Soil and Health Library

Let's Live Magazine, January, 1955

Soil Fertility . . . Its Climatic Pattern

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Our North and South are divided much in the terms of soil conditions, as are the East and the West.

As we have more rainfall, starting with none of it in the Western United States and moving East, there is an increase in the soil fertility until we reach the mid-continent. On going further East, there is a decrease of it. However, in that area the clay content of the soil is still going upwards. The soil also shows increase in the saturation capacity in the Northeastern area. But more rain removes the nutrients from that saturation capacity. The exchangeable essentials for plants go down. The acidity of the soil begins to come beyond about 25 inches of annual rainfall. In the United States at 25 to 30 inches of precipitation, we have the highest point of soil construction with a minimum of destruction. More climatic soil destruction comes in as one goes further East.

The pattern of the virgin vegetation, wildlife, domestic animals, our crops and ourselves in the United States as dependent on the soil, the great resource which feeds all of us--all these are more significant than we believe.

What is grass?

Much has been made about grass and grass agriculture. But what, after all, is grass? Grass is a crop that can stop growing in the summer when the dry spell demands it, and then pick up growth when the rain comes. Grass is on a soil which is not washed out as a result of the low rainfall connected with dry spells. It is that extra fertility left in the low rainfall soil that makes the grass nutritious. It is not the variety or the pedigree of the grass.

It was the fertility of the soil and not the variety of the grass that made the buffalo. The buffalo came only a limited distance toward the East. Where did he survive? He survived and was winter meat for the Indians in Kentucky, where they have the fast horses and the fine women today. The buffaloes were also in some of the valleys of Pennsylvania. The buffalo also stayed out West where today we grow the "hard" or high-protein wheat. There is the basic soil fertility, by which the buffalo could survive and reproduce. And there is the basic soil fertility by which we build the stamina and capacity of the race horses.

Percentage varies

In 1949, the protein in Kansas wheat varied from 9 to 15 per cent. Nine years before, it varied from 10 to 19 per cent. While the protein was going down, Kansas was growing more bushels. But it doesn't take much soil fertility to pile up starch and to make many bushels. It does take fertility, however, in balanced and ample supplies to make protein in the wheat.

This difference in crop quality according to soil development in Kansas may well be a pattern for more extensive areas. If we take the chemical composition of the crops in the western United States and analyze them for potash, lime, and phosphorous, the total of these three amount roughly to 5 per cent. Eastward to the mid-continent--where soils are more developed under more rainfall and yet more washed out--the total of these three elements drops to nearly 4 per cent. Then in the East and South, the total amounts to 2 per cent.

Declining fertility

Accordingly, as the soil fertility is weathered or washed out, we are making crops that are made out of air, water, and sunshine--and less out of the fertility of the soil. By virtue of that declining fertility, we are therefore substituting carbohydrate delivery in the crops for the protein and nutritional values that should be in them.

Crop substitutions and crop juggling are no substitution for soil fertility.

We are concerned, you see, that fertility in the soil is the determiner of the kind of life that is anywhere--or in the ecological pattern in general. Because we have technologies to bring foods, feeds, different plants and animals from one place to another, this covers and blots out the picture too commonly.

In greatest numbers

If we make a map of beef cattle of the United States, then, the beef cow--which is mainly protein--finds herself in greatest numbers West of the Mississippi River on soils that still contain ample fertility. They are under only moderate rainfall and not under high ones where fertility is washed out. It is nothing unusual that the beef cows are in the same region where we have champion basketball teams. Growing basketball champions is a nutritional problem much as is the growing of beef. Beef steaks are high priced because the fertility of the soil is slipping out from under us.

If as dealers in cattle we merely want to hang on fat or escape the responsibilities of food feeding of pigs, then we can operate East of the Mississippi River. There we have carbohydrates aplenty. We say the housewife doesn't like fat. But it would be more correct to say that we can't keep the stock living long enough to take the risk. Such are the problems because we are not nutritionally informed enough to know that the soil has a part in the ecological pattern of even our domestic animals.

No difference

The nutrition of man as the two-legged animal is no different in fundamentals than the nutrition of the four-legged ones.

Unfortunately for us, the four-legged animal has nutritionally helpful instincts to guide it. Man seemingly has thrown away those instincts which once guided him in feeding himself well. He hasn't developed enough knowledge and understanding to make his good judgment an equivalent of the animal instinct.

Degeneration of his own body through failure of proper nourishment is really the problem which we ought to approach, now that degenerative diseases--more than microbes--are killing us off.

Perhaps I would not be entirely out of place to predict for the 20th Century that it will probably be the time when, in terms of better understanding of ourselves and our health problems, we shall emphasize nutrition. In the 17th Century, we studied anatomy; in the 18th, we learned about physiology; in the 19th, we investigated bacteriology.

Now probably we can piece all those sciences together until the 20th Century will emphasize the fundamental knowledge on how to feed ourselves, so that we shall not degenerate, even in the absence of microbes as our enemies. As we cease to fight the microbes and turn to nutrition, there is hope that we shall eventually come to understand how to feed ourselves. The climatic pattern of the soil fertility considered in a large way will give us suggestions by which we can see these seemingly subtle forces at work. As we fill out in the details of that pattern, we shall get still other suggestions by which we can very probably nourish ourselves in reality from the ground up.

Speaking of horse sense, wasn't it the horse that used to be afraid of the automobile at the time that pedestrians were laughing at it?

Let's Live Magazine, February, 1955

Problems of the Small Farm

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I feel this subject of the small farm is so important to the suburbanite that I wish to present herewith Mr. Johnson's report.

