plantation and Wild Rubber *

Years	Total Plantation, Tons	Total Wild (Tropical America and Africa) Tons	World's Production		
			Total, Tons	Plantation, Per Cent	Wild, Per Cent
1905	174	59,320†	59,494	0.3	99.7
1906	577	62,004	62,581	0.9	99.1
1907	1,157	66,013	67,170	1.7	98.3
1908	1,796	64,770	66,566	2.7	97.3
1909	3,386	70,370	73,756	4.6	95.4
1910	7,269	73,477	80,746	9.0	91.0
1911	14,383	68,446	82,829	17.4	82.6
1912	30,113	73,834	103,947	29.0	71.0
1913	51,721	63,280	115,001	45.0	55.0
1914	73,153	48,052	121,205	60.4	39.6
1915	114,277	54,740	169,017	67.6	32.4
1916	158,993	51,086	210,079	75.7	24.3
1917	221,187	56,751	277,938	79.6	20.4
1918	180,800	36,711	217,511	83.1	16.9
1919	348,574	50,424	398,998	87.4	12.6
1920	304,671	36,464	341,135	89.3	10.7
1921	276,746	23,903	300,649	92.0	8.0
1922	378,232	27,878	406,110	93.1	6.9
1923	379,738	26,685‡	406,423‡	93.4	6.6
1924‡	386,703	28,000	414,703	93.2	6.8

* Trade promotion series No. 2, Department of Commerce, p. 5.
† Excluding Venezuela. ‡ Estimated.

Area and Distribution of Rubber Plantations

British.—More than 90 per cent of the rubber used to-day comes from plantations located in southeastern Asia and neighboring islands and in districts under the control of Great Britain, the Netherlands, and France. The total area now planted is 4,200,000 acres, of which 69 per cent is in British possessions. Of this 69 per cent, 63 per cent is in British Malaya, 10½ per cent in Ceylon, and the remainder in southern India, Burma, British North Borneo, and Sarawak.

Dutch and French.—Of the above total acreage, 29 per cent is in Dutch possessions; of this, 17 per cent is in Sumatra, 9½ per cent in Java, and the remainder in Dutch Borneo. Two per cent of the total acreage is to be found in French Indo-China.

Kinds of Plantations

European.—The plantations are of two kinds—European and Asiatic. European plantations constitute about 2,800,000 acres, or two-thirds of the total, and represent a capital investment of totals up to $765,000,000, divided as follows: Great Britain, $489,000,000; the Netherlands, $130,000,000; Japan, $40,000,000; United States, $32,000,000; France and Belgium, $27,000,000; and other European countries, $47,000,000.

Organization.—The estates as a rulc are highly organized and are well equipped with factories, housing facilities, hospitals, and roads. They have the direct or indirect assistance of scientific experts, who furnish information concerning the welfare and improvement of planted stocks with the view of obtaining the maximum yields per acre.

Native Plantations.—About one-third of the total rubber-plantation area, or 1,400,000 acres, is controlled by Orientals. Generally speaking, primitive metbods are used in caring for these plantations. The rubber that reaches the local primary markets from them is poorly prepared, containing a large percentage of moisture, and must be washed and dried before being shipped to the consuming markets of the world.

Projects for the Artificial Control of Output

Some of the more salient facts concerning the growth and present status of the rubber industry of the world have been stated in the preceding paragraphs. It has been noted that more than 90 per cent of the world's ruhber supply now comes from plantations, and that 65 per cent of the European plantations are controlled by British capital. It should be added that two-thirds of the total world output of crude rubber is destined for the United States market.

In 1910 the peak price of $3 per pound for crude rubber was reached; in June, 1921, the price had descended as low as 14 cents per pound. This tremendous decline in the price of crude rubber was mainly due to two causes, viz.: the great increase in rubber-tree planting, which averaged 250,000 acres per annum from 1906 to 1920; and post-war deflation, which paralyzed industry in this country and in Europe, greatly reducing the demand for raw rubber. The over-production of rubber was allowed to become so acute because of the fact that it takes from four to six years for a rubber tree to become productive, and the growers did not realize the cumulative effects that these annual plantings were having.

Stevenson Plan.—The so-called "Stevenson plan" was devised in London by a committee representing the British rubber producers, and approved by the British Secretary for the Colonies. It provided that the legislative bodies of Ceylon, the Malay States, and the Straits Settlements should pass legislation providing for graduated tax levies upon exports of crude rubber, increasing as exports increase and prices decline, and diminishing as prices rise.

In outline, the plan which is now in operation is as follows: The actual production of the year ending October 31, 1920, has been established as the "standard" for each company. Of this "standard" production, 60 per cent may be exported at the minimum rate of export duty, 1 penny, which is to be in lieu of all existing export duties. Exports above 60 per cent of the "standard" up to 65 per cent, are to bear a surtax of 4 pence per pound; and so, for every increase of 5 per cent in quantity, the surtax is to increase 1 penny per pound. When exports reach the standard production the surtax will be 1 shilling per pound.

There is, however, an interesting modifying provision in the plan, designed to raise or lower the percentage of the standard that may be exported under the minimum duty. When the average price of crude rubber in London has been maintained at not less than 30 cents per pound for three months, the percentage of the standard that may be exported under the minimum duty is automatically raised to 65 per cent. If, during the next three months, the average price is maintained at 36 cents per pound, 70 per cent may be exported at the minimum duty, etc., an additional 5 per cent being released at the minimum rate for every increase of 6 cents in price. On the other hand, if the price, for three consecutive months, drops below 24 cents per pound, the percentage of the "standard" production at the minimum duty is reduced to 55; and if this is not effective in bringing up the average price to 30 cents during the next three months, the percentage subject to release at the minimum rate will descend to 50.

Since the "Stevenson" plan has gone into operation the price of crude rubber has risen as much as five-fold and, during the spring of 1925, produced considerable excitement in the rubber manufactories. The defenders of the plan blame the manufacturers for the low prices which necessitated such drastic measures. Opponents of the plan contend that the recent rise in rubber prices was due to increased demand following industrial recovery in this country and stabilization in Europe, and not to the influence of the "Stevenson plan." The only effect of the latter, they claim, is to transfer the rubber trade from England to her competitors. The stimulus of high prices has already created an interest, on the part of the American rubber trade, in the rubber potentialities of our own insular possessions, especially the Philippines.

The present rubber crisis, like the coffee crisis noted elsewhere, is but another example of the inevitable maladjustments which are certain to occur between the production and consumption of a commodity when there is insufficient information or intelligence, regarding the facts in the case, among those engaged in the growing and manufacturing of the given commodity.

EXERCISES

1. In Table 682, Agriculture Yearbook, 1924, are given the annual imports of cocoa, chocolate, coffee, and tea from 1901 to 1924. Arrange these figures so as to bring out the comparison of the relative increase of the imports of these commodities during this period.

2. Why were spices so much in demand during the Middle Ages, and how did this desire for spices stimulate the study of navigation and promote expeditions for exploration?

3. What are the advantages and disadvantages of developing rubber production in west central Africa? What are the possibilities of developing rubber production in the Philippine Islands?

4. Why is the practice of marketing tobacco for a flat price under the regular marketing system particularly disadvantageous to the tobacco producer? In what ways do the tobacco coöperative associations aim to remedy this situation?

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CHAPTER XII

FIBER PRODUCTS

Introductory.—The discovery that fibers could be twisted into thread and the thread made into fabrics is of primeval antiquity. It is known, for example, that the Swiss Lake Dwellers of the New Stone Age made fabrics from flax fibers. A knowledge of the processes of making clothing materials from plant and animal fibers was necessary before large numbers of people could live comfortably in the cooler middle latitudes. A number of fibers contribute to the needs of mankind, and many of the by-products of these fibers play important parts in modern industrial life. Only the most important fibers—those that are used by a large number of the people of the world and enter into the world's commerce—will be discussed here.

Cotton, the most important of all fibers, is a warm-season plant and can be grown successfully only in the tropics and in those portions of the middle latitudes possessing a long, warm growing season. Of the plant fibers, flax ranks second in importance. When grown for fiber, the flax plant is raised only in the cool, humid sections of the middle latitudes. (On the other hand, flax grown for oil is produced in the drier middle latitudes where a warm summer season prevails.)

Henequen and jute are important fiber plants produced only in the tropics.

Plant fibers are divided into two classes, the hard fibers and the soft. The hard fibers, hemp, henequen, and sisal, are used mostly for making rope and twine. Hemp is more expensive to produce and is used mostly for rope, while sisal and henequen are used mainly for twine. The soft fibers, of which cotton, flax, and jute are the most important, are used for making cloth and bagging.

The silkworm is becoming more important as a fiber producer each year. Silk has been used more or less as a luxury for a long time, but in recent years it has come to be considered a necessity by a large class of people in several countries. The production of silk has doubled in the last forty years, so that now it ranks in value with flax as a fiber product, and, if only the flax fiber is considered, silk ranks next to wool in importance.

The animals that produce fibers of importance are sheep and goats. In considering them as fiber producers it is also necessary to consider briefly the other products for which they are raised, and especially the effects of these products upon the wool and mohair industries. The main product in one region may be the by-product in another, and *vice versa*.

COTTON

History of the Cotton Plant and Cotton Industry.—We do not know how the use of cotton fibers, either for thread or for fabrics, was discovered. The plant has been referred to since history began as " the tree with hoary wool "; thus its use as a shrub and an ornament appears to have been known long before its usefulness in making cloth was discovered. India is one of the homes of the cotton plant, and we know that it was used there for making cloth as early as 800 B.C. The Egyptians also knew of its use at an early age. Cotton was being grown in the West Indies and in Mexico when these lands were discovered by the Spaniards. At this early date it was important as a source of clothing material, especially in Mexico.

Although cotton was used for cloth in many countries at a very early date, it did not become an important article of commerce until the beginning of the sixteenth century. The difficulty of separating the fiber from the seed made it more expensive than wool, and consequently it was used only where wool was not available or among the very wealthy.

Developing of Spinning.—The first implements used to spin the fiber into thread were the distaff and the spindle. The distaff was a stick upon which the carded cotton was wound. It was then twisted by hand, and the thread wound upon the spindle. The distaff was replaced by the hand spinning wheel, and this greatly stimulated cotton production. Toward the close of the fifteenth century, the Jersey wheel was introduced; this marks the beginning of the spinning industry in England. About 1530 the Saxony wheel came into use; this was a big improvement, as it had two spindles and a " flyer " which twisted the yarn. The machinery was very crude in structure and no great development took place until the middle of the eighteenth century. Expansion in the cotton industry was held back because of an old prejudice against wearing cotton garments. Taxes were placed on cotton imports into England, and people were taxed and often prosecuted for wearing cotton clothes. Cotton had to compete with the wool spun in the homes; all new inventions were regarded with suspicion, and the inventor was often persecuted and banished from the country. In spite of all this, the trade thrived and the demand for cotton became greater until inventive minds began to create mechanical devices to do away with the great amount of labor necessary to prepare the cotton for clothing.

The first big improvement in reducing the work of making cotton cloth was the invention of the flying shuttle by John Kay in 1732. On account of his invention he was driven from his home, wandered from place to place as an outcast, and died in poverty and obscurity in Paris. The Yorkshire manufacturers tested the shuttle, found that it was a success, and adopted it.

The use of the flying shuttle made it possible to weave faster than the thread could be made, and an appeal was sent out for some improvement in the spinning wheel. John Hargreaves, then a weaver, invented the carding machine, which removed all the impurities from the raw cotton, and later, in 1767, he introduced the spinning jenny. At first his jenny contained eight spindles, but later the number was increased to eighty. He tried to keep his invention a secret, but it was found out, his machine was destroyed, and he was driven out of the country. He went to Nottingham where he patented his invention and became acquainted with a man names James. Hargreaves and James then built the first cotton mill that ever was established.

The jenny would make several threads, at one time, but did not make them fine and hard; in 1769, therefore, Richard Arkwright invented the spinning "water frame" which was an improvement over Hargreaves' invention and made it possible to produce uniform threads of any desired fineness and hardness. In the same year, James Watt made the steam engine a commercial success. At first the new cotton machinery was run by horse power and then by water power; but as the demand for cotton increased and more and larger mills were needed, it was only possible to get enough power by the use of steam.

Samuel Crompton further improved the art of spinning by his invention of the spinning mule in 1779. The mule was so called because it was a combination of the features of Arkwright's water frame and Hargreaves' spinning jenny. At first the mule spun twenty threads at a time, but soon, with mechanical improvement, it was possible to handle as many as 2000 spindles; this greatly reduced the amount of labor required.

With these improvements, the spinning of thread had surpassed the capacity of the crude methods of the weavers. Edmund Cartwright was the first to respond by inventing the power loom. He studied weaving and found that there were just three movements made in weaving the thread; he then set about making a machine to perform these operations, and in 1787 he made the first cloth by machinery.

This series of improvements in the textile industry, in conjunction with the application of steam power to these newly invented machines, caused the capacity of the mills to exceed the supply of raw materials. This problem was solved through the invention of the cotton gin in 1783, together with the availability of large areas of land suitable for cotton production in the southeastern part of the United States. This remarkable series of inventions constituted the technological basis for the Industrial Revolution. Associated with these technical improvements were the growth of city populations, the development of the factory system, the rise of a distinct laboring class, and the consequent expansion of markets.

INVENTORS OF COTTON MACHINERY

Inventor	Machine	Date
John Day	Flying shuttle	1732
James Hargreaves	Spinning jenny	1767
Richard Arkwright	Water frame	1769
Samuel Crompton	Spinning mule	1779
Edmund Cartwright	Power loom	1787
Eli Whitney	Cotton gin	1793
James Watt	Steam engine	1769

WORLD PRODUCTION OF COTTON

Although temperature conditions permit of a wide range in the growing of the cotton plant throughout the tropics and large areas in the lower middle latitudes, other physical conditions, such as amount and distribution of rainfall, topography, and kinds of soil, preclude successful cotton production from a large proportion of these lands. In addition, the competition of other crops and the lack of such economic factors as adequate labor supply, means of transportation, and marketing organization further limit the area in which cotton can be economically produced.

Table XXII shows the average production of cotton in the principal cotton-producing countries in the world for the period 1909–1913. This period was chosen because it is the last one for which reliable statistics can be obtained and it gives an idea of the distribution of cotton production under normal pre-war conditions. The production for 1923–1924 is also shown for those countries where the figures were available, and shows a tendency for some countries to increase

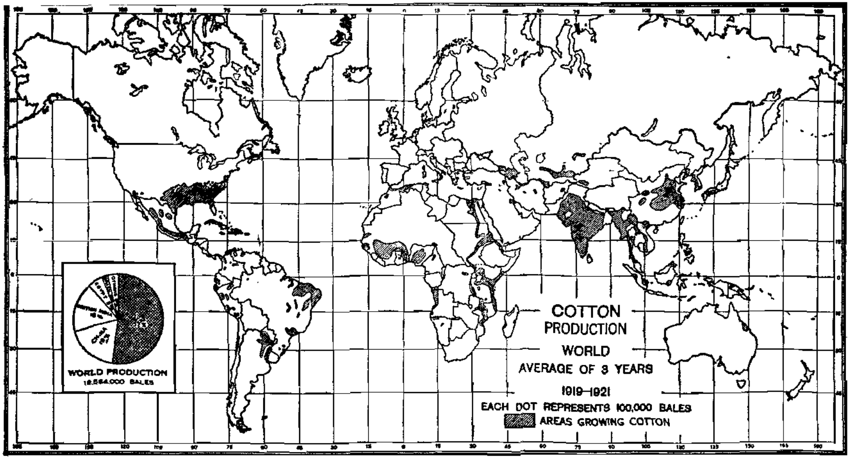

Fig. 83.—The United States produces over half of the world's cotton crop. The total crop of China is placed second by various estimates. In commercial production India is second. Cotton is grown in many parts of Africa and South America, but only in small quantities. Australia also grows a small quantity. Cotton requires a long season of warm weather for growth and proper maturity. Its latitudinal limits north and south fall between 35 and 45°, depending upon elevation and other conditions affecting the length of the frostless season.

Agriculture Yearbook, 1921, p. 326.

their production while that of others is remaining stationary or even decreasing.

TABLE XXII

COTTON PRODUCTION BY COUNTRIES—AVERAGE FOR 1909–1913 AND 1923–1924

(In thousands of bales)

Country	Average for 1909–1913	1923–1924
World*	23,580	19,300
United States	13,033	10,140
India	3,585	4,247
China†	3,473	1,785
Egypt	1,453	1,213
Russia	738	115
Brazil	332	719
Mexico	193	138
Persia	136	130
Peru	110	197

* Estimated total world production, all countries not reporting.
† Estimated by Chinese mill owners to be from 2 to 7 million bales.

China.—China is the third largest cotton-producing country in the world, but as no accurate statistics are taken it is impossible to obtain the exact production. The growing of cotton and the development of cotton manufacturing has increased very rapidly during the last few years. The cotton-producing regions include the basin of the Yang-tse-Kiang and the southern portions of the plains of north China. The cotton is of poor quality, the lint being coarse and short, although the introduction of high-grade American seed in recent years is tending to increase the quantity and to improve the quality of Chinese cotton. China exports about 250,000 bales yearly, mostly to Japan.

India.—Cotton is grown throughout much of India, but the areas of concentration occur in the west central section of that country. While a small proportion of the cotton is grown under irrigation in northwest India, most of it is grown without irrigation in the region of the black cotton soils east of Bombay. The " Rain Cotton " produced on these black soils is planted in the fall as soon as the rainy season is over and is picked in the cool season and in the early spring months which are almost rainless. About half of India's crop is exported, mostly to Japan. The area planted to cotton is about two-thirds as great as that of the United States, but the yield per acre is about one-half as great and the quality considerably poorer. Indian cotton is grown by crude methods and cheap labor. The machinery used for ginning and baling, however, is modern, and the bales are made much more neatly than those of the United States.

Egypt.—The tillable land of Egypt is limited to the delta and a narrow strip along the Nile, because all of the land must be irrigated. About one-third of this area is devoted to cotton production. The yield is large because the cotton is grown under irrigation, the land is very fertile—being flooded by the Nile each year—and the productivity is also kept up by crop rotation. These physical conditions, associated with an abundance of sunshine, contribute to the production of a long-staple cotton of high quality. The plant is grown on very small holdings, most of which are less than 5 acres in size, and cultivated very intensively so that the yield per acre is very high. The work is all done by hand, and the baled cotton is sent to the port of Alexandria where it is rebaled and most of it is shipped to England. Recently the United States has been importing cotton from Egypt and her imports are steadily increasing.

Russia.—Russian cotton is grown mostly in Turkestan and Transcaucasia. The rainfall is very light, and cotton can be grown only in the river valleys, where irrigation is possible. Most of it is Asiatic cotton but some American varieties are grown. Most of the cotton is exported to European Russia. After the Revolution of 1917 the production greatly diminished, as will be seen in Table XXII. This decrease is due to the fact that Russia's cotton land had to be used in the production of rye, wheat, and other grains. Since 1922, however, there has been substantial recovery in the cotton industry and there is a likelihood that within a few years Russia may greatly exceed her pre-war production.

South America.—In South America most of the cotton is produced in eastern Brazil and in the coastal zone of Peru. Peru is especially important in cotton growing, as the product is a brown, crinkly fiber which is mixed with wool in the manufacture of high-priced fabrics. The production is increasing in both Peru and Brazil, but their total production is still very small.

