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CLIMATE, SOIL, AND HEALTH. I. CLIMATIC SOIL PATTERN AND FOOD COMPOSITION

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THAT climate, soil, and health should be put together in this order is more than a journalistic formulation of a short title for this discussion. This order suggests the great fact that our health depends on the soil and the climatic forces that determine it. If we grant the truth of the old adage which says, "To be well fed is to be healthy," then our reasoning powers are not strained to recognize foods as products synthesized by plants (possibly elaborated into higher complexity by animals) and determined as to chemical composition and nutritional value by the soil. Then, if we will associate with these facts our knowledge about the development of different soils from rocks according to rainfall, temperature, wind, and other meteorological components of climate, it soon becomes logical to believe: (a) that climate controls the soil, (b) that the soil controls the nutritional quality of food, and (c) that the quality of our food controls our health of which the teeth are an indicator.

While these connections and interrelations of climate, soil, and health may not have been so clearly drawn and recognized in the past, some aspects of these ideas were implied in the remarks of some German author who long ago said, "Man ist was er isst." In translation, this says, "We are what we eat." Likewise, similar implications were evident in the much-repeated remark of the geologist who said, "We are what we are, because of where we are." Perhaps this is a more highly fragmented way of saying that the environment via the food it provides is a factor in shaping our bodies and our behaviors. Our bodies are products of the climate, then not directly, not according to how wet, how dry, how warm, or how cold we are. We are products of the climate indirectly, or according to the kind of soil the climate makes and how well that soil delivers the dozen or more nutrient elements it must provide in the handful of dust controlling our body's creation.

It has long been the practice to treat some forms of poor health by giving the patient a change in climate. Changes to drier and warmer climates have long been the recommended helps in case of tuberculosis. Here, the climate is supposedly in control of a disease caused by the microbial invasion of the respiratory organs of the body. More recently, rest and proper nutrition are the recommended therapy in this affliction. Very probably, the changes in climate were effective through these very same means, i.e., proper nutrition, since we now know that soils formed under lower rainfalls grow foods that are rich in minerals, high in protein contents, and well stocked with vitamins. Movement of the tuberculosis patient to the drier climate, then, was also a change to better nutrition via better foods grown on soils of higher fertility.

Read before the Fourth Annual Seminar for the Study and Practice of Dental Medicine, The Ahwahnee Hotel, Yosemite, Calif., Oct. 20, 1947.

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We are now in position to catalogue the climatic forces for their services to our good health by way of the fertility of the soil. We can see a general pattern indicating how the climate may keep the soils either under construction or under destruction in terms of their fertility and, thereby, in terms of foods that either feed or fail us. It is the differences in climate that give us the different soils of which some grow the foods to make healthy bodies, sound teeth, and dynamic lives as good social assets; while others make weaklings, carious teeth, and indifferent lives as social liabilities.

Food Quality Comes From the Soil—Bulk From the Weather.—The simple chemical analyses of plant and human bodies by ashing them point out that either of these is about 95 per cent combustible. This major part that burns off consists of carbon, oxygen, hydrogen, and nitrogen, all of which come from the air and water. This large part of the bulk involves but four chemical elements and those are contributed by the weather. Three of them, namely, carbon, hydrogen, and oxygen, are the sole components of carbohydrates, the common compounds making up the major bulk of the plants and resulting from their photosynthetic process. The major bulk of the plant is, therefore, a *suprasoil* and not an *intrasoil* performance.

The ash part of plants, animals, and human beings consists of a dozen or more chemical elements. Any of these present as insufficient quantities brings on some irregularities or failures in the life processes through which there are elaborated the many chemical complexes of service in nutrition and growth. All of the nutrient elements supplied by air and water represent direct contributions as constructive parts of plant and animal bodies. Quite differently for those originating in the soil, many of them do not appear as constituent parts in the final body. They render catalytic and other services, many of which are not yet recognized. Unfortunately, for many of these soil-borne essentials, they are required in such minute amounts that their quantitative variation is still beyond the possibility of measurement. For some of these requisites we do not yet have any valuation, even in connection with any specific body processes. We merely know of the health troubles in their absence.

Since the plant body is built mainly of carbohydrates, the major part of plant growth or its bulk represents feeds or foods of only energy values in nutrition. The plant first puts up its factory. This is built mainly of carbohydrates. For the photosynthetic elaboration of these mainly from the weather, small amounts of some nutrient elements are required from the soil as tools or catalysts even though the resulting sugars, starches, celluloses, and other forms of carbohydrate molecules do not contain them.

It is this increase of bulk by the forage crops as feeds for animals, for example, that we observe so closely. It is the production of such bulk that we use as a measure of the productivity of the soil. The economics of agriculture are built on weights of such masses, since feeds and food are sold by the ton with little or no consideration of their variation in nutritional values. For these reasons, agriculture gives so much attention to the weather. Such is expectable, however, when the carbonaceous products—as elaborations mainly of air and water and sunshine and of only caloric nutritional values—make up the main part of foods and feed; and when the values we use for food rise no higher than the demand for a given bulk for a given price.

