SOCIETY *has its roots in the soil. Do the different broad types of soil on which men live result in different types of civilization? What happens when people migrate from one type of soil to another with which they are unfamiliar? Do civilizations fall because the soil fails to produce—or does a soil fail only when the people living on it no longer know how to manage their civilization? This article discusses such fundamental questions, and concludes with a brief account of the development of soil science as we know it today.*

Soil and Society

By CHARLES E. KELLOGG [1]

AN AGRICULTURE secure from domestic or foreign exploitation and protected from invaders always holds a key place in stable societies. Such societies have roots in their homelands, developed by long living on the same soil, each generation building upon the traditions of the previous one. In a complete culture or civilization, agriculture, trade, science, and the arts all develop together; but the stability of existence and continuity of effort required for this development depend, most of all, on sustained productivity of the soil, which in turn requires management by a secure and virile population of homemakers on the land. The great cultural systems that have made their mark in world history have been built upon agriculture, though their subsequent expansion in industry or trade may have seemed to overshadow these rural beginnings.

Early man was a ranging nomad, constantly changing his abode from landscape to landscape,[2] always in search of new hunting grounds or fresh pastures. Great nomadic kingdoms grew up on the grasslands of central Asia, but they had no stability, no roots, and left few marks on the pages of world history and certainly less on those of civilization; they accomplished little of importance until they settled down—ceased to be nomadic.

The birth of primitive agriculture was the birth of civilization, and with it there came a great change. Occupational classes developed more sharply and definitely, and among many of the people the plow

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[2] The word "landscape" as used in soil geography means the sum total of the characteristics that distinguish a certain area on the earth's surface from other areas. These characteristics are the result not only of natural forces but of human occupancy and use of the land. Included among them are such features as soil types, vegetation, rock formations, hills, valleys, streams, cultivated fields, roads, buildings. All of these features together give the area its distinguishing pattern, which is the landscape.

replaced the sword. These men worked with nature, not to steal but to sow. As a farmer, man himself became closely attached to the landscape, firmly rooted to the soil that supported him. At times the soil seemed bountiful and kindly and again stubborn and unfriendly, but it was always a challenge to man's cunning. He learned to adapt his ways accordingly.

SOIL AND LANDSCAPE

Soil is the natural medium for the growth of plants. Although most soil is produced from weathered rocks, the rain and the sun have changed them greatly. Of still more importance are those changes made by the plants themselves. Thus soil is made through the influence of both physical and biological forces. It is especially the biological forces that give those characteristics to a soil or landscape that are most important to man. Essentially, all life depends upon the soil, and its important functional attribute, productivity for plants, is due more than to anything else to the operation of biological forces, particularly vegetation. There can be no life without soil and no soil without life: they have evolved together.

All features of the natural landscape, conceived as the total environment for living organisms, are interdependent. There is a relationship between climate and vegetation, between parent rock and vegetation, between age and slope, and even between climate and slope. All express themselves in the soil, which is the final synthetic expression of the forces in the natural landscape working together, and by which the nature of the landscape can be characterized better, more completely, and more directly than by any other factor or combination of factors.

Since there is a vast number of possible combinations of these climatic, geological, and biological forces in the world, there is a great number of types of soil; yet these can be grouped conveniently into a smaller number of great soil groups, each having particular characteristics of fundamental significance to the development of human society. Each is characterized by certain internal physical and chemical properties and by certain external features of climate and vegetation (fig. 1).

Every soil type, local or general, has its own elastic limit; each offers certain possibilities, and each has rather definite limitations of production within the particular economic and social framework existing at any time. In any one great soil group there are particular types of food available to man; the landscape exerts certain aesthetic or psychological influences; and within each group particular types of agricultural techniques and social organizations are necessary for man to establish himself.

Soil and Food

Man obtains from the soil, first of all, his food. Primitive man must adapt himself physically to the diet that nature furnishes or move to a more agreeable place. Since the composition of the diet has a pronounced influence upon the physical formation of both men and animals, and since the foods that compose it depend, in turn, upon the soil that produces them, it is not surprising that there are physical variations in people from place to place. As soon as people move

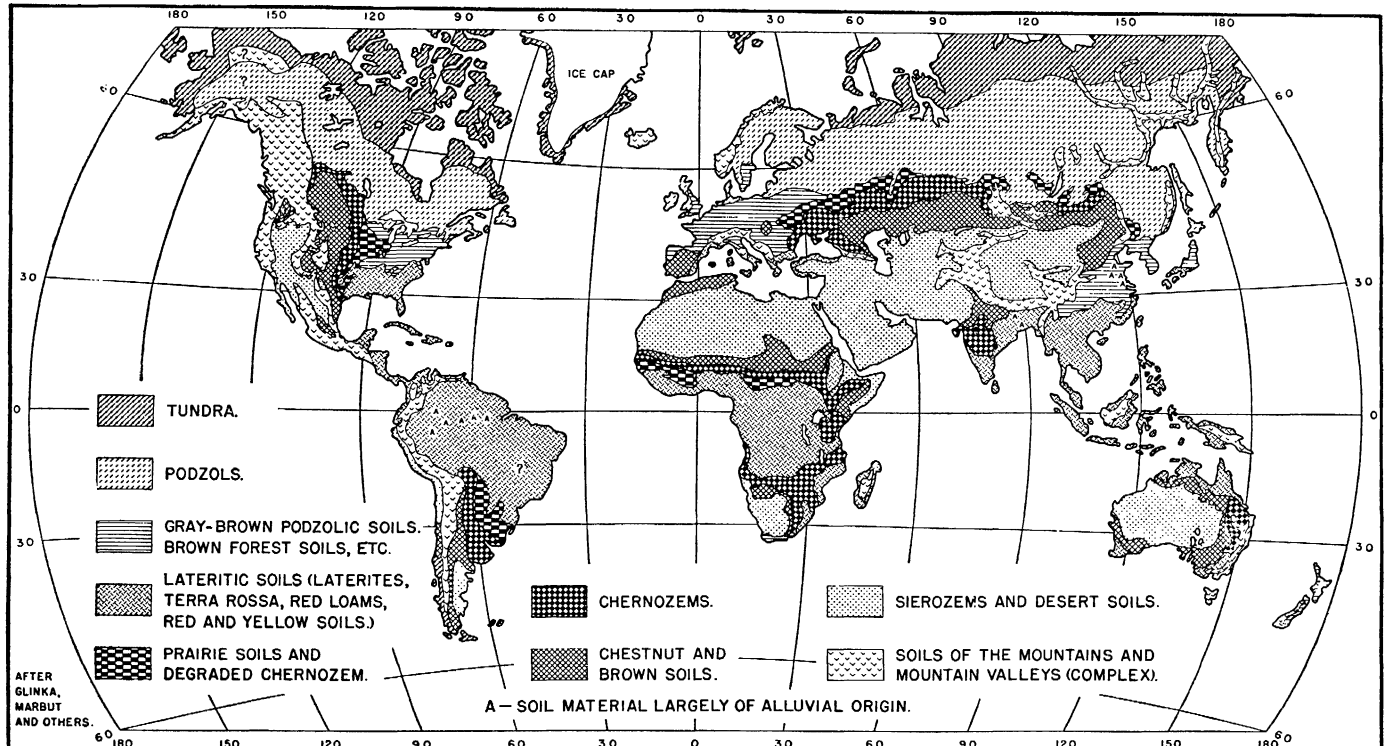

FIGURE 1.—Schematic map of primary groups of soils in the world (see pp. 996 to 1001 for descriptions). Some interesting similarities and contrasts between the people and social institutions in various parts of the world may be partially explained from this map.

