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Joseph B. McDonald

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The Nature of Agriculture

II. THE PLACE OF AGRICULTURE IN HUMAN AFFAIRS *

By considering agriculture as a cooperative art, we have been treating of its generic nature. Now, attending to its place in human affairs, we will treat it in terms of its purpose, which is equivalent to saying, in terms of its specific nature. For just as the form determines the nature of natural things, so the end determines form in the order of practical arts. Thus the specific character of the art of medicine is taken from its end, which is health ; so that whatever form in the activities of the art it must be determined by what is needed to restore or maintain health.

Now the end of any art can mean more than one thing. In the first place it can mean the end of the operation itself, and this end is the proper end of the art as such. In another sense it can mean the use which the product of the art is to serve. It follows, of course, that, regarding the use made of a thing, its production is a means. For this reason, an art which makes use of a thing bears upon the art which produces it as a means to its own end. And, since the means are subordinated to the end, the art which concerns the means is subordinated to the art which concerns the end. To use the words of St. Thomas :

> . . . Every practical art considers both the end and the means. For the art of the helmsman does indeed consider the end as that which it effects and the means as that which it commands. On the other hand the shipbuilding art considers the means as that which it makes, but it considers that which is the end as that to which it refers what it makes. And again in every practical art there is an end proper to it, and means such as are proper to that art.[1]

There is no difficulty in assigning the purpose of agriculture ; its proper end as well as the end to which it refers the product. The proper end of this art has already been refered to as crops, which are, for the most part, food, although a significant part of agriculture's products are other goods, such as cotton, rubber, hemp, etc. That to which these effects are refered is the needs of the members of the domestic and the civil communities. But the arts which are concerned with the use to be made of these products are the arts of economics

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* For the first part of this study, see *Laval théologique et philosophique*, Vol. XIV, 1958, n.2, pp.186-212.

1. *Summa Theologica*, *Ia IIae*, q.8, a.2, ad 3.

and politics, for these are to govern the activities of the domestic and civil communities respectively. In this respect, therefore, agriculture is subordinated to economics (that is, the domestic art), and to politics.

In the *Politics*, agriculture is considered in both these respects. By so doing, St. Thomas says, its nature is determined ; and this is the proper concern of the philosopher.[1] In fact, the entire treatment of these arts of acquiring possessions is undertaken from their relation to economics and to politics. Aristotle first approaches these arts by asking whether they are the same as economics ; or whether instead they are part of economics ; or whether they are neither, but rather ministerial to economics. It is plain, St. Thomas says, in his commentary, that they are in some way related. A ministerial art, he explains, is one that makes something to serve another art. Agriculture is among the first of these arts to be considered, because, as he explains, by means of it not only food but all other goods may be acquired — i.e. by exchange and trade.

St. Thomas then makes it clear that these arts are not the same as economics, for it is the office of economics to make use of the things that are needed for the domestic community, whereas it is the duty of the wealth getting arts to acquire them. But an art by which a thing is acquired is different from the one that makes use of it, as is clear in the case of shipbuilding and navigation. Now, since money and all other possessions minister to the needs of the household, the arts by which these possessions are acquired are ministerial to economics — and to politics — rather than being part of it. He then goes on to show that these arts minister to economics by supplying it with tools rather than with its materials, just as the art of making shuttles serves the art of weaving — for money, and other goods serve economics as instruments.[2]

Now food and other necessities may be acquired either directly from nature, or by means of exchange or purchase. St. Thomas first treats of the arts which acquire things directly from nature, and then of the arts of exchange and money making.[3]

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1. I, lect.9 : " He (Aristotle) says first, therefore, that since we have treated of the wealth getting arts sufficiently in those things which pertain to knowing about their nature, it is desirable to speak briefly, now, concerning those things which pertain to their use, that is how they are to be followed : for all matters of this sort, which pertain to human operations, can be speculatively considered, because it is easy to consider them in general ; but, however, experience with them is necessary, if man is to become perfected in their practice."

2. I, lect.6. — In this place St. Thomas uses the word " pecuniativae " for all of these arts, in a general way, because all other possessions may be acquired by money and, conversely, any of the other possessions can be a means of acquiring money. Moreover, as the text explains, all the other arts lead naturally to the acquisition of money.

3. *Ibid.*, lect.6, 7 and 8.

He establishes the nature of the simple arts of subsistence by a significant comparison between the manner of life which other animals lead, and that of men. Now it is not possible to live without food ; and there are many species of food, suitable to the different species of plants and animals. From this diversity in foods there arises a diversity in the mode of life, both of animals and of men. Among animals, it is seen that some live together peacefully and in groups, while others live separately, by strife, according as their natural food is plentiful and easily found, or not. Some animals live on plants while the food of others is animals, and another kind lives on both. Now those that live on animals live by struggle and separately, otherwise they would not find food ; whereas, in general, those that live on plants, live together and without struggle.[1] The food which men eat differs in a similar way, and their mode of life differs accordingly. Some get their food without either labor or predatory activity, and their life is the idlest. These are the pastoralists or shepherds, who live from domesticated animals. Their only work is to follow their animals from place to place in order to find food. Others live by predatory activity : either they live on the wild animals of the forests, the plains or the waters, such as hunters and fishermen ; or they get their possessions by robbing and plundering. The third kind of simple life is that which is followed by most men, who get their food from the things that grow in the soil, by labor ; these are the farmers. And this last group, together with those who live by trade and business, enjoy an abundance of goods.

Three properties are shown to belong to these simple modes of life which men follow : first, that they are natural forms of acquisition, secondly, that they subserve economics and politics, and third, that they have limits. The reason for calling them natural is this : nature does not, on the whole, leave anything imperfect nor make anything in vain. But it is seen that nature provided nourishment for animals, both at the beginning of their life and when they are matured. Thus nourishment is provided for embryos in the egg, and for baby manmals in the form of the mother's milk. At maturity nature continues to provide nourishment, for some animals in the form of plants, and for others in the form of animals. And, in turn, both plants and animals serve the needs of men. But when a being acquires that which nature provides for it, this is a natural form of acquisition. Thus those arts which are concerned with acquiring the necessities of life are natural arts. And they fall into two groups ; the predatory arts and agriculture.

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1. Cf. BABIN, *op. cit.*, p.73. This division should not be considered as properly biological — it is to be found elsewhere in Aristotle's works — but rather as schematic division with a view to a premiss for an argument.

He then shows that these arts subserve economics and politics : for it is necessary for the acts of economics and politics that those things be acquired and stored up which are required for the needs of life and the utility of the community, both domestic and civil ; for neither can be governed without the necessities of life.

In order to show that these arts are limited, a distinction is made between true wealth and another kind which is its opposite. True wealth consists of those things which satisfy the needs of nature. But the things which are acquired by these arts are true wealth because they can relieve want and supply those possessing them with a sufficiency for living well. But there is another kind of wealth which is not genuine wealth, because it cannot satisfy the appetites of man. Now the wealth which consists of the necessities of life, has a limit for the following reason : no art requires an infinite instrument, either in number or in size. The art of metal working, for example, does not require an infinite number of hammers nor one infinite hammer. But the aforesaid wealth is a kind of instrument of economics and politics, because it is used in managing the household or the civil community. Therefore it is not infinite but has some limit ; and for this reason so do the arts by which it is acquired.

From the foregoing argument of St. Thomas, some conclusions can be drawn as to the superiority of agriculture over the predatory arts. In the first place, from the comparison which he makes between them it is clear that agriculture alone is the proportional instrument for acquiring food and other necessities of life for the civil community. It alone, supplies the abundance and variety needed for the good life. Moreover, only agriculture, among the simple modes of life, permits men to live together and at peace, in the numbers and the diversity of occupations required for political life. Finally, agriculture is superior to the predatory arts because it accomplishes its end by labor, rather than by the chase. Labor is an activity proper to a rational being, inasmuch as it requires the application of intelligence to altering material things ; whereas the chase is an activity more proper to animals. It is by his labor that man exercises his dominion over nature and leaves on it the impression of his rational purpose, making it his own.[1]

Agriculture can also be compared favourably with the other mechanical arts which follow it, and which help to supply the community with the utilities of life. St. Thomas gives some criteria by means of which they may be compared, in lesson 9 of Book I. Those

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1. Pius XI said, in *Quadragesimo Anno :* " Man is born to labor as the bird to fly." Pius XII : " Work is an indispensable means toward gaining over the world that mastery which God wishes for His glory. All work has inherent dignity and at the same time a close connection with the perfection of the person ; this is the noble dignity and privilege of work, which is not in any way cheapened by the fatigue and burden which have to be borne." (Address of Dec. 24, 1947.)

operations, he says, are more truly arts, in which fortune plays a lesser part ; for what happens by fortune is outside the foresight of reason, while that which is done by art in due to the foresight of reason. Therefore occupations such as hunting and fishing are less truly arts than agriculture, for chance plays a bigger part in them. Again, those occupations, such as carrying burdens, mining, etc., which use up the strength and wear down the body, are the most servile. Those which require a minimum of virtue either of soul or body are also less dignified. In each of these respects agriculture is superior to the predatory arts, and in each respect it is equal, if not superior, to most of the mechanical arts.

Having determined the nature of the arts of subsistence, Aristotle considers the arts concerned with making money.[1] First, he compares them with the simple arts of subsistence. They are not the same as the first, says St. Thomas, nor are they far distant in nature. They differ from the others in that they are not natural, since money is not found in nature, but is introduced through experience and art. They are not far distant because the other necessities of life may be acquired by money, and conversely, money may be acquired through them.

To make clear their difference, St. Thomas points out that any article can have two uses. The first is its proper use, as when shoes are used for walking. The second is its common use, namely, that it may be used in exchange for something else, as when shoes are exchanged for bread or some other goods. The second use, though not a proper use, is nonetheless a *per se* use, for when someone exchanges a thing, he is using it according to its value. Now man's needs are many, and as the community grows in size and numbers it is necessary that exchanges of goods for goods be made, if he is to have a sufficiency of these. Exchanges therefore and the arts of exchange are not contrary to nature, because their function is to supplement the natural arts, and to help supply the natural needs and utilities of men.

But there are many things which can satisfy human needs and make for sufficiency, which are found in one place but not in another. Money was first introduced to facilitate such exchanges, because of its convenience. For it was, at first, some durable and scarce thing, such as metal which is easily transported. For further convenience it was minted instead of being exchanged by weight. And following this usage, at first by chance but then by experience and art, there arose the practice of exchanging money for money, where a profit is made on the money itself. The end of such an art can only be the acquisition of more money, and since this kind of wealth has no natural limit, this art is called infinite. Furthermore, he shows,

1. Cf. St. Thomas, *In I Politicor.*, lect.7-8.

this kind of wealth is not true wealth, for it has no dignity of its own, nor can it, of itself, satisfy a natural need.

Now any art which acquires money for the sake of money and by means of money (or by means of goods which can be exchanged for money), is not only infinite, but it does not subserve economics.