In appraising foods and feeds in terms of calories, we have made a good beginning by taking the larger part of their services first. Most of our food serves to supply energy which is most easily measured as calories. The body must be grown first, however, before it can consume compounds for their energy. One must have the furnace before the fuel can be burned. Food serves also to provide the growth of the body. Food must construct the body tissues and also keep them in repair. For this purpose, energy foods or carbohydrates alone will not suffice. For this there is need for proteins, for mineral complexes, for vitamins, and for other complicated molecular structures which are not of simple *photosynthetic origin.* Proteins, for example, are more probably *biosynthetic* products; that is, they are products synthesized by the plant's life processes for which catabolic energy is necessary. They represent the forms of substances through which the life stream flows. When elaborated by the plants, the proteins finally result in the production of the seeds. These represent protein in concentration high enough to be used as animal and human food when the plant as a whole would not so serve.

For the production of proteins, many more kinds and larger quantities of nutrients or fertility of the soil are required than for the production only of carbohydrates. The chemical make-up of the protein molecule suggests that it might well be viewed as the carbohydrate molecule of air and water origin into which some nitrogen, phosphorus, and sulfur of soil origin have been synthesized by the plants. For this process, calcium and magnesium are also requisites even though they are not molecular constituents of protein. Calcium in the soil is a requisite for protein synthesis by plants much as potassium is a requisite for photosynthesis and the elaboration of carbohydrates in their many forms. Legumes, which are protein producers of the highest concentration in their plant tissues, as a whole require generous amounts of calcium from the soil. They draw heavily also on all other fertility elements. It is the liberal supply of fertility of the soil that makes for liberal content of protein and of all other growth-promoting food constituents in the plants. While it is the weather that controls the bulk of crops and the energy values of these as food, it is the soil and its fertility that provide the quality of crops as foods in terms of growth and reproduction.

Ecological Array of Plants in the United States Is Suggestive.—The virgin vegetation of the United States in relation to the annual rainfall and the degree of its evaporation under differing temperatures and wind movement offers a climatic pattern of different plant compositions. The virgin forests were in the southern states east of the Mississippi River, in the northern states over the same extent, and in the states situated along the Atlantic coast. It is in these same regions that there is high rainfall; that the soils are highly weathered and leached of their fertility; that the domestic crops are grown mainly for their carbohydrate values; and that animal production calls for the liberal feeding of protein supplements to make more effective the feeds locally grown.

The virgin prairies were in the western and central United States with an extension eastward across Illinois and as far as western Indiana. These regions have moderate rainfall, their soils are black, deep, and not highly weathered nor leached especially of their lime. These have been the areas of grain production and the livestock grown there has been the main source of animal proteins in our food supply. Here the legume crops grow naturally. It was here that the virgin grass supported the American bison in the thundering herds.

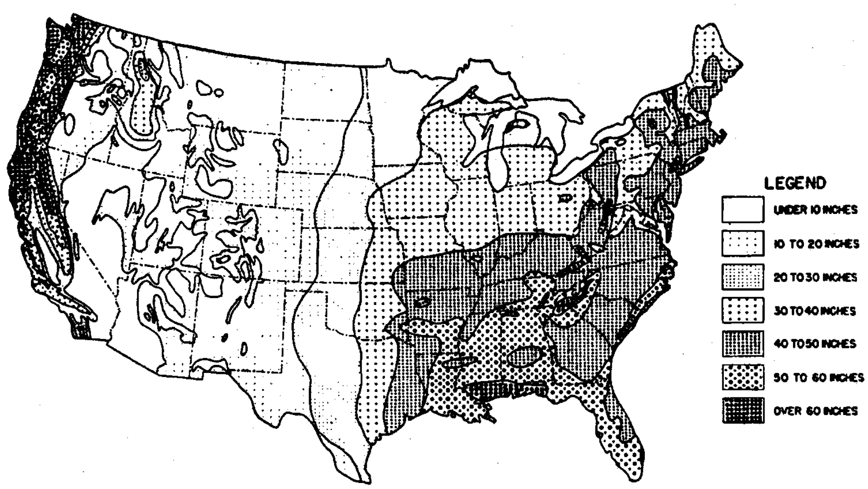

Fig. 1.—Map of the annual rainfall in the United States.

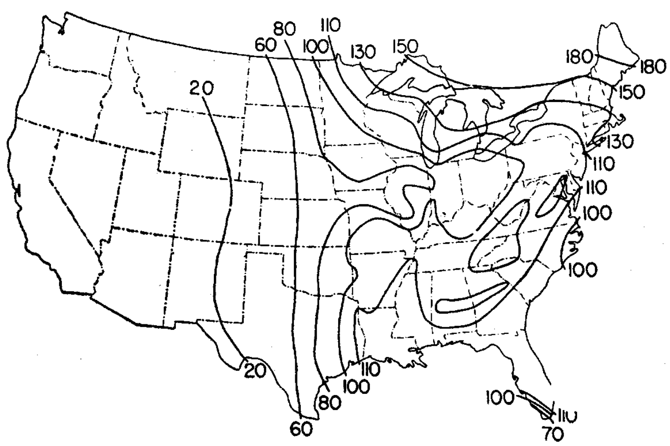

Fig. 2.—Map of the ratios of rainfall to evaporation (times 100) superimposed, giving us the soil map of the United States.

