# CORNELL
# AGRICULTURAL ECONOMICS
# STAFF PAPER

GEOGRAPHIC INFORMATION SYSTEMS IN POLICY RESEARCH:
EXAMPLES FROM AN EVOLVING SYSTEM

by

Ralph Heimlich, Nelson Bills, and Clayton Ogg

November 1983 No. 83-22

Department of Agricultural Economics
Cornell University Agricultural Experiment Station
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York, 14853

# GEOGRAPHIC INFORMATION SYSTEMS IN POLICY RESEARCH: EXAMPLES FROM AN EVOLVING SYSTEM

by

Ralph Heimlich, Nelson Bills, and Clayton Ogg*

Sound, geographically based information on the Nation's land and water resources is essential to meaningful agricultural resource policy research. The need arises out of an uneven distribution of land and water resources across space. This restricts the location of potential resource problems and allows precise targeting of solutions. Within USDA, several data collection programs begun by separate agencies are evolving into a geographic information system with considerable potential. Interaction between policymakers' information needs and research opportunities provided by newly available data has created a system more comprehensive than that envisioned by any of the agencies responsible for each separate component.

This paper discusses the evolution of this system and illustrates its development with several examples of current resource policy research in ERS. The examples point up the opportunities for aggregate analyses based on a highly disaggregated system.

## An Evolving System

Information on land resources and problems for policymaking has been actively collected by the Federal government since Lewis and Clark. The direct precursor to the existing USDA system, however,

---

*Agricultural Economists with USDA-ERS-NRED; Heimlich and Bills are stationed at Cornell University and Ogg is stationed in Washington, D.C. Paper presented at the annual meetings of the Soil Conservation Society of America, Hartford, Connecticut, August, 1983.

was physical data collected by the Soil Conservation Service (SCS) in the last fifteen years. Physical information was systematically gathered in the 1958 and 1967 Conservation Needs Inventories (CNI).

Improvements in this data stemmed from a variety of sources (3). Probably most important, Congressional information needs articulated in the Rural Development Act (1972) authorized a land inventory and monitoring program and required a land inventory report every five years. The Soil and Water Resources Conservation Act (1977) further strengthened the Congressional mandate for a continuing resource appraisal. Development of the Universal Soil Loss Equation (USLE) in the late 1960s provided a quantitative tool making erosion assessments more precise and uniform (14). Experience with resource assessments in river basin studies (5,9) showed that such a disaggregated data base could successfully be used for meaningful resource analysis.

SCS and ERS collaborated in "piggy-backing" the comprehensive Landownership Survey (LOS) onto the 1977 NRI sample (8). An earlier landownership study in 1946 (6) anticipated this effort but was neither comprehensive nor truly geographically based. With the NRI-LOS survey, physical and socio-economic data collection efforts were coordinated, with data from both perspectives referring to the same geographic points at the same time. Joint agency workplans call for completion of the 1982 and 1987 NRI samples and cooperation in data collection on soil conservation practice economics, land conversion and development economics, water use and management and a possible repeat of the Landownership Survey. The 1982 and subsequent inventories will be taken at the same points as in 1977, so changes in land use and management at a single point can be traced over time.

In addition to data collected directly on a geographic basis, two important information systems can be linked to the geographic data. First, the Soil Interpretations Record (Soils Form 5) for each soil series is maintained by SCS in a computer accessible format providing ranges of soil characteristics and estimated potential crop yields. Second, Congress required ERS to collect data on the cost of producing major crops in the Agricultural and Consumer Protection Act of 1973. Surveys were made in 1975 and 1978 and updated through indexing for intervening years. This information is summarized by crop production region in over 800 crop and 200 livestock budgets in the Federal Enterprise Data System (FEDS) (7).

Merging information from inventory and monitoring activities, resource economics surveys, soil interpretation records and crop budgets produces a formidable, nationally consistent, geographically disaggregated data base with great potential for analyzing resource policy issues. The following examples of research using the data base described above are tentative and fragmentary, but serve to illustrate the kinds of capabilities now available for policy and program analysis.