Nevertheless, it is apparent that any art by which money is acquired may be subordinated to economics, if the money acquired by it is used to acquire food or other necessities for the home or the civil community. Therefore, St. Thomas says, there are, in fact, two kinds of money making : in one case the acquisition is ordered to a further end, namely, the governing of the household ; in the other it is not ordered to anything but itself. But because the acts of each kind of money making are the same, one is easily confused with the other. Accordingly there is the kind of money making which is natural and commendable, since by means of it those things are acquired which satisfy natural needs. And it is by an abuse of this first kind of money making that the second kind arises, one that is against nature and blameworthy. The abuse arises from the fact that some do not wish to live according to virtue, but rather according to their own desires. And since there is no natural limit to the objects of concupiscence they seek unlimited money in order to satisfy their concupiscence. Moreover, a second abuse arises because this kind of money making becomes associated with economics. Still a third abuse arises when those who wish to acquire money to satisfy their concupiscence, make use of any power or virtue or art as a means of making money without limit ; and this is to use them against their nature. Therefore it can be concluded that when an art which acquires money by natural things is pursued for the sake of money without end, it turns against nature ; but when money is acquired by means of money for the sake of money, this is altogether contrary to nature.

The modes of agriculture, both past and present, coincide with the distinctions made here by St. Thomas. The first mode of agriculture is the growing of crops for immediate use in the home or for direct exchange in the locality. It may be called subsistence agriculture. It is practiced by some people in most parts of the world, even today. This kind of agriculture is, of course, most natural, and entirely subservient to economics. When those who practise it have strong moral traditions, it has enabled them to live good human lives, with enough goods for frugal decency. And, generally, it has been kind to the fertility of the soil, as the history of agriculture reveals. It has been followed successfully in the orient for thousands of years, in fuedal Europe, and in most parts of America until the development of the Industrial Revolution, and, of course, in all the ancient nations. This kind of agriculture has always been a way of life, and not just a means of acquiring food, and they who follow it are called peasants.

Peasant farming is, of necessity, diversified farming, and the peasants usually possess a strong sense of stewardship toward the soil.

However, in the Western world, today, most crops are raised to be sold for money. Farming has been put on a cash basis. This has been an inevitable development from the first mode of agriculture ; and it is one important reason for the more abundant life which Western people now enjoy. Only through this kind of farming can the farmer participate in the wealth and the other benefits of industrial civilization. It also permits the farmer to specialize in the production of one kind of crop, and to achieve greater efficiency. The civil community benefits greatly also, for the crops can be produced in places and by farmers that are best suited. It is in fact the only mode of agriculture which can supply the food and other necessities for modern nations.

Farming for money follows two fairly well marked patterns : the family type farm and the commercial type farm. Perhaps the most important difference between the two is that family type farming is still a way of life, and only secondarily a means of making money. It is a natural mode of acquisition, for the family farm can hardly be a means to acquiring wealth without limits. It is, therefore, like subsistence agriculture, subservient to economics. Modern governments, as well as those of the past, are concerned to foster and conserve this form of agriculture because of its great importance to the civil community.[1] On the other hand, commercial agriculture is not a way of live, except accidentally, but rather an avowed way to become wealthy. Though it is not *per se* unnatural, it can most readily become so when the thirst for profits begins to dominate its activity. And although it may subserve economics and politics, there is the greatest chance of its diverging from this end. When the desire for profit is subordinated to a proper concern for the fertility of the soil, and for the ends of the civil community and its members, commercial agriculture can be a beneficial art. Its size and resources permit it to take the best care of the soil, and to contribute in many ways to the improvement of the art. But, on the whole, it is better for the community if more of its farmers are of the family type.

Irresponsible commercial farming leads to great damage to the soil, and to widespread social evils. The ignorance or the greed of the family type farmer is not nearly so destructive to the soil's fertility as is its exploitation by commercial farming, because this commands the greatest resources, including those of science. Howard calls such operators the " bandits of agriculture." In the political community

1. Cf. WARING, P. A., and TELLER, W. M., *Roots in the Earth*, New York, Harper, 1943. The authors describe the problems and the rewards of family type farming as it is today in America. Also, cf. SPELTZ, George H., *The Importance of Rural Life According to the Philosophy of St. Thomas*, Washington, The Catholic University of America, 1945.

the activities of these farmers lead to such evils as the manipulation of legislation in their favor, the ruthless elimination of the small farmer, and give rise to a large rural proletariat, exploited share croppers and transient agricultural laborers. The desperate condition of this class of people has called forth denunciation by the Popes and by all responsible leaders. An example of this is the Mexican *Braceros*, who enter the United States in large numbers to help cultivation and harvesting on large farms in the West. They follow the growing season from one region to another, and find it impossible to live a decent family life. Their wages are the lowest and their hours long ; schools are seldom provided for their children ; they live in box cars or tin huts under the worst conditions. Many social evils are fostered under these conditions : crime, loss of Faith, illiteracy, drunkenness, squalor, prostitution, etc.

Howard has this to say about farming for profit :

> Indeed, as soon as any harvest is sold rather than consumed, the question of profit must arise. The problem is one of degree and emphasis. Is profit to be the master ? Is it to direct and tyrannize over the aims of the farmer ? Is it to distort these aims and make them injure the farmer's way of living ? Is it to be pushed even further and to make him forgetful of the conditions laid down for the cultivation of the earth's surface, so that he actually comes to defy those great natural laws which are the very foundation and origin of all that he attempts ? [1]
>
> Perhaps when the time comes for a new essay in farming mankind will have learned the great lesson . . . how to subordinate the profit motive to the sacred duty of handling over to the next generation the heritage of a fertile soil.[2]

The Subordination of Agriculture to Economics and Politics

In the beginning of his commentary on the *Ethics*,[3] St. Thomas shows that there must be a final purpose to human affairs, something for the sake of which everything else is desired, and which is not desired for anything else. He then shows that the science or art which is concerned with such an end will be the supreme science in the practical order ; that it will be an architectonic science. He then shows that political science has the qualities of an architectonic science, and that it is, therefore, concerned with the highest good in human affairs :

> The highest good pertains to the principal and most architectonic science. And this is plain from what has been said above. For it has

1. *The Soil and Health*, pp.60-61.
2. *Ibid.*, p.87.
3. *In I Ethicor.*, lect.2.

been said that the sciences that deal with the things that are for the end are contained under the art or science which is concerned with the end. And thus it is fitting that the ultimate end should pertain to the chief science as concerned with a primary, principal, and most architectonic end, showing other sciences what they should make. But the science of civil affairs is seen to be of this nature, namely the principal one and most architectonic. Therefore it pertains to this science to consider the highest end.

As explained above, agriculture, and the other arts of acquisition are subordinated to politics as to a chief art. The question is : what does this subordination consist of ? St. Thomas discusses this matter in the same lesson of his commentary, saying : two things are to be noticed in an architectonic science or art ; the first is that it shows the sciences subordinated to it what they should do, just as the equestrian art directs the art of bridlemaking. The other is, that it makes use of the subordinated science for its own end. That politics makes use of the other sciences for its own end is manifest, for politics make use of military art, economics and all of the mechanical arts for the welfare of the civil community. But in reference to the first of these properties, St. Thomas says, the practical sciences are subordinated to politics, but not the speculative sciences. Political science cannot show the geometer what to conclude about the triangle, though it can make use of geometry for its own end. On the other hand, it can direct the practical arts as to the determination of their acts ; that is to say, it supplies the very form or exemplar for their work. An example of this would be the way in which the art of navigation determines the very form which the art of shipbuilding brings about in the materials which it uses ; for the form of the ship is determined by the use which is to be made of it.

It would seem, then, that since agriculture is a practical art, it is subordinated to politics in both of these ways. But such is not the case : politics cannot direct such an art as to the determination of its acts, for agriculture is a cooperative art. What it brings about by its work is not an artifact, like a ship, but a thing of nature, namely, food. Both what it produces and the means by which it produces it are determined primarily by nature, and by natural laws. The form that food is to have and the use for which it is intended are determined by nature, not by politics : politics presupposes both this form and its use as necessary instruments for its work and end. Thus St. Thomas says : " And so economics (and politics) is served both by nature, which generates men and food, and also by the wealth getting arts which acquire it, . . ." [1]

However, it remains true that politics has some power to direct agriculture in the determination of its work, namely, in that part of

1. *In I Politicor.*, lect.8.

its work which is proper to it as an art, and especially in reference to its proper end, which is crops. As to the means which are proper to agriculture, even here, as we have pointed out, it must be an imitation of the means used by nature. But to the extent that the end, and the means used are artificial and exceed nature, they are subject to politics and economics. St. Thomas, speaking of this kind of subordination, uses the example of medical art :

> . . . It pertains to the manager of the household and to the head of the civil community to consider health in some way, namely, by making use of the counsel of medical men for the health of its subjects : in another way it does not pertain to them, but to the medical men, to consider from what means health may be conserved or restored.[1]

In other words politics and economics can direct the use of agriculture, just as they can direct the use of any science or art which is subordinate to them, whether speculative or practical. In keeping with its own end, the common good, political prudence can determine who shall practice the art, and where, and to what extent, and so forth. In this respect it will determine the operations of agriculture primarily and directly. But with respect to the form of the operations and the proper means used, politics and economics will not supply the direct and primary determination, but only a secondary and indirect one. By having recourse to experts in this art, domestic and political prudence can insure that the form of the practice is sound, and that the means used are in conformity with the prescriptions of the laws of nature, which serve as the true exemplar for the work of the farmer. In brief, the laws and policies of any government ought to be such as will require the farmer to follow sound practices in his art, and if necessary, teach and aid him in doing so. But to determine what sound practices are, and the means needed to achieve them, is the proper work of experts in this art. Their advice and services are utilized by the government in order to achieve its own end in this matter. In addition, civil authority should determine what is to be grown, and how much, and by whom : " Some way must be found," says Paul Sears, " to apportion to each farmer his task, within reason." [2]

Political control of agriculture is not something novel in human affairs. Land reforms and regulations have been carried out by governments from ancient times until the present. Sorokin, Zimmerman and Galpin say that " There is scarcely any plan or reconstruction of agricultural policy directed toward helping the farmers and peasants at the present time which was not tried in China many centuries ago."[3] The land policies of ancient Rome have been spoken of above.[4]

1. *In I Politicor.*, lect.8.
2. *Op. cit.*, p.171.
3. *Op. cit.*, Vol. I, chap.1.
4. Cf. HOWARD, *An Agricultural Testament*, pp.7-9.