Other Foreign Countries.—Cotton is grown to a slight extent in nearly all of the warmer parts of Mexico, but the commercial production is limited chiefly to the Laguna district and to the Imperial Valley of Lower California. Almost all of the crop is grown under irrigation. About 15,000 bales of cotton, mostly of the Sea Island variety, is grown in the West Indies. A small amount of cotton is grown in Europe, principally in Greece, whose annual crop is about 12,000 bales. Bulgaria and the southern parts of Italy and Spain also produce cotton in very small quantities. In Asia Minor and Persia, cotton production is important only in the districts near Adana and Smyrna. In the Sudan and in East Africa occur vast areas physically suited to cotton production. Dr. Shantz estimates that East Africa alone has 90 millions of acres available for cotton production, an area more than $2\frac{1}{2}$ times the cotton acreage of the United States. Northeastern Australia has a considerable area of land physically suited to cotton growing.

United States.—The United States produces more than one-half of the world's cotton crop. Most of the cotton is grown in the Cotton Belt, which is bounded on the north by the line of 77 degrees mean summer temperature and 200 days of frost-free weather; on the west by the line of average precipitation of 23 inches; and on the south by the line of 11 inches autumn rainfall.

Cotton was grown in all of the southern colonies by the first settlers. Most of the early plantings were experiments and, although they proved to be successful, cotton was grown very little except for home use. Until the beginning of the Industrial Revolution there was little demand for cotton. The first stimulus to cotton growing came during the Revolutionary War, because of the necessity of producing clothing materials at home. Commercial production of cotton, however, began soon after the close of the Revolution, as a result of the initial development of the textile industry in Great Britain.

Sea Island cotton was introduced into Georgia from the West Indies in 1786 and became the big commercial crop because of its long fiber and because of the ease with which it could be separated from the seed. Prior to 1800, Georgia and South Carolina were the chief cotton-producing states. Cotton production in America received a new impetus at this time through the perfection of the cotton gin. Prices were high and improvements took place rapidly, and in 1804 approximately 18,000 bales of Sea Island cotton were produced in Georgia and South Carolina. Upland cotton was grown in Louisiana and on the uplands of Georgia and the Carolinas, but on account of the difficulty of separating the seed from the fiber it did not become popular until after the invention of the gin. It was well adapted to the climate and soil of the inland districts of the southern states, and its production increased rapidly after 1794.

The first great expansion in the growing of upland cotton occurred in the Piedmont region of South Carolina and Georgia. At the outset, cotton production proved to be so remunerative that this crop was grown to the exclusion of others. Since much labor was needed to produce cotton, the cheap labor of the slaves contributed largely to the profitableness of the industry. The purchase of Louisiana in 1804 added to the United States a large area capable of producing cotton. The Non-intercourse Act of 1807 and the War of 1812 resulted in a sharp decline in cotton prices. Production was held in check for those years; the cotton manufacturing industry in this country was encouraged;. and at the close of the war 165 cotton mills were operating in New England.

The close of the War of 1812 marks the beginning of a period of prosperity for the cotton grower and of the westward expansion of cotton production. A large and increasing foreign market was developing, and our cotton mills continued to increase at a rapid rate. Louisiana, Mississippi, and Alabama were being rapidly settled, and by 1825 they were contributing greatly to the cotton crop of the United States. Because of its abundance and consequent cheapness, land was abandoned when the fertility gave out, and new lands were cleared and put into cotton. The result was a continual westward movement of planters and slaves into the new areas. In 1840 more than three-fourths of the cotton was produced east of the Mississippi River. About 1850 eastern Texas began to grow cotton, but the Mississippi Valley was the chief cotton-producing area until about 1880.

Cotton growing in the South received a severe set-back during the Civil War, and the production of 1861 was not reached again until 1877. By this time the United States was the chief cotton-producing country in the world. The reduction of exports of cotton during the Civil War resulted in high prices of cotton in Europe and consequently cotton production in other countries was greatly stimulated.

The recovery of cotton production in the South was retarded not only by the political disturbances incident to the reconstruction period, but also by the transition from the slave plantation to the free-labor system.

During the early 'eighties a movement was begun in the Black Lands of central Texas for the conversion of cattle ranches into cotton-producing lands. During the past twenty-five years Texas has been the leading state in cotton production and is now producing more than one-third of the cotton crop of the United States.

During this period the use of fertilizers in large amounts became common on the light, sandy soils of the southeastern United States, and much progress was made in the planting of better varieties of cotton; these practices, together with the use of better machinery for planting and cultivating the crop, increased the yield per acre and had a tendency to lower the cost of production. Cotton production increased rapidly until 1914, when the United States produced the largest crop on record. Since 1921 the acreage of cotton has been greatly increased, but the total production has not reached that of 1914, which was grown on a much smaller acreage. This has been due mainly to the ravages of the boll weevil and unfavorable weather conditions. With the development of better means of combating the boll weevil, and the introduction of better cropping and livestock systems, it is probable that the acre yields of cotton will increase. During the years 1924 and 1925 cotton production again attained pre-war proportions, largely because of the vast increase which has taken place in acreage.

As the expansion of the Cotton Belt has approximately reached its climatic limits, the only way of increasing production in the United States is by a more complete utilization of the land within these limits or by developing new areas of cotton production. There is a considerable area in the southwestern United States which is suited for cotton growing when irrigated. The first cotton was grown in California and Arizona in 1909, and, when it was found that Egyptian cotton could be grown successfully there, the area was devoted to that type and the production increased very rapidly. In 1912 the production of Egyptian cotton in this region was over 38,000 bales. Besides this over 85,000 bales of short-staple was produced in the Imperial and Yuma Valleys, including both sides of the international boundary line. The area in which the cotton is produced has a long growing season, is free from the boll weevil, and has plenty of water available for irrigation. The land is fertile and apparently similar to that of Egypt. Most of it is farmed by owners and its productivity is being well maintained by crop rotation. The semi-arid regions of northwestern and southern Texas also offer considerable scope for expansion.

Principal Commercial Types of Cotton and Where They are Produced

Sea Island.—Sea Island cotton is a native of tropical America. It ranks high in value because of its fineness and length of fiber. Sea Island cotton is grown at present only on the islands of the West Indies. The best of this type has a fiber about 2 inches in length and is the most valuable of all cotton, as it surpasses all other types in length, strength, and fineness. Sea Island was formerly grown extensively in Georgia and Florida, but production has practically ceased since 1920 because of the boll weevil.

Egyptian.—Egyptian cotton is very similar to Sea Island except that the fiber is a trifle shorter, ranging from about $1\frac{3}{8}$ to $1\frac{3}{4}$ inches; it is second in value per pound. Egypt furnishes the bulk of the crop,

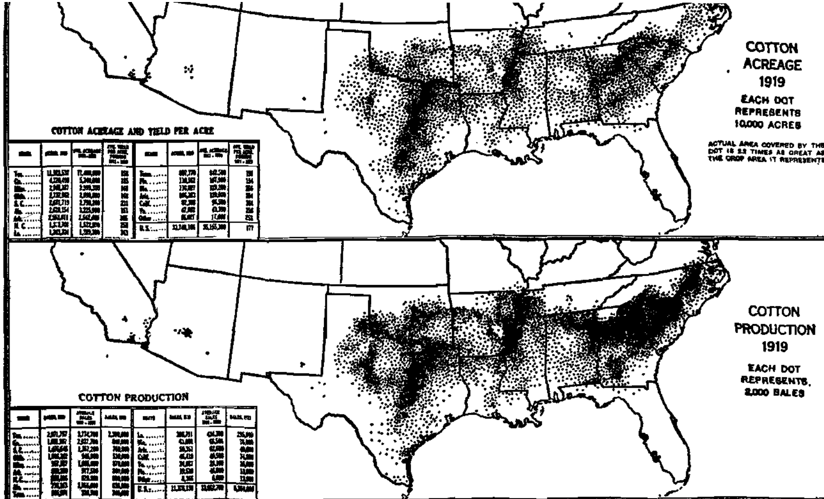

FIG. 84.—The northern boundary of the Cotton Belt is approximately the line of 200 days average frost-free season and 77° mean summer temperature, the southern boundary that of 11 inches autumn rainfall, because wet weather interferes with picking and damages the lint. This southern boundary is now moving northward, as the milder winter temperatures near the Gulf and longer season permit increased injury by the boll weevil. The western boundary of cotton production without irrigation is approximately the line of 23 inches average annual rainfall. The densest areas on the map are districts of richer soils, notably the Black Prairie of

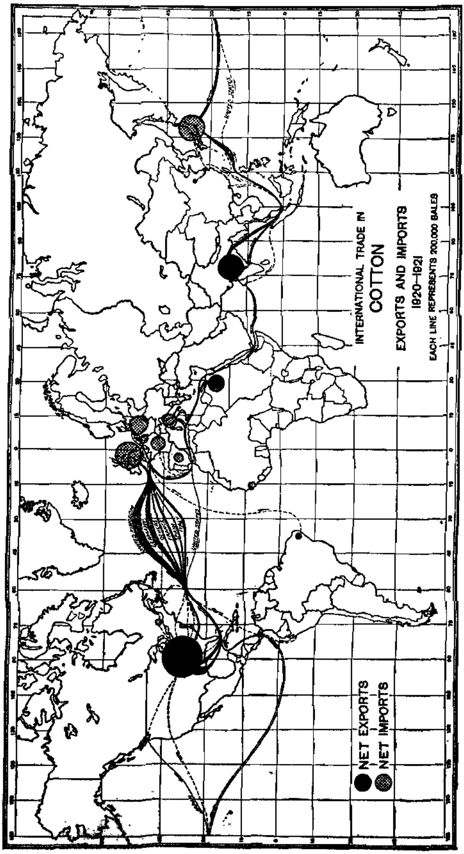

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FIG. 85.—International Trade in Cotton.

and the only other places in which it is being grown successfully are California and Arizona, where production under irrigation is rapidly increasing.

Upland Long-staple.—Upland long-staple cotton is grown chiefly in the United States and ranges in value between the Egyptian and the American short-staple. The staple ranges in length from about $1\frac{1}{8}$ to $1\frac{1}{2}$ inches and for some purposes is as good as Egyptian. It is grown on the richer soils, chiefly in the Mississippi River bottoms.

Upland Short-staple.—Upland short-staple cotton constitutes about 93 per cent of the crop of the United States and about 60 per cent of the world's crop. "American Middling," the standard short-staple grade, is the basis for price quotations of all short-staple cotton. The staple varies in length from about $\frac{7}{8}$ inch to $1\frac{1}{8}$ inches. There are numerous varieties of short-staple. Upland short-staple is the best quality of short-staple cotton and is now being introduced into nearly all the cotton-producing countries of the world.

Asiatic.—Asiatic cotton includes those types produced in the various countries of Asia. It has a staple about $\frac{3}{8}$ to $\frac{3}{4}$ inch long and is used mostly in the Asiatic countries. It is being rapidly replaced by American short-staple.

Natural Factors Affecting Production

Climate.—Cotton is a sub-tropical plant. It does best with moderate moisture and requires a long and uniformly warm growing season. Summer weather with numerous showers and intervening periods of of bright sunshine is typical of cotton-producing regions. Hot, moist nights are beneficial. An extremely high temperature for many days will cause heavy shedding of bolls, unless the soil is well supplied with moisture. Hot winds materially increase the damage in hot, dry summers because evaporation and transpiration are thus greatly intensified.

The best climatic conditions for cotton are found in those regions where a mild spring, with light but frequent showers, merges into a moderately moist summer, with warm days and nights, followed by a prolonged, dry, cool autumn. Such conditions are most favorable, respectively, for plant growth during the vegetative period, for fruiting and maturity, and for the picking season. Cool, moist weather in the spring retards growth, and wet conditions prevent germination and cause the seed to rot. Excessive moisture in the soil results in the development of surface roots instead of a deep root system, so that the plant is unable to withstand successfully even normal dry weather later in the season. Heavy rainfall accompanied by low temperatures during the latter part of the vegetative period is especially detrimental to the plant. After the bolls begin to open, dry weather is desirable, as rain lowers the quality of the cotton, prevents picking, and slows up maturity. It is significant to note that moderate rains in early September will start a new "top crop" of late-maturing bolls which, if not destroyed by frost, increase considerably the yield of cotton.

Soil.—Cotton is grown on practically all well-drained soils in the Cotton Belt. Owing to soil differences, there is a wide variation in yields; in general, the yields on the light, sandy soils are smaller than those on the black lands, unless the former are heavily fertilized. The most productive soils in a normal season are the dark-colored lands, rich in lime and possessing a high content of organic matter, such as the Black Lands of Texas, and the river-bottom lands of the lower Mississippi Valley. The sandy loams of the Coastal Plain, having red and yellow clay subsoil, are next best and give a good yield when fertilizer is applied. By the intensive use of fertilizer on the light, sandy soils, a good yield can be obtained on land that would be otherwise unprofitable. The most noticeable differences in the density of cotton production in the Cotton Belt are due principally to the soil conditions.

COTTON PESTS

Cotton is attacked by many pests, but most of them are easily controlled by poison and proper cropping systems. In early spring the cut worms and May beetles injure the stand. In a wet spring these may do considerable damage, but they are easily controlled by poison. A little later on, the cotton louse, grassworm, and, in the West, grasshoppers infest the cotton area, but these can be held in check by poison and shallow cultivation.

The worst cotton pest is the boll weevil. It has been so destructive in the South that the acre yield of cotton has been reduced more than 25 per cent and a decided change in the farming system has resulted. For a long time, economists have advised diversified farming in the Cotton Belt; but the boll weevil has done more to bring about this change than any other one thing. Rotation is one of the most effective ways to combat the weevil.

The original home of the boll weevil was probably Central America or Mexico. It entered southeastern Texas from Mexico in 1892. It is not known whether the weevil was brought into the United States by cotton imports or by flight. By 1894 it had covered a dozen counties in southeastern Texas and it continued to extend its range annually from 40 to 160 miles until in 1921 it had covered the whole Cotton Belt.

The northern and western limits of the Cotton Belt are less subject to weevil damage than other areas, as the weevil is unable to survive in large numbers through the cold winters of the North or the drier seasons of the West.

In the newly infested areas the damage done by the weevil was often as high as 50 per cent of the crop, but by the use of control measures planters have succeeded in reducing this damage considerably. Variable weather conditions, such as cold winters and hot, dry summers, which may occur throughout the Cotton Belt, considerably reduce the number of weevils that survive to produce progeny which may attack the succeeding crop. On the other hand, a mild winter is usually followed by a heavy infestation of the weevil. Unlike many other insects, the weevil passes the winter in the adult or beetle stage, hibernating wherever shelter may be found, as in old cotton stalks, dead grass, leaves, and the like. Hence the clearing away or burning of all rubbish in the fall or winter is important in reducing the number that will survive. Only a small percentage of the weevils survive through the winter, varying from 11 per cent in a mild winter to 2.8 per cent in a severe winter. Although the emergence of the weevil in the spring varies through the Cotton Belt from March until June, it is possible by early planting and by the use of early maturing varieties to have a crop well advanced before the weevils become numerous enough to be very destructive.

The weevil can not be eradicated but can be controlled to a large extent through methods previously indicated, as well as by the use of calcium arsenate in a dry form, applied when the plants are covered with dew. This method has been used for several years and has proved to be fairly successful.

Pink Boll-worm.—The pink boll-worm has been known in other countries for a long time. It was first noticed in India in 1842 and in Egypt in 1911. It was introduced into Mexico in the same year, probably through seed imported from Egypt. When the Federal authorities learned in 1916 that the boll-worm was in Mexico, an embargo was immediately placed upon seed from that country. The insect, however, did make its appearance in the United States in 1917, the larva presumably having been carried in a shipment of seed which had been brought in prior to the declaration of the embargo. Immediately upon its appearance on American soil, cotton-free zones (that is, areas where no cotton was permitted to be grown) were established. As a result of this prompt action, the pink boll-worm has not, up to the present time, become a serious menace. Entomologists of the United States Department of Agriculture declare that the pink boll worm is probably the most serious single cotton pest in the world. In the Laguna district of Mexico, for example, where it has been allowed to run its course, the estimated damage to the crop is more than 50 per cent.

Other Cotton Pests; Cotton Boll-worm.—The cotton boll-worm is one of the oldest and most widely distributed cotton pests. It is a general feeder, living on many different kinds of plants. It hibernates in the soil and thus may be controlled to a large extent by fall plowing. The same methods that are used to control the boll weevil are sufficient to hold in check the cotton boll-worm.

Cotton Leaf Worm.—The cotton leaf worm has been known in the United States since 1793. It is a native of the tropical regions and does not winter in this country. It flies north, and in some years does not reach this country in destructive numbers. It lives on the leaves and is easily controlled by the application of calcium arsenate. Another defoliater is the red spider, which collects in masses on the under side of the leaves. It can be controlled by cultivation and poison.

COTTON DISEASES

Cotton Wilt.—Cotton wilt is caused by a fungus which enters the roots and so disturbs the circulation of water in the plant as to cause stunting, wilting, and even the death of the entire plant. As it remains in the soil indefinitely, the infested areas can not be planted to the ordinary kinds of cotton. The United States Department of Agriculture has developed resistant varieties, which have now come into general use. The cotton wilt is found mostly in the more sandy soils of the Coastal Plain from southern Virginia to eastern Texas.

Root-rot.—Texas root-rot is also due to a fungus which occurs from Arkansas and eastern Texas westward. It is found principally in the heavier types of soils, especially those of the Black Waxy Belt. This disease causes a wilting of the cotton plant, in midsummer, throughout large areas. It constitutes a serious agricultural problem because no effective remedy has been found and, in addition, it attacks other crops, such as alfalfa, sweet potatoes, and certain fruits. The best method of control thus far discovered is the practice of crop rotation.

Root-knot.—Root-knot is due to a tiny eelworm or nematode which bores into the cotton roots and causes abnormal galls or swelling on them. It dwarfs the plant and reduces the yield. It occurs commonly in association with wilt and on the same types of sandy soils. It attacks several crops but can be controlled by using a rotation with immune crops.

Anthracnose.—Anthracnose is a disease of cotton and is spread through infected seed. It causes damping-off of the young seedlings and some injury to the plant. It is, however, most harmful as a cause of boll-rot in wet weather. It occurs locally over the entire Cotton Belt and is controlled by using seed free from disease, and by crop rotation.

Leaf-spot.—Angular leaf-spot, or bacterial blight, can be found in nearly every cotton field in the South as a leaf-spot, stem blight, and boll-rot. Upland cotton is quite resistant to it, but Egyptian cotton is very susceptible and great losses occur. The use of disease-free seed and crop rotation are the best methods of control.

Economic Factors

Dominant Position of Cotton.—The dominant position of cotton production in the Cotton Belt may be attributed largely to three factors:

First, the world demand for cotton is very great and the lands possessing favorable physical and economic conditions for its successful growth are restricted in area. The strong demand for cotton is due largely to the fact that cotton fabrics provide almost ideal garments for moderately hot and warm weather conditions. The increasing buying power of the people in both the middle latitudes and the tropics will make itself felt in a growing demand for cotton goods.

Second, because of the demands of the crop, cotton provides rather steady employment throughout most of the spring, summer, and fall.

