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Interrelationship Among Export Markets, Resource Conservation and Agricultural Productivity*

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The growing export market for U.S. farm commodities, especially grain, over the last decade has become the basic source of modern farm prosperity. While the public invested in a multibillion dollar supply and marketing control program over several decades to provide agriculture an equitable share of national income, the effects were somewhat minute in improving farm prosperity and asset values compared to the quantum jump resulting from greater exports since the early 1970s. The sources of these increases, greater incomes and populations of developing countries, institutional changes causing the Soviet Union and China to enter Western markets and generally higher per capita incomes and meat consumption the world over, has, barring the negative fallout of major wars, the prospects of furthering the demands for U.S. grain and food exports. This newly acquired prosperity and wealth for agriculture in the immediate future does not necessarily promise a continued payoff for the next generations of farmers. There are two potential reasons why maintenance and further growth may not equally benefit the next generations. One is the tendency of current generations to capitalize the future growth in demand and income for U.S. agriculture into present land values. They have already "banked" this future return to an extent that the current

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return on land investment is very low. While numerous agricultural economists have proclaimed that exports and export policies are the significant future issues of agriculture (Nicol et al.), this is true mainly for farmers who are land owners and have been or will be able to take advantage of the tremendous inflation in land values, resulting from general inflation and the growth in export demand and domestic commodity prices, and realize huge gains in their asset values. Of course, their descendents who inherit these enhanced asset values similarly will gain. If land prices "inflate forever", owners of farm land and their offspring will continue to "gain forever", just as will holders of gold and scarce works of art if they "continue to inflate forever".

Without this "forever inflation", and with a long string of growing future incomes already capitalized into land values, future purchasers of these assets will not find "exports the magic secret to farm prosperity". Farmers then may be realizing a low return on resource values generated from current earnings, just as are current farmers, who also have a mammoth capital gain increment to augment operational income. Farmers of the 1920s, 1950s and 1960s complained mainly because they realized a low rate of return on their resources. New purchasers of land are faced with exactly the same problem. The American Agricultural Movement, as its members capitalized enhanced exports future prices into land values and pressed for price supports which would maintain corresponding asset values and returns, conducted the most violent demonstrations ever staged by U.S. farmers. Prospects are that farmers of the year 2000, will still be claiming low resource incomes and the need for higher support prices. Growing exports and export policies give no promise of eliminating this seemingly ubiquitous problem of agriculture over time.

The second reason why growing exports will not solve all economic problems for all future farm generations is the potential unreclaimable deterioration of natural resources used in farming. The mining of our groundwater supplies in the gigantic Ogallala Aquifer has somewhat paralleled our growth in the exports through P.L. 480 and market forces over the last 25 years. Already the drawdown of the water table is causing some farmers to shift back to dryland farming methods. As groundwater withdrawals eventually drop to recharge levels and the irrigated area shrinks, we perhaps can claim that our former endowment of stock water resources was exported with the enhanced foreign sales of grain in the later decades of the 20th century. The important point is: Export growth will not solve all adjustment and income problems of these farmers in the future.

Perhaps of more long-run importance to society is the level of exports which can be maintained and the set of technologies which can be used while productivity of U.S. agriculture is sustained in the long run. The major complex involved here is soil erosion and related environmental problems. Some agriculturists propose that we are exporting our top soil and future agricultural productivity along with the record amount of grain moving into international markets. Of course, many soil profiles are so deep that each ton of soil lost does not immediately lower productivity. Agronomists have estimated soil loss rates (t or tolerance levels) which vary with soil type and climate and provide an approximation of the rate at which soil can be eroded before productivity declines become effective (Wieshmeir and Smith).

There is considerable evidence that the interrelated forces of farm structure, enhanced exports, high commodity prices and extremely inflating land values have encouraged a near-monoculture type of agriculture which is exploitative in nature and gives rise to high rates of soil erosion and related chemical runoff. Under present machine and crop technology systems there is a strong pressure for farms to become large and highly specialized (hence, the increasing monoculture nature of farming). Becoming larger through land purchases is a popular way to increase wealth under inflating land values. Interest payments on borrowed funds lower income taxes and enhance current after-tax-income while generating long-term capital gains in land value appreciation. With mammoth capital outlays required for huge machinery and land purchases, plus the need for large and immediate cash flows to service interest and principal payments, many farmers are, as one of our farmer friends puts it, "forced to farm the land like hell". While present or potential productivity may be declining, the farmer can accumulate more land and gain automatically as long as land value inflation continues. A part of rapid land value inflation has been indirectly due to export volume in recent years. To an extent, investment in farm land becomes akin to investment in aged tenement buildings in larger cities: Repair of depreciation can be foregone with financial advantage if real estate values maintain a satisfactory inflationary pace.

