Soil and Livestock Work Together

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Livestock is the source of many of our best food proteins. These are the result of complex life processes in the soil, in the microbes, in the plants, and in the animals. All these add up to good food, provided all the essential raw materials are supplied at the starting point, which is the soil. Livestock and soil work together with the soil in control. As a phase of this natural performance of manufacturing proteins, we may well study first the soils under their general fertility pattern as this is suggestive in solving the problem of giving us plenty of protein in the form of meat.

The provision of protein as food is not only a struggle for us humans, but is one for animals and for plants as well. Reproduction—the very purpose of existence—depends highly on this food and body constituent. The stream of life flows, not from one grain of sugar to another, not from one starch cell to another, not from one globule of fat to another, but only from one molecule of protein to another protein molecule. Consequently, if life exists and multiplies itself, it must succeed in appropriating unto itself plenty of protein. This must be done either by the direct synthesis of it from the elements in the weather and those in the fertility of the soil, or by consumption of the amino acids already synthesized by some other living agency. Obtaining protein sufficient for body growth and reproduction is a strenuous struggle, whether it is by the simple microbial cell or the complex human body.

All Life Forms Obtain Their Proteins According as the Soil Fertility Permits

For the human, the protein problem is one of providing both the proper amount and the proper quality of it. As to the amount, this is a problem very often of the economics of purchase. As to the quality, this problem solves itself more readily by choice of those produced by life forms higher in the biotic pyramid, such, for example, as the animal proteins in meat, milk, eggs, and fish. Plant proteins, originating lower in the biotic scale, often leave doubt as to their sufficiency in quality or their completeness in all the amino acids. Fortunately some proteins originating in some forms as low as the yeast, contribute specific qualities coming now to be highly appreciated.

Quality of proteins is a bigger problem according as we consider those given us by life forms of less complicated physiology. The proteins of the complex synthetic potentialities in our meat animals are more nearly like those of our own bodies. They are therefore more nearly complete in quality. Meat is therefore such a universally desired food. Plant proteins too often represent a problem of supplementing them with animal proteins for our proper diet. Microbial proteins have food and feed values too as we recognize in well-ripened cheese for ourselves, and in those synthesized from urea, for example, by the microbial flora in the upper part of the animal intestinal tract for later assimilation during the conversion of feeds in digestive transit.

The problem of proteins for the wild animals is one of finding in the plants all the required amino acids. For this reason the deer browse on only the growing buds, that is, the highly reproductive parts with higher mineral and protein concentrations than the rest of the plant. For this reason deer and other herbivora search out the fertilized fields and cultivated gardens to be considered such terrible marauders. The protein problem for our wild life is serious enough to be a potent force bringing on wildlife extinction against which we are holding out hope while struggling to combat it by other means and in disregard of the soil fertility in control.

For our domestic animals we say it is a problem of "purchasing" protein feed supplements. For some farm animals these can be wholly vegetable in origin. For others they must be both vegetable and animal. For blockaded Britain, this problem meant almost the elimination of hogs and poultry while the farm animals of strictly herbivorous feeding habits were maintained. Here the longer animal gut that permitted more extensive symbiotic services by the microbial synthesizers of protein within it was almost a second Dunkerque in saving that country. The microbes, a life form so low in the biotic scale as to be right next to the soil, played a larger role in solving Britain's protein problem than we are wont to recognize.

The problem for the plant of providing its protein parts represents a still larger struggle. The plant is fixed in place. It must start with the simple elements, and possibly some limited compounds within root reach. From these it synthesizes first its amino acids and then synthesizes the proteins from them. Such is the problem of constructing its body by cellular multiplication, possible only through protein of its own complete elaboration.

Only the plants and life forms lower in the biotic pyramid, according to present knowledge, can synthesize amino acids. It is this plant process, in the main, which makes higher life forms so dependent on plants and through them dependent on the elements of fertility in the soil. It is this dependence of man and his animals on the amino acids—the building stones of the life-carrying proteins—synthesized by the plants generously only on the more fertile soils, that gives a pattern of the protein problem in agriculture. This pattern, in turn, is premised on the pattern of the fertility of the soil.