In England, the ' Enclosure Acts ' were also a means to a reform in agricultural practice.[1] And in our times governments are spending immense sums and making great efforts to help the farmers and to improve agriculture. Sears reviews the measures undertaken by the United States government during the past generation. The 'Agricultural Adjustment Administration,' he says, " is the most gigantic effort at agricultural reform in our history and with one exception in world history." But, he adds, there is even a better way than this : ". . . but it takes courage, patience, faith and skill. It is the method of those leaders who strive to make people desire their own betterment until they themselves begin to work for it, and who, when the people then request counsel, are ready with the wisest counsel that can be given. This is the essence of enlightened democracy, as against the doctrine, however benevolent, of regulation."[2] The ' Soil Conservation Service,' instituted in the United States in the 1930's, was conceived in this spirit. Since its inception, it has been responsible for putting well over sixty million acres of soil to better use, halting erosion and restoring fertility. It is estimated that production on this land has been increased by at least twenty per cent because of this.[3]

Political control of agriculture, however well intentioned, can be most harmful, when the determination of the practice is based on political or economic expedients alone, without being guided by the counsel of agriculturists. An example of this ill advised intervention is described by Sears in the story of the ' Kincaiders '. These were the people who settled in the Sand Hills of Nebraska, after this land has been opened by homesteaders by a law sponsored by the Congressman, Moses Kincaid :

> It consists of billowing grass covered hills lying in a vast rock bowl which holds the meager rainfall and slowly passes it up through the loose sand. In summer when lands east of it are parched and dry, the grass here is green and fresh. But here and there, as fateful warnings which spoke plainly to the practiced eye, were great blowouts. These were funnel-shaped craters dug by the wind into the sand wherever the grass had been removed and the weak turf destroyed. . . . With all her resources nature has a painful task to reclaim these blowouts. Given time she can do it by means of the wiry creeping rootstocks of Redfield's Grass, followed slowly by other venturesome plants, and ultimately by the original turf forming grasses.
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> So long as the land remained in public domain it was leased in large blocks and used as cattle range. Between the hills were numerous lakes where the underground water came to the surface, and about their shores

1. HOWARD, *The Soil and Health*, pp.50-53.

2. "Again, in a great industrial country like our own, where the urban population exceeds the rural the production of essential food and fiber cannot be left to happy chance and the farmer's best guess . . ." *Op. cit.*, pp.170-171.

3. *Ibid.*, chap.XVIII.

were meadows of grass which could be cut and cured for winter feed. . . . But a kingdom like this, the size of Egypt, was too tempting to be allowed such use. It became a political issue. The Sand Hills should be carved up into homesteads each one square mile, and given to the people. Finally a man was elected to Congress on the issue — Moses Kincaid. He secured the passage of the necessary law, and the settlers who thronged in upon these claims were known after him as Kincaiders.

. . . Most unfortunately the area assigned to each homestead, one square mile, was too small to support a family under the conditions which prevailed there. Some confined their activity to cattle but were faced with the fact that enough cattle to support them made too heavy a load on the range. The close cropped turf broke through and the sand began to blow, spreading ruin. Others boldly attempted to plough the ground and plant crops. On the lowland there was some return for this trouble, but at the expense of the hay meadows. On the upland the wind swept down and accross the planted rows swirling the sand into the leaves of the planted crop and shredding them to pieces, finally either burying the crop or leaving its roots bare.

The blame for such misguided efforts . . . rests ultimately on a system which tolerates private privilege in utter disregard of public policy, and which does not as yet understand how science may be made to help in the determining of policy. At the time these measures were planned there were men who knew the Sand Hills from the scientific side and who could have predicted exactly the outcome, but their . . . views were not consulted in any effective way. Like the expert witnesses in our courts, scientists are only supposed to talk when they have arguments for not against a popular or influential project.[1]

The views here expressed by Sears can be taken as a concrete example of the distinction between political and despotic rule, which is made in the very beginning of the *Politics*. Aristotle attacks those who hold that the rule of a prince or statesman over his subject differs from the rule of a master over his slaves only in the number of those ruled. The two kinds of rule, he shows, are essentially different : the rule of the master over the slave is for the private good of the master, and only accidentally for the slave's good ; whereas the political rule is for the common good of those ruled, and only accidentally for the good of the ruler.[2] The political rule is the rule over free men, who, as free men, are ruled by their own consent, and not against it ; and this is because they pursue the common good before their own private good. In fact, for the virtuous man, the common good and his own private good coincide. In its democratic form (which Aristotle calls a constitutional rule), a truly political rule governs equals, and its proper form is government by law rather than by decree. When subjects are ruled against their consent, as happens so often when

1. *Deserts on the March*, pp.53-55.

2. Book III, chap.6, ff.

regulations are imposed by government from above, then the rule approaches the despotic and accordingly recedes from the political. The examples used by Sears make this distinction sufficiently clear in the case of government control over agriculture.

The Practice of Agriculture

Having shown the origin, the properties and the parts of the wealth getting arts, Aristotle goes on to treat of those things which pertain to their use.[1] It is one thing to know about these arts in general, or speculatively — which is easy enough. But to practice them successfully, close experience is required. One who wishes to succeed in agriculture will have to know such things as what fields are good for wheat, which for the vine, the olive, and so forth. Further, he will have to be experienced in the details of cultivating plants and of rearing animals, as well as many other things. Such a one will do well, St. Thomas adds, to learn diligently about particular situations. Aristotle refers those who wish to pursue the matter in this way to the writings of Chares, the Parian, and Appolodorus, the Lemnian, and to others who, like them, have written on the practice of this art.

Experience is the *sine qua non* for successful operation, even when the science of any has been acquired. As he explains in the beginning of the commentary on the *Metaphysics*, experience is the perfection of man's particular reason, while art and science are the perfection of his universal reason. Experience comes from the coalescence of many singulars, received in the memory. Singular things are, therefore, the proper concern of experience, and since all operations are concerned with singular *per se*, experience is necessary in order to act successfully in any field. Without art or science experience can be successful, for even animals can acquire a kind of prudence in their own affairs, and they lack art entirely. Now, singular material things are continually changing and, therefore, to know how to deal successfully with them, many memories about them in their different conditions are required :

> The cause of this is, that actions are concerned with singulars, and all generations are of singulars. For universals are not generated nor moved except accidentally, inasmuch as they pertain to singulars. . . . Thus the doctor does not heal man except accidentally ; but *per se* he heals Plato or Socrates, or some other individuals . . .
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> Whence, since art is about universals and experience about singulars, if anyone has the knowledge of the art without experience, he will, indeed, be perfected in knowing the universal, but because he is ignorant of the singular, due to a lack of experience, he will make many errors in healing : because healing pertains more to the singular than to the universal. . . .[2]

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1. Cf. St. Thomas, *In I Politicor.*, lect.9.
2. *In I Metaph.*, lect.1.

Experience, then, is required in the practice of all arts, but in none of them is it more necessary than in agriculture. A farm is as complex and changeable a thing as nature itself. It is, indeed, more so, because the farmer's operations speed up the tempo of nature and alter it. The soil that the farmer uses is derived from many different sources, and has many mixtures and textures and other conditions. These can vary from field to field. Certain plants do well in one kind of soil, others in another. The time of planting must differ from field to field. The weather, the moisture, the sunlight, must also be accurately estimated from field to field, from operation to operation. Even the practices of his neighbors can alter the conditions of a farmer's land. If, for example, a neighbor should cut down some of his woods, the moisture and drainage conditions of his own fields would most probably be affected. The contours of his land must be carefully considered in all his operations ; and countless other particulars. Even the maximum of guidance from science and experts cannot eliminate the need for experience on the part of the individual farmer. To farm successfully, he must become part of the environment in which he finds himself.

Before science became so important in the operations of agriculture the farmer was guided by nature and by custom. These were the ground of his experience. Nature, through her own operations, not only provided him with an exemplar, but also with many signs, by means of which he regulated his practices. The restlessness of his animals, or the aches of his rheumatism, or an extra heavy coat of wool on his sheep, and other such things were signs of the weather to come. The phases and appearance of the moon told him to plant and harvest. Countless other signs were used by the farmer in place of scientific direction. And, even today it can be said, as Ehrenfried Pfeiffer does, that " . . . modern science has developed no exact rules to take the place of the old farming wisdom indicating the time and manner of sowing." [1]

In the very nature of things, science cannot furnish exact rules for these matters, but only general principles. Experience enlightened by science, must determine the exact rules for each farmer. Howard criticizes severely the present tendency in agricultural research, to divorce theory from experience. He says :

> The usual subdivisions of science into chemical, physical, botanical and other departments, necessary for the sake of clarity and convenience in teaching, soon began to dominate the work and outlook of these institutions [the experiment stations]. The problems of agriculture — a vast biological complex — began to be divided much in the same way as the teaching of science. Here it was not justified, for the subject dealt with could never be divided. . . . in fact agriculture deals with organized entities, and

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[1] *Bio-Dynamic Farming and Gardening*, p.3.

agricultural research is bound to recognize this truth as the starting point of its investigations.[1]

In this passage, Howard had laid bare a confusion in method. The method of research, as he has described it here, is speculative, that is, analytical ; but agriculture is a practical science, directed to operation ; and a practical science should have a practical method, as St. Thomas explains in the commentary of the *Ethics*. That is to say, it should proceed compositively by starting with simple principles and then considering all those circumstances which are necessary to bring them into existence.[2] It is true, of course, that a practical science may be considered resolutively, but the part of agricultural science which proceeds in this way should not be the work of the experiment stations, for these are obviously set up to pursue practical goals, that is, to improve farming practice.

Speaking further on this matter, Howard has this to say :

> The deduction would be in what we are now reviewing, that the agricultural investigator must be well acquainted with practical farming and be prepared to put his conclusions to practical tests over some period of time before he can be certain of what he says. This conclusion is just and with such a corrective, agricultural experiment can live and prosper.
>
> But the exactly opposite conclusion has been drawn. Instead of sending the experimenter into the fields and meadows to question the farmer and the land worker so as to understand how important quality is, and above all to take up a piece of land himself, the new authoritarian doctrine demands that he shut himself up in a study with a treatise on mathematics and correct his first results statistically. . . .[3]
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> . . . Authority has abandoned the task of illuminating the laws of nature, has forfeited the position of friendly judge, scarcely now ventures even to adopt the tone of the earnest advocate : it has sunk to the inferior and petty work of photographing the corpse — a truly menial and depressing task.[4]

By far the most important signs which nature gives the farmer as a guide are pests and diseases, which affect his soil, his plants and his animals. Just as a doctor sees a disease in his patient as a sign of something unsound in his diet or way of living, so do the writers appealed to consider widespread diseases and pests as a sign of unsound agricultural practice. Now health is the perfection of the life of any organism, and both nature and art always aim at the better. Art is defined as a virtue of making things with reason, and because it is a

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1. *The Soil and Health.*, p.77.
2. *In I Ethicor.*, lect.3.
3. *The Soil and Health*, p.78.
4. *Ibid.*, p.81.

virtue, it is concerned with making things well.[1] Since agriculture is concerned with producing living things, its work is only done well when they are healthy. If they are beset by disease it is a sign that the art which produced them is unsound. " Whatever is irregular in a work of art is unnatural to the art which produced that work." [2]