There is considerable belief and some evidence that high exports and the associated high commodity prices and land inflation have accentuated soil erosion on many fragile soils of the nation. So great has this concern become that a number of public bodies and institutions have begun to delve into it. Included are the activities of the National Academy of Science (National Research Foundation), the Office of Technology Assessment, Resources for the Future, the Conservation Foundation, the North Central Regional Research Committee-III, the U.S. Department of Agriculture through its monitoring and analysis work of the Resources Conservation Act (RCA) and a consortium of Land Grant Universities, the U.S. Department of Agriculture and most of the professional societies representing agriculture (Hauser). More empirical evidence needs to be gathered. However, there is growing quantitative evidence that soil loss rates have accelerated in the last decade, with the realized or potential twin effects of reducing land productivity and furthering nonpoint pollution of our streams.

While some progress has been made in conservation tillage methods and conventional conservation practices, there also has been an accentuated shift to crop specialization such as the corn-soybean patterns of the Cornbelt on both level and hilly land. These semi-monocultures, another representation of farming structure as it moves to larger and more specialized farms, give rise to higher levels of soil erosion than did the meadows rotations and diversified farming systems of previous decades.

A larger acreage of row crop, the shift to a near-monoculture and the advent of huge tractor and machine units which cannot be readily used with terraces and contouring interact with the high commodity prices and land values which have been associated with growing exports over the last decade. Studies at different times in Western Iowa show a large increase in soil loss (Blase and Timmons, Hauser, Larson). Timmons reports an increase in nearly 25 percent in erosion rates in Ida-Monona-Hamburg soils in Iowa in less than 20 years and projects large increases over the Cornbelt (Schuh, Timmons 1979a). Of course, the incorporation of set-aside land from the early, 1970s, as exports exhausted surplus stocks and negated the need for grain supply controls, also has contributed to greater erosion. Typically this was somewhat marginal land.

Tradeoffs Between Export and Soil Loss Levels

Certainly at some high levels of sustained exports, in conjunction with certain technologies that might be used in agriculture, soil erosion and agricultural productivity must become important national problems. Extremely high export levels may be attained in the short run which cannot be maintained in the long run if agricultural productivity is to be maintained. A trade-off curve between export levels (in total production levels which for domestic or export use) does exist according to a set of models which we have had operational over a number of years (Daines and Heady,English and Heady, Larson et al., Meister and Nicol, Nicol and Heady, Timmons 1979a). These models are now being used to help the U.S. Department of Agriculture in its RCA monitoring and analysis and for related research. Since these models are documented elsewhere,, we will leave aside detail and summarize only their general characteristics. The models are national and interregional in nature with 105-223 producing regions and 25-35 market regions and a linking transportation submodel. Each producing region includes 5-9 separate land classes with differential erodability and soil loss. (Irrigated regions have 10-18 land classes to allow for both irrigated and dryland crop possibilities.) Soil loss coefficients are defined for each crop or crop rotation, each conservation practice (contour, terrace, strip crop, etc.) and each tillage method (conventional moldboard, no till, conservation till etc.) on each land class in each producing region under the varying climatic conditions prevailing. Restraints at different levels thus can be placed on soil loss per year for each land class in each producing region with export possibilities determined accordingly. (Erosion restraints also can be established for regions, watersheds or other physiographic entities.) One restraints level of particular relevance is the "t" tolerance level, the level of soil loss which agronomists estimate can occur if soil productivity is to be maintained (Wade and Heady). Alternatively, exports can be parameterized or set at different levels while soil loss per acre is measured by land classes within regions, or by regions, watersheds, river basins, etc. When used with an objective function of least-cost or competitive equilibrium the models show the combination of crops, conservation practices and tillage methods (i.e., the technology set) which will maintain a given level of soil loss at minimum cost while allowing a given level of exports to be attained. (As a long-run competitive equilibrium model, it also can show the most efficient combination of technologies for a given soil loss and export combination.) We have been in the process of deriving these possibilities for the U.S. Department of Agriculture in its RCA analysis and now are extending, re-specifying and updating models for the 1985 RCA evaluation. These models not only can indicate the various sets of exports and soil loss levels which will allow sustenance of agricultural productivity over the long run (or the level of soil loss conforming to a given export level or vice versa) but also can estimate the cost of abating soil loss to specified levels and various export levels. They also can provide the basis for estimating the redistribution of income and asset values, especially among regions, associated with any specified or policy-induced soil loss and export sets.

