CHAPTER 6

THE INDIVIDUAL AND FERTILITY MAINTENANCE

Factors Which Determine When Fertility Maintenance Is Economic

There is a rather widespread belief that all exploitation of our soil resources has been bad and that the basic objective of all conservation work must be the introduction of land use which will stabilize our remaining soil assets permanently at their present level. This point of view fails to recognize that exploitation of land resources in the past and at present, where stores of virgin fertility yet remain, may be beneficial to both the individual farm operator and society as a whole. For this to be true, however, all costs of exploitation affecting both the individual and society must be considered. The difficulty lies in determining when conservation is economic to the individual and under what circumstances individual adjustment may be expected when conservation becomes economically and socially desirable.

In considering the bearing of exploitation, conservation, and improvement upon the returns to private enterprise, the distinction made between fertility depletion and soil deterioration is useful for analytical purposes. As was pointed out in Chapter 1, depletion, maintenance, or improvement of fertility may be looked upon as being related to the application of variable costs to the permanent capital assets, and no change in rent or capital value need result. Under these circumstances net returns, net income, and rent become synonymous, and it becomes economic to maintain the level of

fertility at the point where the marginal product just pays for the marginal inputs of labor and capital under the conditions prevailing at the time.[1] This point will be affected by the demand for farm products both at home and abroad and the relative scarcity of land in relation to the other factors of production. This level of fertility will fluctuate in response to changes in the cost price structure. Lower prices for phosphates and lime and higher prices for crops mean that fertility will be increased and yields improved; when the prices of products fall, cash outlays for fertilizer will be reduced as happened in the cotton belt during the period of low prices from 1931 to 1935. In the case of our chernozem soils, however, another factor has to be taken into consideration, and that is the presence of a surplus fertility that has accumulated over the centuries and has no cost of production. This we will call virgin fertility, and the immediate problem is to analyze the factors which determine the point in time where exploitation of virgin fertility should cease and fertility maintenance begin.

Virgin Fertility and Fertility Maintenance

The presence of virgin fertility means that, *for a period of time*, the costs of production are lower than they would be if fertility had to be maintained; this results in higher net returns during the period when exploitation is economic.[2] This has

[1] For a more complete discussion of this point, *see* the two articles by S. von Ciriacy-Wantrup, "Soil Conservation in European Farm Management," *Jour. Farm Econ.*, Vol. XX, No. 1, Feb., 1938, p. 87; and "Economic Aspects of Land Conservation." *Jour. Farm Econ.*, Vol. XX, No. 2, May, 1938, p. 462. The complete relationship of the present input-output ratio and time can be illustrated by a three dimensional graph giving the marginal productivity curve plotted on the X and Y axes with time extending on the Z axis at right angles to X and Y.

[2] Under a given demand situation and where no new land is being brought into cultivation, prices will be determined by the relation of total supply to total demand, and the total supply should be adjusted so that marginal costs equal the values of the marginal products. When land with virgin fertility is competing in a world where fertility has to be maintained on a large part of the land, the marginal supply will largely be determined by those areas where fertility

(*Footnote continued on page 71*)

important repercussions upon land values, types of farming, and the intensive and extensive margins of production. If we look upon virgin fertility as a store of plant nutrients (a fund resource) the utilization of which lowers the current expenses of production and increases the net income (and net returns), we can visualize the net return curves for a system exploiting the virgin fertility and for one conserving this fertility as shown in Figure 3. The shaded area on the left of the intersection of the two lines CE[3] and AB represents the individual gain from exploitation and the area to the right the loss due to continued exploitation. Theoretically, conservation should automatically be adopted at the point D if rent, land values, capital investment, and labor were perfectly mobile, and the farm operator had perfect knowledge regarding the combination of factors and returns for both the exploitive and conserving system. The slope of the returns curve under exploitation will depend upon the topography of the land, precipitation, soil type, and type of farming because these factors will determine the rate at which the fertility is removed. The distance between it and rent (the net returns under conservation) will depend upon the costs involved in maintaining the soil on a permanent basis. These again will depend upon the same factors enumerated above and the comparative advantage between the exploitive and conservation systems. One of the most important problems will be the question whether the

[2] (*Continued*)
maintenance is an important cost; virgin fertility will, therefore, be equivalent to lower cost structures in the areas where it is present and this will mean higher net returns at any level of intensity. When new virgin lands are first brought into production there is, of course, a large effect on price; this, theoretically, should result in a reduction in intensity and a reduced output from the old areas with higher costs, so that a new equilibrium is established. Both intensive and extensive margins will be affected, and the final result will be related to the elasticities of both supply and demand.

[3] The curve CE should, of course, be discontinuous because of the nature of the annual period of production. Smooth curves are used purely as a simplification and to follow formal procedures. It is important to note that the line CE represents both net income and net returns because the concept of fertility depletion implies that no change in rent or capital values occurs.

same general type of farming can be maintained under both the exploitive and conserving systems. If fertility maintenance should require an entirely different type of farming involving adjustments in farm size (or family labor mobility), the problem of adjustment is much more difficult.