Prepared for the
Missouri Agricultural Experiment Station
by O. R. Johnson

Any inquiry in the general field of "Scale and Resource Productivity" cannot avoid the small farm as an important segment, not perhaps because of the physical contribution to the market supply, but rather because of the number of farm families involved and the physical resources under their control. Thus, in human and other physical resources, an enormous potential productive force is involved.

If the 833,501 farm operators in the North Central States--reported in the 1950 Census, on farms of less than 100 acres--were to contribute $2500 each to the supply of farm products sold from farms in 1949 it would mean an annual contribution of two billion dollars. This figure can scarcely be regarded as insignificant. This is over and above what they actually consumed directly on the farm. This $2500 is probably a conservative estimate of what such farms could do, if their human and physical resources were used as effectively as are the upper 50% of the resources in this category.

What is a small farm?

Obviously we must first attempt to define the meaning of the term "small farm" as we expect to interpret it in examining the problems of the small farm. For this purpose inquiry was made of the state representatives of the North Central Region to obtain all the assistance possible in establishing practicable boundaries of this segment. There seem to be two commonly accepted requirements of any size measure. One is some expression which will indicate the amount of employment of the operator's family, and the other, the amount of income ordinarily received from the farm in a year. Neither of these make any reference to efficiency in use of labor, or quality of production, which might result in a larger or smaller income. Each must refer to typical management and representative market prices for the product.

Definition

Both employment and income seem to imply some minimum adequacy concept. This is illustrated in the expression by one state representative that a farm may be too small if--"when organized around the type of farming that the resources are best adapted to it, falls short of providing a level of living equal to that which the farm family might reasonably expect to obtain in other lines that they are qualified to engage in."

Another representative states: "Farms with less than 150 (productive) work units might well be considered small farms." Still a third suggests that small farms are "those making poor use of resources." It would seem that this could include some farms in most any acreage or income category.

Less than average

Another statement was that a small farm should be "one which has less than the average of all resource inputs in any given sample of farms." It may be difficult to adapt this definition to the analysis necessary to reveal the level of resource productivity. Assuming a normal distribution, this could include about half the farms in any random samples Most farm management studies of income reveal some very satisfactory farm business units that are below average in one or more input factors.

Another definition was as follows: "--a farm is small when it gives no more than 12 months' productive employment under optimum levels of capital and technological employment on the unit." This definition is restricted to the physical level and avoids confusing the quality of management with the adequacy of the physical setup. All respondents who disgussed this question either implied or stated outright that in such a small farm class, hobby or part-time farms should be excluded.

Part-time operators

One might question this conclusion when considering that nearly half of all farm families, living on less than 100 acres, do an appreciable amount of outside work and might, therefore, be regarded as part-time farm operators. Furthermore, it is possible that these families have become part-time farmers as a result of the growth of cash requirements in fanning, and have chosen this means as the most likely to produce the supplemental income necessary to avoid serious reduction in living level. This suggests that we might well re-examine our definition of what constitutes a small farm business unit.

Analysis

The small farm possesses features not readily adapted to usual techniques in scale and resource productivity analysis. The value and possibilities of the small farm in our agricultural economy may not be as readily measured as are those of more clearly commercial farm units. It is quite possible that values of a more subjective nature may more nearly determine a farm unit's importance in this category. These values may go a long way in explaining the persistence of the small farm, which more objective measures cannot explain. Productivity of the usual physical resources are ordinarily

measurable in specific statistical terms. The fact that small farms persist in the face of adverse reports of economic feasibility and effectiveness, and the growing menace of cash operating requirements, should suggest a re-examination of the evidence responsible for such reports.

Many cases are known where resources below the optimum combination under other circumstances or environment may yield satisfactory results on small farm units.

Let's Live Magazine, March, 1955

The Pattern of the Small Farm

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Results on small farm units may be so satisfying as to enable such operators to persist through more than a generation. We may be justified in questioning the adequacy of our studies--in revealing the limitations and possibilities of the so-called optimum combination of resources--until we are able more accurately to appraise the psychic or subjective factors involved. These may be more significant resources than we think, and we cannot be expected to determine what constitutes an optimum combination until we learn how to include subjective values. Forces in the physical world may not be the only determinants. Indeed they might riot even be the major ones.

The history of the past quarter century has made our former concept of inadequate small farms fairly useless. As the spread between producer and consumer price has increased, the significance of farm contributions to living has increased. Formerly a contribution of a home and three or four hundred dollars in farm products was a substantial sum. While producer prices have since increased, charges to the consumer for goods and services have advanced much more. Consequently, a small farm can save the family more than double its contribution 25 years ago. The rise in costs of services farmers normally provide for themselves would provide even greater contrasts between small farm and urban incomes.

Location and concentration

Strangely enough, small farms are not found on the frontier as it was once known, nor on the highly productive soil areas where the acre would be much more effective in physical production. In states with large industrial developments, small farms cluster near industrial centers where at least half of them hold non-farm jobs for up to 200 days of labor. The other area of concentration will be chiefly in areas of moderate to low productivity and generally rough topography. The least concentration is found

in the plains states and in the heart of the corn belt. Here farms tend to be large in acreage and to be characterized by either extensive livestock production or heavy grain production and feeding, with a high degree of mechanization.

This shift in concentration provides the chief contrast between present and former small farm problems. If we allow for some distortion because of local industrial or other non-farm employment opportunities, small farm business units are found to occur more frequently on land with poorer soil or rough topography. This is true throughout the north central region. Industrial markets or job opportunities or cheap land will explain most of the concentration.

Limited resources

This is understandable to those acquainted with the problem of the farm family with limited capital resources. Labor supply and management are the abundant factors; consequently, space in which to work becomes of greater concern than does the productivity of the land. Considering a family's needs, acreage operated should vary inversely with the productivity of the land.

