THE CURRENT STATUS OF THE

IOWA CASE STUDY

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I. Introduction

The premises behind Task 2 of IIASA's Food and Agriculture Program are that the basic agricultural resources will, over a long run time horizon, become more scarce and expensive, that changes in the availability and the relative prices of factor inputs will lead to changes in techniques of production, and that explicit account must be made for environmental consequences and feedbacks in land productivity occuring as a result of these changes. In order to identify the broad dimensions of the problem and to obtain general policy guidelines, a series of case studies, formulated in a general methodological framework, have been proposed (Reneau, Van Asseldonk, and Frohberg, 1981).

Implementation of FAP's objectives for Task 2 requires a quantitative description of crop and livestock production processes, including the associated environmental effects which occur as joint products with agricultural production (Parikh, 1981). Environmental effects need to be translated into their impacts on the quality of the resource base for the next period, e.g., how soil erosion changes fertility of the soil from one period to the next.

The purpose of this paper is to provide an overview of the current status of the Iowa Case Study. An earlier paper, "Specification of a Regional-National Recursive Model for IIASA/FAP's Iowa Task 2 Case Study (Heady and Langley, 1981)," contains a more detailed description of the framework and specific model developed for the Iowa Case Study. A preliminary analysis of selected agricultural alternatives is also presented.

The specific objective of the Iowa Case Study is to evaluate both the regional and national impacts of selected legislative policies of the State of Iowa aimed at controlling pollution caused by soil erosion and sedimentation. An Iowa regional programming model is linked recursively with a U.S. national econometric simulation model to determine the effects of such legislation upon production patterns, commodity supply, demand, and price, and other economic factors. Focus is upon the State of Iowa with necessary attention given to Iowa's relationship within the agricultural economy of the United States.

This report is diveded into five parts. Part II reviews the proposed modeling framework used in the Iowa Case Study. A general overview of the model is presented to give the reader a better understanding of the framework from which we approach the Case Study. Part III presents an overview of the components of the regional-national recursive programming model. This section discusses how we formulate the Iowa regional programming model, the U.S. national econometric simulation model, and the method of linking the components together. The results of selected test runs of the model are presented in Part IV. These test solutions indicate how the model estimates the impacts of soil loss control policies upon agricultural production in Iowa. Finally, a summary and conclusions are given in Part V.

II. The Modelling Framework

Concern over the long run sustainability of agricultural production in Iowa is most evident by increased public attention over soil loss and land use. Soil loss is currently recognized as the most widespread and destructive agent involved in bringing about the rapid depletion of the fertility and productivity of the United States' cultivated lands. Soil erosion in Iowa has been severe in 3 out of the past 8 years. It has been estimated that in 1974, 4.5 million acres in Iowa experienced gross soil loss of more than 10 tons per acre (Iowa Department of Environmental Quality, 1975). Gross soil loss of 40 to 50 tons per acre was not uncommon and it reached levels as high as 200 tons per acre in some areas. A soil loss of 100 to 150 tons per acre means that approximately an inch of topsoil across an acre of land has been lost or relocated by water erosion.

In order to alleviate the problem of soil loss, the Iowa Legislature has passed laws which impose limits and practices on land use (Iowa Cooperative Extension, 1972). Under Iowa law "acceptable" limits have been established for every major soil type and on every acre of land. If losses exceed these limits and cause damage to adjacent property, the property owner can file a complaint and seek to have the person permitting the excessive erosion take corrective action to end such losses (Muhm, 1982).

Closely associated with the problem of soil loss is the issue of nonpoint pollution. Sediment is a pollutant which "occupies space in reservoirs, lakes, and ponds; restricts stream and drainageways; reduces the recreational and consuptive use value of water through turbidity;

and, increases water treatment costs. Sediment also carries other water pollutants such as plant nutrients, chemicals, radioactive materials, and pathogens." (Johnson and Moldenhauer, 1970). For instance, suspended sediment concentrations found in the Iowa River have ranged from nine to 4,700 mg per cubic meter in recent years (Iowa Department of Environmental Quality, 1975). It is important to identify and quantify the economic affects of attempts to reduce the sediment contribution from agricultural land use. Previous studies of soil erosion and conservation in Iowa provide a substantial background of information on which the present study benefits (Alt and Heady, 1977, and, Nagadevara, Heady, and Nicol, 1975).

The framework developed to investigate questions relating to soil loss control and its effects upon agricultural production, from the perspective of the State of Iowa, is a regional-national recursive model. This model consists of two main components: an Iowa regional linear programming model and a U.S. national simulation model. A Linkage sector is also included to link the programming and simulation components together.