We have recently constructed a five land class, 105 producing region model to focus on the relationship between soil loss and export levels. The land base (Table 1) consists of 403 million acres of cropland estimated available in 1977 from the National Resource Inventory (U.S. Department of Agriculture). We project 26 million acres will be converted to nonagricultural uses by 2000. All but approximately 24 million acres would be available for the endogenous crops. The land classes are selected so that a range of erosion hazards and farming practices can be represented in the model with prime agricultural lands included in land classes 1 and 2, erosive but otherwise suitable lands in land classes 3 and 4 and most marginal lands incorporated in land class 5.

Table 1. Projected 2000 crop land base for endogenous crops and potential cropland by zone

Item	Region: North Atlantic	South Atlantic	North Central	Great Plains	South Central	Northwest	Southwest	Total
	(1000 acres)							
Endogenous Cropland:								
Land Class 1	1,613	6,459	32,831	7,963	7,421	1,090	2,372	59,749
Land Class 2	6,764	27,775	81,444	31,830	30,333	5,253	3,652	187,052
Land Class 3	1,879	3,463	16,773	25,939	15,292	6,088	795	70,228
Land Class 4	694	1,177	4,846	9,361	5,213	2,138	1,191	24,620
Land Class 5	431	1,118	2,939	4,015	1,808	796	423	11,530
Total	11,380	39,993	138,834	79,108	60,067	15,364	8,434	353,180
High Potential Land:								
Land Class 1	56	597	572	245	528	21	12	2,031
Land Class 2	705	8,756	5,577	3,071	4,342	604	472	23,527
Land Class 3	112	1,074	1,462	2,553	1,969	309	99	7,578
Land Class 4	45	227	370	728	209	103	89	1,771
Land Class 5	81	298	180	551	171	397	1,108	2,696
Total	999	10,952	8,161	7,148	7,219	1,434	1,690	37,603
Moderate Potential Land:								
Land Class 1	94	360	360	132	316	5	8	1,269
Land Class 2	2,214	14,963	8,989	5,006	8,375	993	1,155	41,695
Land Class 3	736	4,517	3,770	7,144	7,423	649	363	24,602
Land Class 4	308	1,748	1,794	3,536	2,486	543	717	11,132
Land Calss 5	500	2,281	1,212	3,548	1,109	968	1,781	11,399
Total	3,852	23,869	16,125	19,366	19,703	3,158	4,024	90,097

The range, pasture, forest and other lands with high and moderate potential for conversion to cropland is incorporated in the model with appropriate conversion costs. Some authors (Amos and Timmons, Shulstad and May) have questioned whether as much as 127.7 million acres could actually be converted to cropland under any set of realistic conditions so we have duplicated our analysis with high potential land only and with both high and moderate potential land available for conversion. Except where noted otherwise below very similar patterns are evident in the results for both scenarios.

We project domestic consumption of endogenous crops in 2000 to be as follows: 199.1 million tons of feed grains (corn, sorghum, barley and oats), 1033 million bushels of wheat, 2293 million bushels of soybeans, 7.7 million bales of cotton, 57.4 and 82.1 million tons of nonlegume and legume hay respectively (from cropland only), and 109.4 million tons of silage. Projections of domestic consumption levels are relatively reliable so no attempt was made to parametize these numbers. Domestic demands do not include a component of grain for gasohol production nor is a biomass crop implicit in the land base. The overall effect of a significant "energy from agriculture" program would be similar in effect to increased exports but differ in detail.

Four different export levels in the year 2000 are examined. The lowest export level (level I) is a 50, 53 and 75 percent increase over historical exports over the period 1977-79 for feed grains, wheat and soybeans respectively. Export levels II, III and IV are a 17, 67 and 117 percent increase respectively over the base export level. The most recently available NIRAP projection falls between export levels

II and III. All export levels are feasible when both high and moderate potential land is available for conversion to cropland, but export level IV is not a feasible level when only high potential land is available for conversion

An important result of our model is that far more extensive use is made of soil conserving tillage methods and conservation practices than are currently practiced. No till is practiced on between 50 and 60 percent of the land in all solutions and conservation till used on most of the remaining land. We feel that there are inherent advantages in the conservation till and no till practices developed and being developed to make these the standard tillage methods of the future. Approximately 70 percent of the cropland is also selected for some conversation practice. Contour plowing is the most important accounting for 50-55 percent of total cropland. Strip cropping is relatively insignificant accounting for around 4 percent in nearly all solutions. Terracing is used on 10 to 15 percent of the cropland with the amount of terracing increasing with exports.