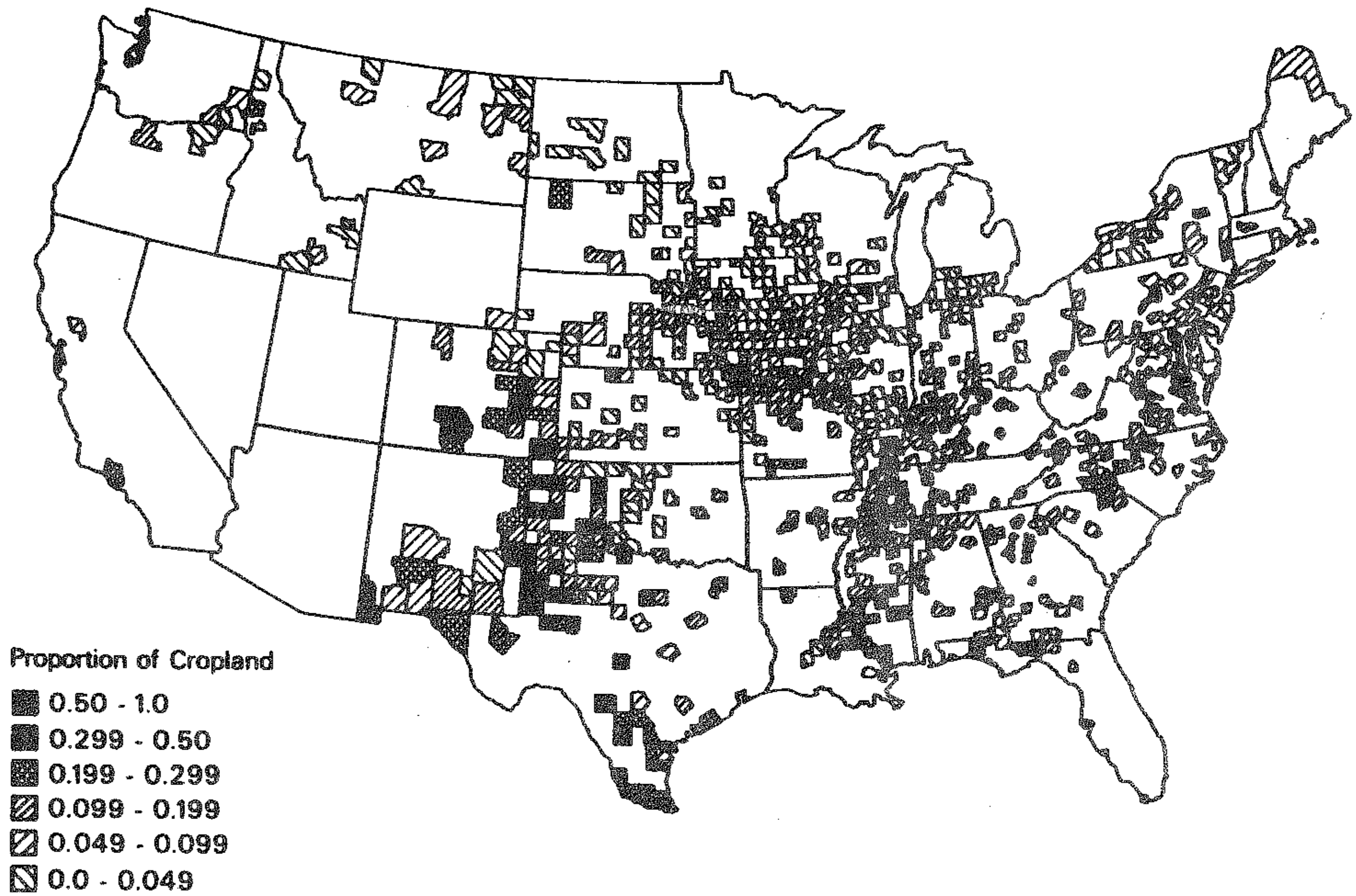
## Agricultural Program Consistency

This example shows the first level of analysis beyond direct presentation of data on existing resource conditions. Here the NRI data are combined with existing program data to estimate the short-term consequences of specific proposed changes in policy. Use of readily available data allows for a rapid response in such inquiries without unduly sacrificing detail and accuracy.

