INFORMATION FOR CONSERVATION DECISIONS: THE IIASA APPROACH

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THE IIASA APPROACH

Sound policy decisions concerning the complex interrelationships between sustainable agricultural production potential, resource use, technical change, and the environment, require much detailed information on the site-specific nature of resource inputs and alternative land-use practices over time. Realizing that these information requirements transcend geographic, economic, and potential boundaries, the Food and Agriculture program (FAP) of the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, has initiated a series of case studies directed at examining the relationships for the United States (Iowa), Hungary, U.S.S.R. (Stavropol Region), Czechoslovakia (Nitra Region), Italy (Tuscany Region), Northeastern Bulgaria, and Japan. The purpose of this paper is to provide an overview of the objectives, methodological framework, and potential information available from this aspect of FAP's research, with emphasis on the Iowa Case Study.

IIASA was founded in 1972 as a nongovernmental, multidisciplinary, international, and applied research institute whose membership includes the academies of science and equivalent scientific organizations of 17 nations. One such organization is the American Academy of Arts and Sciences, which recently took over U.S. membership from the National Academy of Sciences. The three primary objectives of IIASA are: to enhance international collaboration, to advance science (and especially systems analysis), and to apply findings to problems of international importance. Located in Laxenburg, Austria, a small community 16 kilometers south of Vienna, IIASA is housed in a group of historical buildings constructed in the early 18th century as a summer residence for several Habsburg emperors.

The focus of the Food and Agriculture Program (FAP) is the efficient production or procurement of food and its appropriate distribution among the global population. FAP's aims are to evaluate the nature and dimensions of the world food situation; to identify the factors affecting that situation; and, to suggest alternatives at the national,regional, and global levels, not only to alleviate current food problems, but also to prevent future ones. FAP was originally organized into two major tasks. Task 1, called "Strategies: National Policy Models for Food and Agriculture," explores the present shortrun problems of policy. A long-term perspective on the world agricultural situation raises questions about the availability of resources and about the efficiency and environmental consequences of food production techniques. These questions are addressed by Task 2, entitled "Technological Transformations in Agriculture: Resource Limitations and Environmental Consequences." It is Task 2 which focuses upon the series of case studies directed at information for conservation decisions.

The underlying assumptions of Task 2 are that over the coming decades a technological transformation of agriculture will take place which will be constrained by resource limitations and whose environmental implications pose questions regarding the sustainability of adequate production to feed mankind in the future. For the purpose of this project, a region's agricultural production system is considered "sustainable" if the natural resources available at the end of the study period are equal to those available at the beginning of the modeling time horizon.

The research methodology of Task 2 is to formulate a relatively loose-knit series of region-specific case studies within a general recursive programming framework (Reneau, Asseldonk, and Frohberg, 1981). The impact upon agricultural productivity of soil erosion and energy limitations are investigated for each case; however, the studies are also designed to address problems important to the respective areas. Soil conservation is the primary concern in the Iowa model; Hungary focuses on energy availability; Stavropol and Bulgaria stress wind erosion; Czechoslovakia analyzes the agronomic aspects of sustained crop yields; Italy looks at abandonment of hillsides; and, Japan studies tenure arrangements.

Each case study is formulated and developed by a team of researchers from a collaborating institution from within the particular region. Hence, knowledge of local conditions is enhanced. Cooperation among case study participants occurs via conferences and temporary staff appointments at the IIASA facilities in Austria.

The Iowa Case Study is presented as an example; but, it should be emphasized that for each case study, the model used differs in various details. The Iowa model has been specified by a team of researchers from the Center for Agricultural and Rural Development, Iowa State University, with technical assistance from the Natural Resource Economics Division, U.S. Department of Agriculture.

The regional-national recursive model developed for the Iowa Case Study consists of four main components: a regional linear programming model for the State of Iowa (English, et al, 1980); a national econometric simulation model for the United States excluding Iowa (Schatzer, et al, 1981; Roberts and Heady, 1979, 1980); a physical component which determines crop yields based on depth of topsoil and technological change (Pope, Bhide, and Heady, 1982); and, a linkage procedure which transfers information between the regional and national components. The model is designed to determine the profit-maximizing combination of land use patterns and crop production practices for the 12 Iowa Conservation Districts (Figure 1); estimate crop production and price information for the remaining 47 contiguous states; and, adjust crop yields between time periods based on soil erosion and other agronomic conditions. Solutions are obtained in 5-year increments for 1980-2000. This model benefits from the integration of information on the spatial pattern of regional supply, resource use, technical means of production, and the environmental implications (generated by the regional programming model) with the detailed information on market structure and prices of commodities and inputs (generated by the national econometric simulation model). A more detailed description of each model component and the solution procedure appears in Heady and Langley (1981).

