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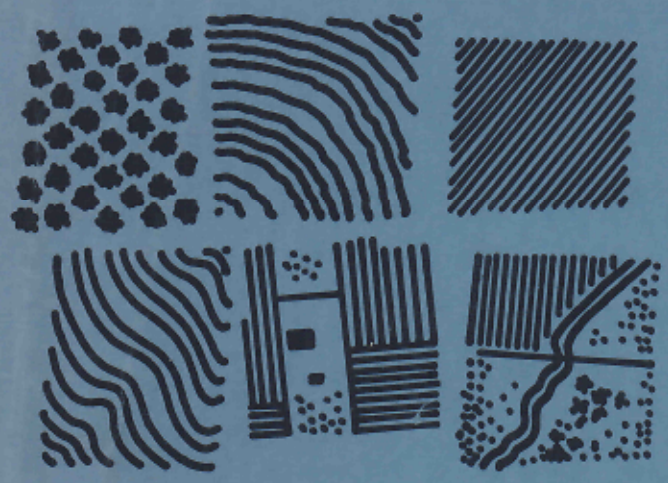

Land Use and Its Patterns in the United States

Agriculture Handbook No. 153
UNITED STATES DEPARTMENT OF AGRICULTURE

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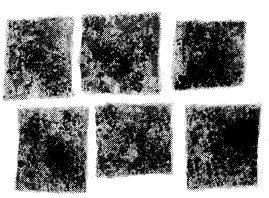

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Preface

The purpose of the study reported here was to contribute to a more mature understanding of the patterns of rural land uses in the United States. The underlying physical factors are described, and their influence is explained in relation to major historical and still evolving institutional determinants of agricultural development and land use. The varied and unequal impacts of industrialization and of the continuing technological revolution within agriculture are emphasized.

This report also demonstrates a methodology for research in land use that is applicable wherever men are concerned with improving the levels of human life through the development of agriculture. Students of agriculture everywhere, and in particular American students and professional agricultural workers, will find the report helpful in broadening their understanding of agricultural land problems. Students and professional workers in agricultural geography will be interested in the general methodological approach used and also in the graphic analysis and description.

A pioneering feature of the report is the use of aerial photographs of 168 local areas with descriptive legends. This part of the report will interest many technical and professional students of agriculture and geography.

In the preparation of the report, valuable cooperation was received from the Food and Agriculture Organization of the United Nations. The concern of this organization with improving the standards of human life through the development and improvement of agriculture in areas where the present level of agricultural production is low led to its interest in research methodology in land utilization in the United States as presented here.

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Land Use and Its Patterns in the United States

Summary

At the beginning of the 20th century, the internal development of the United States took a new turning on the road to progress. Advances were made in rapid succession in the different fields of human endeavor, so much so that no universal yardstick can be applied to measure all the incidental consequences. Both human and material resources were involved. All aspects of man's life were affected. But when land use for primary production is the particular field of inquiry, the application of scientific knowledge and technical skills account largely for the many innovations and improvements.

The marked improvement in the use and productivity of the land necessarily had its repercussion in the lives of the people. When a trend toward declining returns is arrested and within a few years becomes a trend toward abundance, economic and social problems are associated with the change. The reaction to such changes is not confined necessarily to users of the land; their effects are felt by the entire Nation. Even the national boundaries do not represent the ultimate limits of the reaction; these changes affect the man–land relationship the world over to such an extent that a reorientation in the outlook for the future is required.

In the United States, we must recognize, therefore, two distinct periods with opposite trends in the productivity of the land. In one, the productivity of the land declined, sometimes to the point of making it useless for further cropping; in the other, depletion was halted and the productivity of the land improved. Before we inquire into the circumstances that provided the directive forces and helped in the reversion of the trend, a brief review of the events that led up to it is necessary.

The first period is roughly coextensive with the period of settlement, which came to a close at the beginning of the 20th century. Agencies that issued titles to land on which settlers located had no definite information as to the productivity of the land, nor were the settlers able to determine it objectively. All that could serve as a guide was a subjective appraisal of the land's quality, which to the dismay of the settlers, was frequently discouraging. Agriculture was the first industry that supported the settlers, and it was pursued without any particular care for the land. This was generally true of farmers who cultivated their own land, but it was even more the case with the many tenants who had no stake in the land. Abundance of land was the all-pervading concept that dominated the thoughts and activities of the people. Under these conditions, land use was exploitive, and as a consequence, it was frequently accompanied by diminishing returns.

Toward the end of the settlement period and more particularly during the last half of the 19th century, the large-scale application of scientific and technical principles in the manufacturing industries began to affect the national economy. Transportation and communication facilities had not only opened the country locally but had connected the East with the West and the North with the South. Mechanized industrial production had made a running start, which soon produced chain reactions. It not only increased production but also diversified the means of production by developing new sources of energy. The internal combustion engine made its debut at that time. It revolutionized transportation and was soon applied to farm operations.

In this respect, American farmers were in a better position to take advantage of mechanized farm operations than their Old World cousins. As a rule, European farmers had control over fewer acres than American farmers. Consequently, they enlarged their scope of operations proportionately. Even now, in the division of

European estates, approximately 40 acres are considered to be sufficient for a family-operated farm. Practically the same idea was embodied in the American slogan of "40 acres and a mule," which originated with the freedmen. Settlers, however, usually acquired a much larger acreage. According to the Census of 1900, in none of the States that form the eastern humid half of the country was the average size of farm less than 80 acres. In the drier Western States, which include the tier of States from North Dakota south to Texas, farms averaged from 200 to more than 1,000 acres, except in Idaho. Farmers in America therefore, were comparatively well supplied with land on which to use mechanical equipment. This was particularly the case in the Great Plains, where most of the small grains are grown.

Although technology transformed farm operations, science played a major role in increasing the effectiveness of farm labor and the productivity of the land.

Near the turn of the 19th century, a beginning was made in the study and survey of the soils of the country to obtain more reliable information as to how they could be used to produce crops. Their physical characteristics and chemical composition were studied. As a result, their use adaptability, and their adequacy or deficiency so far as plant nutrients were concerned became better known and served as a guide to the use of fertilizers, the conservation and management of the soils, and better adjustment of land use to the potentiality of the land itself.

To obtain a factual background of the manifest climatic divergencies in the different parts of the country, the Weather Bureau established many cooperative stations to record and report the daily readings of the instruments. With the accumulated records over the years, characteristics of local climatic regional variations, and to some extent the hazards of weather, could be determined. Thus, agriculture was able to adjust its enterprises and operations to conform to some extent to the vagaries of weather.

On the economic side, farm-management studies were undertaken throughout the country to help farmers organize their operations more efficiently. This was done especially with a view to improving farm incomes by taking the cost–returns ratio into account, and by adjusting farm enterprises to the advantages and shortcomings of the physical and economic environments in which they were carried on.

The work of county agents and experiment stations had a similar orientation. County agents were appointed for most counties so that farmers could avail themselves of their advice and counsel when special problems arose. The office of the county agent served also as intermediary in the introduction of advances made in agricultural production.

These are some of the more conspicuous landmarks established along the road of progress before World War I. When, therefore, the war emergencies called for increased production, the mechanism for doing the job was available and farmers responded with alacrity.

Progress in this direction did not end with the end of World War I. Although there was a temporary economic slackening, new improvements in industrial and agricultural production occurred. New machines appeared; higher yielding crop varieties were introduced; conservation and management of the soil received greater attention; conversion of feed into food became more efficient; new methods of food preservation and marketing were devised and established; and new wood-using processes provided the foundation for new industries. These and other innovations have affected agriculture and forestry in particular and the country as a whole in general.

Internal development of the country is linked inevitably with the use of the land. This has been true since the first settlers arrived from Europe four centuries ago. The transition from primitive conditions to a highly industrialized civilization was accomplished in a shorter space of time here than in other parts of the world. Moreover, the conversion of the country has been so effective that little land is left that does not bear the imprint of cultural features. This should not be construed as meaning that there is no room or need for further improvement. Actually, our land and water resources are not fully developed. Increase in population alone will require perennial adjustments and improvements in the use of both land and water to accommodate the needs of the people.

Expansions and contractions in the use of the land for primary production must be expected and accepted as part of the growing pains of the Nation. In addition, problems were inherited from the past. Not all the damage inflicted on the land during the exploitive period has been repaired. Of even longer standing is the unfinished business of boundary determination left by the colonies and the States that succeeded them. Uncertain boundaries of administrative divisions and land-ownership units, which stem from the methods of issuing titles that were prevalent in the colonies and the States, are still a fruitful source of contention. These problems, which are connected with civic order and national growth, have awakened interest in ownership and use of the land. To provide a better insight and causal understanding of these problems is the purpose of the study reported here.

The Background

Strains and stresses in the man–land relationship make up one of the issues the world faces today. When examined from a realistic viewpoint, many of the impediments that arise are found to be centered largely in the difficulty of keeping the functional relationship between two factors of a different order in proper balance. Land is relatively static in both quantity and natural characteristics, whereas population is dynamic in both its action and its reaction on the use of land. The density or sparsity of population, its rate of growth, and shifts in the social groupings of the population are variables so far as time and place are concerned. Each has a marked reaction on the use of the land. To these must be added the influence exerted by an advanced economy and improvements in standards of living. As a higher standard of living usually means a greater demand for more diversified and improved products of the land and for proportionately larger acreages on which to produce them, use of a fixed acreage of land requires continuous adjustment to meet the changing needs of the population.

Changing the use of the land to meet the needs of the population is identified with the progress of civilization. Since ancient times, use of land has been intensified step by step to increase production. Primitive tribal society used the land mainly as a hunting and gathering ground. The products of the chase and the edible fruits and plants provided by the natural vegetation satisfied the needs of the population. Later, with the domestication of animals, nomadic herdsmen used the land as open range.

With the planting of crops, a new era was ushered in. It marked the beginning of more intensive use of the land and in turn changed the habitual way of living of the people. Crop planting was the initial step in the direction of development and use of the land for agriculture. Although the patches of land planted were shifted from time to time, people began to attend to fields and domestic animals from a fixed place of residence. Thus permanent settlement as the preferred mode of living was initiated.

In most parts of the world, increasing the production of food, feed, and fiber to provide for the needs of a larger population was not a particularly stringent problem in these early stages of civilization. With increased experience, agricultural practices became more efficient, and this in itself increased production. The standards of living were not so exacting that they could not be satisfied readily by moving to new land, which was abundant. Even though it was not located in the same region, it could be reached and settled through migration or, as was frequently done, acquired through conquest. In arid regions, irrigation was applied early to obtain a reliable supply of food and feed from agricultural production. These, in short, were the chief methods used to adjust the man–land relationship from ancient to modern times.

New Ways of Adjusting Man–Land Relationship Needed

When the present world situation is used as the background of reference for this discussion, it becomes clear that some of the former ways of adjusting the man–land relationship are no longer realistic. All land is now partitioned and under the jurisdiction of one country or another. Some land is still not fully occupied or developed and could easily support more people. But, in most instances, the free movement of people, aside from travel for business and pleasure, is restricted to the confines of their own countries. Paradoxical as it may sound, this is at a time when modern transportation facilities have made man more mobile than ever before. For the most part, any improvement in the man–land relationship to promote the common welfare of the people must first be sought within individual countries.

That the maladjustment in the man–land relationship is now felt more acutely in some parts of a country, or in some parts of the world, as compared with other parts, usually cannot be attributed to a single cause. The combination of fixed and variable factors in each instance must be recognized and studied in its natural setting if the problems contained therein are to be analyzed and solutions found. Natural conditions and wealth differ from region to region, and the distribution of population does not always conform to the distribution of natural resources. In addition, each country or region has its own customs and institutions that govern the actions of the people and, in some instances, control the use of the land. Under these circumstances, it cannot be expected, nor is it possible, that people everywhere can attain a uniformly high level of living from use of the land.

Land use and level of living are related, but neither the one nor the other in itself is a reliable indicator of the potentiality of the land to support the population. Frequently, land use represents only one segment of the regional economy. So far as the level of living is concerned, land use may be secondary to other industries. From the land use standpoint, we have areas of both overproduction and underproduction in relation to local needs. In a country in which the agrarian economy has largely given way to industry and commerce, and where the greater part of the population

resides in urban concentrations, surplus production in some areas is essential to balance the deficiencies of other areas. Actually, as a result of the spreading of cosmopolitan tastes and habits, few corners on the globe have retained a mode of living in which everything needed is furnished by the natural environment of the people.

Adjustment to Physical Conditions

Because of the disparate distribution of natural conditions, resources, and people, the use of land has acquired the characteristics of a commercial enterprise. Many crops are grown entirely as cash crops. Frequently, they are grown for export as well as for domestic consumption or industrial use. This is true also of forest products and the products of the range. With the entrance of land use into the the commercial production field, it became more sensitive to the factors that influence prices and cost of production. Soils, climate, water supply, economic conditions, labor efficiency, increased yields per areal unit, improved quality of products, location of production areas with reference to markets, processing methods, storage and shipping facilities for products, and market demand, are all aspects of the land use complex, which in the more advanced countries receive added recognition and attention.

Food and an adequate diet, the most obvious and in places the most pressing physical needs of man, are singled out at times as the desired goal of land use in improving the level of living of the people. A proper diet is an essential element of human well-being, but in itself it is hardly sufficient to raise the level of living in backward countries and regions. In these countries and regions, more than land use must be taken into account. Raising the productive capacity of the land is conditioned first on an increase in the productive capacity of the people. Workers on the land must be able to produce more than they need for themselves. An advancement of the whole economy is needed to raise the level of living.

Technology and Land Use

With the introduction of mechanized operations in production of food and fiber, the manpower requirements for land use declined. Many persons released from work on the land are now free to follow other gainful occupations. Land use itself is now an industry. Whether we approach the question of standard of living from the viewpoint of land use or of industry as a whole, therefore, we are likely to reach the same conclusion. Production and organization of all branches of industry are so closely interwoven that they must be considered together when improvement in the level of living is the aim. Translated into terms of action, this means that all natural resources must be developed to serve the economy of an area.

How the economics and production techniques of land use have benefited from association with industry is evident from the results obtained. In commercial agriculture, the input–output ratio necessarily receives considerable attention. The knowledge gained from special research and investigations in the physical, biological, social, technical, and economic fields readily finds application in competitive commercial enterprises. Therefore, wherever the results of research in these fields are applied to land use, as a rule, man, land, domestic animals, and plants produce more efficiently than was true a decade or so ago. Much has been done to advance human well-being by applying constructive knowledge and skills to use of land. In addition to these benefits, these accomplishments furnish evidence that progress can be made. They show the way in which it can be achieved, how some of the obstacles to better use of the land can be surmounted, and how production can be increased on a fixed area of land.

Although in recent years science and technology have established an all-time record of accomplishment, they have not succeeded in removing all obstacles to more intensive use of the land. Higher productive uses are excluded on much of the land area mainly because of unfavorable natural conditions. But between the most favorable setting for cultural use of the land and extreme instances in which all major uses are precluded are many intermediate classes with a diversity of complexes, to which use must be adjusted according to physical capability and economic feasibility. Land classes that range from the highest use capability to those with no productive use qualifications are found in the United States.

Within the approximately 3 million square miles of continental United States, physical conditions vary considerably from region to region, sometimes even from locality to locality. This was only imperfectly known at the time of settlement. In selecting sites for settlement, the pioneers relied mainly on their own resourcefulness and judgment, and they did not always locate on adequately productive land. Adjustment of settlement and land use to the physical conditions and the need for the products of the land has been going on since the first settlers arrived.

The United States, which is a comparatively young country, grew rapidly and is still growing. The chief period of internal growth was confined to the last 100 years or so. The population grew from 23 million persons in

1850 to 165 million in 1955. Hand in hand with the growth in population came development of the country's resources. During the latter part of the period especially, industrialization left its mark on countryside and people.

Growth and changes in the old order necessarily affected not only the use of the land but the economic and social status of much of the population as well. The proportion of urban to rural population changed. In 1850, as reported by the census, the urban segment of the 23 million people of the United States was 15 percent. In 1955, more than 64 percent of the 165 million people were living in cities. This movement means that more land is needed for residential and industrial purposes. With 107 million people concentrated in urban areas, the land requirements for outdoor recreation, travel, transportation, and communications have multiplied. Today, lands needed for urban

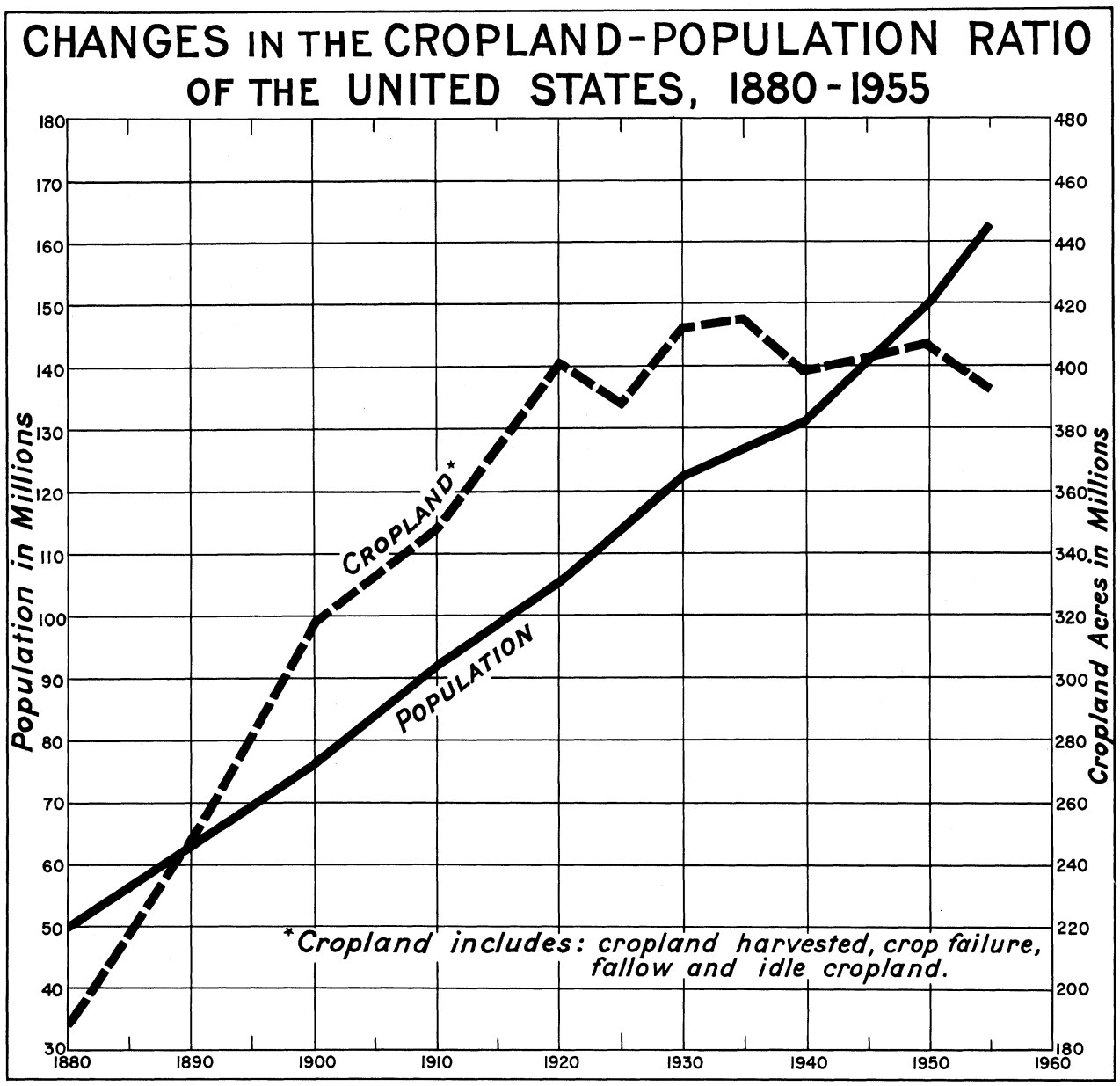

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FIGURE 1.—This chart shows changes in the relationship between population and cropland from 1880 to 1955. Both population and acreage of cropland increased steadily until 1920. After 1920, only population continued to increase. Increase in population, expansion of industries, and scientific and technological advances in crop production brought about shifts in distribution of cropland and affected the man–land relationship.

settlements, rights-of-way for roads and railroads, airports, parks, and related uses in the aggregate approximate the area of the State of Wyoming (*165*).[1]

Land use expanded with the westward movement of settlement. Expansion in acreage of cropland in this direction kept pace with settlement, but the acreage of cropland continued to increase for about three decades after 1890, when the western frontier had almost disappeared. Within the last 35 years, however, the overall proportion of cropland has not changed greatly, although regional shifts have occurred (fig. 1).

The per capita acreage of cropland in the United States, which rose from 3.8 acres in 1880 to 4.2 acres in 1900, fell to 3.8 acres in 1920. From then on per capita acreage declined, but despite a population increase of 56 million people, or 53 percent, from 1920 to 1955, we still were able to produce surpluses. In 1955, the per capita acreage reached a low of 2.4 acres.

Overall Picture of Land Use

Distribution of major land uses in the United States is impressive from the viewpoint of spatial concentration and dispersal characteristics. To these must be added the diversity in composition of the patterns themselves. Land use patterns have assumed local as well as regional characteristics, and these characteristics furnish the background for the economic structure of rural life. Regional concentration or sparsity of some uses has produced contrasts in the pattern of use associations in the national picture. In the main, this pattern reflects man's reaction to the advantages and shortcomings of the natural environment, in that he adjusts his use of the land to what he perceives to be its economic use capability.

For a better understanding of the uses made of our land resources, certain background information is essential. This is true when local land use patterns are under scrutiny, or when the distribution of major land uses over the country are studied. Arrangement of features in the cultural landscape cannot be explained successfully without reverting to the history of settlement, and to the division of the land and acquisition of title to it by the settlers. Similarly, physical features, such as land relief, climate, and soils are controlling factors; they cannot be ignored in a study and discussion of land use. Much of the pertinent evidence is presented in the form of maps and aerial photographs to record the spatial arrangement and distribution of features.

[1] Italic numbers in parentheses refer to Literature Cited, p. 273.

Most of these maps are included in the text, but to preserve clarity of expression in the overall picture, the color map, Major Land Uses in the United States (pocket), is necessary. Even so, the distinctions must be confined to major uses expressed in significant combinations.

Such major uses as the use of forest or woodland for grazing or recreation cannot receive separate areal recognition on the same map because they are dual uses. Use of cropland, especially hayland, for grazing during part of the year is another example. However, to show how the land is used in different parts of the country, a generalized presentation, such as is used in the color map, is necessary.

The land use distinctions represented on the map are largely associations derived from natural conditions. Only cropland, which is responsive to natural and economic advantages or disadvantages of location, is represented as a major competitive use. Cropland is not only widely distributed throughout the country; it also varies greatly as to the proportion of the land area it occupies. When minor land divisions, for instance, townships, are taken as a unit, cropland may comprise anywhere from 0 to 90 percent or more of the total land area. To visualize these quantitative variations of cropland distribution on the map in a true areal relationship, acreages of cropland as reported by counties were represented by means of approximately equal-area dots, as determined by the acreage represented and the scale of the map.

Irrigated land is treated as a special type of cropland, in that cropping the land is largely conditioned on soil moisture derived from sources other than local precipitation. In this respect, it is recognized as a distinct category of cropland. Drained land, which is the opposite of irrigated land, may be considered as belonging to a similar land use category. When quantitatively compared, the acreage of land drained is about four times that of irrigated land. Draining and clearing have been used in reclaiming swamp and marsh land for agricultural production, but drainage has been installed also on cultivated land to improve yields. In the western irrigation districts, drainage and irrigation are frequently combined. Because of its widespread application and its frequently close connection with undrained and irrigated cropland, drainage could not be incorporated in the map.

Although cropland has its own symbol on the map, its associations with other major uses are preserved. In the humid eastern section of the United States, where all three major uses are competitive, crop, forest, and pasture lands are interspersed. As may be observed,

cropland is rather sparsely scattered in many places in the Eastern States.

This can be taken as illustrating distribution only; it cannot safely be interpreted as meaning underdevelopment in all instances. Cropland is more concentrated in the Central Plains, and in the originally forested plains of western Ohio, Indiana, southern Michigan and Wisconsin, the Bluegrass Basin, the Pennyroyal of Kentucky, and some other areas. But the main concentration is found on the treeless prairies and plains of the Central States. An exception is the Coastal Prairie of Texas, which has remained largely grazing ground for cattle. In the West, aside from the Columbia Plateau, where dry grain farming is prevalent, cropland is concentrated in the valleys and basins, and is frequently supported by irrigation.

In contrast to cropland, of which the bulk is confined to the eastern two-thirds of the United States, most of the grazing land is found in the western third of the country. Grazing land used here as an overall classification term includes a great range in variables of plant associations and carrying capacity. Because of these distinctions, two terms are in common use, and to a certain extent, they have acquired a regional preference. In the East, with its more diversified land use patterns, pasture is the more common term, and in the semiarid and arid range country of the West, grazing is the well-established designation. Between these two preferential use areas, however, there is no distinct dividing line. The most pronounced distinction between pasture and grazing is found in carrying capacity. In the East, farm pasture usually has a high carrying capacity; on the Western range, it is very low. Gradations occur, of course; on the Western range, grazing is associated with type of vegetative cover. The lowest grazing capacity is connected with the desert shrub type on which up to 18 acres may be needed to support a cow for a month. Less than an acre of humid pasture may be required. Subhumid and semiarid grassland, open pasture, and forest and woodland grazed are intermediate grazing types. Regionally, they are associated to some extent with seasonal grazing use.

Desert as mapped is land that for several reasons has no productive use. Desert land may be barren rocky ground; barren saline playas, like the Black Desert in Nevada or the Great Salt Lake Desert in Utah; or, as in the Mojave Desert, land that produces some forage plants but cannot be grazed for lack of stock water.

Swamps and marshes are natural land types. Both types consist of waterlogged land but the swamps are wooded and the marshes are chiefly open grasslands. Land use in these areas is somewhat incidental. The swamps may furnish special kinds of lumber from water-loving trees. In favorable seasons, swamps and marshes may provide some grazing, but both are favored areas of wildlife, and if not protected, they frequently become seasonal hunting grounds. Hunting and trapping of muskrats as it is done in the coastal marshes of Louisiana constitutes a rewarding occupation.

Forest and woodland grazed are areas devoted almost entirely to silviculture. Settlements with acreages of cropland too small to be segregated on the map are included in only a few instances. These solid forest areas occupy chiefly mountains and rough land, or land with poor soil. Many of them are included in National and State Forests and Parks. The most extensive solid area of commercial forest in private ownership is found in northern Maine.

Alpine meadows are confined to mountaintops above the timberline. Some of these areas may be grazed briefly in summer, but many of them are only rock outcrop with little or no vegetation. Consequently, they are of little economic significance.

The information needed for delimitation of the areas recognized on the map was derived from many sources. When available, aerial photography was relied on primarily to supply the distributional facts. Most of the country east of the Rockies is covered by aerial photography. But as the difference in scale between the aerial photographs and the United States map is considerable, the contents of the photographic images could not be generalized directly down to the scale of the final map. To do this, State maps of the United States Geological Survey on a scale of 1:1,000,000 served as an intermediary on which the land use patterns were developed from the aerial photographs. Soil, topographic, and geologic maps provided additional reference material. A set of manuscript maps showing land use in the States east of the Rockies resulted from this procedure. These maps provided the principal source for the areal delimitation of the land use features in this part of the country. For the Western States, aerial photography was used also, but less coherent coverage exists for these States than for those in the East. Moreover, the West has land use distinctions that must be determined from other sources.

Whether or not desert shrubland or forest and woodland is grazed is not identifiable on aerial photographs, except where barren ground indicates desert conditions. Actually, the boundary between desert and desert shrubland grazed is often indefinite and oscillating. During winters with some snow cover, sheep can be grazed farther out in the desert than is possible when springs and wells must be relied upon to provide the stockwater. In the delim-

itation of land use areas in the western part of the United States, material provided by the Bureau of Land Management and the Geological Survey of the United States Department of the Interior, the Forest Service and the Soil Conservation Service of the United States Department of Agriculture, and State publications that had a bearing on land use were consulted and utilized. Forest and woodland grazed is a distinction based mainly on the records of the Forest Service.

As a generalized graphic presentation of land use, the map shows the variations in land use that exist in the United States. From region to region, differences may be noted in the intensity with which the land is used, and in the composition of major land use associations. In most places, variations of this kind denote changes in physical conditions. The land use patterns delimited on the map indicate that there are great regional differences in the contributions land can make to the Nation.

Settlement, Division, and Use of Land

In its broadest sense, land utilization may be defined as the use of land by man. The cultural landscape and the multiple combinations in the land use pattern are his work. A number of elements, however, may be discerned in the spatial order of these land use patterns. Some of the organizational features that appear in the design are those devised by individual users. Others are inherent characteristics of settlement by ethnic groups or of the institutionalized system of administrative land divisions. Differences of this kind are particularly noticeable when the areas of colonial settlement are compared with those of later development. (Compare, for instance, plates 32 and 38 or plates 143 and 144. All of them differ from those usually found in the Old World.) The historical factor, therefore, has much to do with land use. If we are to understand the layout of the patterns of land use, this factor must be considered.

In the United States, land use has gone through several stages that do not necessarily correspond to or coincide in all phases with those recognized in other parts of the world. Land use and civilization are closely related. A chapter on prehistoric land use would probably be concerned mainly with the hunting and collecting activities of primitive man. From these more indirect uses of the land, cultural uses gradually developed. At first, these cultural uses amounted only to common use of the land by the members of tribal society but from this use several types of ownership evolved. In some places, they were freeholds; in others, feudal tenure with entailed rights and obligations evolved; or a mixture of both were found. The transition from tribal use to individual ownership is missing in the history of land use in the United States. As a possible exception, the division of the land in Indian Reservations and the transfer of title to individuals could be cited. But this process did not evolve among the Indians themselves. There are also instances in which settlers at first used all or part of their land in common and then divided it among themselves. In so doing, they followed a custom they had brought with them from Europe.

Pre-Columbian Era

The Hunting and Foraging Period

The pre-Columbian history of land use in what is now continental United States probably differs very little from the early cultures of the Old World. From what we know now, these primitive American cultures appear on the time scale much earlier than was at first suspected. Stone artifacts found in interglacial deposits indicate that man was on this continent during the latter part of the Pleistocene Epoch. The actual age of these early American cultures is as yet a matter of conjecture. According to one source, however, they date back from 40,000 to 60,000 years (*48, p. 534*). More recently, by bringing other evidence to bear on the question, these estimates were extended to more than double the time during which the American continent may be considered as having been inhabited (*19*). More definite dates of site occupation, which were obtained from organic remains with the radiocarbon technique (*160*), have been established for a number of places, and new ones are added occasionally. So far, the oldest dates obtained in this way indicate that man was in the Americas thousands of years before the dawn of the Christian era. Only a few examples can be cited.

An archeological site on the alluvial terrace of the Trinity River near Lewisville in Denton County, Tex., probably yielded the oldest direct evidence of man's presence in America. This site, which consists of ancient hearths nearly 20 feet below the surface of the terrace, contained the bones of many food animals, fresh water clams, and snail shells, in addition to a flint spear point and charcoal. Radiocarbon tests on the charcoal indicated that it was more than 37,000 years old. A hearth near Las Vegas, Nev., was found to be some 23,000 years old, and a hearth on Santa Rosa Island about 30,000 years ago (*106, 13*).

Charcoal and bone from a fireplace 6 to 7 feet below the accumulations on the floor of Graham

Cave, Montgomery County, Mo., registered an age of nearly 10,000 years (*27*). Charcoal remains from a rock shelter on the Illinois side of the Mississippi River, about 40 miles south of St. Louis, registered an age of nearly 11,000 years (*104*). A similar age was determined for the occupation level of Allen Site on the Republican River Terrace (*30*). Evidence of early man's presence on the Pacific mainland is provided by "Several pairs of woven rope sandals found in Fort Rock Cave, covered by the Newberry Eruption in Oregon," which were made about 9,000 years ago (*4*).

The latest discovery of a site occupied by prehistoric man is reported from Alabama. Excavations in Russell Cave near Bridgeport, in the northeast corner of Alabama, of successive layers of 14-foot deposits encountered at the bottom a hearth, the remains of which indicated that it had been occupied 8,000 years ago (*105*). None of these prehistoric remains suggests that land was used in these early periods in any way except as a hunting and foraging ground. Indications that man had started to raise crops appear about 5,000 to 6,000 years later.

Beginning of Crop-Growing Era

In the exploration of Bat Cave, Catron County, N. Mex., in 1948, 766 well-preserved corncobs were found in the successive strata of accumulated refuse (*85*). The corncobs in the lower layer, however, provided insufficient material for radiocarbon dating, but extrapolation from the other layers indicates that the corn is from 3,000 to 3,500 years old, which corresponds to about 1,500 to 1,000 B. C. (*4*). Charcoal samples from an undisturbed area in this cave, with which the culture of corn may be correlatable, go back to about 5,000 B. C. (*79*). These discoveries indicate that at that time the land was used for crops. This may postdate the beginning of agriculture by a lengthy span of time. The discoveries also record the progress made in improving corn as an agricultural crop.

The remains of corn in these caves are significant in other respects. Caves and cave dwellings are rather numerous in the arid Southwest. As corn is a cultivated crop, the implications are that to a considerable extent these cavedwellers must have been farmers, and this in a region in which today the natural conditions are not particularly suited to production of corn, except under irrigation. If the climate has not changed in the meantime, the cavedwellers had to grow their corn on favorable spots in the moist bottoms of arroyos, or they had to divert water from the rivers for irrigation. Indications are that they did both.

Centuries later, the Indians on the Atlantic slope of the continent grew corn, beans, melons, tobacco, and other crops. Special cultural methods of growing corn, the chief crop, had been devised, and these were transmitted to the European settlers. With some tribes, agriculture was more or less a community enterprise. Instances are reported in which Indian fields contained several hundred acres (*31, p. 20*). But the Indians were also skillful hunters, and game was plentiful. The number of Indians was comparatively small in proportion to the territory they occupied. Their needs were elementary and a desultory type of farming served to supplement the provisions acquired through the chase. Hunting, fishing, and gathering of wild fruits furnished most of their food. Land use by the Indians was not exacting or exhausting for either land or people. It did not change profoundly the natural environment in which the Indians lived, although some changes in plant cover occurred as a result of burning and other activities. Pioneer settlers sometimes found openings in the forest, mainly near streams, which were abandoned sites of Indian villages or meadows produced by burning the forest. It has been estimated that less than 2 percent of all land in Pennsylvania was cleared of forest growth in this way before the settlers arrived (*47, pp. 2, 34*).

Apparently, the migratory movement of the Indians in the eastern forest zone of America was confined largely to tribal territories or hunting grounds. To a considerable extent, it was seasonal. Families congregated in movable camps and villages, at least for some parts of the year. Even the primitive type of agriculture practiced by the Indians required some attention. Protracted hunting expeditions had to wait for the cooler seasons. But neither hunting nor agriculture was restricted to individual tracts, for land ownership was unknown to the Indians.

Tribal hunting districts, however, were well established and recognized by the Indians. When traders from the East were admitted to the Indian country on the western waters of the Appalachians, a Board of Commissioners, in agreement with the Indian chiefs, allotted one trader to a hunting district. Beaver, deer, and fur skins were the chief articles the Indians had to offer for barter (*142, p. 34*).

Hunting districts or grounds were therefore the spatial limits of tribal authority vested in the Indian chiefs. Evidently there were boundaries to define the districts. That these boundaries were not always definite may be inferred from the friction among neighboring tribes. There were instances, however, in which boundaries were defined by markers. When d'Iberville and his party ascended the

Mississippi River in 1699, they noticed on the first bluffs a large red pole about 30 feet high, decorated with bear and fish heads. They learned that the pole represented a marker to divide the hunting grounds of the Bayougoula Indians from those of the Houmas. Among the Indians, the pole was known as the Istrouma, or Red Pole, which the French translated into Baton Rouge. Thus, the approximate site of the pole is marked, and the French rendition of the name is preserved in the name of the capital of Louisiana (*96, p. 17*).

Farther west on the prairies and plains, most of the Indians were nomads, who used land only as an open hunting ground. The grassland was the natural range of the buffalo, which roamed over the open country in immense herds. As game animals, buffaloes were easy to hunt, and before the white man arrived on the scene, their reproductive capacity more than satisfied the needs of the Indians. The chroniclers of Coronado's expedition (1540-42) reported that the Indians "in the country where the cows are" did not plant corn. These writers noted also that the migratory habits of the Indians were conditioned by the erratic, and no doubt to some extent seasonal, movement of the buffaloes. Several tribes, however, had villages on the Missouri and Platte Rivers and also grew some crops (*102, pp. 603, 622, 870*).

Colonial Period

The Spanish Grants

A more effective use of the land on the Atlantic coast began with the arrival of European colonists, who brought with them their more advanced knowledge of agricultural skills, their seeds and implements, and, in addition, their concepts of property rights and individual land ownership safeguarded by legal provisions. Their immediate task was to establish themselves on the land and to improve it so that it would yield a living for themselves and their families. In so doing, they opened a new chapter in the history of land utilization in America.

Settlement started in Florida in the second half of the 16th century. Farther north it did not get underway until a century later. One of the first acts of the colonists usually was to locate on the land and acquire title to it, although the method of acquiring title and the acreage an individual could claim were not uniform among the colonial powers.

The Spanish crown, applying the law of the Indies to Florida, granted land in peonias and caballerias, that is, the grants were proportionate to the rank of the individual. A peon or laborer received a lot for a house, enough land to grow a crop, and pasture and woodland for a given number of livestock; a caballero received a larger lot and 5 times the acreage of arable and pasture land received by a peon. When, in 1763, Spain ceded Florida to Great Britain, the British Government gave those who preferred to emigrate 18 months in which to dispose of their land holdings. Aside from city lots, nothing remains of these old Spanish land grants. Some Spanish grants from this early period have survived in what is now Colorado, New Mexico, Arizona, and California, or the part of the West that was originally penetrated and settled to some extent by the Spaniards.

Land grants in Florida that were recognized by the United States date from the British occupation, 1763 to 1783, and from the second Spanish occupation from 1783 until Florida was ceded to the United States in 1819 (*141*).

Spain made no formal purchases of land from the Indians. In the English and Dutch colonies, settlement proceeded along different lines. The Indians' right to occupancy of the land was a collective right that was usually recognized; it was extinguished only through purchase from the Indians by the Colonial Government or the settlers.

Settlement by Northern Europeans

Differences in conception of what the Indians' rights were to land, possession of which was claimed by European powers upon discovery, provided a distinctive approach to settlement of the land. Equally distinct were the policies and practices pursued in the colonies of conveying ownership rights of unoccupied land to private parties. Large grants to proprietary governors and trading companies which, in addition to established colonies, functioned under the provisions of their own charters, enabled each to adopt its own policy for disposal of the land. These policies usually followed established European patterns (*60, p. 39*).

In New England, tracts of land were at first granted to individuals, but after 1629 more definite rules of settlement were adopted to "avoid all contentions twixt the adventurers." Community settlements prevailed, but before a plantation or community could be organized, permission had to be obtained from the General Court. Grants of land in common for settlement were made to commoners, or proprietors, as they were called, as the responsible parties of the community. The boundaries of the grants were laid out. The land was divided and allotted to settlers according to rules adopted by the settlers themselves, which differed from the policy used with towns. Lots were not uniform in size. They varied with the personal worth of individual settlers. As a rule, not all the land within the townships was alienated at

the same time. Land that was not assigned to the original settlers was used and held in common and parcelled out later when the need arose. Evidently, this was the prevailing procedure, although it was not always strictly followed. After 1725, sales of land became more general, and leading settlers were able to obtain grants of land on which they did not settle but from which they expected the economic benefits of development (*120, pp. 55-56; 69, p. 26*).

Land division and allotment in the township settlements were controlled by the community, which comprised an area usually not more than 6 to 7 miles square, and frequently much less. This type of land alienation produced continuity of land ownership without overlapping claims or interspersed gores of "no man's land." The system was not so rigid in its aims or applications as to produce geometric uniformity in the size and shape of lots, but its influence was felt when the system of land division adopted for the public domain was shaped (*37*).

The Dutch along the Hudson River had more than one form of land tenure. At first, the West India Company, as the colonizing agency, promoted a seignorial type of settlement, which consisted of large estates owned by the "Patroons." Patroons divided their lands into farms, erected farm buildings, and provided implements and livestock for the settlers. The settlers were tenants. Besides paying rent, they had also to render certain service to the patroon. After the exclusive privilege of the West India Company to deed the land was revoked in 1638, this was changed. A Dutch colonist with 5 family members over 15 years old could then claim 200 acres. Later, under Stuyvesant, settlement in villages was encouraged. Agricultural land surrounding the villages was laid out. With this land frequently went pasture rights in the village commons.

