CHAPTER 7

THE INDIVIDUAL AND CONSERVATION WHEN EXPLOITATION INDUCES EROSION OR SOIL DETERIORATION

Factors Which Determine When Conservation Is Economic

In the preceding chapter we have discussed the case in which only fertility depletion occurred and no permanent reduction in rent or net returns resulted from exploitation; we now turn to the more complex problems that arise when exploitation leads to a permanent reduction in the productivity of the land and to decreasing rents and land values.

When exploitation not only removes the virgin fertility (fertility depletion) but results in an actual destruction of the productivity of the soil (soil deterioration) and permanently reduced rents, the difficulties of the problem of determing the point in time at which conservation becomes economic for the individual are enhanced, partly because of the importance of the interest rate and costs of achieving erosion control. In the early stages of exploitation, before erosion starts to destroy the permanent productivity of the soil, the two cases are substantially alike. As erosion develops, however, the rental potentialities are permanently impaired either by a reduction in total productivity or by a permanent increase in the unit costs of producing the same output as before.

If we assume that costs and prices remain stable over time and that an exploitive system leading to soil deterioration is established on any given area of land, the net income will decline annually as the productivity of the soil is impaired and may finally become zero or have a negative value. Under these circumstances the costs of production (which include returns to family labor) cannot be met. In this case the farm operator faces two alternatives each year; he can either continue to exploit the land or adopt a conservation system that will permanently maintain the physical productivity of the soil and, therefore, stabilize rent over time. Which he will do will depend upon the net returns that can be earned from the alternatives available. He may stabilize production the first year the virgin land is taken up, and the net returns then would be rent because they would continue indefinitely into the future; and on the other hand, he might adopt an exploitive system and not adopt the conservation alternative for ten, twenty, or thirty years. Each year the level of productivity that could be maintained would decline and, therewith, the possible rents and associated land values would also decline annually. Since net returns represent net income less the annual reduction of the capital value of the land (or plus any increment in the case of improvement), the net returns under exploitation would decline annually, and the rate of this decline would be determined by the rate at which the land value was reduced. This in turn would be determined by the rate of physical destruction of the productivity of the soil and the interest rate. For the land being considered we can visualize one curve (CHD in Figure 4) representing the net incomes over time that would be associated with an exploitive system and, calculated from this, a net returns curve ($CHI_{(2)}$ in Figure 4) representing net income minus the loss in capital value calculated at interest rate $I_{(2)}$.

Because rents (net returns under conservation) can be maintained only at lower levels each year as the physical productivity of the land is destroyed, we find that, instead of one rent curve (such as AB in Figure 3) for the conservation system, the height of the rent curve parallel to the X axis will be lowered as time passes, and we will have a whole series of parallel lines (UU to ZZ in Figure 4) representing rents or net returns under conservation systems inaugurated at successive points of time. The loci of the points where each of

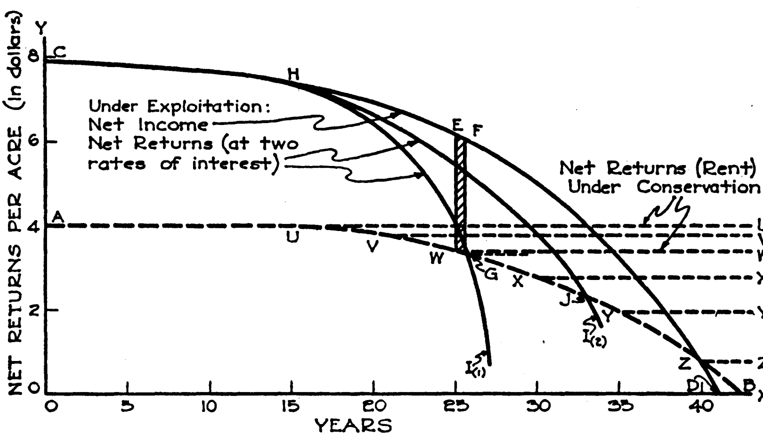

Fig. 4. Net income and net return curves under exploitation and various levels of conservation in the case of soil deterioration (depletion plus capital destruction).

these different levels of rent start in time will be a downward sloping curve, AB in Figure 4. The curve AB may or may not intersect CD (the net income curve under exploitation) depending upon the physical conditions of the erosion taking place, its effect upon productivity, and the increasing costs of controlling erosion as it progresses. Thus, instead of one rent curve AU which will rise and fall under dynamic conditions as new equilibria are established, there is a series of such curves at all levels below AU, and the whole series of curves will rise and fall in response to changes in the price and cost structure. This assumes, of course, that such adjustments are made within the framework of the conservation system and do not result in further exploitation.

