Chapter 1

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Need for Land and Resource Adjustment

A MAIN CHARACTERISTIC of the American economy in the postwar period has been its sustained growth. Starting from a 1947-49 base period, gross national product increased by 90 percent to 1959. Total disposable personal income increased by 83 percent and income per capita of the non-farm population rose 40 percent. But an equally important characteristic of this economic growth period has been the relative decline of income in the farm sector. Total net income from agriculture declined by 20 percent in the period 1947-49 to 1959. Income per capita from farm sources increased by only 16 percent even though the farm population decreased by 30 percent.

Obviously, then, we have attained a level of economic development and per capita income wherein further progress does not reward farm and non-farm sectors equally. The absolute decline in net income of agriculture resulted partly from diminution of foreign demand, but more particularly because of the rate of growth of farm output and the low demand elasticities for farm products. Farm output grew by 50 percent over the period 1940-59 and 25 percent over the period 1950-59. Output per unit of resource also increased by 50 percent over the 20-year period 1950-59. Given the rate of population growth and the magnitude of foreign markets, a more rapid rate of development in agriculture results in a decline in total income from farming.

INCOME AND RESOURCE PROBLEMS

The relative decline in income from farming promises to continue unless the resource and output structure of the industry is to change. On the surface, low income appears to be the problem of agriculture. But family incomes and resource returns which are lower than in other major sectors is only a result. We must look deeper to find the basic cause or problem. True, income has been depressed because commodity prices are low relative to the prices of the resources which produce them. But following the sequence further, commodity prices and resource returns are low relatively because production is large. Still, not even "overproduction" is the basic problem or cause. Production is in surplus, relative to the magnitude of domestic and foreign markets and commodity prices which have been acceptable to farm people, and accumulates in public storage because the quantity of resources committed to agriculture is large. These are the basic variables or causes of the farm problem.

The quantity of resources now committed to agriculture, or to particular products and geographic locations, is too large to allow returns on resources at levels comparable to other industries, if the full productivity of these resources is utilized in farming and finds its way to the market. Aside from the small likelihood that world institutions and market mechanisms might spring open for humanitarian purposes, there is no prospect that demand expansion will change this picture during the 1960's. Hence, given the demand elasticities which are in prospect for this period, the input of resources for agriculture must be modified through either (1) diminishing the productivity of resources now in agriculture, (2) lessening the quantity of resources used in the industry or (3) diverting the "within agriculture use" of resources among farming alternatives. Must is, of course, a strong word. It is used here in the context of earnings for agricultural labor and investment which are comparable with those for resources of equal quality in other industries. Few persons contest this criterion from the standpoint of (1) the need by or the return to the nation's economy and (2) the welfare and equity position of farm families as resource owners. Agreement is much less firm in respect to whether the resource returns goal is to be tackled from the direction of magnitude of output or magnitude of inputs, or in respect to the specific policy procedures for either. An important purpose of this conference is to help assess the relative short-run and long-run productivity and supply of resources in agriculture. In this particular case, the emphasis is on the land resource. Given greater knowledge in respect to resource productivity and product supply, we can better evaluate the economic feasibility and political acceptability of alternative measures in bringing economic balance to agriculture.

But whatever the approach, the basic variables to be manipulated, controlled or "price encouraged" are resource inputs. Even direct output control can be successful only if it effectively diverts resources from the aggregate production process. There cannot be any output control unless input control exists. Our overflowing public granary provides the empirical evidence and treasury cost of an experiment conducted in scale, proving that production control is impossible without effective control of inputs.

The extreme policy mechanisms for controlling or altering inputs, and hence output, are open market prices and rigid production quotas for each commodity and farm. Between these extremes lie a large number of alternative mechanisms which, as is also true for extremes, can be used as pure strategies or as mixed strategies in restoring returns to resources in agriculture at levels on an economic par with other industries.

SUPPLY OF RESOURCES

Agriculture's fundamental problem is not supply of product but supply or quantity of factors. Persistence of resources to remain in agriculture at low returns in the short run pushes heavily on product supply or output, thus depressing family incomes to levels thought to be inconsistent with standards held by American society. The problem is most severe for labor. But it also is important in respect to the short-run allocation of land among different agricultural crops or between farm products and non-food services. Still, however, labor and land are linked economically, and the existence of excess labor in agriculture certainly has the effect of holding land to more intensive uses and in restraining its shift from surplus commodities. Contrawise, the land resource prices and tax structures which are not geared to the services the consuming society prefers are also important in determining society's employment pattern and the requirements or employment for the labor which is its technical complement. Policy or market mechanisms which cause a reallocation of land from surplus grain or cotton production to less intensive products such as grass, forestry and recreation also must alter the demand for labor in particular soils regions.

It is, therefore, impossible to separate the demand and allocative needs for land from that of the labor and capital resources which serve either as technical complements or substitutes with it. The planners of the conference were aware of this fact, but had several reasons for singling out the land resource for particular concentration:

(1) The long-run needs of, and the problems in, diverting land employment differ greatly from that of labor. Relative to the needs and challenges in economic growth before the nation, land does not have the spatial opportunities of labor. Needs in

respect to labor are especially those of geographic and occupational migration, if economic development is to take place optimally. Opportunities in occupational shifts are much more limited for land and even then are geographically fixed. Hence, the means and alternatives for adjusting land and labor inputs do, at some point, part ways. Public investment to bring about labor shifts can best rest on such mechanisms as improved educational, guidance, employment and market information facilities. Those for land, while affected by those for labor, must be of quite a different nature.

(2) The values of American society allow the institution of ownership in land, but not labor. Labor and individual, the motivating unit in our economy, are inseparable, and means which are publicly acceptable for adapting services of land are not similarly acceptable for labor. Along with acceptance of ownership in land but not in labor, American society has been willing to offer a price for letting land remain idle. The time will not soon come when payments direct to agricultural labor become an acceptable means for reducing or shifting farm output.