A different arrangement in land division was introduced by the Huguenots, who settled in the Valley of the Wallkill, where they founded what is now New Paltz. These settlers had bought from the Indians a tract of land of about 36,000 acres, title to which was confirmed by the Governor in 1677. The agricultural land was subdivided by the settlers into rectangular lots, but some of the land near the village and some of the more distant woodland was left in commons, and for a time it was used in common. These rectangular divisions of the land are still in evidence (*39*). As a type of land division, this was the forerunner of a similar system used later in the western territories.

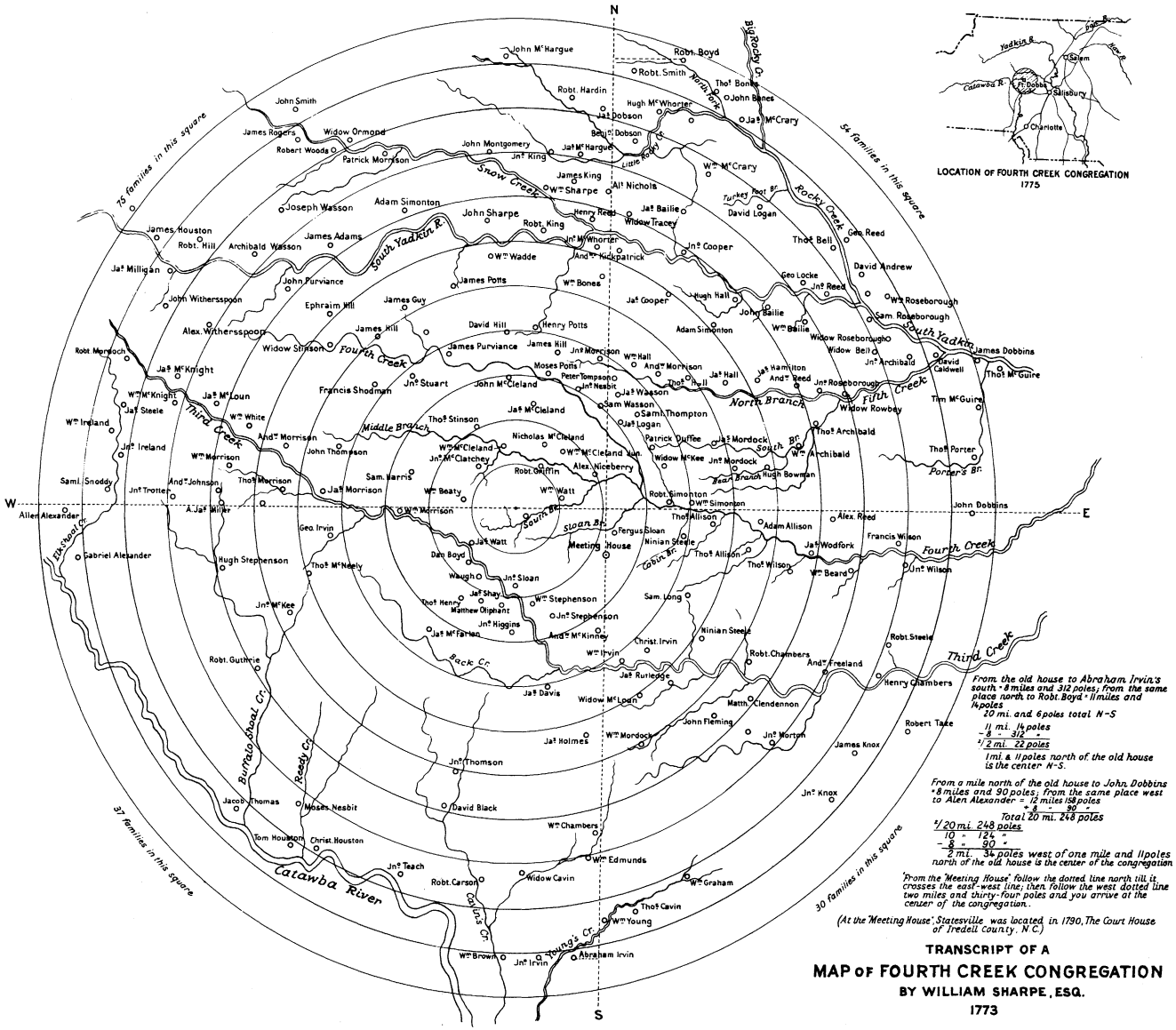
Indiscriminate Settlement

Another form of settlement, which is sometimes referred to as the indiscriminate type of settlement, took place in the mid-Atlantic and southern colonies. Here there was no preconceived method of allocating the land. Settlement in these colonies started on the lands most accessible from the ocean. These lands lay along the shores of estuaries and the banks of larger streams. Plantation owners of the southern Coastal Plains usually acquired large estates in these locations, as did the gentry for their manors in the central colonies. The policy of the proprietary governors of these colonies as to the acquisition of large estates, however, was not uniform. For instance, proportionately there are more manors in Maryland and Virginia than in Pennsylvania and Delaware. Large tracts of land were also sold to speculators who resold it to the settlers at a profit.

William Penn, as the proprietor of Pennsylvania and Delaware, was the largest landowner in the New World. Of necessity, he was at the same time Governor and sales promoter of his domain. Land acquired in his colony was deeded in his name. In 1682, soon after his arrival in the colony, he established a land office, which was charged with the sale of land. According to his instructions, the land was to be laid out in squares for community settlement. His commissioners, however, found it easier to accommodate individual buyers without adhering to a rigid system of land division. Except for Philadelphia, the streets of which were laid out by Penn himself, and Germantown, the system of rectangular land division was not generally applied in colonial Pennsylvania.

The land office functioned for a while, but as time went on, it could not prevent immigrants from moving westward and settling without legal sanction in whatever spot on vacant land they selected. William Penn's death almost caused the land office to suspend operations from 1718 to 1731. During this period, more squatters than legitimate settlers entered the back country. They established their claims and rights to land ownership through occupancy. Some futile attempts were made to dislodge them but after 1750, they were recognized by the proprietors. More land was sold when the office resumed proper operations, but the Revolution ended the disposal of proprietary land (*47, pp. 1-32*).

Although systematic land division had been proposed for Carolina and Georgia, preemption of land in the southern colonies proceeded with no attempt at conventionalized allocation of sites. Colonists entered the higher grounds from the east by following the waters or divides upstream. Others, who came from the north, followed the buffalo trails, which in turn became roads. The Piedmont and the Appalachian Valley received settlers in this way. Each settler selected his homesite, which was usually near a stream and far enough from his nearest



LOCATION OF FOURTH CREEK CONGREGATION
1775

From the old house to Abraham Irvin's south - 8 miles and 312 poles; from the same place north to Robt. Boyd - 11 miles and 14 poles
40 mi. and 6 poles total N-S
11 mi. 14 poles
- 8 - 312 "
+ 2 mi. 22 poles
1 mi & 11 poles north of the old house is the center N-S.

From a mile north of the old house to John Dobbins - 8 miles and 90 poles; from the same place west to Allen Alexander = 12 miles 158 poles
- 8 - 90 -
Total 20 mi. 248 poles
+ 20 mi. 248 poles
10 " 124 "
- 8 - 90 "
2 mi. 34 poles west of one mile and 11 poles north of the old house is the center of the congregation

From the "Meeting House" follow the dotted line north till it crosses the east-west line; then follow the west dotted line two miles and thirty-four poles and you arrive at the center of the congregation.

(At the "Meeting House" Statesville was located in 1790, The Court House of Iredell County, N.C.)

TRANSCRIPT OF A
MAP OF FOURTH CREEK CONGREGATION
BY WILLIAM SHARPE, ESQ.
1773

FIGURE 2.—This map shows how settlement and local government organization developed in the Carolina Piedmont. It illustrates the centrality principle of organization of settlement. The concentric circles drawn around the determined center of the community are spaced a mile apart. (Made available through the courtesy of Mr. Hugh H. Wooten.)

neighbor so that he would not encroach on his neighbor's claim.

In obtaining title to the land, the purchaser received from the Colonial government a warrant of survey for a stated acreage on prevailing terms. The warrant did not specify location; it could be applied to any vacant, unappropriated public land in the colony. A boundary survey of the selected land had to be made and presented, with the warrant of survey, to the land office. If no valid protest was registered within a certain time, the land office then issued a patent to the land. The boundaries on these land plats represented chiefly compass lines run by inexperienced surveyors. The line description started and ended at the same point. These so called "metes and bounds" surveys of the colonial period were not accurate. Conflicting claims resulting from this type of survey provide a continuing source of litigation (*69, p. 23*).

Group settlement developed in places to permit mutual protection and collective counsel and action. Frequently, more than one branch of a family were represented in a group. Thus group coherence was strengthened by ties of kinship. Later, when local administrative units were organized, these groups or congregations served as nuclei for units. The formation and location of such a group settlement is recorded in figure 2. This unique document was made by William Sharpe, an early settler in the Piedmont of North Carolina, who was a member of the Fourth Creek congregation. It illustrates the grouping of the pioneer settlers; their names reveal to some extent their family connections. It is also the first example found in America of the application of the centrality principle in organizing a community. From this community, Iredell County evolved. Statesville, its county seat, is located where the old meetinghouse formerly stood.

Appalachians, the Colonial Frontier of Settlement

Settlement in these colonies was restricted to the eastern slope of the mountains by Royal Proclamation, but as the proclamation was ambiguously worded, it was not taken seriously by either the people or the colonial officials. Indian traders, hunters, explorers, and adventurers entered the "country upon the western waters" very early, but after 1774, settlers arrived in bands and located claims on the land. Among the settlers were holders of military and treasury warrants.

The restraining attitude of England toward the movement of colonists westward across the Appalachians was not shared by other European powers with colonies in America. Spanish explorers, missionaries, and settlers coming from Mexico had entered the Southwest in the latter part of the 18th century, where they established missions and settlements and received grants of land in scattered spots; others moved eastward into Texas where they established some colonies. Even earlier, Spanish explorers and adventurers used Florida as a starting point from which to push northward and westward in their quest of the treasure cities. The best known of these expeditions, of course, is that of De Soto, who advanced through what is now Georgia and the Carolinas into the Tennessee Valley, and from there to the Mississippi. Although these Spanish adventurers claimed for Spain the lands over which they had traveled, the Spanish Government made no effort to settle and develop the country.

Settlement Extended to Western Waters

More than a century later, the French, who had settled on the St. Lawrence River, sent out expeditions to explore the West. They wanted especially to discover the transcontinental waterway which the Indians had told them existed. They explored the Great Lakes region and the upper waters of the Mississippi, which Marquette descended in 1673 to the confluence of the Arkansas. It was left to LaSalle to explore the Mississippi River to the Gulf. In 1683, in the name of King Louis XIV, he took possession of the Mississippi River basin for France, naming it Louisiana. French settlements grew up slowly near the mouth of the river. The trading posts established earlier in the Great Lakes country became colonies to which others were added along the river and the lakes. But French settlements were still widely scattered when, in 1803, Louisiana was bought by the United States from Napoleon for $15,000,000.

The Spanish and French chapters in the history of the United States have left enduring impressions on land and people. The Spanish and French names of settlements and natural features are their legacy; as are their patterns of land ownership and land use. With the accession of the land by the United States, valid land titles were accepted as issued by the former governments, although as a rule, they do not extend over large compact areas. In the public-domain divisions of the land that followed, they stand out as islands having their own land divisions, of which the long-lot division is characteristic of all French settlements (pls. 1 and 137). In themselves, the long-lot divisions would be sufficient to identify French settlements even though the name has been changed. An example is a town on Lake Erie in Michigan; it was originally called Frenchtown but was renamed Monroe in 1815.

After the colonies attained their independence and the colonists assumed the responsibilities of government, the land question was one of the first to need attention. The trans-Appalachian country west of Virginia to the Ohio and the Mississippi was claimed by Virginia. Within this vast stretch of country, even though settlers had established themselves and claims had been laid out, there was no legal authority to issue valid titles to land nor could conflicting claims be adjudicated. To remedy this situation, the Virginia Assembly created the land courts in 1779. The western country was divided into 4 districts. For each district, 4 commissioners were appointed who acted as, and performed the duties of, an ambulating land court. The records of the land court for Kentucky County, which was almost coextensive with the present State of Kentucky, show that the term of the court was 10 months. Meetings were held in forts, churches, and meetinghouses; they were required to be advertised 20 days ahead. The first session was held on October 13, 1779; the last on April 26, 1780. Within this space of about 6 months, which included time for travel in a "hard winter," 8 sessions, lasting in all 79 days, were held in different parts of the county.

The claims adjudicated by the commissioners during this time totaled more than 1,400, of which 1,328, comprising in all 1,334,050 acres, were allowed and for which certificates were issued. These preemption claims were granted as a result of settlement, for which 400 acres each were allowed. For improvement, 1,000 additional acres were granted, making 1,400 in all. In addition, other claims based on military warrants, treasury warrants, and other surveys were located. Altogether, nearly 3.5 million acres, or more than an eighth of the area of the State of Kentucky, were claimed in 1779 under some form of preemption (*159*). The commissioners could not go to individual settlers and verify the boundaries of their claims. Adjudication of an average of 17 claims a day precluded such a procedure.

The land in what is now Tennessee was at first attached to North Carolina. When North Carolina ceded the western territory to Congress in 1784, and to the Federal Government in 1790, it did so with the provision that all land entries and military reservations made under the authority of North Carolina would remain valid. Therefore when Tennessee finally emerged as a State in 1796, it inherited a complexity of land claims and settlement schemes. Much land had been deeded in large tracts to influential men and land companies; North Carolina retained the military reservations and the right to additional land to compensate soldiers of the Revolution in case the reservations could not accommodate the claims; Congress had some land reservations, which were relinquished in 1823. Finally, Indians still occupied some of the land and their claims were not extinguished (*1*). As may be surmised, the landownership divisions that evolved from these tangled claims are usually irregular. Except for Indian lands, which were acquired and divided later, regularity in lines is confined to certain localities.

Defects of Colonial Land Surveys

With the advancement of settlement came also a broadening of the preemption policy. Sales and grants were extended to include the headright system. Essentially, the headright system provided that the head of a family could claim a certain acreage for himself and, in addition, a stated acreage for each member of his family; servants were sometimes included. The headright system was in operation in all the seaboard colonies, but its vogue was greatest in the South Atlantic colonies (*60, pp. 194-236*).

All these methods of obtaining title to land were loosely administered. In colonies in which the indiscriminate method of settlement was used, the land surveys were seldom verified in the field, and conflicting claims to land through overlapping were not unusual. Deeds to vacant lands were issued rather freely, although some colonies were more liberal than others in this regard. This policy did not change at once when the colonies attained statehood. Georgia, in which the headright system was predominantly applied, furnishes an outstanding example.

Only a belt along the ocean that extended inland between the Savannah and the Altamaha-Oconee Rivers was occupied during the colonial period. The counties established within this belt are usually referred to as headright counties in contrast to land-lot counties, which were settled later. In the headright counties, land was granted according to the size of the settler's family but the grant could not exceed 1,000 acres. The granting of land with little restraint in these counties resulted in conflicting claims. After a check of these colonial grants, the Surveyor-General of Georgia on June 17, 1839, furnished the State Legislature with a statement in which he showed that "the twenty-four counties existing in 1796 contained actually 8,717,960 acres of land, whereas the maps and records in the Surveyor-General's office show that in these counties there had been granted 29,097,866 acres" (*83, p. 57*). The report leaves little room for doubt that there were weaknesses in the method of acquiring title to land.

These brief notes on the prevailing customs and procedures of acquiring land titles during the colonial period represent examples selected

to illustrate the different ways in which the settlers occupied the land and acquired ownership of it. All of them fit into the general picture of the times. There was a superabundance of vacant land that had little more than a nominal value. No fixed policy of, or administrative machinery for, settlement existed in the colonies to guide the settlers or to regulate allocation of land.

Land titles could be obtained rather easily. Anyone who was willing to settle in the wilderness and improve the land could obtain a warrant for so many acres, select the land, have it recorded, usually without having the boundaries verified in the field, and pay quitrent. In some instances, even this formality was ignored. Many settlers claimed the land on which they had located, by virtue of occupancy and the improvements they had made. In other instances, individuals and land companies obtained extensive tracts for speculative purposes. They sold the land, not infrequently the same land, to different settlers. Insecurity of title, administrative difficulties, and legal problems resulted. Boundary litigations were frequent. When the public lands question was debated in the House of Representatives of the First Congress in Philadelphia, December 27, 1790, Elias Boudinot from New Jersey said (*133*), "more money had been spent at law, in disputes arising from that mode of settlement, in New Jersey than would have been necessary to purchase all the land of the State."

Rectangular Land Division System of the Public Domain

The Ordinance of 1785

The shortcomings of indiscriminate settlement were therefore known to the founding fathers, who were confronted with a formidable land question. A proposal that the original States cede their western land to Congress was made as early as 1778, 4 years before the provisional treaty of peace was signed. When in the intervening years, the States ceded the territory north of the Ohio and west to the Mississippi to Congress, a system of alienating public land that would avoid the trouble inherent in indiscriminate settlement became a necessity. A Congressional Committee of five, with Thomas Jefferson as chairman, was charged with the task of preparing a survey ordinance that would divide the public lands preparatory to settlement and development. A draft of the ordinance (*34, p. 178*) was reported from the Committee on May 7, 1784. "This ordinance required the public land to be divided into 'hundreds' of ten geographical miles square, and those again to be subdivided into lots of one mile square each, to be numbered from 1 to 100, commencing in the northwestern corner and counting from west to east and from east to west continuously; . . ." The ordinance was tabled for a year. Then, after debate and amendment, it was passed by Congress on May 20, 1785. In the amendment, the original 10-mile-square "hundreds" of the rectangular-land-division system were reduced to 6-mile-square townships.

Surveying began in the same year in Ohio, where the Ohio River crosses the Pennsylvania State boundary. From this point, a line was run westward which served as the northern limit of the "First Seven Ranges" that were to be laid out. As a result of difficulties in the field, the original provision of true alinement of the division lines in an east–west and north–south direction was disregarded, and compass bearings were used instead. Only the exteriors of the townships were laid out in the field at first. The subdivisions were drawn in on the plats; in the field, they were added later. Ohio provided the proving ground of the rectangular system of land division. Tract by tract, as the land was ceded by the Indians through purchase, it was divided into townships 6 miles square, and subdivided into sections, although this was not always strictly in conformity with the system. In Symmes Purchase between the Miamis, the land was divided into sections and townships, but the townships were numbered from west to east instead of north to south. Only in the survey of the last tract in northwestern Ohio was the system applied in its final form.

The Ordinance Modified

The western boundary of Ohio had been surveyed in 1817; it was used as the controlling or principal meridian for northwestern Ohio. From the principal meridian, a parallel or base line was run to the east, thus dividing northwestern Ohio into two tracts in which the ranges and townships were numbered and identified as located NE or SE with reference to the principal meridian and base line (*110, p. 233*). In a rectangular coordinate system, the initial point, or the point of origin as it is now called, is the starting point of the surveys from which the principal meridian and the base line are run true to astronomical bearing north–south and east–west. These lines control the system.

Indiana was the first State in which all the divisions of public land, except the wedge-shaped portion of Congress lands along the Ohio boundary, were controlled by one principal meridian and one base-line parallel. The land surveys of the remaining parts of the Northwest Territory, of Mississippi, Alabama, and Florida in the South, the land that was ceded to the United States in 1803 in the Louisiana Purchase, and the later accessions

RECTANGULAR COORDINATED LAND DIVISION SYSTEM

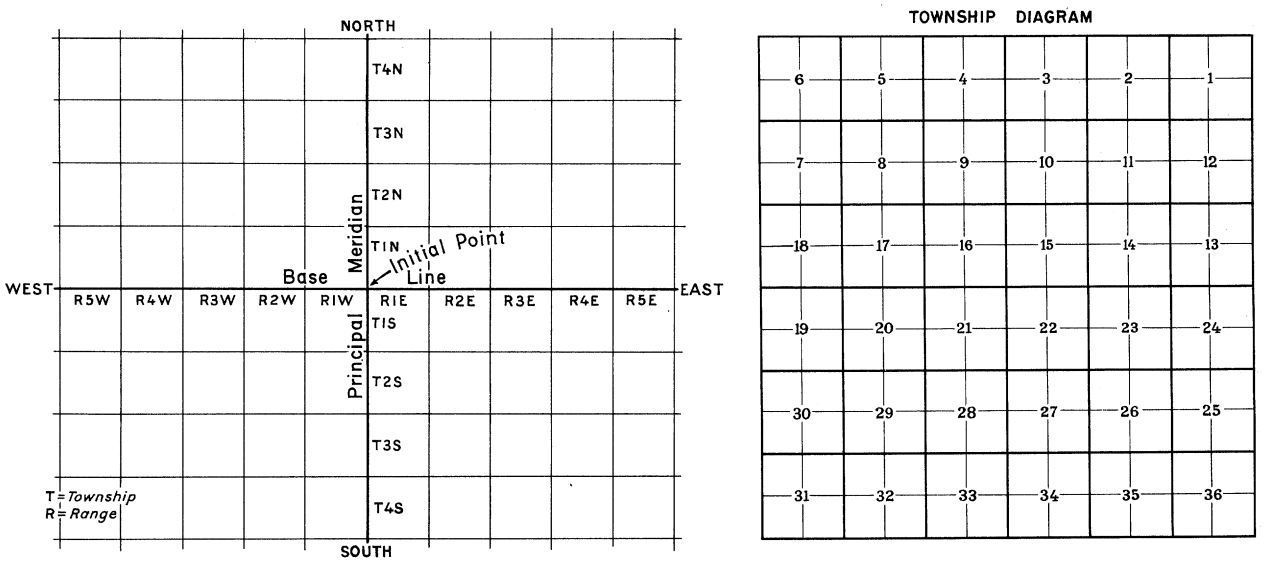


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FIGURE 3.—The 6-mile-square township as shown here was the standard unit of land division named in the Land Ordinance of 1785 for the Northwest Territory. It remains the standard unit for accessions to the public domain. But the intersection of lines may depart from the right angle, and acreages of sections vary. Identification of townships and ranges and numbering of mile-square subdivisions were not always consistent.

of territories across the Rockies to the Pacific Coast, are controlled by these systems of coordinates. But as these land divisions were marked on the ground before the land was settled, these survey districts, to which the individual systems of coordination apply and for which they provide the legal identification of the land divisions, usually are not identified with States. Some of them embrace several States. The smallest applied to about 12 survey townships. A survey township comprises 36 square miles, each of which is numbered as indicated in figure 3.

In the "Seven Ranges" on the Ohio, where the land-division surveys started, and in the district "Between the Miamis," the numeration of townships and ranges, as well as that of sections, does not conform to the system as it developed later. The land-division system, with its rectangular coordinated township identification and numbering of sections as indicated in figure 3, reached its final stage in Indiana. From then on, no further modifications were introduced. All federal land surveys west and south of Ohio were executed in harmony with the principle of the system, although no uniform standard of accuracy was obtained.

The rectangular system of land division as used by the General Land Office is confined to the public domain belonging to the Federal Government. Because of this, the States that originated from the public domain are often referred to as the public-domain States.

Comparison with Roman System

The rectangular coordinated land-division system used in the United States is essentially the same as the one used by the Romans in their colonies more than 2,000 years ago. Size of unit squares, confinement of rectangular coordination to the area of a colony, and terminology are the chief differences. To the Romans, the centuria of 200 jugera (125 acres) was the coordination unit. In the United States, the coordination unit is the township of 36 square miles (23,000 acres). What is now called the initial point or point of origin of the system was called the *Umbilicus* by the Romans. The axis of ordinates, now known as the principal meridian, was called by the Romans *Cardo Maximus,* and the axis of abscissas, which we call the base line, was known to the Romans as the *Decumanus Maximus* (*78*).

One advantage of the rectangular land-division system is that the exact location of a subdivision tract can be described with a few symbols. For instance, the only 160-acre tract of land in the United States that can be identified as the SW Quarter, Sec. 35, T. 11 N, R. 5 E, of the second principal meridian is the quarter-section that forms the southwest corner of Shelby County, Ind.

The extensive and varied uses of the rectangular land-division system in the United States are largely responsible for the interest manifested in the history of the system. A good many papers have been written on the

subject, some with the intention of giving credit to the inventor of the system. So far, apparently, none has appeared in which the whole range of development of the system from its origin to its present application has received the attention it deserves. As an institution, it had an important part in the evolution of scientific principles and their application in civilization. In this instance, the evolution of rectangular coordination, as we know it, is tied directly to the rectangular land-division system and consequently is not the invention of one individual.

An adequate treatment of the history of the rectangular land-division system—its origin, evolution, and transmission—would be beyond the scope of this publication. Briefly, however, a rectangular land-division system was used in China more than 3,000 years ago, and some centuries later one was used by the Romans. Evidently, it is the latter that we have inherited. For purposes of colonization, the Romans divided the land into squares by means of an institutionalized rectangular coordinated system. Each square was called a centuria, and land so divided was referred to by the agrimensori as agro centuriatio—land divided into hundreds. The squares of the land divisions of some of the colonies founded by the Romans in the Po Valley in the second century B. C., notably those near Padua, Cesena, and Lugo, are to a considerable extent still in use today (*78*).

The origin of our rectangular land-division system provided for some time a fertile field of conjectural writing. No statement of its ancestry accompanied its introduction. The connection between the Roman system and ours may be perceived, however, if we remember that in 1784, Thomas Jefferson called these divisions in his draft of the survey ordinance "hundreds," the Latin centuriae. The deduction based on the etymological relationship of the two terms receives additional support from the fact that by that time Latin texts describing the system were fairly accessible to students. By the middle of the 18th century, 20 printed editions of extant parts or whole texts, written by the Roman land surveyors, were issued in different cities of Europe (*11*). This was at a time when new lands in America were being opened up and settled, thus providing opportunities for its application. Systems of this kind were actually propounded by William Penn for Pennsylvania, John Locke for Carolina, and Robert Montgomery for Georgia, and all these proposals were made in Europe.

For the national system, evidence pointing in the same direction was recently uncovered through intensive study of historical records. According to these findings, Dr. Hugh Williamson, who had studied at Utrecht and was the spokesman of the congressional delegation from North Carolina, had suggested the application of rectangular land division to Jefferson. Although this important discovery may not constitute absolute proof of the Roman connection with our system, it clears up an old and moot question as to Jefferson's source of information (*97*).

Rectangular Land Divisions of Non-Federal or Reserved Public Lands

Many of the older States—the 13 original States, Maine, Kentucky, Tennessee, and Texas—had considerable acreages of unsettled and unappropriated land when they joined the Union. To avoid the confusion created by indiscriminate settlement, the national example was followed and the remaining land was divided into rectangular tracts or lots. Ohio, which is usually considered a public domain State, also has some diverse rectangular divisions. Except possibly for one or two small areas, however, the rectangular land divisions laid out by the State governments themselves or by land companies or Federal agencies did not conform entirely to the system used by the General Land Office.

The Northern States

Although these lands were divided into rectangular tracts, the organization of the system differed between districts. In some instances, the divisions are similar to those of the national system. The lands of the Ohio Company were divided into 6-mile-square townships, but irregular lots are not infrequently found in the subdivisions. The lands included in the Connecticut Western Reserve and the United States Military Districts in Ohio were laid out into 5-mile-square townships, quartered, and then subdivided into mainly rectangular tracts but without the regularity of the General Land Office system (*110*).

The unoccupied land in northwestern Pennsylvania was used largely to compensate the soldiers of the Pennsylvania line in the Revolution. For this purpose, the land was divided into rectangular parcels of specified sizes, and the parcels were numbered to be assigned by lottery (*28*).

In New York, large acreages of the western lands were still unoccupied and in dispute between Massachusetts and New York at the end of the Revolution. Commissioners from these States, who met at Hartford, Conn., on December 16, 1786, succeeded in reconciling the claims. It was agreed that New York would retain jurisdiction over the territory while the rights to preemption of the land remained with Massachusetts. Payments on large tracts of land sold by Massachusetts were later defaulted, so that much of the land re-

verted to Massachusetts. Eventually, Robert Morris, a signer of the Declaration of Independence, obtained title to most of the land through purchase deeds from Massachusetts. He then employed surveyors to lay out the land into half-mile-square lots and arrange them in ranges and towns. Morris sold the land to persons in New York who acted as trustees of Amsterdam merchants, usually referred to as the Holland Land Company, who in turn sold the land to individual settlers (*8, 43*). Only a part of the State-owned land was subdivided by the Surveyor General of the State.

In Maine, rectangular land divisions were used while Maine was still a district of Massachusetts. A few ranges were laid out in the south-central part of Maine, and the 50 townships in the eastern part were surveyed and disposed of by Massachusetts by lottery from 1786 to 1788 (*98, p. 44*).

During the colonial period, settlement in Maine was largely confined to the southern part, although some French pioneers had settled in the bend of the St. John River in the north. Much of the land was unoccupied when, in 1820, Maine was admitted to the Union. Although in the process, Maine as a sovereign State obtained jurisdictional authority in its domain, it did not get complete preemption rights over all public lands in the State. For half of the unappropriated public land, or somewhat more than 8 million acres, title remained vested in the Bay State. Massachusetts offered to sell the land to Maine for $188,922, or about 4 cents an acre, but Maine thought the price too high and declined the offer.

From then on, both States had land for sale in Maine, but in order to segregate the land assigned to Massachusetts from the land belonging to Maine, it had to be surveyed. Accordingly, the land was laid out in ranges and townships chiefly 6 miles square, but no uniform system was used. For many of the townships, only the exteriors were surveyed. Lands were then classified as timber, settling, or waste lands. Each State had a land agent who supervised the sale of the lands. After 1832, the two land agents acted jointly in sales of land until about 1854, when Maine acquired from Massachusetts the remaining share of more than a million acres. Much of the land was alienated in large tracts by lumber operators; some was retained by the State; but most of it has remained forest land. It constitutes one of the principal forest regions in eastern United States (*162, pp. 48-65; 156, pp. 5-13*).

The Southern States

In Tennessee and Kentucky, most of the land was settled indiscriminately, but even after both territories had become States (Kentucky in 1792, Tennessee in 1796), tracts of land were occupied by Indians. All land located between the Tennessee and Mississippi Rivers and north of the present Alabama-Tennessee line was still Indian land. This tract was bought from the Chickasaw Indians by the Federal Government in 1818. Andrew Jackson and Governor Shelby of Kentucky negotiated the purchase as Government agents, and even now this part of Tennessee and Kentucky is sometimes referred to as the Jackson Purchase. The tract was divided into ranges and townships governed by principal meridians and base lines. One of these coordination systems is confined to Kentucky's part of the purchase, in which most of the townships are also subdivided into sections as in the national system. But a good many parcels scattered throughout the area do not form part of the system, especially in the northern part of the tract.

In Tennessee, the purchase area was divided into two belts. Each has a principal meridian and the southern boundary functioned as the base line to govern the layout of ranges and 6-mile-square sections, as the townships are here called. Although parcels of land are mainly rectangular and are oriented with the exterior of the sections, they are irregular and are not derived from a uniform subdivision of the sections. In southeastern Tennessee, the area still held by the Cherokees when Tennessee acquired statehood was later laid out into ranges and 6-mile-square townships, divided into mile-square lots. Two systems were used. In one, the ranges are oriented north to south; in the other they are alined with the trend of the mountains in a northeast to southwest direction (*24, 157, 137*).

Georgia's colonial charter included the back country to the Mississippi River. The land that extended beyond the present western boundary was ceded to the United States in 1802, and included in the national public domain. Only about 23 percent of the present State of Georgia was settled at the turn of the 18th century. The rest was still occupied by Indians. From 1802 to 1835, in a number of treaties, the Indians ceded the rights of occupancy, and the lands were opened for settlement. In doing this, the old headright system was displaced by the lottery system. As a result of this change, the land had to be surveyed and divided into lots before a title could be issued. This was done on the rectangular principle. Land districts were established by the original counties and were subdivided into lots; districts and lots were numbered. Although these lots were squares, they were not uniform in size; they varied with the supposed value of the land. In the Cherokee Gold Districts, along the foothills of the mountains, the lots comprised only 40 acres. In other districts, they were squares of 160, 202.5, 250, or, the largest, 490 acres.

Although these are the cited acreages, the squares frequently departed from them by a few acres more or less. The surveying was not precise and was done in a comparatively short time, between 1804 and 1832 (*83, 56*).

Texas

Texas differs in historical background, methods of settlement, and systems of land division, from the States on the Atlantic coast. Changes in its government were rather frequent during the first half of the last century. Texas was part of the Spanish province until 1821 when Mexico gained its independence. After that, Texas formed part of the State of Coahuila and Texas, as a State of the Mexican Federal Republic. At the successful conclusion of the revolution in 1836, Texas became an independent republic, which was admitted into the Union in 1845.

Only a few settlers entered Texas under the Spanish regime. Greater efforts to attract settlers were made during the Mexican and independent periods. Empresarios contracted with the government to colonize assigned areas in the eastern and southern parts of the State. The colonists they brought in were mainly Americans and Germans. When Texas entered the Union, the treaty agreement specified that Texas remain responsible for the public debt incurred by the late republic but retain the public lands that belonged to the former government. However, a large share of its western land claim was sold to the Federal Government in 1850 and thus became part of the national public domain.

Millions of acres of public lands remained at the disposal of the Texas legislature; they were used freely for the development of the State. Land was donated to railway companies, internal-improvement companies, and soldiers and their families. Large acreages were granted to educational institutions. The erection of the capitol building was paid for in public lands, and land scrip was sold by the Republic and the State. But the land had to be surveyed before title could be conveyed to these organizations and the people. Usually, this was done in blocks, which were subdivided into mile-square sections. The sections were numbered for identification (*82*).

Land ownership maps show that not all the blocks and their subdivisions have a north–south to east–west orientation of boundary lines. Nor is there any sharp line of separation between the land divided into squares and the irregular divisions. Tracts with irregular divisions are scattered among the blocks of regular divisions, while inversely, tracts of regular rectangular divisions are found in the area of the older settlement. This arrangement of land divisions over much of the older settlement area in Texas showed more order than is found in some areas of indiscriminate settlement in the East (*119*).

Other Areas

In addition to the areas divided by the States into rectangular divisions, a few tracts of diverse origin were subdivided in this way. Two of these tracts are in Florida—one in Wakulla County and the other in Gadsden County. They are part of the extensive Forbes' Purchase. In the rest of this purchase, the land-office system was expanded. Two more such tracts are found in Indiana—the Vincennes and Clark's Grants made to soldiers of the Revolution. Another is the Beaufort district on the coast of South Carolina, which was divided into land parcels by means of the rectangular coordinate method during the War Between the States for the United States Direct Tax Commission for the District of South Carolina (*163, pp. 41-42*).[2]

The largest numbers of these rectangular division lines are oriented north–south and east–west. However, there are exceptions, some of which have been noted. To permit a more complete picture, it will be well to review the situation. In Maine, the lottery land in the southeastern part of the State, and the towns in the south-central part of the State, are all oriented in a northwest–southeast and northeast–southwest direction. This is true also of the two military grants in Indiana. One of the land-division systems in southeastern Tennessee received its orientation from the trend of the mountains. In Georgia, the land divisions between the Ocmulgee and Oconee Rivers derived their orientation from the trend of the rivers. The tract in Wakulla County, Fla., has its divisions oriented by the general direction of the coast, and the one in Gadsden County by the direction of the River Hurricane. Land blocks with boundary lines that deviate from the north–south and east–west orientation are found in a number of places in Texas, mainly scattered among the other blocks of rectangular division. In the national system, theoretically at least, all dividing lines are supposed to be in true north–south and east–west direction, except in eastern Ohio, where magnetic orientation was substituted for astronomical determination.

The land ownership patterns found in the United States are closely related to the period, and to the prevailing administrative provisions in the area when settlement took place.

Settlement by townships is confined to New England. Indiscriminate settlement, in which selected tracts were deeded to settlers by the grantees of the crown, the colonial government,

[2] A set of the plans of Beaufort District is on file in the National Archives, Washington, D. C.

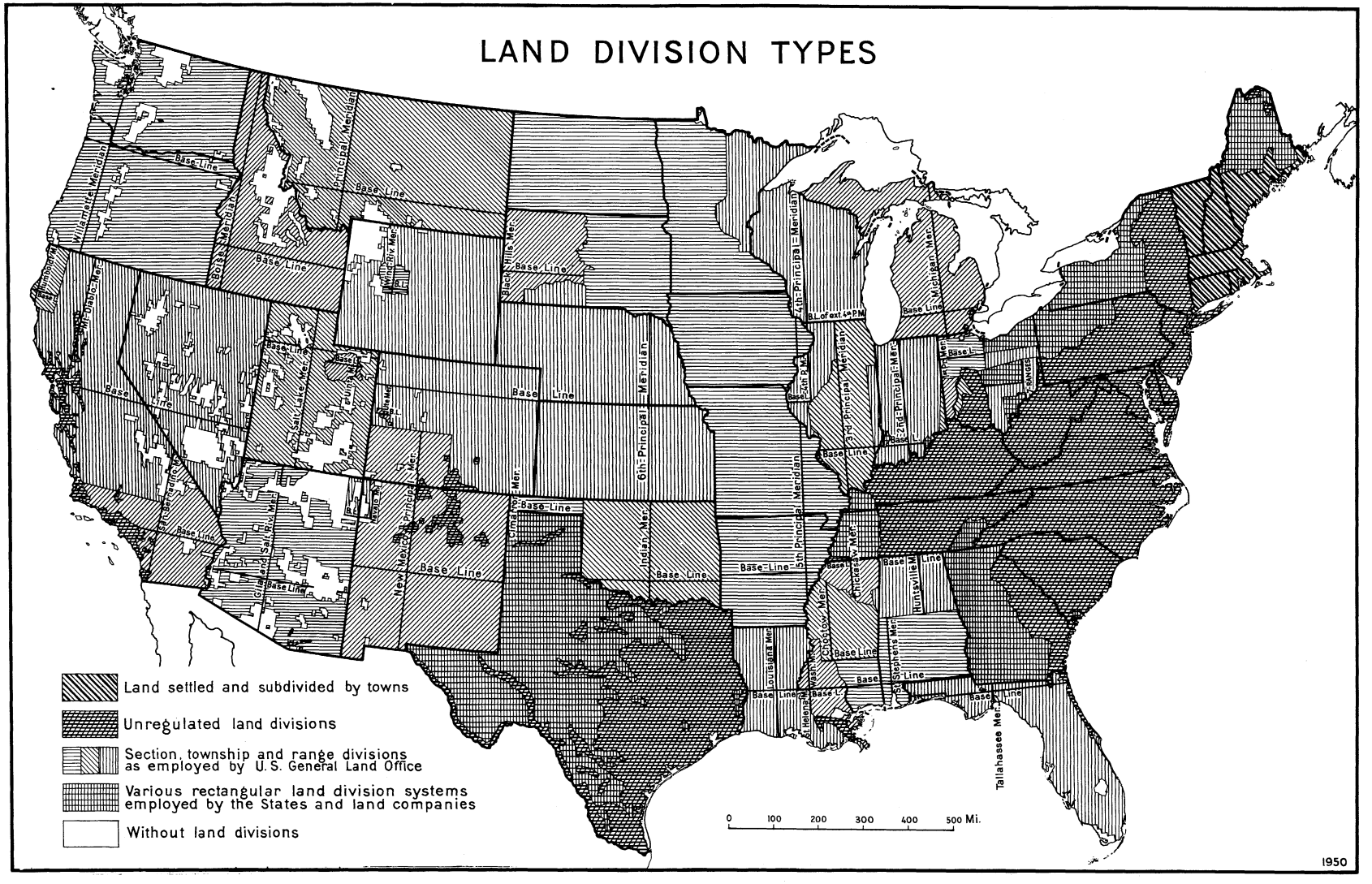

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FIGURE 4.—The areal spread of the different land-division types is illustrated on the map. To distinguish control areas of particular meridians and base lines within the national rectangular division system, different directions of the same space ruling are applied.

land companies, or the newly formed States, is found in eastern United States. The French and Spanish settlements in Louisiana, Texas, the Southwestern States and some other scattered places, must be included in this category.

Divisions into rectangular sections, townships and ranges were applied in the Federal public domain; such land comprises approximately 69 percent of the total area of continental United States. The survey has not yet been completed. There still are some national parks and forests, or lands of low grazing capacity, in which township and section lines are gradually being added to close the open gaps and provide land divisions for management purposes. In addition, more than 9 percent of the total land area, mainly in the older States, has been divided by applying some other rectangular system of land division.

The areal distinctions in the application of land divisions are indicated in figure 4.

Acquisition and Disposal of Public-Domain Lands

With the recognition of the United States as an autonomous country in 1782, the outlook of the people changed. Movement across the mountains and settlement on the "western waters" were encouraged. In fact, soldiers' claims to land compensations could be satisfied only beyond the western fringe of settlement. Most of the States on the Atlantic slope still had vacant land in the mountains, some of which was used as bounty land. The Trans-Appalachian States, which were created from the territories of Virginia and North Carolina, had prior commitments to accommodate the bounty claims of soldiers. Military land reserves also were set aside for that purpose. Soldier bounty warrants were recognized in locating on Federal public-domain lands.