The basic fact of importance under the conditions assumed here is that as time passes rents (or net returns under conservation) are permanently reduced, and the process is not reversible.

Corresponding to this series of curves reflecting permanently reduced rents, and starting at the point U where rent commences to decline as a result of soil deterioration, will be a constantly increasing difference between net income (CD) and net returns (CI) under exploitation. The shape of the net returns curve under exploitation (net income per acre less the loss in the capital value of the land) is, therefore, determined by the curves CD and AB, and the interest rate. The generalization can be made that as interest rates decline, the capital loss increases, and the downward slope of the net returns curve becomes steeper. At a zero interest rate the capital loss becomes infinite, and the net return curve would be a vertical line from H to U. For all interest rates above 0 there will be a series of net return curves starting from H and sloping downwards at a decreasing rate as the interest rate increases. In Figure 4 two such net return curves ($CHI_{(1)}$ and $CHI_{(2)}$) are shown to represent interest rates of 2½ per cent and 5 per cent, respectively.

Two questions immediately arise. First, at what level does it become economic for the individual to conserve his soil under these circumstances? And second, is this necessarily the most economic level from the point of view of society as a whole?

In the case of the individual the point at which conservation becomes economic will depend, among other things, upon the interest rate and will be the point on AB where the annual return (at a given rate of interest) on the financial gain from exploitation equals the annual loss in rent resulting from exploitation. This could also be expressed by saying that it becomes economic to conserve the soil when the capital loss in land value due to the permanent reduction of the productivity of the land equals the gain in annual income resulting from exploitation. In simpler terms conservation is economic where the *net returns* from exploitation equals *rent* at any given rate of interest. On Figure 4 this point is represented by the intersection of the net return curve CHI (at any given rate of interest) and the curve AB, because at this point the net returns from exploitation equal the net returns under conservation (rent). To continue exploitation beyond this point would mean that the net returns from exploitation would be less than the rent that would be obtained if conservation were adopted. Net income from exploitation would be considerably higher than the rent at this point, and the basic importance of deducting the capital loss is revealed. If the operator is not aware of this capital loss, or if he can transfer it to some other person or group, then he will continue to exploit the land.

Figure 4 indicates that for the first fifteen years (A to U), no permanently bad effects result from exploitation of the virgin fertility, and the exploitive system during this period is very much more profitable than the conservation system. During the next five years (U to V) continued exploitation results in some slight impairment of the soil so that when placed under a permanent system the net returns are lowered approximately 20 cents an acre in perpetuity. From V to W the rate of impairment and costs of control increase so that, at twenty-five years, rent under the conservation system is permanently 60 cents an acre lower than it would have been if conservation had been adopted ten years earlier, at U. As the years pass, however, cumulative erosion and increasing costs of control continue to lower the level of rent more and more rapidly, as is indicated by the increasing distances between W and X, X and Y, and Y and Z for five-year periods. Each year the annual gain from exploitation (height of the column between AB and CD) decreases, while the loss in rent due to postponing conservation increases.