(3) During the 1950's, economists and others concentrated on the relative surplus of labor in American agriculture, without parallel emphasis on the relative surplus of land inputs for particular products or aggregate output. The pat remedy of many economists for solving the farm problem has been "reduce the size of the agricultural labor force." Yet, at least in the short run, a reduction in magnitude of the labor force promises little relief in magnitude of farm output. The farm labor force declined by 30 percent from 1940-60; total output increased by 50 percent in the period. This is true because migration of labor from agriculture does not simultaneously cause land inputs to shrink, or even to shift among alternatives. Surplus capacity of labor and machine capital on typical farms is great, and farmers who remain take over the land of those who leave and farm it with equal or greater intensity. Our studies show that remaining operators use a richer mix of capital with this land, and many obtain an even greater output from it than those who leave.

(4) Measures for bringing about an optimal allocation of land should include consideration of the time dimension more specifically than those for labor. Adjustments and programs relating to land need more to concentrate on true conservation problems and alternatives.

(5) Past programs aimed at production control have focused on the land resource. We have been successful only in proving that the policy mechanisms employed for these purposes so far are ineffective in production control. We have created a maze of

programs which simultaneously subsidize improvements of land to (a) increase current production at the expense of the future, (b) pay farmers for withholding land from current production and (c) conserve the services of land for future periods. These programs are justified to the public partly or entirely under the heading of conservation, perhaps as a means of capitalizing on the favorable attitude which now prevails in American society for improving the intertemporal allocation of basic natural resources. Since we have rested so much of our effort to control output on the land resource, and will probably continue to do so in the future, it is important that we attempt to bring better order among the various program elements, particularly when some now in use are a contradiction of each other.

Still, while some features of land and labor resources committed to particular uses in agriculture are separable, the problems in output or product supply which stem from them have common elements in the realm of factor supply. To understand better the mechanisms most readily acceptable and of greatest effectiveness in adapting use of both resources we must first examine the phenomena relating to supply of either the resources or their services. Why, in the short run, are the households which control them willing to commit them to the production process at such low prices or levels of return? In the case of land, particularly, what are the variables or forces which cause it to be held strictly to some uses when the longer-run economic horizon calls for its diversion to other uses?

A complex of other variables also exists which must be analyzed if we are clearly to understand the forces which mold the use of land or which provide potential in directing it into employment which eases the pressure on output, resource returns and family incomes generally. As a starting point in understanding the supply phenomenon of land for particular uses, we need to know more about the stocks of this resource. We make meaningful aggregations of other resources, but we have been unable to do so for land. Is it possible to aggregate land or its services, considering the great variation that exists in soils and climate, against alternatives in technology and capital inputs so that we have a better picture of our national supply of this resource? Until we are able to do so, and relate the potential stock or supply of this resource to the future demand for its services, we have no reliable foundation for planning policies and mechanisms pointed to meshing land use with national developmental needs. More importantly, we lack the basis for selecting consistent programs which will lessen the surplus problem in the immediate years ahead, but provide us with the pattern of land use needed for the longer-run challenges in national economic growth and world responsibilities which face us.

Land supply is a subject which has little concrete meaning. We know the approximate acreage of selected soil types, or that total land used for agriculture approximates 1.4 billion acres while cropland amounts to about 470 million acres. But these aggregates have no great value in national decision making or planning.[1] Needed in soil classification is a method whereby the various soils can be added together to give some operational notion of the total quantity of the land resource and the aggregate production function which attaches to it.

NEED IN ECONOMIC GROWTH

We are extremely in need of a basic and fundamental appraisal of the use of land resources relative to national economic growth and development. Programs need to be designed accordingly, but these must equally recognize the labor resources which have become attached to particular uses of land among different regions. We can push ahead in meshing use of land with prospective economic growth trends only at about the rate we bring about adaptation in use of the human resources now engaged in particular regions. And these human resources are not all engaged directly in agriculture. In farming areas more or less remote from industrial development, employment of persons in business enterprises, public services and social institutions generally is part of the agricultural matrix. These labor resources and households are no less important than those of agriculture in terms of the impact of major shifts in land use on family welfare and potential contribution of these labor resources to the nonfarm growth process which is in prospect for the American economy.

Land Use, Technical Improvement and Economic Growth

The main result or characteristic of economic progress is a rate of increase in national income which exceeds the rate of population growth, with a growth in per capita income accordingly. National economic growth occurs especially because of

[1] For added details in this respect, see Earl O. Heady. Economics of Agricultural Production and Resource Use. Prentice-Hall. New York. 1952. Chapter 10.

(1) technological improvement including improvement of the human resource, (2) capital accumulation, (3) growth in a labor force wherein productivity exceeds consumption and (4) improvement in economic institutions and market mechanisms. All of these have been taking place in the American economy, and there is no doubt that they will continue to do so. But they have different implications for agriculture than for most other industries. Agriculture likely will parallel other industries in technological improvement. Growth in productivity of land and certain associated resources has, in fact, not only kept pace with that of other industries but has outpaced growth in population. The persistent surplus condition stems importantly from this fact.

We do, of course, wish technological progress in all industries as a general contribution to economic progress. Given economic progress and technological improvement in agriculture, however, certain adjustment requirements become unique to land. For the reasons enumerated later, growth in capital and labor employed in agriculture will not keep abreast of the increase for other industries as national economic progress continues. Hence, the major "within agriculture" adjustment to economic growth must fall on land, the immobile and less flexible resource. Adjustments in land use thus become necessary under economic progress if the growth in productivity of land and agriculture exceeds the rate of population growth and the preferences of consumers are to be reflected through either or both pricing and voting mechanisms. This is necessarily true because the pattern of consumer preferences changes as per capita income grows.

First, there are differences among agricultural products themselves. Second, there is a difference between food-fiber products and other products for which land can be used. The magnitudes of income elasticities of demand provide guides for adaptation of land under economic growth. For commodities with income elasticities greater than 1.0, further increases in consumer income are associated with a rate of increase in expenditures which exceeds the rate of growth in income. Unfortunately, no major food aggregates fall in this category, although other important categories of consumer goods and services do.

For commodities with negative elasticities, expenditures per capita actually decline as income increases. This is the situation of cereal products, and as the income elasticity of demand becomes sufficiently low relative to the rate of increase in population, human cereal consumption declines in absolute amounts. With a large enough increase in per acre yield, it is likewise possible for less land to be devoted to this crop. Hence, because of this and other characteristics of demand change under income growth, it follows that the proportion of land devoted to the various major crops also needs to shift under economic development. In general, government programs from 1930 to 1960 served more as institutions to deter these shifts, rather than as mechanisms to aid them and bring about an agricultural or land use pattern consistent with the nation's economic development.