Synthesis of Carbohydrates by Plants is Mainly a Matter of the Weather; Synthesis of Proteins, of the Soil Fertility

The plant's problem of making the carbohydrate part of its food is not so complex. According to the best knowledge, we believe it a process of the union of carbon dioxide and water brought about by the sun driven chemical process we call photosynthesis. Carbohydrates are the result of uniting these weather-given elements for which but few soil-borne nutrients are required. These are magnesium and iron in the chlorophyl for sugar synthesis; potassium for its conversions into other carbohydrates; and possibly others. But all of these from the soil are required in only very small amounts, and then possibly only in catalytic services with none of them appearing in the carbohydrate itself.

The plant assembles this energy-providing part of itself readily. In fact, the carbohydrate is the basic raw material for constructing the plant mass of cellulose and other major parts of its bulk. This process is the readily recognizable demonstration of increase in size that we call plant growth. It is this carbohydrate synthesis that has long been our measure of agricultural production and of the productivity of the soil. So little of soil fertility is required for mere production of carbohydrates that the deficiencies in the soil seldom impose serious restrictions on this process. Carbohydrates, or energy foods for plants do not represent much of a struggle. They are readily synthesized. They are mainly supra-soil in terms of the raw materials and the energy for their construction.

But for the conversion of the carbohydrates of photosynthetic origin into the proteins of biosynthetic origin, much soil fertility is required. For the growth of the protein-rich legumes, we have long known that the soil must supply considerable calcium. For that reason we have limed the land. We now know that non-legumes, too, require calcium if they are to be more proteinaceous.

Calcium is not only an agent in protein synthesis but is also a potent force in mobilizing other nutrients as well as itself into the plant roots. As a consequence, soils that are not leached by high rainfalls but are still stocked with calcium and other mineral nutrients grow forages, both legume and non-legume, that are rich in proteins and rich in minerals of nutrient values not yet fully understood.

Protein production by our crops, which is recognized more commonly as generous seed production calls for a generous delivery of all the soil-borne nutrient elements by the assembly lines in the soil as well as for a carbohydrate manufacturing activity drawing mainly on carbon, hydrogen and oxygen from the weather. Conditions very commonly permit the plants to produce carbohydrates, but for the conversion of these into proteins the conditions are not so generally favorable. For this conversion some dozen or more nutrients of mineral origin with calcium at the head of the list must be provided. We now know that most plants are potentially producers of much more protein, but that the shortages in the fertility of the soil prohibit their meeting their potentiality and limit them to the delivery mainly of carbohydrates.

Soil fertility comes into decided prominence, then, in the struggle for protein by the plant, by the animal and by us humans. The plant's synthesis of itself as carbonaceous bulk is not seriously stymied by deficiencies of some on the list of nutrient elements we call soil fertility. Nor is it stymied if it reproduces vegetatively. Under such reproduction it maintains the bulk of itself seemingly well. Consequently as long as our observation of the plant as bulk is our only criterion of soil productivity, we are oblivious to the role of soil fertility in making proteins as the important services by plants for higher life forms like animals and man. It is the provision of proteins made up of their many different amino acids that determines the seed yield and the reproduction by plants. It also determines the survival of man and his animals with him. It is via protein production by our crop plants that the pattern of soil fertility gives the ecological pattern of the people in the United States and in the world as a whole.