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from one soil to another, a new adjustment is forced by the conflict between the genetic inheritance and the new environment.

With the advancement of knowledge and improvements of technique man is able to improve the products of the soil, according to his requirements and taste, through careful breeding and fertilization. Although several deficiencies, such as those of calcium, phosphorus, and nitrogen, may be corrected by the modern scientist, many of the minerals and vitamins necessary to man occur in such small quantities in plants that their presence and effects still remain obscure. Each of the great soil groups is characterized by certain general levels of plant nutrients. The forested soils of western Europe and eastern United States, for example, are commonly low in phosphorus, calcium, and the bases generally. In the great grassland areas of central North America and Eurasia these nutrients may be plentiful, but iodine may be deficient. Many soils in the humid Tropics are especially deficient in phosphorus. Local soil types may have excesses or deficiencies of such elements as sodium, magnesium, selenium, chlorine, cobalt, nickel, iron, boron, or copper responsible for significant influences upon food plants.

The different races of men, which may be regarded as the finished products in the evolution of a landscape, seem to have developed in restricted localities, each having particular soil conditions as far as the minerals available for plant growth are concerned. Those individuals who survived, over a period of many generations, were those able to adjust themselves to an iodine shortage, a phosphorus shortage, a calcium shortage, an excess of common salt, or whatever local situation obtained. These adjustments called for others, and a distinct physique developed.

With increased trade, the diet of the ordinary person is obtained from a wide group of soils and is less likely to be seriously deficient in some one respect. During previous periods of history, however, food came from a very restricted region, and even today, among backward peoples and in certain low-income groups, a similar situation exists. Under such conditions especially, the diet may have a pronounced effect upon health and disease. Susceptibility to disease, for example, may be induced through poor nutrition long before a direct effect is noted in the outward appearance. It is thought that gland failures frequently are due to an attempt to make an adjustment to a mineral deficiency and also that such deficiencies may have a pronounced influence upon the general physical development of the whole race (*242*).[3]

Aesthetic Influences of Place

Man receives inspiration as well as physical necessities from the soil he occupies. The folk songs of the world are less expressive of the people than of the landscape in which they originated. It is the songs of the mountains, of the desert, of the plains, of the forest, and of the jungles that are distinctive. The powerful influence of the landscape is reflected in literature.

One scarcely realizes these differences until he travels from his own region to another, or until he studies the art of an alien race. People

[3] Italic numbers in parentheses refer to Literature Cited, p. 1181.

from western Europe and eastern United States have emphasized the grandeur of the desert, the mystery of the steppe, and the horror of the jungle, not realizing that their own landscape is emotionally oppressive to the stranger.

AGRICULTURAL TECHNIQUES

The needs of man extend far beyond what nature, unassisted, can furnish him. He must plow and sow—he must work with nature and conduct her producing forces through carefully organized channels. From the accumulation of experience and knowledge, man gradually learns to bend natural forces to his advantage and thus reduce the hazards of life and lessen his direct dependence upon the natural environment. Thus it is through the use of techniques that civilized man produces his particular necessities.

Yet no matter how complicated become these techniques, social or individual, the fundamental fact of agriculture, the relationship between the plant and the soil in which it grows, remains. The very responsiveness of soil to technique is one of its unique characteristics, individual and finite. Unconsciously man adjusts himself to these physical requirements, individually and collectively. His daily life, his work and his play, from the simple acts of life to the more complicated economic mechanisms he creates, are conditioned by the necessities of his landscape. The agricultural techniques that man employs are basically designed to produce a relationship of soil to plant suitable to the aims of man.

Theoretically, there are two general approaches to this adjustment: (1) Change the soil; or (2) choose plants to fit the soil. Usually man combines the two to some extent. While the proper selection of plants most nearly adapted to the natural soil is of the utmost importance, only rarely can crops be grown without tillage and other assistance from man. Further, the plants naturally adapted to the various soils vary greatly in their usefulness to mankind. Through the use of techniques many soils can be made productive of other than the native plants.

These agricultural techniques may be divided roughly into two classes: (1) Those more or less simple methods carried out by the farmer and his family with relatively simple implements. For centuries these have been developing according to the conditions under which the farmers found themselves. (2) Those techniques more directly dependent upon the collective effort of the social group as a whole—the social techniques. Included in this group are those which may be largely physical, such as the development of electric power, and others that are largely institutional or legal. These are determined by the state of knowledge, basic interests, and cultural outlook of the group.

The Simple Techniques

Many of the simple techniques are very old indeed, and their origins are lost in antiquity. One may read in Homer how Odysseus, upon returning from his wanderings, was recognized by his dog lying on a heap of refuse "with which the thralls were wont to manure the land." The development of the hoe, the ax, and even of the plow (except the

tractor plow) has been slow and gradual, almost historyless. In the Old Testament (I Samuel xiii: 20) we find that the Israelites "went down to the Philistines to sharpen every man his share, and his coulter, and his axe, and his mattock." How different, really, were these simple practices of 3,000 years ago from ours today?

Plowing is the oldest and most fundamental technique, and in one way or another it is practiced by farmers everywhere.

> Homer and Hesiod and Virgil knew
> The ploughshare in its reasonable shape,
> Classical from the moment it was new,
> Sprung ready-armed, ordained without escape,
> And never bettered though man's cunning grew,
> And barbarous countries joined the classic reach.
> Coulter and singletree and share and haft
> Frugal of ornament as peasant's speech,
> Strong to their use and simple as their craft,
> Whether to turn the ridge or cleave the rean.
>
> (V. SACKVILLE-WEST, The Land.)

One may find the simple practices suited to the soils of Italy explained in Columella's Husbandary (about A. D. 50) with amazing acumen, even when viewed in the light of modern knowledge. Although Columella remained the authority on agriculture for more than 14 centuries, he made no claim to originality, in the sense of invention.

> But whatever those things be, which, because of the rural discipline of our times, are not agreeable to the opinion or practice of the antients, they ought not to deter the learner from reading. For, with the antients, there are many more things which deserve to be commended and approved by us, than to be rejected (*73*).

Although he draws upon the work of Mago the Carthaginian and many others, he warns that regions having different soils, "being of a different nature, cannot produce the same increase, or yield the same plenty."

Of course, changes and improvements have been made in the simple techniques, especially in the exactness with which the practices are used on particular types of soil, but on the whole the basic techniques employed on the self-sustaining, noncommercial farms have developed very slowly, in marked contrast to the social techniques.

The Social Techniques

The social group must adapt its methods to the soil just as the farmer must use practices fitted to his own particular land. Unless such an adjustment is attained, part or even all of the individuals within the group may find themselves quite helpless to adjust their separate enterprises to their own land. As an example, one might think of those farmers on the sloping red lands of the South, growing corn and cotton on soils that erode easily. Perhaps the individual has failed in the application of his own techniques; certainly some farmers have done better than others in the same community and on the same soils. But until the social group makes certain adjustments, some individuals may be unable to adopt those practices which will conserve the land and maintain their homes. The control of soil erosion in this region and many others is not unrelated to tenancy, agricultural credit, and other problems requiring collective effort for solution.