But our main problem is with food in aggregate, and particularly those products serving as the foundation of the feed livestock economy. With an aggregate income elasticity of demand for food of .2 or less, consumer expenditures on food lag far behind the rate of increase in national income and expenditures on non-food products. In fact, the income elasticity of demand for food in physical form is zero, meaning that poundage of food per person does not increase as income increases, even though the composition of the diet may change. Hence, aggregate demand for food in physical form, without regard to the mix of the diet, can increase at only about the rate of growth (is almost a constant function) of population. With a growth in per acre land yield exceeding the rate of population growth, less land is required to produce the nation's food. As Figure 1.1 illustrates, this condition held true from 1940 to 1960 in the United States. Surpluses did not arise during the period of the war and restoration, but they began as soon as the abnormal postwar foreign demand was eliminated by recovery and improvement of agriculture in other nations. While the rate of growth in output has been only slightly greater than the rate of population growth, the price elasticity of

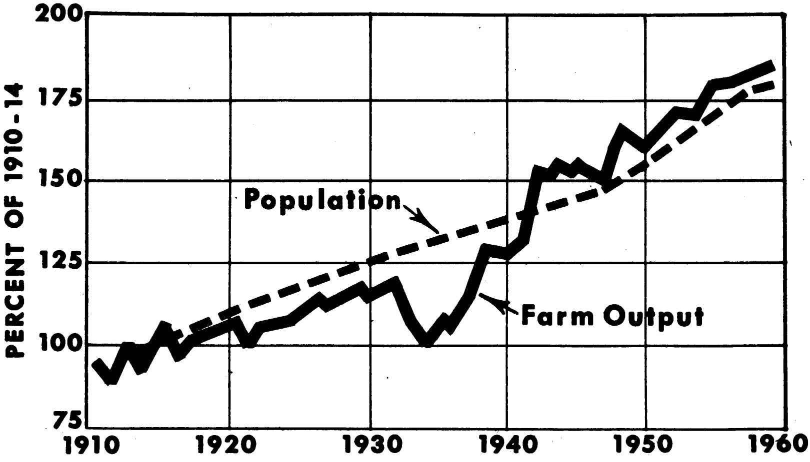

Fig. 1.1. Trends in U. S. population and farm output.

demand for farm products is extremely low. Hence, this small excess depresses prices and incomes by a much greater proportion if it flows "unmolested" into the market. We have, of course, effectively withheld it from the market, or have provided a minimum level to which it could depress prices and income, by storage and price programs for certain basic commodities. Effectively, however, we have not solved our basic land use problem: namely, that of shrinking the magnitudes of inputs for important food products. Storage and price programs of the type used from 1930 to 1960 are not an appropriate means of doing so. They are inappropriate for these purposes, although they can serve usefully for other purposes. The magnitude of stocks and the treasury costs of carrying them are so great that new approaches must be deyeloped. Otherwise, the general public may discredit and eliminate them, even though they can have important uses for stabilizing the farm economy.

Non-food Elasticities

In contrast to the extremely low income elasticity of demand for food product in aggregate, a basic criterion for determining how the use of the land resource should be tempered under further economic growth, the elasticities are much higher for other products of land. Two products with relatively high income elasticities of demand are those of recreation and forest products (e.g. lumber, paper and other products of the latter). Demand for these will grow not only as a constant function of population but also as a function of national income. Other uses of land also have high premiums attached to them as consumer income increases, much higher than for food. Included are highway, airport, residential and similar non-food uses. The latter present, in many ways, less difficulty in respect to the adaptation of land use: they involve a smaller acreage, and non-pricing mechanisms are sometimes used to effect the transformation.

PROGRAMMING NEEDS

The great need is planning and programming of land use in a manner consistent with long-run economic development of the nation. Important guides exist in the income elasticities of demand which have been estimated by market analysis. Their magnitudes can be used to indicate the relative shifts in use of land needed as population and national income progress further.

Concepts and empirical procedures in soil science and production economics can provide a framework, in terms of both economic advantages and physical possibilities, for determining the particular areas which might be shifted. Land tenure and other specialists can prescribe institutions and other mechanisms which are alternatives or appropriate for bringing about the desired shifts needed in gearing land use to national economic development. In general, we have a stock of scientific tools for approaching the problem, although we currently are thin in knowledge of political acceptability among alternative. The tools of these several disciplines, where they are sufficiently developed, should be more effectively and intensively applied to facilitating shifts which are needed for, and can be consistent with, the population and demand patterns of future decades.

It is hoped that this conference can serve as a stimulus in this direction. The collection of sciences represented can provide systematic guidance. The path need not be uncharted to the extent of the past. The framework for analysis should be national economic development, rather than some less appropriate and more restricted realms which could be mentioned.

SUBSTITUTION OF TECHNOLOGY FOR LAND

The American economy has been a dynamic one. It will need to continue so, both to meet the world responsibilities and challenges which face it and to insure reasonably favorable business expectations and employment levels. In contrast to the economic growth which we have experienced and will continue to experience, we could visualize an economy where, except for a few modifications, the general pattern of land use would remain constant. The economy would be one with income growing at only the rate of population and, hence, a constant per capita income over time. Economic growth would be even and at equal rates over the nation. Similarly, technological improvement for agriculture would proceed at the same rate among crops and regions and at the same rate as growth in population. The national land use pattern, once it had been geared to the demand structure at one point in time, could simply be extended into the future, with the only dimension of change being an extended intensity of capital and labor. But growth in the U.S. economy has not been, and will not be, in this pattern. Economic growth has been spatially uneven over the nation, causing the economic advantage to be altered differentially over our land area. Income has increased faster than population, providing a growth in per capita income and changing structure of consumer demand. Technological change in agriculture also has outpaced population and foreign demand growth. It has not been spread equally among regions and crops. Hence, the basis exists for producing our food product with less land, even though our population is increasing.