Despite the extensive adoption of soil conserving tillage methods and conservation practices, the tolerance levels for gross soil loss are exceeded on one or more land class in a large portion of the producing regions even with low export levels. Tolerance levels are exceeded on some land classes throughout most of the North Atlantic and South Atlantic Zones, a large portion of the North Central and Eastern part of the South Central and Great Plains Zones. Tolerance levels are also exceeded in some of the most important agricultural areas in the Western states. The most notable change with increased exports is in the mid-continental states where tolerance levels are exceeded in a large number of producing regions only with highest export levels although more marginal land is brought into production in all regions.

At low levels of export dmand most of land class 5 is not used. Practices adopted on land class 3 and 4 contribute most heavily to erosion. When export levels increase it becomes profitable to adopt practices which conserve soil and productivity on land classes 3 and 4: Soil loss per acre drops sharply for these land classes in many producing regions. The most marginal cropland in the existing land base, land class 5 is brought into use greatly exceeding the tolerance levels. The distribution of gross soil loss from cropland is very skewed in all solutions and becomes more skewed with increased exports. The number of acres in absolute terms exceeding the tolerance levels is not great in any solution and decreases with increased exports nationally and in all regions except for the South Atlantic, Northwest and Southwest.

Conversion of potential cropland to cropland increases with each increase in the level of exports. Potential cropland is available in nearly all land classes in most producing regions, but the distribution of potential cropland is more skewed towards the erosive land classes. The land that is converted at lower levels of exports tends to be the least erosive. As export levels increase a larger proportion of the conversiton is for land classes 3-5.

Gross soil loss increases with exports, but not dramatically at the national level. For example, gross soil loss increases by 21 percent when exports nearly double in moving from export level II to IV for the scenario with both high and moderate potential land available (Table 2). With only high potential land available, soil loss decreases with increases in exports until the highest attainable level of exports are reached where soil loss shoots up rapidly. Comparing the lowest level of exports with the highest, 1.88 and 0.24 tons of soil loss is incurred for each 100 dollars (at constant prices) of increased exports for the scenario with high and moderate potential land conversion and the scenario with only high potential low conversion respectively. But the tradeoff at the national level conceals some of the most disturbing results. Soil loss in the Western two zones more than doubles. There is a very large increase in soil loss both in absolute and in relative terms in the South Atlantic zone where soil profiles are relatively shallow and a high proportion of eroded soil finds its way into water courses and rivers.

Policy Implications and Focus

We expect to be able to provide increasingly refined quantitative estimates of the tradeoffs or possibility frontier between exports, soil loss and productivity coefficients before the 1985 RCA assessment. However, we believe that those already generated provide a relevant basis for policy based on these normative estimates which indicate future potential. Some policy directions become fairly obvious. Society could, of course, decide to "continue all out export efforts while domestic productivity goes down the tube". We doubt, however, that society should or will do so over the long run.

Table 2. Gross soil loss by region with demand levels

Demand	North Atlantic	South Atlantic	North Central	Great Plains	South Central	Northwest	Southwest	Total
	(million tons)							
Full Land Availability								
II	24,468	162,769	299,648	234,507	205,554	21,829	12,043	960,819
III	30,093	198,124	284,156	260,169	215,795	29,665	15,743	1,033,745
IV	26,053	251,577	319,100	282,892	221,783	55,480	39,294	1,196,179
High Potential Land								
I	23,108	155,189	329,298	212,434	178,281	19,768	11,342	929,420
II	24,644	180,476	259,316	230,541	171,072	27,488	12,271	905,811
III	18,254	210,508	265,008	208,278	180,578	45,640	16,269	944,534

If society selects a mix of exports, technologies and soil losses which maintain agricultural productivity and a favorable environment, it could use several approaches. One would be to attempt to set export limits (quotas, embargo limits, etc.) at levels which are consistent with a soil loss level, under appropriate technology, which maintain soil erosion and agricultural productivity at the desired level. For example, a dictum could be announced that exports above some level are to be embargoed. But a policy of this sort would be clumsy to administer (and could imply a farm income maintenance program due to reduced commodity prices). Exports also could be taxed for similar purposes. An upper limit or tax on exports also would be difficult to implement with respect to the most erosive soils. For example, highly erosive lands near the point of exports might be planted to corn, soybeans, cotton and similar row crops while level lands elsewhere were planted to close-grown crops and forages. Export controls would in no way relate to or restrain the type of conservation practices, tillage methods or other technologies which relate to erosion and chemical runoff and as our results indicate would likely not be fully effective in protecting agricultural productivity. Hence, rather than to use export levels as a means to direct land use and erosion control or environmentally related technologies, the causal direction might best be in the opposite direction.