The substitutability of land or labor or management for capital has been given some attention, but no comparable attention seems to have been given to subjective factors which may be responsible, in part at least for the lack of agreement between our objective analysis and actual performance observed in the field of small farm operation.

Abundant capital

Those with abundant capital tend to settle on good land or in a favorable location and to supply themselves with ample equipment. Those with limited capital are forced to content themselves with the poorer lands and more primitive equipment and methods. One result is the clustering of small farm business units in areas more congenial to such limitations. In such areas ownership becomes a highly regarded status, and the utilization of the labor of the entire family on an opportunity-cost basis goes quite a distance in successfully substituting for capital which the family does not have. This may be a real strength in competing with commercial wage and other costs accepted as a matter of necessity on commercial farms.

There are doubtless more factors involved in any adequate small farms study, many of them no doubt as significant as the ones mentioned. The present review will not allow further examination of non-physical aspects nor of those determinants that do not at present possess a well recognized price denominator.

Small farm production

Measuring the contribution of small farms to physical production--in the north central region--can be only approximately achieved from the evidence at hand. The federal census counts the number of farms by acre groups, and also by total sales for the year 1949. Using these available statistics, a rough idea of the contribution of small farms to the physical volume of production contributed to the market is obtained.

The north central region contributed nearly one-half of the cash receipts from farm marketings in 1950. However, all farms selling less than $2,500 worth of products, contributed only three per cent of the total. No single north central state furnished, from these small farms, as much as one-half of one per cent to the 28-billion dollars' worth of farm products sold. These small farms did receive a house and products contributed to the family living, in addition to the value of products sold.

Let's Live Magazine, April, 1955

Income Problems of the Small Farm

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The numerical importance of small farm units far exceeds the significance of their contribution to the market supply of farm products. One third of the farm families of the North Central Region sold less than $1500 worth of products; and 45 per cent sold less than $2500 worth.

When it is remembered that these families must meet cash operating and living needs from these sales, it is not surprising that a large per cent depend on income from off the farm to make ends meet, and to have any opportunity to save.

Outside work

Nearly half of these families did some outside work to supplement cash income from sale of farm products. More than one third did at least 100 days of work off the farm for pay. It is also worth noting that 38 per cent of them had outside income exceeding their cash receipts from farm marketings.

The significance of outside income seems to decline as the size of the farm increases up to the arbitrary 99-acre limit for small farm. Over half the smallest farm operators had outside income exceeding their income from farm product sales, while less than one fourth were in this situation on the 70-99 acre group. The greatest shrinkage was found in the states of group 2 where either the land was highly productive, or the farming was intensive, giving income from sales more significance than would be true in either less productive land areas or areas where industrialization of the area economy is more developed.

Close approximations

All these facts are necessary in properly appraising the position of small farm business proprietors. It must be kept in mind that all these figures are only close

approximations, based on census and other United States Department of Agriculture data which are chiefly the product of sampling. It is believed that they do not seriously distort the picture.

The increased demand on the farm operator's revenues, which has developed over the past decade, has forced him and his family to do just what many non-farm families have done, namely, to resort to outside sources in earning income in order to meet unavoidable increases in cash requirements which present operations or employment cannot yield. This situation must be reckoned with in properly appraising the present situation of the small farm business operator.

Small contribution It has been noted that these small farm operators make an insignificant contribution to the total agricultural product that reaches the market. The market price for that product may, or may not, adequately reflect the full importance of the contribution. The non-farm employment created by this contribution, the consumer function related to non-home produced goods, and the element of stability which this segment contributes must be included in any fairly adequate appraisal of the real contribution of these families to the total economy.

A further item of great economic and social significance is the young people that these families rear and eventually release to other vocations. This item will add substantially to the real value of total contributions by agriculture to the overall economy. This migation from the country to non-farm vocations at approximately the beginning of the young person's productive years, after the farm family has met practically all the cost of rearing, represents collectively an enormous export of capital from the farm to non-farm category.

Government payments

Acknowledgement should be made that government payments to agriculture constitute a part of agricultural income. This item was something less than 200-million dollars for the whole United States in 1949, or less than $40 per farm if spread evenly over the entire agricultural population. It is not included in the cash receipts from sale of farm products quoted earlier in this series of articles.

So far as is known, no one has attempted to assemble a complete list of the debits and credits for any segment of agriculture. The foregoing summary for small farm operators makes no such claim. Only readily obtainable major items have been included.

Let's Live Magazine, May, 1955

Use of Resources of the Small Farm

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Emphasis on outside employment for a considerable part of the labor resource is a significant indicator of efforts of small farm families to make more complete use of the labor supply. Nearly half the families use this means. Consequently, in appraising the effectiveness of resource use this must be given considerable weight. Furthermore, close inspection of the state data shows some tendency for small farm families in more industrialized areas, to give more days per year to outside work. Whether this is because of need, or because the opportunity is there, is not known. Probably the latter is the explanation.

Search for other hints, indicating degree of effectiveness, revealed the type of power used, and may be of some significance in judging the use of the labor force in getting farm work done: Forty per cent of the farms under 100 acres used tractor power. The proportion was highest in the lake states; lowest in Kentucky and Missouri. In the state of Kentucky over half the farms in the small class used horses and mules exclusively. Michigan was the least user of this kind of power.

More achievement

Here the assumption is that human labor resources are probably better utilized where tractor power is more prevalent. This implies nothing with regard to costs of getting the job done, merely that an hour of man's time probably accounts for more achievement.

There may be less effective use of capital accompanying greater use of power on small farms. However, one may equally well question whether or not it is wise to substitute capital for labor wherever the job is adapted to power operation.