Technological improvement, or more correctly, the new capital materials which represent it, serve as a substitute for land. So effective has this process been that land has come into a surplus position as far as current food requirements are concerned. Aside from a breakthrough in international markets, this situation will, given technical improvement at rates of the decade 1950-60, continue beyond the 1960's. Some estimates suggest that we could withdraw as much as 15 percent of our cropland, and still produce products in quantity giving no important rise in farm and food prices. The amount may be more or less than this, but our bulging grain bins provide empirical evidence that the land input devoted to food is greater than needed. Even while surpluses have continued to accumulate, we have had over 25 million acres in acreage and conservation reserves. Too, further technological advances and rearrangements are known and could be applied to more farms. Irrigation, continuous corn with high level fertilization and application of more fertilizer on additional farms are examples.

We have not been sufficiently aware of the fact that technological improvement (or more particularly the new capital forms or materials representing it) serves as a substitute for land. But this is true whether the innovations so represented apply to crop or livestock production. For example, an innovation in nutrition which improves feeding efficiency allows us to get a given output of livestock product from less feed. Since less feed is required, less land also is required. The feed addition serving as the innovation in nutrition is thus a substitute for land. Innovation in livestock breeding and sanitation, crop breeding, insecticides and others serve similarly and have a varying rate of substitution for land, depending on the mix and rate at which they are used on soils of different types. The application is generally the same for all of these biological innovations, but we will illustrate the possibility with fertilizer. Suppose that the per acre response equation or production function for fertilizer applied to land is that in (1) where Y is yield per acre and X is fertilizer input per

$$Y = a + bX - cX^2 \qquad (1)$$

acre. For farms of typical size, this same production function or response outcome can be realized on all acres of the given soil.

Hence, considering only land and fertilizer, the production function for the entire area of the farm becomes that in (2) where $\bar{Y}$ is total production and A is number of acres.[2]

$$(2) \qquad \bar{Y} = aA + bAX - cAX^2$$

Now, setting $\bar{Y}$ at a particular level, we can derive a production isoquant for the farm as in (3). The corresponding equation of marginal rate of substitution of fertilizer for land then is (4).

$$(3) \qquad X = b(2c)^{-1} \pm \sqrt{[4c(A - Y) + Ab^2](4c^2A)^{-1}}$$

Quite obviously, the marginal rate at which fertilizer substitutes for land, in producing a given output, depends on the level at

$$(4) \qquad \frac{dA}{dX} = -\frac{bA - 2cAX}{a + bX - cX^2}$$

which fertilizer is used. As increasing quantities of fertilizer are used for a given state of technology, the rate of substitution will decline. But as other technologies are developed which increase the productivity of fertilizer, the marginal rate of substitution of land for fertilizer will increase.

Price of Substitute Inputs

The rapid use of inputs which substitute for land has not "just happened." The innovations so represented have been put into use because they were profitable. If farmers were not limited on capital and risk aversion in credit use were absent, even more of the materials representing innovations could be used at profit by individual farmers (although this would not hold true for agriculture in aggregate). Why have these innovations proved so profitable? Because the price of the materials representing the innovations has been low relative to prices of the commodities they

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[2]This production function, one for an individual farm, is used to illustrate the possible outcome for a single producer. Yield or total production is a linear function of acreage but not of fertilizer. This is essentially the condition which holds true for individual farms, since the response they can obtain on one acre of a particular soil they can also obtain on other acres. Typical farms are not so large as to preclude this possibility. However, if we forgot about individual farms and considered a national production function, it might be of different form in respect to changing marginal productivity of land. Yet the same general substitution relationships would exist. While only one algebraic form has been used to illustrate the situation for an individual farm, the same general conditions in respect to substitutability and changing rates of substitution would hold true for other algebraic forms.

produce. Price structures, particularly in the postwar period, have favored the substitution of new technology for land. The rate of substitution has been more rapid than the withdrawal of excess land inputs from the commodities for which the new innovations have been used.

Prices of materials representing new technologies have been low relative to farm commodity prices because of the pricing structure of the former and because of the support levels of the latter. Prices of innovation materials have been low relatively because of research in and efficiency of the firms and industries which produce them. Competition in these industries will likely serve as a force causing this effort to continue, in order that the volume of inputs might remain large and/or increase. Even if the rate of technological improvement slows relative to population growth, the substitution process can still continue. However, it would continue at a rate which might slow the speed with which innovation materials are substituted for land. The quantity of innovation materials which a farmer can profitably apply per acre is a function of the production relationship in (1) (more exactly the derivative of this equation or the marginal productivity of the innovation material) and the price of the material relative to the price of the product.[3] Should we reach a time when the rate of population increase is greater than the rate of technological improvement in agriculture, the price of farm commodities would rise relative to the price of innovation materials. Substitution of these for land would then be extended, even with a decline in the marginal rate of substitution. But for the 1960's, it is likely that substitution will continue at rates causing land to be made surplus relative to current food uses.

NEW TECHNOLOGY AND THE PRODUCTION PROCESS

New technology does not represent an "act" apart from other concepts of the production process. Instead it represents a process of identifying the various resources which have a productivity greater than zero in the production process or production function. At a given time we have knowledge of only a limited number of these resources or of their productivity. There are

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[3]In the absence of capital limitation and with sufficient knowledge, the farmer could maximize profits by equating the derivative of (1) with the ratio formed by dividing the price per unit of the innovation material by the price of the product. As the price of the product rises relative to the price of the material, the latter can be used in larger amount and until it has a smaller productivity. Under limited capital, the criterion is different but the marginal productivity and price ratios are still the relevant quantities, in comparison with the same ratios for other products.

literally thousands of these different resources, many of which are yet unknown. As in the production function of (5), we may know of the existence and productivity of resources X through X_r

$$(5) \qquad Y = f(X_1, X_2, \ldots X_r, X_{r+1}, X_{r+2}, \ldots X_n)$$

— including nitrogen, soil of particular characteristics, moisture, sunlight, a particular seed variety and others. Now we identify the resource or material X_{r+1}, or its productivity. It can now be included in the "knowledgeable" physical function, along with other resources or materials. It will be substituted for others, including land, if its productivity is sufficiently high and its price is sufficiently low.