The Effect of Different Interest Rates

The importance of the interest rate may be shown by examining the two net return curves $CHI_{(1)}$ (assuming interest at 2½ per cent) and $CHI_{(2)}$ (assuming interest at 5 per cent). $CHI_{(1)}$ intersects AB at G (twenty-six years) and $CHI_{(2)}$ intersects AB at J (thirty-three years) and indicates in the example shown, that a difference in interest rates of 2½ per cent means a difference of seven years in the point in time at which conservation becomes economic to the individual. The arithmetic relationships may be illustrated by the following calculations: During the twenty-fifth year, W to G on the curve AB, the gain in net income from exploitation over the net returns (rent) under conservation is the height of the column FG or approximately \$2.80 per acre; the permanent loss in rent due to this exploitation is represented by the difference between WW and the new horizontal line from G where $CHI_{(1)}$ intersects AB, and is about \$0.07 per acre. At the interest rate assumed (2½ per cent), the annual return from \$2.80 invested would be \$0.07 and equal to the loss in annual rent. Similarly the loss in land values would be \$0.07 capitalized at 2½ per cent or \$2.80, and this deducted from the net income per acre makes net returns from exploitation equal to the rent, and it is a matter of indifference whether the soil is exploited or conserved during the twenty-fifth year; it would, however, be economic to conserve it after that time because the loss in rent will be greater and the gain from exploitation will be smaller. Similarly, at a 5 per cent interest rate the net returns curve from exploitation will intersect AB at J, and during the thirty-third year the gain in cash income from exploitation over conservation will be \$1.80, while rent will be reduced by \$0.09; this loss in rent capitalized at 5 per cent equals \$1.80; the net returns from conservation and exploitation are identical, and conservation becomes economic in the thirty-fourth year.

If the lower interest rate also affects the costs of erosion control by reducing the annual costs of capital investments that are necessary, it will reduce the declines in rent resulting from exploitation so that the curve AUB will slope downward less rapidly from U to B.

The above arithmetical example illustrates the case when the interest rate has no effect upon costs, and this is true in so far as the decline in rent cannot be offset by capital expenditures but results from permanently lowered yields or increased costs. To the extent that capital investments in terraces, etc., can be used to control erosion, a lower interest rate reduces the annual costs and has the effect of moving the rent curves VV, WW, XX, and ZZ upwards by an amount equal to this reduction. If only the same amount of capital investment occurs over the whole range, the rent curves will all move upwards in identical amounts. This will have the effect of raising the curve UB without changing its slope, and the point U will be farther to the right. Corresponding to this change, the point of origin H of the net return curve $HI_{(1)}$ will move an equal distance to the right and slope down more rapidly and intersect the new rent curve to the left of G. This is necessarily so because the decline in rent due to one year's exploitation remains the same on both curves, while the distance between the net income curve and the rent curve is reduced.[1] The same results occur when any reduction in the

[1] Since $FG = \frac{WG}{i} \times 100$ and WG is the same on both rent curves, the raising of AUB will reduce FG, and a new equilibrium point will be established where $F_1G_1 = \frac{W_1G_1}{i} \times 100$ at an interest rate i.

costs of achieving conservation take place whether due to new inventions, lower wages, or lower interest rates.

The interest rate therefore influences two factors both of which have the effect of making a low interest rate favor conservation. As the interest rate falls, the capital loss representing the decline of the rents is increased, and the comparative advantage of the exploitive system over the conservation system is reduced because the annual payments on capital expenditures for conservation are made smaller.

Factors Affecting the Value of Land

When soil deterioration occurs, land values tend to decline over time and should correspond to the capitalized rents (UU to DB) plus the initial value of the area representing the gains from exploitation (this will be part of the area formed by the two curves CD and AB). At any given interest rate the initial value of the land will be a maximum when calculations are made on the assumption that conservation will be established at the point where it becomes economic to conserve the soil. While we may be justified in applying a straight-line trend to the net income curve from exploitation before any deterioration of the soil occurs (up to U in Figure 4), we cannot make that assumption after deterioration has commenced because, as has been pointed out, the character and relationships of the curves AB and CD depend upon the physical characteristics of the soil, the farming systems concerned, and the costs of establishing the conservation system.

In the example illustrated in Figure 4, the initial value of the land, at an interest rate ($I_{(1)}$) of 2½ per cent, must be based upon the assumption that capital maintenance would take place after twenty-five years. The value, in this case, would be the rent (WW) capitalized at 2½ per cent, plus the present value of the area CEWA. To make the estimate we must know the shape and position of the curves AB and CD and no dynamic changes (e.g., in interest rates, prices, or techniques) may take place over the twenty-five-year period. Such conditions are never met in reality, and land values in the past have reflected net income, rather than net returns, with an increment added to take care of expected rises in value due to a growing population.