If one considers the increasing rainfall in going from western to eastern United States, there are all degrees of development of the soil along with it. The lower rainfall in the western half represents soil under construction with increasing rain giving increasing food values in the vegetation for animal and human growth. Here the vegetation is mineral-rich. Its composition represents a narrow ratio of carbohydrates to protein. This area grew brawny and bony bison by its virgin grass. It grows our beef and lamb today. Its "hard" or high-protein wheat gives us the true "staff of life," in the whole wheat form. Here are the soils whose foods build muscular bodies, produce sound teeth, encourage fecund production, and give good health in general.

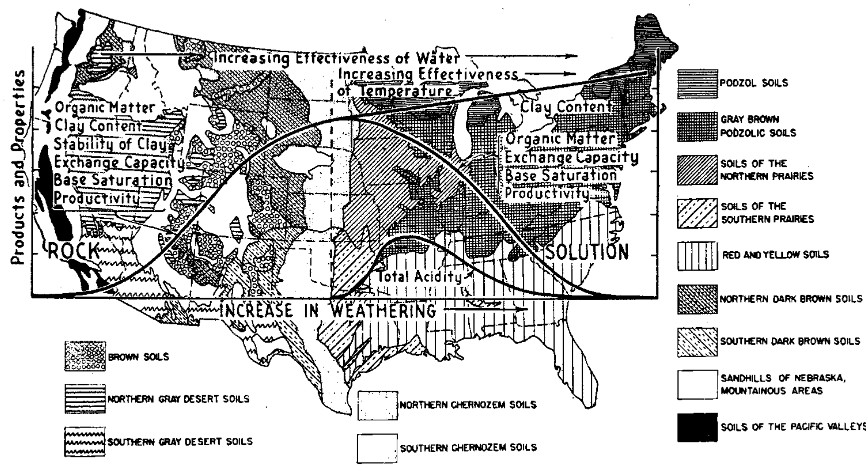

Fig. 3.—Climatic and vegetational soil groups of the United States. (After Marbut, 1935.) The increasing rainfall from the West to the East gives us *soil construction* in the western half and *soil destruction* in the eastern half.

The higher rainfalls in the eastern half represent soils under destruction with decreasing food values for animal and human growth in the vegetation. Here, in general, because the temperature also is higher, much vegetative bulk is readily produced. It is mineral-poor, low in protein, and, consequently, with a wide ratio of its carbohydrates to the body-building food component, namely, proteins. This is the region of the "soft" or highly starchy wheat, the fattening foods, bone troubles, poor teeth, poor reproduction, and poor health through many deficiency diseases.

Principles of Climatic Pattern Verified by Experiment.—Chemical analyses were collected of crop plants native to the regions of different rainfalls in the United States and, therefore, different degrees of exhaustion of the soils of their fertility. These analyses showed that the vegetative parts of the crop plants are lower in their concentrations of the essential mineral nutrients, such as calcium and phosphorus, for example, as the soils are under higher rainfalls and, therefore, soils of higher degrees of their fertility exhaustion. They are lower in nitrogen, the distinguishing element of protein. Thus, the crop products are relatively higher in carbohydrates. As animal feeds and human foods, then, they are filling and fattening in their nutritional effects. But, as for their nutritional values in terms of body building and fecund reproduction where proteins, mineral complexes, and other compounds determined by the fertility of the soil come into play, they are highly deficient as feeds or foods.

Accordingly, then, as the climatic forces of rainfall and temperature are higher in the eastern United States, the soils supply enough fertility, particularly potassium, to grow carbonaceous vegetation. But they are deficient in fertility elements associated with protein production, particularly calcium. As the soils are more exhausted naturally and are producers of the highly carbonaceous and less proteinaceous vegetation, there is a narrow ratio of calcium to potassium in the crop and in the soil. As the soils are under lower rainfall, are still well stocked with fertility, and are producers of the more proteinaceous plant growths, there is a wider ratio of calcium to potassium in the crop and the soil.

Such chemical composition suggests the significant principle, namely, that the more calcareous soils are producers of vegetative growths that contain higher concentrations of minerals, protein, and other elaborations dependent on relatively high fertility of the soil. Conversely, then, the calcium-deficient soils, commonly considered the acid soils, produce plant products deficient in minerals, proteins, and those complexes of high nutritional quality in terms of body growth and reproduction.

That the calcium-potassium ratio of the soils as determined by the climatic forces, representing more fertile or less fertile soils, is in control of the nutritional qualities of the plant products was demonstrated under controlled conditions. Calcium used liberally in the soil with respect to potassium produced a soybean crop of high contents of protein, of calcium, and of phosphorus. When calcium was used in but small amounts in respect to potassium, the concentrations of these soil-borne essentials were low.

More significant, however, was the fact that these latter conditions, namely little calcium in relation to the potassium, gave a yield of crop bulk that was larger by more than 25 per cent. Greater bulk production per acre by one-fourth resulted on the calcium-poor soil. But this larger crop had a concentration (a) of protein of only three-fourths, (b) of phosphorus of only about one-half, and (c) of calcium of only about one-third that of the smaller bulk grown on the calcium-rich soil.

