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Agriculture in the Year 2000 and Beyond

by

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The decade of the 70's can be characterized as the decade of shortages. Resource availability limited this nation's style of life, style of conducting business, and perceptions of possible achievement. Fuel shortages initiated through supply control measures drove prices skyward causing substantial interest in alternative fuels. In the mid 1970's, the price of agricultural commodities increased. These price increases brought about significant shifts in land use patterns. They illustrated the need for an efficient transportation system. They caused increased pressure on existing resources. Weather problems limited supply responses when farmers attempted to increase production. Future irrigation water availability was questioned. The Ogallaha saw dramatic increases in new wells. According to a comparison of Census of Agriculture data, Nebraska, much of which lies on top of this aquifer, saw a 34 percent increase in irrigated acres between 1974 and 1982. Between 1974 and 1978, the nation had an 18 percent increase in irrigated acreage. Local water shortages and locally expensive water were and still are a topic requiring research.

Adjustments to the agricultural commodity shortages were made. Additional land came into production. Zoning laws were passed to keep "prime" farmland in agriculture. Farmers were told to "plant fence row to fence row" and they did.

The decade of the 1980's could well be viewed as the decade of surpluses. Fuel is seemingly in abundance. The sources discovered in the '70's are remaining reserves in the 80's as wells are capped because of the current price/cost situation. Government Agricultural programs are setting aside nearly as many acres as were seen in the 1960's. In 1966, 47.5 million acres were set aside and diverted from production as a result of commodity programs and 15.3 million acres were placed in a conservation reserve. In 1986, there were 49 million acres in set-aside with 3.8 million placed in the long term reserve. Another 35 million will be placed into the reserve during the next three years. It appears that this nation has reentered the 60's era, with perhaps a little more awareness of possible resource and environmental constraints.

An evaluation of these constraints and their possible impacts on the agricultural sector's ability to meet food and fiber demands has just been completed. This analysis was conducted by the Soil Conservation Service and other agencies within USDA. The analysis, the Resources Conservation Act appraisal, is currently out for public review. The analysis was conducted over a period of four years. A component of the analysis was the Agricultural Resource Interregional Modelling System developed at the Center for Agricultural and Rural Development. The primary funding sources for model development included the Soil Conservation Service and the State of Iowa. Major information sources used in the analysis include the National Resource Inventory, the Agricultural Census', the CARD/RCA Crop Budgets, the Firm Enterprise Data System, the Forest Service NIMRIM data base, the Second National Water Assessment, and the output from the Erosion Productivity Impact Calculator. This paper will describe some of the major impacts found when analyzing the information provided by the Agricultural Resource Interregional Modelling System (ARIMS).

Methodology Employed

The major model of the ARIMS is a cost minimizing national inter-regional linear programming model. This model consists of seven sectors including:

- the crop sector;
- the livestock sector;
- the range sector;
- the land availability and transformation sector;
- the transportation sector;
- the demand sector; and
- the input purchase sector.

Each of these sectors are described in detail in other manuscripts. A brief description of the sectors, however, is provided in this section.

Crop Sector

The crop sector is the primary focus of the model. It simulates the production of barley, corn grain and silage, cotton, legume and non-legume hay, oats, peanuts, sorghum grain and silage, soybeans, sunflowers, and spring and winter wheat through predefined cropping practices. These cropping practices require water(if irrigated), land, dollars, energy, and fertilizer; and in return these inputs provide a yield and erosion.

A cropping practice is defined as a rotation on a given land group using a prespecified conservation and tillage practice in a given producing area. There are eight different land quality groups incorporated within the model. The yields for a specific crop under a specific cropping sequence vary with land quality. There are three conservation practices (strip cropping, contouring, and terracing) and one non-conservation (straight row) practice. In addition, there are four tillage methods (without and with winter cover, conservation tillage, and zero-tillage). Finally, summer fallow is incorporated into the cropping practice where applicable.