Several strategies for better achievement of resource goals were suggested in the 1980 RCA appraisal (12). Redirecting the present $800 million per year spent on conservation assistance programs and requiring conservation measures for eligibility in commodity price support programs are two strategies that fall under the general heading of improving USDA program integration and consistency. Economists with ERS and ASCS used 1977 NRI data and ASCS program data to investigate potential erosion reductions stemming from improved USDA program integration (10).

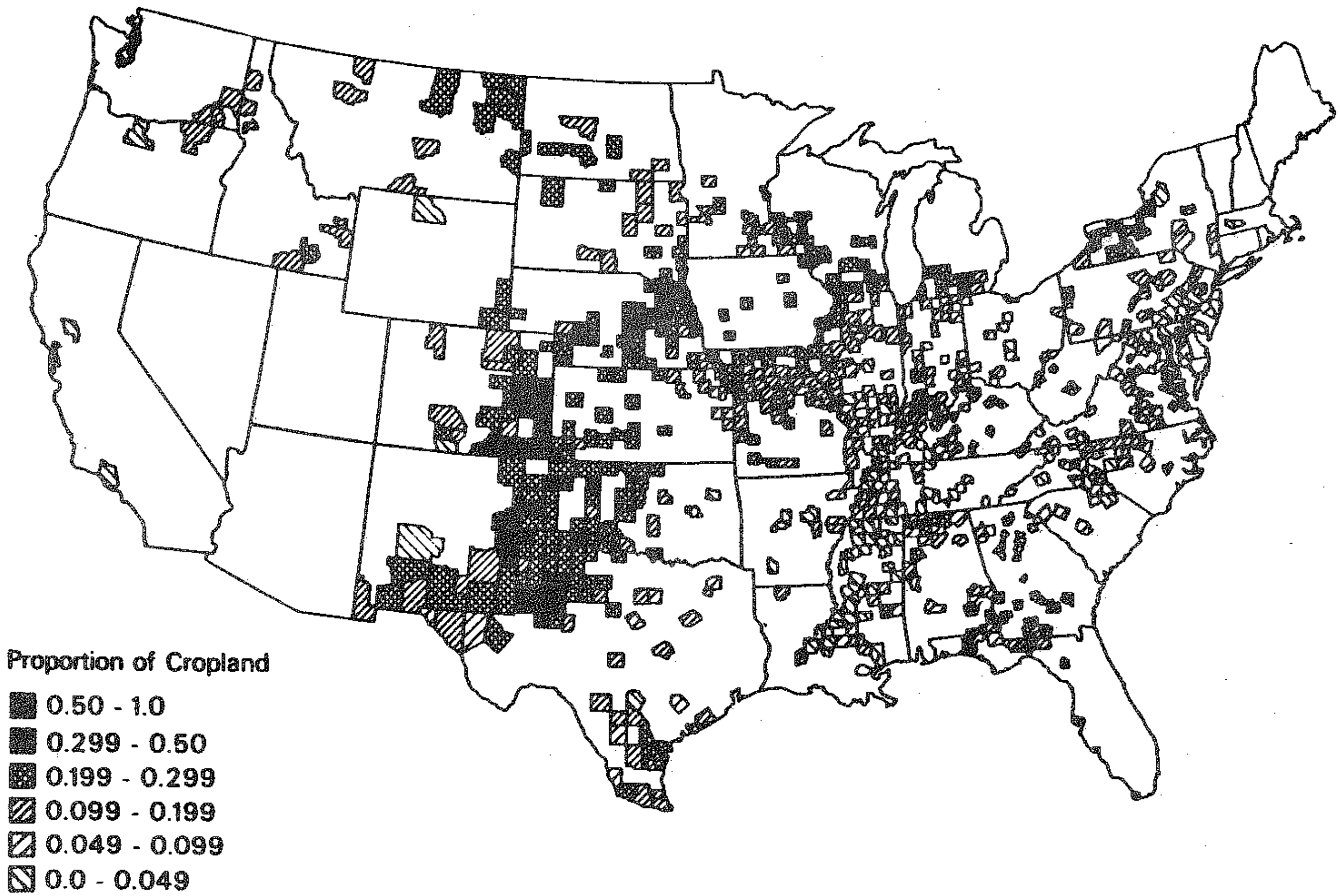
First, tillable acreage in nonerosive (less than 5 tons per acre per year), moderately erosive (5 to 25 tons per acre per year) and critically erosive (more than 25 tons per acre per year) categories for each county was tabulated, and those counties with critically erosive acreage were mapped (Figure 1). Next, participation in ASCS commodity programs was displayed in a similar map for those counties with critically eroding acreage (Figure 2). Comparison of these two maps shows where participation in certain USDA programs offers some leverage on critical erosion problems. Comparison of Figures 1 and 2 suggests that cross-compliance alone may not be effective in controlling critical erosion since much of the worst erosion does not occur in areas with high participation in commodity programs. Several counties in the Mississippi Delta, for example, have more than 30 percent of cropland eroding at critical rates, but none of these counties has more than 10 percent of cropland in ASCS programs. Specific program changes, such as a conservation reserve or a special area cropping system subsidy, may be needed additions to existing commodity programs to achieve program consistency.