Soldiers, however, were only a small fraction of the many people who started to move to new land across the mountains. Many settlers from the East joined the movement to the West. With the opening of the national public domain for settlement, the westward movement of pioneers gained momentum. The increasing number of immigrants from Europe who came to America to establish new homes added to it.

The Northwest Territory

The northern section of the national public domain was at that time known as the Northwest Territory. It consisted of the treaty lands, which were bounded on the west by the Mississippi, on the south by the Ohio, and on the north by the Great Lakes. The Eastern States had conflicting claims to these lands as a result of inconsistencies in the colonial charters. These lands were ceded to the Federal Government. Ohio, Indiana, Illinois, Michigan, Wisconsin, and a part of Minnesota were organized from this territory. The southern section of the Federal public domain comprised Georgia's claim to the land as far west as the Mississippi, which also was ceded with a stipulated compensation to the Federal Government. It provided the major part of the land of what is now Alabama and Mississippi. These territories and the land belonging to the individual States —in all some 844,000 square miles—constituted the original 1783 treaty area of the United States, which had the Mississippi as its western boundary.

Later Accessions

The western boundary, demarked by the Mississippi River, did not last long; however, in 1803, France sold the rest of the Mississippi Basin to the United States (this was the Louisiana Purchase), which slightly more than doubled the original land area of the Union. Within the half-century that followed, a number of other accessions occurred. These accessions included Florida, the Oregon Country, the Pacific Southwest, and Texas. They ended with the Gadsden Purchase from Mexico in 1853. They are summarized and their location and areal extent is illustrated in figure 5.

There were a number of settlements on land grants in Florida, Louisiana, New Mexico, and the Pacific Southwest, but the acreage acquired by these settlers was comparatively small. Parts of Texas had been settled and developed to some extent before it joined the Union, but in so doing, the State did not relinquish its claim to the vacant land. Only the land originally claimed but located outside the present border of Texas was acquired through purchase by the Federal Government and included in the public domain.

Land Disposal

Settlement, development, and disposal of land in such a vast estate did not follow a preconceived plan or policy that could be applied consistently throughout the area. Actually, at the time of acquisition the western country was not sufficiently well-known to permit the evolving of a definite policy adapted to the many different natural conditions to be found there.

The general knowledge of the country was derived from the reports of parties from this and other countries who had started to explore the West from the Pacific or had made their way by land across the continent (*35*). Nor was there a modern antecedent to serve as an example and to provide the guiding experience for formulation of a settlement and development policy that would fit such a vast acreage of diverse virgin land. Under these circumstances, the initial policy—to dispose of the land

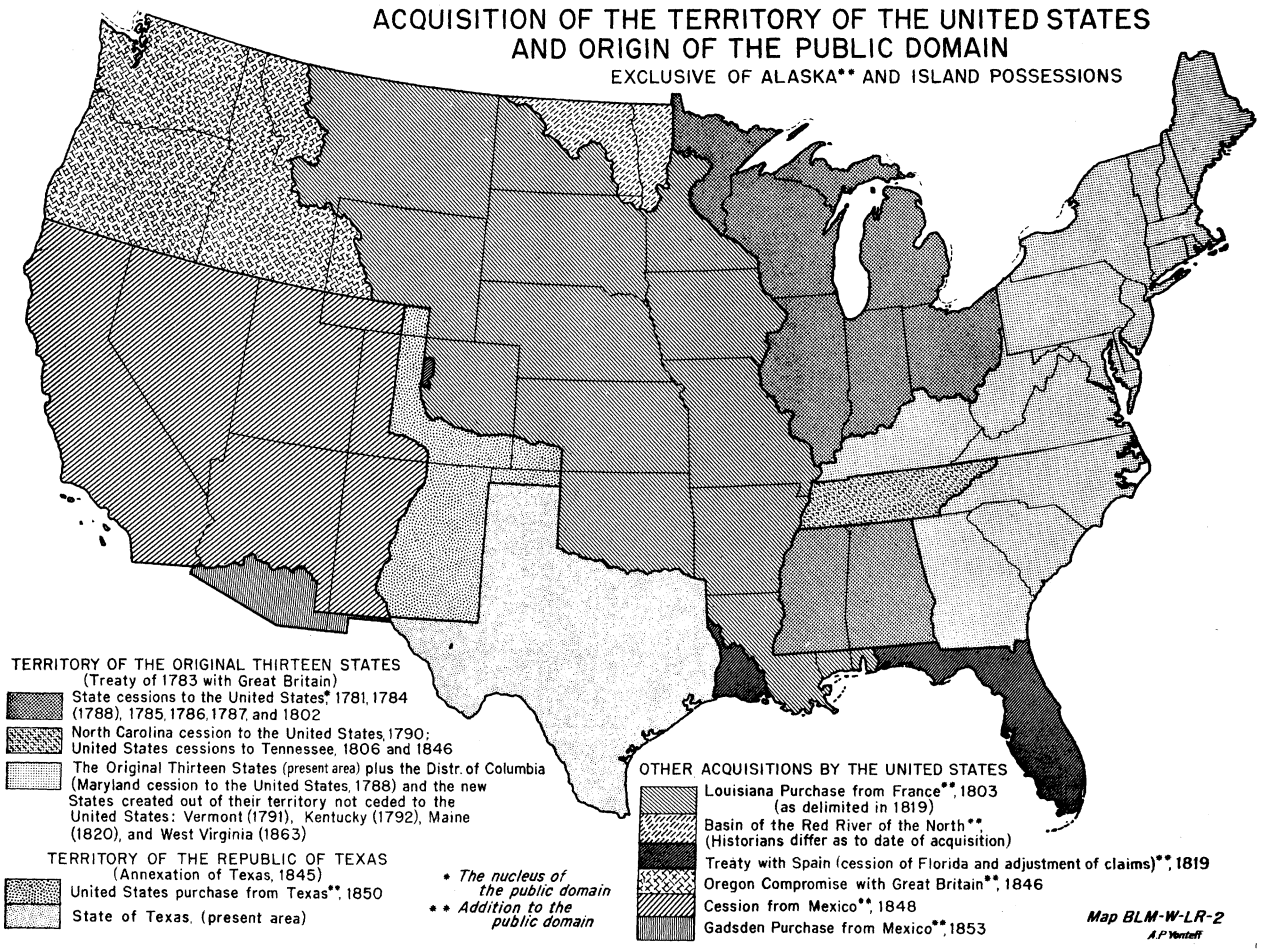

FIGURE 5.—The land acquired by, and at the disposal of, the Federal Government during the first 70 years of its existence inclusive of the lands ceded and purchased from the States, is usually referred to as the public domain. It comprised 2¼ million square miles of land. Much of it was virgin land for which the tribal use rights of the Indians had not been extinguished.

for settlement and development through sale—received its orientation more from the depleted condition of the United States Treasury in the early days of the Nation than from any other consideration.

Although the expected revenue from the sale of the land did not materialize, the system remained in operation for a long time, but other systems and policies for disposal of the land were soon added to permit settlement and development of the country. The cash sale policy for revenue purposes was modified in 1800 by the credit system. It was modified still further in 1841, by the preemption law that permitted settlers to obtain patents to the land by complying with the prescribed length of residence on it, the cultivation requirements, and payment of the statutory minimum price for the land. Paying for the land they had to improve, however, was not popular with the settlers, and the free homestead law was enacted in 1862. Under this act, a settler could locate and claim 160 acres of public land and receive a patent to it by complying with the requirements, which included the building of a house, living on the land for 5 years, and cultivating a certain acreage. In 1910, when homesteading reached the semiarid country, the original homestead act was amended by the Enlarged Homestead Act, which permitted settlers to file a claim and receive a patent to 360 acres of dry-farming land. In 1916, the acreage was again increased in the Stockraising Homestead Act, which allowed 640 acres of desert grazing land to be patented to a settler.

Somewhat different in aims and requirements was the Desert Land Act of 1877. Under this act, desert land capable of irrigation could be bought at the rate of $1.25 per acre by an entryman who could demonstrate that he was able to irrigate and cultivate the land. He was not required to live on it.

These are the principal laws that affected the settlers directly. The land alienated under these laws to homesteaders, through sale or grant, totaled approximately 285 million acres. This does not include military bounty land and private land claims, which add to 95 million acres. Title to an aggregate of 333 million acres was obtained largely by individuals under various laws and mainly through sales, which included preemption sales, scrip location, sales of townsites and lots, timber and stone land, timber-culture land, desert land for irrigation, and so on (*127, p. 63*).

Land Grants

The public land-disposal policies of the Federal Government, however, were not confined to conveyance of land titles to individuals. To expedite and support the development of the country, considerable acreages were granted to the States, Territories, and railroad companies. Land was granted as a subsidy to public institutions, and as an assistance to public works. For the common schools in the Territories and States created from the public domain, 77 million acres were granted to the States. All States also received public-domain land totaling nearly 17 million acres, as a subvention to colleges and other schools; the school lands of the Eastern States were necessarily located in the Western States and Territories, as no public land was available in the East. Tracts of public-domain land comprising nearly 65 million acres also were granted to the States for the building of railroads, wagon roads, canals, river improvements, and other purposes. Finally, under the Swamp Land Act of 1849-50, the transferring of ownership of swamplands in the central and southern parts of the public domain to the States began. This act was later expanded to include swampland in the northern and western public-domain States. The nearly 65 million acres of land granted to the States under these acts had to be reclaimed for cultural use. When combined, the land grants to the States totaled approximately 224 million acres.

Grants of land were also made directly to the railroad companies. The lack of transportation facilities in these early days was a handicap to the development of the country. This was especially true for the West. Months were required for a train of covered wagons to cross the country. The situation was somewhat better in the East. Navigable rivers entered many parts of the country. To these were added a number of canals. However, large areas were without access to water transportation. Settlers had to depend on wagon transport over rough roads to reach markets. Transportation facilities were a prime necessity for the opening of the country. As an aid to construction of railroads, nearly 92 million acres of public-domain land were granted to the companies after 1850. This does not include the land granted that reverted to the Government. The distribution of this land is illustrated in figure 6.

Along the Illinois Central, the zone granted on each side of the road was 6 miles wide, whereas along the Central and Union Pacific Railroads, it was 20 miles wide. Along the Atlantic and Pacific, as well as the Northern Pacific, the zone extended for 40 miles on each side of the road. For many of the railroads, the zones were expanded considerably to provide additional acreage for selection of land in lieu of occupied tracts within the zone of the grant (*34, p. 949*). Much of the railroad land has been sold, but the transcontinental railroads still own a few million acres, which consist mainly of grazing land.

The Remaining Public Domain

Taken together, title to more than a billion acres of the original Federal public domain has either passed into private ownership or has been granted to the States. This does not include the Indian reservations. When the Indians ceded their tribal rights to the land to the Federal Government, they were not left homeless. More than 57 million acres, most of which were part of the national public domain, were set aside as Indian reservations. A few small Indian reservations were established in the Eastern States also.

What remains of the national public domain is land that is either arid, rough, or mountainous. Little of it is suitable for homesteading and cultivation. The arid segment consists of large compact areas which for many years were used as free open range. Competitive grazing affected both the ranchers and the land itself. Through overstocking, the range became severely depleted. The most valuable forage plants of the range, mainly grasses, are the first to become scarce or to disappear from the plant cover altogether. This, in turn, greatly reduces the grazing capacity of the land (*136*). As a conservation measure and to bring order into use of the public domain as grazing land, the Taylor Act was passed in 1934 and amended in 1936. Under its provisions, the remaining unappropriated and unreserved public-domain land was withdrawn from homesteading and sale for purposes of classification, and the grazing land was organized into grazing districts. These districts comprise roughly 266 million acres, which include 95 million acres of non-Federal lands administered by agreement or through lease. Permits are required for grazing in these districts.

Conservation to preserve the use value of public lands that could not be homesteaded in

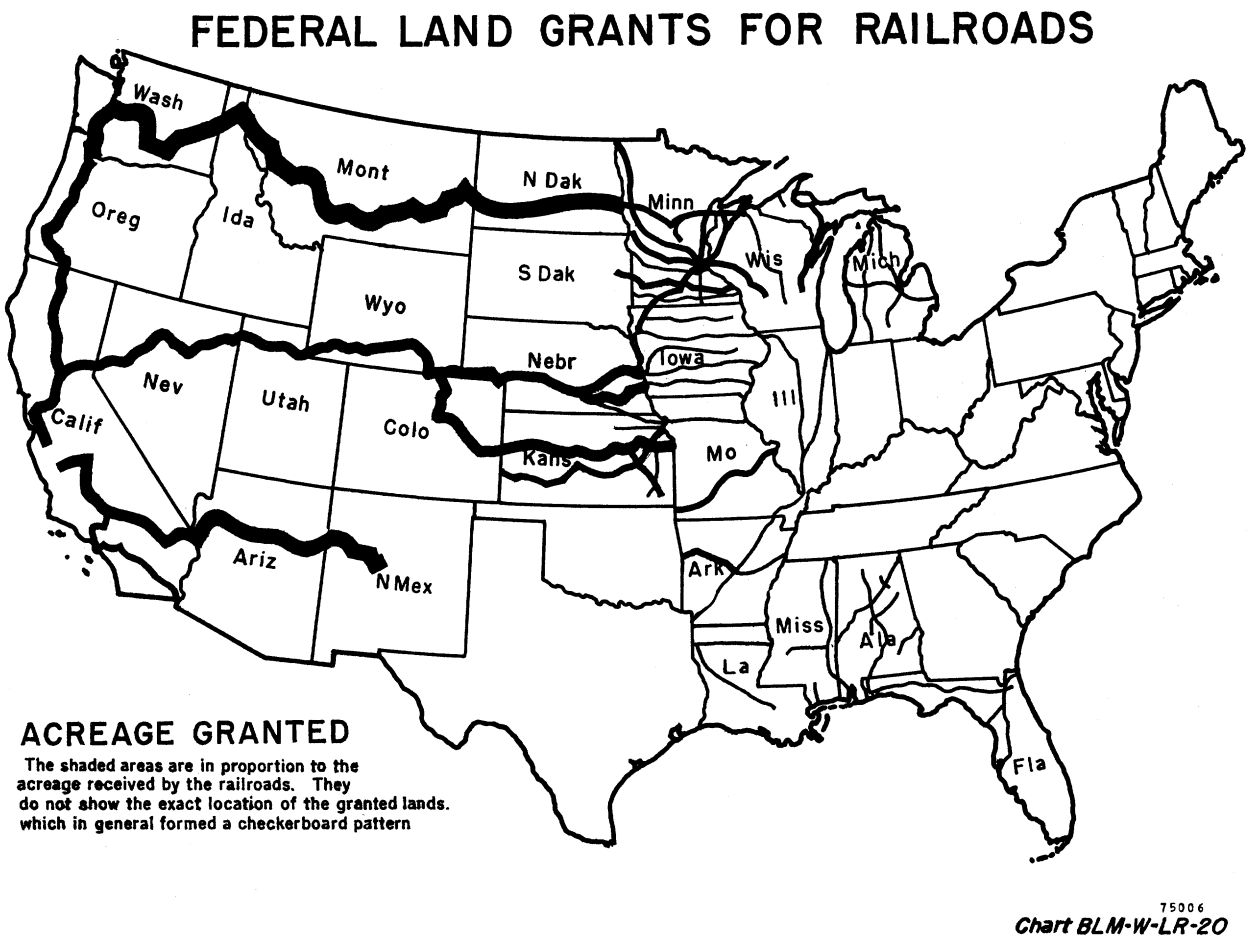

FIGURE 6.—The public-domain land granted to the railroads included alternate sections in a zone from 6 to 40 miles wide on both sides of the road. As the land granted to the roads within these zones usually consisted of the odd-numbered sections of townships, a checkerboard pattern of ownership was produced. Later, the grants were reduced because the railroads did not meet all statutory requirements.

the interest of public welfare was not new. Forest land in public ownership had been as much abused as the open range. To bring these forests under proper management, legislation passed in 1891 authorized the setting aside of public-domain forests as reserves. The authority was later expanded to acquire eastern forest lands through purchase. Most of these Federal forest lands are now included in the national forests and serve multiple purposes. Production of timber on a sustained-yield basis is frequently not the most important purpose. In the West, the bulk of the forests are on mountainous land, which receives the higher precipitation and furnishes water for the arid lowland. Protection of watersheds to prevent erosion is therefore important. Summer grazing is regulated through permits to preserve the grazing capacity and with it to protect the functional value as watersheds. Recreation and wildlife shelter are secondary uses. In round figures, the Forest Service manages 161 million acres of national forests, of which 140 million were reserved from the public domain and the rest is mainly purchased land. In addition, nearly 48 million acres of national forests are administered by other agencies.

National Parks, Monuments, and Wildlife Sanctuaries

Conservation was the leading motive in the establishment of national parks, monuments, and wildlife sanctuaries. National parks were set aside to preserve the scenic values of outstanding natural features for the enjoyment of citizens and future generations. National monuments are dedicated to the preservation of areas having historic or scientific interest. The preservation of the native fauna and flora of these park and monument areas is essential

in maintaining the use values for which they were established. Some of the natural wonders of the world are represented in these reservations. The 4,000- to 5,000-foot chasm known as the Grand Canyon of the Colorado, Yellowstone Park with its geysers, canyons and waterfalls, the peaks, lakes and glaciers of the Rockies, the natural bridges of Utah, the 2,000- to 3,000-year-old Sequoia trees of the Sierra Nevada, the prehistoric ruins of Pueblo cities and cliff dwellings of the mesas (pl. 109), and many others are included. As they were conceived as recreational areas, the parks had to be developed in that direction and made accessible to the public. Roads to and within the parks had to be built and accommodations for visitors provided. More than 2 million people visit the nearly 14 million acres of park and monument reservations yearly.

Wildlife reservations are intended to protect and preserve the wildlife species of the country. Land utilized for these purposes usually has little value for other uses. In the eastern United States, it is chiefly swampland (pl. 156) and in the West, it is of low grazing value. Migratory bird refuges are frequently combined with reservoirs (pl. 88) and other bodies of water, although in some instances, special water-control structures have been installed (pl. 85). In all, as of 1955, approximately 4 million acres were contained in these reservations.[3]

Very little of the Federal public domain is now unreserved and open for homesteading or for sale. Other types of Federal reserves have been set up for national defense, soil conservation, reclamation, mineral reservation, and other purposes. These reserves are administered by the different agencies of the Federal Government in accordance with the purpose for which they were established. More administrative difficulties are encountered in some regions than in others. These difficulties stem mainly from the complicated pattern of land ownership and administrative units that has evolved in the absence of a "well-planned land policy in keeping with the physical nature of the different regions" (*29, p. 15*). Any revenue derived from the use of public lands is shared

[3] The acreage figures that pertain to the national public domain and the Federal land reserves are based mainly on the latest publications of the Bureau of Land Management, Department of the Interior *(127, 107, 108)*.

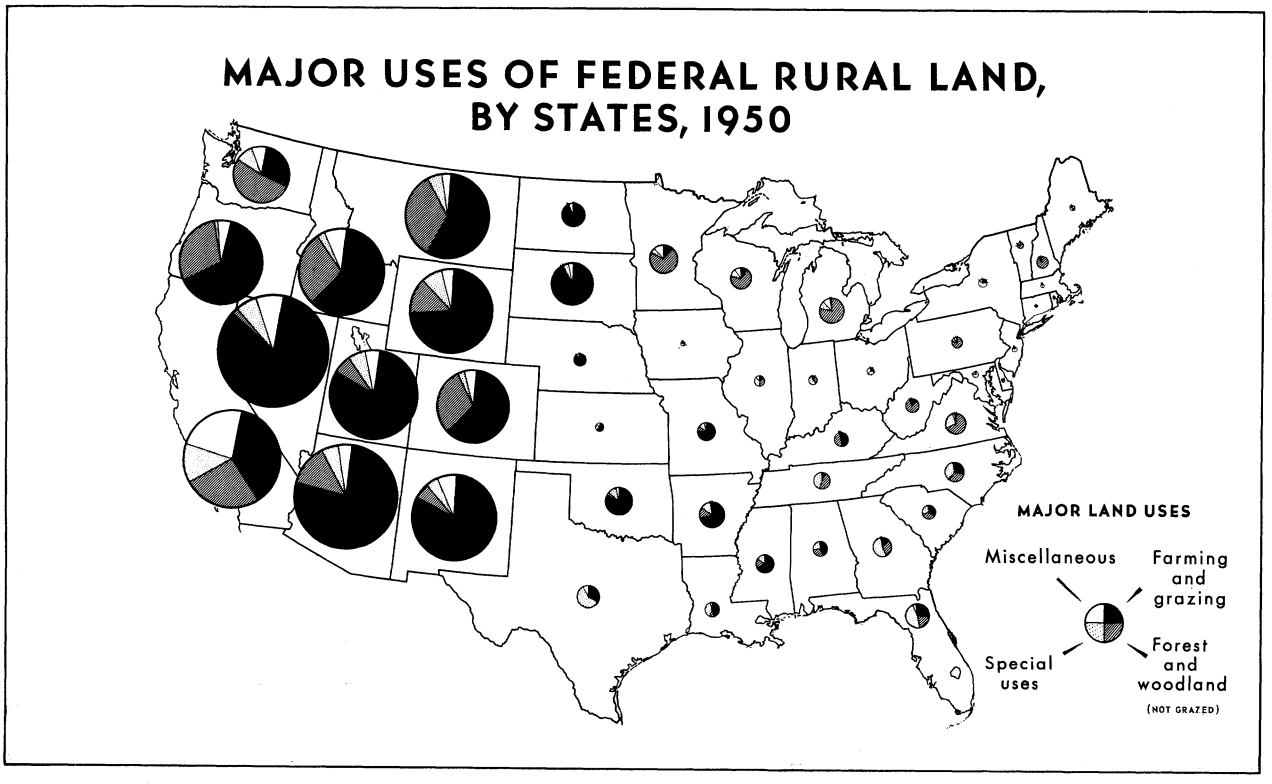

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FIGURE 7.—The pie charts for each State represent the proportion of land in Federal ownership. When the country as a whole is considered, 23.5 percent of the land is administered by the Federal Government. The combination of the two major uses of this land—farming and grazing—may be misleading, as the cropland ratio is only about 1 percent, too small to be represented.

proportionately by the States and counties in which it is collected. The relative distribution of Federal-owned rural land by States, and its major uses are illustrated in figure 7.

Most of the federally administered land lies in the 11 Western States. The proportion is highest in Nevada, where 84 percent of the land has remained in Federal ownership. In the older Eastern States, where title to most of the land was at first transferred to private owners, the Federal Government bought the land. It is now mainly in national forests and parks.

State-Owned Lands

Title to some public land is also vested in the States, and the land is administered by the States. The origin of State-owned land can be traced to several sources. When the colonies became States, they acquired title to the unappropriated land within their boundaries, and some of this land has remained in their possession. In the public-domain States, large land grants were made to the States by the Federal Government to promote development of transportation and communication facilities and in support of schools and other institutions. The swamplands in the public domain were deeded to the States for reclamation. Much of this land, particularly in the Western States, has remained in State ownership. In addition, a considerable acreage of privately owned land, mainly cutover land in the Lake States, has reverted to State ownership through tax foreclosure, and some of the land has been acquired through purchase for particular purposes. In 1950, the States owned a little more than 80 million acres (*29, p. 50*).

To some extent, the administration of State-owned lands is comparable to the national pattern, in which purpose of ownership and use capability of the land are the deciding factors. Accordingly, we find State forests, State parks, recreational areas, fish and game reserves, grazing areas, militia camps, and so on. Administrative problems occur in connection with State-owned lands as they do with Federal lands. They are mainly the result of widely scattered tracts. In the Western States, where State-owned land usually is identified with certain numbered sections in a survey township, the problem stems from the method of transferring public land to the States, and it is

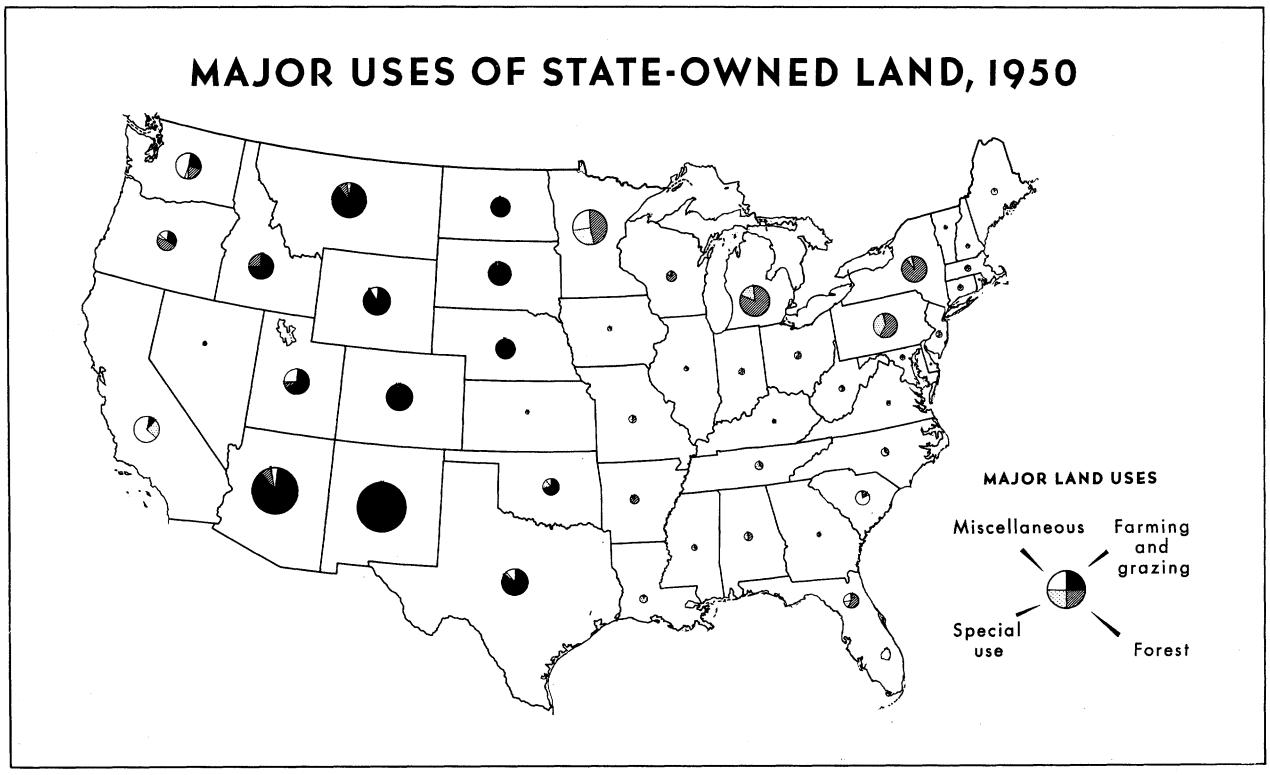

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FIGURE 8.—The acreage of State-owned land in this country is a fifth of the acreage federally owned. Pie charts show distribution by States. Public-domain States have the largest acreages. The importance of cropland is magnified because it is combined with grazing lands. Of the 80 million State-owned acres, 3 percent is used for crops, 55 percent for grazing, and 22 percent for forest-woodland. The rest is in other uses.

probably more troublesome here than in the East. As a rule, these sections are neither large enough nor located favorably enough in regard to water supply to provide an operational unit in themselves. They can be used only in conjunction with adjacent land. Distribution of acreage and major uses by States are represented in figure 8.

Expansion of Settlement and Development in the United States

Geographic location played its part in the colonization and development of the United States from the beginning, and it is an important economic factor now. The large and sheltered harbors on both sides of the North Atlantic, and the somewhat shorter sailing distances between them than between South Atlantic ports were decisive in veering the stream of settlers from Europe in that direction. The rate of growth of the different colonies supports this conclusion.

Early Settlements

The first settlement on the Atlantic coast, made in 1565 by the Spaniards at St. Augustine, Fla., was also the southernmost colony and the slowest to grow. The second, made by the London Company on the James River in Virginia in 1607, which was followed by other settlements on the shores and tributaries of Chesapeake Bay, expanded rather slowly. When the North Atlantic colonies were opened for settlement shortly thereafter, their growth was accelerated by the frequent sailings from Europe to these colonies. These ports functioned as a funnel through which the main stream of settlers from Europe entered America and from which they spread over the adjacent country. The population in these colonies increased rapidly, so that by the end of the 17th century the population and towns of the North Atlantic colonies were larger than those elsewhere on the Atlantic seaboard. Once this leading position was obtained, it was not relinquished by these colonies nor by the ensuing States. Nor have more recent developments changed the situation. The coastal belt between Boston and Baltimore has developed into the most densely populated area of its size in the country.

Comparable figures for equally spaced intervals of the colonial period are not readily available. No census was taken in the colonies. What we know now of the increase in the population of the colonies is the result of research and interpretation of material from many sources (*52*). The first census of population was taken in 1790, by the United States. It is only from then on that we can retrace the progress made from decade to decade in the settlement of the country.

Westward Thrust

The attraction of the wide empty spaces in the Central Plains, the frequently not-so-favorable characteristics for arable use of the land on the eastern slopes of the Appalachians, and the ever-increasing population, provided a combination of factors that engendered the westward movement of the people. But not all sections of the older areas of settlement contributed to the movement to the same extent. Advancing the frontier of settlement westward was far from a uniform expansion movement, nor was it a well-organized and directed effort for the placement of people on the land. The pioneers usually chose the routes they followed and the land on which they settled. Exceptions were largely confined to the older States, where lotteries were sometimes used to decide land ownership.

The westward thrust of people was stronger in the North than in the South. In the northern sector, the movement received considerable impetus from the continuous stream of people arriving from Europe. Most of these immigrants arrived with the intention of joining the movement to the west in search of land on which they could establish new homes. Westward expansion of settlement can be taken, however, only as indicating a general direction. After the pioneers had crossed the mountain saddles, they usually followed the rivers and valleys and spread out in the basins and plains. Sometimes they left unsettled islands for late comers. The first settlers preferred river banks and adjacent uplands. The rivers provided transportation, and from the trees growing near them, even in the grassy plains, the settlers could build their homes and obtain the fuel they needed. The more fertile prairies of the plains were occupied by later arrivals.

In the deep South, the movement was inhibited for want of people. In 1790, Georgia was only partly settled along the eastern border. Here the frontier moved westward very slowly. The neighboring State to the west, Alabama, received its settlers from both north and south. For years, the largest unsettled island was the one along the Alabama–Georgia boundary. Thus some of the more desirable land in the Coastal Plain of Georgia was settled last. The land-division surveys in the districts west of the Flint River were finished in 1827, and the remaining land was disposed of by lottery in the same year. This procedure was followed also in the more hilly and mountainous districts of northern Georgia in 1832 (*56*).

Settlement gained momentum when the advance settlers reached the plains. By then, settlement and development of the newly acquired public domain had formed a realistic partnership in the minds of the people. Various activities preceded actual settlement. On the

national public domain, and in most parts of the country where the rectangular land-division system was used, surveyors usually were there before the settlers. Hunters, Indian traders, herdsmen, members of military expeditions, and explorers, also acted as forerunners and advance guards of the settlers. Like the Indians, they relied for subsistence chiefly on the natural resources of the country. On the plains, the herds of buffalo provided meat for their use and skins and robes as articles of trade. Later, buffalo hunting became an organized commercial enterprise of both Indians and whites. Hunting for meat was degraded into slaughter, and the extensive herds that roamed the plains were soon reduced. As settlement advanced, the buffaloes retreated. Toward the end of the 19th century, when white men had taken possession of the plains, the buffalo, as a free roaming animal, had disappeared as a scenic landscape feature. All that is left of the species are a few individual animals in captivity on reservations. Without the existence of the buffalo, development of the Plains would have been slower (*65*).

Activities in furtherance of the country's development were also in evidence behind the frontier of settlement. The frontier, which was defined by the census as the population-density limit of 2 settlers to the square mile, was in its nature only a conceptional line. If we assume that the 2 persons belonged to the same homestead, and the preemption right was 160 acres, it would mean that only a fourth of the land was actually settled. With this as a premise, it is reasonably safe to conclude that for some time settlement behind the frontier was more active than settlement ahead of the frontier. Settlement, however, was only the initial step in development. Settlers who had located on the land could not remain isolated members of society. They were followed closely by churches and schools. Fast-growing cities and towns sprang up over the country. To bring and keep the people in contact with each other, and to make the resources and products of one part of the country available to others, improved transportation and communication facilities were essential. At first, these facilities were provided by the navigable rivers, wagon trails, and canals. Railroad construction started in the East, and in 1830, some lines were open to traffic. Forty years later, the first transcontinental railroad was in operation.

Opening of the West

In the Southwest, some land grants and settlements had been made by Spain. But it was only after the West became United States Territory, in 1846 and 1848, that the cross-country movement of pioneers gained momentum and the economic development of the West began. The Mormons were among the first to found a colony in Utah in 1847. Shortly after that, the "Forty-niners" started their journeys across the mountains and basins to the Pacific Coast. The covered wagons in which they traveled, however, were slow and the way was hazardous. Travel to the West was greatly facilitated a few years later when, in 1869, the central transcontinental railroad was opened. It was soon followed by other trunklines. These railroads pierced the frontier and ran ahead of settlement. Travel facilities accelerated greatly the westward movement of people, although it was clear by then that the West could not be settled and developed as had the East or the Great Plains.

In pioneer reports from the West, the semi-arid high plains and the country between the Rockies and the Sierra-Cascade Mountains were frequently cited as the Great American Desert. Precipitation on the high plains and in the basins was too low to permit arable use of the land, and the mountains and ranges were rugged. Water was scarce; in its early stages, settlement depended on a readily available supply of water for irrigation. Only in the Pacific Valleys, the Columbia Plateau, and on some benches and mesas at the foot of the Rockies is dryland farming possible. Most of the land in the West can be used only for open grazing. The grazing capacity of the range per areal unit was not high in its original state, and it has since been reduced considerably through overgrazing. Severe natural restrictions preclude homesteading of the land that now makes up most of the remaining public domain (*136*).

The westward movement of the frontier and occupation of the land during the first 100 years of existence of the United States was the prelude to its economic development. Except for some tardy areas, the frontier disappeared near the end of the 19th century, although this did not terminate the westward movement of people. Strong migratory currents from East to West, which again originated mainly in the Northern States, were reported in the early decades of the 20th century (*117*). Internal movements of people in response to areal changes in economic conditions are still in evidence. The progress of settlement made from 1790 to 1890 is illustrated in figure 9.

Natural Environment Changed Through Settlement

The arrival of the settlers also marked the beginning of changes in the natural environment. Houses were built; woods were cleared; and sod was broken. How these activities were carried on depended on the individual who acquired the land and where the homestead was located. When the land was divided into rectangular sections or lots, these divisions usually

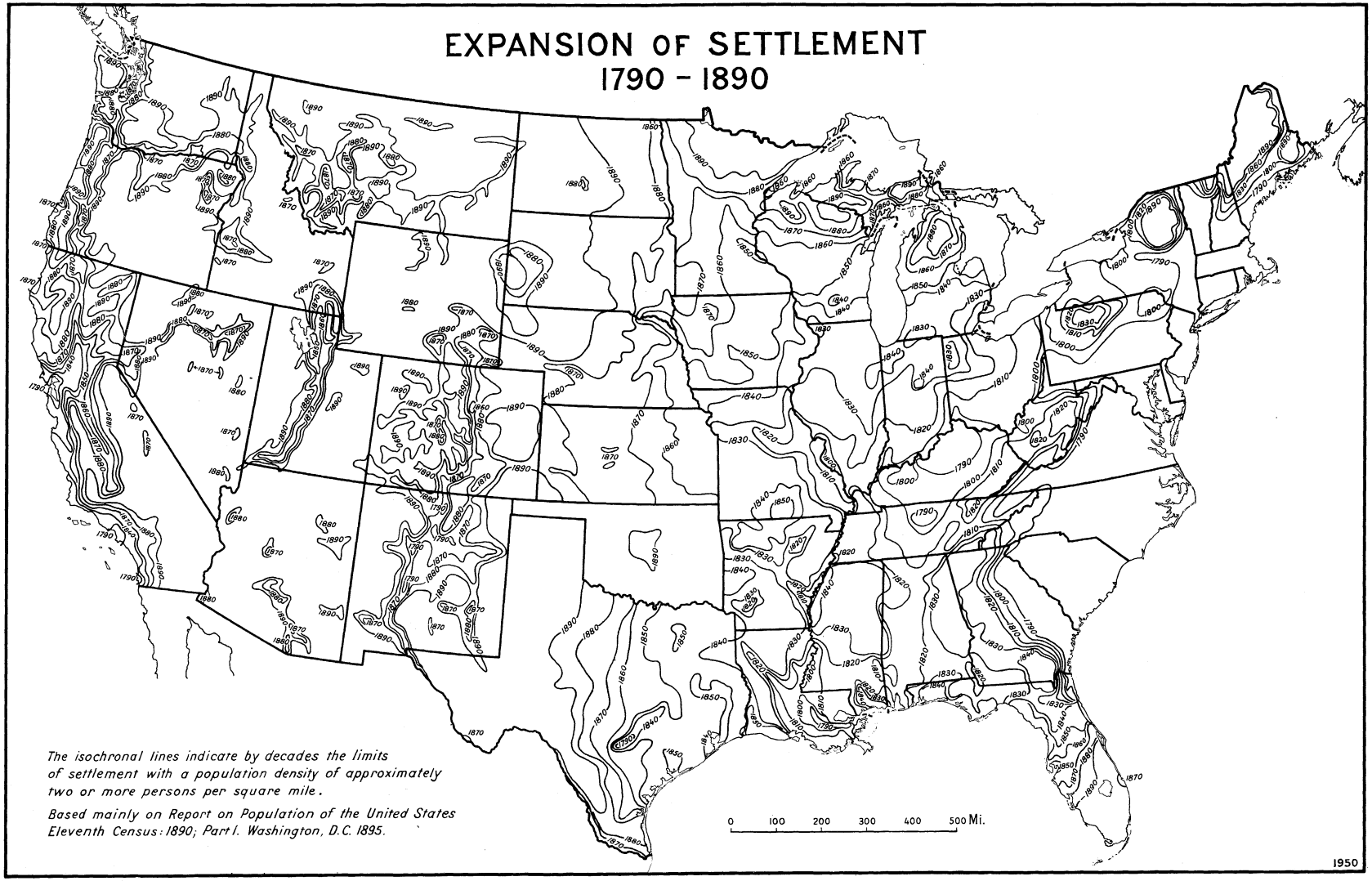

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FIGURE 9.—The westward movement of the frontier from 1790 to 1890, when it came to an end, is shown on the map by means of isochronal lines. The frontier of settlement was not a terminal line, but a ragged fringe. The part of the Great Plains that is now Oklahoma was not opened to settlement until 1889. In the West, settlement was confined for many years to places where water was readily available.

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had more than one function in the development of the country.

The main purpose was to provide a way to describe and identify land divisions for title registrations and transfers. As these divisions were run systematically and regularly, they had much to do with shaping the landownership pattern. In defining real property, the rectangular divisions necessarily provided also the foundation of the land-tax roll for assessors. On public grazing and forest land, they provided the definitions of site locations in the administration and management of the land.

The rectangular divisions not only controlled land ownership; for a large part of the country they provided the grid from which the ground plan of the cultural landscape evolved. In the Central Plains in particular, where much of the land is used for crops, the roads on which farmsteads are located usually follow section lines. The farms on both sides contributed half of the rights-of-way of the roads (pls. 38, 51, 62). In agreement with the grid lines, internal farm divisions follow the same direction. This has produced a rectangular block design formed by the spatial arrangement of fields and pastures, in which scattered farmsteads provide the outstanding features of the landscape. A scattered type of settlement, in contrast to the village community type prevalent in other parts of this country and many parts of the world, is closely related to the land-division system.

Development of Urban Communities

Rural settlement and cultural use of the land are not the only features of the landscape that reflect the original rectangular land-division system. The system also influenced development of urban communities. Most of the cities and towns that sprang up on sites on which the land had been divided into townships and sections have preserved the original divisions. The grid of the land survey provided the spatial order from which the ground plan of the city evolved. Additional streets, parallel to section lines, were fitted into the land-division system, and now constitute the city plan. Chicago, as an example of this type, is used to illustrate city development on a rectangular ground plan (fig. 10).

As may be noted, the map of the developed city is confined to the Loop District of Chicago. Notwithstanding this limitation, the concentration of houses, streets, railroads and their terminals, canals, harbor facilities, and the solidly built-up business district suggest the size of the city. The accomplishment of a development of this magnitude within such a short space of time is necessarily associated with the growth rate of the city itself. In 1850, Chicago had a population of almost 30,000 inhabitants. In 1950, the urbanized population of Greater Chicago within Cook County alone was close to 4,500,000 people. Because of this phenomenal rate of growth Chicago is not typical of other cities in the United States. Although it is unique in this respect, nevertheless the city is symptomatic of the trend toward urbanization in the United States.