Devices for long-distance marketing, including railroads and other means of communication, irrigation, manufacture of power machinery, manufacture and distribution of chemical fertilizers, the development of electric power, the processing and storage of farm products, and legal devices regarding the tenure, use, and disposal of land are obvious examples of social techniques that have a direct bearing upon the relationship between the farmer and his soil.

Man acting as an individual cannot easily supply water to desert soils. He may not be able to provide the soil with the necessary fertilizer. He cannot arrange for protection by military or legal means. He cannot build railroads. Organized society can do these things. Provisions for long-term land tenure must be made by the social group and will depend upon the nature of the soil and the social outlook of the group. If the legal or economic arrangements adopted are not in accordance with the physical requirements of the land, either the people or the land, or, as is more likely, both, will deteriorate.

The development of new social techniques may change the relationship of other techniques to the soil. The construction of railroads, for example, may have the effect of allowing wheat farming in small units in place of ranching in large units; but of course, not unless the soil is physically adapted to wheat growing. The use of any soil cannot be changed beyond a certain elastic limit.

Of particular importance right now is the increase in farm and community refrigeration with the development and cheapening of electric power. Refrigeration frequently is a determining factor in the production of certain animal products and the use of land for pasture. The use of electric power, located at the margins of fields, for tillage and harvesting, is hardly beyond the suggestion stage, but it may prove a great advantage on soils injured by heavy machinery. If present trends continue, electric power will certainly have a profound effect upon agriculture and the use of soils during the next few decades.

Changes in land tenure, together with fertilization and other techniques, have made possible sugar production on a large scale on soils previously used by native gardener-farmers. Many other examples will come to the mind of the reader. Theoretically there is almost no limit to production on any land, provided enough is done in the way of fertilization, irrigation, and so on. If necessary, a glass house may be built over it for temperature control.

In the real world, however, there is an ill-defined, never-stable, maximum elastic limit for each soil beyond which production cannot be increased without a serious decline in labor income. More often, however, the exploitation of land and the people on it comes about from an unconscious lack of adjustment between the soil and the social techniques than from any conscious attempt to increase production. If those farmers growing cotton on the rolling red lands of the South found themselves in a social group where long tenure of the land was possible, with devices for long-term agricultural credit and for furnishing them cheap fertilizer and cheap electric power, they might have a greater opportunity to use their lands for close-growing, erosion-reducing crops—legumes and grasses. Thus they might save both themselves and the land.

RACE AND SOIL

Men and societies are thus products of the landscape. The strong race has first approached a physical and social equilibrium with its own landscape. The great cultural systems, whose subsequent civilizations have made their mark on world history, have, for the most part, originated in a particular landscape on a particular group of soils—the Egyptian, on the alluvial soils of the desert in the Nile Valley; the Arabian, in the semidesert; the classical (Greece and Rome), on the Red soils; and the western, on the leached forested soils of northern Europe.

People may move from one landscape to another, but a race is rooted to the soil that gave it birth (*377*). As soon as people move, serious conflicts develop socially and within the individual. Fundamentally the conflict is between the genetic heritage, carried from another soil, and the new landscape with its different possibilities and requirements. Such conflicts reach from the simple life of the individual to the highest grounds of government and politics. In primitive societies these relationships are quite obvious; among highly cultured societies they are complex and obscure but no less important. The development of science offers a way to extend the elastic limit of soils and lessen the direct dependence of society upon the natural soil. Frequently, however, legal and economic devices have lagged so far behind the scientific devices that the latter have been of little use to increase the social welfare of the people—measured by health and education as well as material well-being.

CHANGES IN SOCIETY

A problem of maladjustment between people and their soil may arise in several ways. First, there are the problems that are due to changes in the people on the land, either from internal or from external causes. One technique may develop much faster than others and throw the society out of balance. For example, the importation of modern medical science and sanitary engineering into some countries, as in many tropical colonies, has been responsible for a tremendous increase in population without a corresponding increase in agricultural production and proper development of social institutions. Exploitation of both land and people may be the result. Contrariwise, a declining birth rate may produce a society with a large percentage of adult workers in proportion to the total number of consumers.

A general change in living standards causes changes in the use of soils. These usually come gradually, however, as a rise in living standards is commonly coincident with a development of techniques for the increase of agricultural production. The development of differences in living standards and the formation of classes may have a profound effect upon the adjustment between farmers and their land. Especially before the inventions of modern times, made possible by the rise of science, one group could have an abundance of leisure and a high living standard only at the expense of other groups. Slavery was likely necessary for the golden age of Pericles. Present-day differences probably are less acute, but much greater than appears necessary from the point of view of the physical capabilities for pro-

duction. The Punic Wars cost Rome over 300,000 soldiers, mostly freeholders, farmers near Rome. Slaves were brought in to fill their places, and a landed aristocracy, much deplored by Columella, arose. Not only that, but free bread made available to the Roman citizens depended upon slave-operated farms at the fringes of the Empire.

It is not necessary to stress the great importance of land tenure to the people of the world. The great systems of aristocracy, until recently dominant in Europe, depended upon land ownership. A great many of the people who came to North America from Europe and founded the American democracy were motivated by the desire to own land and realize the security of a farm home (*78, 409*). Early agriculture in the United States was of a subsistence type, and only a little produce needed to be sold in order to buy the few things not provided by the soil, although standards of living were lower than we wish or need to accept now. In the Southern States, however, slaves made possible a different type of farm organization, and a sort of rural aristocracy developed. In those areas the percentage of tenancy today is very high.

The new democracy was a great boon to those who worked for a living, and especially to the farmer. Land was plentiful, and with courage and industry a home could be made. The job of the State was to provide legal and military protection. As time went on, however, the cities took over some of the manufacturing, and the farmer produced more to sell and purchased more goods and services. He became more of a specialist—in cotton in the South and in cattle and later in grain in the West. Land values rose. Low prices were irritating to the colonial farmer, but they are ruinous to the modern farmer. Money is needed for taxes, for interest, for clothing, and for many things that were of little importance or unknown to the colonial farmer. The modern farmer requires from society something besides legal property rights in the land and military protection.

Few people would suggest a return to the type of subsistence farming practiced in colonial times. Farmers want and need the products of modern invention as much as any other group of people. To obtain them, the farmer must have products for sale. He must have money to pay for his public services and to buy the products of the city. The difficulty comes when the thought of immediate cash return, this year and next, dominates over that of the return for a longer period. Quite generally, the type of soil management that gives the greatest immediate return leads to a deterioration of soil productivity, whereas the type that provides the highest income over the period of a generation leads to the maintenance or improvement of productivity.

The farm home owned by the operator has been and still is an ideal in democratic United States. The soil is more than a source of immediate gain; it represents security for the future. To the extent that this attitude, so fundamentally developed among the small farmers in early colonial times, motivates the farmer and his family, the soil is conserved. Conservation, not for itself but for security and that sustained production necessary to security, is an essential part of any system of permanent agriculture.