Here is the suggestion that photosynthetic products, like the carbohydrates demanding weather mainly, can be rapidly piled up to make the crop bulk by those plants that will grow on less fertile soils. But the biosynthetic products, however, like the proteins and mineral complexes, are not commonly piled up so rapidly by the crops that demand more fertile soils. Plant composition in terms of nutritional values as food is connected with the climate operating through the soil.

Crop Juggling Encourages Neglect of Soil Fertility.—Unfortunately, the declining crop yields brought on by soil exhaustion have not commonly been a stimulus to soil restoration. Instead, they have encouraged search for and importation of substitute crops yielding larger amounts as bushels or tons per acre. Unheeded has gone the lowered nutritional quality, which is an inevitable result if the substitute crop makes tonnage on the soil which was deficient for the synthetic processes carried out by the other crop. Hybrid corn has fallen from a mean protein content of 9.5 per cent to 8.5 per cent during the last ten years. Its feeding value in experiments with chickens has also been less than that of open-pollinated corn. Crop juggling has not been a substitute for soil fertility. Instead, it has encouraged the acceptance of plant products of lower nutritional values hidden from concern because of our attention to bulk.

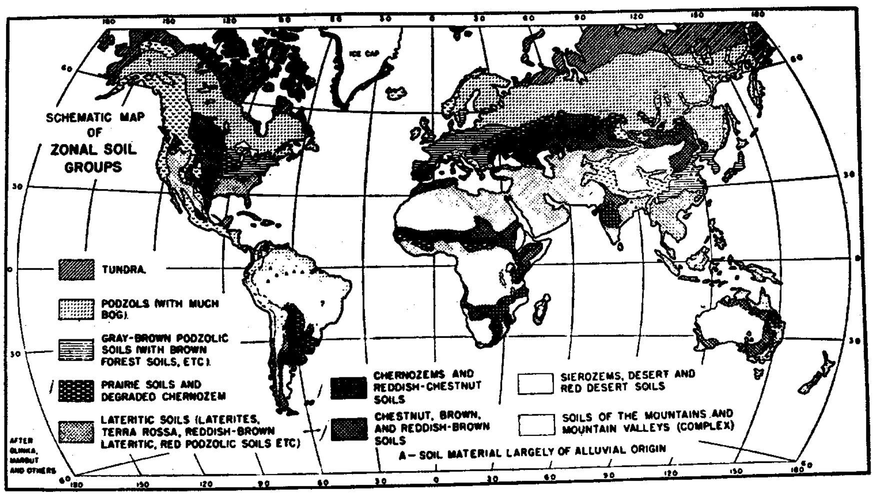

Fig. 4.—The generalized soil map of the world points out the limited areas growing high-protein wheat and livestock, or giving us protein-rich and mineral-rich foods as we find them in the central part of the United States. (Courtesy, C. E. Kellogg and The Macmillan Company.)

The climatic pattern of soil fertility points out that the soil areas producing mineral-rich, proteinaceous foods giving good growth and reproduction are under moderate rainfall in the temperate zones, or in other regions of the climatic equivalent. In the United States, this includes the longitudinal belt of the midcontinent or prairie areas. There the short grasses produced the bison. There the wheat is hard or of high protein content. There the cattle and sheep grow extensively. There the soils are still calcareous and have not been weathered to remove most of the mineral reserves. There it is that we found "the town without a toothache." It is from those soils with the good health of their animals and the good health of their people that we get the prescription by which we can manage other soils to make them give us equally as good health. Our health comes to us, after all, via our food, which is a product of the soil according to the climatic fertility pattern.

CLIMATE, SOIL, AND HEALTH. II. MANAGING HEALTH VIA THE SOIL

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CONCERN about the soil is more than a recent agricultural manifestation under federal stimulation. Those who deal with human food and human health are also showing a growing concern about the fertility of the soil. If "to be well fed is to be healthy," then those who minister to the patient afflicted with poor health, whether of the teeth, or of the body, or of the mind, may well concern themselves with the fertility of the soil by which our nutrition and, thereby, our health are either given us or denied us.

While infectious diseases have been well put under control, the degenerative diseases have increased at an alarming rate. Blood pressure, heart disease, rheumatism, diabetes, nervous diseases, kidney diseases, gastrointestinal diseases, cancer, and other types of degeneration are more prevalent. They now constitute 60 per cent of the total deaths. All other death causes than these make up only 40 per cent, including automobile accidents. We are still far from the realization that the depletion of health goes parallel with the depletion of the fertility of the soil. When once this fact is recognized, we shall study the distribution of diseases according to the soil fertility pattern of the United States, for example, and possibly learn the causes of health deficiencies in relation to soil deficiencies and, thereby, the possibilities of managing good health by way of our foods grown on the more fertile soils.