Supposing that there is some combination of quantitatively optimal levels of exports and soil conservation technology, then the cost (i.e., opportunity cost) of not controlling erosion should be suffiéiently high that it eventually limits production and export levels -- supposedly through a set of price mechanisms which encourage soil conserving land use and technologies and thus increases commodity prices to the needed level in limiting exports to maintain long-run agricultural productivity. The prices (subsidies or taxes) could be related to specific conservation practices, tillage methods and land use technologies which do restrain erosion (and perhaps chemical runoff) to goal levels. To tie the price (i.e., tax or subsidy) of erosion control to the particular practice would be most practical in implementation and in getting erosion control where it is most needed in terms of (a) rates of soil erosion, and (b) the productivity of the land classes and locations to be conserved (Daines and Heady). One variant of this approach would be to institute an export "check-off" to fund such a program perhaps adding to the rationale and political appeal.

Numerous other policy means could be used to attain sets of exported and soil loss rates which would conform with a socially determined goal or optimum. Conforming soil loss levels (such at tons per annum, t levels, etc.) could be established, then farmers could be penalized (fined, jailed, taxed, etc.) for soil losses above these levels. Policy of this nature is attractive from two perspectives: effective agricultural productivity is most genuinely protected; large reductions in soil loss would result (recall the skewed distribution of soil loss) and thus a substantial enhancement of environmental quality. However, this instrument would have low political acceptance and would entail other implementation complexities.

Drawing production and export levels down to conform with maintenance of long-run agricultural productivity (or the level which is determined to be socially and economically optimal via appropriate intergeneration expression of time preference or other criteria) would be expected to increase total market value of sales, and likely net income of farming, since most price elasticities of demand are less than unity. This growth in income through the market per se would be unlikely to result in an equitable redistribution of farming returns: Farmers on level land would have no conservation investment and could even cultivate their land more intensely. Farmers on erosive soils could be faced with both greater investments in appropriate machinery and land preparation and reduced output from a less intensive agriculture. A system of practice subsidies or incentives (i.e., cost sharing, cross compliance, etc.) would be needed to restore equity, as well as attain conservation goals, if unanimous consent were approached in the optimum mix of exports and soil erosion abatement.

Institutional and Other Forces Apart from Markets

The enhancement of markets through exports, coupled with inflation as summarized earlier, can have important impacts on land use and potential land productivity. Not every land class in each location is faced with an immediate precipice of yield declines. Erosion can proceed for some time in areas of deep soils before productivity declines will be experienced or will not be offset by advanced technologies. While they are greatly improving knowledge, agronomists are not in complete certainty and agreement on the rate of soil formation, vis a vis, rates of erosion or land deterioration. Thus a policy based on "t" values may be desired until greater certainty in knowledge is attained. It would seem unwise for a society to let a major portion of its land erode down to the last two inches of soil useful in productivity. It thus is important that policies with respect to exports be integrated with those in respect to soil erosion, resource conservation and environmental considerations.

In making this statement, we are, of course, aware that it is not alone the thrust of market forces and prices which cause exploitation of agricultural resources. Favorable price prospects over time can even place a premium on resource conservation and investment in it for some land resource groups. Frequently, it is not markets and prices per se which cause an accelerated use of stock resources such as groundwater or an exploitive use of land. The institutions and related conditions prevailing in agriculture and surrounding the market can do so. Examples include tenure systems and uncertainty of tenants' returns from conservation investment over time, the supply, terms and repayment schedule of credit, the age and immediate planning horizon of the farm operator or land owner, the paucity of information available to farmers, and others. There also are cases in which profitable conservation practices are not used because the farm operator or land owner is unaware of the level of return. In other cases, conservation practices are adopted with a distributed lag because farmers contrast them to customary practices (e.g., clean-plowed fields with no trash compared to residue-covered land).

Where these voids exist, when conservation practices otherwise would be economic to the individual society, appropriate policy means or institutional change is needed to eliminate them.

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