The Farm and the City

During the early life of a culture, people are close to the land. The seeds of great cultural ideas are germinated in the nursery of undefiled natural landscapes, but their final fruition, their crystallization into dogmas and styles, takes place in cities. The towns of a young culture develop in response to the needs of self-protection and as an expression of the gregarious instincts; but cities may gradually emancipate themselves from the rural landscape and grow apart from the soil as a self-conscious offspring, a creation of uprooted men who have lost their contact with the soil. They cannot survive, however, financially or biologically, except with the support of a healthy, vigorous rural population.

The art of agriculture is inseparable from the art of homemaking. Homemakers are savers—the true conservationists. The substitution of the business of farming for the art of agriculture signified the first encroachment of city ways into agriculture itself. The land and home of the farmer then become capital. Through the inheritance of this capital by farm-born city dwellers, through payment of interest, and in other ways, cities may sap the vitality of the country.

Even though they may gain political control and formulate social and economic policies of their own choosing for the nation, cities in themselves are not necessarily harmful to agriculture and can be very helpful. Indeed, the farmer needs and must have the goods and services of the city if he is to enjoy more than a primitive social life. It is rather the concentration of wealth and credit facilities in the city, especially as associated with absentee ownership, that may work a real hardship on the farmer. As a matter of fact, such controls of credit and finance may be as harmful to large sections of the city's own population as to the country people, if an undue proportion of the fruits of production are diverted away from the producers.

If the cities thus gain power over the country people and use that power in a way that throws them seriously out of adjustment with their landscape, farmers are forced to exploit their land, and there is a decline in soil productivity associated with an inevitable train of social disorders. People say there is an agricultural problem. Inevitably this is accompanied by serious problems in the city itself. A general decline in soil productivity is the effect, not the cause, of these disorders.

Whether such a sequence will take place in our country, with a further increase in tenancy, a general increase in the wealth diverted away from the land, and a decrease in soil productivity, is a matter for speculation. New York State, in spite of its very large city population, has adopted a forward-looking agricultural program. Certainly such a tendency is cause for hope. Although the productivity of our soils is still high, deterioration has been significant during the last generation.

Even more harm has been done to the spirit of large sections of the rural population. This is the really serious aspect of the matter. People without hope do not support democracy. Dictatorships and autocratic governments are accepted by people who have nothing to lose. Men whose only privilege is to exist at the edge of starvation,

humiliated, and with no security for themselves or their families, are easily persuaded to sacrifice their freedom. To them freedom becomes in effect freedom to starve and to sleep under the bridge.

Nationalism and the Farmer

In the struggle for power certain nations may seek to become self-sufficient. Special techniques may be employed in order to produce food and other commodities on soils not naturally suited to such production for a free market. The soils may be used for new crops or for higher yields of crops already grown. At the same time the use of land for other purposes may be discouraged. Through the use of bounties, tariffs, or other devices, governments can, and frequently do, throw the farmer out of adjustment to his landscape, or at least make a new adjustment necessary. At any moment these devices may improve or injure the condition of the individual farmer, depending upon how they influence his own particular farm unit. But if over a long period the tariff or other devices are used to subsidize inefficient production, a serious day of reckoning is likely to come. It is not the purpose to discuss this matter fully here but only to suggest its importance in any consideration of the relationship of the farmer to his land. Frequently the distress in rural areas is due to the influence of such artificial conditions. Again, other seemingly prosperous areas may owe their prosperity to some special economic situation the continuity of which may be broken easily by the caprices of national or international politics.

Some of the most important of these influences may at first glance seem remote from the people affected. For example, an agricultural country producing basic raw materials for foreign trade might find its outlet curtailed through the operation of bounties and tariffs in other countries. If such a country had additional resources, such as iron, coal, and electric power, it might develop industrially and make an approach toward becoming a self-contained unit, with an increase in domestic commerce offsetting all or a part of its previous foreign commerce. If there were not basic materials for industrial development or if certain key resources were absent, such a recourse might be utterly impossible, and the country might find itself in a serious situation, with great capacities for agricultural production but no markets.

Frequently the farmers' interests may come into sharp disagreement with the nation's interest, or what may appear to the government to be the nation's interest. And it is further obvious that in the struggle for national power, untold misery may be brought about through the operation of special economic forces that destroy the adjustment between the people and their soil, even during times of peace.

MOVEMENT OF THE PEOPLE

Not only may problems of adjustment between people and their own soil arise, but other serious problems may develop when people move to a new landscape. Of course, no two regions are identical in all respects but the degree of adjustment that may be necessary varies fundamentally. When the early colonists came to North America they found many new things. Yet the land was forested and well-watered, and the soils were light-colored and leached, much like those of western

Europe. There is little wonder, therefore, that English customs and English common law were easily adapted to the New World. In the southern colonies physical conditions of soil and climate made possible early specialization in cotton and favored the plantation system, as compared to the more general, family-sized farm adapted to the soils farther north. Thus, important differences in the soils of the northern colonies as compared with those of the southern colonies doubtless accounted, in part at least, for corresponding differences in social and economic arrangements relating to their use—differences that reached a critical stage in the middle of the last century.

When people move from one soil to another they bring their old customs and habits with them. Immediately a conflict arises between the old traditions and the new demands. The period of so-called lawlessness in the American plains was a period of such conflict and adjustment. Soil blowing and poverty, following overgrazing and overexpansion of grain growing in part of our western plains, indicate that an adjustment has not yet been reached.

Even though a new society may hold to its old customs and traditions as tenaciously as possible, unless these are replaced as a new equilibrium is established, the society disappears. The more diversified the origin of the people who occupy new areas, the greater their plasticity and the more readily they are able to adjust themselves, their techniques, and their laws to the new situation. The greatly diversified origin of the peoples of the United States probably accounts for their unusual plasticity and their ability to occupy so many different soils. As the population becomes more fixed, more firmly rooted, certain sectional differences in those techniques and institutions which relate directly to the use and capabilities of the soil may become more noticeable. Fortunately for us, that mutual understanding made possible by a common language and free movement of people can aid greatly in dulling the sharpness of these conflicts. The first and fundamental basis for mutual understanding lies in the appreciation that certain techniques and institutions need to be different where the soils are different. In a nation with many soil regions, strict uniformity is inconsistent with democracy, with conservation, and with public welfare.

The most important movement during recent years has been the occupation of the black soils and brown soils of the plains. Although some areas of such soils, as in Rumania, have been used for a long time, the great bulk has come into use since the Thirty Years' War in Europe and especially during the last hundred years. Until the development of railroads and other products of modern invention the great areas of black soils in the world were used chiefly by the nomads and other relatively primitive societies. Since that time the great steppes in Asia and the plains of the Americas and of Australia have become very important as homes for people and for the production of bread grains.

Whereas the soil in the humid regions of, say, western Europe or eastern North America lends itself to the establishment of highly diversified farms with a large measure of self-containment, the soils of the great black lands are especially adapted to grain farming with extensive methods, particularly in the drier portions. The more hazardous climate makes production less certain, more seasonal.