The interrelationships between the Iowa regional and U.S. national models are illustrated in Figure 1. Any regional policy change can be translated into cost and yield changes (A), or resource and/or institutional restraints (B). Production costs and yields are adjusted (C) and used to determine the profitability of production (D). The net profit from crops then is used in determining the range of regional production response through a flexibility restraint formulation (E), and to adjust the coefficients in the regional LP model (F). The LP

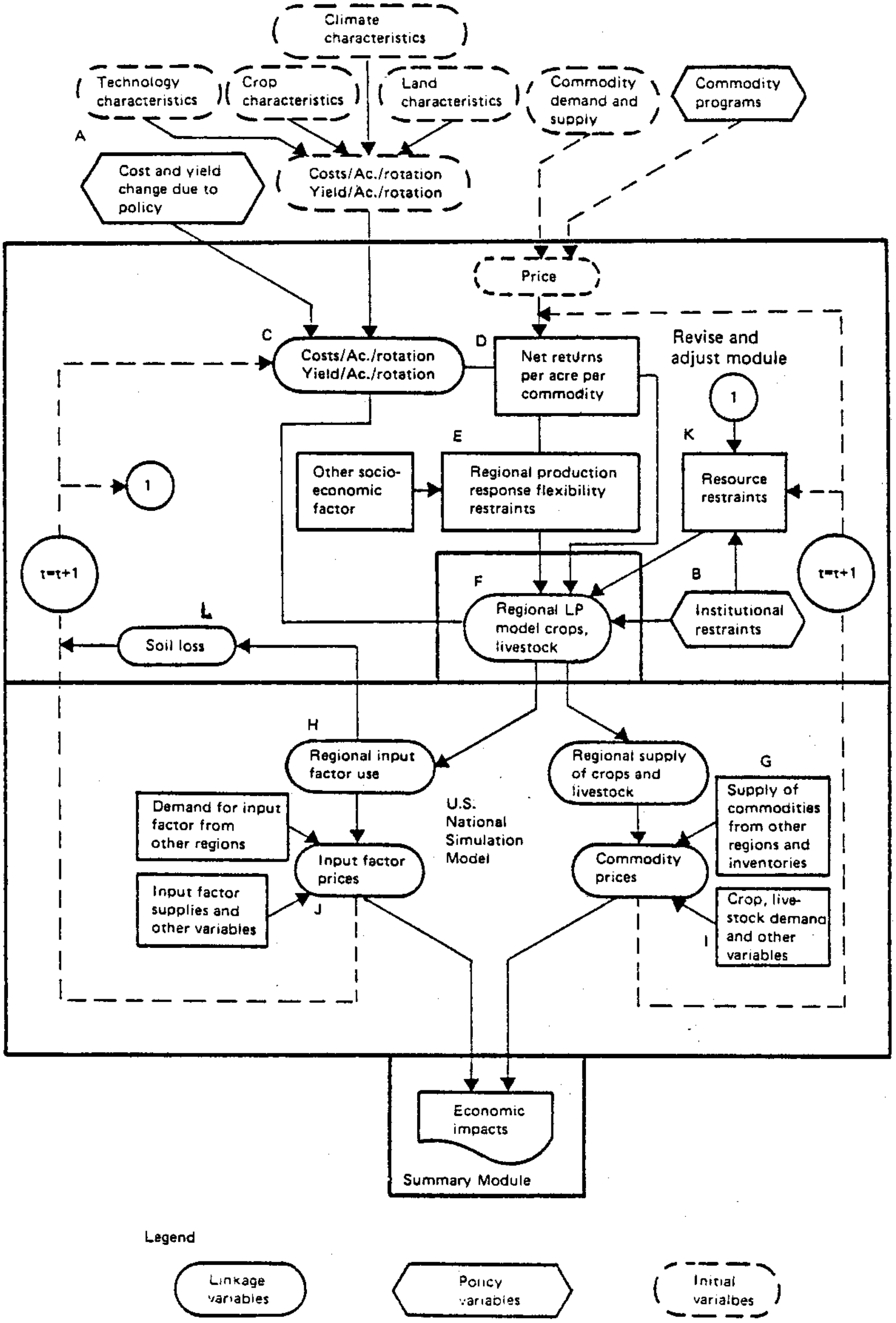

Figure 1. Structure of the Iowa Regional-National Model

model then determines the regional production supply (G) and input factor demands (H). Soil loss is determined as a function of regional input factor use (L). The production supply and factor demand subsequently determine the prices of commodities (I) and input factors (J). These prices are then used to determine production costs, yields, and net profits for the next time period (C) and resource restraint adjustments (K). The process continues until the predetermined time period of simulation is completed.

III. Overview of Model Components

The potential variables and linkages which should be considered in formulating a regional-national hybrid model to investigate the impacts of soil loss upon agricultural production are presented in Figure 1. Part III presents an overview of the individual sectors of the empirical model, beginning with the Iowa Linear Programming Component. A more detailed description of each model component appears in Heady and Langley (1981).