It is the thesis of Howard's book, *The Soil and Health*, that the widespread diseases of soil and crops are the result of unsound agriculture, and that the unwholesome products of such agriculture are, in turn, affecting the health of the population which is nourished by them.[3] Alexis Carrel holds the same position in his well known book, *Man the unknown.*

The same is true about pests ; Sears has this to say of them :

> Weeds resemble those people who thrive best under difficulties and adversity. Prosperity and peace ruin them. They cannot retain their power under a calm and stable regime. Weeds, like red-eyed anarchists, are the symptoms, not the real cause of the disturbed order. When the Russian Thistle swept accross the western ranges, the general opinion was that it was a devouring plague, crowding in and consuming the native plants. It was no such thing. The native vegetation has already been destroyed by the plow and the thronging herds. The ground was vacated and the thistles took it over. It was the same with the American prickly pear which is regarded as an unmitigated pest in Algeria and Australia. . . . No one ever saw a field protected against fire, plow and livestock support a permanent population of thistles, sunflowers, or any other kind of weed.[4]

Another kind of pest is the grasshoppers or locusts :

> We have heard much of the plague of grasshoppers crossing the country like a wave of devastation and consuming every green thing in their path. Yet a fence of three barbed strands of wire has been known to stop them. In the Wichita National Forest is such a fence. On one side the herbage is heavily populated with various types of destructive grasshoppers. On the other side the species is somewhat different and the numbers very much less. Actually, of course, the fence served to prevent overgrazing. But the truly surprising thing is that the hungry pests did not occur to serious degree on the side with the large amount of potential food. Like scavengers and trouble makers who have no place in an ordered existence, they found their opportunity only when the natural balance had been practically destroyed. Thus when man begins the downward course of destruction, does nature operate to accelerate the dizzy process.[5]

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1. St. Thomas, *Summa Theologica, Ia IIae*, q.57, a.3, ad 1.
2. *Summa Theologica, Ia IIae*, q.71, a.2, ad 4.
3. The Soul and Health, p.2.
4. *Deserts on the March*, pp.92-93.
5. *Ibid.*, p.133.

Examples such as these are multiplied throughout the writings of these and other writers. Regarding the most serious disturbance which agriculture is responsible for, Howard observes :

> Soil erosion in the very mild form of denudation has been in operation since the beginning of time. It is one of the normal operations of Nature going on everywhere. . . .
>
> It is when the tempo of denudation is vastly accelerated by human agencies that a perfectly harmless natural process becomes transformed into a definite disease of the soil. The condition known as soil erosion — a man made disease — is then established. It is, however, always preceded by infertility ; the inefficient, overworked, dying soil is at once removed by the operations of nature, and hustled towards the ocean, . . .[1]

The appearance of most of these diseases and pests in farming has coincided with the widespread use of chemical fertilizers and other practices which Howard considers as unsound. Can they not, he argues, be considered as cause and effect ? [2]

Undoubtedly, the first thing to influence the practices of the farmer is custom. Just as man's first moral qualities are acquired by imitating those around him — and especially those he depends on or admires — so also in agriculture, the practices which are customary in the area are the first, and the necessary training ground for the successful farmer. The conservatism of the ordinary farmer is well known to everyone. He is most reluctant to depart from any established custom ; and this is as it should be, for customs, if they are of long standing, are a good sign of sound and successful practice. In the tradition of agriculture, wherever a permanent agriculture has been established, the customary practices become an almost sacred obligation for the farmer.

Howard places the greatest importance on long established customs in agricultural practice, for they represent tried and tested experience. In speaking of his own work, he writes :

> In pursuance of the principle I had adopted of joining practice to my theory, the first step was to grow the crops I had to improve. I determined to do so in close conformity with local methods. Indian agriculture can point to a history of many centuries : there are records of the same rice fields being farmed in northeast India which go back for hundreds of years. What could be more sensible than to watch and learn from an experience that had passed so prolonged a test of time ? I therefore set myself to make a study of Indian agriculture and speedily found my reward. . . .
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> In pursuit of this idea I found I could do no better than watch the operations of the peasants as aforesaid, and regard them and the pests for the time being as my best instructors . . .

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1. *The Soil and Health*, pp.85-87.
2. *Ibid.*, p.81.

. . . At the end of five years tuition under my new professors — the peasants and the pests — the attacks of insects and fungi on all crops whose root systems suited the local conditions became negligible. . . .[1]

III. THE PLACE OF AGRICULTURE AMONG THE SCIENCES

Agriculture, medicine, and any other practical art, may also be spoken of as sciences.[2] And conversely, any science, even the speculative sciences are sometimes called arts. In their common usage, the two words seem to be applied indifferently to all kinds of knowledge and skills. At the beginning of his commentary on the *Metaphysics* St. Thomas uses the word art for all forms of knowledge :

Therefore, since many arts have been discovered for their utility, of which some are for the necessities of life, such as the mechanical arts, some serve as an introduction to the other sciences, such as the logical sciences, those artisans are called wiser whose sciences are not discovered for utility, but for the sake of the knowledge itself, and the speculative sciences are of this sort.[3]

He then adds that we should not assume that art and science are the same thing, or that they belong to the same genus, even though he had used the word art for each of them indifferently.

But because the name art has been used for both science and wisdom as if indifferently, lest anyone think that this name is used synonymously with the same underlying significance for all of these, he (Aristotle) removes this opinion, and refers to his work on morals, that is, the sixth book of the *Ethics*, where it is explained how science, art, wisdom, prudence and understanding differ. And, to speak briefly, wisdom and science and understanding concern the speculative part of the soul, which he here calls the scientific part. They differ however, because understanding is the habit of the first principles of demonstrations. Science is about conclusions drawn from inferior causes. And wisdom considers primary causes.

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1. *The Soil and Health*, pp.3-4.

2. HAMBRIDGE, Gove, *Climate and Man*, in The Yearbook of Agriculture, U. S. Dept. of Agriculture, Washington, D.C., 1941, pp. 5-6. " Today a comparative handful of able or successful farmers are required to feed all the rest of the population and this vast undertaking would be impossible without the aid of science. Indeed it can hardly be said any longer that science aids agriculture ; rather agriculture under modern conditions is itself a science, and one with many complicated and indispensable divisions. Whether he knows it consciously or not, the modern farmer constantly uses the results of research in genetics, soil science, the science of nutrition, medicine (including physiology, bacteriology and parasitology), entomology, plant pathology, . . . engineering, weather science and many others. They all have intensely practical bearing on his everyday work with soils, crops and herds. Moreover the farmer cannot stop with these so-called natural sciences. He must know how to gear his operations into a market affected in a hundred ways by the complications of modern industry, commerce and government."

3. *In I Metaph.*, lect.1.

Whence it comes under the heading of the sciences. But prudence and art concern the practical part of the soul, which reasons about contingent things, operable by us. But they differ : for prudence directs us in actions which do not pass into exterior matter, but are perfective of the one acting ; whence he says here that prudence is right reason about things to be done. Art, however, directs us in makings, which pass into exterior matter, such as building and cutting : whence art is called right reason about things to be made.[1]

Therefore, since agriculture is an art, and a practical one, the first thing to be considered here is why it should also be called a science. To make this clear, we will cite two passages from St. Thomas that bore on this point. The first is found in the commentary on the *Ethics* :

. . . Nevertheless it is to be noted that politics does not seem to be similar to the other operative arts, which are called sciences insofar as they provide knowledge, and potencies insofar as they are principles of operations. For in the other operative arts the same persons seem to be the ones who transmit these kinds of art by teaching them, and who operate according to them : as the doctor both teaches medicine and practices according to medicine. . . .[2]

Here, St. Thomas implies that such arts are called sciences because they are like sciences inasmuch as they are teachable knowledge of the subject, and the purpose of science is the possession of knowledge. They are called sciences also because one who possesses the arts can teach them, and to be teachable is a characteristic of science. But they are not called sciences when considered as principles of operation, in which respect they are to be called arts, not sciences. Accordingly, it can be said that taken absolutely they are arts, but when one aspect of them is considered separately, they can be called sciences. Furthermore, as St. Thomas says in his exposition of Boethius' *De Trinitate,* the part of such arts which is called science is the one which is more general, and therefore more remote from practice :

As Avicenna says, the distinction between theoretical and practical is not the same when philosophy is divided into speculative and practical, when the arts are divided into speculative and practical, and when medicine is so divided. For when we distinguish philosophy and likewise the arts into speculative and practical we do so on the basis of their end, calling that speculative which is directed solely to knowledge of the truth, and practical that which is directed to operation. However, there is this difference when the whole of philosophy and the arts are distinguished on this basis : we divide philosophy with respect to the final end or happiness,

1. *In I Metaph.*, lect.1.
2. *In X Ethicor.*, lect.16.

to which the whole of human life is directed. For as Augustine says, following Varro, ' there is no other reason for a man philosophizing except to be happy.' And since the philosophers teach that there is a twofold happiness, one contemplative and the other active, as is clear in the *Ethics*, calling moral philosophy practical and natural and rational philosophy speculative. But when they call some arts speculative and some practical, this is on the basis of some particular ends of these arts ; as when we say that agriculture is a practical art while dialectic is speculative.

However, when we divide medicine into theoretical and practical, the division is not on the basis of the end. For on this basis the whole of medicine is practical, since it is directed to practice. But the above division is rather made according as that which is studied in medicine is proximate to, or remote from, practice. Thus we call that part of medicine practical which teaches the method of healing, for instance that medicines of such and such a kind should be given for such and such abcesses. On the other hand, we call that part theoretical which teaches the principles directing a man in his practice, though not proximately ; for instance, that there are three virtues, and that there are so many kinds of fever. Consequently, if we call some part of a practical science theoretical, we should not on that account place that part under speculative philosophy.[1]

The theoretical part of a practical art, the part which is called science, is the part which is general, and therefore remote from practice. Now science is not concerned with the singular, while art is, for it is directed to operation. Again, science is concerned with necessary things, and art with things that are contingent. Now in reference to natural processes, to which the operations of arts such as medicine and agriculture are directed, there is no necessity in the singulars, for singular things in nature are contingent. But there is a kind of necessity in the universal natures of natural things, as St. Thomas explains in the same work, and hence it is that there can be scientific knowledge of natural things.

Natures of this sort, abstracted in the above manner (that is, from individual sensible matter), can be considered in two ways : in one way in themselves, and then they are considered without motion and determinate matter, and such consideration befalls them only because of the existence they have in the intellect. In another way they can be considered in relation to the things of which they are the natures, which things indeed exist in matter and motion. In this way they are principles whereby we know these things, since everything is known through its form. Thus in natural science we have knowledge of mutable and material things existing outside the mind through natures of this sort, which are immobile and considered without matter.[2]

Since the properties of natural things are the primary causes of the effects produced by agriculture, with the art acting as a helping

1. Q.5, a.1, ad 4.
2. *Ibid.*, a.2, c.

and directing cause, it can be concluded that that part of agriculture which is called a science will be the one which possesses knowledge of the properties of natural things, which are primarily responsible for the production of crops and animals. Knowledge of these properties directs the farmer remotely as so many principles of operation. But the knowledge of how to make use of these principles in his work under varying circumstances is more properly called art.