Many tasks

There are many tasks on most small farms which have not yet been successfully mechanized. Thus a tractor might conceivably justify itself in releasing the labor force for work which the tractor cannot do. We might even go further and predict that timeliness in performance, and saving children from drudgery or field jobs they could not do without power, may well justify our re-examination of present input-output relationships. When our hypothetical reasoning leads to conclusions contrary to trends in practice, then it may be time to re-examine the reasoning.

There are many obstacles encountered in attempting to apply customary measures of resource productivity to small farms. Usually we deduct all costs (resistances) from the value product and deprive net productivity.

Sentiment's part

Sentiment plays a large part. Sentiment changes as social or economic conditions and goals change. The economist is inclined to criticize the small farm unit because of its obvious economic inefficiences. The social economist (?) and the layman are inclined to defend vigorously the small farm unit because of its past glory, or present unmeasurable values, which cause the maintenance and possibly the expansion of an apparently uneconomic business unit. Or, are there some significant values which the economist has ignored or failed to recognize?

At any rate, small farm business units have persisted through the years of mechanization and they now may have convinced us that their economically unmeasurable contributions are worth retaining even at public expense. Even though they violate most economic laws their sins are forgiven them. Their non-economic virtues seem to have triumphed; or, were such virtues really economic virtues after ail? Is the small farm, with its own labor and management force, its own capital, though meager, its freedom from domination by workers with no ownership interest, its guarantee of a job but not of wages, of a part of its food supply and a place to live, its escape from the wrath of laborers directed at those who finance and direct the workers efforts or who save and invest--destined to become a highly desirable way of life?

Completely commercial

Or, are we too impatient at the hesitancy to shift from the premechanized age to that of fairly complete mechanization and commercialization? Is it possible that the small farm operator, unable and unwilling to commercialize, may possess a strength heretofor unsuspected but fully adequate to support the family through the struggle between capital, labor, and government for supremacy in our economic life; and when the decision is reached, to emerge stronger--comparatively--than those more affluent who quickly embraced the idea of industrialization, but who, like the Kulaks, were soon displaced by a government dominated order?

Some further questions suggested by the persistence of the small farm in these years of exalting the mechanical and submerging the personal factor, may aid us in explaining this apparent paradox.

Is it possible that we are ignoring individuality in both labor and leisure? Might not labor actually become leisure?

Social order

In this great impersonal social order, may not a farm operator and his whole family place a high value on working together?

Are we sure that full-time employment is cheap employment or even efficient?

Why must one constantly adjust his rate of performance with that of his co-workers? How much originality is buried on the assembly line? Is the average efficiency determined by the ability of the least effective?

Is physical volume of output an adequate measure of quality of citizenship or loyalty to democracy?

Small farms better?

Is there any evidence that people from small farms are any better or worse than others?

Are we measuring non-physical production factors as fairly as the physical in trying to measure resource productivity?

Are there satisfaction values which may be highly significant in determining resource productivity? How many units of physical production are equal to the surrender of free choice of a way of life?

Let's Live Magazine, June, 1955

Why Small Farms Are Popular

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All of the north central states have appreciable numbers of small farm business units. And their numbers increase as states industrialize. They are also greater in non-industrial areas on lands of lower productivity or lack of topographic adaptation to mechanization.

The contribution of small farms to the total volume of agricultural production in the North Central region is relatively unimportant.

As a labor resource in industrial areas these small farm units have a high value.

Greater independence

As an escape from urban rigidities or a laborer's status, small farm units offer possibilities to those who prefer greater personal independence--often at some sacrifice of facilities available in town and in highly productive rural areas.

However, most facilities essential to health and basic culture are today within reach of most small farm families.

Comparatively recent developments in the plant and animal sciences offer economic improvement to many small farm operators without sacrifice of the freedom from regimentation awaiting them in many non-farm vocations. 1

Some acceptance

There is some indication that a considerable degree of acceptance of the idea of regimentation is being developed among small farm operators. It is evident that purely economic efficiency cannot be as highly developed on small farms as on larger, better adapted units. However, larger farm units are encountering non-farm costs and

regulations which eventually may reduce some of the obvious efficiencies in balancing resources.

Two problems

The problems, then, seem to center on retaining freedom of choice of a way of life, and being sure that choice is based on fairly complete information concerning what is involved.

Supplementary to these two major problems are some aids which are already well recognized, such as:

Balancing resources to maximize the product of their use.

Eliminating obvious misfits by supplying information concerning better opportunities.

Providing more complete information concerning the eventual results of apparently innocent steps in the direction of regimentation and socialization of agricultural production.

Developing educational programs in extension designed for small farm families to promote more effective use of resources, take advantage of outside opportunities, and understand better the moves to curtail freedom of choice of the farmer and his family.

No price fixing

No significant improvement in cash farm income can be expected through price manipulation because of the small volume of product sold from a large segment of these small farms. Some of these farms, no doubt, possess advantages which will permit greater application of capital and other factors to intensify operation and expand materially the output for sale, but this development can hardly be expected on a large per cent of the small farm units.

A high degree of integration between farm people and non-farm industries to develop more complete use of the agricultural labor force can be expected to contribute to the income of many more small farm families, and to labor needs of a significant segment of industry.

Unfortunate

It would be unfortunate if families with insufficient financial resources to acquire and finance the operation of a commercial farm were denied the opportunity to acquire a small farm on which to live the kind of life they prefer. Our responsibility would seem to be to neglect no effort to see that such families have full understanding of the possibilities and limitations involved in such a program.

Problems of adequate schools, health facilities, recreation, public revenue, communication, and police protection must be examined carefully. It should still be true that these essential services and facilities are an obligation of the general public

to all its young people. Any lack of these facilities should not be considered a sufficient cause for denying to small farm families the right to live out in the country, work together, pay their fair share of the cost of community facilities and avoid the non-farm environment if they so choose. If reasonable opportunity to earn enough to pay the family's share of the cost of such facilities does not exist, the remedy should be in a zoning procedure that applies to any proposed settlement of areas where such costs are unreasonable and prohibitive.