The Iowa Linear Programming Component

The linear programming (LP) component of the regional-national recursive hybrid model can be divided into three sections: an objective function, activities, and resource constraints. The LP component maximizes the net returns from farm production of crops subject to a set of resource constraints (right-hand-sides). The Iowa LP used in this analysis includes 12 spatially delineated producing areas (PA's) which are consistent with Iowa soil conservancy districts (Figure 2).

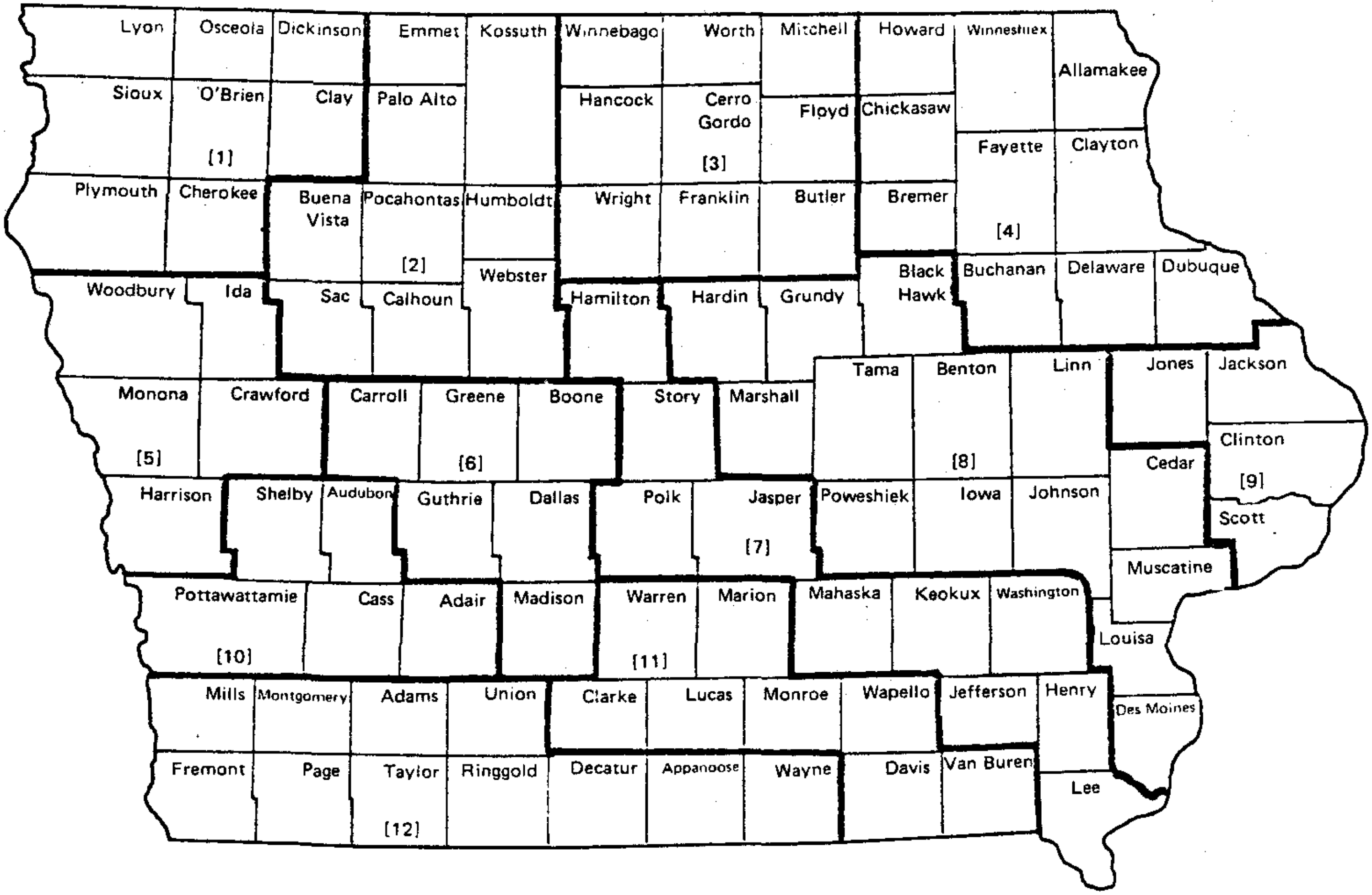

Figure 2. Iowa's 12 Producing Areas

The Objective Function. The objective function is maximized subject to the cost of agricultural production, the gross return of endogenous crops, and the availability of land. Cost of producing agricultural commodities included in the model reflect charges for labor, machinery, pesticides, and fertilizers. The objective function is of the form:

$$\max OBJ = \sum_{i}\sum_{j} P^{s}_{ij} C^{s}_{ij} - \sum_{i}\sum_{k}\sum_{l}\sum_{m} T_{iklm} L_{iklm} - \sum_{i} P^{n} Q^{nb}_{i} \qquad (1)$$

i = 1 to 12 for the producing areas;
j = 1 to 8 for the crops produced;
k = 1 to 9 for the conservation-tillage practices;
l = 1 to 48 for the crop rotations in each producing area; and,
m = 1 to 5 for the land classes.