Increasing Caries Go With Decreasing Soil Fertility.—As a consequence of the second world war, we have only recently gathered detailed health statistics of the portion of our male population between the ages of 18 and 32 years. In these collected records, there is a wealth of vital statistics. Unfortunately, these point out a seriously poor condition of the health of even this younger but supposedly healthier group. Twenty per cent of the first 900,000 were rejected because of dental defects alone. In the state of Missouri, for example, the rejectees for all causes amounted to more than 26 per cent of the selectees. When related to the different soil regions within the state, the percentages of the rejections varied from 20 to 36 per cent, with the increase in the figures in going from the northwest to the southeast, or in going from the more productive to the less productive soils in general. Here is a suggestion from data within the geographical limits as small as a state that doctors and dentists may profitably catalogue our degenerative troubles geographically, and then call in the soil scientists enjoying a close acquaintance with plant physiology and animal nutrition as helps in putting the defects in the soil physiology as possible causes under the defective human physiology.

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Fortunately, some of the facts about the poor health of our teeth, as recorded for almost 70,000 inductees into the Navy, were made public recently. The officers tabulated these records of defective teeth for various purposes by geographical regions. Among the purposes was the need to learn just how many dentists the Navy must have to repair and keep in good order the masticating section of the Navy personnel. For this there were tabulated many kinds of data, among which were the mean number of cavities and the mean number of restorations per inductee. These two taken together give us extensive samplings to permit listing the total number of carious teeth per person between the ages taken according to the various geographic regions. One needs only to rework and rearrange these geographical data in order to make them fit over the climatic soil pattern of the United States and, thereby, show the number of carious teeth as they are different for the different soil areas.

By using these data in this manner, one learns that for the double tier of states adjoining the Mississippi River on the west, the number of cavities per person was 8.38, the number of restorations was 3.70, or the total number of caries per inductee was 12.08 when 16,834 inductees into the Navy were represented.

9.10	8.80	8.38	10.06	11.45	Cavities
6.40	4.30	3.70	4.89	6.10	Fillings
15.50	13.10	12.08	14.95	17.55	Total Caries

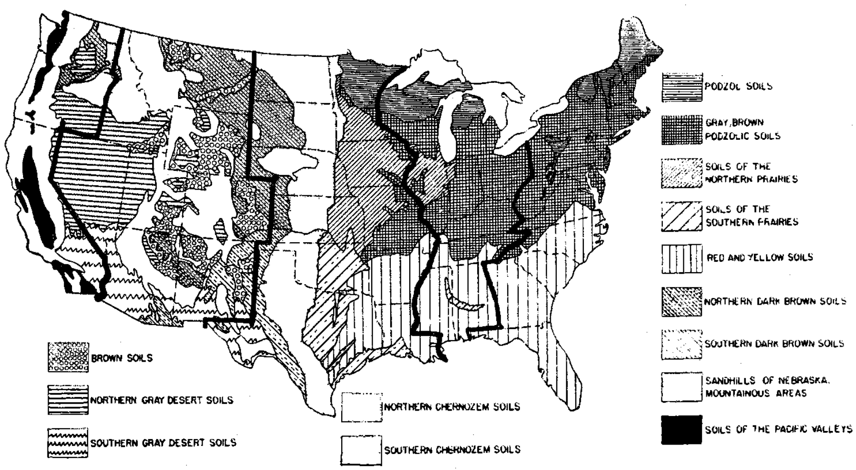

Fig. 1.—Climatic and vegetational soil groups of the United States. (After Marbut, 1935.) The central section of the United States, with its soil development that gives protein-rich and mineral-rich foods, has the lowest number of dental caries. These increase as the soils are less developed in the West and also as they are more highly developed in the East.

For the double tier of states adjoining the Mississippi River on the east, the mean number of cavities per person was 10.06, of restorations 4.89, and of the total, 14.95 per inductee of 13,221 individuals represented. Here, then, in moving from the lower rainfall west of the river to the higher rainfall east of the river, which represents moving from the calcareous to the calcium-deficient or acid soils, there is a significant increase in the caries of the teeth of the younger section of our population.

A still larger number of carious teeth per person was the situation when one goes to still higher rainfalls and the much more highly developed soils of the Atlantic states. By combining the statistics of the separate parts of this eastern and seacoast area, as reported by the Navy, there were the mean numbers of 11.45 cavities, of 6.10 restorations, and of 17.55 totals per inductee when 30,102 were represented.

If one divides the United States into two large areas and takes first the states west of the Mississippi River, with the exclusion of the three Pacific Coast states, there were 8.41 cavities, 3.81 restorations, or a total of 12.22 carious teeth per inductee when 20,506 persons were in the sample. Then, if one takes all the states east of the Mississippi River, there was a mean of 11.16 cavities, of 5.36 restorations, and of 16.52 total per person with 41,596 considered in the lot. In the New England States as a single isolated area with 6,014 inductees considered, the number of cavities was 13.5, of the restorations, 7.8, or of the total, 21.3 caries per person. With such a large number of carious teeth, it seems unfortunate that the human mouth cannot be given more than but 32 in total.

If one superimposes these data by regions on the map of the soil regions of the United States and on the ecological arrangement of the vegetation, it is evident that the highly weathered soils of the northeastern, eastern, and southern states, that once grew forests and now grow starchy, fibrous, and sugar crops, are the soils that are giving the most carious teeth today. Then, also, in contrast, those soils that once were prairies and today are growing legumes freely, or once grew bison but today are growing beef, have less defective teeth. In the presence of such agreements between the pictures of the soils, plants, and animals and the picture of the health of the teeth, one is compelled to give credence to the possible causal connection between the pattern of the decreasing soil fertility and that of the increasing tooth troubles. Such causal connection becomes stronger when these tooth troubles increase as the soils are lower in lime or calcium, and, of necessity, are also lower in the other fertility nutrients which undergo depletion along with that of the calcium according as the climatic forces of rainfall and temperature go higher.