Let's Live Magazine, July, 1955

Creating Good Soil is a Challenge

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When 85% of the population of the United States is urban and only 15% is rural, it is quite evident that our high standards of living are expectedly associated with business, with economics, and with industrial activities of which the assembly line of technological manipulations may well be highly symbolic.

Nevertheless, when one sees the golf links near every city, and the parks within it, they suggest that human beings still yearn for the rural scene with its growing grass and all that the open country and its biological exhibitions of living, growing things can offer.

Back to the soil

Whether it be the backyard flower-gardening wife, or the golf-playing husband of the city-dwelling couple, each is merely giving vent to the universal atavistic inclination to get back to the living soil. They exhibit their desires for contact with nature's assembly line out-of-doors by which the creation of growing things in the open country is so commonly brought about. That is, an assembly line which starts and stops itself with the turn of the seasons, but without either concern or control by man.

Careful observation of any industrial assembly line, however, points out that even it doesn't run itself. Even here where the materials are inert, dead, fixed in quality, and not perishable; and where the final product is only a machine, or a gadget; yet the living human mind is in direction of it.

No exception

The agricultural assembly line within the soil, under Mother Nature's direction, is no exception. The sand and the silt are the mineral reserve sections. From them, by the weathering process, the inactive nutrient elements of crystal structure are broken out to become ionicly--or chemically--active. Other elements, put into new combinations of different secondary minerals, form the clay. This clay is another and important depot along nature's assembly line within the soil.

The clay is the assembly line's major section or depot holding the exchangeable stock of calcium, magnesium, potassium and other cations, or those ions with positive electrical charges. It may also be holding some anions--those with negative charges--like the phosphate, sulfate, nitrate, bicarbonate, and others. These latter, however, are

more often held, and then passed on to the assembly line of agricultural production from the organic matter depots within the soil.

Flow of elements

Thus, within the soil, there is a flow of fertility elements under their own activities, from the *rock to the clay,* and from there *to the root,* all in the presence of ample moisture by which, as a medium, these ionic activities are possible.

This fertility is the control by the soil of creation to which the sunshine supplies the power; the soil contributes the stored water; and the air gives the carbon dioxide originating mainly in root and microbial respiration in the soil; and in which the carbon and the water are fabricated by plants into the carbohydrates--that is, sugars, starches, cellulose, etc.,--the energy foods for the plants, the animals, and man.

True food

Thus the green chlorophyll of the leaves really creates what is truly food for the plants. It is from the digestion of these that the plant gets its biochemical energy when within its cells it burns the sugars, or the fats made from these sugars, just as we do in burning carbohydrates and fats in our bodies.

It is from the burning of parts of these compounds in the plant tissue that energy is provided to make the nitrogen combine into some of the changed carbohydrates, and thus to synthesize the life-carrying protein.

Organic matter

Plants so growing and so dying with their decaying roots left in, and the tops returned to, the soil are the organic matter from the digestion of which the microbial life within the soil must get its energy. It is thus that there results a living soil. Under virgin conditions, then, or starting from the beginning of the mineral earth, the soil is first a rock that is making a temporary rest-stop on its way to solution and to the sea.

But soon it is no longer dead, inert, wholly inorganic. It is changed from the inorganic and dead material to become organic and the living soil. It contains carbon. It supports a microbial flora. It contains a micro- and macro-flora. It is combustible. It takes in oxygen. It gives out respired carbon dioxide. It is truly living.

Inorganic determiners

Soil is not a technological assembly line where only collections of the non-living are built together, or merely assembled, and managed by man. Instead, it starts with the inorganic determiners of the course of creation.

When a dormant seed, a rootlet, or a cutting--all living parts from other life--give the opportunity, these determiners at the various depots integrate--not only add--their contributions. The inorganic materials in a limited or less limited list of elements set the degree of complexity of the creation. The organic matter adds its many items as

elements in cycle, in the form of compounds not fully recognized as yet or understood in plant nutrition for their hindrance or their help.

Assembly line

It is then the living soil that truly creates, since the organic matter under decay contributes compounds actually taken by plant roots as we know sugars, vitamins, and other compounds are. Thus it is a living soil with its assembly line integrating its many items which in summation mean growth by living forms.

Let's Live Magazine, August, 1955

Biology vs. Technology in Growing Things

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Because our daily experiences of our living are so extensively and intimately geared to technology, and because so many of us are too far removed from what is truly biology, the growth of our agricultural crops is viewed as if it were a technological matter which we could readily manage.

In the argument for that there is often cited the hydroponic tank with no more than water and a collection of salts of the inorganic or the ash constituents of the crops to be grown. But we have not demonstrated the hydroponics as means of growing very many kinds of crops, save for those which are mainly a vegetative, cellulosic mass carrying much water, sugar, and starch.

A challenge

Tomatoes, potatoes, spinach, flowers, and similar crops whose reproductive potential has not been tested for a series of generations of growth under hydroponics have been demonstrators of this procedure. As a challenge to the hydroponic technology using the flowing, very dilute, often replenished, inorganic solutions, let us ask the proponents of this method (who are probably opponents of the highly organic soil as a necessity for crops) to grow one crop of mushrooms in their hydroponic tank as a substitute for the rotted manure of the mushroom bed. The crop growth by hydroponics, claimed to be rapid, is no match for the speed with which the mushroom mycelia literally "run" through the bed and grow the mushroom crop.