Figure 1. Proportion of Cropland Acreages Eroding Over 25 Tons/Acre, 1977.




Source: Ogg, Miller and Clayton (10).

Figure 2. Proprotion of Cropland Participating in ASCS Programs, 1977.[1/]




1/ Data for several counties from Iowa have been lost. Available information indicates southern Iowa has participation rates similar to northern Missouri.

Source: Ogg, Miller and Clayton (10).

A number of recent proposals to achieve program integration were analyzed, as summarized in Table 1, by shifting funds from NRI points in counties with low erosion rates to points in counties with critical erosion rates (1, 10). The marginal cost of erosion reduction on critically eroding acres is lower than on acres with less erosion (13), so larger total reductions can be achieved at the same total cost. A combination of targeting variable cost shares and targeted crop diversions could possibly reduce erosion fourteen times as much as under existing programs at approximately the same annual Federal outlay.

Such an analysis of policy options is a first step in examining program consequences for erosion, farm income, public costs and production patterns. Prior to the development of the NRI data base, prospective analysis of program effects was virtually impossible. Improvement is still needed since program participation data is currently only available at the county level. A planned cropland use evaluation will identify characteristics of participants in various farm programs.

## Land Quality Measures

The next example shows how the basic NRI inventory data can be combined with information on soil characteristics and production economics. In this case, both soil and crop budget information were developed for New York State's use-value farmland assessment program, but Soils Form 5 and FEDS data could have been used as readily (2).

The concept of "prime" farmland, as defined by USDA, arose in response to growing demand for agricultural output and shrinking

Table 1 -- Policy Options for Reducing Erosion and Their Costs

| Option | Source of Funds | Erosion Reduction, million tons per year | Costs[1] | |
|---|---|---|---|---|
| | | | Per ton, dollars[2] | Total, million dollars |
| 1. ACP unchanged | Current | 72 | 2.22 | 159.8 |
| 2. Targeting ACP | 25 percent of funds from nonerosive counties | 100 | 1.60 | 160.0 |
| 3. Targeting ACP with variable cost shares | 25 percent of funds from nonerosive counties plus local nonerosive lands | 135 | 1.18 | 159.3 |
| 4. Targeting ACP cover practices to critically eroding lands | Nonerosive land receiving cover practices | 166 | 0.96 | 159.4 |
| 5. Targeting crop diversions within counties | Commodity programs | 627 | 0.24 | 150.5 |
| 6. Targeting crop diversions among counties | Commodity programs | 874 | 0.18 | 157.3 |
| 7. Regulating critically eroding lands | Farmers and consumers | 874 | 0.00 | 0.0 |
| 8. Targeting ACP, variable cost shares and targeting crop diversions | Number 3 and 6 | 1,008 | 0.15 | 151.2 |

1 Federal outlays only, does not include costs to farmers or consumers.
2 Marginal cost of soil conservation by erosion class based on (13).
Source: Ogg, Miller and Clayton (10).

supplies of suitable agricultural land in the 1970s. The USDA definition of prime farmland has policy implications because it is included in the provisions of the Farmland Protection Policy Act and the Secretary of Agriculture's Statement on Land Use Policy, as well as numerous state development control laws such as Vermont's Act 250. Prime land was inventoried in the 1977 NRI. Economists in ERS, concerned that a purely physical definition of land quality ignored important economic considerations, combined NRI data with crop yield and budget information to assess the economics of crop production on lands which meet the prime farmland definition.