Calcium Is a Fertilizer for Our Sake as Well as for the Crop's Sake.—When one recalls that the teeth are an exposed part of the skeleton and, therefore, consist almost wholly of calcium phosphate, and one also recalls that "the sweet tooth is a decayed tooth," it is no stretch of the imagination to see that the highly carbonaceous foods native to calcium-deficient soils cannot be growth constituents or growth promoters of sound teeth. Foods from such so-called "acid" soils cannot deliver much calcium in the mineral form, nor much in the more complex compounds associated with proteins and vitamins. Dentists have long been campaigning for better teeth through less sweets and more protein-rich and mineral-rich foods. They need also to campaign for more calcium and more phosphorus to be put into the field and garden soils growing those foods. As preventionists, they must look beyond the market place for the source of the health troubles they recognize when looking into the human mouths.

Calcium, in the form of limestone, has been a treatment going on our soils now already too long under the belief that it was beneficial to the crops because of its carbonate that was fighting the acidity of the soil. Lime should be recognized as going on the soil for calcium's sake to help the crops do more than simply carry out their photosynthetic processes of making more bulk. Soil acidity is in itself not a detriment. It is, in fact, a benefit. Soil acidity has been a kind of mental bayou within which we agronomists have been paddling circuitously about when we should have been rowing down the straighter stream of clearer understanding of the many physiologic services contributed by calcium and by all the other essential nutrients commonly present with it.

It is now known that soil acidity is in reality a fertility deficiency. We know now also that calcium encourages protein synthesis by plants. It exercises some role in the root by which other nutrients are mobilized into the plant more rapidly and are prevented from going in the reverse direction or from the root back to the soil. Calcium can be nutritionally more effective for animals when ingested by way of the crop than when taken in the forms of the mineral compounds, since the plants taking it from the soil are doing more than merely a service of hauling minerals to the manger. When the human body contains as much as 1.6 per cent calcium and when this element is at the head of the list of nutrients in terms of amounts that must be contributed to our bodies from the soil via our food, it is high time that we see the ordinary farm practice of liming as a soil treatment for the services of its calcium in better nutrition and better teeth for the human body, rather than only for the services of its carbonate as an agency in neutralizing acid soils.

Acid soils have, lo these many years, been supporting the major portion of the world's population. The neutral and alkaline soils have carried only a minor share. Surely, then, we would not suddenly drive all the acidity out of the soils by liming them to neutrality.

Some experimental studies with spinach at the Missouri Agricultural Experiment Station suggest that the fertilizer treatments of the soil can be managed to make this crop a provider of the calcium, magnesium, and other minerals for which this kind of greens is widely heralded. They point out that spinach, grown on a soil which was well fertilized but left acid in its reaction, is high in minerals that are soluble and thereby digestible. But if grown on the same soil that is well fertilized but made neutral in its reaction in doing so, this spinach contains more than enough oxalate to convert all, and more, of its calcium and magnesium into the insoluble oxalate compounds of them that are thereby also indigestible.

Spinach is, therefore, not always the same because of the same pedigree of its seed. Rather, it is spinach with a service in delivering more or less of the necessary soil-borne minerals in a digestible or an indigestible form according to the fertility and the reaction of the soil that grows it. Here is a case where the environment and not the heredity determines the plant's physiologic processes.

Health for our teeth in terms of spinach as a provider of calcium, magnesium, and other minerals is according to the soil that grew it and the climatic forces that made the soil.

While we have been fertilizing our soils, we have been content to judge the results of the soil treatments in terms of increase in tonnage or bushels per acre. This is good agricultural economics when agriculture looks only to the market. It is not, however, necessarily good nutrition for the consumer. Here, in the case of the spinach there was ample production of vegetative bulk. But, unfortunately, on the neutral soil there was no delivery of increased concentrations or totals of the calcium in the greens as possibly better nutritional services according as there were increased applications of calcium on the soil. The consumer who looks to the market wants to buy more than only stuffing for the stomach. He is searching for nutrition for good health. Many potential helps to health may be carried along in the plants from the soil without manifesting themselves also as causes of increased plant mass. Such qualities are hidden qualities that may combat hidden hungers, rather than give satiation by bulk only. They come only via fertile soils and for our sake more than for the crop's sake.