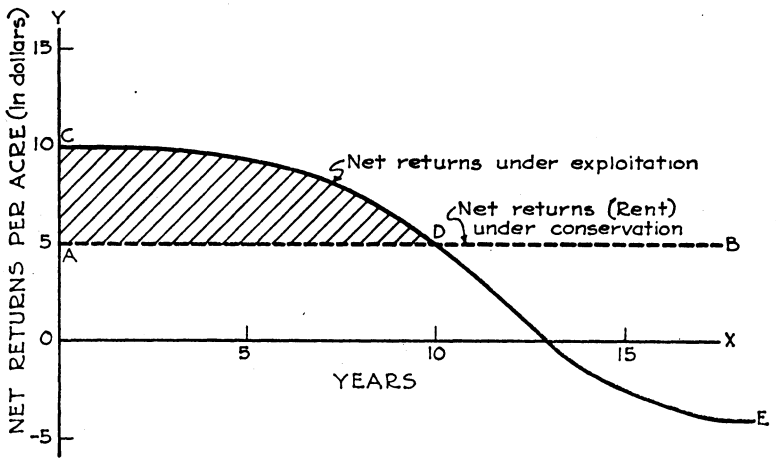

Fig. 3. Net returns curves under exploitation and conservation in the case of fertility depletion.

Price Changes and Fertility Maintenance

Changes in prices of farm products and changes in prices of production factors will cause changes in the shape of the curve CE and the level of AB with the result that the point D will vary in time according to such changes. Under certain cost and price relationships the line AB may be below the X axis and have a negative value. In this case the land might be profitable for cultivation during a period of exploitation of its virgin fertility, or subsoil water supply, but become submarginal for this use as soon as the stores of fertility or moisture are depleted. The costs of producing a sufficient volume of

output with the same pattern of farm size, population, land values, and tax rates would reduce net returns to a negative value.

The determination of the point at which the maintenance of fertility becomes economic is difficult partly for the reason that prices for various competing products vary and the physical data are aften unobtainable. The question of whether we are producing for a foreign demand as well as for the home market also has to be considered. If our production is limited to the domestic market, our natural resources are relatively more abundant; prices, rents, and land values would be lower than those which would result if we were also supplying an export market. Much land at present under cultivation in response to world demand would become submarginal, if our export outlets were cut off, and fertility maintenance involving increased costs would be less economic.

An implication of the above approach, that fertility maintenance involves higher costs or lower net returns than can be obtained from exploitation, may be questioned by many who believe that maintenance would actually increase net income rather than curtail it. The fact that fertility maintenance or improvement would increase net returns in a great many areas is due to a lack of technological knowledge on the part of many farm operators and to certain institutional and economic factors which prevent the change from exploitation to conservation from taking place at the level which would result in the maintenance of the highest possible returns under given conditions. The introduction of better farm management and budgeting analysis would tend to remedy this uneconomic continuation of exploitation if the exploitive nature of the present system should be recognized and its effects upon net returns revealed. If a farmer fails to maintain fertility at the optimum level he will receive a smaller income, and the

adoption of methods to maintain or improve the fertility will then result in an increased income.

Resistances to Adjustments Necessary to Maintain Fertility

Why have farm managers not maintained fertility at the point at which it is evidently economically sound? Apart from such social factors as ignorance, tenancy, and custom, there appear to be certain resistances which are ascribable to the fact that fertility depletion may appear to the farm operator to be the most remunerative practice in the early stages of land utilization on those soil types which have large stores of virgin fertility. There is ample historical evidence of this consideration in the 19th century development of the American Midwest. As was shown earlier, exploitation implies lower costs and tends to be reflected in higher net returns than would result under conservational procedures, and these returns may become capitalized into excessively high land values. This overvaluation of land tends to force the farm enterprise into types of farming with a greater capacity than would be the case if the existence of exploitable virgin fertility had not led to the relatively high capital value of land; consequently, a proportionality of factors of production is established during the period of exploitation different from that which is most profitable when fertility has to be maintained. The fact that farm labor has been historically largely family labor has tended to result in smaller farm units rather than more hired labor; and in order to adjust to the new cost situation resulting from the need to maintain the soil, farm size may accordingly need to be increased. Furthermore, prices of competing products were unquestionably strongly influenced by the supplies resulting from the exploitive system, so that readjustments in these price relationships tended to follow the changes in land use and types of agriculture.

Factors Affecting the Overvaluation of Land

Theoretically, the value of the land the first year should be its expected rent (permanent net returns) capitalized at the current rate of interest plus the present value of the area CDA (Figure 3).[4] If the permanent net returns were $5 per acre and the initial returns under exploitation $10, and assuming CD a straight line trend over ten years, then the value per acre at a 5 per cent interest rate would be $100($5 per year capitalized at 5 per cent) plus $23.51 (initial value of CDA)[5] or a total of $123.51 per acre. This value would then decline annually until it reached $100 in ten years' time. Actually land valuations have tended to take the annual yields, or short-time averages of annual yields, and capitalize these without due regard to the fact that part of the net income was not of a permanent nature and should not, therefore, be capitalized at the current rate of interest. This is one of the reasons why poorer land in many areas is relatively overvalued in terms of its productivity when compared to better land. If in the example chosen the land had been capitalized upon its net income the first year, its value would have been $200 instead of $123.51. Where this incorrect valuation has been made the basis of taxes and mortgages, the effects of this error in introducing untenable fixed charges against the enterprise can easily be perceived.