Third, cotton is a money crop and is not marketed through livestock, as is corn, for example.

Because of the dominant place of this crop in the Cotton Belt, it is not surprising that the production of livestock and the diversification of crops have been so greatly retarded in this agricultural region.

Diversification in the Cotton Belt.—There has, however, been a gradual increase in the number of all classes of livestock of the better grades. Nevertheless, the possibilities of livestock production in the South have apparently scarcely been touched. The mild winters and the potentialities of pasturage at this season are factors of advantage in the establishment of the livestock industry. The development of this industry is important not only in the contributions it may make to the world market, but also because of its efficiency in maintaining soil productivity.

Credit.—In comparison with most other types of agricultural production, cotton growing in the United States rests on credit to an unusual extent. The most urgent credit needs of the cotton farmer relate directly to the production of the crop. Credit is supplied usually through the agencies of the bank, the merchant, or, in the case of tenants, the landowner. The rate of interest varies considerably, depending upon the agency furnishing the credit. In general, it appears that bank credit is by far the most economical. It is highly desirable that farmers become thoroughly familiar with the institutions which in recent years have been provided for the purpose of furnishing them with credit, among which are the intermediate credit system and the Federal farm loan system. The farmer's capacity to utilize these institutions will determine to a considerable extent the amount of interest he will pay and his net returns for the year's operations.

Marketing.—Cotton differs from many farm products in that all of it passes through the channels of trade. It is not fed to livestock, nor is any portion of it used by the farm family. The result of this condition is that a highly organized system of marketing cotton has been developed during the past century. The regular or ordinary method of cotton marketing begins in the village or town where the dealer meets the producer, and ends at the point where the dealer delivers to the spinner. The trading may be in actual cotton or in contracts for future delivery; the former is known as "spots," and the latter as "futures."

"Spot" markets are located either in villages and small towns, in which case they are known as primary markets, or in large towns and cities. In the latter case they are known as interior markets and serve as points of concentration for grading, compressing, assembling in commercial lots, and consigning to destination for consumption.

The cotton "futures" markets are located in New Orleans, New York, Liverpool, and Chicago. The Chicago market was opened recently.

Prices.—The close connection which exists between all these markets makes it possible to disseminate information regarding supply and demand conditions with great rapidity and considerable accuracy. The price for cotton of a given grade and staple at any time thus tends to become uniform over the entire Cotton Belt. The prevailing system of marketing cotton is by no means perfect; but that substantial progress has been made in recent years, in weeding out illicit practices in the cotton trade, can not be doubted.

Coöperative Marketing of Cotton.—Space forbids an extended discussion of cotton marketing in general and of coöperative cotton marketing in particular. But attention should be called to the rapid progress which is being made in this latter method of marketing cotton. Each of the principal cotton-growing states has a state association composed of many thousand farmer members, and these state associations are merged into the American Cotton Growers Exchange. During the past season (1924–1925) 1¼ million bales of cotton, or about 10 per cent of the total crop, were sold by these associations. This tremendous volume of business, representing more than $125,000,000 of value, has been developed in only five years' time and suggests what we may expect along this line of development during the next decade or two. Strong business organizations are being built, not only around cotton, but around each of the other commercial farm products as well, and this movement promises to be the distinctive characteristic of the future agricultural industry.

One-variety Communities.—The farmers' coöperative organization is proving to be highly valuable, not only as a marketing institution but also as a means of improving the quality of the product by the selection of a superior variety of seed. Purity of seed can be maintained only as all of the farmers in a given community adhere to a given variety. Moreover, with a full understanding by the farmers of a given variety, methods are adjusted more closely to differences in soil, season, and time of planting, as well as to control of insect pests and diseases, labor supplies, ginning, handling, warehousing, financing, and marketing.

The general custom at present among American cotton growers is to plant many different varieties of seed in the same community. These become mixed at the public gins, and deterioration immediately begins. Coöperation among the growers, as already indicated, appears to be the only way of solving this problem.

Consumption of the Cotton Crop.—For many years the domestic consumption of the cotton crop of tbe United States has been about equal to the foreign consumption. The tendency in recent years has been for the southern mills to take a larger proportion of the crop than the northern mills.

In conclusion, it may be of value to trace briefly the interactions upon one another of price, acreage, and production of cotton during the past five years, together with the prospects for the immediate future.

Recent Trends and Present Outlook.—The period of post-war deflation of cotton prices extended from the spring of 1920 to the autumn of 1921 and was disastrous to many cotton growers. In the latter year, prices began to ascend on account of the unusually small crop of that year and the upward trend of general business conditions. Moreover, the small crop of 1921 exerted a buoyant influence upon prices during the two subsequent seasons, on account of the depletion of stocks and the consequent unusually small cotton carry-over. The result was that cotton prices continued to show a marked upward trend during 1922 and 1923, thus bringing about a great increase in the cotton

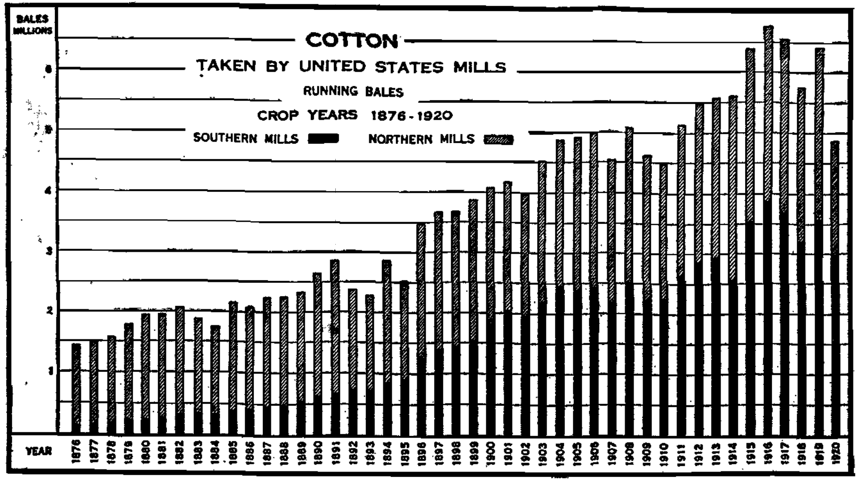

FIG. 86.—The consumption of raw cotton by the mills of the United States increased constantly from 1876 to 1916. The business depression last year caused a great reduction in mill consumption. The southern mills now use more than half the amount consumed in the United States.

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acreage in all cotton-producing areas both here and abroad. A number of European countries have exerted themselves in an attempt to discover new cotton lands or to extend the cotton areas in their colonial or provincial possessions. The result of the price stimulus during the three years mentioned has been greatly to increase the total acreage devoted to cotton and to bring the world production up to pre-war

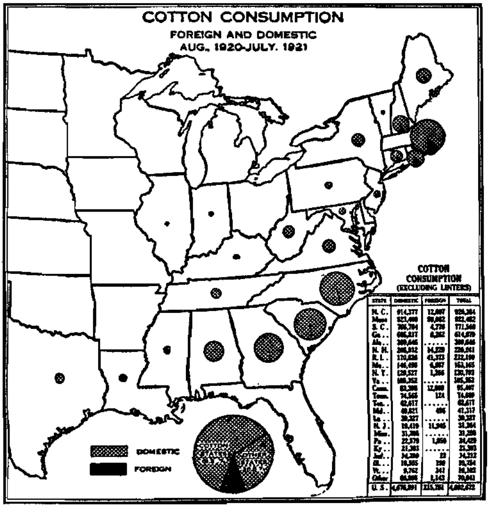

FIG. 87.—The mills in the cotton-growing states took 61 per cent of the total taken by the United States mills. Massachusetts, North Carolina, South Carolina, and Georgia are the leading States. Most of the foreign cotton was taken by the mills of New England.

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figures. During the past season (1925–1926) the production of cotton in the United States nearly equaled the record crop of 1914, but the acreage devoted to the crop in 1925 was nearly one-third greater than that of 1914.

The buying power of a pound of cotton to-day is but little, if any, greater than it was before the War; yet the psychological effect of the three past years of relatively high prices for cotton seems to favor the continuance of the abnormal acreage of the previous season. Should weather conditions prove favorable and insect infestations remain normal, the Cotton Belt will undoubtedly face a grave situation, due to over-production, during the present year (1926–1927), with a consequent further decline in prices.

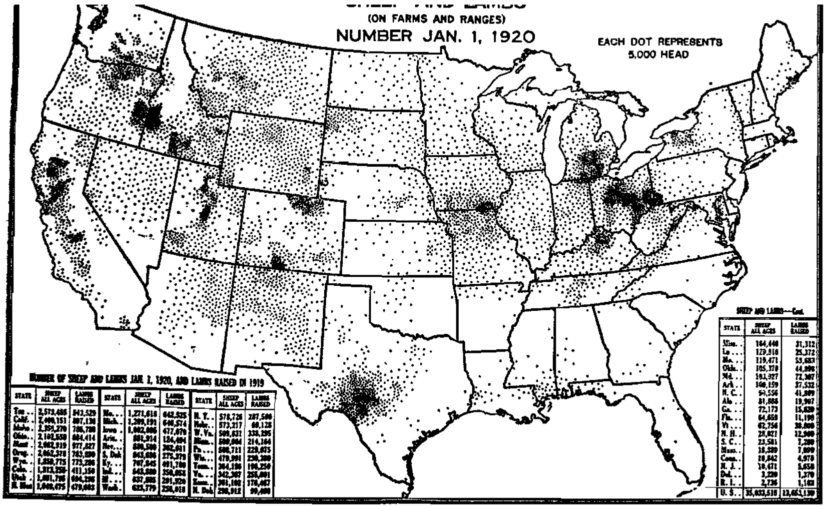
SHEEP AND WOOL

General Considerations.—Wool ranks next to cotton in importance among the fibers and has probably played a more important part than cotton in the spread of civilization. It is a poor conductor of heat, does not readily absorb moisture, and thus serves as excellent raw material from which to manufacture clothing for the rigorous winters in the more northerly portions of the middle latitudes.

On account of the relative non-perishability of wool and the life habits of the sheep, this industry is well adapted to regions remote from the centers of population. Sheep raising has therefore always been one of the world's leading pioneer enterprises. Although the pioneer aspect of the industry is passing away as means of communication and transportation become more highly developed, the above factors make it possible to keep sheep in regions which would otherwise be unutilized, such as the semi-arid regions of the world. This is due to the ability of the sheep readily to adapt themselves to a wide range of climatic conditions, to go for several days without water, and to utilize shrubby and weedy types of forage not consumed by most domestic animals.

Sheep production has become especially important in certain sections of the United States because of the foregoing factors. It is the most efficient means of utilizing the rough lands of southeastern Ohio, southwestern Pennsylvania, and the adjacent territory. In the Corn Belt area, sheep may be used to advantage in clearing fields and fence corners of weeds and in the utilization of forage that is not well adapted to other forms of livestock; and in the semi-arid portions of the West, from Texas to Canada, along with the rugged territory adjacent to and including the national forests, sheep production is of paramount importance.

History of the Sheep Industry in the United States.—Sheep were introduced into the English colonies soon after the establishment of the first permanent settlement. These were the mutton type of sheep which had been in process of development in England for a considerable



NUMBER OF SHEEP AND LAMBS JAN. 1, 1920, AND LAMBS RAISED IN 1919

STATE	SHEEP ALL AGES	LAMBS RAISED	STATE	SHEEP ALL AGES	LAMBS RAISED	STATE	SHEEP ALL AGES	LAMBS RAISED
Tex. . .	2,573,486	643,529	Mo. . .	1,271,616	642,525	N. Y. . .	578,726	287,500
Calif. .	2,400,151	807,130	Mich. .	1,209,191	640,574	Nebr. .	573,217	60,128
Idaho .	2,351,270	786,780	Iowa .	1,062,006	477,070	W. Va.	509,031	338,295
Ohio . .	2,102,550	684,414	Ariz. .	881,914	124,404	Minn. .	500,004	216,164
Mont. .	2,082,919	977,827	Nev. . .	806,500	302,911	Pa. . .	508,721	220,075
Oreg. .	2,062,370	783,890	S. Dak.	843,036	275,370	Wis. . .	479,991	238,380
Wyo. .	1,858,775	773,286	Ky. . .	707,845	481,700	Tenn. .	364,196	190,250
Colo. .	1,813,250	411,150	Ind. . .	643,800	350,058	Va. . .	342,307	255,001
Utah .	1,691,795	694,295	Ill. . .	637,065	291,920	Kans. .	301,198	176,487
N. Mex.	1,068,675	479,083	Wash. .	625,779	256,018	N. Dak.	298,912	90,480

SHEEP AND LAMBS—Con.

STATE	SHEEP ALL AGES	LAMBS RAISED
Miss. .	164,440	31,312
La. . .	129,816	25,372
Me. . .	119,471	53,683
Okla. .	105,370	44,096
Md. . .	101,327	72,307
Ark. . .	100,159	37,532
N. C. .	94,556	41,009
Ala. . .	81,066	19,907
Ga. . .	72,173	15,020
Fla. . .	64,650	11,190
Vt. . .	62,756	38,000
N. H. .	28,021	12,900
S. C. .	23,581	7,200
Mass. .	18,389	7,890
Conn. .	10,042	4,970
N. J. .	10,671	5,650
Del. . .	3,220	1,370
R. I. . .	2,736	1,160
U. S. .	35,033,516	13,653,130

FIG. 88.—Over 60 per cent of the sheep and lambs are in the western half of the United States, largely because sheep can graze on more arid lands than any other kind of domesticated animal, and also are less subject to disease in arid, than in humid climates. The dense spots shown in the West are owing in part to the date of enumeration, January 1, when many sheep are being fed in the irrigated districts, and in part of the enumeration of sheep in that county in which the owner resides, even though the bands of sheep be roaming over distant deserts. The following summer the same sheep may graze on the alpine meadows of the national forests

length of time. At the same period, sheep of the wool, or Merino, type were being introduced into the Southwest by the Spaniards. Within recent times the mutton type from the Northeast and the wool type from the Southwest have been blended to produce an animal which combines the mutton and wool qualities in such proportion as best to meet the demands of the market for both products. Since the development of the sheep industry in the United States, during most of our history, proceeded from the Northeast westward across the continent, it will be of interest to trace it briefly in a few of its most important stages.

Colonial Period.—While wool was of the utmost importance in the household economy of the early colonists and although colonial goverments exerted themselves to encourage the keeping of sheep, conditions in the colonies were not very favorable to sheep production, and the number of sheep increased but slowly. Predatory animals, Indians, and severe winters contributed to the hazards of the industry. While progress in sheep production was slow during the Colonial period, it was nevertheless steady, and even before the Revolutionary War there were a few communities whose output of wool exceeded local needs and entered into commerce.

Revolutionary Period.—Up to the time of the Revolution, woolen clothing continued to be imported from England. During this war, when the supply from England was in large measure cut off, there was a marked growth in the household industry. This gave a temporary impetus to the keeping of sheep.

Embargo Act and War of 1812.—After the Revolution, however, British woolens again appeared upon the markets until excluded by the Embargo Acts and the War of 1812. From 1807 to 1815 the number of woolen mills increased rapidly in this country in order to supply the grades of woolen goods better than homespun, which had hitherto been imported from England. During this period the infant woolen mills had almost perfect protection from European competition. Sheep production increased rapidly in response to the unprecedented demand for wool from these growing American mills. After the war American markets were flooded with woolen goods imported from Europe and a serious depression occurred in the sheep industry.

Tariff of 1816 Protective Tariff.—In response to the insistent demands of the newly established woolen industry for protection against this deluge of European goods, a protective tariff was enacted in behalf of these "infant" industries. This was virtually the beginning of the protective-tariff policy in this country, which has continued down to the present time. Many revisions have occurred in these tariff schedules, and each time the tariff on wool and woolen goods has played a prominent part.

Growth of Large Flocks.—The depression following the War of 1812 continued for several years, and consequently the sheep industry remained stagnant until the early 'twenties, when it began to improve. Between 1830 and 1837 the woolen mills doubled their outputs, a great demand for wool developed, and the sheep industry took on a new form. Instead of the small flocks designed primarily to furnish wool for home needs, large flocks became more and more common, especially among farmers who lived in the outlying districts.

Peak of the Sheep Industry: 1884.—Barring occasional set-backs, as, for example, the crises following the panics of 1837 and 1857, the sheep industry made rapid progress, until in 1884 it attained the highest point ever reached in this country either before or since. At this time the industry had also reached its highest point in the range country of the Far West, toward which it had been rapidly migrating since 1840.

During the period of greatest expansion of the western-range industry, wool production also was expanding rapidly in other parts of the world, especially Australia and Argentina. As it was generally impossible for eastern farmers to compete in wool production either with our West or with those countries, most of them were compelled to give up sheep raising or to turn their attention to the production of mutton.

By 1900 the sheep-producing areas of the country had practically attained the boundaries which they have retained with but slight modifications up to the present time.

World Distribution of Sheep

The southern hemisphere contains four of the six densest areas of wool and mutton production—Australia, New Zealand, Argentina, and South Africa; while the northern hemisphere contains the remaining two—the British Isles and the Mediterranean region.

Australia.—Although Australia has an area about equal to that of the continental United States, a much larger proportion of the island must be devoted to grazing, because of the fact that 60 per cent of its area has an annual rainfall of only 15 inches or less. In the semi-arid regions the shrubs and weeds are not suited to cattle and, as a consequence, the growing of the wool-type or Merino sheep is the main industry. In regions with somewhat larger rainfall, where farming is carried on to a considerable extent, cross-breeds of the wool and mutton types are becoming more important, with the result that Australia, in addition to being first in the exportation of wool, is now third in the exportation of mutton.

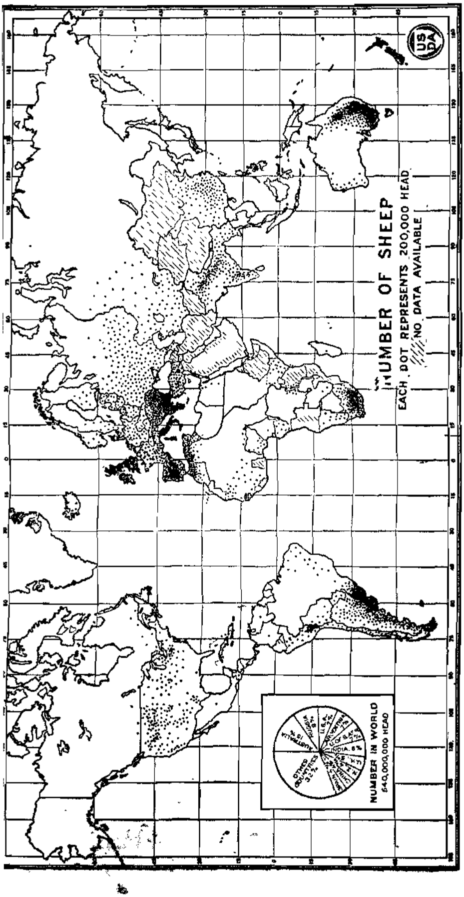


FIG. 89.—The leading sheep-producing countries are Australia, Russia, Argentina, United States, India, Union of South Africa, United Kingdom, and New Zealand. The distribution of sheep in Russia and the United States is less dense than in the other countries. Four of the six densest centers of sheep raising—Australia, the Argentine-Uruguay area, the Union of South Africa, and New Zealand—are in the Southern Hemisphere. These are relatively new lands with sparse population. In the Mediterranean countries topography and climate favor the sheep industry, which is seminomadic in character. In Great Britain the large area of pasture makes mutton and wool production a prominent industry in spite of dense population and high-priced land.