The subalternation of the science of agriculture to natural science

Arts such as medicine and agriculture are subalternated to natural science inasmuch they are cooperative arts. To be subalternated to natural science means that they are subordinated to it as to their principles. The cooperative arts differ from the other practical arts in that they produce something which nature also produces, whereas the others produce things which nature cannot produce. And in the productions of the cooperative arts, as had been said, the principal efficient and formal causes are the natural forces or properties of nature, which it is the office of the art to direct and carry on to their natural ends. In this process the causality of the art is secondary and instrumental. It therefore follows that the primary reasons for the practices used in these arts are furnished by the properties of natural things. It is different with the other practical arts, for in their productions, art is the principal cause, not an instrumental cause. The primary reasons for the practices of these arts are taken from the use to which the thing produced will be put, and only secondarily from the properties of natural things, insofar as the materials out of which artificial things are made are some natural thing.[1] The place of agricultural science among the sciences will be more clear if we consider the teaching of St. Thomas on subalternation as applied to agriculture.

One kind of subordination to which agriculture is subject has already been considered in this paper, that is, its subordination to economics and politics. This was based on a dependence as to purpose, the end of one science or art being ordered or subordinated to that of another. Every practical arts is subordinated to politics in this way. But this kind of subordination does not constitute subalternation, for subalternation requires a dependence in manifesting the truth.[2] Agriculture is not dependent on economics or politics in this respect, but rather on natural science.

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1. St. Thomas, *In I De Sensu et Sensato*, lect.1 : " If, however, there are artifacts which are made by art alone, such as a house or a ship, knowledge of these in no way pertains to the consideration of natural science, just as knowledge of those things which are made only by nature in no way pertains to the consideration of art, except insofar as art makes use of natural things."

2. John of St. Thomas, *Ars Logica*, Book II, q.26, a.2.

Agriculture is also subordinated to metaphysics, as is every other science, for metaphysics treats of the universal principles of being, under which the subject of every other science is contained. But neither does this subordination constitute subalternation, because metaphysics does not manifest the conclusions of the other sciences.[1]

St. Thomas mentions this subalternation of agriculture to natural science in his exposition of Boethius' *De Trinitate :*

> One science may be contained under another in two ways : either as a part, when its subject is part of the subject of that other science, as plant is a (subjective) part of natural body. In this way the science of plants is contained under natural science as one of its parts. Or, in another way, one science is contained under another as subalternated to it. This occurs when in a higher science a reason is given for what the subordinate science knows only as a fact, the way music is contained under arithmetic.
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> Medicine, therefore, is not contained under physics as a part, for the subject of medicine is not a part of the subject of natural science in the respect in which it is the subject of medicine. For although the curable body is a natural body, it is not the subject of medicine in so far as it is curable by nature, but insofar as it is curable by art. All the same, because art is nature's handmaid in healing — in which art too plays a part, for health is brought about through the power of nature with the assistance of art — hence it is that the reason for the practices used in the art must be understood from the properties of natural things. So medicine is subalternated to natural science, and for the same reason so too are alchemy, agriculture, and all sciences of this sort. We conclude then, that in itself and in all its parts natural science is speculative, although some practical sciences are subalternated to it.[2]

From this passage, as well as from what was said earlier, it is clear that agriculture is dependent on natural science for its principles, and this constitutes subalternation. The principles of agricultural science are the properties of natural things, that is, the powers and natural causes of generation and growth in living things ; because there are the proper causes of generation and growth, while art serves as a secondary or helping cause. Agriculture does not have principles other than these which are proper to it. In other words, its principles are the same as those of natural science, with this difference only that natural science considers these principles as they operate naturally, while agriculture considers them as they are subject to direction and help by art. Agriculture moreover knows these principles only as facts, while natural science knows also the formal reasons for them. This is because it is the office of each science to demonstrate the properties of its own subject. But the powers and properties of

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1. Vd. ST. THOMAS' commentary on Boethius' *De Trinitate*, q.5, a.1, ad 6. Cf. J. OF ST. THOMAS, *loc. cit.*

2. Q.5, a.1, ad 5.

living things are natural powers, and therefore it belongs to natural science to demonstrate them, which is to know the formal reasons for them. And from this it follows that the primary principles of agriculture are not the primary principles of natural science. For if the former were the properties of natural things, then they could not be the primary principles of natural science, but rather conclusions which are demonstrated from these properties. Agriculture may know such properties as facts, for it begins with these ; but it does not reach them as conclusions accounted for by theoretical reasons. In other words, the primary principles of natural science are the universal principles of natural things, while the primary principles of agriculture are the particular principles of natural things. Agriculture is more properly concerned with the latter principles rather than with the general, for it is a productive art, and, as such, concerned with singulars. But the proximate principles of singular things are the particular principles of nature, not the general or primary ones. This relationship of subalternation is explained by St. Thomas in his commentary of the *De Sensu et Sensato*, where he uses the example of medicine :

> It also pertains to the natural philosopher to investigate the primary and universal principles of health and sickness, whereas it pertains to the medical man, who is the artificer producing health, to consider the particular principles ; just as it pertains to each productive art to consider the singulars falling within its sphere, because operations are directed to singulars. And the Philosopher proves, here, that the consideration of these general principles pertains to the natural philosopher. . . .
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> First, he shows this by a rational argument. For health is found only in beings having life. From this it follows that the living body is the proper subject of health and sickness. But the principles of a subject are the principles of its proper passions. Wherefore, since it pertains to the natural philosopher to consider the living body and its principles, it is right that he should also consider the principles of health and sickness.
>
> Secondly, he proves it by a sign or example, which concludes from inductive reasoning. For many natural philosophers terminate their investigations at those matters which are also the concern of medicine. Similarly, also, many medical men, who follow physical science more than medical art, not just making use of experience, but rather inquiring into causes, begin their medical considerations from natural things. From which it appears that the consideration of health and sickness is common to both medicine and natural science. And the reason for this is that, since health is caused sometimes by nature alone, for this reason it pertains to the consideration of the natural philosopher, to whom it belongs to consider the work of nature : and sometimes health is caused by art, and for this reason it is considered by medicine. But because art is not the principal cause of health, but rather is an aid and minister to nature, it is necessary that the physician gather his science from that of nature, as providing more primary principles, just as the navigator does from the

astronomy. And this is why those who practice medicine will start from natural principles.[1]

The agriculturists, whose views are represented here, also insist on the dependence of theory, as well as of practice, on natural principles. At the beginning of *An Agricultural Testament*, Howard says :

> Little or no consideration is paid in the literature of agriculture to the means by which Nature manages land and conducts her water culture. Nevertheless these natural methods of soil management must form the basis of all our studies of soil fertility.[2]

And in *The Soil and Health* :

> The introduction to this book describes an adventure of agricultural research and records the conclusions reached. If the somewhat unorthodox views set out are sound, they will not stand alone but will be supported and confirmed in a number of directions. . . . by the farming experience of the past and above all by the way Nature, the supreme farmer, manages her kingdom. In this chapter the manner in which she conducts her various agricultural operations will be briefly reviewed.[3]

And Paul Sears is not less emphatic on this point. In the work cited above, he devotes one chapter to the natural principles of fertility and growth which are the ultimate guide and control in all agriculture, calling it " The Great Pattern ".[4]

The relation of agriculture to mathematics

Some natural sciences, such as astronomy and mechanics, and some practical arts, such as navigation, are subalternated to mathematics ; the question arises whether agriculture too is subalternated in that way. Now subalternation requires that the subalternating science know the formal reason for that which the subalternated one knows only as a fact — as has been said. And when the science in question is subalternated to mathematics the subalternation takes the form of an application of what is formal, namely mathematical principles, to what is material, namely, physical beings and their changes. In the commentary on the *Posterior Analytics*, St. Thomas explains

1. I, lect.1. It should be understood that St. Thomas means all scientific knowledge of nature, when he uses the term ' natural philosophy ' in this place. As he makes clear in this prooemium to the commentary on the *Physics*, all knowledge of nature, whether philosophical or experimental forms essentially one body of doctrine. The science of agriculture is subalternated to natural science in both its philosophical and experimental forms, though more immediately to the experimental sciences of nature, as we shall point out later in these pages.

2. *Op. cit.*, p.B.

3. *Op. cit.*, p.17.

4. *Deserts on the March*, chap.7, pp.60 ff.

this, using as examples the subalternation of geometrical optics to geometry, and of music to arithmetic.[1] For geometry demonstrates the properties of lines, while the science of perspective applies such knowledge to visual lines ; and similarly, music applies the knowledge of numbers to sound. For, as he adds in the commentary on Boethius' *De Trinitate*, music does not consider sound inasmuch as it is sound, but inasmuch as it is proportionable according to number. Such sciences, he states, are intermediate between purely physical science and mathematics, but they have a closer affinity to mathematics, because, in their procedure, that which is mathematical provides the form, while that which is physical, the subject, is matter.[2]

But St. Thomas does not include agriculture among the sciences which are subalternated to mathematics. In the same passage, he says that there are three orders of sciences which deal with natural and mathematical entities :

> Some are purely natural and treat of the properties of natural things as such, like physics, agriculture and the like. Others are purely mathematical and treat of quantities absolutely . . . Still others are intermediate, and these apply mathematical principles to natural things.

And in the passage already cited from the *Posterior Analytics*, he says expressly that medicine is not subalternated to mathematics.

Nevertheless a science, such as medicine or agriculture, that is not properly subalternated to mathematics, may still be related to it in such a fashion that mathematics supplies a formal reason for what the other science knows only as a fact. In the same commentary on the *Posterior Analyctics* he points out that

> . . . many sciences which are not subalternated to each other may be so related that one knows the fact, and the other the cause. This is clear from the case of medicine and geometry. For the subject of medicine is not subsumed under the subject of geometry as is the subject of perspective ; nevertheless the principles of geometry are applicable to some of the conclusions considered in medicine. E.g., the fact that circular wounds heal more slowly is known to the physician as a fact, for he gathered this from experience ; but to understand the reason for this belongs to the geometer, namely, that the circle is a figure without angles ; and hence it is that the edges of circular wound, since they do not come near one-another, are not easily joined. It is to be noticed, however, that this difference of knowing the fact and knowing the cause, which is found in different sciences, is a subordination of another mode, namely, when a demonstration is made through a remote cause.[3]

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1. *In I Post. Anal.*, lect.25.
2. Q.5, a.3, ad 6.
3. *In I Post. Anal.*, lect.25.

The meaning of this passage is that when a science (like mathematics) gives the reason for what another (like medicine) knows as a fact, if the cause is merely a remote cause, and not the proper or proximate one, the two sciences are not subalternated. The fact that a circle has no angles, and therefore no parts approaching one-another, is a remote cause of the slow healing of circular wounds, but it is not the proper cause. The proper cause is not known to mathematics, but rather to natural science. Thus the proper reason why circular wounds heal more slowly is that the scar tissue, which closes the wound, is generated cell by cell, successively, each one being joined to the preceding one : and since there is a larger area to be covered, more cells must be successively produced, which takes more time.