Livestock Production Sector

The livestock sector produces dairy, pork, and beef. The production process is modelled using nutrient requirements, offspring, replacement animals, and capital as inputs. These inputs, when used, produce dairy, pork, or beef to meet the final demands. The production activities can be broken into two types -- final demand producing and offspring producing. The offspring producing activities do produce some red meat, however.

The dairy subsector produces milk as a primary product. However, steer calves are available for use by the beef subsector and roughage fed beef through culling is produced to meet final demands.

Pork production is represented through three production processes. These include: farrow-finish, finish, and feeder pig. The feeder pig operation supplies piglets to the other two production processes. In addition, it supplies some pork (from the culls) to meet the pork final demands.

The final livestock commodity produced in the model is beef. Beef final demands are divided into grain-fed and roughage fed. Cow/calf and cow/calf/yearling operations produce heifers and steers for use in the finishing activities. In addition, these intermediate product-producing activities supply beef to the roughage fed final demand through the culling of the breeding herd. Both the grain and roughage fed activities produce beef and require offspring.

Pasture/Range Production Sector

The pasture/range production sector is based on the Forest Service's data base used in the last Resource Planning Act appraisal. It contains information on the privately owned lands that are classified as grazed lands. These production activities are defined for 34 ecosystems. Under each ecosystem, the resources available to grazed land production are defined through resource units. There are 12 resource units based on productivity and condition class. Five different management strategies are defined, ranging from no livestock to intensive livestock production.

The costs for achieving a given management level and the land requirements are the specified inputs into the production process. The yield of both the grass and the timber (net wood growth), in addition to the sediment, are the outputs from a particular process.

Irrigation and Other Inputs Sectors

Water and nitrogen fertilizers are purchased within the programming model. The use of these inputs are endogenously determined. Other input markets are represented in the objective function value of the basic production processes.

The irrigation sector differentiates between the two basic sources of water -- ground and surface. In addition, two types of models are available. In the major portion of the RCA analysis, no interbasin transfer of water used in agriculture could occur. This is known as the fixed model. Surface water availability is fixed to its present allocation. The alternative model, the flow model allows highest valued agricultural use considerations.

The irrigation model allows an acre-foot of water to be purchased for crop use. As it is pumped, applied, and/or delivered, losses occur. These efficiency losses are accounted for. The variable and capital costs that occur when using water are reflected in the objective function value of this sector. The sunk costs (i.e., cost of drilling the well) are captured in the per acre cost of a given rotation.

The fertilizer purchase activity is expressed in pounds of nitrogen purchased. The objective function value represents the 1980 cost of nitrogen in dollars per pound.

Land Availability Sector

The land resource available to agricultural production is defined at all three modelling levels. There are basically nine different types of constraints. Eight of these constraints impact on the amount of cropland available for production and one impacts on grazing. The basic purpose of these constraints is twofold: 1) to define the available resource, and 2) to reflect appropriate adoption (desertion) rates. In addition, there are four types of land transfer activities defined. These include:

1. Conversion of dry to irrigated land with surface water as the source (PA's 11 - 44) and dry to irrigated land with ground water as the source (PA's 45 - 105),
2. Conversion of irrigated to dry,
3. Conversion of range and forest land to cropland, and
4. Conversion of presently cropped wet soils to prime farmland.

The nine constraint types serve the following roles:

1. Define the amount of land available for dryland production (producing area and land group),
2. Define the amount of land available for surface and ground water irrigation production (producing area and land group),
3. Require each area to bring a certain level of land into production (producing area),
4. Require a predetermined amount of irrigated land to be used (producing area and source and national),
5. Define the amount of land available for grazing production (ecosystem, productivity, and condition class),
6. Limit the amount of acres of conservation tillage in crop production (producing area),
7. Limit the amount of acres of zero-tillage in crop production (producing area),
8. Require at least 1982 levels of terraced acres (market region), and
9. Require a predetermined level of crop land to be in a specific crop (market region).