Agriculture Yearbook, 1923, p. 230.

Though, on the whole, the sheep industry in Australia is on a more stable basis than in the United States, largely because the public lands suitable for sheep raising are leased from the British Government for long periods of time, nevertheless the industry is subject to serious drawbacks as a result of natural causes. The most serious of the adverse natural conditions are prolonged droughts. Rabbits are also a serious pest in some sections, while in other regions prickly pear is destroying much of the range.

New Zealand.—Sheep raising has been the dominant industry in New Zealand since its settlement. In recent years, however, the dairy industry has been absorbing an increasing proportion of the land, labor, and capital resources of the islands. The conditions are ideal for dairying, as the climate is mild and a luxurious growth of forage available for grazing purposes prevails over most of the islands.

New Zealand leads in the production of mutton and exports an average of 250,000,000 pounds annually.

Argentina.—The number of sheep in Argentina has declined from a total of 80 million in 1880 to less than half that number at the present time. For some years the cattle and grain industries have been forcing the sheep industry to the more arid and outlying regions to the South and West, where the fine-wool Merino type prevails. However, about half of the total number of sheep in Argentina are still located in the Province of Buenos Aires, and these are all of mutton breeding. Argentina stands next to New Zealand in the exportation of frozen mutton.

British South Africa.—Except along the coast, the greater portion of South Africa is suitable only for grazing on account of the small rainfall which occurs mainly in the summer months. The Merino or fine-wool types are the dominant breeds throughout this region.

United Kingdom.—The sheep industry is generally associated with the outlying, sparsely populated, semi-arid regions of the world. The United Kingdom, however, serves as an important instance of a densely populated country, with abundant rainfall, whose agriculture consists largely of sheep production. England has played a prominent part in the improvement of animal breeding since the beginning of the Agricultural Revolution of the eighteenth century. In response to her own needs she has developed the mutton type of sheep, and large numbers of these have been sent to her colonial possessions and to other sheep-producing countries, for breeding purposes.

Mediterranean Lands.—The Merino or fine-wool breed of sheep was developed in Spain. The characteristics of this breed represent an adjustment to those climatic influences that make it necessary for the sheep to migrate, each spring, from the hot, dry lowland pastures into

TREND IN NUMBER OF SHEEP IN IMPORTANT COUNTRIES.

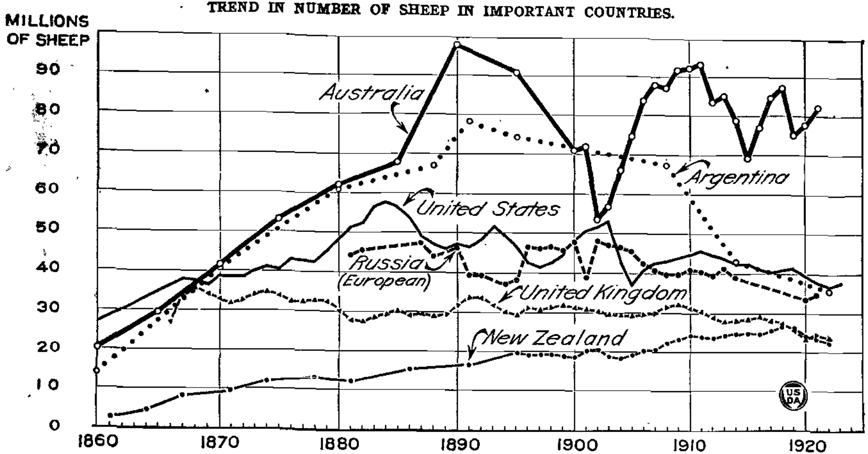


FIG. 90.—In Australia, the greatest sheep-producing country of the world, the number of sheep increased very rapidly from 1860 to 1890. Since 1890 wheat production and cattle raising have been displacing sheep. The sheep industry of Argentina is, likewise, giving way to grain production, and cattle raising. New Zealand continued to increase its number of sheep until quite recently, but dairying may soon check further growth of the sheep industry. Russia maintained a large number of sheep before the War, and there is a vast territory in Siberia and eastern Russia presumably *suitable for sheep raising*. The *United Kingdom, despite its dense population, still* maintains an important sheep industry.

Agriculture Yearbook, 1923, p. 231.

the northern mountains, to obtain summer grazing. As a result, the Merino has developed into a very hardy breed with fine quality of fleece, but with poor mutton qualities. As previously noted, Merino blood has been in demand for the semi-arid range lands of the outlying districts, in all parts of the world where such lands exist.

Sheep production has been from time immemorial an important industry in Asia Minor and in the Balkan Peninsula. This is due not only to the fact that the arid and semi-arid plains are better adapted

RELATION OF SHEEP TO POPULATION AND TO LAND AREA IN 11 IMPORTANT COUNTRIES.

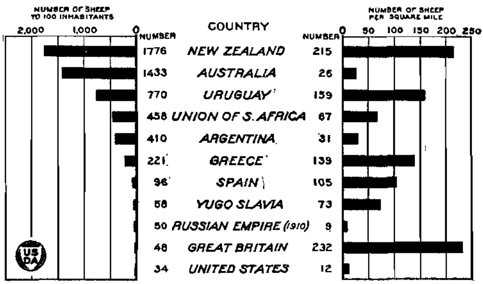


FIG. 91.—The leading countries in the number of sheep for each 100 inhabitants are all in the Southern Hemisphere. These countries are sparsely populated. Great Britain, although densely populated, leads in the number of sheep per square mile, New Zealand standing next. The Balkan States, represented by Greece and Yugo-Slavia, rank high both in number of sheep per inhabitant and per square mile. Spain, the home of the Merino, similarly stands relatively high. Russia, which is second in the total number of sheep, and the United States, which ranks fourth, both have a relatively low number of sheep per inhabitant and per square mile.

Agriculture Yearbook, 1923, p. 233.

to grazing than to any other form of agriculture, but also to the fact that the people of these lands have retained many of the nomadic habits characteristic of their ancestors.

Russia.—Before the War Russia stood second in the total production of sheep. This was due to her large area and not to the density of the sheep population. As in most other phases of Russian agriculture, little is known of the present situation of the sheep industry in that country.

Economics of Sheep Production

Breeding Sheep for the Market in the United States.—The prosperity of the producer of any farm commodity depends upon his alertness in discovering and meeting consumer demands. The sheep producer is confronted with a rather complicated problem in this connection. He is the producer of a joint product, wool and mutton. Circumstances of time and place may modify the relative demand for these two commodities.

Fine-wool Sheep.—Early in the nineteenth century the demand for fine wool encouraged the development of Merino sheep in the United States. New England, particularly Vermont, became famous for the heavy-shearing, wrinkled type, for in those days wool was paramount and mutton a by-product.

Mutton Sheep.—During the progress of the nineteenth century, however, two powerful sets of forces were at work which greatly influenced the sheep industry. One of these was economic, and the other physical. The economic forces tended to cause concentration of population in urban centers; the physical forces tended to attract the sheep industry to the range country of the Far West. The rapid increase in urban population stimulated the demand for mutton, whereas the great distance of the newly opened range lands of the West from these centers of population encouraged the production of fine wool. The westward extension of the railroad, and later the introduction of the refrigerator car, had the effect of bringing the western sheep nearer the eastern market. To meet the growing demand for mutton as well as wool, even the fine-wool breeders of the western range are now striving for mutton development in such cross-breeds as the Delaine Merino and the Rambouillet. Further to emphasize their mutton qualities, as well as to increase the size of the fleece, the above breeds are again frequently crossed with such heavy mutton and wool-producing breeds as the Shropshire and Lincoln.

Hazards in the Sheep Industry.—Losses in the range sheep industry, other than those due to changes in prices of wool and mutton, result from poisonous plants, predatory animals, parasites, straying from the band, and occasionally from the protracted droughts or unusually severe winters. Similarly, losses in the farming states are mainly caused by parasitic diseases. The annual losses on the ranges, from the causes mentioned above, average from 7 to 8 per cent. It is evident, therefore, that the costs of production of sheep can be materially reduced as these sources of loss are brought under control.

Financing the Sheep Industry.—The producer of sheep on the western range is a specialist and operates on a large scale. He requires considerable credit for the most economical conduct of his business. As a basis for loans, sheep possess both advantages and disadvantages. The advantages are that they mature rapidly, and the spring wool clip is usually sufficient to pay for maintenance costs. Sheep, therefore, pay themselves out more quickly than cattle. On the other hand, sheep are subject to a variety of losses as shown above.

The usual sources of credit in past years have been commercial banks, wool-warehouse companies and livestock-loan companies. These agencies are better adapted to the needs of the feeder or finisher of livestock than to those of the grower. As a rule, the term of the loan does not exceed six months. To serve better the needs of the livestock grower, the Agricultural Credits Act of 1923 contains a provision for an extension of the term of discount in the Federal Reserve System from six to nine months. It also provides for the establishment of twelve Federal intermediate credit banks with power to make discounts and advances for periods of six months to three years. The same Act also provides for the organization, under Federal charter, of privately financed and managed national agricultural credit corporations which have in view primarily the credit needs of the rancher or livestock man.

Marketing Wool.—Up to the middle of the last century, sheep were produced primarily for the wool. Whenever the wool market declined to a marked extent, compelling sheep producers to abandon the business, whole flocks were often slaughtered and the carcasses fed to hogs. Supply and demand forces over the entire world influence the price of wool; whereas, so far as the United States is concerned, only the supply and demand forces within the country influence the price of mutton. This is because wool may be kept almost indefinitely without deterioration and may therefore be transported great distances; while mutton must be frozen in order that it may be kept even as much as two or three weeks, and the American consumer does not like frozen mutton.

International Trade in Wool.—Separating the centers of production from those of consumption gives rise to marketing. Nearly half of the world's supply of wool at present is produced in the southern hemisphere. On the other hand, the greater part of the wool is consumed in the northern hemisphere, where the great concentration of population exists. The marketing of wool is, therefore, an important and complicated problem from an international standpoint.

The more common marketing agencies for bringing wool on the market are the country buyer, the country assembler, the central market dealer, the commission merchant, the broker, and the manufacturer.

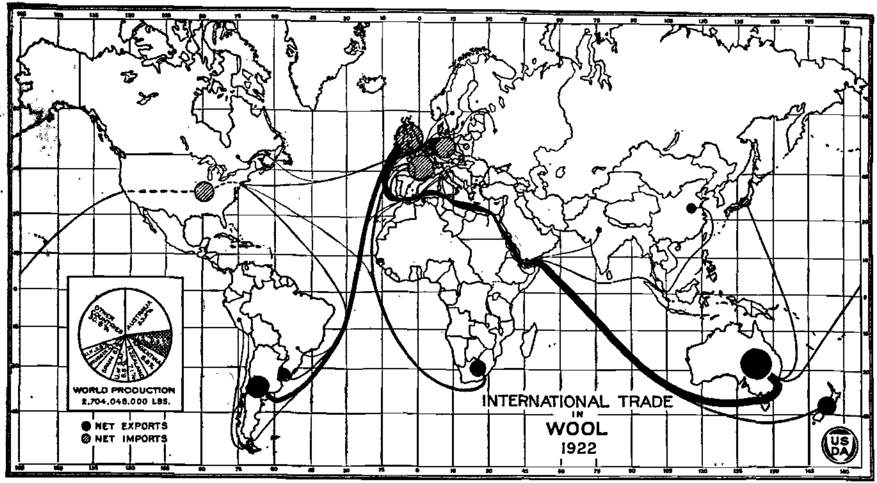


FIG. 92.—The heaviest exporters of wool are the sparsely populated, recently developed countries of Australia, Argentina, New Zealand, South Africa, and Uruguay. These countries supply the fine wools. Most of the carpet wools come from China, India, and western Asia. The heaviest importers of wool are the densely populated, industrial countries of western Europe and eastern North America. The wool trade largely centers in Europe. The United States imports much of its wool through London and Liverpool, but a smaller proportion than before the War.

Coöperative Marketing.—More recently, the coöperative idea has been applied to wool marketing, and it has made considerable progress, especially in the farm-flock areas. Here the wool is pooled and held for the inspection of the wool buyer. In the range country where the sheepmen are specialists and operations are on a large scale, the movement has not developed to so great an extent. However, increasing overhead costs due to rising land values, taxes, and other causes will doubtless soon force the ranchman to combine with his fellows in a more orderly marketing of his product.

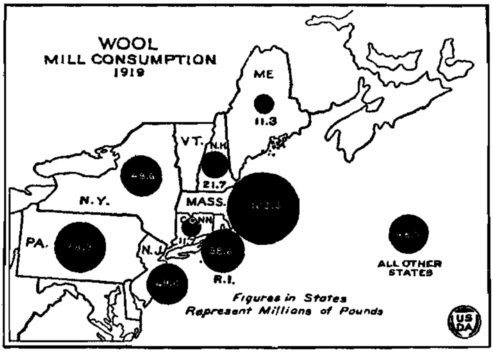


FIG. 92a.—The manufacture of woolen goods is very largely concentrated in the North Atlantic States. Ninety per cent of the mill consumption of wool in the United States is in these states. The industry centers mostly around Boston and Philadelphia. Massachusetts leads in consumption, manufacturing nearly a third of the total. The remaining 10 per cent of mill consumption is not reported separately by States in the census. The consumption in Vermont therefore can not be shown. The figures are based on mill purchases, part of which is in the grease and part scoured.

Agriculture Yearbook, 1921, p. 391.

No Public Market for Wool.—Although from 550 million to 750 million pounds of wool are handled annually in this country, there is no established public market for this commodity. Practically all of this vast quantity of wool is bought and sold by private agreement. Notwithstanding this fact, a very large proportion of the wool passes through two or three leading centers. That is to say, although there are no organized public markets for wool, the marketing of this product is perhaps more concentrated than that of any other important farm commodity.

Grades and Quality of Wool.—Commercial grades of wool are based on fineness or diameter of the fiber. Soil, climate, and feed, as well as breeding, have a far-reaching influence on the production of wool. In some sections of the western range where grass is sparse and sandstorms are frequent, fleeces of Merino and Rambouillet sheep may shrink as much as 65 to 75 per cent in grease and dirt when scoured or cleaned preparatory to manufacture; while fleeces from sheep of the same types, when grown on blue-grass pastures where sandstorms seldom or never occur, may shrink only 50 to 60 per cent. Such characteristics as strength of fiber, spinning property, and length of staple are also affected by the conditions of soil, climate, and feed.

Tariff.—The United States is a deficit wool-producing country. The American sheepman is, therefore, vitally interested in import duties on wool. As shown above in tracing the development of the sheep industry in the United States, the demand for a tariff on wool first arose in 1816 after the protection afforded by the Embargo Acts and War of 1812 had disappeared. A complete summary of the tariff acts from 1816 to the present time is given in Table XXIII.

Outlook.—The World War not only stimulated sheep production far beyond peace-time needs, so that at its close the world supply of sheep had greatly increased, but in addition there also developed an abnormal accumulation of both raw and manufactured wool, all of which contributed to the serious depression of prices in the wool industry during the general deflation period following the War. During the past three years, however, the recovery in the sheep industry has been marked, in distinct contrast to the slow recovery in the beef-cattle industry. The future of the sheep industry for the efficient manager appears to be unusually bright. There are no longer vast areas of unoccupied lands to be taken over for sheep production. The exploitive character of the business will have to give way to scientific husbandry, as population pressure relentlessly forces more economical utilization of land resources. The necessity of stability in production and prices will become greater as the capital investments in land and equipment rises. The sheepmen of the United States, therefore, like all other classes of specialized agriculturists, are facing the time when, in addition to practicing more scientific management upon their individual ranches or farms, they must also organize the industry as a whole. Increased attention must be given to such general problems as tariffs, general business conditions, and business cycles, in order to remove the industry, as far as possible, from the realm of chance to that of stability and prosperity.

TABLE XXIII

Rates of Duty on Wool Imports under the Tariff Acts 1789–1922*

Date of Act (and when Effective)	Rates of Duty
1789–1816	Free.
April 27, 1816 (July 1, 1816).	First act. 15 per cent ad valorem.
May 22, 1824 (July 1, 1824).	Value of 10 cents a pound or less, 15 per cent; other wool, 20 per cent until June 1, 1825; 25 per cent until June 1, 1826; 30 per cent thereafter.
May 19, 1828 (September 2, 1828).	4 cents a pound plus 40 per cent to June 30, 1829; plus 45 per cent to June 30, 1830; plus 50 per cent thereafter.
July 14, 1832 (March 4, 1833).	Value of 8 cents a pound or less, free; other wool, 4 cents a pound plus 40 per cent.
March 2, 1833 (January 1, 1834).	Duties exceeding 20 per cent to be reduced to 20 per cent by yearly reductions to July 1, 1842.
Sept. 11, 1841 (Oct. 1, 1841).	All rates below 20 per cent to be 20 per cent.
August 30, 1842 (August 31, 1842).	Value of 7 cents a pound or less, 5 per cent; other wool, 3 cents a pound plus 30 per cent.
July 30, 1846 (December 2, 1846).	30 per cent.
March 3, 1857 (July 1, 1857).	Valued at 20 cents a pound or less, free. All other, 24 per cent.
March 2, 1861 (April 2, 1861).	Value of 18 cents a pound or less, 5 per cent; value over 18 cents to 24 cents, 3 cents a pound; value over 24 cents, 9 cents a pound.
June 30, 1864 (July 1, 1864).	Value of 12 cents a pound or less, 3 cents a pound; value over 12 cents to 24 cents, 6 cents a pound; value over 24 cents to 32 cents, 10 cents a pound, plus 10 per cent; value over 32 cents, 12 cents a pound plus 10 per cent. Scoured wool, three times these rates.
March 2, 1867 (March 3, 1867).	Class 1 (clothing wool), value of 32 cents a pound or less, 10 cents a pound plus 11 per cent; value over 32 cents, 12 cents a pound plus 10 per cent. Class 2 (combing wool), value of 32 cents a pound or less, 10 cents a pound plus 11 per cent; value over 32 cents, 12 cents a pound plus 10 per cent. Class 3 (carpet wools), value of 12 cents a pound or less, 3 cents a pound; value over 12 cents, 6 cents a pound. Washed, Class 1, twice these rates; scoured, all classes, three times these rates.
June 6, 1872 (August 1, 1872).	All wools, 10 per cent reduction of former rates.
March 3, 1875 (March 4, 1875).	10 per cent reduction of June 6, 1872, repealed.
March 3, 1883 (July 1, 1883).	Class 1, value of 30 cents a pound or less, 10 cents a pound; value over 30 cents, 12 cents a pound. Class 2, value of 30 cents a pound or less, 10 cents a pound; value over 30 cents, 12 cents a pound. Class 3, value of 12 cents a pound or less, 2½ cents a pound; value over 12 cents, 5 cents a pound. Washed, Class 1, twice these rates; scoured, all classes, three times these rates.
October 1, 1890 (October 6, 1890).	Class 1, 11 cents a pound. Class 2, 12 cents a pound. Class 3, value of 13 cents a pound or less, 32 per cent; value over 13 cents, 50 per cent. Washed, Class 1, twice this rate; scoured, Classes 1 and 2, three times these rates.
August 27, 1894 (August 1, 1894).	Free.
July 24, 1897 (July 24, 1897).	Class 1, 11 cents a pound. Class 2, 12 cents a pound. Class 3, value of 12 cents a pound or less, 4 cents a pound; value over 12 cents, 7 cents a pound. Washed, Class 1, twice this rate; scoured, Classes 1 and 2, three times these rates; fit for carding or spinning, Class 3, three times these rates.
August 5, 1909 (August 6, 1909).	Class 1, 11 cents a pound. Class 2, 12 cents a pound. Class 3, value of 12 cents a pound or less, 4 cents a pound; value over 12 cents, 7 cents a pound. Washed, Class 1, twice this rate; scoured, Classes 1 and 2, three times these rates; fit for carding or spinning, Class 3, three times these rates. Foregoing rates are in the minimum tariff; the maximuml tariff is 25 per cent higher and is to be in force to March 31, 1910, and thereafter, unless the President by proclamation declares no discrimination by particular countries.
October 3, 1913 (December 1, 1913).	Free.
May 27, 1921 (May 28, 1921).	Clothing wool, unwashed, 15 cents a pound; washed, 30 cents a pound; scoured, 45 cents a pound.
September 21, 1922 (September 22, 1922).	Wool not improved by admixture with Merino or English blood, in the grease, 12 cents a pound; washed, 18 cents a pound; scoured, 24 cents a pound. If used for carpets, rugs, or other floor coverings, duty refunded. Other wool, in the grease or unwashed, 31 cents a pound of clean content; scoured, 31 cents a pound. (All rates subject to change by President after investigation of cost of production, domestic and foreign.)