As we extend technological knowledge thus, we both increase the possible product from a given land area and raise the rate at which aggregate capital (due largely to its new forms representing innovation) substitutes for land. The long-run tendency for this substitution to occur is illustrated in the decline in farm land prices relative to the prices of farm products and relative to the price of other inputs. Given a fixed supply of land, one would expect, apart from the offsetting forces mentioned here, population growth to cause land price to rise relatively. The same would not hold true for inputs such as fertilizer, machinery and other items which might more nearly have a constant supply price (in contrast to land which would have a steeply rising supply price if we tried to increase it in aggregate). Yet relative to farm product prices, the real price of land has declined by almost 20 percent since 1910. This decline emphasizes the relative increase in the "effective" supply of land services since the earlier period. The real price (i.e. price of resource relative to price of farm products) of fertilizer has declined even more, or by around 35 percent, a development which has itself encouraged the substitution of fertilizer for land. In contrast, the real prices of farm labor, farm machinery and farm supplies in general have increased since 1910. The decline in real price of fertilizer has taken place not because it has been reduced in relative importance in the production process (the opposite has held true) but because of technical improvement and competition in the fertilizer industry. The decline in real price has caused it to be "demanded" in larger quantities. In contrast, however, land is not used in larger quantities (its stock is fairly well limited) and has declined in relative price because other resources have increasingly substituted for it, thus increasing its effective supply against national food demand.

Increasingly, the product of agriculture is becoming less a function of the services of land and labor and more the product of the services of capital items representing improved technology. The capacity of agriculture to produce is less limited by our land area and depends more on other sections of the economy. Capacity has been added through development and expansion of the industries which furnish the agricultural inputs substituting for land. Relative to our population and the productivity of soil our supply of land is relatively larger than it has been at any time since 1885. It appears that this situation will continue for some time, and likely will be accentuated by chemical and biological developments in prospect. While agricultural output once had an effective restraint defined by land area or a spatial limit, this is no longer true. Agriculture is now similar to industries such as filling stations, department stores and others where space or area is not the restraining force for output. We must learn to live with this surplus capacity, a fortunate development since the nation has obtained "food capacity" by producing it, rather than by conquering it as has been an historic approach of many nations.

Unfortunately, we have not been sufficiently aware of the fact that new technology (e.g. the new capital resources which represent it) is a substitute for land. We have not planned programs, of either an educational or action nature, which encourage and allow diversion of surplus land inputs for particular uses as the substitution process takes place to those services and uses which are consistent with long-run economic growth and conservation needs. It is time we did so, to help erase the price and income problems of agriculture and for more complete attainment of the longer-run needs and goals of the nation.

We have a definite public policy for developing resources which substitute for land. This systematic and vigorous effort is represented by our public investment, through Land Grant Colleges and the U. S. Department of Agriculture, in developing new technology to substitute for land. This course is the safe and prudent one for a nation faced with population and economic growth. But we have not completed the public decision when we fail to aid the conversion of land to other uses, once it has been replaced or caused to be surplus relative to present uses.

PRICE POLICIES AND SPATIAL ADJUSTMENT

Numerous policies can be used to better mesh the agricultural plant with economic development. Policies of the past have generally been unsuccessful because they have been tied too loosely to national economic growth. We need to develop and use policies which are more consistent with the economic development in prospect. These policies must also be politically acceptable. But acceptability of various policies also is a function of education and knowledge of means and ends, or of alternatives and consequences. We have done much less to inform and educate farm and other people on the basic nature of economic growth, in relation to land use needs, than we have in educating farmers on how to use and substitute other inputs for land. To be certain, we need the latter as part of our economic development investment and because of the world challenges which face us. Leaving out the possibility of war, the major competition between East and West will be in promoting internal growth, partly as a means of aiding growth elsewhere over the world. It will benefit mankind if this proves true, and the likelihood is great that it will. Still, it makes little sense to invest in research and education to show farmers how to substitute other inputs for land, without a parallel effort to help them understand the connection between this process and economic progress. It also makes little sense to aid the substitution of capital inputs for land, causing immense output pressure to grow up in agriculture, without providing understanding and market or institutional mechanisms so that this pressure can be relieved to (1) lessen the depression of resource returns in agriculture and (2) allow greater society realization of the gains which are made possible through the substitution of new technology for land and labor in agriculture.

Production control and land diversion programs of the past have generally been unsuccessful as attempts to eliminate surpluses and low resource returns in particular sectors of agriculture, partly because they have been forced into a tight spatial restraint. They have not sufficiently recognized that economic growth and development, within both agriculture and other industries, does and should take place at differential rates over the nation if our natural resources are to be developed most efficiently. The same program elements have generally been applied to all soils and locations, probably because the policy focus has been that of income equity and short-run welfare considerations. In some manner, we must break away from this spatial restraint, while retaining income and equity considerations deemed relevant by American society. We need to shift the use of land in different geographic and soil regions in line with its physical production possibilities and relative economic advantage as technological progress in agriculture, national income and consumer preferences progress over time. To do so would mean concentration of major land use adjustments in particular locations. It would mean a much less intensive agriculture and a further and more rapid shrinkage in farm and non-farm populations in these locations.

But even this problem is tied closely with rates of economic development in particular areas. For example, in some areas of the Southeast where industrialization is progressing at a rapid rate, a shift of land from annual crops to forestry need not require a major population shift because job opportunities exist in the community. In contrast, however, a shift from wheat to grass in marginal areas of the Grain Plains entails a much more severe adjustment. Industrialization often does not exist as a means of reemployment of people who are replaced from farming, and the entire business and social structure is affected as geographic migration occurs. These considerations are important, and both short-run and long-run policies need to be adapted accordingly. For short-run policies, it is important that the economic interest and compensation possibilities of all people in the community be considered, with programs structured accordingly so that more basic adjustments will be encouraged. For long-run policies, opportunities for improved use of the human resource now attached to land needs to be given particular emphasis.

Education is especially important in this scheme. With uneven economic growth over the nation, it is important that society invest appropriately in education of youth, so that those in regions declining in a relative economic sense acquire the skills and knowledge for productive application upon migration to more rapidly growing regions. Education and other migration aids relate closely to adjustments in the national pattern of land use. So far we have handled this complex of problems inadequately, largely because we have tried to segregate and isolate solutions on the farm front from economic development forces. The economic growth tides are simply too great for us to do so, unless we are willing to live with farm surplus and income difficulties of magnitudes as large or larger than those which now exist.