where: $P^{s}_{ij}C^{s}_{ij}$ is the gross return received by farmers for selling crop j (C^{s}_{j}) at price (P^{s}_{j}) in producing area (i);

$T_{iklm}L_{iklm}$ is the cost of production (T), dollars per acre, of rotation (l) with conservation-tillage practice (k) on land class (m) in producing area (i), multiplied by the level of crop production activity (L); and,

$P^{n}Q^{nb}_{i}$ is the price of nitrogen fertilizers (P^{n}) multiplied by the quantity of nitrogen purchased (Q^{nb}) in producing area (i).

Activities. Activities in the Iowa LP model are divided into crop production, crop sell, and nitrogen purchase activities. Crop production activities simulate rotations producing corn grain, corn silage, legume and nonlegume hay, oats, sorghum grain, soybeans, and wheat, in crop management systems incorporating rotations of one to four crops. Each rotation is defined for three conservation methods: straight-row, strip cropping, and contour plowing. Each conservation method is associated with three tillage practices: conventional tillage, residue management, and reduced tillage. Each of these combinations are defined on the land class to which they would apply. Thus, each rotation combined with specific conservation-tillage practice defines a unique crop management system. Coefficients defined for each activity include the cost of production, land use (one acre), the quantity of nitrogen required, the yield adjusted for conservation-tillage practice, and the average number of tons of soil leaving the field during a one-year period.

Constraints. Constraints are incorporated at both producing area (PA) and state levels. Land is used solely for crop production activities. Five land classes, representing an aggregation of the 29 class-subclasses in the Conservation Needs Inventory (1971), are defined for each of the 12 PA's. Crop transfer rows simulate the marketplace for 8 endogenous commodities: corn grain, corn silage, leguminous hay, nonleguminous hay, oats, sorghum grain, soybeans, and wheat. These transfer rows for each crop for each PA take the form:

$$\sum_{klm}\Sigma\Sigma Y_{ijklm} L_{ijklm} - C^s_{ij} = 0 \qquad (2)$$

where Y_{ijklm} is the yield per acre of crop (j) in rotation (l) with conservation-tillage practice (k) on land class (m) in PA (i), L_{ijklm} is the activity level, and C^s_{ij} is the gross return per unit of crop (j) sold in PA (i).

The two statewide constraints in the model are nitrogen used for crop production and soil loss resulting from crop production. The nitrogen fertilizer transfer constraint acts as a marketplace for the supply and demand of commercial fertilizers used for the production of crops. The general form of the nitrogen constraint at the state level is:

$$Q_i^{nb} - \sum_{ikl}\sum\sum N_{iklm} L_{iklm} \geqslant 0 \qquad (3)$$

where Q_i^{nb} is the quantity of nitrogen fertilizers purchased for use in crop production in PA (i), N_{ijkm} is the nitrogen requirement from commercial sources necessary for crop rotation (l) with conservation-tillage practice (k) on land class (m) in PA (i), and L_{iklm} is the crop production activity level.

The soil loss row is an accounting row to determine the quantity of soil lost in the production of crop commodities. The form of the state soil loss equation is:

$$\sum_{ilm}\sum\sum S_{iklm} L_{iklm} \geqslant 0 \qquad (4)$$

where S_{iklm} is the quantity of gross soil loss occuring for crop activity (i) with conservation-tillage practice (k) on land class (m) in PA (i), in tons per acre, and L_{iklm} is the crop activity level.

The U.S. Econometric Simulation Component

The purpose of the U.S. econometric simulation component of the Iowa regional-national recursive system is to estimate resource use and commodity output originating in the United States other than Iowa. These estimates are summed with those originating solely within the State of Iowa (from the programming component) to determine important economic variables in the national market.

The econometric component is based upon the CARD-National Agricultural Econometric Simulation model (CARD-NAES) originally specified by Schatzer, et al (1981), and Roberts and Heady (1979, 1980), with some restructuring being done for this study. CARD-NAES depicts farmers' behavior in the purchase of major inputs and can be used to characterize the response of farmers to many changing variables which relate to production decisions.

Major categories of agricultural production are included in the simulation sector by five crop submodels--feed grains (corn, sorghum, oats, and barley), wheat, soybeans, cotton, and tobacco; five livestock submodels--beef, pork, lamb and mutton, chicken, and turkey; and, a submodel which aggregates components from each of the other ten and sums those results with the exogenously determined variables for the rest of the U.S. agricultural sector. The submodels can be described in general terms as follows: a) resource demands in the current year depend directly or indirectly on lagged commodity and resource prices, lagged resource demands, and other variables; b) current production depends upon the current quantity of resources demanded; c) supply in the current year depends on current production, carryover, and imports; d) average current year commodity prices depend on current supply, exports, and other variables; e) commodity demand in the current year depends on current price, and other variables; f) gross income in the current year depends on current price and production; and, h) quantity supplied is required to equal quantity demanded primarily through inventory adjustments.