* Agriculture Yearbook, 1923, p. 305.

HARD FIBERS FOR BINDER TWINE

Henequen.—Henequen fiber (sometimes but improperly called sisal) has been imported in steadily increasing quantities into the United States during the past forty years. The average annual imports of this fiber, which were 40,000 tons during the five-year period 1887–1891, had increased to an annual average of 148,000 tons during the four-year period of 1918–1921.

The two features of the henequen situation that are of especial interest to the American farmer are that this fiber constitutes the source of supply of the raw material used for the manufacture of binder twine, and that practically all the henequen imported into the United States is obtained from the States of Yucatan and Campeche, Mexico. The condition of their henequen industry, therefore has a very important bearing on the welfare of the grain-producing industry of the United States.

Importance in Yucatan.—The production of henequen is by far the leading industry of Yucatan. In value, this fiber constitutes about 85 per cent of the total exports, the others of importance being chicle gum and hides.

Both soil and climatic conditions of Yucatan are peculiarly well adapted to the cultivation of henequen, whereas they are ill adapted to the cultivation of most of the other staple crops of the tropics. Under these circumstances, the maintenance of the henequen industry in a prosperous condition is a matter of vital importance to the people.

Climate.—The climate of Yucatan is tropical, the lowest recorded temperature being 48° F. The precipitation is relatively low, approximately 30 inches per annum, and there is a long dry season. These conditions are favorable for henequen, although occasionally during an exceptionally long dry season even this hardy plant suffers some injury. It would be difficult to find any other staple tropical crop so well adapted to the climatic conditions in the northern part of Yucatan.

Topography and Soil.—The area used for henequen production has a relatively flat and somewhat broken topography. The soil is largely composed of a porous, partially decomposed limestone in which there are numerous pockets, and in places a thin fertile covering. The land is so rocky that trees can not be planted until holes have been blasted for them to grow in, and frequently even the small henequen suckers are propped up with small stones in places where there is practically no soil. Under these conditions the profitable cultivation, on a commercial scale, of any other crop would be exceedingly difficult if not impossible. These unusual soil conditions, however, are practically ideal for henequen. Most of the planters believe that the fertile soils are not favorable for this crop. One objection to its cultivation in such soils is the increased cost of keeping down the weeds and undergrowth, which grow very quickly in this country even on rocky lands.

Plantation Organization and Management.—In the early years of henequen production on plantations, prices were high and large profits could be obtained even with poor management. In more recent years, competition with other fibers has brought down the price of henequen, and costs, including labor and equipment, have greatly increased, thus making good management essential to success.

The statistics on the number and size of plantations are not accurate, the total number of henequen plantations in Yucatan being variously reported to be anywhere between 200 and 850, according to what is considered a plantation. The great majority of these plantations produce less than 200,000 pounds of fiber, while a few produce 1,000,000 pounds or more. More accurate statistics of acreage, with respect to the age of the plants, would be desirable as a basis for estimating the production during the next six years. The young plants do not yield fiber until six or seven years after they are set in the field, and the old plants yield reduced quantities, so that under normal conditions it is not profitable to harvest leaves from them.

Production of Henequen and Imports into the United States.—The following table shows the world production of henequen since 1901 and the proportion produced by Mexico, together with the imports of the raw product into the United States.

TABLE XXIV

HENEQUEN PRODUCTION

Years	World Production, Short Tons	Mexican Production, Short Tons	Per Cent Produced by Mexico	United States Imports of Raw Henequen	Years	World Production, Short Tons	Mexican Production, Short Tons	Per Cent Produced by Mexico	United States Imports of Raw Henequen
1901...	....	105,600	100	70,076	1912...	195,230	169,230	86	157,478
1902...	....	108,000	100	89,583	1913...	207,019	181,019	87	163,424
1903...	....	123,633	100	87,025	1914...	231,086	205,086	88	213,048
1904...	....	126,243	100	109,214	1915...	211,109	186,109	87	183,542
1905...	....	128,366	100	100,301	1916...	243,300	217,300	89	221,126
1906...	....	123,182	100	98,037	1917...	195,796	165,100	84	143,871
1907...	....	127,964	100	99,061	1918...	210,390	160,640	76	151,876
1908...	....	137,452	100	103,994	1919...	176,320	143,465	81	144,542
1909...	....	118,768	100	91,451	1920...	223,133	187,063	83	180,759
1910...	....	127,348	100	99,966	1921...	143,657	113,675	78	115,722
1911...	172,100	146,100	85	117,727	1922...	122,138	92,138	73	79,458
					1923...	....	....	....	100,032

Need of Price Stabilization.—Much might be said of the importance to the Mexican producer of stabilizing the price of henequen. When prices fall he tends to stop stripping the plants, and they are permitted to bloom and die. When prices advance to a high point, cultivation is over-stimulated, excessive production is brought about, and collapse of price is inevitable. Neither of these results is of benefit to the American consumer, who is chiefly the American farmer, and he must look with sympathy upon plans which are intended to bring about a fair return to the Mexican farmer and to maintain an even and progressive flow of production to meet the American demand.

Abaca.—The best and highest-priced grades of binder twine are made of abaca (sometimes but improperly called manila hemp). The abaca fiber of commerce is obtained exclusively from cultivated banana-like plants.

Climate and Soil.—The industry is almost completely confined to those portions of the Philippines and Java where the climate is moist and warm and where the soil is fertile, deep and loamy, of rather loose texture, and well drained. A rainfall of 60 inches or more is required, and this must be so distributed throughout the year that there is no severe drought at any season. Many of the best plantations in the Philippines are on volcanic soils, near the bases of mountains sloping South and East, where there is abundance of rain, good drainage, sunshine, and protection from strong winds.

Grades.—Twelve different grades of abaca are quoted on the market, the differences resulting chiefly from greater or less care in cleaning and preparing the fiber. Most of the *pure manila* binder twine is made of the *midway* or medium grade.

Other Hard Fibers.—Other hard fibers used in a limited way in making binder twine, chiefly for mixing with henequen or abaca, are sisal, hemp, phorium, manila maguey, miscal maguey, cabuya and mauritius.

Jute.—Jute is the cheapest of all fabrics and ranks with henequen and abaca as a commercial fiber. It can be grown in a number of countries, but its production is confined almost exclusively to eastern Bengal in the vicinity of Calcutta. Here, with the periodically over-flowing Ganges, there is the right combination of tropical climate, flooded land, and cheap labor. Jute is an annual with long slender stems, 8 to 12 feet high. Only three months elapse between the transplanting of the seedlings and the harvest.

Like hemp or flax, jute fiber is separated from the stalk by soaking in water from four to thirty days, after which the bark is stripped off by hand and the fiber separated from the plant tissue by beating the stems upon the surface of the water.

The yield of jute is from 1200 to 3000 pounds per acre. The United States imports from 60,000 to 100,000 tons annually. Jute normally costs less than 4 cents a pound, delivered in America. The relative cheapness of products made from this commodity is largely due to the ease with which the fiber may be woven into fabrics.

Jute fiber is used mainly for the manufacture of gunny sacks, bagging, carpets, and the like.

Flax.—Two important articles of commerce are produced from flax: oil from the seed, and fiber from the stem. In general, the type of plant that produces oil is not so good for fiber, and *vice versa.*

Natural Factors in Flax Production.—The most favorable natural conditions for fiber flax are a cool, moist climate and fertile loam soils with good drainage. Hot, dry weather checks its growth, and a severe drought ruins the plant for fiber production.

Areal Distribution and Production of Flax.—Flax is one fiber in the production of which the Continent of Europe predominates. Japan is the only important non-European producer. The production of flax in the principal producing countries, for the period 1909–1913 and the years 1921, 1922, and 1923, is shown in the following table:

TABLE XXV

FLAX STATISTICS FOR IMPORTANT COUNTRIES*

Country	1909–13 Acreage, 1000 Acres	Per Cent of World Total	1909–13 Seed Production, 1000 Bu.	Seed Production, Per Cent of World Total	1909–13 Fiber Production, 1000 Bu.	Fiber Production, Per Cent of World Total	1923 Seed Production, 1000 Bu.
Argentina	4,113,434	25.93	31,117	28.17	....	....	58,584
India	3,818,080	24.07	19,870	17.99	....	....	21,320
Russia*	2,789,082	17.58	16,861	15.27	694,756	54.64	11,023
United States	2,489,800	15.70	19,543	17.70	....	....	17,060
Canada	1,034,874	6.52	12,040	10.90	....	....	7,140
Lithuania*	143,257	0.90	1,126	1.02	49,703	3.91	1,056
All Others	1,474,784	9.30	9,885	8.95	527,004	41.45	....
World Total	15,863,311	100.00	110,442	100.00	1,271,463	100.00	116,183

* Estimated for present territory.

International Trade.—Much of the flax produced in these countries is consumed within the producing country, although before the War Russia exported large quantities. Belgium, Germany, and the United Kingdom are the principal importers of flax.

Uses.—The flax fiber is used chiefly in the manufacture of linen thread and cloth. Ireland produces the largest amount and the best quality of linen. Other important producers are England, Scotland, Belgium, France, and Czechoslovakia.

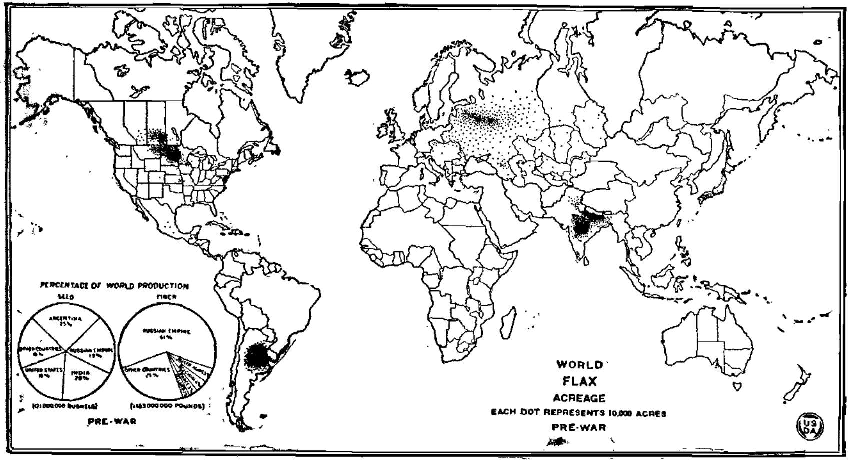


FIG. 93.—Pre-war flax acreage of the world and chief producing countries. Four centers of flax culture are to be noted—central North America, Argentina, Russia, and India. In pre-war production of seed flax the five leading countries in order were Argentina, India, the Russian Empire, the United States, and Canada. The maximum world production of flaxseed was reached in 1912 and 1913, according to available statistics, when over 130 million bushels were produced each year.

Agriculture Yearbook, 1922, p. 534.

SILK

History.—The first silk was probably produced in China, and many interesting legends are associated with its early history. In spite of the reported vigilance of Chinese officials, who desired to confine the silk industry within the nation, it spread at an early date to India and Japan, and thence at later periods to other parts of the world.

Areal Distribution and Production of Silk.—The following table shows not only the parts of the world in which the production of raw silk is carried on, but also the amount of the commodity produced in the principal countries engaged in this industry.

TABLE XXVI

WORLD PRODUCTION OF RAW SILK *
(In thousands of pounds)

Country	1909–13	1919	1920	1921
Total	63,466	76,577	74,982	67,843
Japan	29,318	52,578	48,230	45,642
China †	17,463	14,474	19,278	12,379
Italy	8,523	5,942	4,045	7,330
Levant	5,832	2,293	2,293	1,654
France	990	540	331	551
Austria	726	331	331	....
Others	614	419	474	287

* "Some Great Commodities."
† Exports only.

Consumption.—The United States is the principal consumer of raw silk, but is not able to produce it because of the great amount of cheap labor required. The manufacture of silk, however, is mostly accomplished with machinery and requires relatively little labor, so that much of the raw silk is made into cloth in the United States. Women and children are largely employed in the silk manufactories. New Jersey, Pennsylvania, and New York have the largest silk mills in the world, and the United States absorbs more than half of the world's supply of raw silk. A tariff protects the industry, and the increasing home demand for silk goods gives it a very bright outlook.

The following table shows the amount of raw silk available for consumption in the principal silk-manufacturing countries of the world. These figures show the amount of raw silk used in the factories of these countries and should not be construed to mean the amount of finished product consumed.

TABLE XXVII

CONSUMPTION OF RAW SILK BY COUNTRIES*

(In Thousands of pounds)

Country	1909–13	1919	1920	1921
United States	22,632	44,329	29,259	44,871
France	12,684	11,210	8,832	5,493
Japan	7,117	17,314	26,008	12,566
Germany	8,713	....	2,246	2,549
Italy	4,658	3,757	3,407	2,469

* "Some Great Commodities."

Artificial Silk.—An imitation of silk, called cellulose silk, is made by means of a chemical process in which sawdust or cotton waste is converted into a jelly-like mass, similar to the mucilage from which the silkworm makes its cocoon. This jelly is forced, by means of air pressure, through very small apertures in glass, which, make the filaments as fine as silkworm strands. These are reeled into a silk thread, as is done with the cocoons, several filaments being used to make a thread. The making of artificial silk originated in France, and from there it has spread to all silk-manufacturing countries. The thread is not as strong as genuine silk and not as durable, but it is only about half as costly and can hardly be distinguished from the real article. Its use as a substitute for silk for a number of purposes is progressing rapidly, and it is bringing articles made of silk within the reach of large numbers of people who previously were unable to afford them.

EXCERCISES

1. Referring to Fig. 94, suggest reasons for: (a) the wide fluctuations in the yield of cotton per acre; (b) the increasing acre yields up to about 1907 and the declining acreage yield since that date; (c) the trend in total production.

2. What advantages and disadvantages exist in the following countries for the extension of cotton production: Brazil, China, East Africa, India, and Australia?

3. Referring to Fig. 90, explain the trend of sheep production in Australia, Argentina, United States, Russia, United Kingdom, and New Zealand.

4. What influence will the penetration of railroads and farming into the interior of Australia have upon the sheep industry?

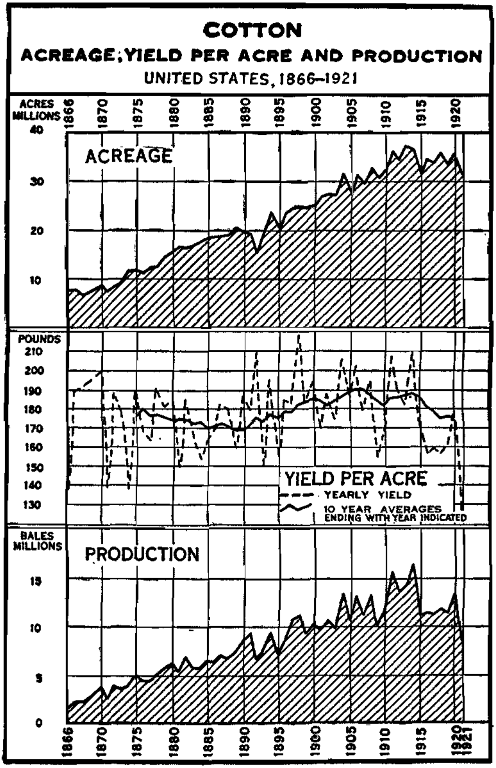


Fig. 94.—The acreage of cotton expanded rapidly from 1866 to 1913. The trend since 1913 has been downward. The yield per acre varies greatly from year to year, the trend was upward from 1890 to 1907 and has been downward since the latter date, and last year was the lowest recorded. The crop of last year was the smallest since 1895.

Agriculture Yearbook, 1921, p. 336.

5. Explain the downward trend of sheep production in Germany. (See Clapham, The Economic Development of France and Germany.)

6. Explain the localization of henequen production in Yucatan and of jute production in the lower Ganges valley.

7. What physical factors obtain in the fiber-flax producing areas? In the seed-flax producing areas?

8. On pages 18 and 19 of the Cotton Section, Atlas of American Agriculture (published by U. S. D. A.), are given figures of cotton production and cotton exports from 1790 to 1915. Average these for ten-year periods and construct a bar diagram to represent the data.

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CHAPTER XIII

OUR TIMBER RESOURCES

Original Area.—Our forests originally covered an area of approximately 822 million acres, or two-fifths of the total land area of the United States. The original stand is estimated to have been not less than 5200 billion board feet.

Present Area.—Our forest land area is now estimated at 468,600,000 acres, of which 138,000,000 acres is virgin timber; 113,000,000 acres a second growth of saw-timber size; 136,400,000 acres is second growth of cordwood size; and 81,200,000 acres is forest desert, or land originally forested but now divested of forests and bearing no vegetation of economic significance.

FOREST REGIONS OF THE UNITED STATES

Northeastern.—The northeastern white pine forest extended from Maine across to New York, Michigan, Wisconsin, and Minnesota. It embraced an area of about 150 million acres and an original stand of merchantable timber estimated at 1000 billion board feet. Other types of trees included in this area are red pine, spruce, hemlock, cedars, and some hardwoods as in Wisconsin and Michigan.

Southeastern.—The yellow-pine area is in the Southeast and originally consisted of about 220 million acres. The stand of timber is estimated to have been approximately 1000 billion board feet. In this region is found, in addition to the yellow pine, the cypress, gum, magnolia, tulip, and oaks.

East Central.—About 252 million acres in the east central section of the United States was originally covered with forests of hardwoods. The initial stand of this timber amounted to approximately 1400 billion board feet. Among the different varieties of trees in this section are the oak, maple, ash, elm, hickory, walnut, and basswood.