Medicine, agriculture, or any similar science can borrow explanatory principles from mathematics in this way ; and they can also borrow them from sciences which are still more general than mathematics, such as logic or metaphysics, without becoming subalternated thereby. Thus St. Thomas says : " And so it is that the more abstract and simple the objects of a science are, the more applicable its principle are to other sciences. Thus the principles of mathematics are applicable to natural things, but not vice versa, for physics presupposes mathematics ; but the converse is not true, . . ." [1] He explains why this is so :

> Motion is not in the category of quantity in virtue of what quantity is, but shares somewhat in the nature of quantity from another source, namely, according as the division of motion derives from either the division of space or the division of the thing subject to motion. So it does not belong to the mathematician to treat of motion, although mathematical principles can be applied to motion, and therefore, inasmuch as the principles of quantity are applied to motion, the natural scientist treats of the division and continuity of motion, as is clear in the *Physics*.[2]

It is in this manner that mathematical principles are applied in science of agriculture. For example, in determining how to plow a sloping field so as to prevent the soil from being washed away, geometrical principles are applied ; and in producing new strains and varieties of plants and animals through genetics, arithmetical principles are put to use.

It may be concluded, therefore, that the attempt to learn the proper reasons for agricultural practices from mathematics is contrary to the nature of the science. This seems to be the opinion of Howard,

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1. *Expositio in Boethium de Trinitate*, q.5, a.3, ad 6.
2. *Ibid.*, q.5, a.3, ad 5.

when he speaks of the place which statistics has assumed in agricultural research :

> The final phase has been reached with the letting loose of the fiend of statistics to torment the unhappy investigator. In an evil moment were invented the replicated and randomized plots by means of which the statisticians can be furnished with all the data needed for their esoteric and fastidious ministrations. . . .
>
> The deduction would be, in what we are now reviewing, that the agricultural investigator must be well acquainted with practical farming and be prepared to put his conclusions to practical tests over some period of time before he can be certain of what he says. This conclusion is just, and with this corrective, agricultural experiment can live and prosper . . .
>
> But the exact opposite conclusion has been drawn. Instead of sending the experimenter into the fields and meadows to question the farmer and land worker so as to understand how important quality is, and above all to take up a piece of land for himself, the new authoritarian doctrine demands that he shut himself up in a study with a treatise on mathematics and correct his first results statistically. The matter has been pursued with zest and carried to extremes . . .
>
> But the proof of the pudding is in the eating thereof. Can the statistician give any practical help when the use of the small plots gets into difficulties? In one case I personally investigated about 1936 the answer is : most emphatically no. This occurred at the Woburn Experiment Station, a branch of Rothamstead. During the summer I was invited by the vice president of the Rothamstead Trust, the late Professor H. E. Armstrong, F.R.S., to help him discover why one of the sets of permanent manurial experiments at Woburn had come to an end. After a long treatment with artificials the soils on the greensand had gone on strike : the cereals refused to grow. Why? I have a vivid recollection of the visit. We were first given a learned lecture on the past history of the plots with tables and curves galore by the officer-in-charge. We then visited the field. . . . We saw the plots that had given up the struggle. No crop was to be seen, only a copious growth of common mare's tail (*equisetum arvense*). I then inquired whether a really good crop could be seen on similar land. We were shown a fine crop of lucerne nearby which had been manured with copious dressings of pig muck. The cause of the going on strike of the Woburn plots was now clear and the cure was obvious, but before explaining this to the Officer-in-Charge I inquired what had been done by the Rothamstead staff to elucidate this trouble. It appeared that all the data and all the information available had been laid before the Director and his staff, including the statisticians, but without result. Neither the official hierarchy nor the higher mathematics had any explanation or advice to offer. I thereupon explained the cause and pointed to the cure of the mischief. Constant applications of chemicals to this sandy soil had so stimulated the soil organisms that the humus, including the humic cement of the compound soil particles, had been used up. This had led to pan formation and to the cutting off of the air supply to the subsoil. All this was obvious by the establishment of a weed flora mostly made up of *Equisetum*. My diagnosis

would be confirmed by an examination of the soil profile which would disclose a sand pan some six to nine inches below the surface and the development of the characteristic root system of this weed of poorly aerated soils. This injurious soil condition could be removed by a good dressing of muck followed by a crop of lucerne. A soil profile was then exposed and there was the pan and the root system exactly as I had foreshadowed. It was merely a case of reading one's practice in the plant. Long practical experience and many years spent in root studies had instantly suggested the cause of the Woburn trouble. Many years observations and first hand experience of the lucerne crop enabled me to suggest a cure for the pan formation. How could statistics and the higher mathematics be a substitute for the faculty of reading one's practice in the plant ? . . .

Can statistics or the statisticians help in unravelling the nature of quality — that factor which matters most in crop production, in animal husbandry and in human nutrition ? We cannot weigh or measure quality and express the result in numbers which the statistician can use. But our livestock instantly appreciate quality and show by their preference, their better health, their improved condition and breeding performance how important it is. The animal, therefore, is a better judge of one of the factors that matters most in farming than the mathematician. But on this important point — the verdict of the animal — the records of our experiment stations are silent. At these institutions crops are weighed on metal or wooden balances so that figures — the food of the statistician — can be provided. But if many of these experimental crops, particularly those raised with chemical manures, are tested in the stomachs of our livestock — the real balance of the farmer — they will be found wanting.[1]

We will now consider these principles of the science of agriculture : first, there are the particular or proximate principles from which the science begins its investigations ; then we have the universal principles investigated by the philosophy of nature, which serve as the ultimate reasons for the practices of agriculture.

The first principles of agriculture

Three things can be said about the principles of agriculture, which are corollaries of its subalternation to natural science. The first of these is that the principles of natural things which agriculture makes use of will be many rather than few. Being an operative science, it is directed to singulars, and therefore it is more properly concerned with those principles of nature which are closer to singulars. These are particular principles, and they are in fact as numerous as the species of natural things. Agriculture wants to know, for example, not just principles for producing vegetables, but special principles which produce growth in peas or cabbages, and how they differ. For it is

1. *The Soil and Health*, pp.78-80.

only when this is known that peas and cabbages can be produced more successfully.[1]

The second is that agriculture will be more properly concerned with those natural principles that are more subject to human control. For agriculture is concerned with natural things not as producible by nature, but as producible by art. Climate, for example, is a principle of growth which must be reckoned with in agriculture, because it helps to determine the species which will thrive in each area, and the amount of growth which is possible under such and such conditions. But climate is subject to human control only to a slight degree, and that indirectly. The soil's moisture, on the other hand, is a principle of growth that is much more subject to our control, and is therefore of much greater concern to agriculture. The condition of the soil and the types of plants and animals to be produced are still more subject to control, and therefore of great concern to agriculture. The soil's fertility is most directly and most considerably affected by the activities of agriculture, so that the natural principles which govern fertility should be the chief concern of agriculture.[2]

The third consideration is that agriculture, being directed to practice, is more properly concerned with the principles of generation and growth as they occur in the concrete, rather than separately, or abstracted from their relationships with other things. It is more properly concerned with natural things in their natural order as affecting each other by their actions and by their being acted upon, than it is with these things considered in a general, abstract way. To ponder these in an abstract manner is not of much help in the production of food.[3] Howard criticizes the well known wheat experiment which was carried on at Rothamstead on these grounds.

The main object of these experiments was to determine whether wheat could be grown continuously by means of artificials alone or with

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1. Cf. JOHNSON, Samuel, *How Crops Feed*, New York, Orange Judd Co., 1913, p.17. " That crops grow by gathering and assimilating food is a conception with which all are familiar, but it is only by following the subject into its details that we can gain hints that shall apply usefully in agricultural practice."

2. JOHNSON, Samuel, *op. cit.*, p.104. " For the husbandman the soil has this paramount importance, that it is the home of the roots of his crops, and the exclusive theater of his labours in promoting their growth. Through it alone can he influence the amount of vegetable production, for the atmosphere and the light of the sun are altogether beyond his control. Agriculture is the culture of the field. The value of the field lies in the quality of its soil."

3. KRAUS, E. J., *Sources and Cycles of the Nutritive Elements*, in *Food and Life*, The Yearbook of Agriculture, Washington, D.C., U. S. Dept. of Agriculture, 1939, pp.405-406. " As scientific knowledge progresses, it becomes increasingly obvious that the whole cycle of interactions and interdependencies of plants and animals must be studied simultaneously. These must then be integrated in terms of the environment in which the plants develop. By this method a comprehensive grasp of the biologic problem of agriculture may be gained, and the whole interpreted in terms of its social significance."

no fertilizer, and also to compare the results obtained by chemicals on the one hand and by farmyard manure on the other. The results are considered to prove that under Rothamstead conditions satisfactory yields of wheat can be obtained by means of chemicals only, that no outstanding advantage follows the use of farmyard manure, and that further on the no-fertilizer plot a small but constant yield of grain can be reaped. A subsidiary but very important result is also claimed, namely, that the fertilizing has no appreciable effect on the quality of the wheat grain.

In spite of all the devotion that has been lavished on these Broadbalk trials, at least four major mistakes have been made in their design and conduct which completely discredit the final results.

In the first place an error of sampling was made at the very beginning. A small plot cannot possibly represent the subject being investigated, namely the growing of wheat, which obviously can best be studied in this country on a mixed farm. We cannot farm a small strip of wheat land year after year, because it is difficult to cultivate it properly ; the area does not come into the usual rotations and is, therefore, not influenced by such things as the temporary ley, by the droppings of livestock, and by periodic dressings of muck. The small plot therefore, cannot represent any known system of British farming, any of our farms, or even the fields in which it occurs. It only represents itself . . .

In the second place, the continuous cultivation of wheat on a tiny strip of land is certain to create practical difficulties. Such land cannot be kept free from weeds because of the short time available between harvest in August and resowing in October. No cleaning crops like roots crop can, therefore, be used. This difficulty duly happened at Rothamstead. The weeds got worse and worse and finally won the battle. Mother Earth rejected the idea underlying the continuous wheat experiment. The original conception of these trials has had to be modified . . .

In the third place no steps were taken to isolate the plots from the surrounding areas and to prevent incursions from burrowing animals such as earthworms. . . . We know that artificials, sulphate of amonia in particular, destroy the earthworm population wholesale ; but, that after the nitrification of this manure has taken place the area is again invaded by more of these animals. A small oblong strip about half an acre in size is, therefore, obviously useless for determining the effect of artificials on the soil population. The unit should be a square at least ten acres in area. This wholesale destruction of the earthworm probably helps to explain the failures in wheat growing which often attend the application of the Rothamstead methods to large areas of land. The lowly earthworm — the great conditioner of food materials for healthy crops — is murdered and no effective substitute is provided.