Helpful demonstration

But, as a beginning, and for a good start in our understanding of what makes things grow, the hydroponic idea is a very helpful demonstration. It uses water as a means to dilute the inorganic salts. It obviates the danger of too much salt. It permits renewal of the salt supply, since only by an enormous amount of water under such required dilution could enough salts be delivered to mature the crop.

Water, however, is the medium for ionization of the salts to make their elements active for root entrance. Soil areas of crop production must contain both water and fertility compounds. Dry soils with salts in excess are the saline and alkaline areas with no crops. Hydroponic technology uses solutions so dilute that it duplicates the laws of gaseous behaviors and does not duplicate the soil where within root-reach the nutrient supply dare not be in highly concentrated salt form, but yet must be large enough in quantity, and in active form, to mature a significant crop.

Far different

Soil, as the assembly line, is then far different from hydroponics. So is the mushroom bed with its rotted manure. Decaying organic matter in the soil, similar to the clay there, is a colloid on which adsorbed nutrient elements are held, and from which they are exchanged to the plant roots. Also for the nutrient release, by the decay of the organic matter in the soil, the increasing rate of this process is timed to be highest when the seasonal conditions suit the speediest growth of the crop.

Nature has synchronized these two performances--that is, the decay of the residues of past crops and the growth of a new crop, by making the increased rate of decay of the organic matter within the living soil provide the means of increased nutrition of the crop above the soil.

Nature's management

Hence, the cause of the crop growth is a living soil under nature's management. Crop growth is not the result so much, then, of a technology under man's manipulation. Rather, it is an exhibition of the biology of Mother Nature.

Organic decay is an agency for the increased weathering of the disintegrated rock. By it the living soil makes the dead rock elements become active to support more life. Our thinking has not pushed forward our understanding of what makes things grow. Our comprehension of those processes has not gone much beyond the "solution" idea of hydroponics. We have not yet seen the soil as the handful of dust into which the moist breath is blown by the weather, nor comprehended how that can mean the creation of life. There is reason, then, why--for so many folks--there is as yet no concept of the "living soil." Hence, there can be no living soil in their vision when so commonly "we are down on what we are up on."

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Organic Soils and "Good Constitutions"

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That the soil is living may well be illustrated in trying to bring about a loose soil structure in a flower pot, or in the putting green of a golf course, by mixing peat, sawdust, or other cellulosic matters with the soil, and then discovering that the potted plant or the grass crop does not grow well as a consequence.

Very often the plant or crop turns yellow. The grass appears to be "burning out" and fails in spite of good rain or applied water. The farmer experiences the same with the damage to a fall-seeded wheat crop after turning under much straw of a preceding wheat or oat crop, or the stubbles of a matured soybean crop. The wheat crop, followed the turning under of such cellulosic organic matter--supposedly to enliven the soil--is said to be "burned out." On the contrary, it is apt to be "starved out" for the nitrogen taken away from it by the living soil's crop of living microbes. These are in competition with the grass sod crop and of the golf green, or with the wheat crop of the farmer, or with the plant in the pot, not so much for water as for nutrients.

Balanced nutrition

The living soil must, first of all, be balanced nutrition for the microbes, the major life of the soil. This life in the soil is the soil's primary crop that must be fed properly. It eats at the first table set in the soil. The grass crop, or any other supra-soil growth, eats at the second table. The high carbohydrate contents of the sawdust, the peat, or the straw, are not carbohydrates of energy value to the plants.

Plants use sunshine energy and chlorophyll to make their own energy foods by photosynthesis. But, plowed under and buried in the soil, those highly carbohydrate substances are energy food for the microbes with too little nitrogen or protein added along with it, or stored in the soil, to balance this large allotment of carbon.

Energy supply

They draw that nitrogen supply in the soil down far below the level required for nourishing the competing crop with nitrogen. Thus, the living soil given too much of only energy supply in the organic matter, and too little growth-promoting nitrogen or protein with it, feeds even the microbes with a poor diet. As a consequence, their competition with the crop means just that much too poor a diet for the latter. The agricultural crop is thus "burned out" and must be a poor one because it was on a truly living soil. But that living soil was one not fertile enough to feed two families--

namely, first the microbes under Mother Nature's management and, second, the crop plants under human nature's management.

Nutrition from the soil for microbes and for the plants may be under *not only a shortage* of any element, *but also* under *imbalances* in regard to combinations of many of the nutrient elements when we manage the soil as only a technological procedure that dumps on fertilizers, whether organic or inorganic, in the belief that "if a little is good, more is better."

Poor biology

This policy of generous applications of even the supposedly insoluble limestone rock as a soil treatment has now shown itself as a case of poor biology, though it might be considered good economics and excellent technology.

Fortunately, the microbial life of the soil tolerates any shocks of imbalance in soil treatments better than they are tolerated by our crops. The living soil can stand up under shock better than the crop can. Hence, the naturally higher levels of organic matter in our virgin soil, and the accompanying much larger numbers of highly active microbes, have been what might well be called the "constitution" of the soil. This term implies about the same as the doctor indicates when, in speaking of his patient, he says, "He has a good constitution." By that statement the doctor merely designates the biological capacity of his patient to survive in spite of, rather than because of, the doctor's technological treatments.

"Good constitutions"

Our soils of high organic matter content have thereby had "good constitutions" through the protection of which the commercial fertilizer prescriptions have been successful, rather than because of the knowledge of their biological function and behaviors in the soil exhibited by those prescribing them.

If, then, we are to grow good crops of nutritious food--a good grass agriculture feeding our livestock, a fine lawn, or an excellent putting green, which can continue to grow while we cut it back often--it is well to build up the soil in organic matter as well as in the inorganic chemicals. That means a good soil constitution to grow the grass in spite of, if not because of, the able green's keeper and all he tries in hoping to make the grass grow continually.