Although most cities whose streets are laid out on a rectangular pattern are located on what was formerly the public domain, they are not confined exclusively to the public domain. Some of the eastern cities founded in colonial times have the same characteristics. As previously mentioned, Philadelphia was one of the first cities in which the rectangular divisions were applied. Baltimore and Savannah were others. But in none of the cities that was laid out on the rectangular principle have the builders adhered as closely to the classic model as in the plan of Washington, D. C. In that city, the Capitol building marks the point of origin of the rectangular coordinate system. The axes intersect each other at right angles and divide the city into four parts. Identification of streets and numbering of buildings are controlled by it. In this respect, the capital no doubt furnished an example for other cities in which the numbering of buildings follows the same principle.

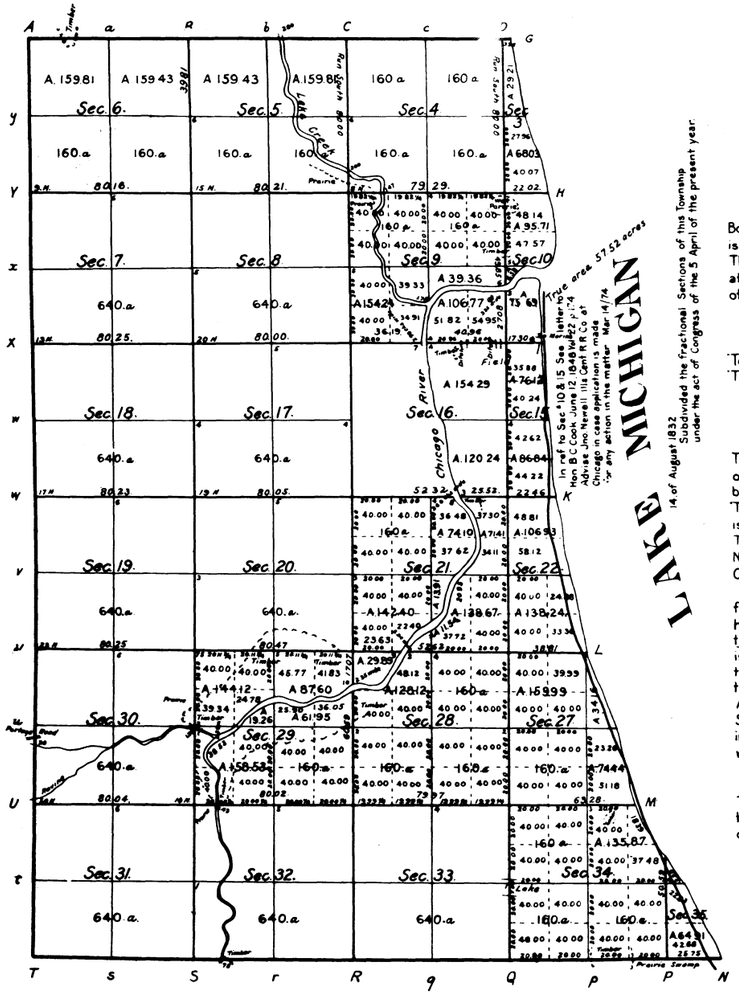
Reactions to Land Divisions

An additional function of the rectangular land-division system takes us into the field of political geography. Over much of the country where rectangular divisions are in effect, the survey lines marked on the ground have furnished the boundary lines of political divisions. In some instances, even State boundaries are identified with the system. The boundaries between northwestern Ohio and Indiana, between South Dakota and Wyoming, and between Oklahoma and New Mexico, and the northern boundary of the Texas panhandle are examples of this kind. These lines were used most extensively, however, in delimiting and organizing the counties. In some States, county boundaries and boundaries of minor civil divisions are based almost exclusively on rectangular land divisions. This is not true in western Texas. Because counties in western Texas show considerable regularity as to size and are rectangular with uniform orientation, one may conclude that county boundaries also are derived from the land divisions. In this instance, however, the county boundaries and property lines do not coincide.

The use of the rectangular land-division system on such an extensive scale, and with the many functional applications it has found in the United States, has no parallel in any other country. To a considerable extent, it controls the movements of the population. It provides a frame of reference for orientation and, to

Fractional Township 39 North of the base line Range 14 East of the 3rd principal Meridian
Except that part of Section 16, which lies on the left or West side of the Chicago river.

A



Scale of 40 chains to an Inch.

The notes used in the construction of this Plat are contained in the field books numbered as follows Viz of the South Bndy in Book 146.
" " West & North Bdy Book 147.
Subdivision and Meanders in ——— Book N° 781.
none of said notes State at what Variation the Surveys were executed. Nor do the notes of the Exterior boundaries refer the Surveys thereof to any principal Meridian.
Book 146 is without Signature, 147 is not signed; the name "John Walls". is written on the first page. Book 781 is signed John Walls.
The Meanders of Lake Michigan, along fracl Section 10, commence at the corner of fracl Sections 10 & 15, and run Thence along the East Side of fracl Section 10" c. l.
" North 2 West 14.50.
North 4 West 8.29
North 5½ West 11.89.
"To the mouth of the Chicago River
"Thence, across the Mouth of Chicago River"
" North 29 East 4.47."
" North 10 East 14.05."
" North 4 West 19.00."
" North 14 West 10.43. To the corner of fracl Sects 3 & 10.
The Meanders of the Chicago river, were commenced on the South Side of Said river, at its Mouth" (but the notes do not give any other Connection between Said meanders and the Meanders of the Lake), and were run "Thence up Said river to the forks in Section 29, which according to the notes is considered as high up as it is navigable." "Thence across the river due North 2° 23' "Thence down the North Side of said river" "To the mouth of Chicago river on the North Side" but the notes give on connection between the Said Meanders of the Chicago and the Meanders of the Lake.
In the construction of this Plat, and in estimating the areas of the fracl of fracl Section 10, the Meanders of the South bank of the Chicago are considered as having commenced at the point, which (in the Meanders of the Lake) is called the mouth of Chicago river" and the course N. 29 E. 4.47 chns mentioned above is supposed to terminate at the upper point of the Mouth of the Chicago and said termination is taken as the point to which the Meanders of the North Side of the Chicago Close, as stated above.
As the Meanders of the Chicago are taken on farther than its forks in the S.W. quarter of Section 29, the area (158.53 acres) set down in said quarter includes the part thereof which lies North of said river, as well as that which lies to the South.

W. Mc Rea.
Surveyor Office St Louis 4th of May 1836.

The true area of the S.W fracl ¼ of Sec 10 (S. of Chicago river) is 57 $\frac{44}{100}$ acres the quantity (75.69 acres) formerly set therein being erroneous is this day crossed over with ink.

E. T. Langham.

Plat Recd with Sur Genl's letter of May—1836 in answer to Commr's call for it dated May 11, 1835.

14 of August 1832 Subdivided the Fractional Sections of this Township under the act of Congress of the 5 April of the present year.

True area 57.52 acres

In ref to Sec 10 & 15 See letter from B. C. Cook June 12, 1848 Vol. 2 p. 74 Where an appeal (Uncl. R. C. of Chicago) in case application is made for any action in the matter Mar 14/74

Surveyor Office St Louis 16th March 1831.
The above plat of fracl Township N° 39 N, R. 14 East, is conformable to the field notes (as explained in the above marginal remarks) of the surveys of said Township, contained in field books, numbered respectively 146-147 and 781, on file in this office.

W. Mc Rea
Surv. of Pub. Lds.

Surveys Office,
St Louis 28th May 1836
The above plat, statement and certificates are correctly copied from N° 47 of Illinois plats in this Office.

E. T. Langham

B

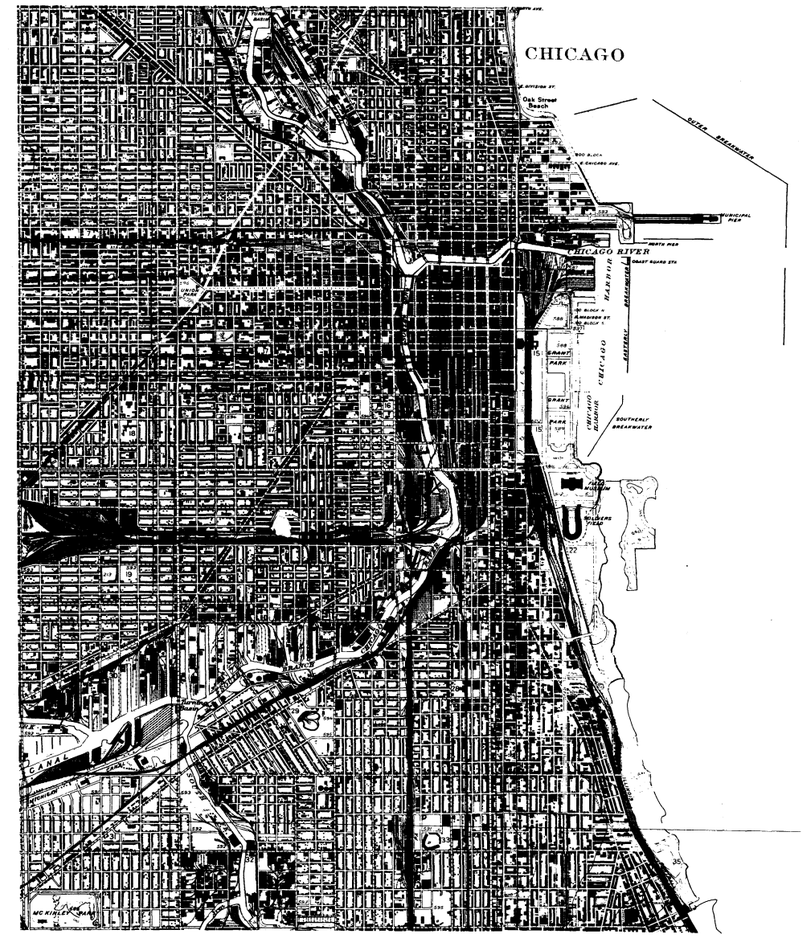


FIGURE 10.—The two plats pictured here represent the same tract of land with a time lapse of almost 100 years. In the interval, an uninhabited prairie spot was converted into a metropolis. On the second plat, only the larger engineering structures can be detected. Section and quarter-section lines were converted into streets; the blocks formed have the same east-west and north-south orientation as the section lines. (Plat B from U. S. Geological Survey.)

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this extent, it has become a part of American life. Americans are accustomed to the rectangular spatial order, but visitors from abroad are frequently impressed by it; they regard it as a distinctly American characteristic.

The system has both excellent qualities and shortcomings. Its greatest advantage when properly applied consists of the ease and certitude with which a tract of land can be defined and identified as to size and location in instruments of land ownership. It has also produced continuity in land ownership without overlapping claims or interspersed gores of no-man's land.

In regard to land use, especially when the land is used for crop production, it cannot be said that the rectangular land-division system is uniformly well adapted to all situations. On level and slightly rolling land, the system provides compact operating units that can readily be organized into separate fields. On strongly rolling and hilly grounds, this advantage is less apparent and there are disadvantages also. In order to conserve the soil, the farm plan should take into account the lay of the land. The steepest parts should be left in woods or pasture. The cultivated fields should be adjusted to the contour of the slopes and cultivated accordingly (pls. 48, 55, 57). In many places, this has not been done and severe damage from erosion has resulted.

From economic and social viewpoints, the scattered type of settlement produced by the division of the land into squares has certain inherent disadvantages. Economic disadvantages are mainly the result of the inevitable increase in mileage over which community service must be furnished to isolated farms. Mileage of roads, telephone and electric powerlines, mail delivery, and school bus service could have been reduced by using long-lot rather than square divisions for farms (*6*).

The mode of settlement and division of the land were the first historical events that left a lasting impression on the land and produced regional distinctions in land use patterns. Advances in technology and modification of social and economic conditions have also affected land use profoundly, particularly the distribution and extent of land needed for the higher uses. Changes in land use that have resulted from these innovations form a part of land use history. Changes of this kind have affected both urban and rural land requirements and land use patterns.

Shifts in Land Use

Shifts in major rural land uses have occurred since the first settlement of the country, but only after the West was opened for occupation did they become of regional significance. Many settlers first chose sites that were poorly adapted to agriculture. Later, they moved to the Central Plains and western valleys. Within the area of early settlement, particularly in the northeastern mountains, the many abandoned farm sites have left their imprint on the present land use pattern. Much of the former cropland has reverted to woodland or is used only for pasture (pls. 3, 7). A somewhat similar movement has recently taken place in parts of the South, where considerable acreages of cropland have been abandoned. Dilapidated farmsteads and old fields furnish mute evidence of the change in the land use picture (pls. 129, 134).

Although in the East the acreage of cropland has been greatly reduced, an equally remarkable expansion occurred in the plains and valleys of the West, largely because of technological implementation and improved management of water. On the semiarid western plains, an operator could hardly have cultivated enough land with the old implements to produce an adequate economic return from small grains. Cultivation and harvesting with machines have eliminated this handicap to a large extent, although occasional crop failures must still be taken into account. Large fields are the rule in this part of the country (pls. 62, 63, 65, 74). In the arid or semiarid valleys of the West, application of water through irrigation has changed markedly the land use potentiality and with it the land use pattern (pls. 79, 82, 84, 88, 106, 107, 108, 124).

At times, changes in land use have been introduced without proper account taken of the use potentiality of the land, or of the actual or future needs of the people. Statistically, these changes are recorded as shifts in the relative acreages used as cropland, grazing land, and forest. For a long time, clearing forested land for agricultural use exceeded in extent the commercial cutting of forest for lumber. But the demand for lumber increased rapidly, and most of the eastern forest land was cut over faster than it was taken up by settlers. Actually, a large part of the forest land is physically unsuited to use as cropland. Nonetheless, our natural timber wealth has been depleted severely. A similar situation prevailed on the grazing lands of the West. Much of the western public domain can be used only for grazing. It was used in common for that purpose by competing herdsmen. In this instance, overgrazing reduced the carrying capacity of the range.

Exploitation of our land resources in crop, grazing, and forest land was characteristic of the early stages in national development. To some extent, it was unavoidable in the process of opening up the country and settling the people on the land. In time, however, warning

signs of danger ahead appeared. The movement for conservation resulted. How conservation has been implemented to some extent through inclusion of land in reservations and districts was mentioned previously.

Inclusion of certain lands in reservations is an effective device of conservation, but it can be applied only to publicly owned land. It does not reach the land that is at the same time the most valuable and the most vulnerable to destruction—the cultivated land in farms. Conservation measures to protect the Nation and its farmers were ultimately extended to cultivated land. In the main, these measures are designed to combat erosion damage to the land and thus to conserve its productive capacity. Use of erosion-control measures is voluntary. Such preventive cultural practices as contour plowing, strip cropping, and terracing provide a characteristic distinction in the land use pattern that is usually associated with soil-conservation districts (pls. 18, 114, 126, 149, 163).

Changes in the land use pattern are not confined to rural uses. In more recent times, impressive changes have occurred in urban land uses, particularly on the urban fringes of the larger population centers. With the increase in population and its urbanization, cities are expanding rapidly. Rural and urban settlements, which in antiquity and the Middle Ages were separated by walls, are gradually merging. With modern transportation facilities, feasible commuting distances have increased enough to permit many people to live in the country and work in the city. As a result, in most places, no distinct line of separation exists. In the transition zone, urban and rural land uses are frequently interspersed (pl. 8). Expansion and improvement of roads and of air transportation have carried the urban influence far into rural areas. Frequently, urban elements in the form of nonfarm residences, factories, and landing fields are injected into the otherwise rural land use pattern.

These are the more important historical events and influences that are expressed in existing land use associations and patterns. Others that are not mentioned here may have produced equally pronounced distinctions. For instance, reclamation in its two major forms—irrigation and drainage—and mineral exploitation, which affects surface use, have their historical backgrounds. Usually, however, they are closely allied with other factors. They are discussed later in this report.

Physical Conditions and Land Use

It is an old and tried dictum that land use capability for production of food, feed, and fiber is closely related to the prevailing physical conditions of the area. The distributional characteristics of major land uses in the United States demonstrate its truth. The higher uses are usually concentrated in areas in which natural conditions for cultural use of the land are most favorable. In other areas, physical limitations may be so severe as to exclude them altogether or make them possible only when human ingenuity can overcome the drawbacks.

Land relief, temperature, precipitation and water supply, soils, and natural vegetation, each contribute in varying degree toward shaping the natural environment, or the so-called biological complex, to which plant and animal life adjusts itself. That the natural environment is so complex is due not only to the many physical factors involved but to the fact that these factors are causatively related among themselves. In extensive areas, however, one or the other of these factors plays a dominant part and thus eliminates one or more major uses of land. Although these factors are related, they must be considered separately.

Land Relief

The spatial arrangement of mountains and plains had its origin in distant geologic ages, which are usually expressed in millions of years. During these earlier geologic periods, the tectonic forces were more active; it was then that the volcanic activities and crustal movements produced the highlands from which rock weathering and solution, runoff, and erosion carved the mountain massifs, chains, and plateaus that flank the country in the East and West (fig. 11). In this respect, the alinement of our mountain systems is distinct from those of the rest of the world in that their trend is mainly in a north to south direction. Rainfall, natural vegetation, and certain soil characteristics derive their orientation largely from the physiographic background.

Rock Formations Affect Land Use

Aside from the broader aspects of the influence of geology and physiography on the country as a whole, they are also of local significance. Landforms, which provide the background of the more localized activity of man, frequently show distinctions derived from the nature of the surface rocks, to which land use also had to be adjusted. Whether the surface rock is limestone, shale, sandstone, or one of the igneous or metamorphic rocks is reflected not only in terms of soil texture but often in surface configuration as well. In many places, abrupt changes in rock formations have caused

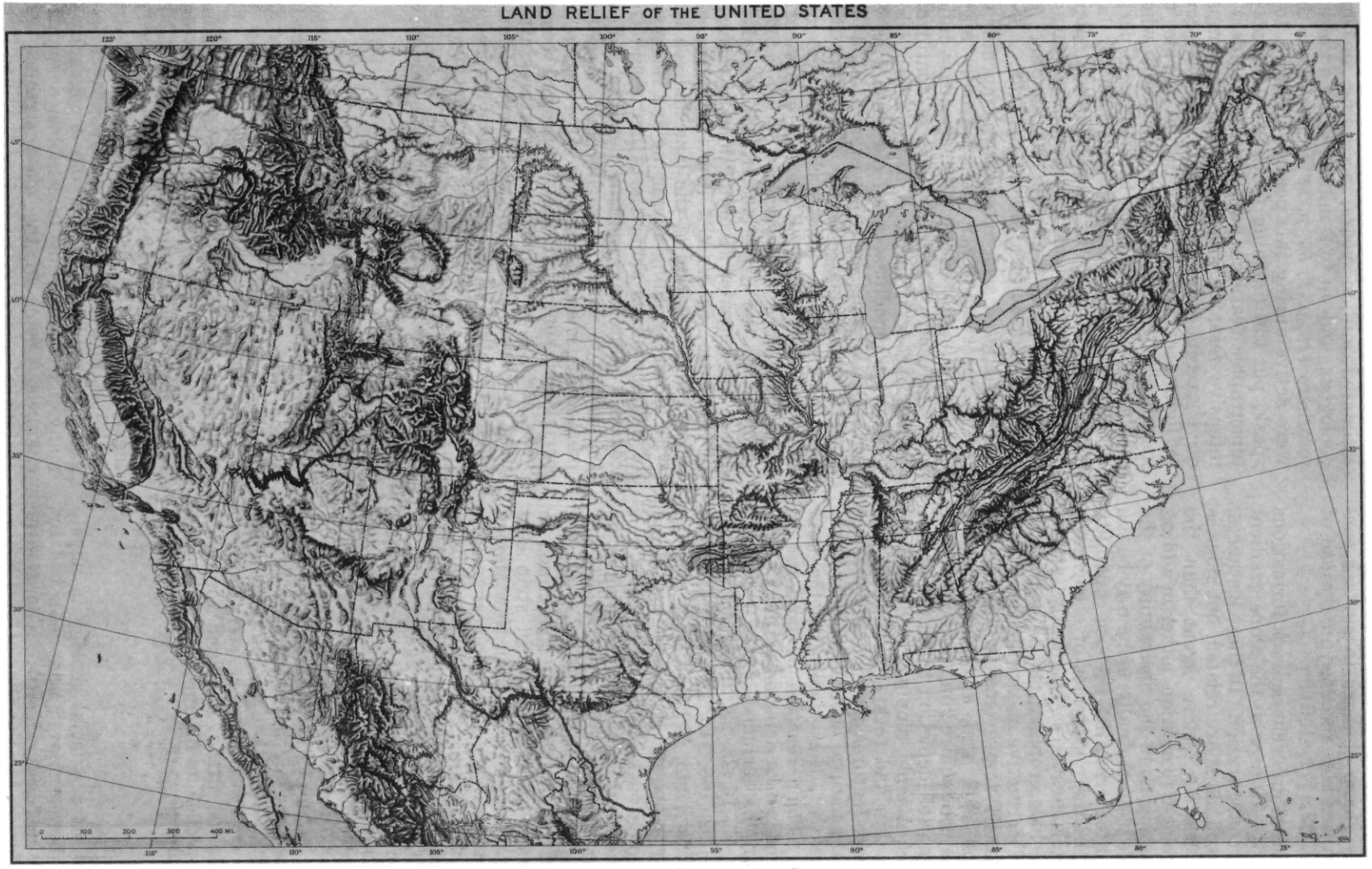

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FIGURE 11.—In its major aspects of mountains and plains, plateaus and basins, land relief furnishes the key to an understanding of the spatial distribution of climatic phases, natural vegetation, soils, and tillable land. The mountain ranges on the east and the west and the extensive plains in the center of the country, where much of the cropland lies, provide the physiographic setting for the use of our land.

almost equally sharp changes in surface conditions, which are also recorded in the use of the land (pls. 27, 111, 159).

A contact line of different bedrock formations may also mark a change in the slope gradient of the surface configuration. In these instances, rock outcrop and slope are related, but slope is frequently a more effective agent than the underlying geologic formation, either in adding to or in detracting from the desirability of the land for arable use. Actually, slope may be the chief factor in determining the use capability of the land. In their extremes of occurrence, slope characteristics are frequently strong enough to preclude cropland use altogether, or at least until corrective measures have been applied. Drainage improvements may need to be installed on level land, and terracing and contouring may be required on strongly sloping land to prevent soil depletion through erosion. Frequently, on steeply sloping land the soil mantle is too thin and rocky for cultural use. All of these slope features are sometimes closely associated in the natural environment, and to a considerable extent, they determine the land use patterns. Some reaction of land use to slope conditions can be detected on most of the aerial photographs included. (See especially pls. 9, 10, 13, 15, 16, 23, 28, 29, 34, 35, 43, 44, 48, 53, 56, 90, 92, 106, 115, 123, 130, 131, 139, 141, 145, 146, 147, 148, 149, 158, 161, 164.)

Location of minerals is closely associated with the geologic background of an area, but only when they are known and exploited do these deposits affect the surface use of the land. This is true particularly when the deposits are near the surface and are mined in open-pit operations, as is done in strip coal mining or the mining of pumice in New Mexico and Oregon, and as was done in placer mining operations in California. Strip mining usually prevents further use of the land for cultivated crops (pl. 17). The total acreage affected by strip coal mining, as compared with the total acreage of cropland in the United States, is relatively small, but it increases at the rate of 10,000 to 15,000 acres each year. Because of its exploitive nature, strip mining frequently affects the economy of the community (*149*). Oil and gas fields and other mining operations, although not so destructive as strip mining, interfere with the use of the land for other purposes and reduce its productivity while they are in operation (pl. 14).

Glaciation

The relation of preglacial geology to physiography has been explored and described by many authors (*41, 44, 45, 80*). The case is somewhat different for the Glacial or Pleistocene period, which comprises the events of an estimated million years, according to some geologists, and up to 2 million years according to others (*48, p. 1; 64, p. 16*). The forces that were active during this period, and that, so to speak, put the finishing touches on the major topographic features, have been the subject of intensive research and study only in comparatively recent years. The facts that have come to light are fascinating. But as a rule, the geomorphic features of the landscape whose origin can be traced back to the glacial period do not have the overall implications for land use capability that the mountains and plains have. In some regions, however, these features have not been negligible in shaping the conditions for cultural use of the land.

The glaciated area extends over much of the North American continent. Virtually all of Canada, but only about 700,000 square miles, or 24 percent, of the land area of continental United States, is included in the area. Obliteration and modification of old landforms and formation of new ones, however, are not confined to the glaciated area. Glaciation itself was the result of climatic changes that must have produced reactions over the entire earth, but which were most effective in a broad belt adjacent to the drift border, the periglacial zone. The repeated accumulation and recession of immense ice masses near the poles also caused an oscillation of the land and sea level with a corresponding advancing and retreating of the shorelines along the Atlantic and Gulf coasts. Quaternary marine deposits indicate the extent to which these lowlands were submerged at times. In the glaciated region, the periglacial zone and the submerged coastal belts are soil and topographic features attributed to glacial, wind, and water action during this period that either improved or reduced the use capability of the land. The extent to which the land was glaciated and the area that was submerged for a considerable time are shown in figure 12.

The Glaciated Region

Modifications of the preglacial topography in the glaciated areas are due mainly to the action of the glaciers themselves. The abrasive and grinding force of these slowly moving ice masses, which were estimated to have had thicknesses in places of more than 2,000 feet, must have been enormous. This is evident from the rounded mountain slopes in New England, and the striae (grooves) engraved on the rocks. In the plains, the deposit of drift material, in the form of boulders, gravel, sand, and clay, obliterated the old topography in many places by filling in established drainage channels. Some of the main streams were obstructed and diverted so that they had to cut the new channels (pl. 74).

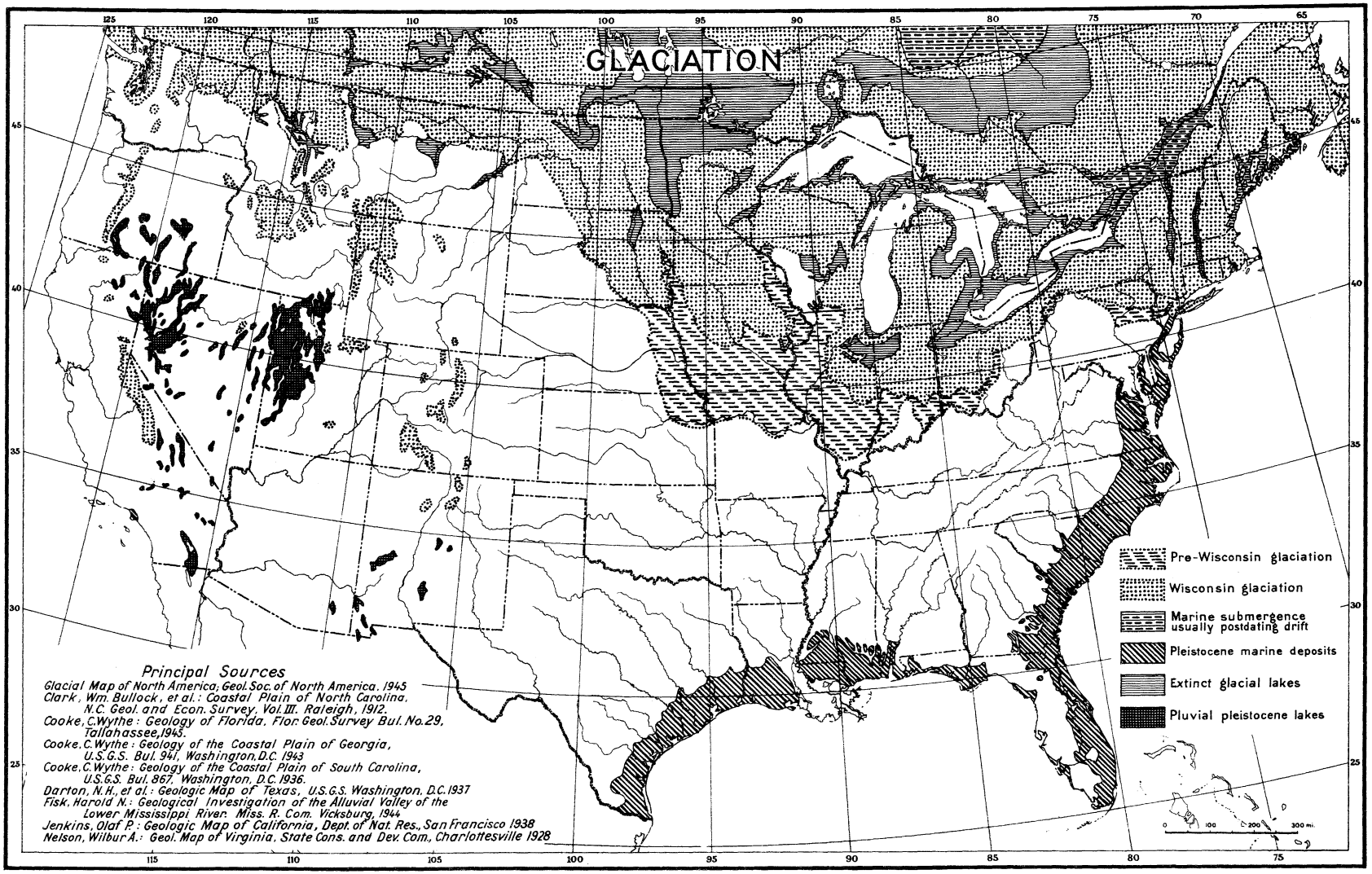

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FIGURE 12.—Broadly speaking, the Ohio and Missouri Rivers are frequently considered as forming the southern limits of ice invasion. Outside the glacial limits extensive lakes, of which only small remnants remain, formed during pluvial periods. Pleistocene marine deposits along the Atlantic and Gulf coasts reveal that the sea level fluctuated considerably with the advancement and retreat of the ice sheets.

Accumulations of drift material, frequently of considerable thickness, were left by retreating glaciers over most of the glaciated plains. Where the extensive glacial lakes had formed, these deposits were partly reworked and lake deposits were added (pl. 40). As ground moraines and lake plains usually have smooth surfaces with inadequate drainage, large areas had to be drained. The larger part of the land improved by artificial drainage lies in the glaciated region (pls. 45, 54). But not all wet lands can be drained economically. Over much of the younger drift plains, the dissected stream-erosion type of topography has not yet developed. The surface is billowy and there are shallow depressions. On the open plains are areas with many such depressions, or kettleholes. These kettleholes resulted from the melting of imbedded ice blocks left by the retreating glaciers in the drift, or were produced as pools in shallow runoff channels made by the waters of the melting glaciers (pl. 71). In themselves, the kettleholes may not be large but because of their numbers, they reduce the cultivable acreage materially. Also, because of their irregular distribution, they are a serious obstacle to field operations. This again reduces the acreage available for cropping. In the Great Lakes forest region, where rainfall is fairly heavy, development of drainage was retarded because of glaciation, and many lakes and swamps are found there.

Glaciers also produced landforms that protrude above the general level of the country and thereby affect the use of the land. Terminal moraines in the form of low ridge belts are accumulations of drift and till along the convex edge of the glaciers. The surface configuration of these moraine belts consists of a random arrangement of knolls with more or less sharply defined depressions interspersed. Terminal moraines may be so rough that the land cannot be used for cultivated crops. In more moderate instances, only the scattered smoother portions can be so used (pl. 69). Eskers are curved, low, narrow ridges composed of stratified drift deposited by water within steeply walled channels or tunnels in the ice. More prevalent than eskers are drumlins, which are low, oval-shaped hillocks more or less densely arranged over broad fields. As a rule, drumlins are about 60 to 100 feet high and up to a mile or more long; they were shaped by the moving ice with the major axis in the direction of the flow. Slope and elevation in these areas usually are not sufficiently prominent to act as a detriment to use of the land for cultivated crops, but fields must be adjusted to the trend of the drumlins (pl. 47). In less developed areas, fields are scattered among the drumlins.

Outwash plains and glacial lakebeds are also associated with glaciation. Outwash plains and deltas consist of stratified sediments deposited by waters that issued from melting glaciers. Most of these deposits comprise the coarser particles of drift, which sometimes approach pure sand. In these instances, the land is not suited to cropping (pl. 49). Glacial lakebeds, as a rule, have heavier soils and smoother surfaces, and consequently a higher use value. In places along the beachlines of these lakes, cultivated fields are adjusted to the orientation of the beaches (pl. 70).

Land Use Affected by Glaciation

Distinctive landforms and soils are the main surface features of the glaciated area that have affected land use to a considerable extent. In distribution and spatial arrangement, these two distinctions may be closely associated within restricted areas, or in extensive tracts one or the other may determine the land use capability. Land use necessarily shows man's reaction to these conditions and this has produced diversity and contrasts in land use patterns.

Immature relief and drainage development on late till and morainic deposits are the order over extensive areas. What the relief would be without glaciation can be perceived when the driftless area in southwestern Wisconsin is considered. The driftless area appears as an island in the glaciated region, although it was never entirely surrounded by ice. As the area was not glaciated, the old relief features that developed from sedimentary rock formations exposed to protracted erosion were not obliterated by till, nor was the process of erosion interrupted by ice. The tilted and dissected plain was preserved (pl. 48). In contrast to the old erosion surface, the proximate areas of late till and morainic deposits present a chaotic assortment of hillocks and depressions with no well-developed drainage system (pl. 46). In both instances, the land use pattern reflects adjustment to these features.

The soils of the glaciated region, perhaps more so than the landforms, have had both beneficial and restrictive influences on land use. The millions of acres of waterlogged and swampy lowland composed of large tracts and small depressions have an organic soil cover, mainly peat. In their natural state, these lands support some tree growth. Where the peat is deep, however, even the trees are stunted (pl. 50). Reclamation for agricultural use is feasible for some areas but not for others. Also prevalent over extensive areas are the rocky and stony soils that restrict land use to forestry, recreation, and support of wildlife (pls. 3, 5, 6, 41). Almost equally detrimental to agricultural use of the land are the extensive sandy plains already mentioned. At opposite extremes are the drift plains and glacial lakebeds on which

some of our most productive soils developed (pls. 12, 40, 51, 37, 42, 45).

In the mechanical processes of grinding, mixing, sorting, transporting, and redeposing surface minerals, the action of ice and water during the glacial period produced a series of land characteristics that have affected the economic use potentiality of the land. The spatial arrangement of these features, however, is far from uniform. Large land areas were improved by these redistributional processes; the productive capacities of others were depleted or impaired. In the glaciated region, these dissimilarities in surface conditions, together with differences in climate, account for the diversity in the physical adaptability of the land to cultural uses. This diversity has found expression in regional and local land use patterns.

The Periglacial Zone

Although ice and water brought about superficial changes in the glaciated area, no less important surface modifications were produced through the operation of climatic forces in the adjacent belt, which is usually referred to as the periglacial zone. The periglacial zone was defined by Zeuner in 1945 as "that zone surrounding an ice sheet, in which the cooling effect of the ice produced frost climate" (*101, p. 1467*). Temperature, however, was not the only climatic agent during the Pleistocene Epoch that affected conditions of life and changed the surface of the land outside the glaciated area. Air-mass movements caused by changes in temperature distribution, combined with pluvial and dry periods, were even more effective than temperature in shaping some of the surface features that condition land use today. Evidence of their activity during the Pleistocene Epoch can be found as far south as the Mexican border or the South Atlantic Coastal Plain. For our purpose, therefore, the whole of the United States outside the glaciated region is considered as located in the periglacial zone.

The periodic changes in temperature that accompanied the repeated advancing and retreating of the ice sheets had their counterpart in pluvial and dry periods attended by strong air-mass currents. Wind and water were the primary agents that modified soil and topographic features in the periglacial zone, while the floral and faunal associations adjusted themselves in response to periodic changes in temperature and moisture conditions. Only in terms of climatic changes can the occurrence and distribution of some of the surface features and fossil remains of plant and animal life be explained.

Pluvial and Dry Periods

That pluvial periods alternated with drier periods is evident from the beachline records that reveal the geologic history of the intermountain lakes (*48, pp. 469–476*). Lakes Bonneville and Lahontan, the two great lake systems in the intermountain basin-and-range region, covered a number of adjacent basins during the pluvial periods of the Pleistocene Epoch. The high-water level of Lake Bonneville, on the eastern side of the intermountain region, was more than 1,000 feet above the present level of the Great Salt Lake. At that time, it covered an area of more than 19,780 square miles. At its highest stage, Lake Lahontan in western Nevada, which extended into some basins of Oregon and California, covered an area of 8,422 square miles and had a maximum depth of more than 500 feet. Pyramid, Winnemucca, and Walker Lakes are existing remnants of Lake Lahontan, and there were other Pleistocene lakes in the intermountain basins. In most instances, they are now playas; their shorelines provide mute evidence that at one time they were lakes.

These high beachlines indicate that precipitation was higher and evaporation lower than they are at present. The delta deposits covered by lake deposits and shorelines on intermediate levels support the conclusion that these variations occurred in cycles. In their present state, these old lakebeds have their own land use characteristics in that the lowest parts of the basins are practically desert. Longtime flooding of these closed basins and leaching of the soils and surface rocks of the easily soluble salts they contained concentrated the saline contents through evaporation at the bottom of the lakes. Because of the toxicity of these salts, most plant growth is eliminated from these now dry lake bottoms. The Black Rock Desert in Nevada and the Great Salt Lake Desert in Utah are the two largest and best known.

The pluvial periods also find expression in the stream-erosion topography of the periglacial zone. A marked distinction in topography occurs between the younger drift plains (pl. 36) and the unglaciated plains (pl. 35). In much of the younger drift plains, drainage is not fully developed. In the unglaciated plains, stream erosion has been active longer and has dissected the plains more thoroughly. The topography of the badlands in the Dakotas and Montana could hardly have resulted from the present low rainfall in these areas. It suggests that the origin of these lands is associated with the pluvial periods of the glacial epoch. Because of the dissected surface, much of the land in this region is not suited to arable use (pls. 68, 72).

Farther south, in Texas and New Mexico, "the surface features of the High Plains as well as the development or at least the extensive modification of the larger canyons, and the bounding escarpment are the result of quaternary erosion and deposition" (*42, p. 435*). The High Plains, especially the Llano Estacado, are not as incisively dissected by streams as is the country below the escarpment to the east. Only shallow draws that carry water intermittently have formed on the plateau. There is little runoff. Most of the precipitation that falls is absorbed by the soil and the sand dunes, or it is caught and retained in the many shallow depressions and playas that dot the surface. Subsidence or slumping in some of the older rocks beneath the smaller basins and deflation through wind action during arid stages, with solution as a contributory factor, explain the origin of these basins (pls. 119, 120).

The Alluvial Valley of the Mississippi

Erosion induced by running water was not confined to uplands. The waters of the rivers, which were charged with the sands and gravels washed out upstream, were effective in their scouring actions. In places, they cut deep trenches. The canyon of the Canadian River, which divides the Texas High Plains, and other canyons farther north, such as the canyon of the Cimarron River, are of this type (pl. 113). A more voluminous job was done by the Mississippi River.

According to the latest investigations, the Alluvial Valley of the Lower Mississippi River contains the buried river system that was in operation at the late stage of glaciation (*46*). At a time when the water level of the gulf, as compared with the elevations of the land, was much lower than it is today, the Mississippi River excavated a valley that was a great deal deeper than the present valley. At the upper end, near Cairo, the main channel was approximately 100 feet above the present sea level, or about 200 feet below the present valley floor. Near the gulf coast, these channels were more than 350 feet below the present sea level, or about that much lower than they are now. The gradient of the 600 miles of the Lower Mississippi had therefore about 150 feet more descent than it has today. The river was straighter, and sediment could be carried farther and in greater volume. It has been estimated that at that time about 1,500 cubic miles of sediment were removed from the lower valley and transported by the river into the Gulf of Mexico. This figure does not include the sediment brought into the valley by tributary streams (*46, p. 11*).

With the melting of the ice sheets and the attendant rising of the gulf's water level, the streams that had excavated the valley began to fill it up again. Aggradation was accomplished in several ways. The master stream periodically flooded the valley and dropped its load of gravel, sand, and silt, while the tributaries built alluvial fans where they entered the flood plain. With construction of the flood plain went also modification of river channels. With the decrease in the slope of the valley, the Mississippi River developed meander loops, built natural levees, and shifted its channel frequently. It has not changed greatly since. "With its diversion through Thebes Gap the Mississippi River established for the first time a comparatively deep-water channel from the head of its alluvial valley to the Gulf of Mexico. From the standpoint of flood control and navigation, this channel is the best that has existed in the history of the alluvial valley" (*46, p. 55*).

The reconstruction of the Mississippi flood plain therefore is in the main glacial with surface deposits that consist of recent alluvium. In elevation, the present flood plain has not attained the old level. Some remnants of the old plain have elevations that place them above the flood level (pl. 133). In all, the Alluvial Valley of the Lower Mississippi comprises about 50,000 square miles, the delta included. This total consists of about 35,000 square miles of flood plains and about 15,000 square miles of old plain terraces in the northern and central part of the valley.

Flood Control and Drainage.—From the land use viewpoint, the structural history of the Alluvial Valley of the Lower Mississippi is significant in that it is reflected in the land use pattern. Ever since white men settled in these extensive flood plains, they have struggled to control the river. The soils of these plains are inherently productive, but in its natural state very little of the land could be used for crops with safety. Only the higher portions, which consisted of natural levees built up by the larger streams, were sufficiently well drained to permit cultivation, and even these were subject to occasional flooding when the river reached high-water stages (pls. 132, 135, 137, 140).