Social Welfare and Changes in the Interest Rate Over Time

An interesting problem of social policy arises when we consider the effect of changes in the interest rate over time. During the early expansion period of this nation, interest rates were high, and land values were low. Exploitation under these circumstances was economic to the individual. However, we know that capital accumulation can occur with great rapidity and that interest rates fall as capital becomes more abundant. This raises the question whether society should anticipate a declining interest rate and encourage conservation which may not be economic at the present rate of interest but would be economic at an anticipated future rate. The answer appears to depend upon whether the individual in anticipating increases in land values includes this factor in his estimate of the future, and to what extent capital can be substituted for land.

Interest rates are only one among many factors affecting the value of land; increases in population, the development of transportation systems, world trade, and the growth of cities are all important. Insofar as officials representing society can make more accurate forecasts of the future than do individuals, the government is justified in using appropriate means to guide and assist the individual in making a more rational estimate of the future. Capital may be substituted for land in varying degrees: Drainage and irrigation represent sunk capital which is inseparable from land as such, while manure and fertilizer represent soil amendments which may replace exploited fertility. If we assume perfect substitutability, no case can be made for any social action which encourages investment in land at the expense of investment in other industries, because this would simply result in a lower social net product over time. If, on the contrary, we assume that substitution is possible only at increasing costs (this is implied in the declines in net returns from UU to ZZ in Figure 4) and further assume that the individual makes no allowance for a decline in interest rates, then social action to encourage capital maintenance or conservation when it is otherwise not economic for the individual would increase the social net returns over time. In the example assumed in Figure 4, conservation is not economic at twenty-five years at an interest rate of 5 per cent but is economic at 2½ per cent. If we knew that the interest rate would decline from 5 per cent at twenty-five years to 2½ per cent at thirty years, then the value of the capital loss at twenty-five years is not \$0.07, capitalized at 5 per cent (\$1.40), but should be \$0.07 capitalized at 2½ per cent (\$2.80), and discounted to its present value. In general, therefore, when a decline in interest rates is anticipated it is economic to conserve the land at that point when the anticipated future capital loss, discounted to its present value, is greater than the increment to current income gained from exploitation. This approach may, of course, be broadened to include all anticipated changes and simply represents a more correct accounting procedure which should be followed by an individual if the information were available to him. However, if the decline in interest rates is anticipated, the demand for long-time securities with a fixed interest rate would be so great that their prices would rise, and their yields decline, until a new equilibrium position had been established.

The Interest Rate and the Substitutability of Capital for Land

A decline in interest rates, however, also affects the slope of the curve AB showing the decline in potential rents over time, because the lower the interest rate the greater the possibilities of substitution of capital for land. To take a simple example let us assume that the physical productivity of a piece of land is reduced by exploitation over a period of ten years, but can be restored to its initial productivity by a capital outlay of $25 an acre without any change in the type of farming or labor requirements. At an interest rate of 5 per cent the decline in net returns at the end of ten years would be 5 per cent of $25, or $1.25. If, however, the interest rate declined to 2½ per cent during the ten-year period, then the decline in net returns at the end of ten years would be 2½ per cent of $25, or $0.625. This means that the locus of the rent curve would be 62½ cents higher at 2½ per cent interest than at 5 per cent interest.

The impossibility of using a zero interest rate for society is well illustrated at this point because, at a zero interest rate, the curve AB becomes a straight line. No decline in net productivity would result from exploitation, capital would have perfect substitutability for land, and exploitation would be economic to the point where CD intersects the new AB. At the same time, land earning any return would be infinitely valuable, but since no decline in net productivity results, no decline in land values would take place. Under these circumstances Figure 4 becomes identical with Figure 3, and erosion or soil deterioration is no different from fertility depletion.

As interest rates decline, the elasticity of substitution of capital for land increases, and to the extent that this occurs the importance of soil erosion or soil deterioration to society declines. Even at low interest rates, however, the elasticity of substitution of capital for soil structure and its associated productivity may remain very low. This problem is related to the uniqueness of the productive powers of a given soil type; if they are unique and cannot be replaced at any cost, then the elasticity of substitution of capital for land is zero. Where a fertile topsoil has a subsoil that is responsive to management, so that terracing, liming and fertilizing, together with several years of green manuring will permanently restore the productivity, the elasticity of substitution might be very high at low interest rates and low at high interest rates.