The Iowa Model: Some Results

Recently, the model briefly described above, was used in analyzing some regional soil loss policy alternatives. A base solution was found

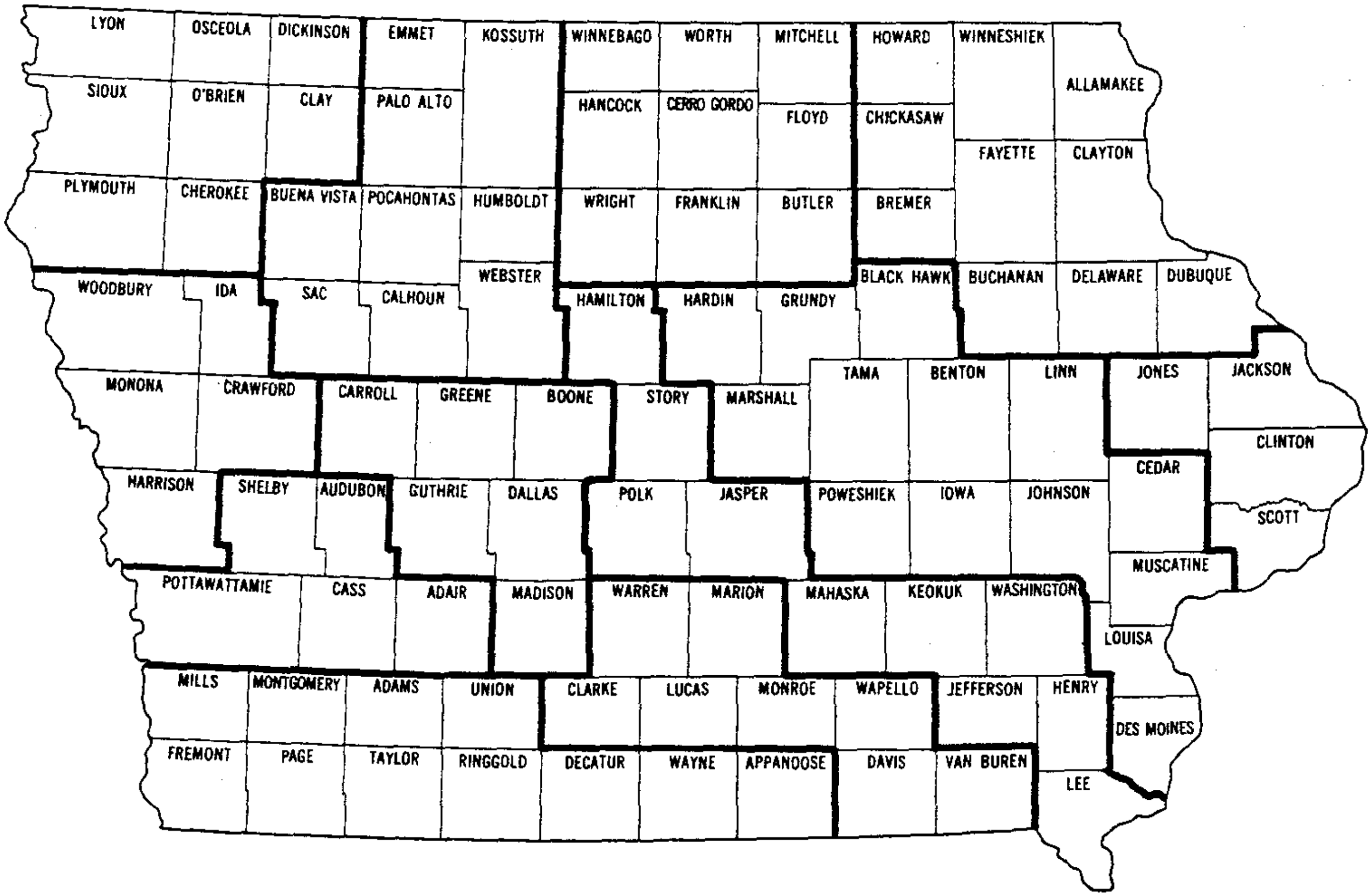

Figure 1. Iowa's 12 producing areas.

assuming that farmers would maximize profits. Then two alternatives were formed. The first alternative explored the changes that would result if the production technologies available to the farmer could not exceed a ten ton soil loss level (10T). In other words, all technologies that produced an average annual soil loss of greater than ten tons were banned. The second alternative banned the production alternatives that exceeded a five ton soil loss constraint (5T). While numerous results were generated for these alternative solutions, for the purpose of this paper only a few are selected.