CARD-NAES consists of 210 equations (151 for crops and 59 for livestock) formulated primarily in a sequential framework. Annual time series data are used to estimate the structural parameters of the model using appropriate statistical estimation techniques. Most equations are estimated from 1949-76 data with portions of the livestock submodels using 1953-76 data.

The Linkage Component

The purpose of the Linkage Component of the Iowa regional-national system is to retrieve and transfer information between the programming and econometric components; and, to revise and adjust selected variables between time periods to simulate the recursive sequence of agricultural production and its interaction with the environment.

The basic solution procedure for the Iowa model is shown in Figure 3. The regional LP component is first solved for the profit maximizing level of crop production and resource use for the State of Iowa. These values are summed with estimates of production and input use occuring in the United States excluding Iowa (estimated from the national econometric simulation component) to obtain national totals. Commodity prices and other important economic variables are estimated in the econometric component. Crop yield adjustment factors are determined based on inches of top soil lost, and are used to revise the crop yields in the LP sector. The newly estimated commodity prices are used to revise the crop sell coefficients in the LP objective function. After the LP input data matrix has been revised, the programming component is solved for the next time period, thus repeating the entire

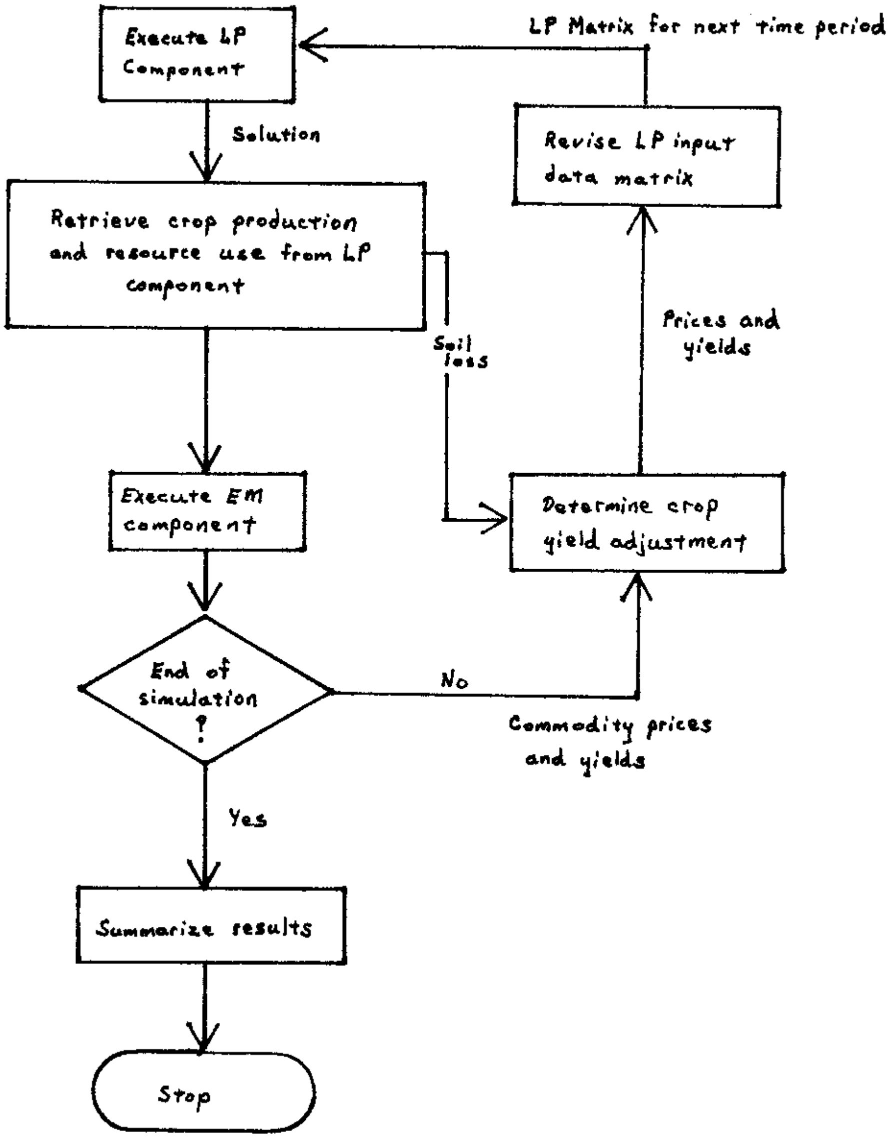

Figure 3. Basic solution procedure of the Iowa model

process again until the predetermined number of simulations are completed.