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The Soil's Assembly Line

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Growth of any vegetation is always promoted by cell multiplication (except in some cases like the watermelon in which what seems to be growth occurs because the cells are only expanded by putting in more water.

Any cell multiplication calls not for carbohydrates, not for fats, but for proteins delivered regularly, and all else usually accompanying the proteins. Proteins are also required for protection against disease, and for reproduction of the species.

Assembly line

If the growth of grass in a pasture, on a lawn, or on the golf green is to be maintained, the soil's assembly line must be delivering fertility steadily with nitrogen and all other required helps for protein production--coming both prominently and regularly. Any protein synthesis calls for many life processes supporting it. They need not be merely in gear or running. Instead, the must all be doing so in complete integration, coordination, and interaction with each other. It calls, therefore, also for many intra-soil conditions like aeration, relative moisture, limits of temperature, and others, as well as certain supra-soil conditions for the processes to run the plant's assembly line of making carbohydrates, proteins, fats, vitamins, etc., from the elements and compounds to be truly growth.

"Better" pasture grasses are not necessarily "better" as feed for the animals because they make more mass and more complexity of the protein. Better grasses must make more protein to protect themselves from diseases. They are also makers of protein in seed, as their method of reproduction, in place of multiplying by cuttings, rhizomes and other vegetative means of keeping the species surviving. *We must see the plant struggling to grow itself, to protect itself and to multiply itself. We must help it in those objectives of its own survival first and its services to us second.*

Living body

In this there is a basic principle--namely, that the grasses in their growth are a living body. There are many requirements to be satisfied if the physiological processes within the plant are to be maintained at a high level. Also only as those functions are more numerous and more complex do we have vegetation that is apt to be called "better."

It can be such only as the soil is "better" in its fertility supply, in the moisture, in the air, and in the biological dynamics which keep it living and active in all that a soil does when it grows plants. To keep on growing is the plant's struggle for which we give it all too little support via the soil.

Little chance

First of all, we like grasses best--whether pasture, lawn or golf green--that keep on growing regularly. But we clip grass back and give it little chance to grow tops by which to build reserve nutrients into the root system. That root system is, therefore, shallow. Regrowth after every clipping back calls for nutrients reserve in the roots and a high level of fertility for protein-making, since only protein synthesized within the plant results in plant growth.

Instead, we dodge that nutritional responsibility to any plant that can serve us. We start to search for another grass as if grasses could be found that will tolerate starvation coming via the soil. Only as the soils are living providers of the soil fertility and an environment which keeps grasses producing protein--not just vegetative bulk--can a crop be expected to be kept on living, especially if pruned back regularly by the cow or the lawn mower.

Fertility imbalance

The imbalance of fertility for a shallow-rooted crop is common if we expect to grow it by a hydroponic procedure with a dead soil serving as only the site for the demonstration. Salts and water are too much of a shock treatment. That kind of treatment represents much of what is man's struggle to make grasses grow themselves. But after composting the fertilizer salts with the organic matter to let the microbes take the shock and bring about their own quick recovery--as is true in the compost pile--the composted and transformed salts combined with the decayed plant residues represent a new constitution for the soil. Such composted matter put into the soil represents better microbial liberation of fertility, more water retention, regular temperatures, and a timing of the rate of decay by the season, to keep grasses growing.

Naturally, there are some climatic limitations for truly "living" soil. One must therefore appreciate man's possible error in his high hopes to grow certain grasses where he fails to observe that nature never grew them.

Not natural

Bowling on the lawn is common in Great Britain. The game of golf rose to its height in one section of that country. Pastures are the idol, as it were, of the Herefords, the Aberdeen Angus, the Shropshire, the Clydesdale and other animals with British-sounding names, as real grazing. But when grasses are moved out of that setting as, for example, southward--even within the north temperate zone into high temperatures and spasmodic distribution of rainfall--they are no longer "naturally" on what is truly "living" soil for them.

Soils are not living under our control, rather we are living under theirs.

A matter of biology

While we may think technology is so readily under control of human nature, we dare not forget that the soil as a creative manifestation by Mother Nature is biology--not technology. Industry may readily exercise control of what it does, since it deals only in technology. But agriculture cannot exercise such control since it deals mainly in biology.

Managing the soil is not just technology. It is also biology since the soils that truly feed us, that grow proteins, and that keep crops growing will do so only if they are truly living and not dead soils. They must be considered (1) in their climatic setting, (2) in relation to the physiology of the crop they are to nourish, and (3) the biochemical as well as the chemical services at all times in the growing reason, if their assembly lines are to put out the maximum for our pleasure and profit by the growing things.

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Some Aims of Soil Research

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Much as the definition of research depends on the person doing the defining, so the aims of research may depend on the one who is doing the aiming.

For our purposes here let us exclude from true research the repetition of previous researches for greater refinement, and of facts already established and reported.

Modern techniques of measurement permit refinements today which were not possible a short time ago.

Feeding trials

For example, in animal feeding trials in low winter temperatures and summer highs, it was established long ago that the animal accommodates itself, by means of extra feed, to temperatures below 70° F. But the animal cannot accommodate itself so readily to temperatures above 70° F. Now, with modern refrigerator aids and heating apparatus, it is possible to study the animal's physiology by increments as small as a degree or two--and thus refine the basic facts of former research.

This repetition under more refinement scarcely is research unless it adds new facts and new principles, or it shifts the temperature figure previously established.

Evolution of research

Research in its evolution of new knowledge usually includes four steps or phases--(1) observations; (2) theories prompted by those observations; (3) experimental tests of the theories; and (4) conclusions drawn from the results of the tests.

A few of the aims of some soil research--rather than what soil research in total is aiming to do--may be briefly outlined here.