The extent to which overvaluation may have occurred would depend upon the slope of the net return curve (CE)

[4] It is important to note that this example refers to fertility depletion only. and no destruction of permanent productivity occurs.

[5] The value of the area CDA at the beginning of the period can be calculated from the formula

$$V_0 = A_0 + \frac{A_1}{1+r} + \frac{A_2}{(1+r)^2} \cdots + \frac{A_{n-1}}{(1+r)^{n-1}}$$

For further discussion of this problem, *see* D. B. Ibach, "The Role of Soil Depletion in Land Valuation," *Jour. Farm Econ.*, Vol. XXII, No. 2, May, 1940, and the note by J. J. Livers and G. H. Craig on this article, *Jour. Farm Econ.*, Vol. XXII, No. 4, Nov., 1940, p. 773.

under the exploitive system and the height of CD above AD. These in turn would depend upon the physical characteristics of the soil. A very rich, deep soil might have a relatively slow decline in net productivity, so that the point D might not be reached for decades, and the tendency would be for values to be established at the higher levels for a protracted period. Where the soil is shallow the curve would tend to be steeper and point D might be reached in five to ten years. The types of crops grown during the period of exploitation would also play an important part in determining both the speed at which the virgin fertility would be used up and the comparative advantage of the exploitive system.

The point of particular importance, however, is that once point D has been reached it becomes economic to increase costs and maintain fertility upon a permanent basis (unless the line AB is below the X axis and the land is submarginal for maintaining an acceptable level of living under the present farming system), because after this point failure to maintain the resources will result in lower and eventually negative net incomes. While it may be economic to maintain the soil resources at point D, there are many factors which may prevent this from taking place, and these factors are related to the type of change involved. If the change is merely a matter of applying lime and fertilizer it may be adopted readily; if it involves a change in crop rotations and the adoption of a livestock system of farming to replace or supplement a cash grain system, the change may take place more slowly, and institutional resistances may be more obstructive. Where arable farming is not economic when maintenance costs are necessary, the area may have to be abandoned or turned to other uses.

Fertility Maintenance and Social Welfare

From the point of view of preventing the destruction of vital natural resources, there seems to be little need for society

to control land use and see that the maximum net returns are obtained because, in the case of fertility depletion, no permanent damage to the resources results, and the land can be brought back to a higher level of productivity. Should widespread underproduction exist due to mass ignorance and inertia, society might be justified in initiating action to stimulate more economically feasible production, but in our present dynamic society the use of education, the revision of customary concepts, and some mitigation of institutional resistances might be all that is necessary from the point of view of maintaining the optimum level of soil fertility. On the other hand, if past overvaluation has led to too high fixed charges in taxes and interest, more direct social action might be desirable in order to avoid the wholesale dispossession of farmers due to the inevitable depreciation of the land assets. In the case of fertility depletion the need for economic planning therefore grows out of institutional factors and rigidities, and there is no theoretical basis for a conflict of interests between social and individual points of view. Changes in demand, the quantity of capital, and the interest rate would be reflected in prices and in cost combinations. Under pure or nearly pure competition, the point at which fertility maintenance would be economic would fluctuate according to the changes in these elements. Because the process of depletion is reversible (when no *permanent* lowering of net productivity takes place), new equilibria can be established at various levels. The reasons these automatic adjustments do not take place are largely institutional and social in nature and reflect such factors as custom, immobility of population, inflexibility of farm size in given areas, tenure patterns, and inflexibility of fixed charges; these rigidities result in inflexibility of adjustments at the intensive and extensive margins of production.

In a dynamic economy, fertility depletion and improvement may perform a useful function in providing a method of cushioning shocks due to price fluctuations. During a

period of low prices, costs may be cut by curtailing inputs and drawing upon fertility which may later be replenished during a period of higher prices. Similarly, where income is needed for immediate expenses for the education of children, or for buildings, or livestock investments, it may be economic to deplete the fertility of the soil and rebuild it when there is less urgent need for current income. This essentially represents a disinvestment of one form of capital and investment in another. Whether such a procedure is economic depends, among other things, upon the availability of loans, interest rates, the amount of the temporary income gained from reducing costs, and the cost of restoring the fertility later. The procedure may not only be economic for the individual but also for society as a whole when the new investment yields larger returns than the old. During the World War of 1914–18 the phosphorous content of the soils in Germany was greatly depleted, which made necessary abnormally high applications of fertilizer for a decade afterwards. Under such circumstances neither "conservation" nor fertility maintenance is economic either for the individual or for Society.