The Linkage component can be decomposed into three subsectors: Retrieval, Adjustment, and Revision. Linkage variables, defined as variables providing information from the regional model to the national model, and vice versa, must be specified for these three subsectors. In the current version of the Iowa model, information retrieved from the Iowa LP component includes production levels of endogenous crops, soil loss, nitrogen fertilizer use, and land use in each of 5 land groups for each of 12 producing regions. Crop production and fertilizer use are inputs to the econometric component, while soil loss and land use are inputs to the Adjustment and Revision subsectors of the Linkage component.

The purpose of the Adjustment subsector is to adjust the estimated crop yields due to the affects of soil loss. The tonnage of soil loss from each soil mapping unit, estimated by the Universal Soil Loss Equation, is converted to inches of soil loss using equation (5):

$$ISL_{im} = \frac{TSL_{im}}{SBD_{im} * TACRE_{im}} \qquad (5)$$

where ISL_{im} is the estimated inches of soil lost in producing area (i) on land class (m), TSL_{im} is the total tons of soil lost, SBD_{im} is the average bulk density of the soil, and, $TACRE_{im}$ is the total acres of cropland.

Once inches of soil loss is determined from equation (5), the revised soil depth is determined by equation (6):

Estimated crop production in Iowa for Alternatives I and II for 1980 and 1985 are presented in Table 1. The impact of removing production practices which lead to soil loss greater than five tons per acre (Alternative II) is most noticeable for oats, soybeans, and wheat. Soil-saving production practices typically include small grains in various rotations. Many of the profit-maximizing soybean activities do not contain small grains in the rotation. Corn maintains its comparative advantage in most producing areas and is produced primarily with reduced tillage cropping practices. The most significant changes in crop production occur, as expected, in producing areas experiencing the highest level of soil erosion, e.g., PA's 5 and 10 in western Iowa. Shifts in relative total crop production among the endogenous crops between 1980 and 1985 are due to changes in relative commodity prices.

Cropland acreage, soil loss, and commercial nitrogen purchases, for Iowa in 1980 and 1985 for Alternatives I and II appear in Table 2. Acreage harvested is an aggregation for all endogenous crops. The estimates of average soil loss/acre indicate that in Alternative I (with no erosion restrictions) soil loss ranges from an average of 2.86 tons/acre in PA 2 to 14.08 tons/acre in PA 10. Eight of the 12 PA's exceed the 5 tons/acre goal set by the Iowa State Legislature.

Prohibiting the use of crop management practices which result in excess of 5 tons/acre soil loss (as in Alternative II) affects the level of soil loss in each PA in Iowa. For example, in PA 10, soil loss drops from an average of 14.08 tons/acre to an average of 3.23 tons/acre. This reduction is due to both erosive land going out of production and changes in crop management practices. Limiting crop production

The Revise subsector of the Linkage component takes information from the Retrieval and Adjust subsectors and revises the LP component for the next time period. The revision reflects the expected yield and commodity prices for next period's production response.

IV. Results of Alternative Test Solutions

The Iowa Regional-National Model presented in Part III is used to investigate crop production activity in the State of Iowa under two alternative test solutions. Alternative I is a base run with no restrictions on soil loss at either the state or PA level. This solution indicates the optimal level of production of the seven endogenous crops and the resulting soil loss for each producing area in Iowa when no restrictions are placed on the amount of soil leaving the field via water erosion. Alternative II attempts to limit soil loss by prohibiting the use of any crop management system which has been estimated to cause greater than 5 tons of soil loss per acre. This solution indicates the changes in crop production in each PA (i.e., changes from Alternative I) which are necessary to meet the 5 tons (or less) per acre criteria.

A test run for the years 1980-85 is conducted to test the computer software. The results presented indicate the level of crop production for corn, oats, sorghum, soybeans, wheat, and legume and nonlegume hay, acres used for crop production, acres left idle (available for crop production but not utilized), total soil loss, average soil loss/acre, and quantities of commercial nitrogen purchased. These variables are for each PA in Iowa.

$$\text{SOILD}_{imt} = \text{SOILD}_{imt-1} - \text{ISL}_{imt} \tag{6}$$

where SOILD_{imt} is the average soil depth of land class (m) in PA (i) at time (t). The revised soil depth for each land class in each PA are divided by the average plow depth (PLOW) to determine the plow depth factor (PDF) for each land class in each producing area:

$$\text{PDF}_{im} = \text{SOILD}_{im} \; / \; \text{PLOW} \tag{7}$$

A crop yield adjustment factor (YADJ) is determined for crop production activities on each land class in each PA according to the following criteria:

$$\text{IF} \begin{bmatrix} 1.0 \\ 0.9 \\ 0.8 \\ 0.7 \\ 0.6 \\ 0.5 \\ 0.4 \\ 0.3 \\ 0.2 \\ \ \end{bmatrix} < \text{PDF}_{im} < \begin{bmatrix} \ \\ 1.0 \\ 0.9 \\ 0.8 \\ 0.7 \\ 0.6 \\ 0.5 \\ 0.4 \\ 0.3 \\ 0.2 \end{bmatrix} \text{THEN, } \text{YADJ}_{im} = \begin{bmatrix} 1.00 \\ 0.95 \\ 0.90 \\ 0.85 \\ 0.75 \\ 0.60 \\ 0.40 \\ 0.30 \\ 0.20 \\ 0.20 \end{bmatrix} \tag{8}$$