The Mississippi River still floods the valley periodically. These floods are not only damaging; they are sometimes disastrous. Local and State efforts to control them were formerly of little or no avail. Not until the Federal Government developed a comprehensive flood-control program, built levees, and set aside bypasses, was the threat of damaging floods materially reduced. Flood protection is the chief safety measure needed by the inhabitants, but it is not sufficient for a fuller development of the valley (*61*). A rather high annual precipitation, which increases from an average of 40 inches in the north to 60 inches in the south, keeps much of the lowland wet and swampy (pl. 135). Artificial drainage has been installed

to some extent, but more can be done to expand the agricultural use of the land. The Alluvial Valley of the Lower Mississippi has undeveloped potentialities. Not all the land can be reclaimed for crop production, but the proportion used for the purpose is comparatively small. Of the 42,000 square miles, crops were harvested from only about 14,000 acres in 1954. Most of the reclaimed land lies at the upper end of the valley and in the Yazoo Delta.

Wind Reactions

As a modifying agent of surface conditions in the periglacial zone, wind has either improved or reduced the use capability of large acreages. Pluvial periods during the Pleistocene Epoch alternated with periods of aridity, which were accompanied by heavy sand and dust storms. Evidence of these storms is found across the country. Aeolian rock sculpture and rock polish commonly occur in the arid region. They indicate that the winds of the Pleistocene Epoch were stronger and more prevalent than are winds today. This supposition is supported by the observations of investigators, who report that the rocks polished by these sandblasts are now losing their polish through exfoliation (*66*). The arrangement and location of sand dunes and the occurrence of loess shows that the predominant direction of these strong winds was from west to east.

Aeolian sorting, transport, and deposition of sand and silt (*113*) in the Pleistocene Epoch, and more recently, have affected extensive areas, particularly in the Columbia and Snake River Basins and the Central Plains. In all of these areas, agricultural use of the land is involved.

The Columbia Basin

In the Columbia Basin, most of the uplands and plateaus are covered by a disjointed mantle of loess from a few to 250 feet thick, from which the soils developed. That the loess mantle of the Palouse country, as the loess-covered eastern plateaus of the Columbia are frequently called, is older than the last stage of glaciation is evident from the channeled scabland tracts that cross the westward sloping plateau. During the Wisconsin stage of glaciation, the escape waters of the glacier, which had advanced to the northern rim, ran across the plateau and washed out these braided channels through the loess down to bedrock (*14*). Much of the plateau was made useless for crops. Scabland can best be used for pasture. Similar loess deposits have accumulated on the high benches on the eastern side of the Snake River Basin. As in the Palouse country, they are used for production of small grains. The loess on the plateaus consists of the wind-sorted-out silt from the lower parts of the basins. Sands and sandy soils are prevalent on the lower levels and silt is characteristic of the plateaus (pls. 90, 91, 92, 93).

A similar sorting action by winds occurred in the Great Plains, though on a larger scale. This, at least, is the explanation advanced for the existence of the extensive areas of sand and loess in this part of the country.

Sand and Loess Deposits in Plains

The largest of the sand areas, known as the Sand Hills of Nebraska, occupies an area of about 18,000 square miles in north-central Nebraska, or about one-fourth the area of the State. The sandhills are arranged in dune-ridge formation, although not all of them are made up entirely of sand. Some of the larger ridges, especially, contain a hard core of tertiary material in places. Apparently the wind started to work on the tertiary deposits in the early stages of the Pleistocene Epoch. The sandhills probably started as blowouts and coalesced later. In the process the lighter materials—the silt and clay particles—were ripped out and transported eastward by the winds, at times for hundreds of miles, before they were deposited as loess (pl. 59). As the coarser sand grains could not travel far, they were left behind (pl. 66).

The Sand Hills of Nebraska, as well as the smaller sandhill areas south of the Platte River and those in eastern Colorado and other places, must be regarded, therefore, as source areas of the loess mantle that covers the land to the east. In addition, the Box Butte tableland west of the sandhills, the plains of Wyoming, and other parts of the Great Plains are still making noticeable contributions to these loess deposits. From an experimental 8 days' collection of dust in Lincoln, Nebr., following the duststorm of March 20 to 22, 1935, it was calculated that at that time the deposit was 4,800 pounds per acre (*81, pp. 156–167; 158*).

Loess deposits in the Central Plains reach a thickness of more than 200 feet in places. They cover extensive areas in eastern Nebraska, northern and western Kansas, practically the entire area of pre-Wisconsin glaciation, and bluffs, especially those on the east, along the Alluvial Valley of the Lower Mississippi. Because the loess deposits usually are deepest on the valley slopes near the main rivers, it has been thought that the alluvium of these valleys was the main source of the loess. But apparently this supposition is not supported by the findings of recent investigations, at least not for the Missouri and Upper Mississippi Valleys. To what extent the broad loess belt along the eastern side of the Alluvial Valley of the Lower Mississippi obtained its silt from the Great Plains or the alluvial valley is still undecided.

Considered from the viewpoint of land use, the action of the wind has changed the use capability of vast stretches of land. Most of the sandhill country in the Great Plains can be used only for grazing. The cropland found in these areas consists mainly of shallow depressions within the ridges, in which the soil is loamy and more retentive of moisture. Some cultivated crops are grown in these depressions. The main crop, however, is hay from native grasses, which grow luxuriantly in these moist places. The hay is used for winter feeding. As a rule, the soils that developed from loess are very productive, but they erode easily and must be cultivated with care. Because of this, the steeper slopes cannot be used for crops (pl. 139).

The Llano Estacado.—How wind action has affected land use in a more restricted area may be observed with reference to cultivated land on the Llano Estacado, the southern part of the Texas High Plains. That winds have helped to shape ground conditions may be deduced from the presence of sand dunes and their distributional arrangement.

The Llano Estacado is a tilted tableland. It rises from 3,000 feet along its southeastern escarpment to 5,000 feet at the northwestern promontory. (See figure 20.) Consequently, it is exposed to winds. It is defined by bounding escarpments, except at its southward extension, where it merges into the Edwards Plateau. The eastern escarpments are about twice as high as the western. Differences in elevation between the Pecos River Plains and the Llano Estacado marked by the escarpments are usually only about 100 to 200 feet, but they serve to control the movement of the drifting sands. Sandstorms that originate in the Pecos Valley have lodged the sands in dune formation at the foot of the escarpments, and only where the escarpment is broken have the sands drifted onto the tableland.

Two distinct traverse dune belts were formed in this way. The northern belt has an average width of less than 10 miles, but it is more than 100 miles long and traverses 4 predominantly agricultural counties. The southern dune belt traverses chiefly grazing land. It is not quite as wide as the northern belt and is only about 70 miles long. Traverse dune belts whose formation was controlled by gaps in the surface obstruction are unusual. The only other dune belt of this type in the United States is in Wyoming. This belt has its inception on the flats of the Big Sandy River in the Bridger Basin, crosses the Continental Divide north of the Leucite Hills, and thence enters the Red Desert. It is from 1 to 2 miles wide and about 50 miles long. But as it is located in open range country, this dune belt affects land use less than do the traverse dunes on the Llano Estacado.

On the Llano Estacado, sand dunes are not the only modification of surface conditions that can be attributed to wind action and that affect the use capability of the land. Larger tracts of land than the sand dunes cover either received a surface layer of light sand or were subjected to wind erosion and deprived of most of the topsoil. Because of this, most of the land in the more exposed counties next to the southwestern border of the tableland is suitable only for grazing. In Andrews, Karnes, and Yoakum Counties, Tex., and the eastern part of Lea County, N. Mex., the greater part of the land is covered by light sand. In Lea County, however, the tableland next to the Mescalero Escarpment has a shallow rocky soil. A similar situation prevails farther south over much of the land in Ector, Upton, Reagan and Glasscock Counties, where the soil either is shallow, gravelly and rocky, or has a heavy silty clay surface soil (*21*). Land used for crops in this broad range belt on the tableland is confined to scattered areas in which the soil is deep enough and retains enough moisture to permit its use for that purpose.

In the transition zone, from the range belt in the southwest to the agricultural section at the northern end of the Llano Estacado, a number of large playa basins show evidence of wind action. These basins are much larger than the many saucerlike depressions that dot the plateau. Saline lakes or playas that contain water during most of the year occupy the lowest parts of the basin floor. Subsidence may account for some of these basins, but the more directly observable evidence is deflation through wind action. The eastern sides of most of these playas contain dune ridges that parallel the shoreline. This is evidence that wind was at work (*42, p. 488*).

Not all of the observable ground features that are the characteristic result of wind action can be thought of entirely as finished products of the Pleistocene Epoch. We know that dramatic wind action did not cease with the retreat of the last glacier. But usually it is conceded that the strong winds that produced these modifying surface features occurred in cycles during the Pleistocene Epoch. Deductive evidence that during periods of relative aridity in that epoch, air currents were more powerful and persistent than they are today is provided by the playa dunes. These playa dunes have now entered a stage in which degradation through water erosion is more effective than the building-up process through aeolian deposition (pl. 120).

Although wind deposits and denudation on the Llano Estacado demonstrate the effect of wind on the use of the land for crops, equally

large accumulations of sand are found in other parts of the West. In most instances, these sandhills and dunes occur in arid and semiarid country. Therefore, they are not controlling factors in cropland use. In some instances, these dunes are almost sterile of vegetation and thus exclude productive surface use. These sandhills are found in the valleys and plains of New Mexico, the San Luis Valley in Colorado (pl. 81), the Imperial Valley of California, and many other places. Aeolian accumulations of sand are found also in the more humid part of the country, particularly along streams and on the southeastern and eastern shores of Lake Michigan. As these last are in the glaciated region, they probably postdate glacial drift. All these inland deposits, however, have one characteristic in common; all are found on the eastern side of the valley or basin in which they occur. In this respect, loess and sand dunes furnish corroborative evidence that the strong winds that built up these deposits were predominantly westerly winds.

The Coastal Belts of Pleistocene Marine Submergence

The lowland margins of the Coastal Plains along the South Atlantic and Gulf Coasts, although they may be considered as lying in the periglacial zone, have their own Pleistocene history, which differs markedly from that of the rest of the country. The difference in the geologic history between these lowland belts and the rest of the Coastal Plains consists of the repeated submergence by and emergence from the waters of the ocean during Pleistocene time. Low and high sea levels were the companion events of the respective glacial and interglacial stages. Vast quantities of water were locked up in the polar icecaps during the glacial stages and released when the glaciers melted and wasted away. At its highest stage, the sea flooded the land to an elevation of about 270 feet, and at its lower level, the shoreline receded on the Continental Shelf. Findings at the mouth of the Mississippi River indicate that the sea level was more than 350 feet lower than it is today. The extent to which crustal movements may have contributed to the oscillation of the ocean level is an open question.

Although we have no definite time scale to show the duration of glacial and interglacial stages, there are indications that the warmer intervals may have been the longer ones. Judging from the accumulations of marine deposits, they must certainly have lasted for thousands of years. The first submergence evidently was the highest; each succeeding one flooded a correspondingly smaller margin of the lowland. Evidence of the repeated flooding of the lowland is preserved in the marine deposits of clay, sand and gravel, and in the old beachlines that separate the lowland terraces along the lower Coastal Plains (pl. 161).

Surface erosion is not very active on these terraces. Natural drainage channels have not been cut back far enough to dissect the interstream flats. Thus much of the land is inadequately drained. The best drainage usually is found in the interior belt and on rising ground next to the bottom lands of the larger creeks and rivers (pl. 168). Deficient drainage has impeded economic development over much of these coastal belts. One requisite for further economic development of these areas, therefore, is drainage improvement, although conditions are not the same everywhere. The eastern lowlands differ markedly from those west of the Mississippi, as is evident from the present stage of development. Aside from surface configuration, soils and climate have much to do with this distinction.

In the western section of the Gulf Coast lowland, much of the land that rises above the tidal marshes that fringe the coast is used for crops. The rice-growing area of Louisiana and Texas lies in this lowland belt. The central part of the Gulf Coast Prairie in Texas is used largely for grazing, although the soil is fertile and with proper drainage much of it could be used for crops.

Toward the southwest, soils and climate change. The soil becomes more sandy and some dunes appear (pl. 125). Rainfall decreases to the extent that irrigation is needed to grow crops on the better land. The acreage of cropland might be expanded within this part of the Coastal Belt, but improvements in drainage would be needed (pl. 127). Most of the lowland north of the Delta is in forest, but with improved drainage, more of this land could be used for crops.

On the Atlantic side, the Coastal belt, which was submerged during the Pleistocene Epoch, stretches from the southern tip of Florida to Sandy Hook, N. J., although the submerged area is not equally well defined everywhere.

The Middle Atlantic Coastal Plain from New Jersey south to North Carolina is deeply incised by estuaries that reach up to the Fall Line. Over most of the area, differences in elevation from divide to tidewater are sufficient to facilitate drainage and induce erosion. Back of the tidal marshes lie some areas in which improvement in drainage is necessary for cropland use, but on the whole drainage is not the problem that it is farther south. In this part of the Coastal Plain, geologists are not in full accord as to the upper limit of Pleistocene marine submergence (*49*). As presented on the map, it is a generalized interpretation of various sources.

Pocosins and Bays.—A different situation prevails in the South Atlantic belt from Vir-

ginia to Florida. The Dismal Swamp on the Virginia-North Carolina boundary in the north, and the Okefenokee Swamp on the Georgia-Florida boundary in the south (pl. 156) may be considered as significant terminals of this coastal belt. In this part of the country, where wet lands and swamps are outstanding characteristics, "swamp" is a general term for waterlogged land. Locally, especially in the Carolinas, these swamps and wet depressions are usually referred to as pocosins and bays.

Pocosin, as a generic name of wet land, is derived from the Indians and is usually translated as "dismal." The bays probably received their names from the bay trees and bushes that grow in these swampy depressions. For purposes of discussion, bays and pocosins must be considered as distinct entities, although in some instances they are interrelated. The chief distinction between the two lies in their distribution, size, and form. Bays consist of elliptic depressions of various sizes with or without sandy rims. They occur on the upper and lower parts of the submerged belts. Pocosins are the large irregular bodies of waterlogged land that occupy the interstream flats on the lower terraces.

From the beginning of settlement, these upland swamps and depressions have impeded extension of cultural use of the land. During the early stages of settlement, landowners tried to reclaim parts of these large swamps, mainly with negative results. The fact that similar projects have been proposed in more recent times is an indication that the nature of these swamps is not yet fully appreciated.

Of the two types of wet land, the bays are the more remarkable. Most of them have a symmetrical oval form, which is smooth in outline and sharp in definition. With exceptions, they have a fairly uniform northwest-southeast orientation. So far, these terrestrial surface features have been reported in no other part of the world (pls. 162 and 167).

In the Carolinas, these oval depressions number around 3,000. As they have a clustered distribution, in some localities they occupy much of the land. In the aggregate, pocosins comprise an even larger acreage than bays. In a few instances, however, bay formations have been engulfed by pocosins, and in these instances the two are merged. In connection with land use, bays and pocosins, as the major drawback to the development of the region, are of more than theoretical interest.

These depressions in the Coastal Plains of the Carolinas were reported by the early explorers, but it was only after aerial photography came into wider use that the elliptical shape of the bays was fully exposed. Aerial photography supplied the first documentary evidence of the characteristics of form that aroused interest from which studies of their origin were started. Studies having as their objective the genesis of these swampy areas are preponderantly centered on the oval bays. How widespread public and scientific interest in these unique surface features is may be judged from the many articles on the subject that have appeared. Meteoritic scars were the first suggested explanation of their origin. This was followed by several others, so that the origin of the Carolina Bays has become a controversial question. Not all the papers on the subject have been examined by this writer, and no review or appraisal of the different hypotheses advanced can be attempted here. But judging from what earlier and later papers had to say on the subject, apparently no attempt had been made so far to correlate the occurrence of bays with the geologic formations of the Coastal Plain or with the findings of related fields of inquiry. When this was done, it led inevitably to conclusions that differ from the ones currently propounded.

Distribution of bays usually is described as confined to the Coastal Plain and extending northward to the Virginia boundary and southward into Georgia. To obtain a more definite concept and picture of the distributional characteristics of the bays, the aerial index photographs were used as source material and their location was plotted on a small-scale map (fig. 13). Although the map shows only the larger bays, it discloses the distributional limits, the clustered concentrations in some places, and the open scattered occurrence in others. Both the limit of occurrence and the distributional pattern indicate that development of bays presupposed propitious ground conditions.

That ground conditions are involved is evident from the restricted distribution of bays. Bays are not casually scattered over the entire Coastal Plain; they are confined to the quaternary or marine deposits of the Pleistocene Epoch. Even within this belt, the clustered concentrations, or the widely scattered occurrence or absence, of bays indicate that not all sites were equally favorable to their development. In general, however, bays are more numerous in the upper half of the belt than in the lower half near the coast.

With occurrence of bays confined to the marine deposits of the Pleistocene Epoch, their inception is automatically restricted to the later stages of that period. This conclusion is supported by the findings of direct investigations. Moreover, the distributional characteristics indicate that more or less favorable sites existed for their development, although so far no field investigations have been undertaken to establish the relationship. In the absence of more specific information as to how the bays orig-

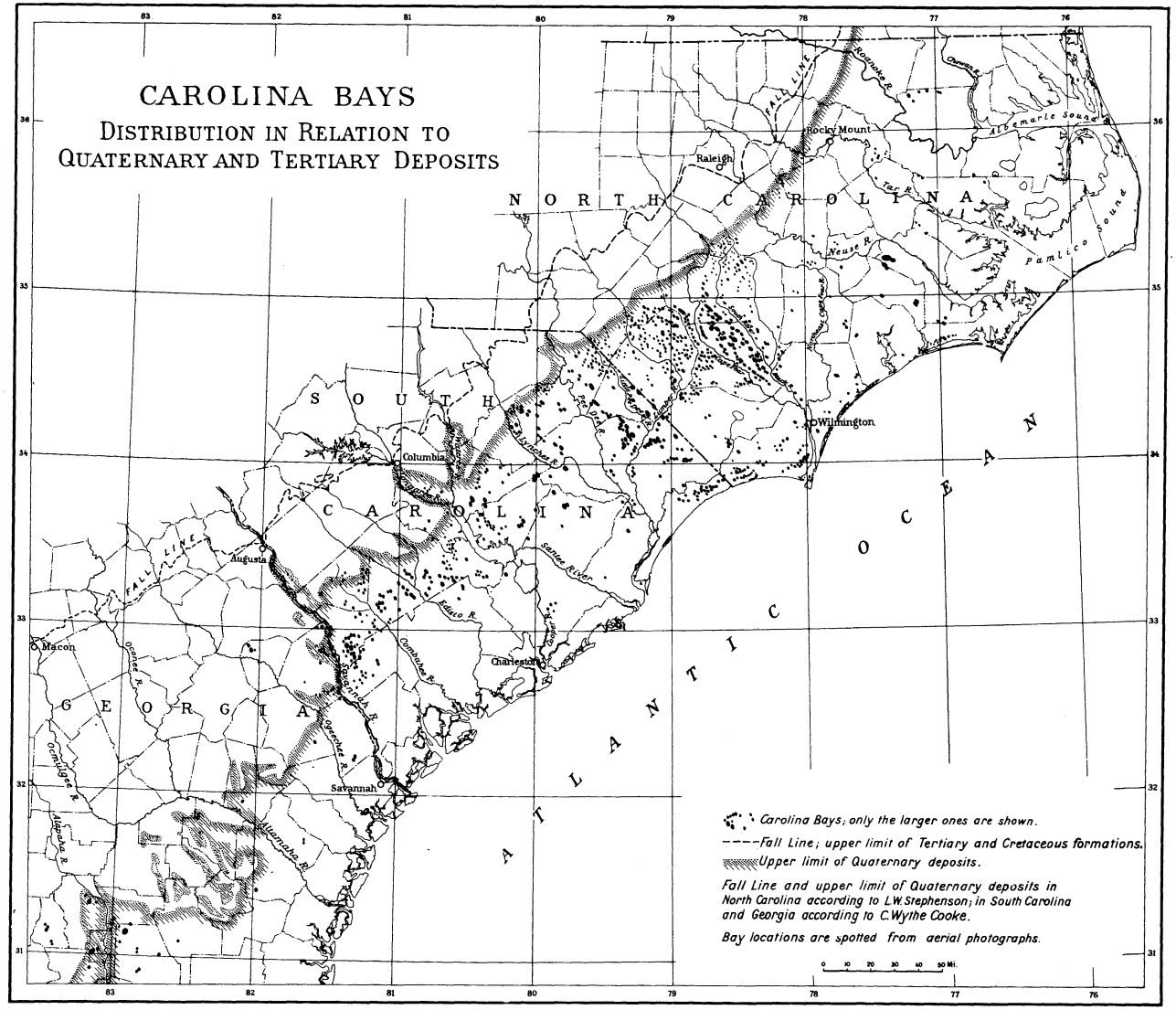

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FIGURE 13.—The Carolina Bays consist of smoothly outlined, shallow, oval depressions, with major axes alined in the slope direction of the Coastal Plain. They are usually found on undrained interfluvial tracts. Not all of them could be represented on a map of such small scale. However, the clustered distribution pattern and the upper limit of occurrence may be seen. Bays are swampy, semiswampy, or lakes.

inated, the findings of geologists can be used only as a premise for the formulation of a working hypothesis in which subsurface conditions receive consideration.

Obviously, subsurface conditions cannot fully explain the formation of bays, but they hold the key to the spatial distribution and sites that have the structural requirements for their formation. If, for instance, bays are considered akin to sinkholes produced through solution, one of the more soluble minerals, either limestone or marl, would need to be present in the substratum. Marls are known to occur in the Coastal Plain from Virginia south into Florida and west along the gulf, but they are not continuous in the Carolinas. Consequently, when an attempt is made to correlate occurrence of bays with marlbeds, no consistent relationship can be found. Bays occur over and outside marlbeds, which indicates that formation of bays does not depend on the lithologic nature of the deposits; it also eliminates solution as the chief bay-producing process.

Although solution cannot be adduced as the chief agent in formation of bays, it is a potent factor in shaping surface conditions throughout extensive areas in the Coastal Plain. In the northern part, particularly in the Great Dover Swamp and White Oak and Lake Pocosins, where remnants of rims of exceptionally large bays are found, sometimes with eccentric smaller ones inside the larger ones, indications are that solution was active also. The bays evidently formed first and were enlarged through solution into pocosins. The bay in Dover Swamp is shown in figure 14.

BAY IN THE GREAT DOVER SWAMP

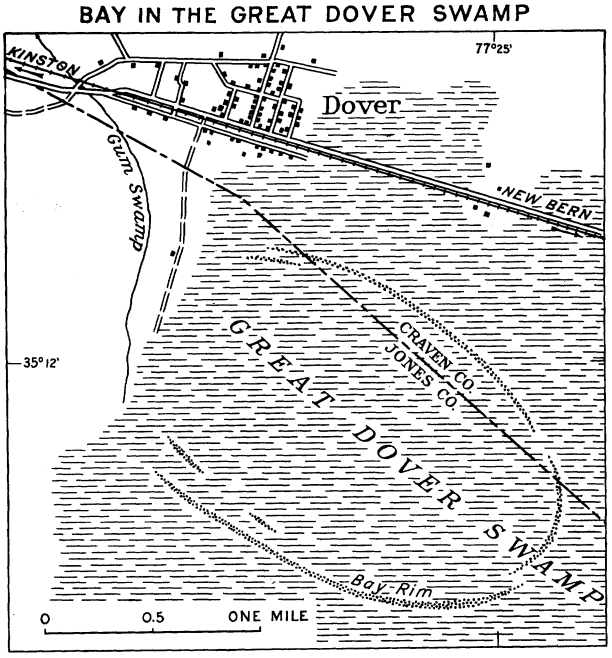

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FIGURE 14.—Bay rim remains are found at the western end of Great Dover Swamp in James County, N. C. The bay is about 2 miles long and more than a mile wide within the outer rim. Its position and elongated shape indicate that Dover Swamp with its bay developed over the preglacial channel of the Neuse River. The bay lies within the bend of the river and is oriented in line with the river above the bend.

In southern Georgia and over much of Florida, where marl and limestone formations are extensive, solution depressions, in the form of either swamps or lakes, are numerous (pls. 154, 157, 158). Usually these depressions are more irregular in outline than bays, but some are oval and have acquired some of the bay features. This is true even of those that are outside the belt of Pleistocene marine deposits. Big Dukes Pond in Jenkins County, Ga. (pl. 160), is an example (*50*). In this part of the Coastal Plain, however, bays are not the typical bays of the Carolinas. Therefore, there is a zone of transition from the solution type of depression and the area of real bays. As some solution depressions have acquired the outward appearance of bays, it is clear that more than one agent was active in the formation of bays.

Development of Bays.—Surface observations in themselves cannot account fully for the operation of bay-forming processes. All the factors that have a bearing on the problem and that may have contributed to the formation of bays must be examined. They include surface and subsurface conditions. If the pertinent factors known to exist in the area are correlated, new exterior forces are not needed for a satisfactory, though still provisional, explanation of the origin of the bays.

Subsurface conditions that may help to throw some light on the development of bays must be sought in the upper strata of the deposits. These stratified deposits mark periods of uplift and subsidence, of submergence and emergence, which induced the alternating processes of deposition and erosion. The mantle of Pleistocene marine deposits that was laid down in this way is comparatively thin. Apparently, in many places, it was deposited on a channeled surface. These channels were probably first noticed and described nearly a century ago by Emmons (*40*), who investigated the marlbeds of eastern North Carolina to establish the value of marl as fertilizer. During his examinations, he noticed a deposit that he believed might be used in certain instances as a soil amendment. These deposits were associated with the marl. He writes: "The circumstances attending its deposition were peculiar. It appears to have been deposited immediately after a period of denudation, as it rests not only upon the marl, but extends into, and fills deep channels which

had been cut out of the marl during the period alluded to. Hence, it appears to send down long tapering columns which extend sometimes to a point near the bottom of the bed. This formation, however, was formed from quiet waters, as there is no evidence of a rush or violent flow of waters, by the presence of larger rocks or even coarse pebbles." Since then other geologists have reported on these channels.

Channeling of the erosion contacts of the Tertiary with the overlying Quaternary deposits evidently was involved in the formation of bays in that it provided internal drainage channels where no surface drainage had developed. With some variations, these channels corresponded roughly to the slope of the plain, as do the major axes of the bays.

That development of bays had its inception during the later part of the Pleistocene Epoch was confirmed by the pollen investigation of Jerome Bog and Singletary Lake, both of which are in the cluster of bays that extends through Bladen County, N. C. Associations of pollen fossils in the successive levels of deposits provide a record of the adjustment of vegetation to changes in climate. The pine-fir-spruce level indicates the coldest stage; it is identified with the Wisconsin glaciation period. To supplement the pollen record, organic layers of Singletary Lake were used to determine age by means of the radiocarbon technique. It was found that the zone of maximum pollen concentration provided by the hemlock-beech-hickory-oak association, which is near the top of the sediments and indicates a moderate postglacial climate, had an approximate age of 10,000 years. The radiocarbon data indicate that the middle organic layers are more than 38,000 years old (*15, 51, 103*). But if a uniform rate of sedimentation is assumed, the lowest layers of bay sediments are estimated to be anywhere from 40,000 to 100,000 years old.

More important than changes in temperature during the Pleistocene Epoch in any attempt to explain the formation of bays were the changes in precipitation and wind velocity. Sufficient evidence has accumulated to indicate that mechanical rather than chemical processes were active in the surface layers, and that they were supplied primarily by the precipitation and winds of Pleistocene time.

Pluvial and dry periods have left incontestable marks of their occurrence, but there is no evidence to permit comparison of intensity with present conditions. Indirect evidence, derived mainly from biogeographical records, and the assumed reaction of the air-mass movement to the extension of northern ice sheets provide an idea of the amount of precipitation that fell during the later part of the Pleistocene Epoch. A map of North America, indicating the "Hypothetical mean annual rainfall at the maximum of the Wisconsin glaciation," in comparison with the present mean annual rainfall, has been worked out on this basis (*33*). As represented on this map, precipitation in the southern Coastal Plain was heavier during the Wisconsin glaciation than it is now. Even currently, this area receives a rather heavy precipitation (fig. 15). The annual average ranges from 45 to more than 50 inches, a good proportion of which falls in heavy downpours.

Frequent heavy drenching of nearly level or slightly undulating land, in which much of the moisture is absorbed by the soil, sets in motion the internal sorting action of the particles that comprise the soil. In the process of infiltration, the percolating water washes the finer particles of soil down from the upper levels, and they are precipitated in the lower levels. How effective this process is in dislodging the finer particles of soil may be judged from the results of an experiment conducted at the New Jersey Agricultural Experiment Station. The experiment extended throughout a year in which total precipitation at the station was recorded at 45 inches, about normal, but with a heavy concentration of rainfall in the early part of the growing season. From measured spot results of the experiment, it was calculated that of the finer particles of soil, more than 800 pounds per acre had been washed down from the upper plow-depth level into the subsoil, some of them to a depth of 20 to 30 inches. Consequently, the pores of the subsoil became clogged, internal drainage was impaired, and damage to the crop resulted (*95, p. 13*).

During the pluvial periods of the Pleistocene Epoch, where surface drainage was inadequate most of the water infiltrated the soil, but eluviation or leaching did not always stop at the subsoil level. Apparently over channeled contacts the downward moving water gravitated toward the subterranean drainage channels. Protracted washing dislodged the finer particles of the sediments and flushed them down into the underground channels. In time, this, combined in some instances with solution, reduced the overburden and brought about slumping over the underground outlets. The shallow depressions thus formed must have been filled with water repeatedly. The action of waves evidently helped both to smooth the shorelines of the bays and to build the rims. Sand left on the surface was exposed to the action of the wind during dry stages. Wind action no doubt accounts for the broad spoilrims on the eastern quadrant of some of the larger bays.

Evidently, the process of eluviation continued intermittently for some time. Gradually, it silted up the underground channels. The channel fillings discovered and described by Emmons (*40*) may have been of this type. The progressive clogging up of the pore spaces in the

channels retarded the movement of water. The water was held in the depressions long enough so that the sediments brought in by wind and the percolating water had time to precipitate at the bottom. Accumulation of sediments in the bays was slow. In Singletary Lake, the rate of accumulation has been calculated at 1 inch for each 730 years. The shallow waters and wet bottoms of the depressions were favorable for establishment of the swampland vegetation that produced the accumulation of organic deposits, which are more or less prevalent in the bays.

For the time being, the genesis of the Carolina Bays can be presented only as an inference of the available evidence. But interior limits of bay occurrence, and their age, distributional characteristics, and orientation, all point toward the premise that the underlying geologic structure provided locally a favorable ground condition, and that the waters and winds of Pleistocene time were the forces that produced the bays. Not all the premises on which the conclusions are based can be verified. Others that might be verified have not yet been investigated as, for instance, the relationship of bays to subsurface channels. Until these points are cleared up, the conclusions reached remain hypothetical.

Other Wet Lands.—Wet lands, swamps, pocosins, and bays are the predominating physiographic features of the landscape in the lower Coastal Plains. Very little pocosin or swamp land has been reclaimed. Much of this land is not suitable for reclamation through drainage. The extensive peat deposits in these swamps would not provide a desirable soil for the usual types of farming. Consequently, these lands would be better left in forest to serve as wildlife refuges (pl. 156). A number of the smaller bays on higher ground, for which drainage did not involve elaborate engineering, have been reclaimed and the land is now used for crops (pl. 162). Aside from the comparatively small reclaimed areas in these parts of the Coastal Plain, cropland is closely adjusted to drainage. Usually, cropland is found in belts along the swampy bottoms of rivers and creeks, where drainage is better or can be improved through ditching (pl. 168), and along the old shorelines of Pleistocene time, which are usually a few feet higher than the surface of the interstream flats (pl. 161).

The bays and pocosins of the Carolinas, however, are not the only basins found in the Coastal Plain. Clustered or scattered shallow depressions occur on the Delmarva Peninsula, as far north as Townsend, Del., and over much of southern New Jersey. Although these basins are thought to be related to the Carolina Bays, they lack the most impressive characteristic of the bays, the prevailing elliptical shape with major axes oriented in a southeast–northwest direction. They have other characteristics in common. All the basins are associated with poorly drained land and consequently produce the same economic reaction. As a rule, they have retarded conversion of the land to primary production, and as they depend largely on interior drainage, they are instrumental in helping to recharge the ground water supply (*161, 100*).

The agricultural use potentiality of the land in the lower Coastal Plain is not necessarily restricted to the land now used for crops. A more diversified type of farming, featuring more livestock, might be introduced. Crop specialties for which the climate is favorable could be grown also. Growing of these specialties, however, usually requires heavy applications of fertilizer, as soil leaching is more active here than in other parts of the country. In either case, expansion of agriculture would need to include reclamation. Aside from the extensive swamps, a considerable acreage of wet land with fairly good soil would require clearing and community drainage for agricultural use. In most instances, the natural obstacles cannot be removed by individual effort. Because public aid would be required, the public at large would need a fuller understanding of these obstacles.

Influence of Climate on Land Use

It is evident that climate controls the use of the land to a certain extent. Because of this, climate deserves more than casual recognition by those who use the land, especially those who live in transition zones where the hazards of weather are greatest. Precipitation, temperature, sunshine, and wind operate in conjunction and in varying degree affect the use capability of the land. Variations in climate and their spatial distribution are largely the result of differences in latitude, along with modifications produced by the arrangement of land and water bodies and the location of mountains and plains with reference to prevailing winds.

Precipitation

In the lower and middle latitudes, the amount of precipitation permits or restricts the number of alternative major uses that can be made of the land. The three major land uses—crops, grazing, and forests—are possible as alternative uses with adequate precipitation during the growing season. With a decrease in precipitation, the number of alternative uses is reduced. Forest use is eliminated first, and finally only grazing remains. With increasing aridity, even grazing becomes impossible.

In the United States, the use capability of large areas is affected by insufficient precipitation. In general, precipitation decreases from east to west but no uniform precipitation re-

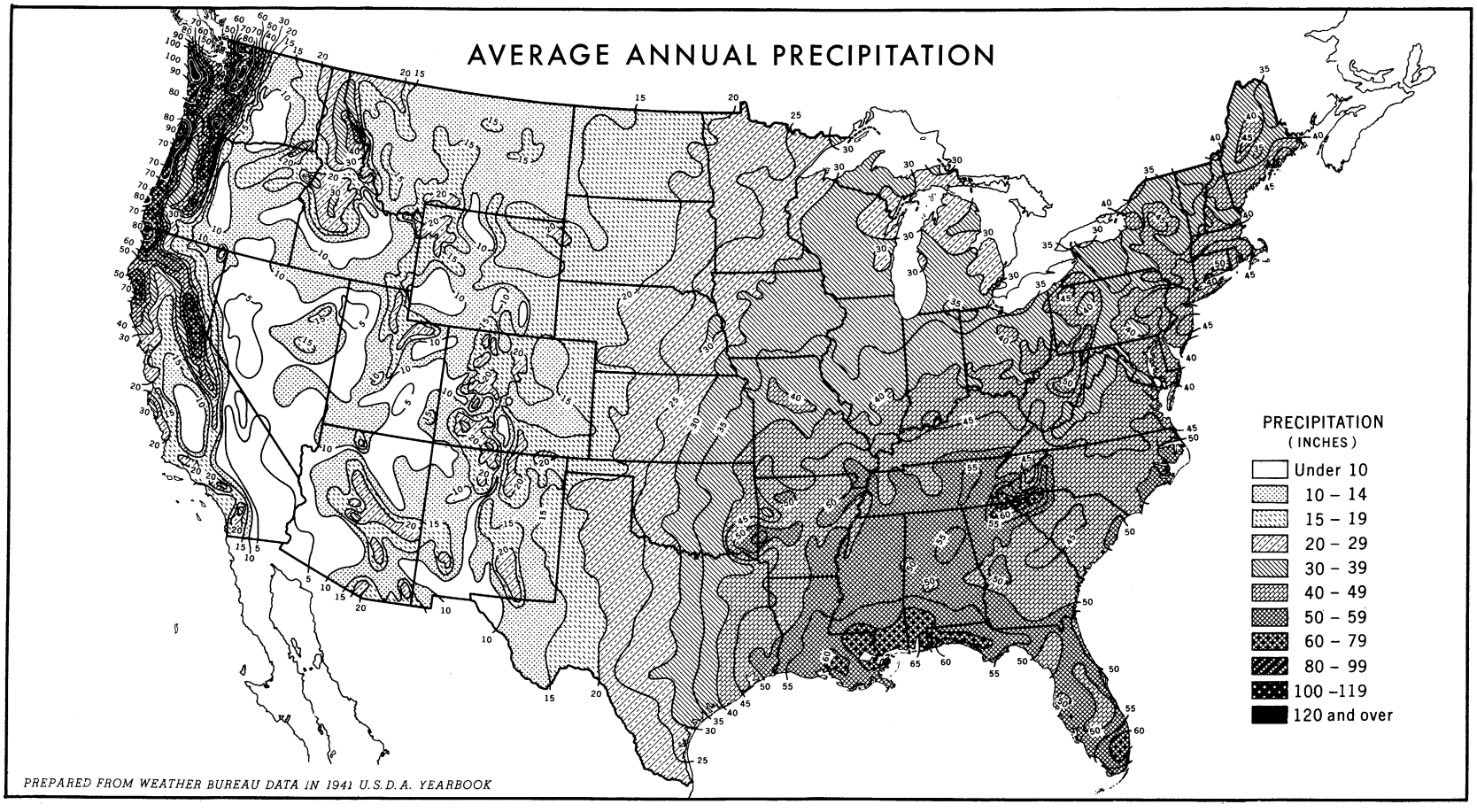

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FIGURE 15.—From this map, the overall distribution of precipitation can be visualized. Averages were derived from records that have varied widely over the years. They do not indicate what may be expected in any one year at any particular place. Distance from the ocean and arrangement of mountains and plains with reference to the prevailing direction of the wind affect the amount and distribution of precipitation.

quirement can be cited as constituting the lower limit to cropland use. In the South, which has a higher evaporation and transpiration ratio, more is needed than farther north. In this connection, average annual precipitation is frequently cited as indicating such limits. Admittedly, average annual precipitation is useful in illustrating general conditions, but it is not a reliable index of what may be expected, nor does it reflect the prevalent seasonal distribution of precipitation within a region throughout the year (fig. 15). The seasonal distribution of precipitation is important in some regions and for certain crops. In the semiarid Great Plains, rainfall is particularly appreciated after a prolonged dry spell in spring or summer at a time when crop failure can be averted (*139*). In the arid fringe, departures from the mean annual precipitation are sometimes pronounced. In this belt, deficient precipitation is a hazard that is recorded not only in low yields or crop failures but in higher crop-insurance rates, which increase proportionately with the risk involved.

Occasionally, there are significant departures from what may be considered normal amounts of precipitation. Moreover, average annual precipitation is not a true indication of the moisture supply available for crops. Seasonal distribution of precipitation and temperature, and length of growing season have much to do with the effectiveness of the moisture supply that is derived from precipitation.

Departures from the annual mean precipitation are significant even in the humid eastern part of the United States (*77*), but as a rule they are of little consequence. Crop yields are affected by too much or too little rain, but they are seldom damaged to the extent of approaching total failure. The risk from too much precipitation is not so much the result of seasonal variation as it is of intensity of rainfall. Torrential rains are rather frequent in some sections of the Southern States (*144, 166*). The heaviest concentration of rainfall is found along the gulf coast from Louisiana east to and including northern Florida, where annual precipitation is heavy. On inadequately drained land, the soil remains waterlogged for some time after such rains, and this is a drawback to agricultural use of the land. On well-drained rolling-to-hilly country, these torrential rainstorms, with their sudden increase in runoff, produce damaging floods and accelerate erosion.

The other extreme on the precipitation scale is reached in the western high plains and the intermountain basins and valleys. Aside from the mountains and plateaus, precipitation here is so low that the land can be used only for grazing. If crops are grown, irrigation is required. Some years ago, the Bureau of Reclamation estimated that about 240,000 square miles received less than 10 inches of precipitation annually. Within this area, a good proportion receives even less than 5 inches of annual rainfall, and although this amount may be sufficient to sustain some pasture plants in places, the absence of stock water precludes use of this land for pasture most of the time. Only during the occasional winters in which snow falls and stays on the ground can sheep be driven in to pasture such land.