High Protein Delivery by Plants Occur on the Calcareous Soil Developed under Moderate Rainfall and Temperature

Since soils are a temporary reststop by rocks on their way to solution and the sea, they vary widely in fertility according to the distance they have been pushed in that direction by the climatic forces of rainfall and temperature. In the early stages of this travel, the soils that are still mainly rock because of low annual rainfall, do not contain enough clay. Nor is that clay sufficiently saturated by a diverse list of nutrient elements through extensive rock breakdown to make productive soils. Very often the clay of such soils is saturated with too much sodium. But under increased amounts of rainfall approaching 30 inches annually, and under moderate temperatures like those of the temperate zone, the soils contain ample clay. This soil separate is well stocked with calcium and other nutrients, to say nothing of there being left also plenty nutrient mineral reserves in the silt separate. These by their continued breakdown serve to maintain a relatively high nutrient saturation of the clay. Such soil areas grow the annual and periodically dormant grass crops we call the prairie grasses. They do not allow forests or other perennials to survive their drought periods. This is the region of the highly proteinaceous vegetation that supports the herbivora today much like it supported the buffalo which the pioneer found so plentiful on the western prairies and plains.

Under annual rainfalls higher than 30 inches the perennial vegetation like the forests is common. With these and still heavier rainfalls but moderate temperatures the leaching effects on the clay result in the removal of its stock of adsorbed fertility. The leaching substitutes hydrogen or acidity on the clay for it. The reserve minerals in the silt are weathered out to leave the silt and sand fractions that consist mainly of quartz and hence of no nutrient values.

Under both higher rainfalls and higher temperatures, the clay as the remnant of rock weathering is no longer the silicate compound with its high exchange capacity for nutrient ions. Instead, it represents the loss of silica and is the red lateritic clay so high in iron and aluminum with almost no exchange capacity. It fails to hold even hydrogen or to be acid. It will therefore hold little or none of the many other cations with nutritional services to plants, animals, and man. Tropical red soils then have little fertility absorbed on their clay. Nor do they contain reserve minerals as potential fertility to be weathered out eventually as is true for soils under moderate rainfall and moderate temperature. They are therefore producers mainly of wood. Animal and other higher life there struggles for proteins. Carnivora rather than herbivora are the rule in their fauna.

Soils that are productive, in terms of delivery of protein, then are those developed under moderate to scanty rainfall in the temperate zone. It is on these where vegetative bulk is not so plentifully produced because, as we so commonly say, "there just isn't enough rainfall". Soils that are highly productive in giving us carbohydrates and much vegetative bulk, occur under higher rainfalls. These larger amounts of water, when under moderate temperatures, leach them to a state of strong acids on a montmorillonitic clay, but to a lateritic clay with almost no acidity under tropical heat. For vegetation as a generous producer of protein there must be both enough rainfall for carbohydrate production and at the same time enough of the fertility of the soil for the biosynthetic conversion of this fuel food into protein as the growth-promoting food. This combination of climate and soil fertility is not so universally found. Hence it is evident that protein production is not so universal an occurrence. Rather it is in limed areas. Outside of these areas it is possible only as we duplicate their fertility conditions by our management of the soil.

Soil Fertility and Protein Production Patterns of the United States are Suggestive

A careful study of the fertility of the soils of the United States formulates a pattern of it that gives helpful suggestions for our struggle with the protein problem. Starting from the arid West and going eastward, there are increasing rainfall and increasing degrees of the development of the rocks into soil. This gives increasing clay content and an increasing stock of fertility on that clay until the rainfall amounts to that of about the mid-continental area. The still higher rainfalls then as one goes eastward from there mean the loss of fertility from the clay and the substitution of acidity for it. This increasing incidence of acidity represents a sharp decline in the supply of the many fertility elements. Unfortunately, however, the calcium supply decreases so much faster than the others on the list of soil-borne essentials. This results then in a narrowing ratio of the calcium to the potassium, for example. This fact represents a decided reduction of the protein-producing power inherent in the calcium, while the carbohydrate-producing power represented by the potassium is much less reduced. Consequently, in this lowered ratio of the exchangeable calcium to the exchangeable potassium, brought on by soil fertility removal either by nature or by man, we have the clue for the lowered protein output by the soils while the output of carbohydrate holds up. Here is the chemical foundation in terms of soil fertility from which we must take our suggestion and work in making protein-production possible through judicious soil management.