Since these farmers must buy many of the things produced by the farmers of the humid region and therefore are more dependent on a cash income, they are more concerned with and influenced by general economic conditions; and they are impelled more strongly toward cooperation for the protection of their economic interests. Whereas diversification of the farm enterprise offers some escape from the sharper fluctuations of a price economy in humid areas, these possibilities are limited in the plains. The traditions of individualism, developed among the people of the forested soils of western Europe, came into sharp conflict with the demands of the grassland soils. The tendency appears to be toward the development of strong sentiment for cooperation. What the final outcome will be is uncertain.

A considerable change in the type of use to which soils are put may be made by the new occupants of a region, especially when assisted by a military force raised in the homeland. Perhaps some of the most striking examples are to be found on the soils of the Tropics. The native tropical farmer is more a gardener than a farmer. His tools are the spade, the ax, and the hoe, and he requires the minimum of trade with other people. Several of the strong nations built on the soils of the temperate forested regions have colonized these areas and developed a highly efficient, highly capitalized plantation system of agriculture with extreme specialization in sugarcane, bananas, rubber, or other crops. Whether or not the native people are better off, happier, under such a system may be open to question. Even with the same techniques of production, there may be great differences to the people between systems owned locally, in which the wealth produced remains in the area, and those whose ownership is outside. What system will prove to be permanent and adapted to the soil is a question that will arise when outside support is withdrawn.

These examples serve to emphasize the importance to the land and the people of the influence of people outside the land itself. Although each soil type may be said to have an elastic limit beyond which its use cannot be pushed, the particular point at which this limit is found at any time depends upon economic conditions. Men work and live in a social world, and their individual physical needs must be supplied by techniques consistent with the economic and social characteristics of their environment as well as with its physical properties. Thus the limit of production of tropical soils in self-sufficient, democratic societies may be one thing, and the limit under a strongly controlled system designed for maximum production, quite another thing.

The great era of colonization during the fifteenth to the eighteenth centuries carried the Europeans and European ideas throughout most of the world. Slowly the forces of the new environments have broken down many of the old traditions and brought changes in techniques, laws, and customs to the point where the new races have reached a new individuality, sometimes in striking contrast to the old.

DEVELOPMENT OF CULTURAL SYSTEMS IN RESPECT TO SOIL GROUPS

Although it is impossible to divide the course of human history into neatly arranged and precisely defined categories, certain general and overlapping cultural periods are recognized in accordance with their

relative political and cultural contributions. Four of these are especially interesting to us and have been particularly important to our own civilization—the Egyptian, the classical (Greece and Rome), the Arabian, and the western (our own). Each of these cultural systems is characterized by more or less individual contributions to religion, art, and science. The previous systems seem to have progressed through periods of cultural growth, followed by periods of political expansion and mechanical development under city dominance, and finally declined, accompanied by a loss of ideals, depopulation, and cultural decadence. Causes have been sought for these great changes, and many explanations have been offered. Changes in climate, exhaustion of soils, and similar physical phenomena sometimes are given a large place in such explanations.

Evidence does exist for changes in climate. For example, it is known that prior to glacial times the Sahara Desert probably was greater and more terrible than it is today. Later, while much of Europe was covered with ice, this region became moist and more suitable for the growth of plants and animals. After the glaciers receded this temporary condition was changed, and the desert has returned nearly to its previous state (*121*). To what extent such changes have influenced the general course of human history during the past few thousand years it is impossible to say, but on the whole their influence would seem to be very greatly exaggerated by certain specialists in the physical sciences. The inadequacy of simple explanations of current human affairs should make us question their adequacy when applied to those of our ancestors.

The effects of soil exhaustion are especially difficult to evaluate. Soils are productive for plants only when correctly managed. Crop growth depends, therefore, upon both soil and husbandry, and a failure of either is sufficient to prevent production. Examples may be found of a temporary occupancy of land being terminated because of a failure of the soil. For example, irrigated soils may produce well for a few years and later become impregnated with salts and finally be abandoned. Soils subject to erosion under the generally prevailing type of management may, because of man's failure or inability to make the necessary adjustment, become so badly eroded as to be unfit for use for many years. Although there are many instances of such failures, their influences are relatively localized. There is no evidence of a general soil exhaustion and decline in productivity except as men have failed as husbandmen.

Furthermore, it must be understood clearly that even within a comparatively small region local soil types vary enormously in their inherent productivity for the prevailing type of farming adapted to the region as a whole. Only rarely are there large areas of soil uniformly productive and unbroken by patches of stony, hilly, or otherwise unsuitable land. In societies with increasing population, land suitable for farming may be unavailable to the new farmer. It may be impossible for him to purchase good land or otherwise obtain secure tenure. If he farms at all, his choice may lie between leasing good land at high rents for short periods and purchasing the poor land. Even on relatively poor land, the greater security of tenure may offset the advantage of better soil under a leasing or sharecropping system.

Thus, in the United States the best farms of a region may not always be on the best land. But the force of economic necessity sometimes has driven people to land so poor that failure was inevitable. Farms have been established on such areas of relatively unproductive soil, later to be abandoned. After such abandonment the land may be in a worse condition than it was originally, because of further depletion of fertility, erosion, or from other causes, until natural processes have had time to restore the soil. But this sequence should not be confused with the exhaustion of cropland; such land never was cropland in accordance with any likely economic pattern.

During the early periods of a culture, most of the people live close to the land. The soil satisfies nearly all of their requirements, and especially does it represent their principal security against the future. During this period the great fundamental ideas of the culture germinate, later to be expressed in distinctive music, architecture, literature, science, and philosophy. The main outlines of a cultural system apparently exist prior to the growth of great cities and mechanical development.

As each such system develops and becomes powerful—passes from the cultural stage to the civilization stage—it seeks to expand politically, first over the soil of its origin and later to other soils. By military forces, raised in the homeland, it seeks to subdue and control other peoples. For example, the Roman Empire, developed upon the red soils of the Mediterranean, later expanded to other landscapes in the east and to the north. Slaves were brought to Rome, and a new type of farming replaced the early type—the type that had produced the hardy Roman soldiers of the Punic Wars. The land was farmed by slaves, supervised by a bailiff, not by the owner, while the owner had other interests in the city and looked to the land for only a part of his income. The land became capital; the fruits of its production were diverted away from the farm to the city, Slowly the agriculture declined, and Rome was fed by grain grown by slaves or serfs at the fringes of the Empire. But more important, the sources of the virile blood that built the Roman Empire began to disappear, while a new group in the forests of northern Europe began to awaken. Roman agriculture became weakened, not from a failure of the soil itself, but because of a failure of men. With this breaking of the ties between men and soil came the weakening of the home race. Pressed by the vigor of a rising culture in the Near East and finally by the new races to the north, Rome was destroyed; or, perhaps more accurately, new trends were initiated.

Although theories are advanced from time to time that soil exhaustion has been directly responsible for the decline of ancient nations, it is likely that the reverse is more commonly true. The soils of Italy are probably producing more now than ever before. It was not the soil of Rome that failed, but the men.

This rise and fall of cultural systems is no simple matter. It is possible that there are no causes and that the whole of human history may be explained as some sort of mystic rhythm of birth, maturity, and death. But unless one completely rejects the idea that men have some responsibility for the direction of their destiny (and, fortunately,

not many do reject this idea), the mistakes of our ancestors need not be repeated.