Changes in precipitation usually pass through a gradual transition, although exceptions to this rule occur. In the western mountains, strong contrasts in relief have produced equally strong contrasts in precipitation within short distances. The strongest contrasts are found near the Pacific coast. Humid onshore winds from the ocean discharge much of their moisture in their ascent over the Coastal Range and the higher Sierra Nevada and Cascade Mountains, while the valleys behind these mountains receive little. In this way, Mt. Olympus in Washington receives the highest precipitation in the United States. According to some publications, it may exceed 140 inches, although no station records apply to the higher levels. Northeast of the mountain on Puget Sound, some 30 miles from the crest, the annual mean precipitation decreases to less than 20 inches. A similar contrast exists farther south between the western slope of the Sierra Nevada, where annual precipitation is about 50 inches, and Death Valley, 40 miles to the east, where it falls to about an inch, the lowest in the United States. Land use must be adjusted to these conditions. The humid western slopes of the mountains support a heavy forest growth, whereas the drier valleys—those between the coastal ranges and the Sierra-Cascade Mountains—have developed into the most diversified agricultural land use areas we have. Where rainfall is too low for the most effective agricultural use of the land, it is supplemented by irrigation. Water is supplied by the runoff from the bordering mountains.

Precipitation differentials between the higher and lower places in the Rocky Mountains are marked, as is effectively recorded by the vegetation. Changes in vegetation from lower to higher elevations indicate that in the mountains more moisture is available for plant growth as a result of higher precipitation and a lower evaporation-transpiration ratio. Tree growth and forest use of the land are therefore confined to the mountains. The lower limit of tree growth, however, is not uniform; it is higher in the south and lower in the north, and it varies also with exposure. In these mountains, forests occupy an elevation belt. The upper limits of the belt are defined largely by temperature, while the lower limits are chiefly a matter of precipitation. Of the two, the lower

limit is frequently more sharply defined than the upper (pl. 81).

Temperature

The influence of temperature on land use in middle latitudes is not as closely related to major uses as is precipitation, but its restrictive power increases with advancing latitude and higher elevation (pl. 11). When the prevailing temperature is so low that frost may occur in any month, use of the land for crops other than hay is almost excluded. The length of the frost-free period and temperatures during the growing season have much to do with the kind of crops that are grown in a region (pl. 4). Within the humid eastern half of the United States, the crop belts known as the Cotton, Corn, and Dairy Belts, are largely the result of temperature. That modifications in temperature through elevation and land relief are involved in delimiting these belts may be observed on the northern boundary of the Cotton Belt. The northern cotton limit skirts the Southern Appalachians and Ozark Mountains, but in the Mississippi Valley, it extends as far north as Cairo at the southern tip of Illinois.

Elevation

The following example illustrates how differences in elevation modify climate and with it affect the agricultural use of the land. Apparently, Johnson Mesa in northern New Mexico is the highest place in the United States where crops, aside from hay, are grown. On this mesa, wheat, oats, and barley, in addition to hay, are grown at an elevation of 8,200 feet. The frost-free season averages about 110 days (pl. 112). At the other extreme is the Imperial Valley in southern California, the lowest spot in the United States at which crops are grown. Here most of the cultivated land is from zero to 200 feet below sea level (Salton Sea is –240 feet) and the valley has an average of more than 300 days without frost, or practically a year-round growing season. In some years, there is no frost. Subtropical fruits and vegetables for the market are grown in winter (pl. 107). The latitudes of these two areas—Johnson Mesa and Imperial Valley—are only 4 degrees apart.

Winds

Wind makes the headlines more often as a result of its violent temper and destructive propensities than in recognition of its more gentle moods and beneficial functions as a distributor of temperature and moisture over the earth's surface.

The free motion of the atmosphere provides a many-sided topic for discussion. Early Renaissance cartographers decorated the margins of their maps with wind faces in all quadrants, that is, wind blew from all four corners at the same time. This is about the impression that a casual observer may get at times. So many contingencies affect the movement of air that apparently no order of any kind exists. In reality, air mass drifts follow prevalent directions in response to several factors. In this instance, the cause and effect relationship stems from the heating of the air in lower levels and latitudes, and the cooling off in higher elevations and near the poles. The air movement itself derives direction from the rotation of the earth, the distribution of land and water bodies, and the arrangement of relief features on the land. Not all these factors are constants. The seasonal rhythm of climate usually induces changes in wind direction. In so doing, it may have a compensatory effect on the distribution of precipitation. Some regions are so constituted that no benefits accrue from these changes. As an example, the arid intermountain basins and valleys of the West are parapeted by mountain ranges to the east and west, and little moisture can reach them from either the gulf or the Pacific Ocean.

In some regions, the prevailing winds have produced distinct landscape features. Trees that bend picturesquely indicate the prevailing direction of the wind. In the Western Plains, where there are no obstacles to break the force of the wind, field operations frequently take account of the force and direction of the wind to prevent soil erosion. Stripcropping is often resorted to, and the strips are cut diametrically across the wind direction. The result is a striking land use pattern characteristic of these areas (pls. 65, 73, 74). Shelterbelts are also a form of wind protection in some parts of the Plains. On the eastern prairies, where some trees can be grown, they are planted in protective belts on the windward side of the farmsteads. These windbreaks are an outstanding feature of the landscape in otherwise treeless plains (pls. 54, 62, 67, 70).

Adjustment to Climate

That land use must harmonize with climate is usually recognized, but the hazards involved are not always appreciated. No area is entirely free from these hazards, but in one form or another certain areas are more exposed to them than others. In subtropical areas, an occasional heavy winter frost may damage citrus fruit. Late spring frosts are a hazard to deciduous fruits. Damage from drought and hail is more frequent and severe in the semiarid belt. Tornadoes are usually confined to the Southern and Eastern States, but heavy rainstorms that cause floods may be expected to occur anywhere within the humid and subhumid zones. In summer and fall when the weather is dry, protection from forest fires is most needed. Heavy snow endangers livestock

and wildlife on the open range. These are a few examples of climatic hazards in the United States that are related to use of the land.

The connection between climate and the capabilities of land use, particularly for agriculture, became apparent with the settlement and development of the country. The land became drier and the vegetation sparser as the settlers moved farther west. They called the semiarid plains the "Great American Desert," an indication that reliable information as to weather was needed for development of the country. Agriculture still has particular need for it. Most crops have their own range of climatic conditions under which their growth is most successful. It was obvious that climatic reports and records from stations scattered over the country were needed. The United States Weather Bureau had its inception in 1870, in the Signal Service of the United States Army. Some two decades later, it was transferred to the United States Department of Agriculture, and it was later moved to the United States Department of Commerce. Its functions and the number of reporting stations have expanded steadily. In 1955, there were more than 10,000 reporting stations, of which only about a third were staffed with paid personnel. The rest were operated by unpaid cooperative observers.

The literature on weather, climatology, and meteorology is voluminous. Only a few of the publications that present the subject comprehensively with a land use orientation can be cited here (*74; 118; 135, 1941; 146*).

Soils in Relation to Land Use

Use of land for primary production is in reality mainly concerned with the use of the soil mantle. Thus, the importance of the soil in relation to land use is highlighted, as not all soils are equally well adapted to specific uses. The economic significance of the many recognizable properties of soil increases when these properties pertain to arable land. Whether the land can be used successfully for production of cultivated crops depends, in many instances, on the nature of the soil. How the soil must be managed to produce the best yields year after year is again related to its characteristics.

Soil characteristics may be thought of as the marks of distinction that evolved in the process of soil development. Usually, they are referred to in terms of soil profile. Fully developed soils consist of a vertical succession of layers, which soil scientists call horizons. These layers may differ in texture, structure, color, and chemical composition. In their stratified sequence from the surface down to the parent material, they compose the profile of the soil. Many factors have contributed to the morphological characteristics of the soil profile. Some of these influences vary with location in the local environment; others are identified with natural conditions of regional extent.

Parent Materials

To begin with, the parent material of the soil has certain characteristics of its own, which to some extent are transmitted to the soil. The parent material may consist of the accumulated debris produced by weathering and disintegration of the underlying rock. In these instances, the rock may be limestone, sandstone, slate, or granite, to cite only a few petrographic distinctions, so that the soil-developing processes had to act on minerals of differing textures and chemical compositions. As a result, the soil develops characteristics, which in popular parlance are frequently identified with the rocks from which the parent material was derived. This is true also when the parent material consists of unconsolidated glacial, fluvial, marine, lake, or wind deposits. Most of the characteristics inherited from the parent material are recorded in the texture and chemical composition of the soil. Extensive and compact areas can be identified as having soils developed from parent material, which are derived from the same or similar geologic formation. In other areas, the geologic background is more complex; it is this complexity that is usually responsible for a number of soil types in any locality.

Climate as It Affects Soil

Among the soil-developing agents, climate ranks highest in that it affects the soils both directly and indirectly in more than one direction. The direct action of weather is both mechanical and chemical; soils are affected by precipitation, temperature, wind, and running water. Indirectly, climate operates through the intermediary of vegetation and animal life in that their contributions to soil building are already adjusted to climatic factors.

Two major soil groups, those well leached and those incompletely leached, are produced by humid climates as opposed to those produced under subhumid and arid conditions. All of the incompletely leached dryland soils have one characteristic in common: All have a calcareous zone in the lower part of the profile that rises gradually to the surface with advancing aridity. A gradation of soils brought about by the differentials of temperature, which affect the color of the soil, is particularly noticeable in the forested humid part of the country. When compared with northern soils, well-drained southern soils are more colorful, especially in the subsurface horizons. The latter range from pale yellow to dark red. The former are usually grayish or brownish. The processes that produced these distinctions in color are known as

podzolization for the gray-brown soil and laterization for the yellow-red soils.

There are many transitional phases. Soils in the podzolic soil group frequently encroach on the lateritic soils. Podzolization is mainly a process of leaching in a cool to temperate climate under forest cover. Laterization is characterized by the presence of iron oxides and hydroxides of aluminum; it occurs commonly in humid tropical regions. In the United States, only weak stages of laterization have developed. The yellow and red soils of the South fall into this class. Red pebble land, which contains pebbles of iron concretions, furnishes the best example.

Effect of Natural Vegetation on Soil

Natural vegetation, which is related to climate, has also contributed toward development of the soils. In so doing, it has produced its own marks of distinction. Soils that developed under a grass cover are easily distinguished from those that developed under a forest vegetation. Forests do not produce humus in the upper mineral horizon of the soil as do grasses. The humus produced by the northern forests carpets the forest floor; when dissolved, it is leached to a lower horizon. In southern forests, very little organic matter accumulates. In the warmer climate, decomposition is speeded up to a point at which little organic matter is left from one year to the next.

In contrast to the forests, a grass-type vegetation produces humus in the upper layer of the soil through root decay, which gives these soils their black or dark brown color. Black earth, or Chernozem, is usually cited as representative of this kind of soil. Chernozem, a soil group developed under grass cover in a subhumid climate, is almost black. At a depth of about 3 feet, it has a zone of calcium accumulation. The prairie soils of Iowa, central Illinois, southern Minnesota, and northern Missouri represent a predominantly American kind of soil development, which has much in common with the Chernozems, but which, because they are leached, lack the calcareous zone. In the opposite direction, with the transition from the tall to the short grasses of the steppe type of vegetation, the humus content of the soil decreases and the color changes to brown. Finally, when the grasses give way to desert shrubs, the humus content of the soils becomes so negligible that the soil loses much of its color. Arid soils are ordinarily a light gray.

Animal life both within the earth and on its surface has also contributed to development of soils, but as its action is desultory, it is not discussed here.

Soils Affected by Land Relief

Differences in land relief also produce differences in soils. These differences are due largely to the reaction of the processes of soil development to drainage. For normal development of soil, well-drained but not excessively drained land is needed. On steeply sloping land, erosion is likely to be too active to allow sufficient time for proper development of the soil profile. Soils of the steeper mountain slopes, therefore, are mainly shallow and rocky. On rugged mountainsites, the rate of erosion may even exceed that of rock weathering and the rocks may remain barren.

Low gradients and level surfaces produce soil profiles of their own as a result of inadequate drainage. The precipitation that falls on such land drains off slowly. It is largely dissipated through evaporation, transpiration, or infiltration into the soil itself. In these instances, the internal movement of water in the soil carries with it the finer particles from the upper horizon and deposits them in a lower horizon. This results in formation of hard or clay pans, which in turn impede internal drainage of the soil. The process is known as eluviation.

In shallow depressions of the humid region, in which water moves only sluggishly or remains standing most of the time, swampland vegetation usually takes possession of the area. Over the years, it builds up an organic soil, which consists of layers of peat and muck. As we now know, the extensive peat bogs in the eastern half of the United States were thousands of years in the making and have their own land use implications (pls. 50, 156).

Development of Soils Affected by Other Factors

The major factors of soil development have been mentioned. Other factors are more restricted in their fields of operation, but within these limits they are just as effective as the major factors in determining land use capability. The playas of the arid West are examples of this kind. When these basin floors were flooded by the runoff from the tributary watershed, they also received the salts leached out from the rocks and soils of the area. When the water evaporated, the salts remained. In places, these saline accumulations are so concentrated and toxic as to prevent plant growth altogether. In these instances, soil salinity accounts for the desert condition. The Black Rock Desert in Nevada and the Great Salt Lake Desert in Utah are the largest deserts of this type in the country.

Wind as a disturbing element in soil development is most active in the subhumid-semiarid belt. The use capability of extensive areas has been reduced by the action of the wind. The Sand Hills of Nebraska is such an area; it forms a compact area of 19,000 square miles north of the Platte River within the subhumid zone. Here, the sorting action of the wind has carried off the finer particles of the soil but

has left the ridges of sand. In contrast to the adjacent country to the north and south, where much of the undissected plain is used for cultivated crops, the Sand Hills can be used only for grazing (pl. 66). The cropland scattered over the Sand Hills lies in the moist depressions, where native grasses are cut for hay to supplement livestock feed in winter. Smaller areas of sandy land in the subhumid belt, in which land use is confined to grazing, are located on the High Plains and the Coastal Plain farther south (pl. 125).

Wind action is no doubt responsible for another type of soil development on the Llano Estacado, which has brought about a similar reduction in land use capability. Rainfall over much of the southern end of the Llano Estacado is sufficient to permit production of cotton, and it is grown in a number of places where the soil is suited to the purpose. In extensive areas, however, the surface soil is sand that was blown in from the Pecos Plains to the west. In other areas, the topsoil is shallow because part of it has been removed by the wind (pl. 120). The largest area with a sandy topsoil abuts the wide breach in the western escarpment south of the Mescalero Rim. The two transverse sand-dune belts formed in the same way are even more impressive in the restrictions they impose on land use. (See figure 20.) In these instances, the best use that can be made of the land is grazing.

Use Capability Affected

Light sandy soils in the humid eastern half of the country have decreased the utilitarian value of land in several instances. The outwash plains in northwestern and central Wisconsin and the north-central part of the southern peninsula of Michigan seem destined to remain in forests almost exclusively. Outside the glaciated region, well-known parts of the country fall into the same category. The Pine Barrens of southern New Jersey, and the Sand Hills below the Fall Line in the Carolinas and Georgia, are the larger areas for which recreation and forests are the best uses that can be made of most of the land.

Shallow and rocky soils have also eliminated alternative land use possibilities over considerable areas. Rough topography and rocky, shallow soils have made the mountains a stronghold of forests. But there are other areas, like the Superior Upland in Minnesota, tracts in northern Wisconsin and Michigan (pl. 41), and New England (pls. 2, 6), which are not mountainous but which have rocky soils that are a serious obstacle to cultivation. Because of this, forest combined with recreation is the prevailing land use. Outside the forested region, the only major land use left in such instances is grazing. In the Great Plains, the Flint Hills of Kansas furnish an illustration. In the Flint Hills, extensive tracts of grassland dominate the landscape. Cherty soils, frequently shallow, developed from the residuum of limestone, explain the predominantly grazing use of the land in the Flint Hills (pl. 61). The lava flows in the Snake River Plain are similar land use controlling features (pl. 89).

Land use is not always so positive in its reaction to soil distinctions as to eliminate one or the other of the major uses altogether. In a good many instances, land is in a marginal class for certain uses because of the soils, especially when crop production is involved. Handicaps imposed by soils can be overcome to a considerable extent through skillful management, use of soil-improvement practices and soil amendments, and selection of crops best suited to the soil. In the South, soils of comparatively low natural fertility, that would not qualify for common field crops, are in some instances used successfully to grow winter vegetables. Whether or not land is marginal is therefore not entirely a matter of soil and other physical conditions. The human factor also enters into the equation. Use of the land may revolve around questions of land ownership and tenure as well as market demands and prices of crops and products. Areas with soils in the lower productivity brackets, however, are more sensitive to these socio-economic influences. As a result, they show the greatest shifts in major land uses. In New England and the South, where much of the land falls into this class, these shifts are pronounced.

Man's dependence on the products of the soil leads inevitably to the conclusion that the soil should be regarded as a permanent resource base of organic production. As the needs of the country are rising, the preservation and improvement of the soil are essential to ensure not only sustained but increased production. From the national viewpoint, soil conservation is a social obligation that will benefit not only individual landowners but also the community and the Nation as a whole.

Pioneers Exploited Land

Soils have not always been considered in the light of future needs. Conservation as a concept did not disturb the pioneer settlers. They had to wrest a living from the land with simple implements by dint of hard labor. Their knowledge and experience of the destructive forces of nature were slight. The cultural practices they followed were in keeping with their meager resources. Usually they were calculated to satisfy immediate needs. Although the pioneers usually selected the smoother land for arable use because of its natural advantages and their own physical limitations, they seldom took into account these advantages or limitations when it came to field operations. The

usual procedure was to lay out the land in tracts that might be oriented by property lines or might follow the trend of the topography, but in cultivating the land, slope or contour was not followed. All too frequently, continued cultivation in this way induced erosion that not only depleted the soil but in many instances made the land useless for further crop production.

Induced erosion is closely associated with steepness of slope, characteristics of precipitation, erosiveness of the soil, and the cultural practices followed. The most severe erosion damage is found on rolling to hilly land in the humid and subhumid parts of the country. In extreme instances, cropland has been gullied to the extent of eliminating arable use from further consideration. Abandonment results, and the land usually reverts to brush and forest. There are exceptions to the rule. Erosion in the humid grassland soils of the Rendzina group is likely to reduce their use capability from arable to pastoral. The Black Prairie Belt soils of Alabama and Mississippi and the soils of the Black Prairie in Texas belong in this group. These soils developed on soft chalky limestone under grass vegetation. Originally, they were rich in humus and lime, almost black, and very productive. Continuous cropping to cotton and corn, both row crops that induce erosion easily with indifferent methods of cultivation, has greatly depleted the soils. With the removal of much of the humus layer, the soils have become heavier. This retards cultivation in spring. As a result, cotton has become more susceptible to boll weevil attacks. Changed soil and biological conditions have also brought about a change in use of the land. The Black Belt of Alabama and Mississippi, which at one time was the leading cotton-producing district of the South, is now a livestock area. Most of the former cottonland is now in grass, to which the calcareous soil is well adapted, and is used for pasture and production of hay (pl. 150). A somewhat similar trend is noticeable in the Black Prairie of Texas, especially in the southern part (pl. 116).

Soil erosion is not always the result of the action of water. On the High Plains, where rainfall is scanty, wind erosion is likely to be just as active during protracted dry periods, and as damaging to soils as water erosion (pl. 63). Abandonment of cropland has resulted from it in a number of places. With use as cropland eliminated, only pastoral use remains.

Soil erosion from both water and wind has caused permanent loss of soil over much of the country. It has reduced the productive capacity of the land, and in many instances it has damaged the land to the extent of making further use as cropland impossible. Damage incident to erosion is not confined to land from which the soil has eroded. The silt and sand washed from the slopes are carried by creeks and streams to lower levels and deposited in flood plains and stream channels. Eroded, unprotected upland accelerates runoff, and clogged-up water channels slow down streamflow and increase the danger of floods. Reservoirs located on the streams are silted up, their water-storing capacity is progressively reduced, and their span of usefulness is shortened proportionally. Accelerated runoff and increasing damage from erosion led finally to the extension of conservation measures to the soils, which in many parts of the country have produced their own cultural landscape features.

Conservation measures extend to all major land uses, including use for recreation and preservation of wildlife. On the western open range, it means controlled grazing as provided by grazing districts, and improvement of the forage plant cover. In forested areas, conservation is concerned with the proper management of forests to obtain higher and more sustained yields of wood products, and at the same time to preserve the forests, including the natural fauna and flora they shelter. Fire protection, restocking of denuded areas, and watershed protection are some of the measures that serve these purposes. A number of areas have been set aside as reservations to conserve the scenic values of the landscape as historical monuments, areas for preservation of wildlife, or catchment areas to obtain a dependable supply of pure water. In agricultural regions, conservation efforts are directed primarily toward soil conservation. Contour plowing, terracing, stripcropping, and keeping the land under protective cover are practices followed to prevent erosion. Stripcropping is also resorted to in the Western Plains to minimize wind erosion. Wherever soil conservation practices are followed, they produce a new and impressive land use pattern (pls. 13, 18, 53, 65, 73, 74, 114, 121, 126, 143, 149, 151, 163).

The soil regions mentioned in the text can be identified readily in figure 16.

Aside from having acquired local site characteristics, soils also show regional affinities that may be derived from land relief, geologic formation, climate, natural vegetation, drainage, or a combination of these factors. Only the regional associations can be shown in a strongly generalized representation to illustrate occurrence and distribution of different soils on a small-scale map, such as this one.

The map shown in figure 16 and its legend were prepared more than 25 years ago. Thus they do not reflect all the latest concepts in soil classification. They are in general agreement with the soil map in the 1938 Yearbook of Agriculture. The soil regions, as delimited on the map shown here, readily permit tracing

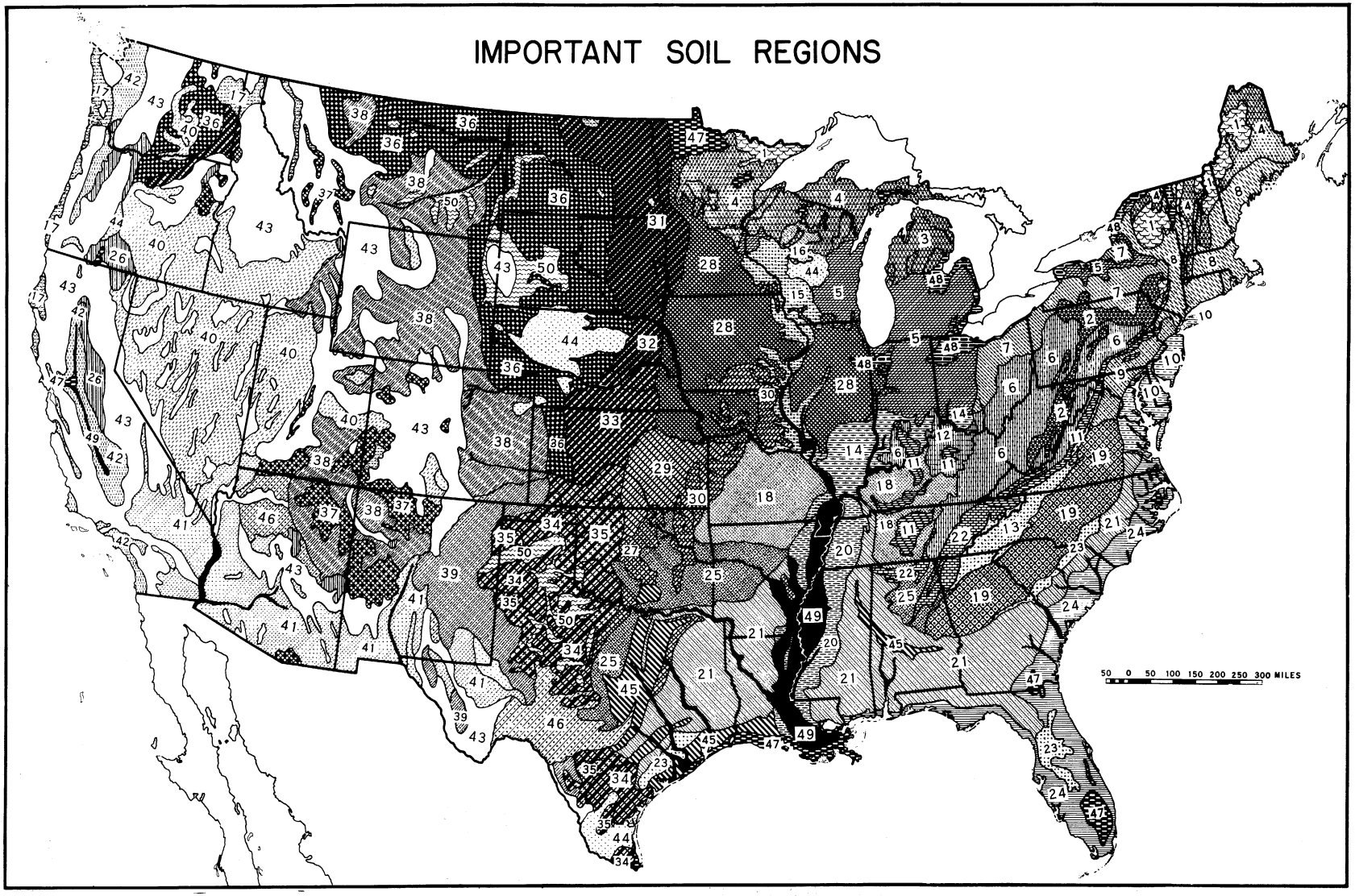

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FIGURE 16.—Map showing soil regions. (Prepared in the former Bureau of Chemistry and Soils.)

Legend for Map

Podzols.—The profile consists of a thin organic layer above a gray leached layer which rests on a dark-brown or coffee-brown horizon. The Podzol is developed usually under a coniferous forest in a cool, moist climate. Its inherent productivity for crop plants is low. The figures below refer to area numbers on the map.

1. Rough stony land, including areas of shallow Podzols.
2. Chiefly loams and silt loams, developed from sandstones and shales of the plateau and mountain uplands.
3. Dominantly sands and loamy sands, developed on glacial drift.
4. Dominantly loams and clay loams, developed on glacial drift.

Gray-Brown Podzolic Soils.—The profile has a rather thin organic layer over grayish-brown leached soils which overlies a brown horizon. The soils are generally acid, at least in the surface. These soils develop in a moist and cool-temperate climate under a deciduous forest and are inherently more productive than the Podzols.

5. Dominantly loams and silt loams, developed on calcareous glacial drift.
6. Brownish-yellow silty loams or stony loams with hilly relief developed on sandstones and shales.
7. Loams and silt loams, developed on acid glacial drift and composed of sandstones and shale material. Some of these soils are imperfectly drained.
8. Dominantly stony and gravelly loams, developed on glacial drift.
9. Loams and silt loams, developed mainly on the crystalline rocks of the northern Piedmont.
10. Largely sandy loams developed on the sands and clays of the northern Coastal Plain.
11. Chiefly brown silt loams, developed on limestone.
12. Shallow soils developed on interbedded limestone and calcareous shales.
13. Loams and stony loams from granitic material with hilly to mountainous relief.
14. Silt loams with heavy clay subsoils, developed on Illinoian glacial till.
15. Silt loams developed largely from loess.
16. Imperfectly drained grayish silt loams with silty clay loam subsoils, developed from acid glacial drift.
17. Largely loams and silt loams with yellowish subsoils, developed from sandstones and shales.
18. Grayish-yellow to reddish silt loams and cherty sil tloams, developed from cherty limestones.

Red and Yellow Soils.—This group of soils consists of two general types of profiles that are intimately associated. Both have thin organic layers. The profile of the red soil is a yellowish-brown leached layer over a red horizon while the profile of the yellow soil is a grayish-yellow leached layer over a yellow horizon. Both developed under the forest in a moist warm-temperate climate. Generally, the yellow profile is more pronounced under the coniferous forest and the red under the deciduous forest. The inherent fertility of the yellow soils is relatively low and that of the red soils medium.

19. Dominantly brownish-red clay loams and gray sandy loams, developed largely from crystalline rocks of the southern Piedmont.
20. Yellow to light brown silt loams, developed on loess.
21. Dominantly gray to yellow sandy and fine sandy loams with some sands and fine sands, developed from Coastal Plain materials.
22. Largely brownish-red to red silt loams and clay loams, developed from limestone.
23. Grayish-yellow to light brown sands and fine sands of the Coastal Plain.
24. Grayish fine sandy loams, with some gray or black loams, developed in the flatwoods area of the Coastal Plain. Includes areas underlain by coralline limestone.
25. Grayish-yellow to reddish fine sandy loams and silt loams, developed from sandstones and shales. A considerable portion is hilly and stony.
26. Red soils of the north Pacific slopes.

Prairie Soils.—The profile of the Prairie soil grades from a very dark brown or dark grayish-brown surface through brown to lighter colored parent material at a depth of 2 to 5 feet. It is developed in a moist temperate climate under a tall-grass prairie. Inherent fertility for crop plants is high.

27. Reddish-brown soils of variable texture, developed on sandstones, shales, clays, and sands.
28. Dark brown silt loams with yellowish-brown subsoils, developed on glacial drift and loess.
29. Dark brown to reddish-brown silt loams and clay loams, developed from limestone and calcareous shales.
30. Dark brown or grayish-brown silt loams, having heavy subsoils or claypans.

Northern Chernozem.—The profile has a black or dark grayish-brown surface soil grading below into light-colored material that is calcareous at 2 to 6 feet. It is developed in a temperate to cool subhumid climate under tall and mixed grasses. Inherent productivity is high.

31. Black, silt, and clay loams, developed on calcareous glacial drift and associated lacustrine deposits.
32. Dark grayish-brown loams and silt loams, developed from loess.
33. Dark grayish-brown silt loams with claypans developed from loess.

Southern Chernozem—Dark Brown Soils.—The profiles have dark brown to reddish-brown surface soils underlain by brown or red horizons, grading below into light-colored material that is calcareous at 3 to 6 feet. These soils develop in a warm, subhumid to semiarid climate under a mixed tall- and short-grass prairie.

34. Heavy or moderately heavy dark brown soils, developed from calcareous materials.
35. Predominantly red and brown sandy loams and sands, developed largely from unconsolidated calcareous sands, silts, and sandy clays.

Northern Dark Brown (Chestnut) Soils.—The profile grades from a dark brown surface soil into a whitish calcareous horizon at a depth of 1½ to 3 feet. These soils develop under mixed tall and short grasses in a temperate to cool semiarid climate.

36. Dark brown soils developed on unconsolidated, calcareous sands, silts, and clays.
37. Dark brown soils, developed on heterogeneous material associated with mountainous and plateau terrain.

Brown Soils.—A brown surface soil grading at a depth ranging from 1 to 2 feet into a whitish calcareous horizon. The profile is developed in a temperate to cool, semiarid climate under short grasses, bunch grasses, and shrubs.

38. Northern—chiefly brown loams, developed largely on unconsolidated sands, silts, and clays.
39. Southern—chiefly light brown to gray fine sandy loams to silty clay loams of smooth relief, developed largely on limestone or unconsolidated sands, silts, and clays.

Sierozem and Desert Soils.—Grayish and reddish soils, closely underlain by calcareous material. These soils develop in an arid climate under short grass and desert plants.

40. Northern—gray and grayish-brown soils of variable texture, developed largely on loess and alluvial fan material.
41. Southern—gray, brown, and reddish soils of variable texture, developed largely on alluvial fans.

Soils of the Pacific Valleys.—42. Includes a number of variable zonal, azonal, and intrazonal soils that are too intimately associated to separate on a schematic map. These soils developed under a range of climatic and geological conditions.

Intrazonal and Azonal Soils.—These soils may possess one of the two general types of profile: (a) The profile may express a local condition as drainage or parent material rather than the zonal profile of the region; (b) the profile may be too immature to express a zonal type.

43. Rough and mountainous (azonal).
44. Largely azonal sands, some of which are associated with bogs.
45. Black (or brown) friable soil underlain by whitish material excessively high in calcium carbonate. These soils developed under a prairie vegetation and are known as Rendzinas (intrazonal).
46. Shallow stony soils from limestone (azonal).
47. Marsh, swamp, and bog (intrazonal).
48. Soils largely intrazonal, developed on lake plains.
49. Alluvial soils (azonal).
50. Rough broken land.

the influence of soils on land use on a regional basis.

For more localized information, the soil surveys can be consulted. Soil characteristics are mapped by counties with considerable detail. Much of the country is now covered by soil surveys, and the relationship of soil types to land use is discussed in each soil survey report.

The literature on soils is voluminous. A listing of county and areal surveys alone would fill pages. Only a few of the principal publications issued by the Department of Agriculture on the broader aspects of soil development, soil characteristics, and soil distribution can be cited here (*86; 73; 135, 1938; 128; 10*).

Natural Vegetation and Land Use

The term "natural vegetation" is sometimes thought to refer to the original vegetative types, which in America belong to pre-Columbian times. However, very little of our present vegetative cover belongs to these types. Some small remnants of them remain, but with the use of the land by civilized man, most of the original plant associations were modified to a greater or lesser extent. For the natural vegetation with which we are here concerned, a somewhat broader concept is implied; in addition to the occasional remnants of the original vegetation, all vegetative types that grow without cultivation are included.

Natural vegetation is one of the chief assets in the economy of the country. Natural vegetation provides the only means of using land that cannot be used or is not needed for cultivated crop production, building sites, service areas, and so on. How significant a part the natural vegetation plays in the national economy may be perceived by comparing the acreages in major uses. In 1954, cultivated crops were grown on about 380 million acres, or 20 percent of the total land area of the United States, while on about 1,314 million acres, or 69 percent of the land area, natural vegetation was used. The rest is made up of urban areas, parks, service areas, desert, swamp, and wasteland. Thus natural vegetation on more than two-thirds of the land contributes to the national economy. This contribution is invaluable to the national economy, as some of our more important industries—the animal industry, the lumber and wood-working industries, the naval store, paper, printing, artificial fiber and leather industries, among others—largely or wholly depend upon it, either directly or indirectly. To the economic contributions made by the natural vegetation should be added the values imparted to the countryside by the voluntary growth of trees, shrubs, and grasses (fig. 17).

To a large extent, the three major types of vegetation indicate the potential use capability of the land. If forest land is well drained, has a smooth, not too strongly rolling, hilly or mountainous surface and a good soil, it can either be left in forest or, when cleared, used for cropland or pasture. Grassland may be used for either cropland or pasture. The only economic use that can be made of arid desert shrub land without irrigation is grazing.

The natural vegetation is a permanent asset to the Nation. However, neither the yields nor the composition of the natural plant cover remains the same with use or even with time. Modifications occur when man takes possession of the land or when the climate and other biological factors change. For instance, the native chestnut, which formerly was commonly found in eastern forests, has almost disappeared as a result of the chestnut blight. In both the North and the South, a number of exotics have been added to the list of trees.

Natural Vegetation Changed by Land Use

Changes in the composition of the original vegetation that were brought about through man's use were usually accompanied by a decline in productive capacity. Clearing and use of the land for crops, especially in the eastern half of the country, greatly reduced the extent of native vegetation. In addition, the productive capacity per areal unit of the remaining natural vegetation was lowered. This was true of all major vegetative types—forests, prairies, and desert shrubs. Usually the natural vegetation was one of the resources that was first exploited. In the early stages of settlement, the native vegetative cover was used without a proper understanding of the need to safeguard its reproductive ability in order to retain its functional value in protecting the land and the water supply, and its enduring value as a basic economic resource. The result was an increasing deterioration, which makes proper management essential when natural vegetation provides the principal means of using the land.

Forest.—Originally, forests occupied a rather compact zone in the eastern part of the United States. Some prairie areas were interspersed, for instance, the Black Prairie of Alabama (pl. 150), the prairie areas of Texas (pls. 127 and 128), and some smaller ones in the Alluvial Valley of the Mississippi (pl. 133). There were also the open areas of Indian origin previously discussed. Aside from these occasional breaks, the forests stretched across hills and valleys without interruption to a park-like fringe (pl. 52), where they gave way to the prairies. In contrast to the East, the forests of the West were confined mainly to the mountains. They did not reach as far as the valley floors (pl. 81). They are identified largely with the central and northern Rockies, and the Sierra-Cascade and

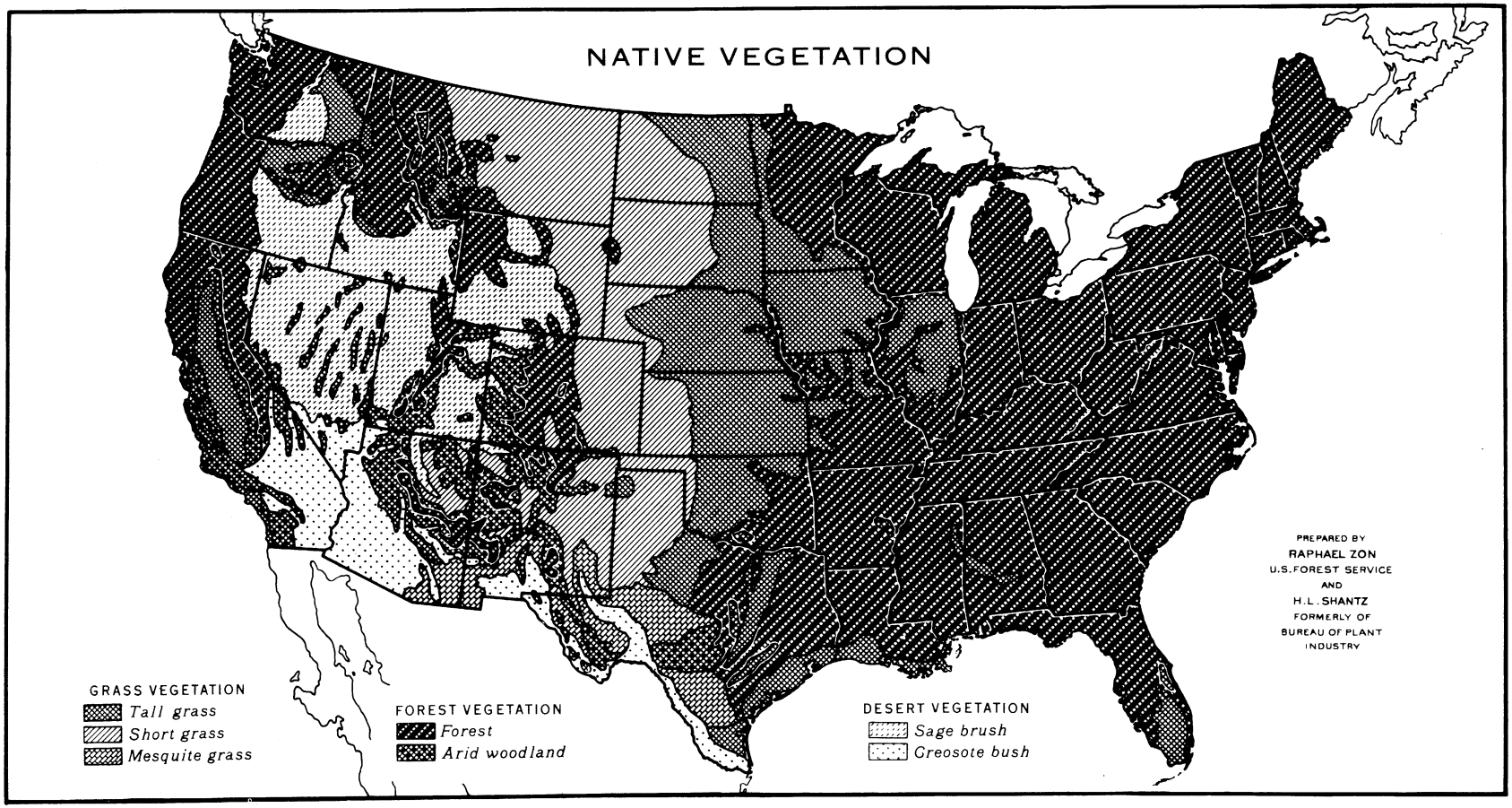

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FIGURE 17.—What is now regarded as natural vegetation is the successor to the native vegetation found by the colonists and pioneer settlers of the country. The vegetative cover represents an adaptation to the physical environment and consequently mirrors the prevailing natural conditions. The distribution of forest, grassland, and desert shrub is controlled largely by climate.

Pacific coastal ranges. Included are a number of the higher disconnected mountains, mesas, and ranges that have forest cover. Forest growth on many of these mountains and mesas is rather sparse and open. On the lower elevations, it gives way to arid woodland of the pinon-juniper and chaparral types (pls. 83 and 84). On others, particularly the western slopes of the Pacific coastal and Sierra-Cascade ranges, which are exposed to the moisture-laden winds from the Pacific, forest growth is heavier than elsewhere on the North American Continent (pls. 95 and 99).

As the country developed, inroads were made into the more than 900 million acres of original forest and woodland. In the East, nearly half the original forest has been cleared to make room for cropland, pastures, cities, roads, and so on, but shifts from forest to cropland and reversions of cleared land to brush and forest are still going on. Proportionately less extensive is the clearing of forest land in the West. Much of the virgin forest has been cut over by now, some was destroyed by fire, and most of the rest is in the western forests. Restocking of depleted forests to restore the former stands and provide for future needs has not always progressed satisfactorily. Profound changes in the original forest cover have been brought about by man's activities. One of these is the reduction in areal extent with its distributional adjustment to the economic use capability of the land. The other is the frequent modification of the density and composition of tree associations in the second growth (*54*).