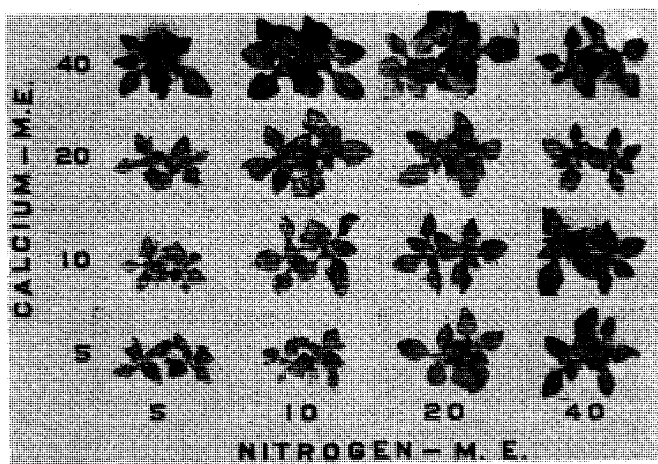

Fig. 2.—Higher amounts of nitrogen and calcium in the soil for spinach protected this crop from attack by the thrips insects (two rows on right), while lower amounts of these protein producers left the spinach open to attack (two rows on left).

Soil Deficiencies in Phosphorus May Be Tooth Troubles.—One can scarcely mention calcium in connection with teeth and not mention phosphorus at the same time. These two nutrient elements are always closely associated in human physiology. When phosphorus plays its roles in plant physiology, here, too, it is usually linked with calcium. Phosphorus as a natural mineral occurs in combination with calcium. Along with these two commonly accepted nutrient elements there is usually a small amount of fluorine, as for example, in the mineral apatite in which all three occur naturally. Phosphorus has always been only a small part of the original rock and, therefore, it is only a meager component of the soil developed therefrom. It is not surprising, then, that phosphorus should be in the soil in limited amounts and be limiting the plant's growth performances and, thereby, the animal and human growths. When the teeth carry so much of this element, its deficiencies in the soil and food may well be expected to register themselves in disturbed tooth physiology.

The mobility of the phosphorus in the soil is determined not only by its concentration and by its total amount there, but also by the requisite degree of acidity of the soil. Highly calcareous or highly limed soils of near neutrality in reaction leave the phosphorus in the less soluble and less active forms. Very highly acid soils do likewise. Hence, only moderately acid soils mobilize this nutrient effectively enough to pass significant amounts into the plants, our foods, and, thereby, our bodies. Phosphorus deficiencies may, therefore, be anticipated rather widely because the soils are widely deficient or have been mismanaged to make them behave as if so. Much is yet to be learned about phosphorus in the soil and our condition of health from its deficiencies there.

Either Acid or Lime in Excess May Be Soil Deficiencies and Diseases.—Just as soils east of the Mississippi River are deficient in many nutrient elements because they are acid, or because the clay is so highly saturated with hydrogen, in like manner are the soils west of that particular line deficient in many nutrient elements because they are neutral or are highly saturated with calcium. Just as such high saturation of calcium immobilizes phosphorus, so it also makes less effective the manganese, the boron, and possibly other nutrients in the soil. The many troubles in growing crops on neutral soils under irrigation are not new to the close observers of the sick-looking fruit trees in our western areas specializing in the production of this type of food. The troubles with cattle that chew bones when grazing over calcareous soils have long been indicative of a deficiency in this element of bone building and reproductive services. Phosphate fertilizers have for many years been the major means of getting bigger crops in the regions of lower rainfalls and, therefore, on the soils still highly calcareous.

If one looks at the map of poliomyelitis in the United States in 1946, it is quite tantalizing to note that this human affliction befell the larger percentages of the population, not on the acid soils east of the Mississippi River, but on the calcareous soils of their northern area just west of that line. Cannot such an observation of a disease pattern as a seeming superimposition on the soil pattern of deficiencies be the hypothetical basis for investigating the possibility that such a baffling disease like poliomyelitis might be the long chain of events originating in some nutrient deficiency in the soil? When calcareous soils are possible deficiencies in phosphorus, in manganese, in boron, and possibly others for our plant and animal crops, may they not be similar deficiencies for the human crop also?

While we have been ready to recognize the extreme complexity of the physiologic processes of the human body that must take its dozen soil-borne elements as food in highly complex compounds, we have not been ready to believe that there is a complexity of the physiologic processes of the plant also taking almost these same dozen elements, but in their simplest form, from the soil. When the plants are the synthesizers of the compounds that are demanded by the animal and the human being as their foods and when plants cannot carry out their synthetic performances only as the essentials for them are properly provided, can we not anticipate deficiencies of some of the dozen soil-borne nutrient elements as probably common for the plant? And then when deficiencies in most of those same soil-borne elements, possibly both in the elemental form and as specific complex compounds coming as food, may be deficiencies for the human body, need we hesitate any longer in seeing much that is called disease as merely hidden hunger originating in the soil?