Final and Intermediate Commodity Transportation

This sector transports endogenous crop commodities of barley, corn, oats, sorghum, soybeans, and wheat. In addition, the livestock commodities of calves, yearlings, beef, pork, and dairy are transported from market region to market region. The crops are transported primarily by rail, although barge routes do exist along the Missouri-Mississippi Rivers and the Great Lakes. Most of the routes are between adjacent market regions. Longer haul routes do exist, however; and are defined if mileage is reduced by ten percent.

Demands

The purpose of the demand sector is to reflect the levels of production required to meet certain expectations. This sector drives the model and consists of domestic demands, feed demands, and export demands for the commodities contained within the model. Regional demands are based on per capita consumption levels a set of industrial demand levels that are prespecified. Exports are predetermined, with port location estimated as occurring from the East, Gulf, or West. Exogenous livestock demands for feed are specified as feedgrains, other concentrate, and roughages. Because of space limitations, only total demands for the year 2030 are illustrated plus the three alternative levels of exports are presented in Table 1.

Alternative Futures

Moving 45 years into the future is not done without error. To evaluate the sensitivity of the "Best Guess" , the Resource Conservation Act Analysis employed a set of alternative futures. These alternative futures either impacted the technology available, the level of production required to meet demands, or environmental considerations. Twenty five alternatives were evaluated during the Appraisal process.

The Role of Technology: Whenever a projection into the future is made and resource adequacy is being scrutinized, technology is an extremely important consideration. In this study, three levels of technology are introduced in three areas: crop yields, livestock production per breeding female, and feeding efficiency.

The baseline, low, and high technology crop estimates are shown in Table 2. Between 1980 and 2000, corn yields are expected to increase from 107 bushels to 150 bushels and by the year 2030, to in excess of 200 bushels. Wheat is expected to increase from about 34 bushels nationally to nearly 70 bushels by the year 2030. An increase in livestock production is forecasted to be 60 percent by the year 2030 for beef and pork. The average cow herd in the United States will be producing 20,000 pounds of milk per cow in the year 2030 (English, Maetzold, Holding, and Heady, 1983).

Alternative Environmental Constraints: There are numerous environmental constraints employed in this analysis. The baseline required current terracing levels and limited the amount of conservation and no tillage acres. In addition to these constraints, 40 million acres were removed from production in the Conservation Reserve solutions. In addition, the Conservation Reserve solutions had the Conservation Compliance in effect. (This was achieved by requiring a certain percentage of the acreage planted to also employ practices that would achieve "T" levels of erosion or better. Additional constraints included water quality constraints where output from the Resources For the Future's water quality model were placed within the modelling framework. One alternative, the Environmental Enhancement solution, contains the Conservation Reserve, the water quality impacts, and a pesticide reduction/decreased corn and soybean yield alternative future.

General Findings

There are far too many results to be reported in this paper. Therefore, we will only attempt to provide a sampling of the results and will concentrate the analysis on land use, erosion and cost of production for endogenous crops and livestock, for the baseline solutions. The results presented in this paper will be national in scope and no attempt will be made to regionalize, except with respect to land use. There are four baseline solutions, one each for the years 1982, 1990, 2000, and 2030. Each of these solutions is tied to the preceding years' solution in that erosion impacts on productivity, water use levels, and land conversion are carried forth from one solution to the next. Yields, water availability, water costs, and land availability are the primary variables impacted.

Land Use

Land use requirements decrease through the year 2000 (Table 3). This is a result of technological progress outpacing the expected rate of change in the demand for food and fiber. This trend is reversed, however, between 2000 and 2030, as reflected in an increase in cropped acres of 34 million. By the year 2000, 160 million acres can be taken out of production without affecting the nation's ability to meet projected demands. Much of this "idled" land occurs in the Northern Plains (40 % of nations idle land) and Southern Plains (16%).