Grassland and Arid Shrubland.—The natural grasslands of the Central and Western Plains have experienced an even greater transformation than the forests. Of the more than 500 million acres of the original prairie and plains grassland, about half is tilled and used as cropland. If the appraisal is confined to prairies, the proportion is higher. Most of the subhumid or humid undulating prairie land that is not needed for other special uses has been converted to cropland, although grasses still play an important part in the rotation systems of farmers (pls. 45, 51, 54, 60, 64). The one-time prairies make up the largest and most compact crop-producing farming region in the United States. Less extensive and coherent in its spread is the conversion of the virgin sod into tilled land on the short-grass plains (pls. 68, 73, 80, 111, 113, 120). Severe restrictions are imposed by soil, climate, and physiographic features. Most of the land can be used for grazing only, and this must be supplemented by winter feeding. The feed used for this purpose is largely wild hay cut from native grass meadows. Much of the 14 million acres of native grass meadows reported for the United States is in this region. Overgrazing had lowered the carrying capacity of the range but it is now improving in response to management.

The desert shrub vegetation, plus Pacific bunch grassland, desert grassland, and savanna, is confined to the arid and semiarid West (pls. 67, 77, 78, 86, 98, and 100). These are types of vegetation on which the encroachment of cultivated cropland is least in evidence, except where irrigation is carried on. Either precipitation is inadequate, or the surface is too rough or the soil too shallow to make the land suitable for tillage (pl. 76). Outside the irrigated land, only grazing remains as a possible use, and even grazing is precluded on extensive tracts in the Mojave-Colorado Desert because no water is available for livestock. Although the area occupied by the desert shrub-grass vegetation comprises in all about 300 million acres, its grazing capacity per areal unit is low when compared with eastern pasture. The natural productivity was further lowered during the half-century in which the semiarid and arid parts of the country were used by herdsmen as free open range. Unregulated use resulted in overgrazing, which not only depleted the forage but deteriorated the range. The best and more palatable forage plants, particularly the grasses, almost disappeared and were replaced by plants less desirable or worthless for pasture use. As a result of these changes, the carrying capacity of the western range area was reduced by about half. A turn for the better in the management and improvement of western pasture set in with adoption of the Taylor Grazing Act in 1934. Under this act, about half of the public domain was included in grazing districts, within which grazing is regulated (*164, 136*).

A different transformation of the range occurred with use in the desert grassland and savanna country, which is confined chiefly to the southern range. When white men arrived in this part of the country, they found open prairies with occasional clumps of mesquite, live oak, cedar, and other woody plants. At that time, grasses were the dominant vegetation. Today, brush frequently dominates the landscape. No doubt several contributory factors facilitated invasion of grassland by noxious brush, but the chief factor was man himself. Overgrazing destroyed the grass turf that protected the soil and made the spread of brush vegetation possible. The invasion of brush has materially reduced the carrying capacity of the range, and has made control of brush a major problem of these areas (pls. 117, 118, 123) (*167, 53*).

Vegetation Still Adjusting

Although the natural vegetation has been disturbed by man, adjustment of plant associations to soils, climate, and ground moisture is

still in evidence. There are exceptions, some of which go as far back as the pre-Columbian era. The extension of the prairies into the humid zone of the United States is cited as an outstanding example. Several reasons have been advanced to explain the extension of grassland into the forest area. Repeated burning is one. A temporary eastward extension of a warmer and drier climate in postglacial time is another. Probably both fire and fluctuations in climate occurred before the advent of European settlement, and contributed their share to produce what appears to be an anomalistic distribution pattern of vegetation. But there are also indications that climate as now constituted may tip the scale in favor of grasses. So long as average annual precipitation alone is considered the controlling factor, we find that the prairies of the Central States are located in the humid zone. This conclusion is supported by the absence of the calcareous horizon in the lower part of the soil profile. The climatic aspect changes somewhat when precipitation is considered in relation to evaporation.

As Albrecht puts it, "When precipitation is put against evaporation as ratios according to Professor Transeau, there are suggestions for the prairie conditions in the central states far east of the commonly considered prairie areas of the low rainfall" (*3*). The relationship between climate and plant distribution is illustrated on the map "Climatic Provinces and Plant Growth Regions of the United States," by C. W. Thornthwaite and F. L. Mulford (*118*). A similar conclusion may be drawn from a study of climatic fluctuations. In year-by-year fluctuations, as worked out by Thornthwaite for 40 consecutive years, the moist subhumid type occurs sufficiently frequently eastward to make it the normal type for the prairie part of the Central States. It may well be, therefore, that these drier years constitute the critical climatic element in the prairie extension (*118*). That the controlling forces of prairie and forest distribution have not always been in perfect equilibrium is evident from shifts of the prairie-forest boundary, which occurred before settlers appeared on the scene and which are recorded in soil characteristics. Much of what was formerly the Big Woods in southern Minnesota must have been prairie at one time. To some extent, the soils still show prairie characteristics, but they are changing to the gray-brown podzolic forest soils (*86, p. 63*).

Even in its modified forms, natural vegetation responds to the forces of nature. In its distributional pattern, it reflects adjustment to climate, physiography, and soils. Changes in these conditions are sometimes sharply defined. To this extent, they also affect land use, which may mean a sharp transition from dual-use capability to unilateral uses or vice versa, depending on the viewpoint from which the subject is approached. The Sand Hills of Nebraska, the Flint Hills of Kansas, and the southern part of the Llano Estacado in Texas and New Mexico have been pointed out as examples in which the soil restricts land use to grazing. In several areas in the humid zone, and especially in the Coastal Plains, the very light or very heavy soils favor forestry as permanent use. A reaction to soils in another direction is noticeable in the semiarid part of the upper Deschutes Basin in Oregon. The eastward extension of the pine forest is almost coextensive with the volcanic pumice deposits of this area. Pumice has a high water-holding capacity, and this may have been a factor in the eastward extension of the forest.

As a rule, land relief and climate favor forest vegetation for mountains but there are exceptions. In the intermountain region of the West, where the amount of precipitation is near the lower limit for forest growth, frequently only the northern and eastern slopes of the mountains are forest clad while the southern and western slopes are covered with grasses and shrubs (pl. 75). Sharp distinctions of this kind are due to a modification of the local climate. The evaporation ratio on the southern and western slopes is higher than that on the eastern and northern slopes. As a consequence, the moisture requirements of trees are not met. A distinction of a similar order, which is caused by diminished rainfall, exists on a larger scale between the eastern and western slopes of the Cascade Mountains. On the western slopes, which receive a heavy precipitation brought in by the onshore winds from the Pacific Ocean, the forest cover is so dense that undergrowth is suppressed and grazing is eliminated (pl. 95). The forest use is the best use that can be made of these western slopes. On the eastern slopes, which are in the rain shadow, precipitation is lower, the tree stand is comparatively sparse and open, and plenty of room is left for grasses to grow (pl. 94). In this instance, land use is a combination of grazing and forestry.

Effective Use of Range

When the natural vegetation provides the only opportunity of using the land, obviously land use must be adjusted to the capabilities of the vegetative cover. This is particularly true when grazing is the major use. In this respect, semiarid and arid vegetations have their own use limitations, which are usually low carrying capacities with restriction to certain months of the year. These limitations are again subject to the cycle of precipitation. To use the range effectively, seasonal shifts of livestock are necessary, and they have developed into a migratory movement of livestock

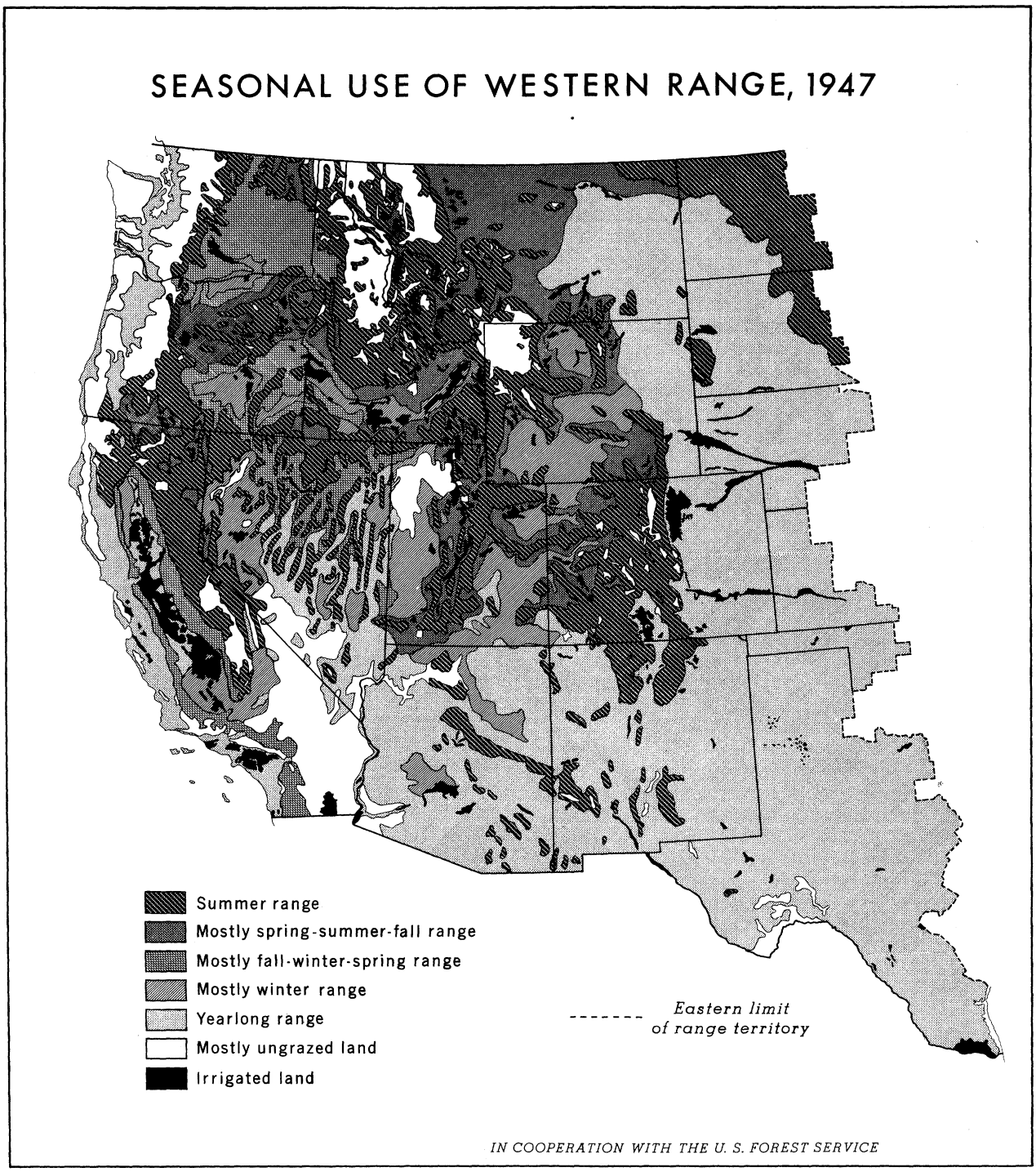

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FIGURE 18.—In our western mountains and basins, grazing depends upon the seasonal movement of livestock. On the higher levels, pasture is available only during the warmer season. On the intermediate levels, the range is used mainly in spring and fall. In the basins and valleys, it is used during the winter and is frequently supplemented by winter feeding. Summer and winter ranges are often more than 100 miles apart.

that is repeated each year. The movement, which is frequently referred to as transhumance, follows a natural trend. It is not unique to the United States. In middle latitudes, where grazing is available in the mountains, livestock is kept through the winter on lower levels, moves with the advancement of spring to higher grounds, and in summer is grazed in the mountains. At the end of the summer season, a reverse movement sets in, which ends in the valleys. Seasonal migration of livestock occurs in most of the western mountains and basins, where yearlong grazing is not feasible. Summer and winter grazing grounds are often far apart so that livestock, and particularly sheep, may have to travel considerable distances, most of which is done by trailing. Motortrucks and railroads are also used to some extent (*63*). National forests provide about 8 million animal-unit months of grazing in summer. On the winter range, grazing often must be supplemented by feeding, which is done chiefly with forage produced on irrigated land (fig. 18).

In the East, only the Cumberland Plateau is large enough to deserve mention in this connection. The vegetation of the Cumberland Plateau is that of a cutover forest, which is used by the few farmers on the plateau as an open range. Some of the valley farmers drive their livestock to the plateau where it grazes for about 6 months in summer (*89*). At lower levels, grazing in the forest is still practiced to a considerable extent throughout the South (*148*). In recent years, however, with the intensification of forest growth over much of the higher ground, the forest range has been reduced. As of 1958, it is confined mainly to the Coastal Plain.

Use for Recreation

Natural vegetation has so far been considered primarily as an economic asset in the light of the uses made of it. From this viewpoint alone, the improvement and proper management of the natural plant cover assumes paramount importance. Economic uses of the natural vegetation, however, are not the only uses that are vital to the welfare of the people. There are functional uses which, in some instances, transcend in importance the benefits of economic use. With the congregation of people in urban centers, outdoor recreation in scenic places offers its own compensation. Its benefits to society have been recognized by Federal, State, and community governments, which have set aside park areas totaling about 19 million acres for recreational use. Wildlife, too, depends chiefly on natural vegetation for food and shelter. To preserve the species, refuge areas, in which the natural vegetation is usually preserved, have been established in different parts of the country. Together, these areas comprise about 8 million acres. But over much of the land the chief function of the natural vegetation is the conservation of soil and water, which can be accomplished only if the perennial plant cover itself is conserved. Economic and functional uses of the natural vegetation can be combined in most instances, but proper safeguards are essential to preserve its use potentiality in both directions.

The accumulated literature on the natural vegetation, its uses, and its abuses, reflects the importance of the subject in connection with national welfare and development. Only a few publications of national scope can be cited here (*109; 135, 1948, 1949*).

Water Management and Land Use

Broadly speaking, the use of land cannot be divorced from the use of water. Water is the complement to land, on which plant, animal, and human life depend. Because of this relationship of water to land, water is a main factor in determining the use capability of the land itself. As recorded in the amounts of precipitation received in various parts of the country, water is unequally distributed in space and frequently in time. Much of the land receives very little; other areas receive a large amount. By force of necessity, the early settlers recognized these conditions. Where water is scarce, settlement is sparse. Conversely, wet and swampy land was avoided also.

Natural Distribution of Water

That to a certain extent the natural distribution of water can be controlled and improved was discovered in the early stages of civilization; some of the old cultural centers developed as a result. The Indians diverted water for irrigation. Along with the settlement of the country went the development of its resources, water included. Old drainage ditches, dams, and mill ponds are evidence of regulation and use of water with the meager equipment the settlers had at hand. Management of water has become an integral part of the development of the country. In its advanced stage, water management cannot be regarded as exclusively concerned with the regulation of the water supply on land used for agricultural production. Management of water is essential to obtain a reliable supply for our urban and industrial concentrations so that the health and welfare of the people can be safeguarded. Development of hydraulic energy is frequently included in

the water-management projects that serve multiple purposes. But from whatever angle the management of water is approached, the land and its use are involved in one way or another.

As nature's way of distributing water leaves much to be desired so far as human needs are concerned, man has had to improve the distribution pattern. Rainmaking was part of the religious ritual of the Indians, but we have little evidence by which to judge its efficacy. Of late, rainmaking by scientific methods has shown some promise, but whether man can succeed in distributing rain at will where it is most needed and prevent it from falling where it is damaging is debatable. The processes used in desalting salt water for desert irrigation have received attention recently. Research is making progress in reducing the cost of desalting sea and brackish water, but these processes are still in the laboratory stage. Except for such places as Kuwait on the Persian Gulf where conditions for application of one of these processes are exceptionaly favorable, they have not been perfected to the point of making their more universal use economically feasible.

For the time being, we must depend on the available supply of moisture, and efforts toward water management are directed chiefly toward modifying the distribution of water after it has reached the ground. This may be done by either holding water where it is needed or bringing it there, by preventing undesirable accumulation of water, or by checking too rapid runoff and flow. Frequently, the chief function of a water-management project is expressed in its name. Irrigation, drainage, soil conservation, flood protection, use of inland waterways for navigation, city water supply, ground water use and control, water storage, pollution abatement, and hydroelectric power development are the main objectives of water management. Many of these objectives may constitute individual projects, but more often related objectives are combined in multiple-purpose projects, or all of them may form part of a river-basin development plan.

Water Management

River watersheds are the accepted units of water management. If they had been strictly adhered to, that is, if water use and control had always been confined to the available water within drainage-basin divides, the growth of some of our largest cities would have been inhibited by water shortages. Gravitational flow has always been the chief means of water distribution, but modern techniques now permit the lifting of volumes of water through pumping from one basin into another. This technique is used successfully in some water-utilization projects.

An example is New York. Although the city is on the Hudson River and is partly surrounded by the waters of Hudson Bay, it went to the Catskill Mountains for a desirable source of water. It supplemented this supply by tapping the headwaters of the Delaware.

Denver, which is in a semiarid region, grew until a shortage in the water supplied by the runoff from the eastern slopes of the Rockies began to be felt. To avert a drought in city water, Denver diverted some of the runoff from the Pacific slope of the Rockies through the Moffat Tunnel to the Atlantic slope.

Los Angeles probably had the most serious problem of water supply of any large city. Because of its rapid growth, this city soon reached the limits of the supply of water available from the surface and subsurface of the basin in which it is located. To augment its supply, Los Angeles brought water by means of an aqueduct from the Owens River 250 miles to the north and across the mountains. From a purely technical angle, the replenishment of water in the Los Angeles Basin from such a distance was a remarkable accomplishment, but there were legal complications also. Before the city appropriated the water of Owens River, it had been used by settlers in the Owens Valley for irrigated farming. With the acquisition of the water and land of Owens Valley by the city, the settlers were deprived of their use, and the valley reverted to arid grazing. Meanwhile, Los Angeles and its adjacent communities continued to grow and soon needed even more water. The nearest supply was on the Colorado River. Bringing water from that river to the Los Angeles area required the building of an aqueduct 240 miles long. The water had to be lifted in stages for more than 1,600 feet across the intervening mountains (*129*).

These are three examples of large cities that have solved their water problems by drawing on the resources of additional drainage basins. Not all cities, however, have the same problem. Chicago, for instance, lies on the divide between two large drainage systems, that of the St. Lawrence River and that of the Mississippi River. The city water is taken from Lake Michigan on the St. Lawrence side, and discharged into the Illinois River, a tributary of the Mississippi; in this instance, a considerable volume of water is diverted from one basin into the other.

Diverting water by lifting it across a divide is not reserved exclusively to cities. It is used to some extent in irrigation projects. The Big Thompson project in Colorado operates on this principle, as does the Grand Coulee project in Washington. An inverse procedure is followed in the Central Valley of California. Water of the Sacramento River is not distributed by gravity alone. After it reaches the lower end

of the Sacramento Valley, the surplus not used in the valley is lifted again by pumps into the San Joaquin Valley where it is used largely for irrigation (*129*). All these are multiple-purpose projects, in which storage of water, control of floods, generation of power, and use of water are integrated.

River basins as units of water management are affected by the physical and economic conditions characteristic of the area. Also, as they frequently comprise extensive areas, they are composed of political divisions under different jurisdictions. All the larger river basins include parts of a number of States, which sometimes have conflicting interests in water-resource development that must be adjudicated before a project can be undertaken. Rivers that cross or form part of the international boundary, like the Rio Grande, the Colorado, the Columbia, and the St. Lawrence, pose problems on the international level. Distribution of water and development of power are involved in all these problems. Added to the St. Lawrence River problem is inland navigation. Agreements with Canada and Mexico are essential to the working out of equitable solutions to conflicting claims and the preservation of friendly relations with our neighbors.

Water management is essential in most parts of the country where agricultural use of the land is concerned, but it is particularly so where water is scarce and thus becomes the controlling factor in the development of the area.

In the arid West, where production of crops usually depends on irrigation, the valley dwellers should be directly concerned with the management of their water supply. Management of water must start at the source of the water in the mountains, which constitute the main catchment areas of precipitation. Storm or snow water that runs off too fast is likely to do more damage than good. To hold the water in the mountains so it can be delivered steadily when needed is a part of management. This is the function of the vegetative cover. Vegetation retards runoff on slopes and gives water time to infiltrate the soil. Protection of the vegetative cover of the mountains from misuse and depletion is a sound water-management measure. It is needed also to maintain the use capability of the mountains as summer grazing grounds or for production of timber.

As elsewhere, precipitation in the mountains varies considerably over the years, and this variation affects use of water in the valleys. Much of the precipitation falls in the form of snow, which accumulates in winter, melts during spring and early summer, and thus furnishes the irrigation water needed in the valleys. So that operations in the valleys may be adjusted, forecasts of the quantity of water that will become available from accumulated snow are now made successfully from snow surveys. On about 1,000 snow-survey courses laid out over the western mountains the snow is measured monthly in the latter part of the winter. The results obtained provide the basic data for the forecasts (*87*).

Storage Reservoirs

A dependable water supply cannot be obtained in most instances without storage reservoirs from which the water can be released as needed. The larger irrigation districts, which include much of the nearly 25 million acres of irrigated land in the West, could not have been established without provision for storing a reliable supply of water. (For irrigated land, see colored map in pocket, and plates 79, 82, 84, 87, 88, 98, 101, 102, 103, 104, 106, 107, 108, 110, 122, 124.) A similar need exists for perennial hydroelectric power generation. Hydroelectric powerplants on rivers with uncontrolled flow frequently have steam plants as standby units for emergency use. To a considerable extent, flood control must rely on reservoirs to detain the waters. Catchment basins have been acquired and set aside by some urban centers. The water is stored in reservoirs for the needs of the cities. Water stored or retained in reservoirs, therefore, serves many purposes.

In 1948, nearly 1,000 reservoirs of more than 500-acre-feet storage capacity were in operation (*58*). Almost 200 more have been constructed since then, and others are under construction. These reservoirs cover more than 8 million acres. This does not include natural bodies of water in which control dams have been installed. Most reservoirs submerge the land permanently, and to this extent, they reduce the area of land. Some of the submerged land was good farmland in operation. In such instances, construction of reservoirs meant removal of the farmers from their lands.

Reservoirs of a type about which little information is available cannot be included in any areal or numerical estimates. These are the small artificial lakes or ponds that serve mainly private interests. These homemade bodies of water may serve as fishponds, swimming pools, or basins to hold stock water. No complete count has been made of these ponds, nor is the acreage they cover known. But they are numerous, and more of them are found in the subhumid and semiarid parts of the country than in either the humid or arid regions. Furthermore, their number is increasing rapidly with the expansion of conservation programs. In the subhumid and semiarid regions, where precipitation is not plentiful but gully erosion is severe, the dams constructed frequently serve a dual purpose. Erosion control comes first and storage of water second. As of 1949, about 40,000 dams of this type had been constructed

(*140*). As an illustration of farm-pond construction in a subhumid region, Lincoln Township in Comanche County, Okla., may be cited. Within this township, which contains 36 square miles, 89 ponds were counted, an average of about 1 per farm (*138*). Not all of these ponds hold water the year round, but they serve their purpose for most of the year.

Soil conservation revolves around water management, particularly when water erosion is the issue. Control of runoff to check its erosive force and to retain water on the land where it is needed is the chief objective of water management in this instance. Not only is the soil conserved in this way, but the productivity of the land is improved at the same time. Grass cover is one of the most effective erosion-control measures but it cannot always be applied. Such mechanical practices as contour plowing, terracing, installation of grassed or rubbled water runways, construction of dams to control gully formation, or establishing an erosion-resisting vegetative cover on badly damaged slopes must be resorted to frequently if the desired result is to be obtained. All these measures are designed primarily to conserve the soil. However, by controlling runoff, they also help to prevent floods through retention of water on the land so it can replenish the subsurface water supply that nourishes our springs and streams.

Drainage Installations

Checking the speed of running water and storing and distributing it where it is needed make up a side of water management that has its counterpart in measures designed to accelerate the movement of water and to protect or relieve places that receive an excess of water. Projects of this kind are better known as drainage and flood-protection enterprises.

Distribution of precipitation governs the location of most of the land that usually receives an abundant supply of water. Of the total land area of the United States, about 45 percent receives an annual average of more than 30 inches of precipitation. Aside from the western mountains, most of this land is in the eastern half of the country. Because of slight slope or a combination of slight relief and heavy soils, extensive tracts in the Coastal and Inland Plains have or have had inadequate natural drainage for the best use of the land. To these must be added the relatively broad flood plains of the larger rivers that traverse the Coastal Plains. In contrast to the East, drainage needs in the West are associated not with high rainfall but with irrigation.

Drainage installations may be divided into two categories according to whether they can be or have been accomplished by individual action of a landowner or operator, or whether community action is or was essential. Only small-scale drainage works can be undertaken by individual users, and then only when drainage outlets are available. By far the largest acreage of drainable land requires community action for drainage installations. Community organization may take the form of drainage districts. These districts may extend across county boundaries, in which case they have a legal standing of their own, or they may be functionally integrated with the county government. How these drainage enterprises operate depends, therefore, on legal authorization by the States in which they are located. According to the 1950 census, drainage in 10 States is organized and managed by counties and in 30 States by districts (fig. 19).

Most of the land in drainage enterprises is on the till plains and glacial lakebeds of the North Central States. In many of these areas, drainage is not of the reclamation type because much of the land was used for crops before artificial drainage was installed (pls. 37, 42, 45). Surface and internal soil drainage were deficient, however, and to produce the best yields and reclaim wet spots required drainage improvements. Reclamation was the more prevalent objective of the drainage districts in the South. In most instances, the wet and swampy land required not only drainage improvements but clearing of the forest vegetation as well. In the Mississippi flood plains (*61*), drainage and clearing were supplemented by levees to protect the land from frequent overflow (pls. 12, 20, 21, 24, 25, 34, 39, 40, 45, 50, 51, 54, 97, 132, 135, 136, 140, 141, 142, 150, 155, 162, 168).

Reclamation and land improvement are the chief objectives of drainage enterprises in the East. In the West, drainage has acquired a third function in connection with irrigation. Seepage from upper irrigation ditches frequently produces alkaline accumulations on the lower levels. To prevent or relieve these areas from the toxic concentrations of salt in the soil requires drainage installations on the irrigated land. In these instances, irrigation and drainage are interdependent (pl. 103).

About 100 million acres of wet and swampy land are to be found in the United States. Most of these lands are along the South Atlantic and Gulf coasts and the Alluvial Valley of the Mississippi River. Although the acreage in drainage districts is expanding—it has now passed the 100-million-acre mark—not all the wet lands and swamps can be reclaimed economically. A considerable part of these lands can be reclaimed, however, when more agricultural land is needed. Some of them are already included in drainage districts, but they have not yet been developed. For the larger swamps, with soils not well adapted to agricul-

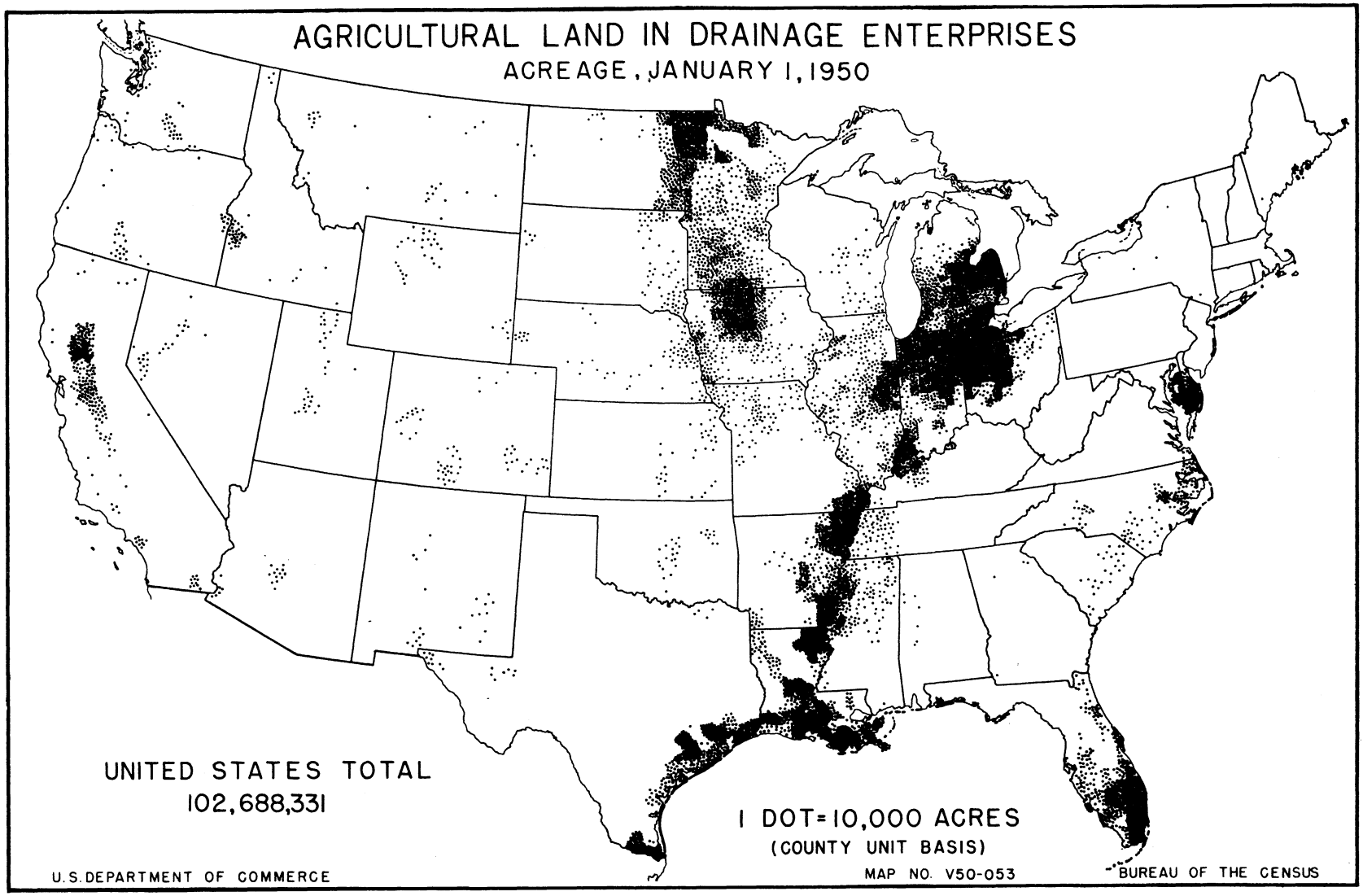

FIGURE 19.—Coastal lowlands, interior plains, and humid climate account for the concentration of wet and swampy lands in the East. Reclamation through drainage was started along the Atlantic Coast in Colonial times but little was accomplished. Organized community drainage enterprises are to be found in the Central States, the Alluvial Valley of the Mississippi River, the Gulf and Atlantic coasts, and southern Florida.

tural production, forests and wildlife refuges probably will remain the best use capability (pl. 156).

Ground Water

Water management as discussed here is concerned primarily with the regulation and distribution of surface water. With the development of the country, however, it was found that in certain areas and localities, ground water was as much of an economic resource as surface water. Therefore, it has been drawn upon to supplement the scanty surface supply. Some cities rely almost exclusively on the supply of ground water to operate their water systems. On farms, the domestic water supply may be obtained from flowing springs, or it may be rainwater collected in cisterns. More frequently, it is derived from wells that tap the ground water. On extensive tracts of western rangeland, grazing would be restricted were it not possible to obtain stock water through pumping from below the ground. The use of ground water for irrigation purposes has also expanded. Ground water is now used more extensively than in the past. As a result, warning signs in the form of lowered ground-water tables are frequent.

The case of the Los Angeles Basin, where the fresh water taken from the ground was replaced by salt water, requires no elaboration. Some years ago, a noticeable lowering of the ground-water table in the Central Valley of California was reported. Ground water collects naturally in valley bottoms and on basin floors and it is in these locations that prospects of finding sufficient quantities for community use are best. By way of contrast, the most recent large-scale development of ground-water use for irrigation occurred not in a valley or basin, but on the southern part of the High Plains of Texas and New Mexico, the Llano Estacado.

The Llano Estacado is unique in this respect, in that it can be classed more nearly as a broad plateau or tableland some 30,000 square miles in area, which slopes gently toward the southeast. From an elevation of 5,000 feet in the northwestern corner, it descends at an average rate of about 11 feet per mile to 3,000 feet at the southeastern rim. Distribution of rainfall follows an inverse order, that is, it decreases with the increase in elevation. Mean annual rainfall decreases about 7 inches, or from about 21 inches in the east to about 14 inches in the west. As these figures indicate, rainfall is not plentiful. What the figures do not reveal is that rainfall is distributed irregularly over the seasons and occurs erratically within seasons and from year to year. As a rule, most of the rain falls during the warm season, although usually it is not heavy enough to produce runoff from the tableland. Only occasionally are rainstorms heavy enough to produce running water in otherwise dry drainage channels. When this happens, the water may be discharged into three different river systems, those of the Red, Brazos, and Colorado Rivers. These three rivers have the upper ends of their drainage basins on the Llano Estacado, and no outstanding divides separate them (fig. 20).

As a result of the arrangement of escarpments in the plain across the prevailing wind direction during the Pleistocene, the soils of large areas on the tableland were also modified to the extent of changing the use capability of the land. Cropland is confined to isolated areas in the southwestern counties on the tableland. The reason for this sparsity of cropland is to be found in the soil. Back of the bluffs, the soil is mainly shallow and rocky. Sand drifting onto the tableland through the gaps of the escarpment produced the long traverse dunes and the large tracts of sandy soil in the southern counties. The land can be used only for grazing. In the northern counties, where the soil is deeper and heavier, the land is used more extensively for crops.

Crops have been grown on the Llano Estacado for decades with dry-farming methods. But the low and fluctuating precipitation has made crop yields uncertain. Pump irrigation as a supplement to rainfall is a comparatively recent innovation; it has spread rapidly and has greatly increased yields and production. Withdrawal of ground water, however, has exceeded the rate of recharge. As a result, the ground-water table has been lowered.

For the last half-century, land use on the Llano Estacado has been divided between grazing and crop production. As about 75 percent of the annual precipitation falls during the growing season, dryland farming is possible with a number of crops, such as wheat in the northern higher belt, cotton in the southern division, and sorghums for the entire area. Comparatively mild winters permit grazing the year round, but stock water for the animals had to be obtained largely from wells by pumping, with the pumps operated by windmills. Water for domestic use of the farms and in the towns was also obtained mainly from the supply of ground water. The proved availability of ground water led to its use for irrigation as early as 1911, but it was not until 1935, when more efficient pumps were installed, that its potentialities were fully realized. This realization ushered in a period of rapid expansion. The greatest expansion in pump irrigation has occurred since World War II. As reported by the census, in 1944 less than 400,000 acres were irrigated on the Llano Estacado, whereas in 1949 more than 1,600,000 acres were irrigated. This was an increase of more than 300 percent in 5 years.

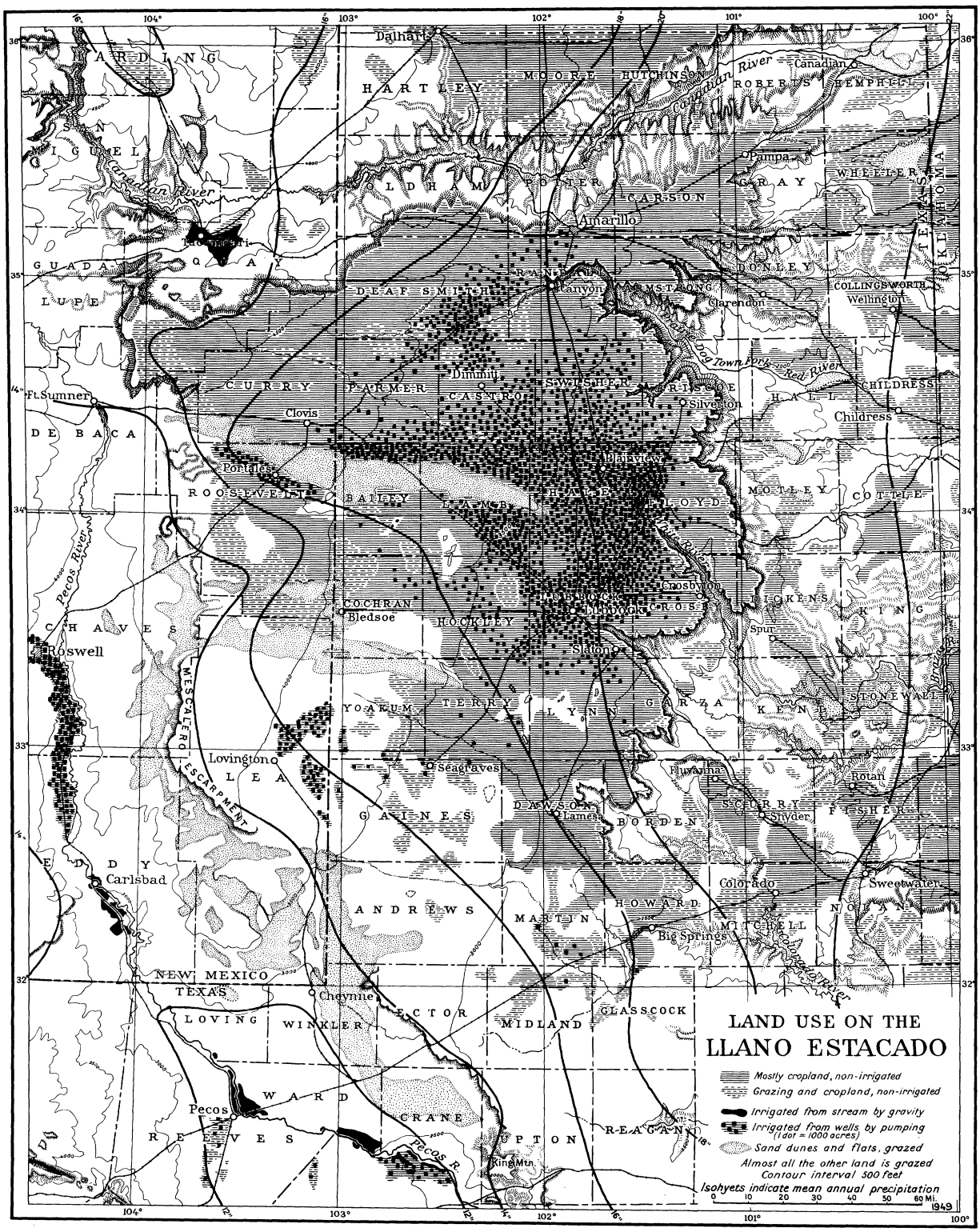

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FIGURE 20.—The Llano Estacado consists of the southern part of the Texas High Plains. The Canadian River Canyon separates it from the northern part. It is a slightly tilted tableland defined on three sides by an escarpment and connected on the south with the Edwards Plateau. The eastern rim drops for more than 500 feet in places. On the west, the escarpment is usually less than 200 feet high and is broken at some points.

Changes of this magnitude are certain to be felt in the economy of the region. Not only have yields risen to an all-time high, but crops that require more water have also come into the picture. The grain sorghum, corn, alfalfa, and other crops now grown on the Llano Estacado could not be grown without irrigation. How irrigation has affected production may be illustrated by cotton. For 1944, the census reported 555,000 bales of cotton harvested in the counties on the Llano Estacado. In 1949, the harvest had risen to 1,649,000 bales. To produce this crop required, in 1948, an estimated withdrawal of 1.2 million acre-feet of ground water for irrigation, which was about 97 percent of all ground water lifted to the surface in that year. For 1954, the census reported an increase in irrigated cropland of 2.9 million acres, but production of cotton declined to 1.3 million bales.

Withdrawal of ground water to irrigate such an acreage exceeds the rate of recharge from infiltrating precipitation and affects the level of the ground-water table. From 1938 to 1949, the ground-water table was lowered up to 50 feet in places. The greatest recession of the water table occurred in areas of heavy withdrawal by closely spaced pumps. However, the number of wells is increasing. As reported for 1950, 14,000 wells supplied the water to irrigate 1,860,000 acres on the Texas side of the Llano Estacado alone. The pumps were operated by either electric motors or combustion engines using butane, gasoline, or natural gas (pls. 119, *A* and *B*) (*7, 84*).

The lowering of the water table is a sign that withdrawal and recharge are out of balance. It indicates that more difficult times are likely to be ahead. A lowered water table reduces the availability of water to the pumps and increases the cost of pumping. Use of ground water for irrigation has economic as well as physical limitations, and these limitations may become effective before the supply of ground water is exhausted. Although the supply of ground water can be replenished, a steady supply can be assured only when withdrawals do not exceed the recharge capacity. To accomplish this, control and management are as essential for ground as for surface water.

The use of ground and surface water for irrigation is no longer confined to the West. In recent decades, irrigation has expanded in most of the Eastern States. The increase in irrigated acreage in the rice-growing areas corresponds closely to the expansion in rice culture. In other parts of the humid belt, irrigation is applied mainly during dry spells, when the evaporation-transpiration rate rises above the rate at which precipitation provides the moisture required for optimum plant growth. Irrigation is particularly successful in areas of intensive crop production, for instance, in fruit- and vegetable-growing districts (pl. 19). To cite an example reported by the census, Florida expanded its irrigated acreage from 126,000 acres in 1939 to 485,000 acres in 1954. Deficient soil moisture in these areas may be supplemented through subirrigation or ditch irrigation, or with sprinkler systems.