Certain generalizations of importance to agriculture and to agricultural people seem to emerge.

For the most part, each of the great cultural systems of the past has been developed on a particular group of soils.

The endurance of a cultural system seems to have depended upon the ability of the people to achieve and maintain an adjustment of their techniques and laws to their soil.

For endurance, the people of each soil region must have political freedom to adapt their economic and social institutions to their own land.

If the new occupants of a soil do not, or cannot, adapt their social and legal institutions and their techniques to the new conditions, deterioration of the people, the soil, or both, may take place rapidly.

The final exhaustion of the land follows, not precedes, the exhaustion of the people. In a final effort, exploited people pass their suffering to the land.

Security of tenure in the land for the farmer through satisfactory leasing devices or ownership seems absolutely essential if our democracy, our people, and our soil are to endure.

Some societies have maintained a satisfactory relationship to their soil for a long time; others for a short time. It is impossible to forecast whether we shall be able to achieve such a relationship or how long it may endure.

Our country has many greatly contrasting soil regions with enormous variations in capabilities and necessities for use. With the proper balance of national solidarity and local autonomy this complexity can give rise to an even richer culture. Should we fail to recognize the special needs of the different regions, it might lead to destructive sectional conflicts.

THE DEVELOPMENT OF SOIL SCIENCE

During the course of human history, men have interested themselves deeply in the problems of agriculture, and slowly there has been built up a certain body of knowledge for dealing with them. An important part of this knowledge has been gained by direct observation and experience. Much was already available at the beginning of the Christian Era and was brought together by such writers as Varro, Pliny, Cato, and especially Columella. Even long years before this time, men were skilled in the use of manures and lime, crop rotations, irrigation, terracing, and similar techniques for the maintenance of soil productivity. Almost all of this knowledge was gained by the trial-and-error method over a very long period. The Chinese made a schematic soil map of their country about 42 centuries ago, as a basis for taxation and for the administration of agricultural affairs.

In each society the pursuit of knowledge for its own sake always has been an adventure of certain men having leisure and the requisite ability; however, the development of knowledge regarding soils and their use at any particular time or place, especially the applied phases of the subject, has been conditioned by the particular problems pressing for solution.

With the greater stability of Europe following the Treaty of Westphalia at the close of the Thirty Years' War (1648), populations increased rapidly. The soils of Europe were generally poor in both structure and fertility, and men became pessimistic about the future. In 1798 Malthus wrote his Essay on Population, developing the idea that population had much greater possibilities for increase than the food supply. The misery of the French peasants at the end of the eighteenth century stimulated thinkers in the physical sciences as well as in the fields of economics and politics. During this same period of unrest, out of which was born the concept of democracy, modern science developed rapidly in its application to agricultural problems as well as to those of industry and commerce.

The fact that the European students of economics and political science of this period did not foresee the ultimate rise of agricultural science, the great era of colonization just ahead, and the future importance of the black soils should not cause us to minimize the importance of their ideas (*237*). Yet, because of their limited geographic point of view, they did not conceive clearly the relationship between soil and the people. This could not be realized sufficiently until a world perspective became possible. Thus it was that for many years the problems of agriculture were attacked piecemeal and more or less separately by the physical scientist, the political scientist, and the economist. All were motivated by the same distress, but unfortunately each worked with his own tools, singly insufficient for the task. To what extent there is today a lack of mutual understanding and cooperation among these groups is left to the reader's own experience and imagination.

In the early eighteenth century Jethro Tull invented the grain drill and horse hoe and advocated cultivation, which led to the development of a system of crop rotations, including cultivated crops and legumes, known as the Norfolk system of Lord Townshend, replacing the old fallow system. Although based upon the theory that particles of soil entered the root directly, cultivation reduced weeds and improved yields. Where accompanied by marling, manuring, and careful husbandry, wheat yields increased to nearly 20 bushels to the acre on many farms.

Meanwhile chemistry was developing rapidly, especially after the perfection of the quantitative balance by the great Lavoisier. Despite the fact that he organized an experimental farm and devoted his time to the improvement of agriculture, he was led to the guillotine in 1794. The court simply observed to the defense, "France needs no scientists!" Despite handicaps, scientists continued their investigations at an accelerated rate. The old alchemistic theories concerning the principle of plant growth were beginning to melt away in the light of the new science. Acre yields of wheat rose from about 10 bushels to nearly double that during the 50 years after Lavoisier.

Field experimentation was begun in 1834, and shortly before the establishment of the famous Rothamsted Experimental Station in England (in 1843) the great German scientist, Justus von Liebig, had definitely stated the balance-sheet theory of plant nutrition: "The crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure."

The reasonableness of Liebig's views and the power of his influence put an end to the alchemistic theories of plant growth. His theory received a serious blow with the discovery of bacteria, especially of those responsible for the fixation of atmospheric nitrogen, but it recovered and dominated much of the agricultural thinking in western Europe until recent years.

Although the theory was a great advance at the time, it probably did more to retard the development of soil science during the early part of this century than any other factor. In accordance with such a concept, the soil was considered a more or less static storage bin of plant nutrients. But soils are not static. Through the natural processes of development some materials are being lost; others are being added. Fresh minerals are being weathered. Some soils receive frequent deposits of alluvium. Others have new minerals added from beneath as the surface soil gradually erodes. Soils vary greatly in their responsiveness to management quite apart from variations in the supply of plant nutrients, important as these are. The theory singularly failed to recognize the dynamic nature of the relationship between the soil and the plant.

To man the important and significant attribute of the soil is its productivity for useful plants with the use of such techniques as he may employ. A productive soil must furnish compounds containing the required elements in proper balance for the normal growth and composition of those plants man requires for growth, health, and reproduction. This depends upon the nutrient status (fertility) and the physical condition (structure) of the soil. Both these qualities are important to plants and are themselves largely due to the activities of plants, animals, and micro-organisms. Thus the soil is primarily the medium for the growth of living things and is largely a product of living matter. The impossibility of setting up an adequate balance sheet for such a dynamic entity is obvious. Supplies of nutrients must be maintained. Some of our most productive soils require large applications of fertilizer. But the kinds and amounts are not determined by simple bookkeeping.

Since the scientists of western Europe were confined to a region having about the same general features of climate and vegetation, it is not surprising that they did not conceive the importance of these factors. The differences they saw were rather easily attributable to simple differences in slope, drainage, and parent rock. Yet, imperfect as they were, the new ideas stimulated agricultural science enormously. By the end of the nineteenth century, experimental fields had been established throughout western Europe. Chemical fertilizers began to be used with great success. By the beginning of the twentieth century, yields of grain had risen to over 30 bushels to the acre in England and Germany, nearly 300 percent since the death of Lavoisier. As far as western Europe was concerned, Liebig's theory worked.

Thus, in response to a definite and pressing need, western Europe developed a system of agriculture capable of producing far beyond the dreams or hopes of the eighteenth-century democrats. Even though these results were based upon an anormous amount of painstaking research, there still was no scientific system in soil science comparable to that in botany, chemistry, or mineralogy.