Rocky Mountain.—The total area in this section, which is not in one continuous strip but is composed of scattered patches, amounts to 110 million acres. The original stand of timber in this area was

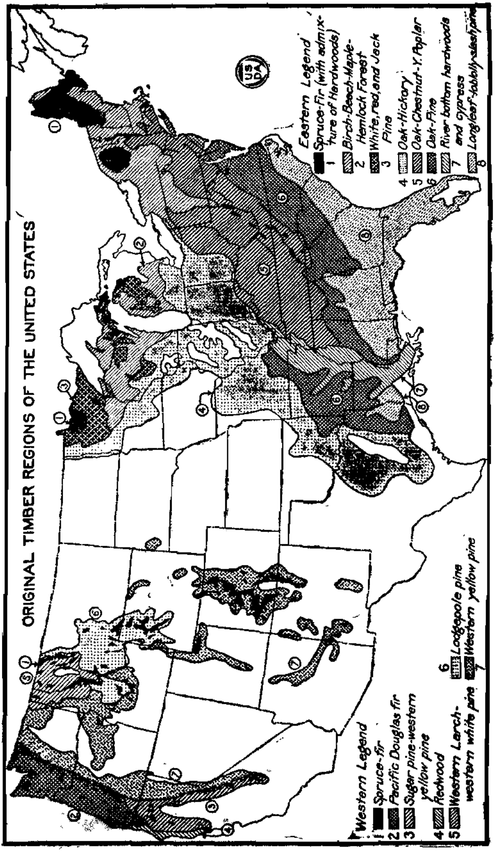

FIG. 95.—The original eastern forests formed 83 per cent and the western 17 per cent of the total. Of our present forest land the East has 75 per cent and the West 25 per cent. But the West now has 61 per cent of the remaining saw timber supply.

Agriculture Yearbook, 1922, p. 85.

approximately 400 billion board feet and consisted of several varieties of pine, red cedar, spruce, and Douglas fir.

Pacific.—The three Pacific Coast States originally contained a forest area of 90 million acres with an estimated timber stand of 1400 billion board feet. On account of the favorable climate, the trees in thick stands have grown to mammoth size, which accounts for the extraordinary forest resources of this section.

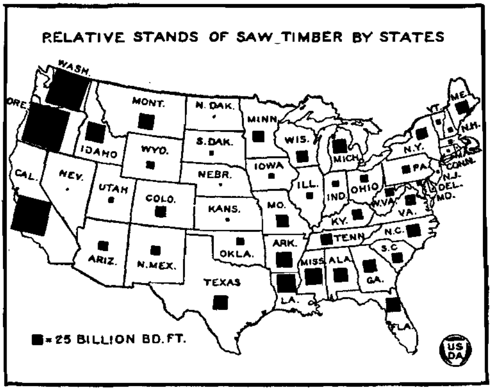

FIG. 96.—Most of our standing timber is in the South and West. The Middle Western and Northeastern States, though our largest consumers of timber are far from producing the timber they use.

Agriculture Yearbook, 1922, p. 87.

THE EXPLOITATION OF FORESTS

Farmers.—The systematic timber destruction practiced by the pioneers did not cease until about 1880, when the removal of timber by lumber companies had reached such momentum as to equal the demand for new lands for agricultural purposes. From that time onward, timber was no longer cut to be destroyed in order to furnish more farm land, but to be utilized in our rapidly growing industries. Since 1880, as we shall observe later, forest denudation has occurred much more rapidly than the land could be absorbed for agricultural purposes.

It is estimated that, up to 1880, the timber from approximately 150 million acres, or nearly one-fifth of our original forests, was completely destroyed in order that the land might be used to build farms. This process of wanton destruction of timber, for which during many generations there was no market, in order that the land might be used for a higher purpose, was entirely justified on economic grounds during much of the period in which it was practiced. But there can be no doubt that the practice continued for many decades longer than was economically desirable on the basis of a long-time point of view of timber supply and proper land utilization. The false psychology engendered was that we had an inexhaustible supply of timber, that under all

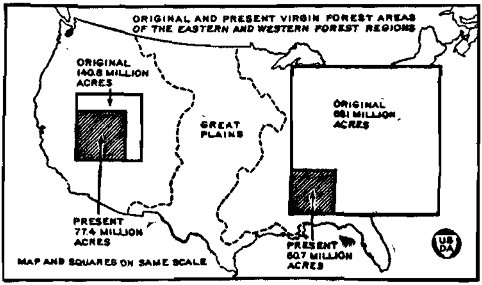

FIG. 97.—Only a remnant of the original Eastern forest remains, and nearly half of the virgin forests of the West have gone.

Agriculture Yearbook, 1922, p. 88.

circumstances forests were an obstacle to be removed by the readiest means at hand, and that all land was properly destined to be put under the plow. Three centuries of action under this philosophy naturally makes it difficult to stem the tide and to produce a strong current in the opposite direction, even with a timber famine inevitably staring us in the face and a relative superabundance of cut-over land poorly adapted to agricultural purposes.

Migration of Timber Destruction.—Up to 1850, New England and New York were the centers of lumber production. By 1860, Pennsylvania had reached her zenith of timber production. During the 'eighties and 'nineties, Michigan, Wisconsin, and Minnesota had risen, flourished, passed their peak, and were on the downward trend of timber production. More recently, since the beginning of the present century, the great timber resources of the South have suffered a like fate. The great burden of supplying timber for vast and growing industrial enterprises, the requirements of which, in spite of the use of substitutes, is increasing year by year, now rests largely upon our final timber reservoir in the extreme northwestern corner of the country, 2500 miles or more from the principal points of consumption. When it is considered that 75 per cent of our lumber supply now comes from our virgin forests, it will be apparent how serious this drain is coming to be.

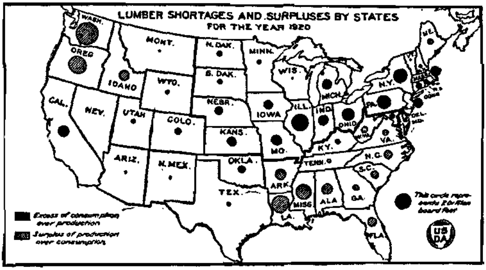

Fig. 98.—Our greatest industrial and food-producing regions—the area north and east of the heavy line—cut only 23 per cent of the lumber they use and must ship in 77 per cent, chiefly from the South and far West.

Agriculture Yearbook, 1922, p. 118.

Lumber Industry.—During the past fifty years, the exhaustion of our forests is no longer attributable to the destruction of timber in order to make room for farms, but to the loss and waste attributable to the operations of the lumber industry.

CONSERVATION OF FORESTS

Lest there be misunderstanding, it should be repeated that the activity of generations of farmers in ridding their land of trees and destroying the saw logs does not leave them open to censure in any way. Likewise, the more recent failure of lumber companies to utilize forest materials fully should not be condemned indiscriminately. It must be kept in mind that economic considerations set limits upon the degree to which forest materials may be utilized.

Waste.—On the other hand, to the extent that lumber companies fail to utilize materials that might profitably be used, or to equip themselves with efficient machinery in order to avoid waste, they are justly subject to public condemnation.

Fires.—Perhaps the greatest single cause of timber waste is attributable to forest fires. Not only is there an immediate waste of timber, but the seedling trees are frequently destroyed, second-growth trees are retarded, and in extreme cases the organic matter on the surface of the soil is so disturbed as to interfere with the development of new growth. The National Conservation Commission in 1908 estimated the annual loss of merchantable timber by fire since 1870 at $50,000,000, approximately 90 per cent of which was economically preventable and was therefore waste.

Public Attitude.—The public has up to the present time been indifferent to the forestry situation, in spite of the fact that forest depletion is immediately responsible for much of the distress complained of in our every-day affairs. As in many other instances in current life, the public fails to connect grievances with their true causes. Not only is the high cost of homes and furniture directly attributable in a large measure to forest exhaustion, but the products of all industries that utilize wood in any form—and that includes most of them—are higher in price because of the mounting costs of all forest materials. Thus forest exhaustion is an important contributing cause to general high costs of commodities.

The rapidly rising prices of timber products are certain soon to break down public indifference to forest conservation. The need for flood control, stabilization of stream flow, and prevention of gully erosion, related as these things are to forest conservation, is also helping to focus public attention upon the problem.

National Forests.—The first big step toward forest conservation was taken by the Federal Government through the establishment of our national forests. In 1891 the first reserve was set aside by President Harrison, the principal objectives being to prevent the destruction of the forest cover in order to maintain uniformity in stream flow, and to provide a source of merchantable timber. Since then many additions to the reserve have been made in the administrations of Presidents Cleveland, McKinley, and Roosevelt, so that at present the Federal Government owns 89 million acres of forest land, located mainly in the Rocky Mountain States. In addition, the Government owns about 70 million acres of commercial timber or timber-growing land in Alaska, of which 20 million acres are in national forests, while the remainder in the open public domain receives no protection from fire and no attention to timber growth. In 1897 the Division of Forestry was established and Gifford Pinchot was made Chief.

Administrative.—The national forests are administered with a view to securing the most efficient utilization of timber, water, pasture, and other resources, by those who have the best right to them. Upward of 2 million tourists visit them annually, and more than 800 hotels and 1500 stores have been built for the convenience of the public. The mineral resources are open to development, as on unreserved land, and the mining population amounts to between 35,000 and 40,000. Grazing land is leased to stockmen, and the mountain streams are utilized for power development, between 80 and 90 plants having been erected. Careful management of the national forests includes not only the reduction of fires, the replanting of trees, and the growing of nursery stock, but also the sale of all merchantable materials for which there may be a market.

Weeks' Law.—The foregoing discussion of our national forest policy relates to the situation as it existed between 1891 and 1911. The Weeks Law, enacted in 1911, initiated the policy of Federal purchase of forest lands in the eastern states and also made available limited funds for coöperative work with the various states in the protection from fire of state and privately owned forest and cut-over lands.

Clarke-McNary Law.—During the past four years Congress has manifested increasing concern over the lack of reforestation on the immense acreage of non-agricultural land in private ownership. This concern finally resulted in the passage of the Clarke-McNary Forestry Law during June, 1924. The policy of the United States, under the provisions of this law, is to assist, through coöperation with the states, in the protection and proper management of timber-growing land under private ownership. The objectives are, in part, summarized as follows in the Annual Report of the Federal Forester, Colonel W. B. Greeley, for the fiscal year ending June 20, 1924:

Greeley's Report.—The outstanding event of the year in national forestry was the enactment of the Clarke-McNary Law on June 7, 1924, which takes its place with the Weeks Act of 1911 and the earliest legislation authorizing the creation of forest reserves from the public domain as a milestone of progress. For many years the efforts of the Federal Government toward the goal of forest conservation dealt largely with the timber lands in the public domain and the subsequent extension of Federal ownership to the areas where it was urgently needed in the Eastern States. To establish the National Forest enterprise as a practical and permanent public undertaking was the great accomplishment in forestry of the first two decades of this century. As a Federal Activity it had to precede an attack upon the still larger task of bringing about the growing of timber on nearly 400 million acres of land not owned by the public but from which probably 80 per cent of our forest products must come in the long run. On the extension of forest practice over these lands the country must rely largely for balancing its current consumption of timber by replacement through new growth. The Clarke-McNary Act, while confirming and expanding the policy of national forest ownership, strikes directly at the lack or inadequacy of forest production on private land. The new law has thus built an important enlargement into our national forestry structure.

Commercial forces are now placing a powerful pressure behind the practice of forestry by private landowners. Two great obstacles

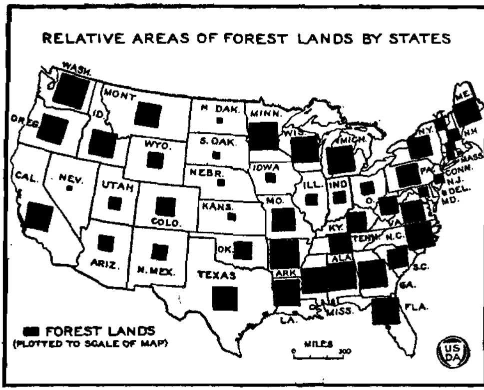

FIG. 99.—Though the original forests have largely disappeared, we still have plenty of forest land, if rightly used, to grow the timber we need; and the most of this land is in the East, where the timber is most needed.

Agriculture Yearbook, 1922, p. 89.

in the path of this economic development are (1) the fire hazard to which forests are subject and (2) the danger of taxation that will make timber growing unremunerative. The Clarke-McNary Law strikes at each of these obstacles, with the purpose of clearing the way so that commercial timber growing may go forward with the greatest possible momentum. It provides for nation-wide coöperation between the Federal Government, the states, and private forest owners in organized protection of all the forest lands in the United States. It extends the coöperation in this field previously afforded by the Federal Government under Section 2 of the Weeks Act, by removing its limitation to the watersheds of navigable streams and by crediting private expenditures for forest protection which are made in pursuance of state laws under state supervisions in the division of cost between the Federal Government and the states. The Federal Government will approve the essential requirements in fire organization and protection methods to be followed by the coöperative states, in order to insure efficiency in accomplishing the objects of the national policy. One of the these requirements will be uniformly that areas containing young forest growth shall be protected as fully as tracts of merchantable timber, since the primary object of the law is to increase the production of wood for future requirements. An appropriation of $2,500,000 annually is authorized for forest protection, which it is estimated represents about one-fourth of the cost of adequately safeguarding the state and private lands of the country from fire.

A second feature of the new act provides for a comprehensive study of forest taxation, in coöperation with the states and other appropriate agencies, and devising tax laws adjusted to the economic needs of timber growing. The prevailing system of property taxes, as applied to forest, results in the continuous taxation of timber in all stages of growth and piling up a heavy financial burden upon forest production long before it yields a return. Such taxation creates an obstacle, part financial and part psychological, in the way of private reforestation. Unless extremely moderate, as it is in some portions of the United States, it may largely defeat private reforestation. Exemptions or bonuses designed to promote timber growing where it is not economically feasible are unsound. Forestry must stand upon a solid economic footing and must pay its share of community revenue. The problem is rather one of adjusting the methods of taxation to the long-time nature of timber crops so as to permit landowners to take advantage of an economic opportunity where it exists.

Approximately 80 per cent of the area suitable and necessary for timber production in the United States is in private ownership and it is very likely that private capital will own at least 70 per cent of our timber-growing land in the future. Renewal of timber on this vast acreage and the proper management of such forests constitutes over three-fourths of the problem involved in providing future timber supplies. The Federal Congress recognized this situation by making private participation in reforestation and forest management the principal objective of the Clarke-McNary Law. This law aims to make conditions favorable for the private practice of forestry through financial aid to timbered States in developing adequate forest protection organizations and through coöperation with the states in a thorough study of the problems associated with the equitable taxation of land devoted to forest production and the timber crops produced on such areas.

It is estimated that four-fifths of our future timber supplies will be grown in the timbered regions of twenty-two states, as these states contain the bulk of non-agricultural land suitable for the production of desirable lumber material. The remaining twenty-six states are, obviously, equally interested in the proposition of rebuilding our forest resources for these states, and, being largely non-timbered, will be the first to suffer during a period of timber scarcity. The enactment of the Clarke-McNary Law commits the Federal Congress to the policy of participation in the forest-fire prevention and control work to the extent of 25 per cent of the total cost of such work on the timber-growing land in the United States. Under this plan, states in the Great Plains region, and other states having a very small amount of timber-growing land, will contribute to the cost of renewing forest growth in the twenty-two states containing the bulk of our forest land.

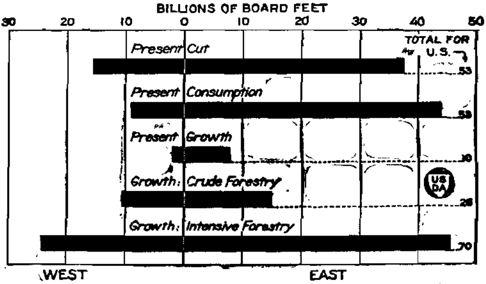

FIG. 100.—Although we are going to the West for more and more of our lumber and other products cut from saw timber, the bulk of the consumption is in the East; and the East should, in the future, grow two-thirds of our saw-timber supply.

Agriculture Yearbook, 1922, p. 146.

Forest Administration.—At the present time, of the 470 million acres of forest land in the United States (excluding Alaska) 89 million acres are owned by the Federal Government; almost 9 million acres by states; and 450 thousand acres by municipalities. The remainder, or 371 million acres, is owned by private individuals or companies. Of this, 150 million acres are farm wood lots and 221 million acres are owned by lumber companies, mining companies, railroads, and others who have no permanent interest in the land except as timber growing promises commercial profits.

As the virgin timber supplies are exhausted we shall become more and more dependent upon the amount and character of the timber we actually grow. This dependence at the present time would mean a reduction in our annual use of wood from 22½ to 6 million cubic feet. By the simplest measures, consisting mainly of fire protection, we can ultimately increase production on our present area of forest land to

14 billion cubic feet, so that it would be necessary to reduce the present consumption by somewhat less than half. By intensive forest culture we can balance or even increase our forest consumption of wood. Up to the present time, however, stable forms of forest ownership favorable to timber growth have lagged far behind the rate of forest denudation.

Fires.—Even fire protection is only about 30 per cent efficient; between 1918 and 1922 an average of 33,500 fires occurred annually, burning over more than 7 million acres of forest land. Notwithstanding this fact, forest protection has made enormous strides since 1910.

Insects and Diseases.—Losses due to insects and diseases are also taking a tremendous toll, annually running into millions of dollars. As in the case of fires, the Federal Government, the states, and private individuals are beginning to coöperate to fight the pests. The funds provided have hitherto been totally inadequate to meet the situation; it is hoped, however, that under the provisions of the Clarke-McNary Law conditions will be materially improved.

Taxation.—Annual taxation of growing timber compels the same crop to pay taxes many times. An outstanding present need is a system that will defer the principal burden of taxation on growing forests to the time of the harvesting of the crop, without being inequitable to other taxpayers or materially curtailing local revenues. Within the last dozen years, ten states have passed special forest taxation laws, most of which embody the so-called "yield tax." This taxes the land annually, but the timber only when cut. Scientific management of forest land in private hands is now being retarded more because of unsuitable taxation than from any other cause.

Present Status of Timber Growing in the United States.—The following table, taken from the Agriculture Yearbook of the United States Department of Agriculture of 1922, shows in a general way the progress that has been made to date in the use of forest land for growing real timber crops.

TABLE XXVIII

STATUS OF TIMBER GROWING IN THE UNITED STATES*

	Total	Federal	State	Municipal	Private
Total forest area, acres	469,500,000	89,100,000	8,700,000	450,000	371,250,000
Per cent of total	100.0	19.0	1.9	0.1	79.0
Proportion protected from fire, per cent	55.0	99.5	97.0	98.0	43.0
Approximate proportion managed for timber crops, per cent	23.0	98.0	80.0	50.0	4.0
Area planted, acres	1,450,000	180,000	86,100	33,700	1,150,200
Rate of planting yearly, acres	35,800	7,500	7,100	1,400	19,800
Expenditures for forest production†	$16,388,00	$9,785,000	$5,021,000	$300,000	$1,282,000

* Agriculture Yearbook, 1922, p. 170.

† Not including special forest road and trail appropriations or expenditures for slash disposal. Also excludes $625,000 spent by State and endowed forest schools on forest education.