Aside from the objectives of water management that are directly related to land use and domestic and industrial supplies of water, others only indirectly connected with land use usually form an integral part of the larger water-management projects. Inland waterways for navigation and prevention of pollution are of this kind. In either instance, maintenance of sufficient flow and depth are necessary for the purpose.

Next to cities, rural land use is the chief beneficiary of water management, which has many facets. Only the main ones are mentioned here. Frequently, in its operations, technical, scientific, economic, social, and legal questions are closely related. Technology has now advanced to a point at which great physical obstacles can be surmounted. However, the large projects have many aspects other than technical. Although a project may be possible technically, the feasibility of undertaking it may hinge on questions of cost, economic and social benefits, or the possibility of clearing the legal hurdles involved. Needless to say, these questions should receive prior consideration because of their far-reaching implications and consequences.

Effects of Industrialization on Land Use and Rural Life

Rural Life Before Industrialization

There was a time when most people lived directly on and from the land. Food was provided by crops and domestic animals; home industries converted the fibers and lumber into clothing, buildings, and furniture. Only a comparatively small proportion of the crops and animals or animal products were available for disposal to townspeople, and only a few essential articles were purchased. This picture of American rural life describes living conditions of pioneer settlers only a little more than a century ago. This type of self-sufficing economy did not apply with equal force to the southern plantations or northern manors that were organized primarily for cash production.

During the early periods of settlement, the needs of the people were relatively rudimentary. Human labor and animal energy were the forces that cleared and cultivated the land. The implements used and the tillage operations were simple. Nonetheless, the settlers relied on the land to produce a living, although they knew little of the productive capacity of the virgin soil. Nor were they able always to appraise correctly the advantages and drawbacks of the natural environment in which they built their homes. Land was settled where it was unoccupied, and where the settlers thought they could make a living. Some of them expected to find a means of livelihood in the mountains almost as readily as could others in the valleys or plains. Site location was not considered of paramount importance or relevance to the use of the land, nor was it evident that physical factors were endowed with economic and social attributes as later turned out to be the case. In many places in the northern and southern Appalachian Mountains, land that would now be considered submarginal for agricultural production was settled and cleared. The standard of living did not concern the population then to the extent that it does today. But the pioneers cherished the tenets of freedom and the opportunity to establish homes.

Industrialization of the Country

The old American way of living changed markedly with the westward movement of settlement and the industrialization of the country. Agriculture as the major industry using the land was profoundly affected by these two developments. Settlers who moved to the prairies and plains found the physical conditions for agricultural production more favorable than in parts of the East. Extensive tracts of land with smooth undulating surfaces and fertile dark soils were ready for the plough. On most 160-acre homesteads, much or all of the land was tillable. The settlers were able to produce a great deal more than they could use. The surplus was disposed of on the domestic and foreign markets. Inland waterways at first provided the main shipping facilities. They were soon supplemented and later almost superseded by railroads and highways as connecting links between farms and markets.

With the settlement and development of the Central Plains, a new spatial order in the economic structure of the country emerged. Agriculture, which had been the main occupation of the people, moved westward and established its gravitational center in midcontinent, while manufacturing, service, and mining became the dominant industries in the more populous East. With the opening and development of the West, additional shifts in agriculture and industry occurred though not to the extent of revising completely the outstanding distributional characteristics of these industries. The agricultural character of the Great Plains is evident from the use made of the land. Measured in terms of proportion of land used for crops, the Central Plains contain the largest and most homogeneous area of the country in which crop production is preponderant. The concentration of industries and principal markets is reflected by the urban aggregations of population in the East.

Expansion of settlement and industrialization of production began to transform the country immediately after the Revolution. These two forces operated in the direction of developing resources and improving standards of living. The introduction of labor-saving machinery is largely responsible for development of the manufacturing industries and for the commercialization of agriculture. Although their application was not restricted, not all parts of the country could benefit from these innovations to the same extent. Advantages or shortcomings of location prevented uniform development, and regional differences in economic and social conditions resulted.

To provide a more effective exposition of the disparate distribution of agricultural production and market centers, two maps were prepared. Figure 21 illustrates the relative proportion of land used for crops in different parts of the country. Figure 22 visualizes the distribution of population. A comparative study of these two maps will reveal that concentration of cropland does not necessarily produce a concentration of people, and conversely, that only in exceptional cases is a concentration of people the result of intensive use of the land for agricultural production.

A comparison of the distribution of cropland with that of population will disclose the difference in location of centers of industry and commerce and production centers of agriculture.

Advantages of site account largely for development of cities in different localities. These advantages may consist of transportation and port facilities as they are found along the inland waterways of the Great Lakes and the coast, or the proximity of raw material and sources of energy.

The Case of Cotton

The relationship of changing land use through expansion of settlement and industrialization of the country may be perceived by considering what has happened in the case of cotton. Cotton is a cultural plant. Its fibers were spun and woven into fabrics by the peoples of India and those of the old civilizations in America centuries before the first European settlers arrived in the New World. Settlers in

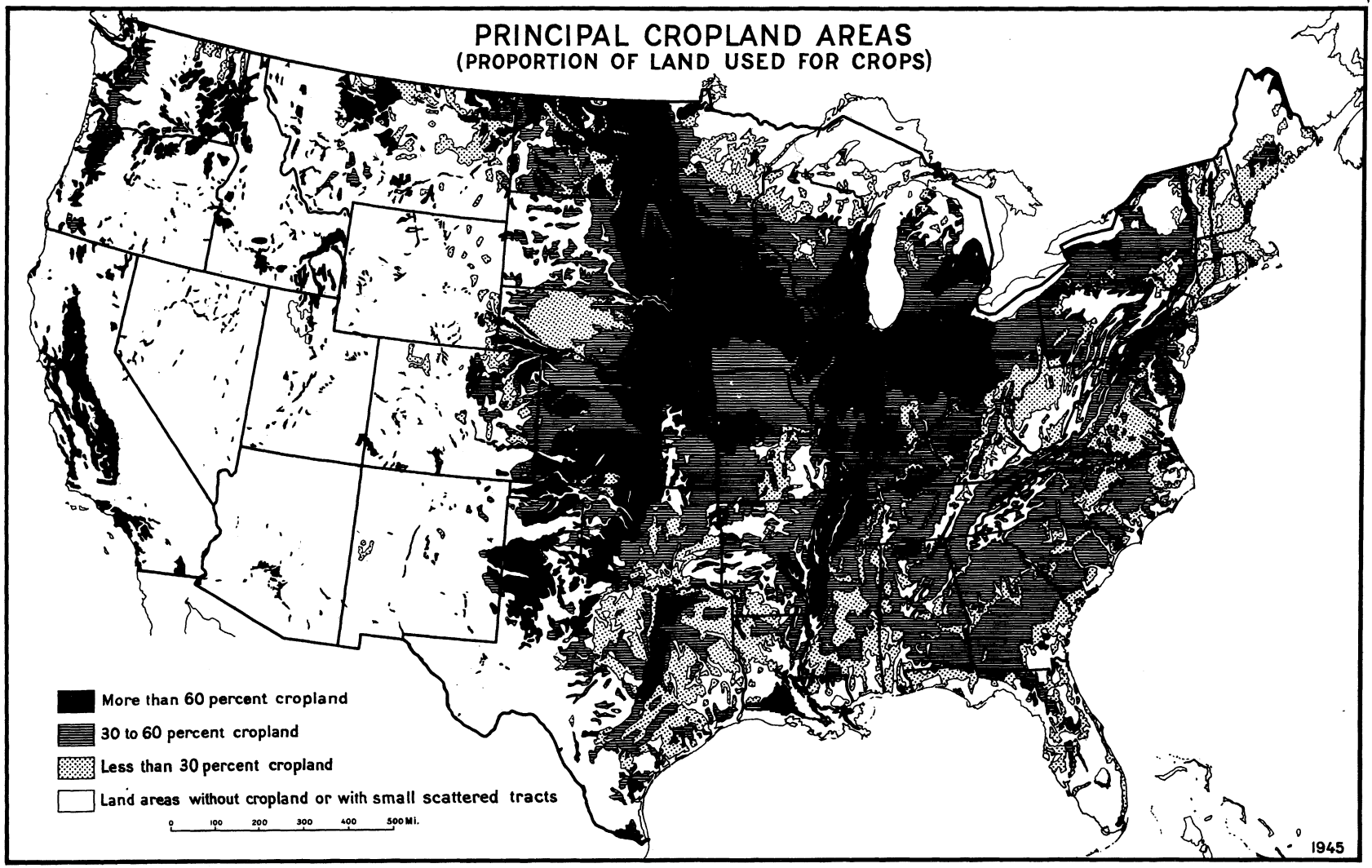

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FIGURE 21.—When the proportion of land in crops is used to illustrate relative intensity of land use in different parts of the country, the relationship of land use to physical conditions becomes evident. Much land in the Western States is arid and irrigation is practiced. Rough mountainous land, poor soil, or inadequate drainage is found in much of the East. The largest concentration of cropland is in the Central Plains.

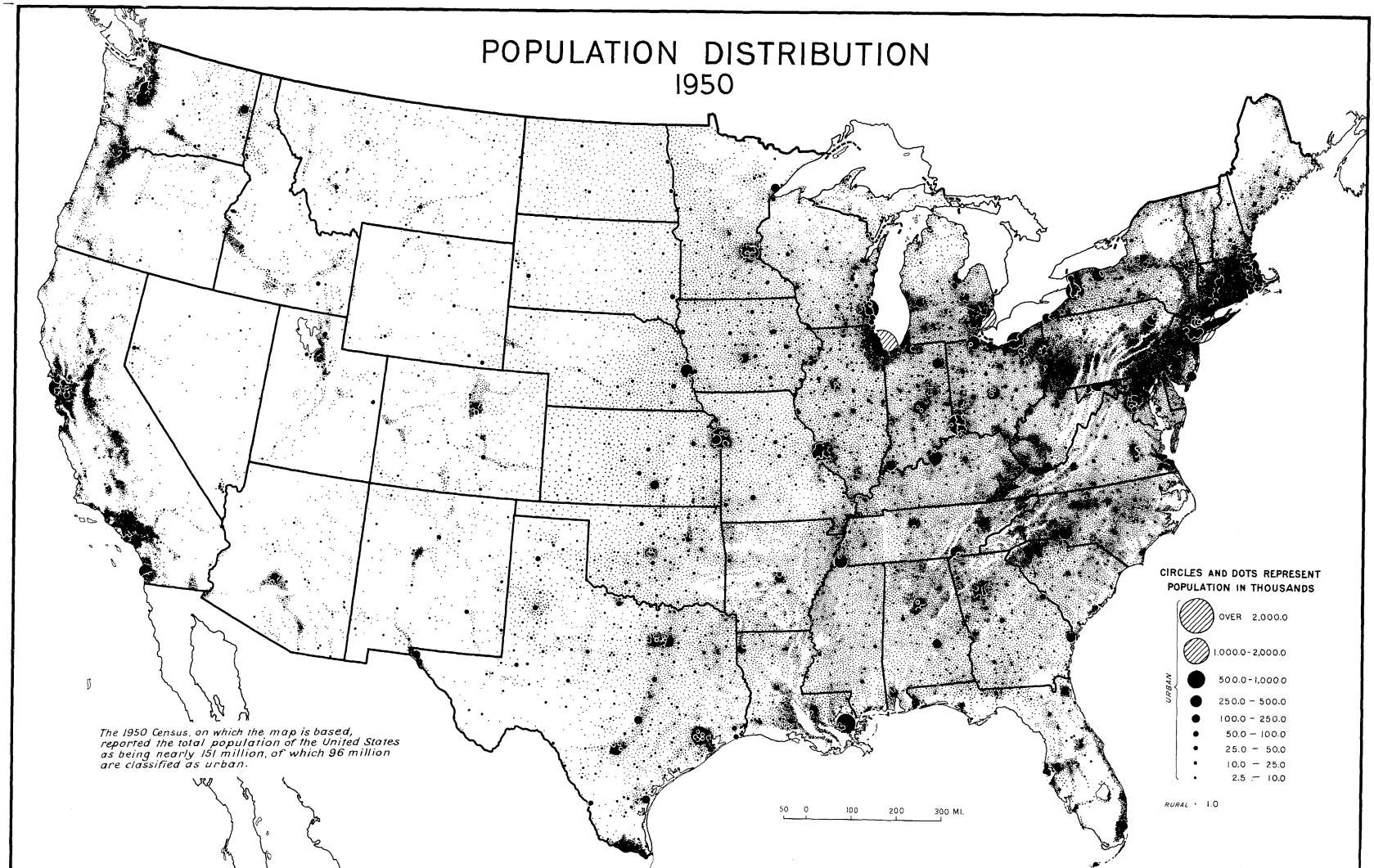

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FIGURE 22.—An outstanding feature of the distribution of population as shown on this map is its unevenness over the country as a whole. Approximately 85 percent of the total population is east of the 100th meridian. The greatest concentrations of population are in the North Atlantic and Great Lakes States, which contain sites favorable to the development of large urban centers.

the South Atlantic colonies and the French settlers in Louisiana had begun to grow cotton brought in from the West Indies mainly for their own use.

Cotton textiles had been produced with machinery in England since 1769, but the industry was handicapped in its development by the high price of cotton. In the colonies, it remained more of a home industry; homespuns were an important article of clothing during the Revolution. It was not until 1784 that 8 bags, or some 3,200 pounds of cotton, were exported to England. Production of cotton remained low until, in 1793, it was stimulated by Eli Whitney's invention of the cotton gin. Up to that time, the cotton fiber or lint was separated from the seeds by hand, which was time-consuming. It took an operator a good part of a day to clean a pound of cotton in this way. Whitney changed all this. With his first gin model 60 pounds of cotton a day could be cleaned, and with his 1794 model 1,000 pounds a day could be ginned. Since that time, the operating efficiency of cotton gins has been further stepped up. With present equipment, ginning a bale of 500 pounds of cotton requires from 2½ to 3 hours of man labor, depending on the design of the gin and whether the cotton is picked by hand or harvested with a mechanical stripper. Mechanically harvested cotton contains more leaves and trash, which slow down ginning operations (*114, 90*).

Cotton was the first crop to feel the impact of mechanization. Whitney's invention made it profitable, and the effects were felt in different directions. Not only was more cotton grown on established plantations, but the plant also migrated westward with the advancement of settlement in the Southern States. Except for the War Between the States, production of cotton expanded, with minor ups and downs, until recent decades. Some cotton is grown in all Southern States from the Atlantic to the Pacific wherever a frost-free season of 200 days or more prevails and where soils and soil moisture are favorable for its production.

Production of cotton reached its peak in 1926 when more than 44 million acres yielding nearly 18 million bales were harvested. Since then the acreage of cotton has declined, but the decline has been offset to a considerable extent by an increase in average yield per acre. This increase was brought about through the breeding of improved varieties, the use of better cultural practices and fertilizer, and through insect control. The average yield for the first 2 years on record—1866 and 1867—was less than 150 pounds per acre. The average yield per acre recorded for 1955 was more than 400 pounds, which means that the average yield of cotton per acre increased by more than 100 percent in less than a century (*134, 1952, 1956*).

The increase in yield per areal unit made a reduction in cotton acreage necessary to bring production closer to the demand level. Nonetheless, among the crops grown in the United States, cotton still ranks second in point of acreage used, which fluctuates now around the 20 million mark, and in value of product, which in recent years has amounted to more than $2,300 million. The United States produces more than half of the world's cotton. A large part of this cotton is exported to other countries. Growing cotton, therefore, is more than a strictly domestic enterprise, for cotton that reaches the international market must be produced in competition with other cotton-growing countries. Even at home, cotton has its competitors in the form of artificial fibers, which in many instances have taken its place.

As it is now grown, cotton is entirely a cash crop. This has affected economic and social conditions in the producing areas and also in the industrial districts for which cotton provides the raw material. Some cotton for industrial use had been shipped to New England before the ginning process was perfected. When cotton became available in quantities to furnish the raw material for mill operation, a new industry was born. The textile industry of New England grew with the expanding production of cotton and the increase in population. Cotton textile mills are now found in the South, also, and in many other parts of eastern United States.

Mechanization of field operations also has benefited cotton producers. Of all the field operations, harvesting cotton by hand picking is the most laborious. It is only recently that this process has been mechanized. Harvesting cotton with a mechanical stripper is not all gain, however. Although much labor is saved and the harvest is speeded up, the grade of cotton is lowered and some cotton is left in the field. In western Texas, where the climate is drier than in the eastern part of the Cotton Belt, a 2-row mechanical cotton stripper operated by 2 men can harvest 2 acres of cotton per hour. In North Carolina, about three-fourths of an acre per hour is the average rate. Moreover, the operation of a mechanical cotton stripper is conditioned on both favorable weather during the harvest season and nearly level land. Steep slopes, contour rows, and terraces are obstacles to operation of mechanical strippers (*115*).

Mechanized Crop Production

More significant than any other change in farming methods was the mechanization of field operations in production of all major crops. Mechanization not only changed farm operations; it also advanced farming from a self-supporting family occupation to a commercial

enterprise. That such far-reaching changes resulted from it is due mainly to the increase in efficiency of farm labor. These innovations have found their widest application where crops and physical setting lend themselves to mechanized operations. For instance, mechanized production of small grains on nearly level land, a subhumid or even semiarid climate, and a productive medium-textured soil showed the greatest gains in efficiency of farm labor. A comparison of man-labor requirements for some of the main crops grown with old and new methods will help to explain the significance of mechanization.

Wheat.—Around 1800, the man-labor requirements for production of wheat, expressed in United States averages, were about 56 hours per acre yielding 15 bushels, or 373 man-hours per 100 bushels. A century later, these requirements were reduced to 15 hours per acre yielding 14 bushels, or 108 man-hours per 100 bushels. In 1954-56, the average number of man-hours needed to grow an acre of wheat yielding 19.3 bushels was 4.3 hours, or 22 hours per 100 bushels. This is only 8 percent of the per acre requirement in 1800, or 6 percent of the requirement per 100 bushels.

Corn.—Corn, the most extensively grown crop in the United States, has a record no less remarkable. Corn grown for grain in 1800 required an average of 86 man-hours per acre producing 25 bushels, or 344 man-hours per 100 bushels. By 1900, these man-hour requirements had been cut to about half, and by 1954–56 they had declined to 11.8 man-hours per acre yielding 41.3 bushels, or 29 man-hours per 100 bushels. The average number of man-hours required to grow an acre of corn, therefore, was reduced to 14 percent, or, on the 100-bushel basis, to 8 percent of the requirement 150 years ago.

Cotton.—By means of yield estimates for 1800, a similar series of figures that indicate man-hour requirements has been prepared for cotton. According to these estimates, in 1800 the average labor requirements for growing an acre of cotton yielding 147 pounds of lint were 185 man-hours, or 601 man-hours per bale. By 1900, the average yield per acre had increased to 191 pounds, and the man-hours needed to grow it had declined to 112, so that only 280 man-hours were needed to grow a bale of cotton. For the 1954–56 period, the average yield again increased. It is now 386.7 pounds per acre, which require, on the average, 77 man-hours, or 96 man-hours per bale. The average number of man-hours required to grow cotton has therefore been reduced in 150 years to 42 percent of the former requirement per acre, or 16 percent per bale (*26, 62*).

These three sample illustrations of the increase in farm labor efficiency are averages for the United States as a whole; they cannot be regarded as norms that are applicable to regions, much less to localities. Recent regional studies reveal that under favorable conditions much greater savings in man-hours per acre have been attained than may be suspected.

For instance, in the hard winter wheat region of the High Plains, wheat can be grown and harvested with less than 2 man-hours of labor per acre. Corn is grown for grain in the Corn Belt with from 6 to 20 man-hours per acre. Like corn, cotton has a considerable spread in labor requirements, depending on the region, yield and variety, and the extent of mechanization. On the High Plains of Texas, irrigated cotton yielding 418 pounds of lint picked partly by hand and partly by machine required 34.5 man-hours per acre. On nonirrigated land, an acre of cotton yielding 200 pounds of lint harvested partly by hand and partly by machine required only 21 man-hours. In California, cotton grown on irrigated land producing around 700 pounds per acre of lint picked mainly by hand required 99 man-hours per acre. In the humid East, however, without mechanical picking and moderate yield, cotton usually requires more than 100 man-hours per acre (*125*). Similar departures from the averages of man-labor requirements must be expected in areas in which modern production practices are not or cannot be followed to any extent.

Other Crops.—These three crops—the principal crops in point of value—have also contributed proportionally more than the others to the general decline in farm-labor needs as a result of mechanized operations. However, with few exceptions, all other crops follow a similar trend. This is especially true of the grain crops. Some crops are less affected by increased efficiency of farm labor, but more so by the increase in per acre yields. Tobacco is an example of this type of crop. Forty years ago, the average yield per acre of tobacco was 816 pounds, which required 356 man-hours of labor, or 44 man-hours per 100 pounds. In 1954–56, the average yield per acre was 1,461 pounds, with a labor requirement of 490 man-hours, or 34 man-hours per 100 pounds. Per acre yields of practically all crops have increased in the last half-century. This also explains the statistical differences in man-hours required when applied to areal or crop units. These differences help to explain, in most instances, the fact that the increase in labor efficiency cannot be attributed entirely to mechanization of farm operations. Increased yields are also responsible to some extent.

Efficiency of Farm Labor Increased

Increases in efficiency of farm labor have been recorded ever since the country was set-

tled, but the greatest gains have been made since 1910. Comparison of figures representing average performances for the beginning and end of this period may be helpful. From available records, it has been calculated that in 1910 the man-hours of labor per crop-acre for the United States amounted to 38 hours. By 1955, they had declined to 17 hours. At the same time, the production efficiency index of farm labor per hour on a 1947–49 base had risen from 46 in 1910 to 132 in 1955. In other words, during this 45–year period, the labor requirement in man-hours per acre declined by 55 percent, whereas the productive capacity per man-hour increased by 187 percent.[4]

Changes of this magnitude in the efficiency of farm labor brought about through technical advances in the processes of crop production and increased yields could not fail to react on land and people. These innovations not only modified the old order of farming; they also affected the use of the land in different directions. With the displacement of horses and mules by tractors, the land needed to grow feed and fodder for draft animals became available to grow crops or feed or to be used as pasture for meat and dairy animals. The number of horses and mules displaced in this way ran into the millions. The number of horses and mules on farms reached its peak from 1915 to 1918, when more than 26 million were reported; from then on their number declined. In 1955, less than 4 million were reported. Instead, 4.3 million tractors, more than 2.7 million motortrucks, and more than 4.4 million automobiles were reported on farms. What a decrease of this size in number of draft animals means in terms of land use becomes apparent when the acreages needed to produce the feed for these animals are compared. In 1915, 91 million acres were needed to produce feed for horses and mules. By 1955, only 9 million acres were needed for this purpose. The livestock–acre ratio is not exactly the same for the two periods because changes in feed rations were taken into account in the computation. As these figures indicate, in the process of mechanizing farm operations, the use of 82 million acres of land almost exclusively in farms shifted from production of horsepower to production of farm products (*134, 1952, pp. 455, 651; 1956, pp. 359, 433, 447*).

The displacement of animated energy and labor by motorpower and machines was not confined to horses and mules. Farm families and workers on farms were also affected. Statistics register a decline for both, despite a substantial increase in the total population. In 1910, the total population of the United States was 92 million, of which 32 million were living on 6 million farms. In 1955, the total population was 165 million, of which 22 million were living on 5 million farms. As indicated in round figures, the total population increased by 73 million in the 45–year period, but the number of farms decreased by more than a million, and the farm population by 10 million. These are not the only instances in which a gain in labor efficiency had an inverse reaction on the man–land relationship. During the same period, even though the number of farms declined, the land in farms rose from 879 million to 1,158 million acres. Cropland harvested, however, rose only from 317 million to 333 million acres. Farm employment declined from 13.5 million in 1910 to 8.2 million in 1955. Expressed in relation to total population, the ratio was 1 farmworker to 7 people in 1910 as compared with 1 to 20 in 1955. This is of profound socio-economic significance. As indicated, a reduced labor force provided the agricultural products for 72 million more people in 1955 than in 1910 and for export as well, and this was accomplished with only a slight increase in acreage of cropland (*134, 1956*).

Type-of-Farming Areas

The statistical evidence of changes in agricultural production presented so far applies to the country as a whole, but the ratio of change does not apply uniformly to all regions. Some regions are affected more than others, mainly because of specialization. Regional specialization evolved through adjustment of the scope of farming enterprises to the potentialities found within the environmental frame of natural conditions and economic opportunities. This type of adjustment has been going on since colonial days.

That not all colonies were equally suited to production of certain crops became apparent at the beginning of settlement. Wheat, for instance, was tried by the early settlers of New England but smut soon made its appearance and greatly damaged the crop. In the colonies south of the Hudson, however, wheat was more successful. There, it soon became a commercial crop to be sold in northern markets. These natural advantages and drawbacks of different regions gradually became known with the advancement of settlement and use of land.

Regional specialization involves all products of the land. The supply–demand relationship created by regional specialization is therefore not confined to land and city; it also requires

[4] Unpublished data.

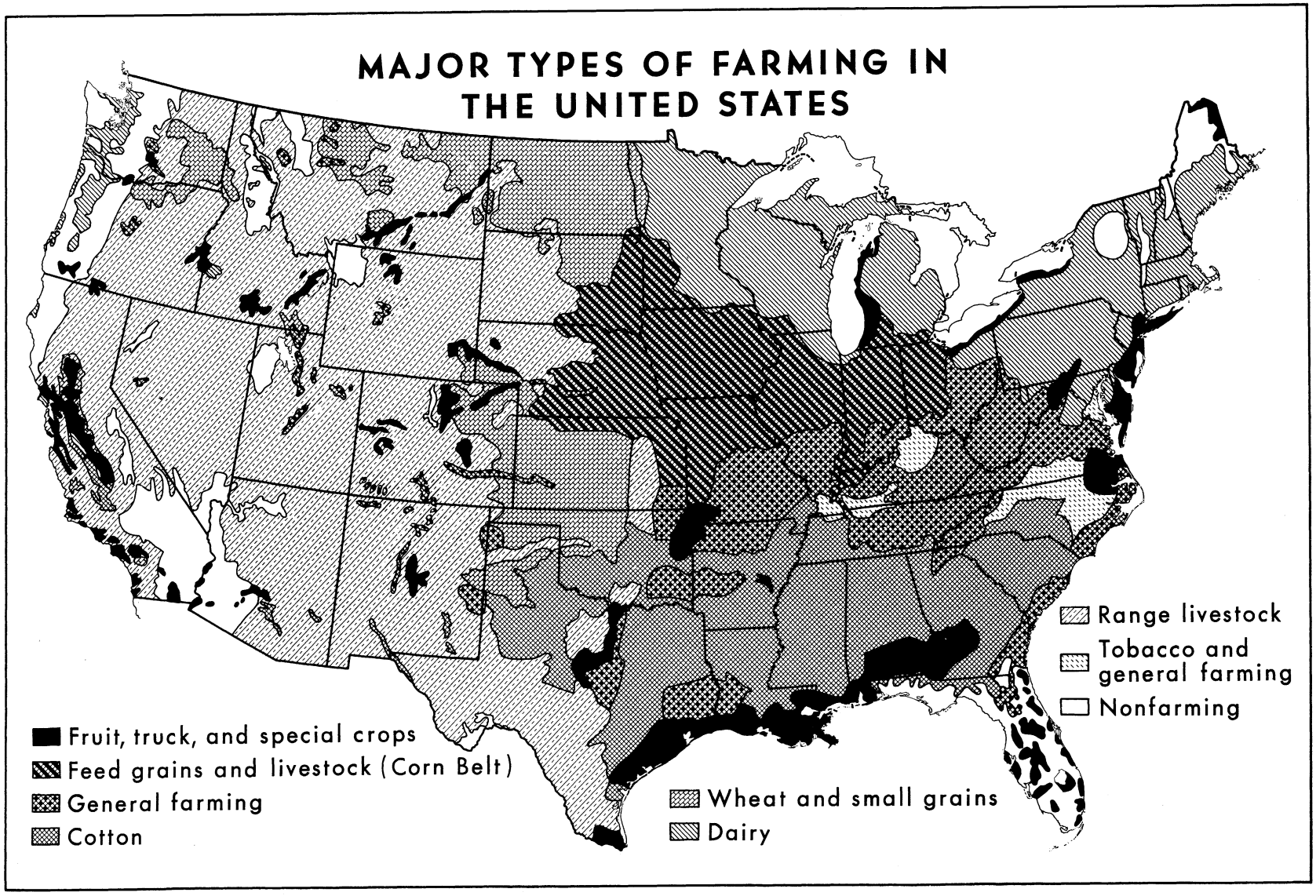

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FIGURE 23.—Agriculture is sensitive to advantages of site. Climate, soil, or lay-of-land alone may create a favorable or an unfavorable environment for different types of farming. The regionally specialized production areas shown on this map represent adjustment of agricultural production to natural conditions. But proximity to markets was also a factor in development of the fruit, vegetable, and dairy industries.

exchange of products between regions. This interlocked economic relationship between regions is not limited to the United States; it extends to most countries.

As settlement moved westward, it was found that large regions were so handicapped by low precipitation that the land could be used for a few grain crops only. Farther west, the land could not be used for crops, except with irrigation. From east to west is therefore the main direction in which the major use capability of the land changes because of differences in amount of precipitation. Within the more humid eastern section of the country, changes in type of farming occur mainly from north to south. These changes are due largely to the decrease in temperature, and the shortening of the frost-free season with advancing latitude. Although the character of the soils and the land relief are also involved, terms such as "Cotton Belt" and "Corn Belt" have become popular. The arrangement and distribution of the major type-of-farming areas are illustrated in figure 23 (*123, 38*).

Type-of-farming areas as represented on the map should not be regarded as permanently fixed in outline or internal structure. Change may be expected with the passage of time. For a time, a particular type of farming may constitute the best adjustment that can be made to the prevailing natural and economic conditions of an area, but farming responds also to economic inducements or limitations. These inducements or limitations may stem from changes in market demands and prices, modifications in farming methods, introduction of new crop varieties or new crops, concentration of specialty crops, or reclamation of land. With either inducements or limitations, some changes may be expected. These changes affect the type of farming and social and economic conditions as well. Some of the changes that occur are mentioned in the pages that follow.

The Corn Belt

The central part of the country is so richly endowed by nature with physical qualities favorable to agricultural use of the land that it has reached a high degree of development. For the most part, the surface is undulating to slightly rolling. Consequently, aside from the short slopes along the incised drainage systems, it presents few obstacles to farming or to construction of transportation and communication systems. Straight-lined field operations, straight highways, roads, and railroads are prevalent features of the landscape, and they represent adaptations to the rectilinear divisions of the land.

No less favorable than surface relief to agricultural production are climate and soils. Climatically, the larger part of the Corn Belt lies in the humid and subhumid part of the country. Annual precipitation averages 25 to 40 inches, of which usually more than half falls during the warm season. Temperatures are warm in summer and moderate in winter. The frost-free period ranges from 140 to 180 days. The soils have developed mainly from glacial till under grass cover and are naturally productive. These features combined produce a physical background that is adapted to farming. As a result, the proportion of all land in crops is higher in the Corn Belt than in any other area of similar size in the country.

Animal industry and crop production with feed crops predominating from the beginning provided the orientation for the agricultural development of the Corn Belt. Corn, which had been the chief crop of the Indians, was transmitted by them to the earliest settlers. The growing of corn succeeded wherever summer temperatures averaged around 65° F.

From experience gained in different parts of the country, it was found that in no other region could corn be grown more successfully than on the central prairies. Thus corn became the dominant crop and earned the region its name. Other crops—wheat, oats, rye, and hay particularly—were grown with corn in rotation, although the composition of the cropland pattern has been altered (*150, 152, 151*). These changes were not confined to farming; they affected the economic structure and social divisions of the population as well.

In the Corn Belt, the technological improvements and scientific methods developed during the last few decades have found ready application. Crop production has become almost entirely mechanized. With the disappearance of draft animals, the acreage of hay and forage crops needed to feed them declined, but production of corn gained in importance. Corn was no longer an exclusive food and feed crop. It had found industrial uses and with them expanded its market demand. As a result, corn is now grown largely as a cash crop. Production of corn was further stimulated by the advent of hybrid corn around 1933. From that time on, hybrid corn has gained in favor. Today, about 90 percent of the corn grown in the United States is hybrid corn. The average per acre yield of corn in the United States was 25 bushels in the 1926–30 period, as compared with 38 bushels in 1950–54, an increase of more than 50 percent (*134, 1956*).

Corn is not the only crop in the Corn Belt that has affected farming profoundly; soybeans have also affected it. The soybean, a native of Asia, was brought to America as early as 1804, but it did not become an agricultural crop of major importance until about 30 years ago

(*92*). It was only after the soybean had become acclimated and its value as a field crop had been recognized that it started its rise to prominence. In 1925, 1½ million acres were planted, but less than a half million acres were harvested for beans. Average yields were 11.7 bushels per acre. Three decades later in 1955, the total planted acreage for the United States was more than 20 million acres, of which 18 million were harvested for beans. The average yield was 20 bushels per acre, or a total of 374 million bushels. The significance of this figure in this connection arises from the fact that 251 million bushels, or 67 percent of the total, was produced in the Corn Belt (*134, 1956*). This sudden rise in soybean production not only affected the economy of the Corn Belt; it was felt around the world. It reversed the position held by the United States on the international market. This country had been the world's largest importer of soybeans and its products; it is now the largest exporter. That soybeans made such phenomenal gains in the Corn Belt was due largely to its similarity to corn so far as conditions of growth were concerned. Soybeans can be grown in rotation with corn or as a replacement crop when corn does not get the proper start in the spring.

Changes of this magnitude in yield and kind of crops grown could not fail to affect farm organization as well as the economic status of the region and the social grouping of the people. The large-scale production of crops for industrial use attracted industries to the small towns, the population of which increased rapidly. Up to the early decades of the 20th century, the population of the Corn Belt was predominantly rural, and the country towns grew slowly. With the arrival of industry, especially in the eastern part of the belt, the trend in population growth was reversed.

As indicated by census figures for the last few decades, the urban population is increasing rapidly while the rural population is barely holding its own and, in some instances, is decreasing. This is one aspect of regional development that is of more than local interest and concern. From both national and farm viewpoints, much can be said for the preservation of the fertile land of the Corn Belt for crop production. The extension of urban settlement reduces the land available for crops and often encumbers the remaining farmers with a share of the cost of development and an increase in service charges. This kind of urban extension, moreover, is not confined to one region. It can be found around most urban centers, where suburban development is spreading. In some instances, zoning ordinances have been adopted to guide land development in order to prevent misuse or waste of land and other resources.

The Great Plains

Large-scale mechanized production of crops had its inception in the Great Plains. Topographically and climatically, the Great Plains represent the most favorable natural environment for mechanized crop production in the United States. Large unbroken rectangular fields on slightly rolling or nearly level land with a minimum of precipitation during the harvesting season provide the regional setting. Small grains, mainly wheat, are the principal crops grown on the Western Plains. They are produced entirely with machine operations. With straight-line operations a mile or more long, a grain grower of the Plains frequently can cultivate and harvest fields that comprise hundreds of acres, an accomplishment that could not be approached with the farm implements formerly available (pls. 62, 63, 65, 74). Without modern mechanical equipment, much of the land in the semiarid plains that is now utilized for crop production could not be used for this purpose with any expectation of economic returns. Because of the cyclical variations of climate over the years, average yields are comparatively low and crop acreages fluctuate.

Because of the low and irregular precipitation, which averages between 15 and 25 inches annually over most of the higher part of the Great Plains, a more diversified cropping schedule is not possible and crop yields are unreliable. Recurring droughts are a hazard to crops. Small grains are the principal crops that can be grown here with any degree of success. Wheat, oats, barley, and rye are grown, but wheat predominates; in some sections wheat farming approaches a monocultural type of agriculture. In the 10 States represented in figure 24, *A* and *B*, the acreage now used for wheat is more than twice as large as the acreage used for oats, barley, and rye combined. Recently, despite occasional setbacks and the ever-present hazard of weather, the acreage of wheat has expanded more than have the acreages of other grains.

In other parts of the country, acreages of wheat have contracted. In 1925 in the 10 Plains States, around 32 million acres were in wheat. In 1950, close to 50 million acres were planted to wheat; in 1955 only 42 million acres were seeded. These expansions and contractions of cultivated land on the western semiarid margin of the Plains, however, cannot be attributed to a single cause. Economic factors are involved also. For instance, high prices for wheat provided an inducement to expand the acreage of wheat. The ultimate outcome of the contest between mechanical efficiency, the vagaries of climate, and the changing market prices of the crop is not yet known.

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WHEAT YIELD PER SEEDED ACRE

In the Great Plains, 1926-48

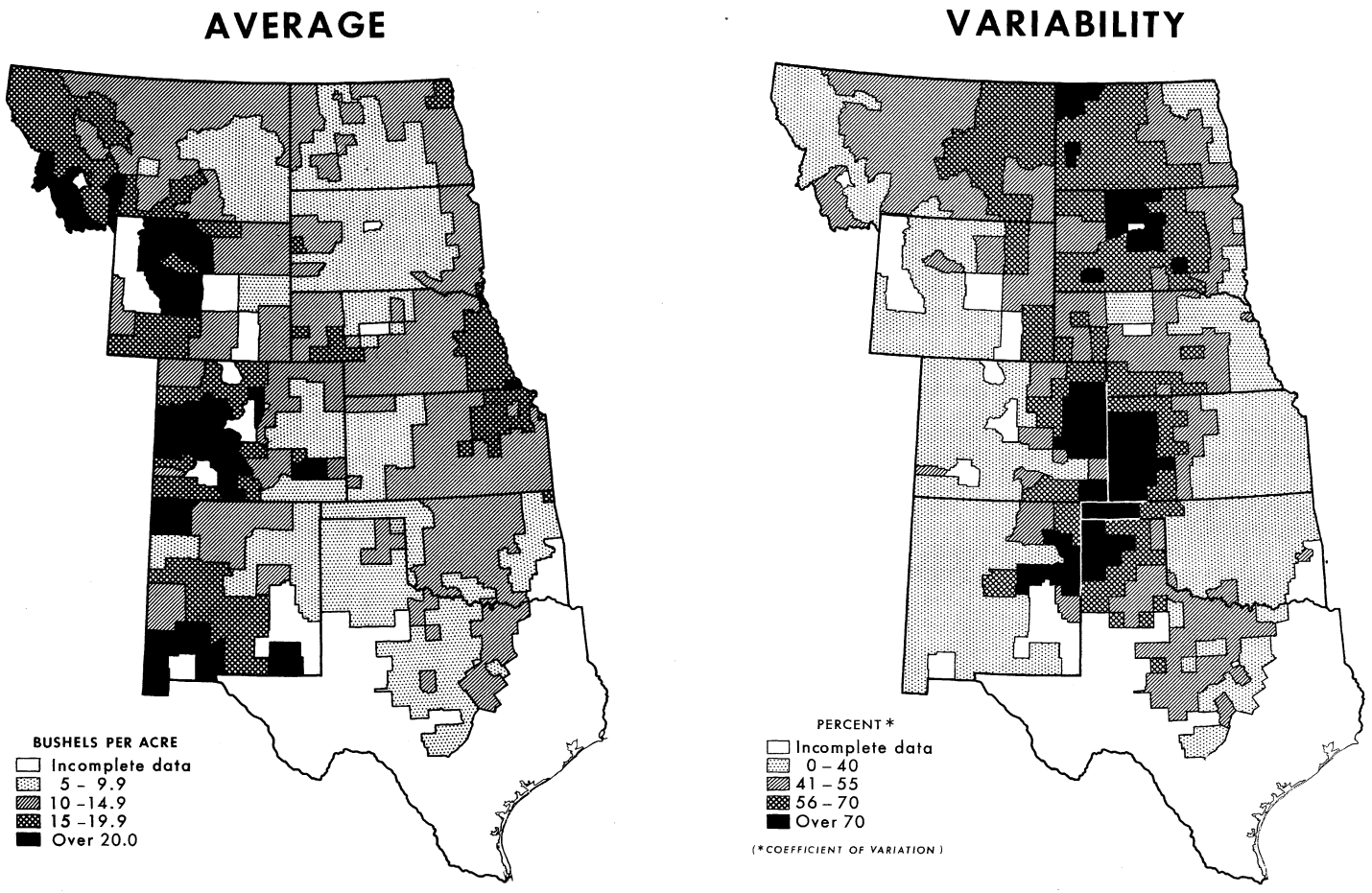

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FIGURE 24.—Distribution of average wheat yields, and distribution of variation in wheat yields in the Great Plains are shown in this chart. The two parts of the chart cover the same area; both are based on yields of wheat by counties over a 22-year period. But neither the distribution of average yields nor the variation in yields conforms strictly to climate. In areas where it is practiced, irrigation has its effect.