Up to this time in our land use we have been putting limestone on our soils under the mistaken belief that the benefits from it rested in the reduction of the acidity of the soil by the carbonate radical. Unwittingly, we have been applying calcium and helping to manufacture more proteins in the legume forages. But, unfortunately also we have gone forward in our soil liming campaign under the belief that lime is all that is needed, and that "if a little is good more will be better". This generous use of lime has mobilized out of our soils and into greater production of our crops many of the other elements among which potassium has been most prominent. We are now coming face to face with the soil's need for potassium. We have credited the lime and its neutralization of acidity with working wonders while unbeknown to us it was helping to exhaust our soil fertility more rapidly in many other respects than calcium.

It is essential to remember that we need potassium to make the carbohydrates first in the plant before it can convert them into protein. Red clover was once said to fail because of acid soils. But this crop as a great livestock feed has not come back on increased acreage now that we have the hordes of trucks covering thousands of acres with limestone. It has not come back because our humid soils need potassium as well as calcium. They possibly need also many other nutrient elements if clover is to grow and to manufacture the collection of amino acids that constitute its proteins and make it such a desirable feed.

We have been fighting soil acidity when we should have been supplying calcium as the foremost help in protein synthesis by our crops. We have been thinking only one element of fertility when we should be thinking several. We have been hunting for new crops instead of restoring the fertility to sustain those that are of higher nutritive values because they require more help from the soil fertility to make themselves so. Instead of undergirding the more nutritious forages in their struggle to synthesize protein we have been juggling crops with their production of tonnage per acre as the only criterion. Sweet clover, bolstered by an application of limestone, replaced red clover because the former has a tremendous tonnage-producing power. This replacement has occurred in spite of the vigorous protest of our cattle against sweet clover as a feed for them, and our appreciation of red clover and alfalfa as so much better feed. Soil acidity has been a mental bayou within which we paddled circuitously about when we should have been rowing down the stream of straighter thinking to reach the conclusion that soil acidity is not a serious trouble per se, but is only the reciprocal of the exhaustion of the soil fertility.

We have been Mining Our Soil and Moving Westward rather than Maintain Their Fertility

We have now had enough experience in the production of feeds and livestock in the United States to have the problem areas well located. High output of protein as beef and mutton is most efficient on the soils well stocked with calcium and less weathered of their other fertility elements. It occurs on the soils where plants can manufacture themselves more from the soil and less from the weather and make more protein. High output of fat as hogs may be found where starchy feeds dominate and the lower fertility limits us to crops originating more from the weather to give mainly carbohydrate products. That we have been mining our soils and thereby are being driven westward is now becoming evident. The milksheds of the East are no longer producing milk by means of the wheat bran, the shorts, and the other concentrates moved eastward so freely from the more fertile soils of the western 'hard" wheat area. The largest beef cattle market is now Kansas City with other cities located approximately along the same meridian of longitude also handling more sheep and cattle than ever before.

Right here in the Cornbelt we have swelled in our pride of pushing up the yield as bushels of corn per acre, yet during the last ten years the protein concentration in that feed grain has dropped from an approximate average figure of 9.5 to 8.5 per cent. The bulk-producing and the fattening powers of our agricultural output have held up. But the power for promoting growth and reproduction, which resides in the protein and not in the starch of the feeds, has gone down. Hybrid corn that disregards its need for reproducing itself, does not report to us the shortages of soil fertility by manifesting its increasing sterility. Here in this feed crop, like in the horticultural crops that are multiplied by cuttings and buddings instead of by seeds, the carbohydrate production holds our attention and generates economic satisfaction while no attention goes to the declining soil fertility that is making seed production —and thereby the plant's reproduction—impossible.