Finally, the adjusted crop yields to be used in the LP input data for the next time period are determined by:

$$\text{Y}_{ijklmt+1} = \text{Y}_{ijklmt} * \text{YADJ}_{imt} \tag{9}$$

where all terms have been previously defined.

Table 1. Crop production in Iowa for Alternative I (Base Solution) and Alternative II (T-value Restricted) for 1980 and 1985 by producing area

		Corn		Oats		Soybeans		Wheat	
PA	Year	Alt. I	Alt. II	Alt. I	Alt II.	Alt. I	Alt. II	Alt. I	Alt. II
		(Thousand Bushels)							
1	1980	194,585	182,375	1,200	5,715	19,686	16,462	0	0
	1985	165,358	153,149	1,200	5,715	29,452	26,228	0	0
2	1980	218,099	214,892	1,781	1,781	981	1,892	1,039	1,039
	1985	103,621	104,945	1,781	1,764	33,943	33,491	1,041	1,076
3	1980	284,631	283,278	1,351	1,351	1,216	1,605	1,373	1,372
	1985	136,666	137,673	1,351	1,338	43,366	43,033	1,373	1,410
4	1980	148,541	159,199	874	874	22,782	19,567	6,789	6,783
	1985	82,644	90,652	874	1,125	42,663	39,689	6,789	6,862
5	1980	73,208	63,262	515	719	14,313	6,227	0	0
	1985	73,208	46,583	515	719	14,313	9,377	0	2,816
6	1980	60,408	67,346	2,220	2,199	24,951	19,576	1,990	2,025
	1985	58,121	66,070	2,220	2,199	25,671	21,553	1,990	3,114
7	1980	90,923	121,427	2,179	2,153	42,558	31,397	4,397	4,504
	1985	90,923	99,143	2,179	2,160	42,558	34,828	4,397	9,020
8	1980	149,845	220,398	4,137	4,098	65,010	40,203	5,048	5,426
	1985	149,845	144,303	4,137	5,303	65,010	49,000	5,048	15,660
98	1980	30,747	49,279	1,570	2,088	15,511	8,848	1,668	1,559
	1985	30,747	38,278	1,570	1,596	15,512	11,050	1,668	3,058
10	1980	63,820	54,564	816	1,142	11,676	4,685	0	0
	1985	63,820	39,231	816	1,142	11,676	7,385	0	2,582
11	1980	9,530	18,244	2,664	3,157	11,751	9,110	5,148	4,741
	1985	4,421	17,563	2,663	2,639	13,290	9,281	5,148	5,124
12	1980	81,531	66,435	0	2,221	13,815	11,698	3,393	4,872
	1985	82,485	66,435	2,679	2,221	14,362	11,698	26	4,872
IA	1980	1,405,686	1,509,699	19,307	27,798	244,250	171,270	30,845	32,321
	1985	1,041,859	1,044,025	21,985	27,921	351,816	296,583	27,480	55,594

Table 2. Cropland acreage, soil loss, and nitrogen purchased in Iowa for 1980 adn 1985 by producing area