The projected soil loss levels for the years 1985 through 2000 are shown in Table 1. In the Base solution, gross soil erosion increases from 170 million tons in 1985 to 189.5 million tons in the year 2000. When production practices are banned if they exceed a ten ton soil loss level, gross soil erosion is reduced by approximately 44 percent and in the 5T solution a reduction of 58 percent is projected.

Table 1. Projected gross soil loss in Iowa, 1985-2000 by alternative

Year	Alternative		
	Base	10T	5T
	---------(million tons-----------------		
1985	170.0	94.3	74.9
1990	176.1	94.3	74.8
1995	182.4	103.8	78.1
2000	189.5	107.1	64.7

Since the model estimates both prices and quantities, these change over time as well as between alternatives (Table 2). In the Base, production of both corn and soybeans increases over time. When production possibilities are reduced based on the level of allowed soil loss, corn production increases while soybean production decreases. This is a direct result of the decrease in the ratio of net returns to production costs for soybeans relative to that for corn.

Finally, the 5T solution illustrates an increase in the net return[1] when compared to the Base over the long run (Figure 2). However, in the first few years a decrease in net returns result. Farmers would lose money in the short run but gain over the long term.

The gain in net returns is a direct result of conserving the soil. As previously stated, the yields are negatively affected if a loss of topsoil is projected. Thus, a profit maximizing farmer with a short time horizon would, on some soils and in some areas of production, consume soil. If that time frame were lengthened he/she would choose other production practices that consume less soil.

The results between 1995 and 2000 would probably not occur. The model assumes that Iowa will maintain its historical share. One would suspect that during the 1995-2000 time frame shifts would occur given these results that would alter this assumption.

The seven case studies currently underway in cooperation with IIASA's Food and Agriculture Program are in various stages of completion, with the Iowa and Hungary studies perhaps the most advanced. The Iowa model

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[1]Net return in this paper is defined as return to land and management.

Table 2. Projected corn and soybean prices and production for the Base, 10T, and 5T solutions, 1985-2000.

Commodity and year	Prices[a]			Production		
	Base	10T	5T	Base	10T	5T
	-----dollars per bushel----			---------thousand bushels--------		
Corn						
1985	1.38	1.43	1.53	7,725	7,586	9.385
1990	1.22	1.31	1.40	7,026	7,680	8.981
1995	1.24	1.38	1.54	8,079	8,705	16,293
2000	1.41	2.01	2.50	9,986	11,816	16.293
Soybeans						
1985	4.34	4.49	4.79	9,004	8,362	6,761
1990	3.97	4.26	4.99	9,122	8,402	7,105
1995	4.53	4.99	5.75	9,267	8,495	7,066
2000	5.35	6.02	7.16	9,368	6,878	1,406

[a]In 1975 dollars.