Margin of Adjustment

Adjustment in land use will be brought about directly by adjustments in capital and labor resources used with land. Land use can be adjusted at either the intensive or extensive margin. Adjustment at the intensive margin would leave land allocated to present crops or uses, but cause fewer capital and labor inputs to be used with it. Adjustment in the extensive margin generally would mean a shift to crop alternatives other than those now emphasized on less productive soils. It would require a diminution in land inputs for major field crops. If land use were shifted into line with prospective demand and growth trends of the nation, some regions would need to make such major shifts as from wheat to grazing or from annual cash crops to forestry. Some regions would be converted largely to recreational areas. Our national policies have attempted to avoid these shifts through programs encouraging or forcing comparable curtailment of land inputs for all farms or regions.

These short-run policies, or modifications of them, may be needed to avoid the extreme burdens which would fall on particular persons and communities if the longer-run shifts were telescoped into an extremely short time span. We probably have the choice, in the realm of welfare economics, of either (1) providing compensation to those who suffer a capital loss or depression in earning power as the pattern of agriculture is changed in particular regions or (2) extending the span of time over which adjustments are made and concentrated in particular regions. Recent price and income policies contribute to both. They have not eliminated migration of people from farming; they have largely retarded the shift of land in problem areas, while providing compensation directly to farmers, and indirectly to other businesses, within these areas. Later chapters throw light on the means that are possible and publicly acceptable for better meshing the reallocation of both human effort and land to the products needed most under economic development.

Society could, of course, decide that adjustments to mesh agriculture and land use with national growth should not take place and try to create a "national agricultural museum." The museum would be represented by policies to "keep the structure of agriculture the same as in the past," so that we could see farming in its historic dress. But speaking through the market, society has not chosen to do so. It has voted higher prices for labor which has migrated from the most "burdened" sectors of agriculture to other regions and industries. Labor has left agriculture most rapidly in those regions where agriculture is least adapted to the future. Society has not created legal or institutional barriers to keep it from doing so, although it has not always provided optimum facilities for migration. In this sense, we must believe that society chooses regional adaptations over the long run. Current policies slow the process and lessen the pain for those who remain. They prevent an adaptation of land much more than they prevent an adaptation of labor.

Inevitably, then, even if due to labor transfers, differential adjustments are going to be made among regions in land use. We need to decide on the best pricing, institutional and compensation means for facilitating these adjustments. As an illustration of the patterns of change which might be expected, we cite some tentative results from a study in production economics underway by the writer and Al Egbert of the U. S. Department of Agriculture. The details and qualifications of the study will not be cited here because they are given elsewhere.[4] The empirical analyses apply to grain production, since this is the realm of greatest surplus and land use adjustment needs.

The Models and Results

Regional adjustment programs require determination of regions that should stay in and that should go out of production. Several programming models were developed. Our results apply to production of wheat, corn, oats, barley and grain sorghums since these are the commodities of greatest storage burden. We determined which regions should continue to produce these grains and which should shift to other products to make annual output approximate annual "requirements" or disappearance of these products. The year 1954 served as the basis for relating output to requirements because the research was initiated at that time. Requirements are considered to be "discrete" quantities representing disappearance of grain in 1954 adjusted for normal exports, livestock populations and food requirements. We assumed farming techniques to be those of 1954 and supposed, to make the computational burden manageable, that requirements coefficients were constant within each region. The results would be modified with up-to-date technology but the general pattern would remain the same.

Production patterns resulting from three programming models are presented in this section. The United States was broken down into 104 producing regions, each with these three activities: feed grains, wheat for food and wheat for feed. Restrictions included land or acreage constraints for these crop activities in the 104 regions, plus two restrictions for total United States feed grain and food wheat demand. Without slack variables for disposal activities, the coefficient matrices are of 106 x 310 order. The model allows us to consider the comparative advantage of different regions in producing food and feed grains. The objective in two models is that of minimizing the cost of meeting

[4] Earl O. Heady and Alvin C. Egbert. Programming regional adjustments in grain production to eliminate surpluses. Jour. Farm Econ. 41:4:718-33. Nov., 1959.

demand requirements. Maximizing profits is the objective in one model.

Model A. The objective function for this model is

(6) $$\text{Min. } f(X) = C_1 X_1 + \ldots\ldots + C_k X_k + \ldots\ldots + C_r X_r$$

where C_k is a subvector of per unit costs, containing n elements to represent costs of producing feed grains and wheat in the k-th region; and X_k is a subvector of crop outputs, with n elements representing production levels in the k-th region. In this case, c_{jk}, the unit cost of producing the j-th crop in the k-th region, includes only the labor, power, machine, seed, fertilizer and related inputs for each grain. It does not include rent and farm overhead or fixed costs. The restraints of (7) where x_{1k}, x_{2k} and x_{3k} refer respectively to outputs of feed grains (barley, corn, oats and grain sorghums), feed wheat and food wheat in the k-th region and p_{1k}, p_{2k} and p_{3k} stand for the per unit land inputs for these activities in the k-th region; while S_k is a vector of acreage

(7) $$x_{1k} p_{1k} + x_{2k} p_{2k} + x_{3k} p_{3k} \leq S_k$$

restrictions in this same region. The production possibility relations include 104 inequalities such as those in (7). The restrictions in S_k are the largest acreages devoted to grains in the 8 years prior to computations. In addition to these acreage restraints, there are two discrete demand restrictions:

(8) $$x_{11} + x_{21} + x_{12} + x_{22} + \ldots + x_{1k} + x_{2k} + \ldots + x_{1r} + x_{2r} = d_1$$

(9) $$x_{31} + x_{32} + \ldots + x_{3k} + \ldots + x_{3r} = d_2$$

In (8), a national "demand" restriction for feed grains, the coefficients of all x_{jk} are 1 because units of output are in terms of a feed equivalent expressed in corn. The feed grain demand restriction is measured in this same unit, with total units representing the 1954 level of feed grain disappearance adjusted for normal livestock production. Coefficients in (9), a national demand restriction for food wheat, are also 1. For requirements restrictions in both (8) and (9) an equality was used to indicate that annual output must exactly equal annual requirements, with requirements at the 1954 level adjusted for normal livestock production, exports, population and feed uses, as corn and small grains are grown in fixed rotational proportions in regions such as the Corn Belt.