The Comparative Advantage of Exploitive Crops

Apart from the interest rate, the point at which conservation becomes economic will be determined by the distance between the curves CD and AB and the rate at which curve AB slopes downwards.[2] The distance between the net returns curves for both the exploitive and the conservation system will depend upon the comparative advantage of the exploitive system compared with the best alternative conservation system. This will vary greatly between types of farming regions and the degree of change which may be necessary to achieve conservation. In general, in areas where the exploitive system has a great comparative advantage over the conservation system, exploitation will continue much longer, and greater losses in permanent net productivity will take place, than where the comparative advantage is small. This is particularly true in the case of an exploitive corn-hog system compared with a conservation system where more roughage and less grain are produced, in the case of cotton compared with most other alternatives, and in the case of wheat compared with extensive grazing and long rotations. Where a general

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[2] *See* the discussion by Schickele of the breaking point of natural fertility, *Economics of Agricultural Land Use Adjustments*, *op. cit.*, p. 365.

mixed type of farming prevails, the conservation system may mean very little difference in the combination of factors and conservation may become economic before the virgin fertility is exploited and before permanent damage results.

From this theoretical analysis, any factors which increase or maintain the prices of such crops as cotton, corn, and wheat relative to the prices of other products, increase or maintain the comparative advantage of these exploitive systems and make the exploitive system (where it is being used) more economic than it would be if the relative prices for these products fell. Moreover, any factors which reduce the costs involved in adopting conservation tend to shift the comparative advantage to the conservation system.

Factors Affecting the Rate of the Decline in Rent

The major factors affecting the rate at which permanent productivity under exploitation is reduced can be divided into two groups. The first deals with the physical factors determining the kind and rate of erosion, and the second deals with the related factors affecting the costs of control. The first group deals with such factors as the seasonal distribution and intensity of precipitation, topography, soil type, and the land use pattern. These are the major factors which determine the rapidity of sheet erosion and degree of gullying. Because they vary between areas, farms, and even fields, the rate of destruction of the productivity of the soil varies. In the case of the factors affecting the costs of control, the physical conditions mentioned above, the amount of damage done, the changes in the farming system necessary to achieve conservation, and interest rates are important. In general, the costs of achieving control increase as erosion continues because more terraces and dams are needed and greater changes in land use have to be introduced. In attempting to determine whether conservation is economic on any individual farm, the annual capital loss due to continued erosion, the capital costs of achieving control, and the probable effect of the changes upon net farm income have to be considered.[3]

Factors Determining the Effect of Exploitation Upon Prices

In the case in which the capital good being considered is unique in that it has no substitutes and cannot be replaced (in the case of soil this implies a cost of restoring productivity equal to infinity), the simplified assumptions regarding a constant cost-price structure cannot be maintained. A reduction in the quantity of the capital good will affect the prices of the products, and the present capital value must reflect the discounted anticipated values of the future. The change in future prices will be determined by the elasticity of the demand for the products (this reflects the possibility of substitution by consumers) and the amount of the reduction of the capital good in relation to its total quantity. If only a small part of the capital good were being destroyed and the demand were highly elastic, the effect upon prices and capital values would be slight. If a large part were being destroyed and the demand inelastic, a large increase in price and capital values would have to be anticipated. Under these circumstances exploitation or disinvestment would be economic up to the point where the marginal increase in income from exploitation equalled the value of the increment of resources used up (when the present value of the resource reflects the increase in prices due to the curtailment of total output).

This example is of little value for practical purposes because it is difficult to imagine such a unique capital good, but it serves to illustrate the relationship of substitutability of the capital good to the elasticity of the product demand and to

[3] For a method of making these estimates, *see A Method of Estimating the Economic Effects of Planned Conservation on an Individual Farm*, by Arthur C. Bunce and George Collier, U.S.D.A. Bul., Misc. Ser., No. 463, Jan., 1942.

future prices. Since the degree of substitutability varies for various soil types, each will have a different set of curves showing the net income under exploitation and net returns under conservation. At the same time, the elasticity of the demand for the particular products will affect future prices as the supply is reduced. To make a perfect adjustment the individual would have to know not only the future interest rate but also the probable effect of exploitation upon future prices, and then discount the anticipated future land values to the present. Because of the dynamic nature of our economic universe, in which demand and techniques change rapidly, the level at which conservation becomes economic is also dynamic and variable.