Education.—Considerable educational work is being done by state forestry organizations in thirty-two states, by the Federal Forest Service, which now reaches into twenty-seven states, and by the twenty-two forest schools in tbe United States. The Forest Products Laboratory, located at Madison, Wisconsin, deals with research into a great variety of problems relating to forestry and forest products.

Like any other widespread economic or public movement in the United States, progress in timber growing rests fundamentally upon the understanding of the problem by the everyday man as well as the landowner or industrial user of timber.[1]

Outlook.—Two great forces are conspiring to bring about a more scientific administration of our forest lands—public necessity and private opportunity. The public is becoming conscious of the impending timber shortage through the rising prices of timber products, and may soon be expected to exercise its prerogative and demand that land suitable for timber crops be used for that purpose. On the other hand, the public must see to it that such conditions are created as to insure to the private timber grower, be he a farmer with a small wood lot or a lumberman with a vast area, as much protection against loss of his property as if he were engaged in the production of an annually maturing crop. Each year we see a growing disposition on the part of the public to grant this protection, and we may reasonably expect that private capital will respond more and more vigorously as the safeguarding of the property becomes definitely assured. In some cases an amendment to the state constitution will be found necessary to prevent the annual taxation of a crop that matures in from fifteen to fifty years. It is probable that further denudation of our forests and consequent increase in prices of forest products will have to take place before the public will become sufficiently awakened to pass the necessary and appropriate legislation that will make private forest culture safe and profitable. But that this day will ultimately arrive there can be no doubt.

Already, on much of our deforested areas, the financial return to be obtained from forest culture, if protected against fire loss and unjust taxation, is greater than could be obtained from the use of the same land when devoted to annual farm crops. A large and growing number of people now see that it is better economy for us to devote our poorer lands to forest crops, of which we already stand in great need, than to devote these lands to such crops as cotton, corn, or wheat, of which at present we normally have a superabundance. The relatively high

[1] Agriculture Yearbook, 1922, p. 172.

prices now prevailing for forest products as compared with the prices for farm crops show clearly that the utilization of our national land supply is out of adjustment; more land should be devoted to forests and less to crops, and both the suitable forest lands and the suitable crop lands should be cultivated more intensively.

EXERCISES

1. In the process of settling the public domain, what forces contributed to the over-emphasis on the utilization of all lands for crops at the expense of lands better adapted to forest or range purposes?

2. What are the indirect effects of forests upon such problems as erosion, regularity of stream flow, irrigation, and the use of streams for power?

3. How would the proper proportioning of our lands for crops, forests, and pasture purposes help to prevent excessive quantities of crops, such as wheat, corn, and cotton, from flooding the market.

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AGRICULTURE IN WORLD TRADE

"The percentage of the world's trade which is governed by differences in natural resources is increasing, while that which is governed by differences of industrial phase, and of aptitude for particular sorts and grades of manufacture, is less now than formerly; but yet its absolute volume is increasing. This increase is specially great in the case of central Europe. Almost every place is developing new means of communication with neighbors on either side of her in widely different industrial phases. Much of the trade which passes over the eastern borders of Germany has its origin in the present backwardness of Slavonic Europe as much as in her own advance.

"A great part of the world's resources is wasted through the unhealthfulness of a large part of its surface. But there are reasons for hoping that this evil will be gradually remedied; and, if so, then the rate of migration, which has prevailed in the last century, may probably continue for at least another; meanwhile, the energies of those races which were civilized while Europe was still barbarous, may be aroused and trained in modern methods. Should these changes come to pass, the economic forces of western Europe may be over-matched by those of each of at least two other Continents: the main courses of the world's trade will probably then be governed by climate conditions, and pass between north and south more generally than ever before."

—MARSHALL.

CHAPTER XIV

ORIGIN AND DEVELOPMENT OF TRADE

In previous chapters (particularly in Part I) it was shown that population is increasing at such a rapid rate in comparison with the economic land supply that it has become necessary to take more careful stock of our land resources from a world standpoint, to survey and classify our lands with reference to their economic usefulness, and to consider policies for their future conservation and proper use.

Part II showed how climate, physiography, and soils serve to establish a physical basis for domestic plant and animal distribution because of the natural advantages which certain regions enjoy over others for the growth of the various species of animals and plants. Out of these facts has grown, in a large measure, the tendency toward regional specialization in crop and livestock production, which is so characteristic of modern agriculture.

As a result of the movement toward regional distribution of crops and livestock, based upon the advantage which one region enjoys as compared with another, there are coming to be more or less definite areas devoted to cotton, for example, others to corn, wheat, dairy cattle, and various combinations of these, as is shown in Part III.

At this point it is desirable to examine the various factors that have made it possible for mankind to practice regional specialization and to enjoy the innumerable products which could not have been economically obtained in any given local area. This leads to a consideration of trade in agricultural products, which is both a cause and an effect of agricultural specialization.

BASES OF TRADE

If each individual ordered his life activities so as to make, by his own efforts, entire provision for all his daily wants, there would be no trade as between individuals; no surplus would be produced by anyone for exchange. Similarly, if small groups or societies of human beings made entire provision each for its own wants, there would be no trade as between groups. Also, if each nation or political division managed its economic life so that all its wants were supplied solely from articles of local production there would be no trade as between nations, that is, there would be no international or foreign trade.[1]—Reprinted by permission from Outlines of American Foreign Commerce, by Bishop. Published by Ginn & Company.

At first, no doubt, each man produced everything needed by himself and his immediate dependents. During the course of ages, social and economic life became more complex, as represented in the greater complexity of the nation as compared with the tribe, the tribe with the clan, and the clan with the family. Within these groups it was discovered that certain individuals possessed special aptitudes for doing certain things, and these people gradually came to devote all or most of their time to performing certain specialized tasks, thus giving rise to the arts and crafts. They exchanged all or part of their specialized production for commodities desired for individual consumption. Thus trade began, limited at first, but gradually expanding as transportation facilities improved.

Widening of the Market.—As transportation improved and the market widened, division of labor was extended, and greater quantities of goods became available for purchase and sale. Eventually, exchanges spread beyond national boundary lines and trade became international in character.

Population Increase.—Division of labor, or, as we have called it specialization, resulted in the production of greater quantities of goods with the same amount of human effort, thus making it possible for more people to live and to live better than could otherwise have been the case. The result was that, as division of labor proceeded, population increased, making further division of labor, and consequently exchange, both necessary and profitable.

Wants Diversified.—Moreover, civilized man's desire for more goods of various kinds knows no limits and thus serves as a further constant stimulus to the extension of trade. Every man in civilized society is now able to command the services of innumerable people in all quarters of the world in return for that which he has to offer, and as a result he may enjoy such a variety of goods as even kings could not have dreamed of a few centuries ago when trade was relatively local in character.

Distribution of Natural Resources.—Division of labor, increase in population, and diversification and multiplication of wants have already been briefly referred to as stimuli of exchange. Another important cause giving rise to trade is the uneven distribution throughout the world of natural resources. If all countries were evenly and similarly

[1] Bishop, Outlines of American Foreign Commerce, p. 1.

endowed with natural resources there would be relatively little exchange between countries or between different parts of the same country; there would be a minimum of both foreign and domestic trade. Kansas, for example, does not have a large trade with Nebraska, but both trade mainly with manufacturing districts. Norway and Sweden trade little with each other, but both trade extensively with Great Britain. Because of differences in topography, soil, geology, nearness to the sea, and climate, there is a great variation in the resources and products of countries, as well as of regions within the individual political subdivisions. Mountains and plains, humid and arid regions, shore lands and inland areas, sandy districts and fertile black prairie lands, are typical examples of contrasting areas yielding dissimilar articles of wealth, each producing certain commodities the others may lack, thus furnishing a sound basis for trade.

As scientific knowledge of the use of the physical environment increases, and as competition between nations for industrial and commercial supremacy becomes the keener, there likely will be a more intelligent use made of each type of natural environment. Ultimately, on the assumption (which most people nowadays would not be disposed to admit) that wars are to be no more, each country and each region, in the interests of efficiency, should be utilized for the production only of those things for which it has natural advantages. If this were accomplished a great stimulus would be given to an enduring commerce.[3]

Thus we see the fundamental relationship between the physical environment and trade. It is more economical, that is to say, it requires less energy to move goods from places where the natural environment is favorable to the points of consumption, than it is to attempt to create artificially the environment for certain kinds of plants and animals near the centers of consumption.

North and South Trade.—Climate is the most important physical factor causing differences in natural production from the standpoint of trade in agricultural products. The products of the tropics are radically unlike those of the temperate and middle latitudes:

No manipulation of man can ever equalize conditions of production between these widely differing regions; the tropical fruits can not be rasied on a commercial scale in Connecticut, nor can arctic furs originate in Colombia. We would therefore expect, from a theoretical standpoint, to find a great and flourishing trade built upon this natural foundation. As a matter of fact, there is not now nor has there ever been a great volume of North and South trade as compared with the trade between East and West.

[3] Bishop, Outlines of American Foreign Commerce.

Trade Depends upon Civilization.—In neither the tropics nor the frigid regions, however, is there much industry and trade or a high civilization. The people are backward and their wants are few. In the tropics the conditions of life are so easy that the inhabitants have lost all ambition. In the frigid zones the conditions are so hard that the people are constantly occupied in eking out an animal existence. Only in the temperate zones is the relation of man to nature such that man is ambitious and nature responds favorably to his efforts. Thus, while the temperate zones and the tropics have a sound natural basis for trade, in that they are complementary trade areas, in reality they have relatively little commercial intercourse. There are those, however, who have unbounded faith in the future development of this trade and who believe that eventually it may surpass that which flows east and west. It is to be hoped that scientific research will find a way of permanently raising the scale of industry and civilization within the vast tropical areas, so that they will not only furnish the temperate zone countries with an ever-increasing volume of their peculiar products but also become great and certain markets for temperate zone products. Thus would the trade of the world receive a great impetus through the development of a north-and-south commerce.[3]

Differences in Industrial and Social Development.—At the present time, as in all other periods of history, trade is largely between East and West. This is due to the fact that civilization developed first in the East and moved gradually westward—first to western Europe and then across the ocean to America. During much of American history we have had existing side by side, and extending in more or less irregular zones across the continent, five distinct stages of economic development; the hunting, pastoral, agricultural, manufacturing, and financial stages. All but the hunting stage still exist in this country. These differences in industrial and social development have always been and still are among the most important bases of trade and exchange. The industrial East must exchange products with the agricultural interior in order that the wants of each section may be the more completely satisfied.

Racial Differences.—In the past, when peoples were more isolated from each other than they now are, a sort of racial impress was given to their manufactures, making their goods no less distinctive than the peculiarities of the different peoples themselves and their markets. While modern commercial intercourse tends to standardize production over the entire civilized world, goods from the Orient, and even those from certain European countries, still retain a certain national or racial impress which distinguishes them from goods produced elsewhere and thus gives rise to exchanges in order to satisfy human desires more fully.

[3] Bishop, Outlines of American Foreign Commerce, p. 11.

Law of Comparative Costs.—The differences in physical environment, industrial and social development, culture and skill, that are characteristic of the different peoples of the world, create comparative advantages and disadvantages which are reflected in the course of trade. Not only does the principle of comparative advantage explain trade between nations, but in a country whose resources are varied, as, for example, the United States, it explains inter-regional or domestic trade as well.

Trade Mutually Beneficial.—If it be assumed that the objective of economic activity is to provide more goods in greater variety to an increasing world population, trade and exchange are essential. In times past it was thought that trade benefited only one party to the transaction, and that one man's gain was another's loss; but to-day it is well recognized that legitimate trade is mutually beneficial.

MODERN THEORIES OF TRADE

Mercantilism.—It has already been noted that the great material benefit that a country or a region derives from exporting some of its own goods consists in providing thereby the purchasing power abroad for those products of other countries which, because of comparative disadvantages of various kinds, the exporting country can not or does not produce itself. Yet this fundamental truth has not always been appreciated. During the sixteenth and seventeenth centuries it was generally accepted by thinkers on the subject that trade was beneficial to a country only when its exports exceeded its imports and a net balance of gold flowed into the country. This was called a "*favorable balance of trade*" and all kinds of legislative restrictions were imposed upon foreign commerce in order to obtain for the country this much-coveted gold.

Even to-day there are many intelligent citizens who do not realize that trade is essentially an exchange of goods or services, for goods, and that the country that exports more than it imports is not necessarily the wealthier country. In fact, the reverse is almost invariably the case. Without going into details as to the probable causes of such discrepancy between imports and exports, suffice it to say that a country may have a claim on another country's goods for other things than the merchandise it sends. Debtor countries, as, for example, the United States prior to the World War, may export more merchandise than they import, in order to pay interest charges on their debts. Other causes for exports of debtor nations exceeding imports of merchandise include the following: shipping and insurance services rendered by other countries; *tourists' expenses; remittances sent to friends and relatives abroad.* All of these must be paid for by goods sent from the debtor country, and represent the so-called "*favorable balance of trade.*"

Since the War the United States has become a *creditor* nation and, unless Americans make huge investments abroad, the imports of merchandise into this country will become much greater than the exports. In other words, our balance of trade will, for the first time in many years, become *unfavorable* from the "mercantilist" standpoint; but this fact is not likely to throw the American consumer into a panic. It does, however, create many intricate problems of trade readjustment with which the American farmer is intimately concerned.

Free Trade.—Mercantilism remained the dominant economic philosophy among the commercial nations of Europe for two centuries. During the latter part of the eighteenth century, however, a reaction against government interference with trade took place, and, in England especially, the philosophy of free trade gained complete ascendency by the middle of the nineteenth century. The advocates of free trade contend that commercial relations between countries should be unhampered, in order that the principle of comparative advantage may work itself out as completely as possible. Although mercantilism ceased to be the dominant philosophy governing trade a century and a half ago, it still exerts an influence and there are many individuals to-day who are still in the mercantilist stage in their thinking about this problem.

Protectionism.—For a while the free-trade philosophy seemed to be destined to dominate the field, but shortly after the middle of the nineteenth century it began to suffer a reaction even in its principal strongholds. Accordingly, during the past half-century or more, there has developed an economic philosophy midway between the old mercantilist policy of minute restriction of trade and the free-trade policy of no restriction at all. This policy is known as protectionism and consists in placing a tax on goods imported into this country in order to prevent too great an influx of goods, which would tend to lower the price of this class of goods paid to American producers. It is a difficult thing to determine which American industries should be given tariff protection and how large a duty should be imposed upon the multitude of articles imported into the country. At the present moment (January, 1926) the farmers of the Mississippi Valley are making insistent demands, which it is not politically expedient to ignore, for tariff-revision. The proposals are taking on some new and interesting forms, yet the importance of the tariff as a factor influencing the material prosperity of a nation is probably greatly exaggerated.

THE INDUSTRIAL REVOLUTION

Some attention has already been directed, in previous pages, to the origin and development of division of labor and its effect upon trade or exchange. At this point it is desired to call special attention to the beginning of the period in which this tendency toward minute division of labor, with its accompaniments—inventions and extension of the markets—became so marked as to make this period stand out as the greatest economic epoch in history.

Industrial Revolution.—The Industrial Revolution may be said to have begun about the middle of the eighteenth century with a series of inventions in connection with the textile industry and the steam engine. The principles discovered were soon extended to other industries, including transportation. The result was that in a short time, as history goes, methods of manufacturing and transportation had been completely transformed and the modern industrial world had come into being.

The percentage of rural population decreased rapidly in all countries affected by the Industrial Revolution, and city populations increased correspondingly. Moreover, the total population of this country increased by more than 100 million during the past century, while that of Europe increased by more than 300 million. These facts furnish the clew to the explanation of much of our domestic and foreign commerce.

Contemporaneously with the urban Industrial Revolution, there was occurring an Agricultural Revolution, less striking to be sure, but nevertheless very significant. In England it took the form of notable improvements in breeds of animals and plants and in improvements of cultural methods of crop production. In America it took the form largely of mechanical improvements in connection with an abundance of cheap land. These two movements, which started in the eighteenth century in England and in the nineteenth in America, have continued uninterruptedly to the present and lie at the very basis of modern trade or exchange in agricultural products. These Revolutions in both the urban and the agricultural industries have promoted division of labor and specialization, differentiated more or less sharply the urban and rural populations, caused the concentration of the population in cities, and thus multiplied trade and exchange.

CHAPTER XV

DOMESTIC TRADE IN RELATION TO AGRICULTURE IN THE UNITED STATES

Until the middle of the nineteenth century, agriculture was the dominant industry in this country. While differences in climatic, soil, and topographic factors in the different sections of the country gave rise to a considerable volume of internal commerce before the Civil War, it was insignificant compared with the present volume which has resulted from the tremendous industrial development following the war.

Since the Civil War our population has quadrupled, and the greater portion of this increase has been concentrated in urban centers; the per capita wants of this vast increase in population have increased both in quantity and in variety; territorial concentration of production in agriculture, manufacturing, and other industries has become pronounced; transportation by rail, by water, and by highway has improved tremendously; and finally, our home market has been preserved from serious outside competition. These factors have all conspired to bring about a development of internal trade beyond the imagination of man half a century ago.

This tendency toward regional division of labor, urbanization of population, growth of manufactures, and development of trade, has been accompanied by serious maladjustments within the agricultural industry itself and between agriculture and urban industry. The problem of adjusting the different parts of the agricultural industry within the industry itself and of adjusting agriculture to other industries constitutes the field of agricultural economics. It involves such matters as land utilization, marketing, finance, taxation, transportaton, tariffs, and the like, most of which were considered quite remote from agriculture until recent years.

Regional Distribution of Industries Basic in Internal Trade.— From the viewpoint that commerce is the taking of things from where they are plentiful to where they are needed, the underlying basis of our extensive internal trade is to be found in the geographical or sectional distribution of our abundant natural resources and of the industries to which these resources give rise. Of the various sections of the country differently endowed with Nature's riches and possessing each its peculiar type or types of industrial life as the result of an intelligent adaption of the population to its environment, not a single section or region is sufficient unto itself. In these days of industrial specialization, the various regions of the country, from the standpoint of trade, are becoming more and more dependent upon each other. In other words, specialization makes toward increasing economic dependence which means an ever-increasing volume of inter-regional trade.[1]

We have already seen that the northeastern section of the country has developed dairying to a high degree and must look to the Middle West for its feed-stuffs. In the Cotton Belt the population is dependent primarily on the cotton crop, all of which is exchanged for money with which the cotton grower purchases food and manufactured goods produced in other parts of the country and in foreign lands. The same may be said of the cereal, wool, meat, and horticultural regions. In Part III of this book, the regional distribution of agricultural products all over the world was shown, and in Part II the physical factors underlying this distribution were pointed out. It has been shown also that the utilization of these comparative physical advantages for crop and livestock production is dependent upon adequate transportation facilities, and again upon great industrial centers with large populations to consume the products of the surplus-producing areas.

The significance of agricultural specialization, the concentration of manufactures, and the growth of city populations with their increasing wants, in relation to the growth of domestic trade, can scarcely be exaggerated. The mutual interdependence of the different regions upon each other has become extremely marked. Nearly one-fourth of our entire population lives within a radius of 200 miles of the City Hall in New York, and this city alone has about one-twentieth of the nation's population.