In the fourth place, the fertilizing scheme has never been allowed to impress itself on the variety of wheat grown. The seed used every year has been obtained from the best outside source. The fertilizing has influenced the soil but not the plant. The wheat raised on each plot has not been used to sow the plot for the next crop. The plant has had a fresh start every sowing. The Broadbalk experiment is, therefore, not a continuous wheat experiment as regards one of the two most important factors on trial — the wheat plant itself. . . . Had the harvest of each plot

been used for resowing, in a very few years an important result would have been obtained. The effect of artificial manures, which we know is cumulative, would soon have begun to influence the stability of the variety itself and to cause it to run out. In some period between twenty-five and fifty years the wheat would have ceased to grow and the Broadbalk experiment would have collapsed.[1]

As has been cited above, he also holds that experimental stations have been responsible for another error in the organization of their science :

> The usual subdivision of science into chemical, physical, botanical and other departments, necessary for the sake of clarity and convenience in teaching, soon began to dominate the outlook and work of these institutions. The problems of agriculture — a vast biological complex — began to be subdivided much in the same way as the teaching of science. Here it was not justified, for the subject dealt with could never be divided, it being beyond the capacity of the plant or animal to sustain its life processes in separate phases : it eats, drinks, breathes, sleeps, digests, moves, sickens, suffers or recovers, and reacts to all its surroundings, friends and enemies in the course of twenty-four hours, nor can any part of its operations be carried on apart from all the others : in fact agriculture deals with organized entities, and agricultural research is bound to recognize this truth as the starting point of its investigations.[2]

Howard appeals to two natural principles as the foundation of agricultural science. The two outstanding characteristics of life on this planet, he points out, are variety and stability.[3] The variety of life is obvious to the most casual observer. And in addition to the vast number of visible forms of plant and animal life, there is an even greater number detected by use of the microscope. Except where there is perpetual frost, there are large numbers of these forms present. Even the deserts have their complex communities of plant and animal life. Each of these forms and each individual has a function to perform in the activities of nature. As Aristotle said, nature is not niggardly like the Delphian smith who fashioned one tool for many uses ; it supplies a proper instrument for each task.

The stability of life is not so apparent as its variety, but it is, nevertheless, the dominent principle. It reigns, Howard says, " by means of an ever-recurring cycle, a cycle which, repeating itself silently and ceaselessly, ensures the continuation of living matter. This cycle is constituted of the successive and repeated processes of birth, growth maturity, death and decay." He calls this cycle by

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1. *The Soil and Health*, pp.72-75.

2. *Ibid.*, p.77

3. What follows here is a summary of the natural principles of agriculture, as found in *The Soil and Health*.

the ancient title of ' The Wheel of Life '. Even the inanimate part of the earth is taken up into this cycle. The sunlight, the water of the oceans and streams, the elements of the atmosphere and the rocks and minerals which make up the solid portion of the planet. The law which governs this great cycle is the law of balance ; and this balance, says Howard, is based on enormous reserves.[1]

At the center of this cycle is the life of the plant, upon which animal life and the utilization of the other substances of the earth depends. In Aristotelian terms, the life of the plant consists in the operations of the vegetative powers. The object of these activities and powers is food. The reason for the primacy of the plant in the economy of life resides in the fact that, while animals are able to release energy only, plants in their vital operations not only release but also accumulate it in a form that can be utilized by themselves and by animals as well. For plants do not merely find their food as animals do : they manufacture it. To do this they intercept the sun's energy by means of the chlorophyl in the green leaf, utilize it to decompose carbon dioxide and water, which are relatively low in energy, and recombine parts of them with other elements drawn from the soil (and to some extent from the atmosphere) into sugar, which is high in energy. This sugar is then utilized by plant and animals in their growth. In this process the plant releases oxygen, which the animal needs to release the energy in its food. And, similarly, the animal releases carbon dioxide which the plant makes use of. Thus, if there were only animals in the world, or even too many animals in relation to plants, energy would be continually used up without accumulation, and life would eventually be spent. For the green leaf of the plant is the only agency for utilizing the sun's energy, and also the only one to take the earth's elements from the soil and the atmosphere, combining them into the complex substance that is food.[2]

Although the plant manufactures its food in the green leaf, it gathers most of the materials for this food through the roots from the soil. These materials are passed from the roots to the leaves by the sap currents. It is this stored up energy which not only makes the plant a food for animals but also permits it to reproduce itself in other individuals, either by seed or some other means.

The soil is not only the source of the plant's nourishment, but also the home and proper environment for its roots. Fertility of the soil is derived from at least four sources, each of which is of primary concern to agriculture. It is a serious mistake to think of the soil as an inert medium ; it is, in fact, pulsating with life, full of organisms. The first factor in fertility is the presence of these organisms in suffi-

1. *The Soil and Health*, pp.18-19.

2. *Ibid.*, pp.20-22. Also, MANGHAM, Sidney, *op. cit.*, pp.151-152.

cient numbers and variety. Among these are burrowing animals, especially earthworms, insects, and the countless numbers and varieties of microscopic plants and animals. These organisms use each other for food, as well as the decayed remains of organisms and the minerals of the soil. In so doing they help to prepare and condition the materials which are gathered by the plant roots for the sake of nourishment. The earthworm, for example, deposits its excrescences called casts. Of all the soil materials, these are perhaps the most available and richest in proteins. It is estimated that several tons of casts are deposited each year in an acre of fertile soil. Moreover, the organisms referred to alter the structure of the soil and its physical conditions ; they also help to aerate it properly, making it in all a suitable environment for the plant. Some of these organisms (the micelia) even enter into the roots of certain plants and are digested by them, thus adding another rich and restorative element to the plant's nutrition.[1]

The second element is the organic portion of the soil itself, which consists of decaying and decayed bodies of plants and animals. The decay of these bodies follows well marked patterns, resulting in a more or less stable end-product called humus. Humus is spoken of by many writers as the utmost single factor in soil fertility : it is the very storehouse of fecundity. As Howard says, it is nature's most significant reserve :

> A very perfect example of the methods by which Nature makes humus and thus initiates the turning of her Wheel is afforded by the floor of the forest. Dig down idly with a stick under any forest tree : first there will be a rich accumulation of litter made up of dead leaves fragments of bark, bits of decaying wood, and so forth, passing gradually as the material becomes more tightly packed into rich, moist, sweet-smelling earth, which continues downwards for some inches and which, when disturbed, reveals many forms of tiny insect and animal life. We have seen here a glimpse of the way nature makes humus — the source from which the trunk of the tree has drawn its resisting strength, its leaves their glittering beauty.[2]

Selman Waksman's observations on the effects of humus in the soil may be summarized as follows : the first is physical : it modifies the texture color and structure of the soil, as well as its moisture holding capacity, to make it a more suitable home for plants. The second is chemical : it influences the solubility of certain soil minerals, forms compounds with certain elements to make them more available for plant nourishment ; and it increases the buffering qualities of the soil. The third is biological : it serves as nourishment for soil organisms and supplies certain essential nutriments for higher plants. It is

1. *The Soil and Health*, pp.23-25.
2. *Ibid.*, pp.26-28.

also a storehouse of essential elements for plant life. A goodly amount of humus in the soil is practically equivalent to a high degree of fertility.[1]

One reason for the primacy of this factor in agriculture lies in the fact that the farmer himself can make humus directly. And he must do so, because it is the only way that he can restore the balance which has been disturbed by his activities.

The third element considered by agriculture is the rock and mineral portion of the soil. This share is provided by the decomposition of the rock which underlies the soil, such as the erosion of mountains, and so forth. Wind, water, sun, climate and the work of soil organisms gradually reduce the rock to soil particles of different size, texture and mineral content. These constitute a large portion of the raw materials for plant food. Moreover the qualities of these particles help to determine the texture and structure of the soil and the conditions of its workability.[2]

The fourth element is the moisture content of the soil. This depends primarily on the amount of rainfall, and to a lesser degree on the climate, structure and contents of the soil. The structure and humic content of the soil is of special importance in holding and making best use of the rainfall. In cooler climates the evaporation is less, and the moisture therefore does more good. The amount of moisture, says Sears, is the chief determinant of the pattern of vegetation in the world. Where the rainfall is heaviest there are forests ; where less, prairies and steppes ; where least, deserts.

Water is necessary for plants as is food. As much as ninety per cent of the substance of plants is water. Moreover the plant's roots cannot absorb the nutriments present in the soil unless these are more or less dissolved in the water which covers the soil particles. On the other hand, when the water does not drain from the soil but remains and saturates it, the plant's roots are unable to perform their function for lack of oxygen. When this occurs, the nature of the soil changes and less satisfactory plants appear.[3]

The fact that the stability of life is achieved by the cycles of life and of vital operations, has obtained far greater attention from science in recent years. The growing awareness of this master principle is evidenced by the development of the science of ecology, a branch of biology which investigates the life of organisms in relation to their environment.[4] The principles of this stability are balance and reserves, as has been mentioned. Examination of these inter-related cycles and communities of living things, whether in general, or in their

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1. *Soil Microbiology*, New York, Wiley, 1952, pp.124-147.
2. HOWARD, *op. cit.*, pp.29-30.
3. Cf. SEARS, *op. cit.*, chap.VII, " The Great Pattern ".
4. WOODBURY, Angus, *Principles of General Ecology*, New York, Blakiston, 1954, p.6.

specific detail, confirms the idea that life is such that its continuation requires a balance of births and deaths, growth and decay, construction and destruction. Moreover, all of the immediate causes, effects and conditions of this cycle are cycles in their turn. As E. J. Kraus says : " The interrelation of the soil, the atmosphere, the plant and the animal is a cycle in which the same materials are used over and over again." Even the sunlight, which is constantly pouring into the world, is received in cycles, diurnal and seasonal. The rocky core of the earth, from which soil is continually being made, is carried to new places by wind and water ; thus new land is continually being made and old land continually replaced. The moisture cycle starts from the large bodies of water by evaporation, is carried inland by air currents, deposited as rain, and hence gradually finds its way back to the ocean by gravity. The air currents are also cyclic ; and both of these cycles, moisture and air, are controlled by differences in temperature, which originate in the solar cycles.

The cycle of life itself takes place not only in each organism but also in the organization and growth of plant and animal communities. Here, no less than in the life of each individual, balance and reserves are the controlling principles. Sidney Mangham speaks of the communities of plant life in the following terms :

> Similarly, in nature, when a new site is exposed, as in a chalk quarry or a gravel pit, or on a freshly emerged sandbank or shinglebank, or on the alluvium left by a retreating flood, colonization by plants almost invariably follows. A long succession of different plant communities develops and culminates in a climax community, the highest type which is determined by the nature of the soil and the prevailing climate, together with the plants available for yielding seed or other reproductive structures. All over the earth since plants first appeared this ceaseless change has gone on. The pioneer plants which arrive on a barren spot prepare the way for their successors. Bacteria, algae, lichens, mosses, and sometimes fungi are among the first to appear on exposed moist rocky surfaces, and they gradually alter the site by disintegrating the rock and by forming a layer of plant remains. In this way the first comers provide roothold and nourishment for the seedlings of higher plants, whose development and decay in time may make possible even the growth of trees.[1]

When a climax has been reached, the gathering and elaboration of fertility ceases, as well as the succession of communities : the cycle becomes stable. The changes occurring from then on are not called developments but adjustments. Cycles of animal life accompany and interact with these changes in the plant communities, and are always found along with these.