Land Improvement or Reclamation

When we turn from the problem of exploitation and conservation to that of improvement or reclamation, we find that identical problems and relationships exist except that instead of disinvestment we consider investment. Instead of a series of declining net returns curves, we would have a series of increasing net returns curves, and as long as the increase in net returns from the investment of labor and capital in land is greater than the returns from alternative opportunities, the investment is economic. Low interest rates encourage improvement, and anticipated declines in prices due to increasing output will discourage improvement. The problem of improvement is particularly important in the case of podzolic soils and, just as we find great differences in the effect of exploitation on soils with a high virgin fertility, so do we find differences in the responsiveness of forest soils to treatment.

Difficulties of Adjustment by the Individual

The foregoing general theoretical approach indicates the factors which determine the point at which conservation becomes economic for the individual. The question immediately arises as to whether this level of conservation is economic from the point of view of society as a whole. In the case of fertility depletion alone, the process is theoretically reversible. New equilibria can be established in response to dynamic changes and no permanent losses need result from the adjustments. In the case of erosion, exploitation may lead to permanent reductions in net productivity, and the process is not reversible. Thus, temporary factors such as high prices which may afford a greater comparative advantage to the products of an exploitive system, or high interest rates which make it less economic for the individual to conserve his soil, would then result in permanent losses in net returns extending into the future should these factors not be correctly discounted by the individual.

Entirely apart from the question as to whether society is justified in encouraging conservation at an earlier level than is economic for the individual, society is certainly justified in inducing conservation when it is economic from the individual's point of view as well as from the social point of view. The factors which may cause continued "uneconomic" exploitation were discussed previously, but it may be useful to consider one further illustration based on Figure 4.

Let us assume that at an interest rate of 2½ per cent it is economic for an individual to conserve his soil after twenty-five years of exploitation, and that at this point (W on AB) the gain from exploitation ($2.80 per acre) exactly equals the capitalized value of the permanent loss in expected future net returns ($0.07). In order to enter upon a conservation program with adequate information, an owner operator would have to know the following facts:

(1) That the permanent net productivity of the land was being reduced by the assumed amount, and that this meant a loss of capital assets of $2.80 an acre. This loss in capital

value would have to be recognized separately from other factors causing changes in land values.

(2) He would have to know that the annual gain from exploitation compared to a conservation system had amounted to $2.80 per acre. In other words, he would have to know what his returns under conservation would be, and this involves a complete analysis of the capital costs involved in adopting a conservation system, the changes in land use and practices required, and the effect of these upon crop production, the livestock system, labor requirements, and final net returns.

Besides knowing these facts the operator would have to have the adaptability or managerial ability to handle the new system efficiently, and also he would have to have the initiative and energy necessary to plan and carry out the changes as soon as he became aware that they were needed.

Such information is certainly not available for most farmers, nor is there any great financial gain to act as a spur to individual initiative. If losses in capital value are covered up by rising land values, due to population increases or an expanding foreign market, conservation simply appears to mean a reduction in annual income in the present.

If we consider the case of a tenant operator on an annual lease, the chance that he will adopt conservation without pressure from the landlord is indeed remote. In this case the gain from exploitation is shared between the tenant and the landlord, but the total capital loss will generally be borne by the landlord. When this is true, it is to the tenant's advantage to exploit the soil as long as the exploitive system gives a higher annual return than conservation, regardless of the permanent damage done to the land. To remedy this the landlord would have to be aware of the capital loss involved; he would have to be able to suggest alternatives and accept a lower rent now in order to maintain it in the future. On the other hand, if the tenant were occupying the land upon a permanent basis he might adopt conservation measures in order to assure himself of a permanent return over the future.

When we also consider that a change to a conservation system may involve adjustments in farm size and intensity, that prices have fluctuated violently over time, that American agriculture has developed historically on an exploitive basis, and that institutional patterns may have to be profoundly changed, the widespread prevalence of uneconomic exploitation is not amazing. Under these circumstances social action is palpably necessary and should benefit both society and the individual.