		Acreage Planted to Crops		Cropland Not Used		Total Soil Loss		Average Soil Loss/Acre		Nitrogen Purchased	
PA	Year	Alt. I	Alt. II	Alt. I	Alt. II	Alt. I	Alt. II	Alt. I	Alt. II	Alt. I	Alt. II
		(Thousand Acres)				(Thousand Tons)		(Tons/Acre)		(Thousand lbs.)	
1	1980	2,382	2,350	9	41	16,420	6,667	6.89	2.84	207	194
	1985	2,382	2,350	9	41	16,328	7,575	7.27	3.22	180	167
2	1980	1,957	1,957	12	12	3,919	3,951	2.00	2.02	288	284
	1985	1,957	1,957	12	12	7,286	5,939	3.72	3.03	144	164
3	1980	2,386	2,386	9	9	5,552	5,232	2.33	2.19	384	382
	1985	2,386	2,386	9	9	9,555	8,375	4.00	3.51	191	193
4	1980	2,347	2,347	68	68	9,324	7,056	3.97	3.01	212	226
	1985	2,347	2,347	68	68	12,673	8,624	5.40	3.67	133	145
5	1980	1,292	938	168	522	17,186	2,851	13.30	3.04	105	85
	1985	1,292	938	168	522	17,186	2,637	13.30	2.81	105	68
6	1980	1,347	1,347	16	16	7,525	4,206	5.59	3.12	78	97
	1985	1,347	1,347	16	16	7,728	4,530	5.74	3.36	76	88
7	1980	2,269	2,269	60	60	14,678	9,011	6.47	3.97	141	185
	1985	2,269	2,269	60	60	14,678	9,641	6.47	4.25	141	161
8	1980	3,288	3,288	121	121	20,019	11,172	6.09	3.40	206	294
	1985	3,288	3,288	121	121	20,019	11,933	6.09	3.63	206	213
9	1980	850	850	61	61	5,702	2,728	6.71	3.21	44	64
	1985	850	850	61	61	5,702	2,912	6.71	3.43	44	567
10	1980	1,197	881	163	478	16,848	2,946	14.08	3.34	87	69
	1985	1,197	881	163	478	16,848	2,744	14.08	3.11	87	56
11	1980	981	981	81	81	3,234	1,964	3.30	2.00	26	37
	1985	981	981	81	81	3,553	1,950	3.62	1.99	20	36
12	1980	1,738	1,571	65	231	15,803	5,067	9.09	3.23	110	90
	1985	1,738	1,571	65	231	8,297	5,067	4.77	3.23	106	90
IA	1980	22,034	21,165	833	1,700	136,210	62,851	6.18	2.97	1,888	2,007
	1985	22,034	21,165	833	1,700	140,853	71,927	6.39	3.40	1,433	1,419

to management practices having less than an average soil loss of 5 tons/acre, in effect, reduces the average soil loss for each producing area well below the 5-ton limit.

Some changes in the level of commercial nitrogen fertilizer purchases for each PA occur between Alternatives I and II. These changes correspond to increases or decreases in corn production in the respective producing area.

It should be emphasized that these results are preliminary and that the specific estimates are subject to change as improvements and/ or additions are incorporated into the modeling framework. Also, other information is available from this model (e.g., commodity prices, input factor use, etc.); but, are not presented here.

V. Summary and Conclusions

The model discussed in Part III and the test solutions in Part IV represents an intermediate stage in the development of the IIASA Task 2 Iowa Case Study Project. Work is currently in progress at CARD to improve the existing structure and include additional aspects which may provide a more complete investigation of the types of questions anticipated by the Food and Agriculture Program. Important aspects of the various components of the Iowa Case Study currently under development are discussed in this part of the paper.

Work in progress on the U.S. national simulation sector is primarily directed toward estimation of acreage response functions for the 47 continental United States excluding Iowa, interactions of government policy variables with agricultural production, and the demand for input factors. The historical share approach to obtaining acreage estimates for the 47 states implicitly assumes that the national model dominates the projection process, while an implicit assumption of the regional-national structure is that the regional model should dominate. Hence, it would be more consistent with the proposed model framework to estimate directly the acreage response for the 47 states other than Iowa. Regional acreage response functions are being estimated for each endogenous crop.

Government agricultural policy variables affect acreage response, crop yields, costs of production, commodity prices, and other aspects of production. A complete system should account for these affects. Methods of introducing policy variables into the regional-national framework are progressing.

The demand and supply of input factors of production play an important role in the potential sustainability of agricultural production. In regards to soil loss, investment in terracing and other forms of land improvement will need attention. Olson (1980) offers suggestions from which to develop a means of estimating investment behavior.

The estimates of soil loss per acre are currently based on the best judgement of experts working in this area. Proceedures to improve these estimates are currently in progress. Additional information on the proposed soil loss simulator may be found in Huang and Rosenberry (1982).

The model specified in Part III may be applied to the analysis of alternative scenarios concerning the interrelationships between agricultural production and the surrounding environment. Potential scenarios include the following: a) restrictions on selected outputs from the production process, such as alternative soil loss limits, an example of which is presented in this paper; b) restrictions on selected inputs into the production process, e.g., the quantity of nitrogen fertilizer available for application; and, c) the impact on production patterns in Iowa due to changes in relative input and output prices. Changes in certain exogenous variables and policy instruments in the econometric component will have various impacts upon relative prices paid for inputs and received for commodities; and, subsequently, upon agricultural production practices in Iowa. After such a change, the impacts on soil loss, production levels, patterns, and costs, and commodity prices can be estimated.

Additional examples of the hybrid modeling technique are available. A regional-national model has been developed to investigate questions of irrigation and groundwater limitations for the State of Nebraska (Langley, English, and Heady, 1982). Nebraska shares Iowa's western border. The Nebraska model does not include soil loss coefficients, while the Iowa model does not include irrigation coefficients. Also, the model can be expanded to a multiregional model of the entire United States (or other country) as resources become available and such a model is needed (e.g., Huang, et al, 1980; Langley, Huang, and Heady, 1981).

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