Russian Contributions to Soil Science

During the period of social upheaval in western Europe, Russia had remained essentially a medieval empire, controlled by a landed aristocracy. Although educational facilities were available to a very small part of the population, scientific work proceeded somewhat along the lines developing in western Europe, and many individuals rose to great eminence in biology, chemistry, and other fields. Soil science developed along entirely different lines. Whereas the soils of western Europe generally were unproductive unless carefully managed and heavily manured, many of those of Russia, notably the great areas of black soils (Chernozem), were highly fertile and had an ideal structure for the growth of the grains and grasses. Yields were frequently low, to be sure, but this was more a matter of poor tillage, poor seed, unstable climatic conditions, and the method of farming in small strips.

Russia was a vast country, containing within her boundaries many strongly contrasting landscapes and peoples. For the administration of such an empire, it was first necessary to determine of what it was composed. Investigations were necessary to solve problems of colonization and administration. In traveling over this vast area the intelligent observer could scarcely avoid noting the close relationship between climate, vegetation, and soils. Finally, about 1870, there sprung up a brilliant school of soil science under the leadership of Dokuchaiev, followed by Sibertsev, Glinka (fig. 2), Gedroiz, and others. In contrast to the agricultural chemists of western Europe, who studied specimens of soils in the laboratory, the Russian scientists first studied the soils in the field and supplemented these data with laboratory results. They noted that each soil was characterized by a distinct series of layers or horizons with particular characteristics, according to the nature of the landscape with which the soil had developed. Five principal factors were recognized as chiefly contributing to the properties of a soil: (1) Climate, (2) vegetation, (3) parent rock, (4) relief, and (5) age. Slope and parent rock were more or less passive and of local influence, whereas vegetation and climate were active factors responsible for regional characteristics and for the great soil belts running through the Empire.

From the concept that each soil had its individual character as a soil and its own geographic extension as the product of a particular environment, it was possible to erect a system of soil classification in which the various types of soil might be placed. As applied to great regions, the Russians developed such a system, based largely on those characteristics brought about by climate and vegetation, and many of the Russian terms, such as Podzol, Chernozem, and Solonetz, are now used by soil scientists everywhere. Since the boundaries between climatic belts and vegetative zones were nearly coincident in Russia, much weight was given the climatic factor. Modern investigations have shown that native vegetation is more important and that the influence of climate is partly indirect as a determinant of vegetation. The detailed investigations of soils necessary for elaborating the system to include local soil types significant to small units of operation—fields and farms—was not attempted on a significant scale by the early Russian scientists.

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The stimulation of the new Russian ideas was enormous. Already a large amount of information was available regarding soils in western Europe and the United States, but the data were scattered and unrelated. Analytical data and data on crop yields under various systems of management were abundant but of limited practical use until they had been related to definite soil types and could be expressed geographically. In the United States this problem had already been recognized and a beginning toward its solution made in 1899. Field techniques developed rapidly,[4] and by the close of the World War many counties distributed over the country had been investigated and mapped. Thus, in the United States and western Europe, there was a great deal of information, and the formulation of these data into a system founded upon the new principles has been rapid since the World War. That is, it has been rapid when measured in terms of previous accomplishments, but distressingly slow when measured in terms of present need.

Development in the United States

It should not be inferred that the researches of the Russian school were anywhere near complete or that the details of their science were entirely applicable to other countries having different soils and different problems. Because of the similarity of soils, it might be expected, however, that scientific methods that had been successful in western Europe would be equally successful in eastern United States. From a strictly scientific point of view, a great deal from both schools of thought is of tremendous value to us in the development of a body of knowledge for dealing with our own problems. Science knows no boundaries of time or place; no nation, race, or class has a monopoly on the world supply of intelligence or imagination. Yet the development of techniques in the applied sciences must be shaped considerably by the problems to be attacked, and these problems in our own country, if not unique, are at least our special responsibility.

Whereas problems of soil fertility and management occupied the chief attention of agricultural research institutions in Europe, they have received major consideration in only a very few of those in the United States. The availability of new lands in the Ohio and Mississippi Valleys, and finally in the West, relieved any serious pressure of population that developed in the East. Problems that arose in these areas could scarcely be resolved by the European methods, developed where intensive farming was economically feasible and based upon the unconscious assumption that soils differed but little in their capabilities for production. Certainly up to the close of the World War agriculture in the United States was eminently successful, if measured in terms of production or labor income, as compared to that of other nations.

Problems of land tenure, of stranded settlers, and soil depletion, which are serious now, became apparent several years ago. These and many others are parts of the critical problem of land utilization now upon us. Difficulties may be ahead, serious difficulties that might have been avoided. Some glaring mistakes have been made

[4] Without the splendid work in geology accomplished by a large group of distinguished American scientists, many of whom were with the U. S. Geological Survey, such progress would have been impossible. American soil science owes a great debt to F. W. Clarke, N. S. Shaler, C. R. Van Hise, F. Leverett, T. C. Chamberlain, W G McGee, and many others.

and some serious maladjustments have gone long unmended. We could have done better, but by and large, when compared to those of other nations, our soil resources have been used effectively for their principal function—to furnish homes for the people. Recent changes in population and in industry, the growth of great cities, the social and economic influences of the World War—these forces make new adjustments essential. Certainly the answers to these problems could not be expected before the problems themselves were recognized.

Many of these land problems pressing for solution are distinctly of a regional character. This had been recognized by a few American soil scientists 40 years ago. Contemporary with the Russian school, Hilgard of the United States came to somewhat similar conclusions regarding the correspondence among soil regions, biological regions, and climatic belts (*164*). He left a large heritage of data and observations, and, except for nomenclature, his textbook (1906) is still perhaps the best volume on general soil science written by an American. Perhaps Hilgard (fig. 3) came a little too early; whatever the reason, his ideas were slow in taking root.[5] Hopkins in Illinois,[6] King in Wisconsin (fig. 4), and several others have achieved success locally, using the European methods, especially in areas having soils somewhat similar to those in Europe. But many of the problems that seem of great importance now were not realized by people generally until the late 1920's.

Milton Whitney (fig. 5) and his coworkers in the Department of Agriculture began calling attention to the failure of the balance-sheet theory, as applied in the United States, about 1900. A few years later Curtis F. Marbut began his researches in soil morphology and soil geography. Inspired by an intimate knowledge of the contrasting landscapes of the United States and realizing the basic principles underlying any solution of the growing agricultural problem, he seized on the new tools developed by the Russian school and pushed his own researches vigorously along the lines of a new concept. Through these researches, and especially through the influence of his radiant personality, a system of soil classification for the United States was developed.

This does not mean that nothing had been done previously. As a matter of fact, a great deal had been done. The fertilizer industry had grown rapidly, guided by research. Lime for legumes was being used at an increasing rate, and methods for inoculating them with the proper bacteria were developed. Many other techniques were greatly improved. But the data were scattered, incomplete, and too unorganized to answer accurately practical questions as to what techniques should be applied to particular farms and to what degree.

The development of a system of soil science made possible the organization of these data and their utilization in solving agricultural problems. At the same time the inadequacy of our knowledge in terms of the problems to be solved became clearly apparent for the

[5] Another American, C. F. Vanderford, published an obscure bulletin in 1897, The Soils of Tennessee (*438*), in which he called attention to this intimate relationship between soil and plant and anticipated many of the modern views in soil science, especially those respecting soil erosion. Unfortunately his publication received little attention.