Erosion

Assuming that the idled land is adequately protected, and not contributing to the level of erosion, erosion levels are reduced 30, 50, and 40 percent as we move from 1982 to 1990, 2000, and 2030, respectively. This shift in sheet and rill erosion is largely a result of the land use changes reflected above and a shift toward conservation tillage techniques. Acres that are clean tilled drop from 69 percent of the total to 27 percent in 2000 and 10 percent in 2030. Average sheet and rill erosion rates drop from 6 tons per acre in 1982 to 3.5 in the year 2030. Land that is eroding at 25 tons per acre or more is at 5 % in 1982 and drops to 2 % by 2030.

Costs of Production

In 1982, based on the Economic Indicators of the Farm Sector (National Economic Division, 1987), total production expenses were 140,653 million dollars. Since the model does not add value to feed (18,592), charge land rental (6,219), include interest on real estate (10,480), purchase intermediate livestock commodities (9,696), nor grow all commodities (estimated at 24,153), this cost can be reduced to 70,413 million dollars. In addition, the model is expressed in 1980 dollars; thus, an adjustment of .8528 (based on the CPI) is made to the 70 billion dollars. The Objective function of the model when meeting 1982 demands is 53,512, not including transportation costs. This is approximately eleven percent less than what was actually experianced. Between 1982 and the year 2030, the costs of production decline by only one billion (1980) dollars. In 1990, however, a five billion dollar decrease and in the year 2000, nearly a ten billion dollar decrease is projected. These decreases correspond to the decrease in land under cultivation.

Conclusions

The analysis indicates that under the baseline or "most likely" solution, this nation should not have much trouble in meeting food and fiber needs. Furthermore, if one were to examine the alternative futures, it should be stressed that neither lower technolgy (Low Tech.) nor higher exports will result in a critical resource situation under **NORMAL** weather conditions. However, if available technology were limited to a subset of that used in the study (i.e., a banning of chemicals), a critical resource situation may result.

From the analysis, it appears that erosion levels can be economically reduced through shifts in tillage methods. In some regions, however, the technology is not available to move from an erosive to non erosive condition. This is especially true in the Plains areas, where summerfallow activities dominate the production choices. It will be difficult for these regions to meet future conservation compliance regulations. Our analysis indicates that Conservation Compliance when wind erosion levels are included will further exacerbate the "idled resource" situation projected in our model solutions.

Table 1. Projected demand levels for corn, soybeans, and wheat, 1990, 2000, and 2030

Year and Crop	Domestic Demand	Export Level		
		Low	Moderate	High
	...............(Billion Bushels)...................			
1990:				
Corn	1.47	2.45	2.88	3.11
Soybeans	0.26	0.93	1.06	1.15
Wheat	0.76	1.47	1.80	1.89
2000:				
Corn	2.02	3.24	4.20	4.94
Soybeans	0.26	1.28	1.64	1.89
Wheat	0.78	1.78	2.31	2.58
2030:				
Corn	2.13	5.33	8.19	11.25
Soybeans	0.40	2.35	3.72	4.84
Wheat	0.87	2.80	4.28	5.51

Table 2. Projections of changes in yield

Crop	Low		Moderate		High	
	2000	2030	2000	2030	2000	2030
	.................(Percent Increase)..................					
Feedgrains	20	50	40	100	60	150
Hay	10	25	20	50	45	110
Wheat	25	50	50	100	75	150
Soybeans	50	60	60	120	120	180

Source: (English, et. al., 1984)

Table 3. Projected land use requirements in the years 1982, 1990, 2000, and 2030

Year	Cropped	Idled	Total	% Idled
	............(million acres)		....	(Percent)
1982 Actual	328.3	92.3	420.7	22
1982 Solution	309.4	106.0	415.4	26
1990 Solution	292.6	117.6	410.2	29
2000 Solution	242.0	161.2	403.2	40
2030 Solution	276.2	110.0	386.2	29