Model B. This model is the same as A, except that land rent is included in c_{jk}, the per unit cost of producing the j-th crop in the k-th region. The model represented by B was used because only grain crops are used as competitive alternatives. Inclusion of rent in B gives some weight to alternative crops. Since grains are the major crops in the regions delineated, rents are largely based on grains. Hence, the estimates arising under models A and C are likely more appropriate than those of B.

Model C. This model is the same as A in terms of nature and number of activities, restrictions and production costs, except that it gives some recognition to transportation costs to demand regions. Instead of minimizing costs as in (6), we maximize profit since C_k is now a vector of net prices for the k-th region. We use differentials in net prices in each region to account for transportation costs to consuming regions. Prices in each region are equal to those in a central market, less the cost of transportation from the region.

Assumptions of Model A result in regions being withdrawn from production of all grains in southeastern Colorado, eastern New Mexico, northern Utah and eastern Wyoming and Montana. Some regions scattered over Texas, Nebraska, Oklahoma, Missouri, Kansas and New York also would be withdrawn. In the Southeast, regions representing a large acreage would be withdrawn from production of grains (Fig. 1.2). The major wheat and

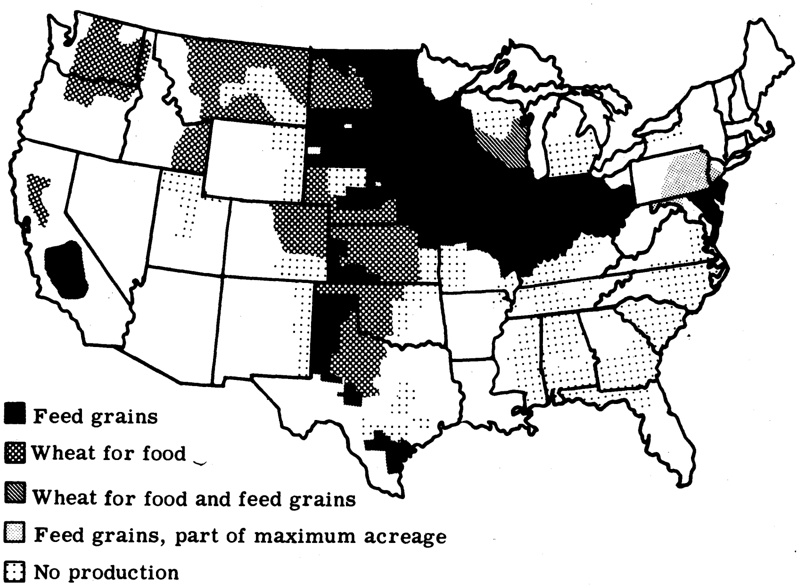

Fig. 1.2. Production pattern specified by Model A.

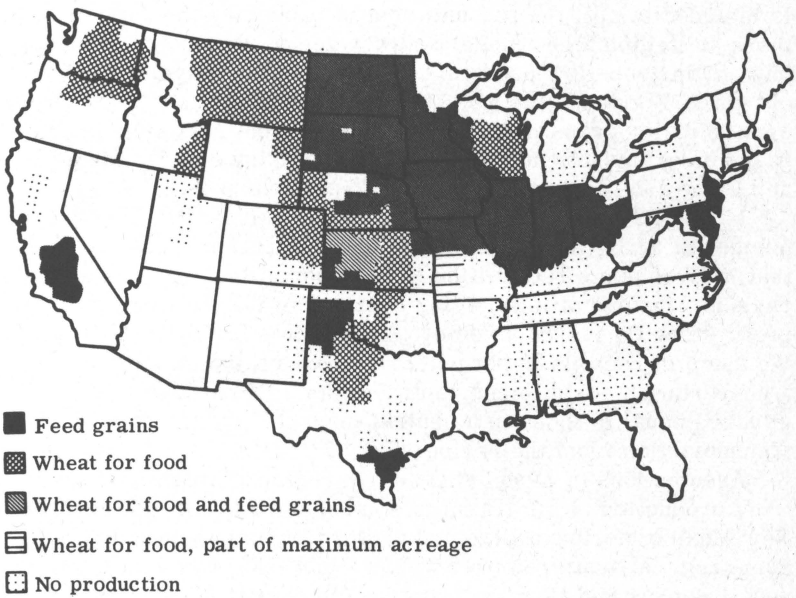

Fig. 1.3. Production pattern specified by Model B.

feed grain areas would remain entirely in production under the construction and assumptions of this model.

<u>Model B</u> (Fig. 1.3) provides a spatial production pattern differing somewhat from both A and C. Under B, all of Montana would be devoted to wheat for food, the Oklahoma panhandle and Pennsylvania would be shifted out of grains and the region in southwest Missouri would be used for food wheat. A large part of Kansas would be used for both wheat and feed grain.

Under Model C (Fig. 1.4) large parts of Montana, Washington, Oregon, Idaho and Nebraska would be devoted to wheat for feed only. In parts of Nebraska and Colorado wheat would be grown for both feed and food. In the upper plains, North Dakota and South Dakota would be devoted to wheat for food. Also, slightly more feed grain would be produced along the Atlantic seaboard and the Gulf of Mexico. While there is considerable difference in the food wheat and feed grain patterns specified by models A and C, they largely agree regarding regions specified to remain in grain production. Only five regions specified for production of some grain by Model C are not specified by Model A. Conversely, only one region specified to remain in grain production by Model A is not specified by Model C. Hence, only four more of the 104 regions would be needed to meet feed grain and food