[6] For a picture of Dr. Hopkins, see p. 568.

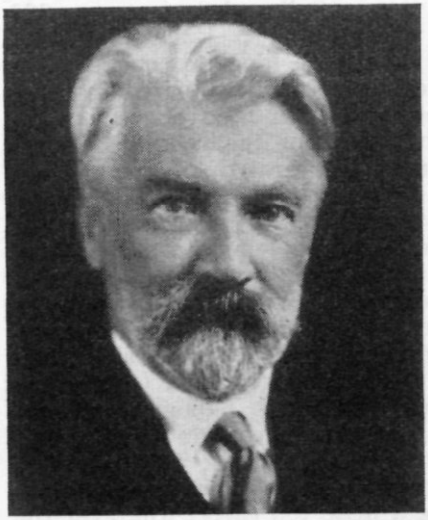

FIG. 2.—Konstantin Dmitrievich Glinka (1867-1927) was for many years the leader of the Dokuchaev school of pedology. The publication of his great textbook in 1914, Die Typen der Bodenbildung, and the translation in English in 1927 as The Great Soil Groups of the World and Their Development, first made the work of this school widely known to western European and American soil scientists.

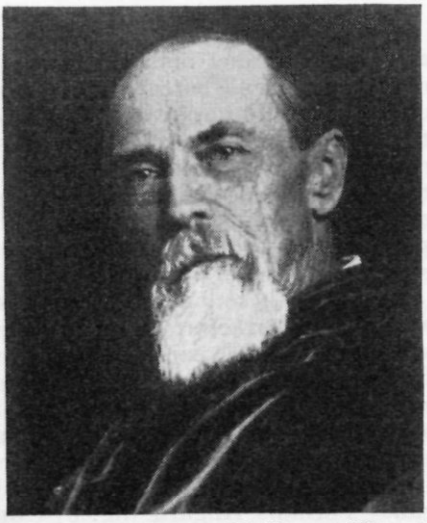

FIGURE 3.—Eugene Waldemar Hilgard (1833–1916), an early pioneer in soil science in the United States, for many years connected with the University of California. He is noted especially for his studies of the relationship between soils and plant associations, of salty soils, and of the irrigation of soils in arid regions. His great textbook, Soils, is classic.

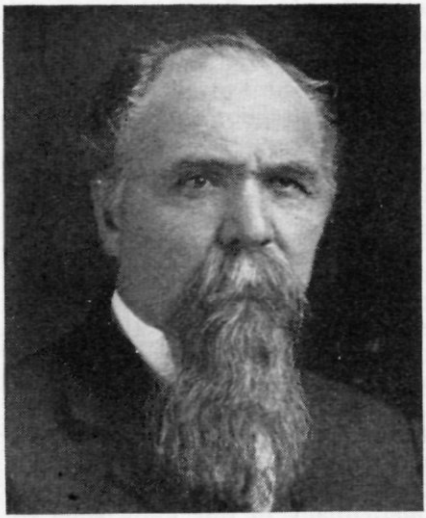

FIGURE 4.—Franklin Hiram King (1848–1911), for many years connected with the University of Wisconsin and noted especially for his work on the physical properties of soils and the relationship of these properties to the use of the soil.

FIGURE 5.—Milton Whitney (1860–1927), for many years chief of the U. S. Bureau of Soils. He began the soil survey work in the United States and initiated many other soil researches which laid the foundation for our present concepts of soil.

first time. At his death in 1935, Marbut left us the foundations for a system of soil science. The staggering task of developing this system in accordance with our national need is still ahead.

FUTURE DEVELOPMENT

Agricultural science as a whole has developed remarkably in the United States, but in a piecemeal fashion. Especially there has been only a beginning in the application of soil science to problems of agriculture and the people on the land, and already there is danger of the application attempting to go beyond the basis of fact that must support it. In part this is due to the late development and recognition of critical agricultural problems in the United States, especially in respect to the land.

Another important factor may be the extreme specialization in the research field. As scientists become more and more specialized and objectives more narrow, coordination of attack in applied fields becomes more difficult. The highly trained specialists may tend to become segregated, cloistered, and to lose their contact with the land and the people who make their living from it. Only specimens of soils may be brought into the laboratory. A soil in the field or in the garden contains moisture, bacteria, and living roots. It is responsive to the rain and the sun. When man uses it, he uses it in its whole environment. Studies of the soil must be made in that environment, which is in the field. Yet without the careful work of the chemist, the physicist and the biologist in the laboratory, field studies are likely to be superficial and illusive. Both laboratory and field investigations are needed, not as ends in themselves but as contributing to the common objective of determining the highest capabilities of our soils in a system of permanent agriculture.

American agriculture consists of many agricultures. Problems relating to the whole can be stated only in the most general terms. Reference to particular regions, and above all to individual farms, must be based on specific knowledge. What is learned in one region may have little application to another. What is a desirable course of action on one farm may be ruinous on another. Especially in the American democracy, the individual farm is important as well as the group or region. Any regional adjustments must go along with the individual adjustments. Thus soil science in the United States must be detailed in its application, must be inspired by an understanding of the detailed problems, and at the same time must recognize regional groups of soils and determine their characteristics and limitations. Both are important; both types of data are essential to any solution of our agricultural problems. Too many of the ideas we have now are generalized from too few particulars and are inspired more by books than by the land; and too many of our books are written simply from other books, not from studies of actual soils and the problems of the people who live on them.

In certain parts of the country a measurable beginning has been made in the development of a body of scientific knowledge regarding the soil; in other parts only a little is known. Fortunately the spectacular problem of soil erosion has lately received some public attention. Yet the broad fundamental problem of the relationship between the

soil and the people who use it, of which the question of erosion is only one part, is less generally realized. Certainly problems of rural land use, of rural health, of rural tenancy, of rural taxation, of rural schools, and many others are realized, and keenly so, by many of our people. What is not understood fully is that these are all intimately associated with the same fundamental problem—the relationship of the soil to the people living on it. Several of these rural problems are and should be studied from the point of view of economics and sociology, but such an approach by itself is, in the very nature of things, only one step, and more or less superficial so long as it stands alone.

Man lives and must work to supply his needs in an environment that is both social and physicial. All the land in the United States could be made to produce crops, and there is none that will produce without labor. What land will be used at any moment, with what techniques, and with what success, depends upon the social and economic frame of reference within which people work, as well as upon the physical environment. Every time the economic and social conditions change, a new physical problem is created, and each time a new technique is developed, a new economic question appears. New problems for both the physical scientist and the social scientist will arise as long as society changes. And when society ceases to change, the end will have come. Students of agriculture are coming to this realization. Soil studies in an economic vacuum and economic studies in a physical vacuum compete for uselessness as contributions to a solution of our land problems.

There is more serious thinking regarding our soil problems today than ever before, and the new American soil science is developing. It is still too early to prophesy how rapidly this development will proceed—whether it will be able to make a real and substantial contribution to the solution of our present problems, or whether they must wait for a future generation. Some of them are serious and may not wait too patiently. The young soil scientist must keep his books, study them, and learn from the past. But above all, may he seek his inspiration from these human problems on the soil.