Holding nutrients

For many years our soil research has aimed to understand how soil can hold plant nutrients in sufficient supply for an entire season when the same nutrient supply, if put into a solution as plant growth medium, would demand--for the necessary dilution--more water than the soil could retain within root reach. If put into solution in the water within root reach, the resulting high salt concentration would kill the seedlings.

As another aim in soil research, the dynamics of ionic adsorption and exchange suggested the theory of a contact area of the colloidal root and colloidal clay as the center of the chemo-dynamics, by which nutrients are held in quantity and exchanged to the advancing root, which is offering for them the active hydrogen originating in root respiration.

Fortunately, for these aims, some funds which had accumulated from the sales of legume inoculation, and an able young Swiss chemist reluctant to leave the United States after the expiration of his scholarship visa, were the combination to facilitate the testing.

Legumes consume

All this told us that legumes--representing a proteinaceous root with higher adsorbing energies than the non-legume roots with less of protein--will exhaust soil-fertility to a much greater degree in a single crop than the non-legumes.

Naturally, then, the non-legumes can be grown on the same soil for many more crop successions than the legumes. Whether the plant is producing mainly carbohydrates, or is converting much of these into proteins, is significant in many aspects, connecting themselves with the suite of ions going from the soil into the roots and thereby into the plant.

As the plant produces more carbohydrate and more bulk, the efficiency of nitrogen as nutrient would be considered to go higher. According to the theory of Willcox, the maximum amount of nitrogen to be taken from an acre of soil should give over 6 tons of dry matter per acre in soybean forage; over 13 tons per acre in corn; and almost 56 tons per acre in sugar cane--all of these from 318 pounds of nitrogen.

The mineralogy of the soil is now a returning and revived research aim. Professor E. W. Hilgard, author of an early work on soils under date of 1914, recognized at that early date the mineral reserves in the silt more than he did the fertility adsorbed on the clay fraction, as the sustaining fertility of soils under a long period of regular productivity.

Colloidal clay acid

Aided now by progress in the science of mineralogy, the colloidal clay acid comes into crop production via its action in processing the insoluble mineral reserves for sustaining fertility as well as via the soluble compounds of the starter fertilizers it adsorbs and exchanges to the plant roots.

Just what soil research is aiming to do depends on the individual who is aiming. It will depend, not on a majority vote of any scientific body assembled, nor on agronomists grouped according to geographic, agricultural, or economic categories. Rather the aim of research will be higher as the vision of the researcher can be extended by more basic facts at his command for extrapolation of his thinking far enough into the unknown to bring maximum benefit to agriculture and all that is dependent on it.

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Make Tax Allowance for Fertility Depletion

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The 85 per cent of us living in urban areas do not yet feel any obligation to help maintain the fertility resources coming to us gratis from the people in the rural areas.

How soon will we wake up to the obligation we owe to those who maintain reasonable levels of soil fertility so that we may be fed well?

We are set up in urban commercial businesses and industries of which the laws, economics and taxation procedures are so formulated under carefully lobbied legislation that our capital investments in them are self-perpetuating. Even for the minerals or rocks taken out of the limestone quarry, for example, the owner-investor may be allowed a depreciation, or depletion, figure as high as 15 per cent of the income. For the owner-investor in an oil well, it may be a larger amount. The capital investment in these mineral businesses is soon recovered.

Cuts farm capital

But for the mineral fertility taken out of the soil and delivered in the crops to the urban population without charge for it, there is as yet no economist or authority on taxation suggesting the justice of a depletion allowance to the landowner, or investor in that kind of real estate, for the perpetuation of his soil fertility capital in his farming business.

His investment in the minerals in the soil for the food production for all of us is being liquidated gradually under the economic thinking (or the lack of it) which contends that the farmer is thereby taking a profit. On the contrary, he is compelled to throw his financial, and our national security by installments into the bargain every time he makes a sale of his products. Those of us on the urban receiving end of that transaction get those installments gratis and flush them into the sea.

Soil exploitation

We are parties to the crime of soil fertility exploitation, but yet are crying against the rising costs of living. We are slow to see that such short sightedness in our economic, agricultural, and other policies toward the fertility resources in the soil are undermining seriously our national security.

All this is the more serious with a growing pressure on the soil's production potential by our own increasing population to say nothing of that by the rest of the world calling on us to share that potential with them.

Lime helps

Liming our soils deserves consideration as an operation undergirding our future security in food, and particularly those foods of high protein content.

We have long known that lime is needed for legumes. We are slow to see that need as one for the production of the protein, rather than the tonnage yield of the crop. It is lime via that route that gets us our meat, milk and eggs. Viewed in this light, one cannot escape the question whether we dare expect the farmer to continue liquidating his fertility assets under the false concept of taking a profit and at the same time ask him to purchase large amounts of calcium and magnesium to aggravate his rate of liquidation all the more.

Isn't it about time that as a basic agricultural policy we design the required machinery of economics and taxation to guarantee the self-perpetuation of the farmer's fertility capital which must feed all of us, both urban and rural?

Same views?

Perhaps now that the fertility restoration by liming the soil is moving itself into the more exact category of soil chemistry for the nutrition of our plants, our animals and ourselves--should not the maintenance of the soil fertility and thereby of agricultural industry be interpreted by the same views in economics and taxation as those prevailing in other industries?

Perhaps we can bring about self perpetuation of our soil fertility capital under the agricultural business in the rural areas in the same manner as perpetuation prevails for monetary capital under all businesses in our urban centers.

If that situation is consummated, then liming the soil for calcium's sake will become big business by meeting the major needs in our soils--namely, lime and other fertility-restorating aids through which there can be guaranteed greater national food security for the future of all of us.