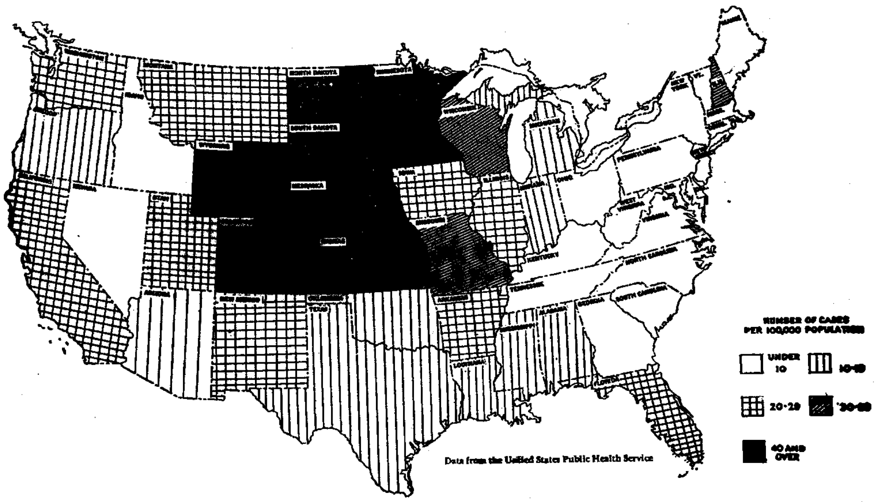

Fig. 3.—Distribution of infantile paralysis in the United States—1946. The concentration of infantile paralysis in the highly calcareous soils with their deficiencies of phosphorus, and possibly manganese, may be suggestive for research on this malady. (Courtesy Merck & Co., Inc.)

Management of Animal Health via the Soil Is Practical.—We have been managing the soil for the health of our domestic animals and recognizing the fertility properties of the different areas as favoring certain physiologic activities by the animals. Cattle men have known the areas where cattle grow well but fatten less well, and those where they fatten well but are grown with difficulty. The major cattle business has consisted of growing them west of the Mississippi River and shipping them east of that line to be fattened. Within an area as small as a single county, the cattle feeders will prefer the corn from one soil area while they frown on that coming from another. The farmers know that the more fertile soil grows animals more efficiently and encourages more fecund reproduction. The animals have been breaking through fences, not to go from one farmed field to another, but from the farmed pasture to the unfarmed area of grass on the public highway or railroad right of way. Cattle have been telling us that they do not care for the very green, tall, grass spots with high nitrogen and, therefore, low mineral contents in the pasture spots marking their droppings. The animal's choice or the bioassay rather than the chemist's assay of the crop has been the better guide for managing the health for the animal.

Diseases of domestic animals and other troubles suggest their pattern according to the soil fertility pattern. Distribution of the wildlife by species suggests a relation to the climatic pattern of soil fertility. More pronounced are the differences in the size of body, in the rate of reproduction, and in the survival under severe seasons of the specimens of the wildlife within the same species according to the fertility of the soils supporting them. In Missouri, the size of the cottontail rabbit and the breaking strength of the bones go down as one goes from the northwest to the southeast or from the more productive to the less productive soils, in general. It may seem to be an odious comparison to point out that as the soils in the state of Missouri grow smaller and weaker-boned rabbits, they also grow men with higher percentage rejections from the military service. Nevertheless, the soils with a low nutritional output as feeds for animals may well be of low nutritional output of foods for man unless man aged with a view of offsetting the fertility deficiencies.

Hope Lies Ahead for Our Management of Human Health via the Soil.—Public recognition of the soil as the source either of our poor or our good health is just beginning. We have been managing our soils with some suggestions for animal health, but even there possibly the instinct of the animal has been a more potent factor than has the master's knowledge about fertility of the soil. It was Professor Evvard of Iowa, the inventor of the self-feeder for hogs, who recognized the hog's good judgment of its feed when he said, "If you will give the pig a chance, it will make a hog of itself in less time than you will." In dealing with the selection of our own foods, the judgment of its nutritional value is wholly our own. It is not a combination of judgments, of which one is the animal's instinctive recognition of the true fertility quality of the soil growing it, as is the case when the feeds are selected for and partly by the hog.

While social and economic forces have been at work to push the quality of our foods farther away from our appreciation of the soils growing them because of mass production, refinements, processing, packaging, preparations—if not almost predigestions—and other destructions or removals of qualities both known and unknown, there is an increasing concern about the quality of our food according to the soil growing it. Managing the garden soil for better health is not a new idea. But when the questioning of a good number of undulant fever patients of a rural area revealed that scarcely a one had thought of better quality in their vegetables by using lime, phosphorus, and other fertilizers on the garden, there is much education in health and preventive medicine to be done by those of us in the fields of agriculture and home economics as well as in the fields of medicine and public health.

Curative medicine as a profession has grown because of the earning it provides. Unfortunately, preventive medicine does not have that same remunerative stimulus. There are not antitoxins to be injected for a fee, nor special drugs to be sold, for deficiency diseases. When we had more than a million folks given to attending the medical needs of 130,000,000 before the degenerative diseases increased so seriously, does the hope ahead lie in more dentists, more doctors, more nurses, and more hospitals? Must we not see our hope in the prevention of degeneration by way of managing the soil to grow good health? Must we not find some way to escape the mounting costs of fighting sickness and disease? If the soils growing our foods are fertile enough to grow much protein, then along with that protective quality will come other benefits. By taking our food from such soils, we will be able to take our vitamins and minerals from the plate with a knife and fork instead of from the drugstore as pills. When more people really learn that it requires fertile soils to grow protein-rich, mineral-rich, vitamin-rich foods and when they also exercise the proper choice of foods that mean good nutrition, we shall not need one-half of the population to minister to the bad health of the other half. We shall more nearly all of us be managing our own health by way of the soil.