The cycle which is of most immediate practical concern to agriculture is the nutritive one. It is by nutrition that the living being

1. *The Earth's Green Mantle*, p.25

comes to maturity and prepares new individuals to replace the parent, and this is accomplished by constructive activity. Simple and complex substances are compounded into the more complex substance, food ; and this, in turn, into the still more complex substance, the organism. This is one phase of the nutritive cycle ; the other consists of the decomposition of living beings into a less complex form of food. If the process continues further, it resolves to simpler compounds and elements, the raw materials of food. In nourishing itself the plant takes carbon dioxide and water from the soil, along with minerals, which have been compounded into suitable forms by natural agencies and by the work of soil organisms. In the process, the plant releases oxygen into the air, to be utilized by animals. Animals, in turn, release carbon dioxide to the air. In the decomposition of plants and animal nitrogen is released into the air, and further returned to the soil in combinate forms, where it nourishes soil organisms. The minerals which have been transformed into plant and animal tissue, are also returned to the soil in a form more available to plant roots when decomposition occurs. All of these cycles are by nature self-adjusting and continuous, because they are balanced. Humus, the storehouse of fertility, is a chief factor in the continuity of this cycle. As Howard puts it : the law of nature's farming is the law of return.

The successful farmer need not know philosophy, even though some farmers are in fact more philosophical in their views on nature than many so-called philosophers. On the other hand, just as it is the office of philosophy to delve into political science — as distinguished from the exercise of political prudence which is the task of every citizen —, it is the business of philosophy to know what agriculture is, with respect both to nature and society. Eminent ancient philosophers were deeply interested in this subject, and the most outstanding of contemporary authors on agriculture write in the same vein. The purpose of these pages needs no further justification.

CONCLUSION

Man lives by reason perfected by art, just as the animal lives by instinct, which in some is perfected by what is comparable to prudence in man. All the arts invented by man are required for the completion of his life ; but first, in point of necessity and time, are the arts by which food is acquired ; and first among these, not in time but as to need and perfection, is agriculture — the art by which civilized man acquires his food. Not only is agriculture the first among the arts of civilized life, but it is also the matrix of the other arts which grow up around it. Moreover, agriculture has this added significance, that when its activities are unsound, the very existence of the civilization which it makes feasible is threatened, for unsound agriculture not

only affects the quantity and quality of the food produced, but tends at the same time to destroy the soil's fertility, upon which the food supply depends.

Aside from our need for it, agriculture has always been highly esteemed as a way of life which breeds many virtues in those who practice it, fostering a highly desirable class of citizens. It has likewise been prized as a natural way for man to take his place in nature ; not simply as being part of nature, but as sharing in the ordering and fulfillment of nature, not to mention its embellishment. For there is a beauty all its own in the cultivated country-side.

Many philosophers, from ancient times to the present, have treated of agriculture. A philosophical study of this subject should aim at determining the nature of the art, of its parts, principles and relations to the other arts and sciences. Unlike a specialized or technical study of the art, its philosophy will remain general, speculative and not directly conducive to practice. Nevertheless, it can serve twofold purpose. First, it can help to complete philosophy itself, which, as St. Thomas says, should have some doctrine on any subject to which human reason extends. Secondly, it can contribute, speculatively, to understand the problems that arise in the practice of the art.

In reference to its nature, it should be understood that agriculture belongs to a group of arts which are called cooperative. Now the purpose of every art is to make something which nature either does not make or does not make in a way that only reason can provide — as in making spectacles. Art presupposes nature, for nature is an intrinsic principle of coming to be, whereas art, like reason itself, is a principle extrinsic to nature. Unlike nature, the power of art does not extend directly to the very substance of things, but only to what is extrinsic though inherent to their substance, such as quality and quantity. Furthermore, all art imitates nature as far as it is able to. For art as a cause is in our reason, whereas the cause of the things of nature is the divine intellect ; but our reason resembles the divine intellect, and effects which proceed from similar causes will accordingly be similar, at least in a proportional way. In this regard, the works of our arts and crafts can hardly fail to imitate the Mind which fashioned natures that are its works.

But in the things produced by some of the arts, nature operates as a passive principle, where art is the chief agent ; whereas in things wrought by cooperative art nature operates as an active principle, and is therefore the chief agent of the product. Art, in the latter case, operates as an adjuvant cause, directing nature's activities to their proper effects, surpassing the products of nature left to herself. Cooperative arts act for the same end and by the same means as nature does — or would, if she could. This relation is a first principle in farming. Agriculture is necessary inasmuch as nature does not

supply food in the quantity and quality required for life in the civil community. The civil society is itself a product of art, not of nature alone, and its needs must therefore be met by an art to supplement nature.

Like every art, agriculture has its proper end and means. Tillage, cultivation and husbandry are the principal means, while their proper end is crop. Each of these is something which nature unaided does not provide. All the same, even here nature is the principal agent, agriculture its helper. For this reason farming must be proportional to the activities of nature and adjust them by using similar means and reaching out to the end that nature would pursue, namely to food for man. But because the means we are bound to use as well as the use we make of the very purpose of agriculture, interrupt and disturb the balance of nature in some measure, still another activity is required in agriculture, namely, fertilizing, which restores and keeps the natural forces at work in balance. This operation too must imitate and adjust to natural processes.

The end of agriculture is crops, but the end to which crops are referred is the needs of the domestic and the civil community. It is the function of economics and politics to govern the domestic and the civil community, respectively ; and this means to make use of the things produced by the other arts. But an art which makes a thing is subordinated by its end to an art which makes use of it. Therefore agriculture is subordinated to economics and to politics, in such a way that these exercise a power of command over it. But this power does not extend to determining the proper practices of agriculture, except indirectly. The determination of these is derived from natural laws, just as in the case of the medical arts, the art of teaching, and the other cooperative arts. For this reason, the control exercised by politics over agriculture should not be a despotic but truly political, meaning it should not be governed in a way that is contrary to its own principles, which are determined by natural laws that should not be thwarted.

Crops, like all other goods, can be produced either for direct consumption, or for exchange or sale. Moreover crops may be exchanged or sold either to satisfy some other natural need or for the sake of making profit on the exchange itself. From this distinction three species of agriculture can be recognized. Subsistence agriculture is practiced to satisfy the immediate needs of the domestic community or locality. Family type agriculture produces crops for exchange or sale, but generally to satisfy natural needs ; the commercial type of agriculture produces crops for profit. All of these forms are needed in a complex industrial civilization, but each of them must be evaluated according to the way we treat the fertility of the soil — which agriculture must regard as a sacred trust — in view of the good life of the community. To the extent that profit becomes a goal in agriculture,

it tends to depart from its primary allegiance to the norms of fertility and to the needs of the community ; and this readily leads to abuses in both directions. The family type of agriculture is less likely to trespass in this regard, and the art of politics is wise in fostering such farming.

The successful practice of any art requires experience, for art is concerned with particulars, and experience is the perfection of man's particular reason, just as science is the perfection of his universal reason. To acquire this experience the farmer will be best guided by three norms. The first is the exemplar, which is furnished by nature in her own operations, in forest, prairie and waters. The second and more immediate norm is the successful practices of other farmers, especially those of long standing. The third is a negative norm, namely, the prevalence of diseases and pests among his crops. These should be regarded as symptoms of unsound practice rather than obstacles to be removed.

Today the farmer tends to look to science rather than to these norms, for all his guidance ; but this seems to be an inversion of right order, for science should follow experience and explain it, rather than precede or supplant it. The best example of an agriculture based on experience, without science, is Chinese agriculture, which has been practiced with outstanding success for four thousand years.

Considered in its whole essence agriculture is an art, not a science. But the part of it, considered separately, is called a science, namely, that part of it which is general, remote from practice, and which provides the first principles to guide this practice. Being a cooperative art, agricultural science is subalternated to natural science. This means that its principles are taken from natural science, so that what is known to agriculture as a fact is knowable in natural science as to its formal reasons. The first principles of agriculture are the properties of natural things. But the properties of natural things are demonstrated by natural science from its own principles.

Some practical arts, such as navigation, are subalternated to mathematics ; but agriculture is not subordinated in this way. St. Thomas calls knowledge of the former type ' mixed sciences,' whereas, he says, agriculture is a purely physical science. The proper reasons for its practices are the properties and principles of natural things, not mathematical principles. Yet it seems as if agricultural science is now seeking its proper reasons in mathematics, a tendency which is misguided. Mathematics can, indeed, supply reasons for agricultural phenomena, but these serve as remote, not as proper principles.

Three characteristics of the principles of agriculture are deducible from its subordination to natural science. First, that they are many rather than few, for it is concerned with particulars, and the proximate principles of particulars are many. Secondly, that it is concerned with the properties of natural things as they exist in the concrete,

and not abstractly, for agriculture is a practical art, not a speculative study. Thirdly, that agriculture is more properly concerned with those natural properties that are subject to human control rather than with those that are not, since it is concerned with food as produced by art and not by nature.

The principles of agriculture, says Howard, are dominated by two master principles, namely, variety and stability. The variety is the vast number of natural forms, living and non living. Stability is achieved by a vast cycle of changes, composition and decompositions, generations and corruptions, growth and decay. In natural conditions, this cycle is self regulating, goes on and on, and achieves a natural balance. At the center of this cycle is the life of the plant, and its nutritive activity. Supporting and conditioning the plant's life cycle are the cycles of sunlight, temperature, air, water, minerals from the soil, the soil population (plant and animal forms which live in the soil and condition it for plant life) and, finally, the decayed remains of living beings in the soil, which reaches a state of stability in the form of humus. Humus is practically the equivalent of fertility and is, perhaps, the most important single principle in agriculture as well as the factor most subject to control by the farmer.

Speaking generally, natural science supplies the explanatory principles for agriculture ; with the more particular and proximate principles — and therefore those which are directly and practically applicable — coming from the special sciences of nature ; and those which are absolutely universal, remote, and not directly applicable to practice, being determined by the generalities of natural philosophy. These primary principles, which are the speculative foundations of agriculture as it were, are the final, material, formal, and efficient causes of the variety and stability in nature.

The continual and balance cycle of generations, corruptions, and movements is explained first by its final cause : All things tend to imitate the perfection of their Maker. But natural beings cannot do this in a simple and changeless way, but only by an endless cycle of changes through which the species, not the individuals, achieve a measure of permanence.

JOSEPH B. MCDONALD.