Widening of the Market.—Years ago, with the exception of those products which were produced near the seaboard or along an internal waterway, goods were consumed, to a very large degree, near the point of their production. All this has changed to-day. In many lines of industry the producers, hundreds or thousands of miles apart, compete with one another in markets far removed from the scene of production.[2]

Selling the Goods.—The limiting factor in most industries has thus come to be the selling of the goods rather than their production. Not until recently has this important subject received scientific study; and many years must elapse before the technique of disposing of the

[1] Bishop, American Foreign Commerce.
[2] *Ibid.*, p. 85.

products of surplus-producing regions will have become as highly developed as the technique of production.

Marketing of the Products of Agriculture.—Permanent interest in marketing problems first arose in connection with agricultural produce about twenty-five years ago, but only during the past ten years has notable progress been made. The unnecessary disparity which too often exists between the price received by the farmer and that paid by the consumer for the same article indicates clearly that we still have far to go in the attainment of a satisfactory price adjustment for farm products. So long as each farm produced a variety of things, primarily to be consumed within each household or at most within the local community, there was little trouble. But when society had developed to the point where the population became centered largely in cities, and agricultural production became more and more highly specialized, giving rise to a surplus over local needs, serious problems arose. This condition of affairs appeared in the United States soon after the Civil War. Marketing problems became acute during the 'seventies, 'eighties, and 'nineties, and spasmodic efforts, usually of a political character, were made by the farmers for their correction. As stated above, however, really scientific efforts to solve marketing problems are of recent date.

The agricultural marketing system, as we commonly know it, arose spontaneously as this process of agricultural specialization went on, and as individuals saw opportunities for profit in the purchase and sale of farm commodities. The newer tendencies for bringing farm products to the consumer will be briefly touched upon in a later chapter.

CHAPTER XVI

AGRICULTURE IN RELATION TO FOREIGN TRADE

General.—While our domestic trade in agricultural products constitutes 85 per cent or more of the total, the much smaller percentage of our trade that is carried on with foreign nations attracts far greater public attention. So true is this that the casual observer, reading current periodicals, might well conclude that the great bulk of our agricultural products was destined for export. Just now (January, 1926) the problem of how to handle the agricultural " surplus " is perplexing the administration and promises to result in important political realignments during the next two years. Neither the political nor the detailed economic aspects of this " surplus " problem can be entered into within the limits of this work. But that our agricultural " surplus," which is less than 15 per cent of our total agricultural production, presents a difficult problem both politically and economically, can not be doubted.

Meaning of Foreign Commerce.—Foreign commerce includes all transactions involving the purchase and sale of commodities and services as carried on between buyers in one country and sellers in another country. If this conception is correct the business of foreign trade for the United States, as well as for all other countries, is bilateral. There has been a marked tendency, in this country, in matters pertaining to foreign trade, to concentrate attention upon selling goods abroad, and to overlook the necessity of importing; as a matter of fact, in the minds of many people foreign trade means little more than selling abroad. There has been manifested, in recent years, a tendency, however, toward a stronger realization of the fact that a country can not expect to continue selling large volumes of goods in foreign countries without expecting, at the same time, to buy liberally from abroad. Properly considered, the foreign trade of the United States involves two complementary concepts—the buying from other countries and the selling to other countries.[1]

Place of Foreign Trade in American History.—During Colonial days and up to the Embargo Acts of 1807 and the War of 1812, foreign trade was of far greater relative importance in the United States than it has ever been since. Not only were great quantities of raw material,

[1] Bishop, American Foreign Commerce, p. 63.

produced in this country, shipped abroad to be exchanged for manufactured goods, but our merchant marine had grown to such magnitude that it undertook the carrying of merchandise of other countries as well. But the life-and-death struggle in which England and France were engaged during the first fifteen years of the nineteenth century tempted each of them to encroach upon American shipping until in utter despair Jefferson, who was then president of the United States, ordered all our ports closed and ships anchored. These were the Embargo Acts already referred to. The embargo was maintained for several years, and no sooner was it raised than it was in effect restored by the War of 1812. Thus for a number of years our flourishing foreign trade and shipping industry were paralyzed and did not recover until 1835. The recovery was retarded by the fact that after the Napoleonic Wars European countries attempted to become self-sustaining with respect to foodstuffs and our own people in large numbers had turned to manufacturing and to internal improvements. In a word, after two hundred years during which we had had our eyes fixed on Europe, the seven years of isolation from Europe, due to the embargoes, caused us definitely to turn our back upon Europe and to engage in the magnificent task of subduing a continent.

Growth of Our Export Trade.—While the absolute volume of our foreign commerce during the past half-century has far surpassed that of post-Revolutionary days, it has never since assumed the relative importance it had then. Moreover, the content of our exports has changed radically. In the earlier period such commodities as furs, rice, indigo, and tobacco were the most prominent. Soon after the beginning of the nineteenth century, cotton became more important, and by 1860, it constituted more than half of our total exports. As previously noted, western cereals, flour, and provisions increased in importance as the western lands were taken up.

After the Civil War the development of our free and fertile lands in the Mississippi Valley was greatly accelerated by the introduction of labor-saving machinery on a vast scale and the rapid extension of our railroad system. Moreover, a vast army of Civil War veterans in the prime of life, together with a still larger army of foreign immigrants from western Europe, furnished the necessary human brain and brawn for the rapid exploitation of these rich agricultural resources.

The several natural productive areas of the country were all brought within the world's markets and came to be utilized each for the purpose for which it was best adapted by nature. This specialization in production resulted in a remarkable development of domestic trade between the several specialized areas of production, and in a considerable growth of the export trade as well. A conscious desire to foster the home market, however, made the welfare of the domestic trade the leading concern of our people, but in the meantime the foreign demand for the products of our farms, mines and factories had caused our expert trade to assume enormous proportions.[2]

Up to 1900, breadstuffs, cotton, and animal products continued to head the list of exports, but their relative importance began to decline after 1880. Contemporaneously with the relative decline in the exports of farm products occurred a relative increase in the exports of manufactures and miscellaneous articles. This tendency continued down to the outbreak of the World War. This means, as far as agricultural products are concerned, that the domestic consumption of farm products has increased more rapidly since 1890 than has the increase in their production.

During the World War our total exports increased about 35 per cent in physical volume and more than 200 per cent in value. Agricultural products shared fully in this tremendous increase in the value of our exports. For almost two years after the signing of the Armistice the value of our exports continued to increase, but during the past five years there has been a marked downward trend in their value.

Import Trade.—Certain facts concerning foreign commerce, outlined in a previous chapter, may be restated in the words of Bishop:[3]

Foreign commerce is essentially bilateral, involving the two-fold relationship of buying from abroad as well as selling. The leaders of economic thought throughout the world have outgrown the mercantilist idea of national prosperity being dependent upon selling more than is bought, the balance to be settled in gold. Trade is essentially barter, the exchange of commodities for commodities, and in the long run no balance of importance remains. There are some persons, however, who while not calling themselves mercantilists base the bulk of their reasoning regarding foreign trade upon antiquated mercantilist doctrines. The sooner such ideas are discarded in favor of the bilateral or reciprocal aspect of foreign commerce, the better it will be for all concerned.

Attitude Toward Exports and Imports.—There never has been any question, in the minds of merchants, manufacturers, politicians, and the general public, regarding the desirability of selling our goods abroad. Ways and means of increasing our sales abroad are always popular, and this is as it should be.

The same can not be said regarding the attitude of these groups toward imports. Here their state of mind frequently ranges from indifference to positive hostility. Only in those cases where we clearly

[2] Bishop, American Foreign Commerce.

[3] American Foreign Commerce, p. 109.

can not produce the commodity ourselves, or do not care to do so, is there general agreement that imports are desirable. Yet in all probability this attitude is changing and, with a more general understanding of the true nature of trade, we may expect the antipathy toward imports to disappear entirely.

Public Attitude Changing.—The idea is gaining ground that in buying foreign products, either in exchange for goods or for the purpose of permitting the cancellation of debts due us from the citizens of foreign lands, we are not rendering a favor to the foreigner by our purchases, but that we are taking the natural and best course whereby our lives are made more comfortable and full by the consumption of their distinctive products.[4]

By way of emphasis, it may not be amiss to repeat what has been stated previously as to the reason why it is as beneficial for us to import as it is to export goods. We have seen that exchanges between countries are motivated by the same forces as are exchanges between individuals, localities, or regions within a country; that trade arises out of division of labor among groups which in some instances happen to be nations; that in order to satisfy man's expanding wants it is often necessary to go beyond national boundaries; that on account of differences in climate, soil, and topography there are corresponding differences in plant and animal life, which, if human wants are to be more fully satisfied necessitate the movement of these commodities from one part of the world to another; and finally that, because of the principle of comparative advantage, it is wasteful for us to try to produce, in this country, certain things that can be grown or made more cheaply in other lands.

If We Want to Sell We Must be Prepared to Buy.—President Wilson in his message to Congress in 1919 said:

> Anything which would tend to prevent foreign countries from settling for our exports by shipments of goods into this country could only have the effect of preventing them from paying for our exports and, therefore, of preventing the exports from being made. The productivity of the country, greatly stimulated by the War, must find an outlet by exports to foreign countries, and any measures taken to prevent imports will inevitably curtail exports, force curtailment of production, load the banking machinery of the country with credits to carry unsold products and produce industrial stagnation and unemployment. If we want to sell we must be prepared to buy.

Mr. George E. Roberts of the National City Bank of New York, in an address entitled "The Functions of Imports in our Foreign Trade," delivered at the Seventh National Foreign Trade Convention at San Francisco in May, 1920, said in part:

[4] Bishop, p. 110.

It would be idle and unintelligent for us to meet in conventions and plan to build up a great export trade expecting to collect the proceeds in gold. We have done too much of this in the past. We have given all our thoughts to exports, to selling our products in other countries, without considering how the foreign customers we are seeking will be able to make payments for their purchaser. That problem is just as much ours as theirs for they cannot solve it without our help, and they cannot buy unless they are able to render reciprocal service to us.

In another connection Mr. Roberts says:

A proposal to adopt a policy of greater liberality toward imports than this country has maintained habitually in the past will run counter to the long-established views of many people, arouse apprehensions and perhaps create some dissension even within the Association itself, but the question must be dealt with, one way or another. An argument can be made for a policy of exclusion and isolation, keeping out all foreign products which are competitive in any degree with our own and restricting our exports correspondingly, and another argument may be made in favor of a more liberal policy which will afford an opportunity for a larger development of trade on mutally advantageous lines; but no well-supported argument can be made in favor of trying to expand our exports without increasing our imports. That is a waste of energy; it simply cannot be done. We must choose a consistent course.

Mr. Thomas W. Lamont, in commenting upon the portion of President Wilson's message to Congress, quoted above, and upon President McKinley's utterance in his Buffalo speech delivered just before his death, makes the following interesting observations, in Harper's Magazine, March, 1921:

This has been axiomatic of trade since the world began. Yet many Americans still fail to realize that, as to our foreign trade, it is now truer than ever before. These individuals go back to the days before the war when we were buying *transportation* and *capital*. They fail to realize that with America turned creditor nation she must now —if she is to continue to sell abroad—buy goods or even securities. These individuals—be they in the Congress, or scattered throughout the land—will one day—and that not far distant—wake up to realize that if we wish to maintain our foreign trade, we must take a far deeper and more coöperative interest in the affairs of the nations abroad than we ever took in the old days. . . . If Congress should pass laws which work so as inevitably to cut down our imports of those articles that foreign countries can furnish us, we shall at the same time automatically be depriving those countries of the ability to buy our cotton, wheat and other products.

Under the caption, "Why Not Quit Buying Abroad," in the Nation's Business, July, 1921, Mr. Lewis E. Pierson of the Irving National Bank said:

Our products sold in foreign fields must be paid for in the products of foreign fields. The course followed by the transactions may be long and tortuous. It may include various periods of time, may pass through many lands, may be expressed in strange tongues, may involve the use of money, credit, and exchange. The identity of the original product may be completely lost sight of, but the essentials of the transaction remain unchanged. Product pays for product, product replaces product, not necessarily immediately but ultimately. It is true exchange. Only the products are important. All the other elements employed are facilities in between.

Enough testimony from men qualified to speak upon the subject has been submitted to make it clear that exports are but one-half of the trade equation, imports being the other half. At no time in our history has there been such pressing need for a clear understanding of this subject on the part of the public as now.

Character of Imports.—Prior to the Civil War our imports consisted predominantly of completely manufactured goods in return for the foodstuffs, cotton, and animal products we sent abroad. After the Civil War, up to 1914, our own manufactories grew rapidly, and the percentage of completely manufactured goods imported speedily declined. The importation of crude materials for use in manufacturing, on the other hand, increased greatly. These facts illustrate clearly the complementary character of trade relationships.

During the World War and for three years after the Armistice, our imports continued to be abnormally large, especially if considered on a value basis. While imports from Europe naturally declined during and immediately following the War, there were large increases from Canada, Argentina, Chile, and Japan, so that the total imports during this period were the largest in our history.

Outlook.—Forecasting the future relative amounts and value of imports as compared with exports for this country is fraught with considerable danger; but it would seem that with the reversal of our traditional position from a debtor to a creditor nation there will also occur a reversal from our traditional excess of merchandise over imports to an excess of imports over exports. However that may be, there is no question regarding the fact that during the next decade or two considerable and perhaps increasing attention will be given to the exportable surplus of farm products. At the present time, as previously noted, this problem occupies the center of the stage from the standpoint of national agricultural legislation. Economic research during the next few years will doubtless help to clear it up.

CHAPTER XVII

AGRICULTURAL ORGANIZATION

We have already seen how physical and human factors, aided by improved transportation and communication, have caused a high degree of regional specialization in the production of the various types of domestic plants and animals. If we could project ourselves off into space for some distance and view the entire earth from such a point of vantage, we should observe a sort of checkerboard effect in the way in which crops and livestock have distributed themselves over the earth. This, as we have already noted, is in accordance with the principle of comparative advantage, resulting from such natural forces as climate, soil, and topography, on the one hand, and such human factors as skill, inclination, and habit, on the other. As a result of these natural and human factors, together with the devices which man has developed for economically moving goods great distances, we now have, in all parts of the world, areas devoted to a certain limited number of agricultural products.

Some regions enjoy such distinct advantages over others in the production of a given type of plant or animal product that much of the energy of the people is devoted to the production of that particular commodity. This has been observed to be the case with such horticultural products as citrus and other types of fruits; non-perishable products such as cotton, wheat, and corn; and, in general, all kinds of farm crops and livestock which now pass in such great volume through the channels of trade.

This situation is in marked contrast to that which existed in all parts of the world prior to the nineteenth century. The typical family or local community of that day was practically independent of the outside world, or, as we often hear it expressed, each family "lived at home."

To-day each region, having been found peculiarly suitable for a given type or a limited number of types of agricultural products, is devoted more or less exclusively to the production of these commodities, and these are produced in far greater abundance than is needed in the region so peculiarly fitted for their production, or frequently even in the

the entire country. This brings about the necessity of moving crops and livestock from their points of origin to centers of population, and results in the phenomena that have been previously described in the chapters on domestic and foreign trade.

Surplus Production.—Until recent years the surplus products resulting from what we have called regional or territorial division of labor were permitted to move from the surplus-producing areas to the centers of population in a more or less haphazard fashion. People did not become conscious of the big change that was taking place in agricultural production until it had gotten well under way.

Marketing.—Only within the last two decades have the most discerning men come to see that this high degree of specialization in agricultural production requires a far more systematic way than that which now prevails of bringing the surplus product of any given region to the centers of consumption. This has given rise to a tremendous interest in the problem of marketing farm products in such a way that both farmer and consumer may benefit by the economies that result from producing things where the natural and human factors are most favorable.

Farmer Business Organizations.—We are now at the beginning of an era in which the growers of farm products recognize that their work is not complete when they have produced the crop. They are coming to see more and more clearly that, in order to enjoy more of the things which have been produced by other specialized producers the world over, they must find some way of translating the particular crop which they have grown into the maximum number of dollars. For it is no longer the size of their crop, measured in pounds, hampers, bushels, or bales, which determines the necessities and comforts which they will enjoy, but rather the dollars which they will receive for their surplus product.

Thus farmers are now confronted with the same type of problem as that which confronts the men who sell their personal services, or the manufacturers who sell a single or limited line of goods. And the more specialized they become, the closer is the analogy.

During the past fifty years or more, laborers have learned that in order to sell their services to the best advantage they must act together and bargain with their employers as a unit instead of competing among themselves and thus driving their wages down. During this same period, owners of capital have learned that cut-throat competition tends to destroy the value of their property and have consolidated numerous small competing units into great corporations which are comparatively non-competing.

Farmers alone, of all the great classes of society, have come down almost to the present time under a disorganized system of disposing of the special products of which each economic area has a surplus. The great problem now before the agricultural industry is so to organize their business that their product may be converted into the maximum number of dollars, and to see that the largest possible number of dollars are returned to the individual farm families.

Agriculture Composed of Many Sub-industries.—Agriculture is really not one industry but a group of industries. We have, for example, the dairy, swine, beef cattle, cotton, citrus fruit, and many other sub-industries. Each of these sub-industries is producing a commodity or group of related commodities upon which a farmer business organization may be built. It is easy to see that in the case of specialized agricultural industries, just as in the case of other specialized industries, the problem of selling the product at a price which is satisfactory to the producer becomes increasingly difficult. Moreover, the probability of maladjustment of supply to demand becomes greater as specialization increases. The need for proper adjustment of supply to demand—the determination in advance of what the probable supply and demand are likely to be under a given set of price conditions—is coming to be imperative in agriculture. In other words, we have come to the point in our specialized system of agriculture where we must give more time to bringing about orderly production as well as orderly marketing.

Commodity Coöperative Associations.—The revolutionary changes in modern agricultural conditions, from the varied self-sufficing type of pioneer days to the specialized interdependent type of to-day, call for many changes in agricultural organization. The problem of adjusting production to consumer needs, with respect to both quantity and quality, is one that can not be solved by thousands of growers acting independently of each other. Daily and seasonal gluts or deficits on the market can not be corrected except through organized effort on the part of those engaged in the commercial production of a given commodity.

To meet the requirements of these changed agricultural conditions, a new type of business organization is in process of development, viz., the commodity coöperative association. These farmer business organizations differ fundamentally from the usual form of business corporation which prevails in urban industry. The obvious reason for this is that agricultural production is carried on over widely scattered areas, by a great number of independent operators The marketing superstructure must necessarily be adapted to the peculiarities of this type of production enterprise, and the coöperative form of business organization on a commodity basis seems best suited for the purpose.

It is manifestly not within the province of this book to undertake a detailed discussion of the various phases of the agricultural industry. The dominating purpose of the author has been to give a broad perspective of the modern agricultural industry from a world standpoint. The more detailed consideration of both the technological and the economic side of agriculture constitutes the major portion of the agricultural college curriculum and involves the sciences dealing with animals and plants, as well as agricultural economics, accountancy, and statistics.

The author has endeavored to stimulate in the student a greater interest in the following topics: first, the relationship between population pressure and agricultural resources; second, the nature and influence of physical factors upon the distribution of crop and animal industries; third, the present and probable future distribution of crop and animal industries throughout the world; and fourth, the economic and technological problems which have resulted from man's effort to make the best use of the principle of comparative advantage—that is to say, the problems arising out of agricultural specialization, viz., trade.

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