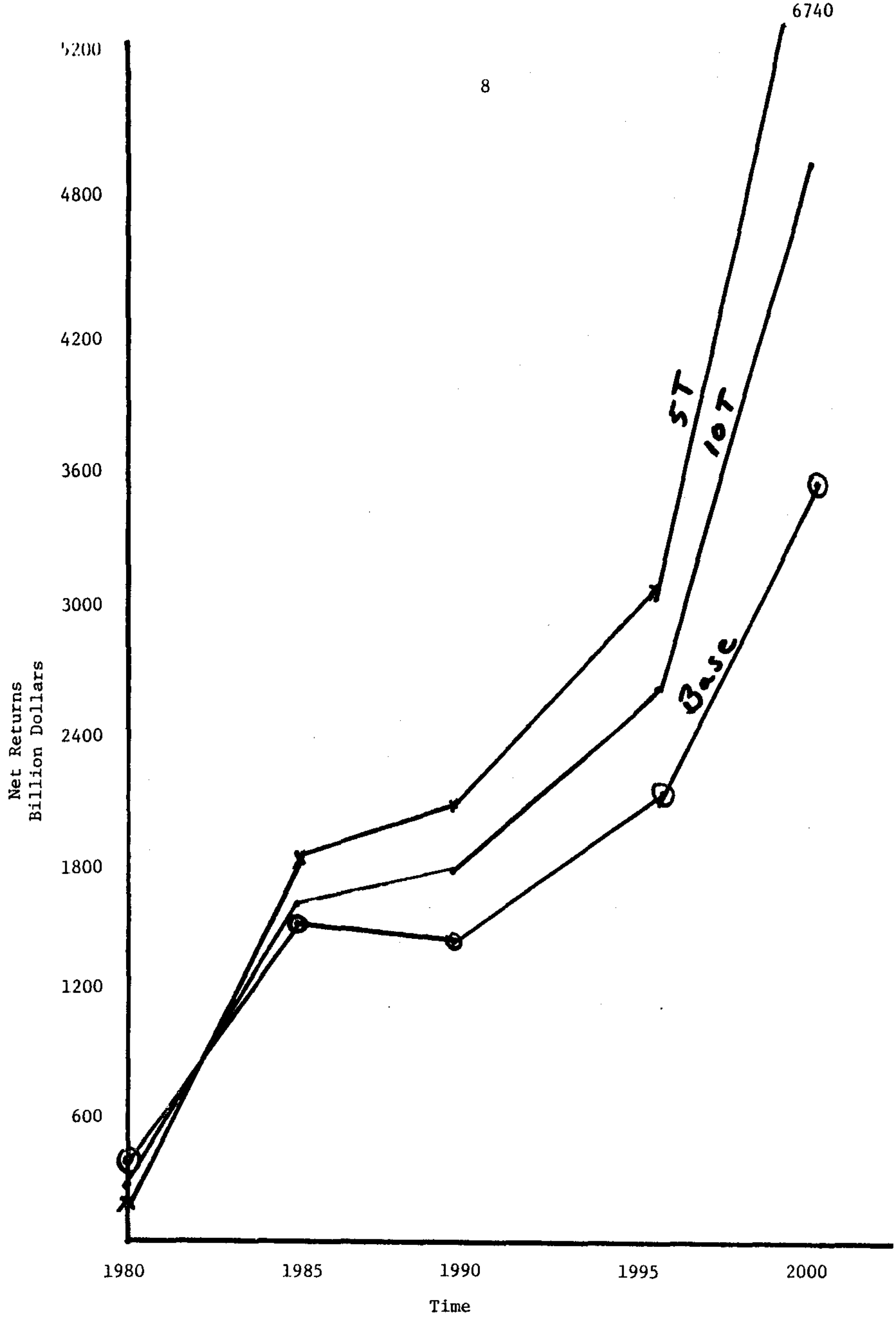

Figure 2. Net return for land and management by alternative.

has been used for some preliminary analysis to investigate crop production activity under alternative soil loss limits. Such limits have been imposed by the State Legislature of Iowa to alleviate the impact of soil erosion on Iowa's agricultural lands. Other potential scenarios which may be investigated with this type of model include analysis of the implications of controlling soil erosion via tax or subsidy schemes; restricting the availability of selected inputs into the production process (e.g., nitrogen fertilizer, energy supplies, etc.); and, shifts in production patterns in Iowa due to changes in relative input and output prices. 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).

It was stated at the outset of this paper that sound policy decisions concerning sustainable agricultural production potential require much detailed information regarding resource inputs and alternative land-use practices over time. The Food and Agriculture Program's Task 2 project makes a significant attempt at addressing these information requirements over a variety of geographic, economic, and political situations.
The type of research questions which Task 2 seeks to provide answers include, but are not limited to, the following:

- What future trends in agricultural output are likely if soil erosion is allowed to go unchecked?

- Which combination of crop rotation, tillage method, and conservation practice will best maintain the productivity of the region's agricultural lands over the designated time horizon?
- What are the short- and long-term implications of limited fertilizer and energy input supplies upon sustainable agricultural production?
- What are the least-cost means of controlling soil erosion -- restrictions, taxes, subsidies, or a combination of these?
- What are the production levels and value of output projections under alternative conservation programs?

Of course, the answer to sustainable world food production will not come solely from these seven case studies. A major drawback of this project is the limited number of case studies, especially for less developed countries. However, the IIASA/FAP Task 2 project does mark an important step forward in international cooperation in this difficult and diverse area of research.

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