Animal sterility, too, is an increasing trouble. We are not apt to see this as a problem of producing protein in the form of sperm and ova dependent on soil fertility via proteinaceous and mineral-rich feeds. Crop juggling with bulk as the objective has brought more carbonaceous and less proteinaceous forages and feeds into our systems of land use. With them have come the increasing animal deficiencies. We are not very apt to see the declining soil fertility as the cause of these and take to treating our soils for their prevention. Instead we are apt to build a false hope on artificial insemination and other contrivances of the breeding business.

Seemingly only by more disasters will we eventually come to see in the fertility of the soil the ultimate of the synthetic performances that give us protein, which not only represents the power of reproduction but the power of growth itself. When only 60 per cent of our annual pig crop survives to be marketed, and when "shy-breeders" cause much of our animal reproducing power to stay idle annually, we need to see that these troubles in their pattern of severity superimpose themselves on the soil. We cannot continually move westward to fertile virgin soils. We must face the problem that we can no longer run away from it.

The Protein Problem is a World Food Problem According to Soil Fertility

Two world wars that were fought under the slogan that "Food Will Win the War and Write the Peace", ought to encourage our inventory of the soil resources that were the food resources by which one group of the fighting nations became the victors while another became the vanquished. We may well look to the soil fertility supplies by which the Three Great Powers emerged in the category of that distinction and only by which they will stay there.

One needs to look at the soil map of the world and to remember that proteins of high food value as found in hard wheat, beef, and mutton, for example, are the products of soils that are only moderately weathered. Such soils and such protein products, then, must occur under moderate rainfalls and in the temperate zone. Such soils with extensive areas of hard wheat and animal herds in large numbers occur in the mid-continental United States. Likewise there are similar extensive areas in the Soviet Republic. It is these soil fertility resources in terms of protein production that give strong suggestions why these two nations are listed among the Great Powers. As for England in this category with them, the British Isles do not have extensive areas of soils that produce hard wheat. But when Canadian soils represent high protein-producing powers, and corresponding soils are extensive in Australia and South Africa—all parts of the British Empire—there is ample suggestion that ships on the sea represent the strength of this third one of the Three Great Powers.

The strength of any nation—in what is too readily considered as a political strength—depends on high levels of fertility of the soils that represent protein production as food. The weak powers, under the analysis for their soil resources, all reflect very clearly their insufficiency as producers of food proteins. It is in terms of soil fertility resources and not of international politics that the world must be inventoried if we are to understand and solve the international food problem. We must realize that it is very acutely a protein problem rather than one of only calories.

Conservation of Fertility Must Become the Major Effort of Soil Conservation

Seemingly we are still nomadic in our hopes and in our thinking about our future food supplies. We are delayed in realizing that about all the land areas of significant protein power have been taken over and put into production. We are still more delayed in appreciating the problem of maintaining in the future the capacity to produce protein where such was a simple matter in the past. We need careful inventories of the fertility resources in our soils, and of the supplies of minerals that can serve as fertilizers in soil fertility restoration. Those of us living in cities, those managing big industries, and all in the congested food-consuming rather than food-producing centers need to understand and appreciate the rate at which our soils are being exploited and not rebuilt. All of us need to aid and encourage soil restoration in terms of those nutrient elements serving in the struggle for protein (a) in the life of the microbe in the soil, (b) in the life of the crops in the field, (c) in the life of the animals, and (d) in our own human lives. We need to realize that T-bone steaks are not grown on city pavements, but only where the fertility of the soil keeps the assembly lines filled with the raw materials on which all agricultural production, and thereby food production, depends.

As fast as that realization comes to us, we shall become soil conservationists aiming not only to stop the damages to the soil by running water, but also to rebuild the fertility strength in the body of the soil. It was by that kind of strength that the soil originally saved itself and that it can do so again under our realization of the fertility facts and by our action accordingly. Only as we build back according to the pattern of the soil fertility can we solve the problem of producing plenty of protein, which as a food product is not the particular concern of the meat industry alone, but of us individuals, of the nation, and of the whole world itself.

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