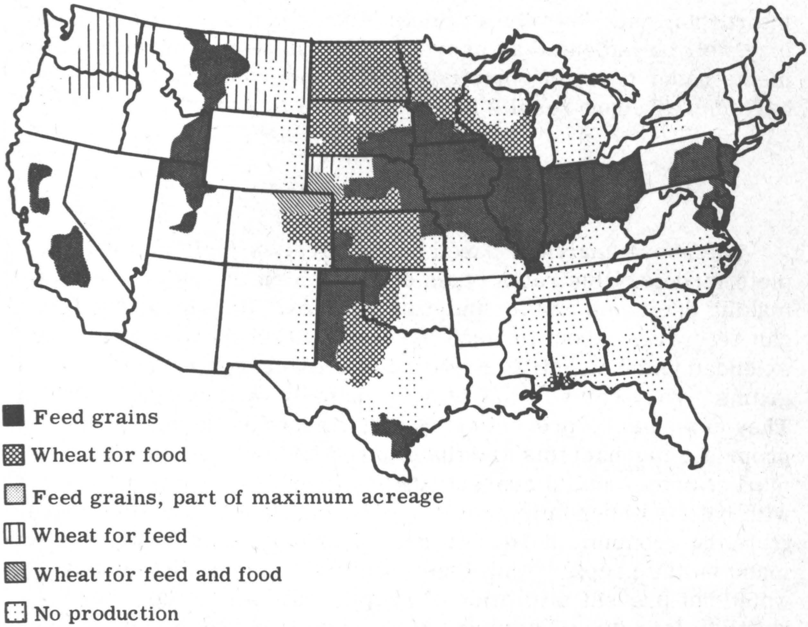

Fig. 1.4. Production pattern specified by Model C.

wheat requirements in Model C than in A. The five additional regions for fulfilling feed or food requirements under C include regions in eastern Virginia, northeast Ohio, western Kansas, southern Alabama and northern Utah. The region specified by Model A, but not by C, is in northeast South Dakota. Thirty-five entire regions and part of a small region in western Kentucky would not be required for grain production in Model C. The pattern is the same, except for the six regions noted above, for Model A.

The three models are consistent for 88 of the 104 regions. They specify 88 regions that should remain in grain production or shift completely out of grains. Hence, disagreement among the three models existed only for 16 regions. Consistency between models A and C, the two models deemed most appropriate, existed for all but six regions.

The results, computed with average regional coefficients and current farming techniques, illustrate both needed data and the types of analyses possible with today's principles and computing facilities. Use of "today's techniques" provides the reason that the entire Southeast is indicated as "not required" to meet annual demand requirements. It is likely, of course, that technical improvements on the horizon will change the degree of interdependence between regions. Parts of the Southeast, then, may well be indicated as necessary for meeting demand requirements under types of objective functions considered here. We have more recent results showing this to be true.[5]

Program Elements

The above analysis, based on relatively simple and incomplete models, illustrates types of data which the public needs for making decisions and formulating policies. Regional adjustments can be brought about through the free market mechanism or by extended and concentrated soil bank and acreage reserve programs. They can be brought about rapidly or they can be gradual. They can even be prevented. Society must decide on both the appropriate mechanisms and the desired timing. Obviously, free market prices would concentrate adjustment in areas which mesh with national economic growth needs, but they would also concentrate the economic burden or cost of gearing production to demand on the people within these regions. Production quotas would not prevent migration of people, but they would retard shifts in land use. Later chapters provide better insight or hypotheses for public choices in these directions.

But regardless of the decision which the public makes on policies, it needs to include the appropriate supplement policy measures for ends deemed relevant. For example, a shift from wheat to grass entails upwards of five years. A shift to forestry involves a longer period and one generally beyond the planning span of middle-aged operators who depend solely on farming. Even a shift from wheat to grass requires added capital, and income drops sharply in the transition period. Hence, special credit programs to allow conversion and farm enlargement may be necessary. Programs to supplement incomes during the transition period may also be necessary. These are elements of an overall program needed to facilitate land use shifts consistent with the present developmental and income trends of the American economy. If broad regional adjustments were to be made, choice also would need to be exercised among such alternatives as (1) using free market prices for the purpose, (2) government purchase of the land, (3) renting the land from farmers, (4) purchasing

[5]It is recognized, of course, that not all land in the "going out" areas would be shifted or all that in the "staying in" areas would remain under present uses. The degree of aggregation and the linear structure of the model bring about these conditions. But the models are for broad diagnostic purposes. They need to be extended in more detail by soils specialists and production economists.

farmers' rights to produce surplus crops, (5) paying farmers to use their land only for particular commodities. These are the types of alternatives to be analyzed in later chapters dealing with the public mechanisms available and the political acceptability of alternatives.

CONSISTENT PROGRAMS

Our efforts touching upon adjustment of the land resource are highly segmented. Aggregatively, they are not tied sufficiently to the economic growth trends of the economy. Individually, they are not sufficiently consistent in respect to purpose. On the one hand, we use conservation and acreage reserve payments to induce farmers to withdraw all capital from land, causing the land to be withdrawn from market production in order to reduce output. On the other hand, we provide ACP payments to farmers to use more capital items on their land, causing output to be increased in the immediate future. We provide conservation payments and assistance to help save land which is in danger of erosion but may be needed for future generations. But we also provide payments and assistance to aid farmers on level land who have no true conservation problem.[6] We make payments and provide assistance to drain level land, to irrigate level land, to use soil amendments on level land, most of which speed up the rate at which we use stock resources in the soil and add to output when we already have a surplus of farm products.

It is time that we incorporated our problems and programs of economic development and conservation into a comprehensive and systematic model for the land resource. Public investment in our segmented, and often inconsistent, approaches to land use and adaptation has been great from 1930 to 1960. Undoubtedly, the investment, including a large portion of that concentrated on the surplus problem, has been large enough to have allowed attainment of major adjustment needs, had our sights been on systematic and long-run economic development. We are at a stage in surplus accumulation and world responsibilities where we must begin to plan accordingly. We must see land use in its broader context and fit our research, education and action programs into a consistent economic growth and general equilibrium model. The conference was planned to bring together agronomists,

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[6]For a distinction between production practices and conservation practices or investment, see Earl O. Heady. Economics of Agricultural Production and Resource Use. Prentice-Hall. New York. 1952. Chapter 27.

economists, political scientists and others representing the variables which appropriately belong in such a model or approach. It is not expected that it will provide all the answers. But it should provide suggested directions and appropriate hypotheses. We hope that it will serve as an aid to research workers, educational specialists, program administrators and agricultural leaders, providing better images of the adjustment problem, technological and economic growth trends, prospective developmental trends and program alternatives.