This analysis demonstrates that, although there is a high degree of correspondence between the physical measures of prime farmland and soil productivity, the prime farmland criteria are restrictive enough to exclude substantial acreages of productive New York farmland. The study found that 2.2 million cropland acres in the State rate as superior from the standpoint of net annual returns, but more than one-fifth of this acreage is not classified as prime under USDA definitions (Table 2). Conversely, almost 5.5 million acres of New York cropland produces low net incomes, but just under 1.0 million acres have the physical and chemical properties to classify as prime land. Further analysis with this data base indicates that, after controlling for other variables influencing net income, prime land contributes only about $3 per acre to the average net return on New York cropland (Table 3).

The study concludes that net income and soil productivity data lend considerable support to the notion that the USDA prime farmland

Table 2 -- Expected Productivity and Net Income for Prime and Not Prime New York Cropland[1]

| Net Income[3] | Productivity[2] High Prime | High Not Prime | Low Prime | Low Not Prime |
|---|---|---|---|---|
| | Thousand acres (percent) | | | |
| High | 1,787 (23.3) | 400 (5.2) | 0 (0.0) | 13 (0.2) |
| Low | 816 (10.6) | 1,750 (22.8) | 164 (2.1) | 2,749 (35.8) |
| Total | 2,603 (33.9) | 2,150 (28.0) | 164 (2.1) | 2,762 (36.0) |

1 Includes sample points in crop production and points with high or medium potential for conversion to cropland.
2 Measured as total digestible nutrients (TDN). High productivity is greater than 50 percent of the high TDN production of 4.54 tons per acre.
3 High net income is greater than 50 percent of the high net income of $78.60 per acre.
Source: Bills, Heimlich and Stachowski (2).

Table 3 -- Ordinary Least Squares Regression Estimates of Variables Influencing Net Income, New York

| Variable | Parameter Estimate[1] | Mean |
|---|---|---|
| Net income per acre | dependent variable | 25.78 |
| TDN per acre | 25.83* (.465) | 2.55 |
| TDN per acre on prime farmland | 3.07* (.191) | 1.23 |
| Lime (0,1) | -10.56* (.568) | 0.79 |
| Rotation | 0.70* (.023) | 63.20 |
| Constant term | -79.52 | |
| | $R^2$ = .896 | |

1 Standard errors are in parentheses. Asterisk indicates coefficient is signifcant at 95 percent confidence level. Data are 1,149 NRI sample points.
Source: Bills, Heimlich and Stachowski (2).

designation detracts from qualitative distinctions to be made between cropland resources in New York. Assessments of the State's capacity to sustain the production of agricultural commodities based on the prime farmland definition are distorted accordingly. While only a pilot study, such an analysis can be readily undertaken for the Nation by substituting FEDS budgets and Soils Form 5 yield data for the New York data used in the study. The authors are presently investigating such an extension. The available data permits a good deal of experimentation with alternative definitions of soil quality, each suited to its specific purpose, a degree of flexibility never available in national-level studies before.

## Cropland Supply

The final example is prospective and illustrates how the full range of available data could be brought to bear on a resource issue. Despite current crop surpluses, a long-term concern within USDA is the adequacy of our cropland base to meet future demands for food and fiber. Applying basic micro-economic concepts to the physical and economic data now available can help answer some of the "what if" questions posed by unstable world commodity prices, rising production costs and continuing urbanization and erosion.

The 1977 and 1982 NRI inventories include data on both existing and potential cropland. For each sample point, Soils Form 5 yields and FEDS crop budgets can be combined with expected future prices to estimate net returns to variable and fixed factors of production for an array of alternative crop enterprises. A rational producer would continue to operate only those resources which yield a positive return to fixed and variable inputs (4). With modern computing methods, determination of net returns for each sample point in the Nation over a range of output prices can be accomplished rapidly, delineating the amount of cropland put into production with the technology specified in the crop budgets under the assumed prices. Such estimates could be summarized for subareas within the Nation and would aggregate to a national estimate. Over the longer term, such an analysis could be applied to both cropland and potential cropland, utilizing the results of the proposed land conversion economics survey to add amortized development costs to the fixed production costs.

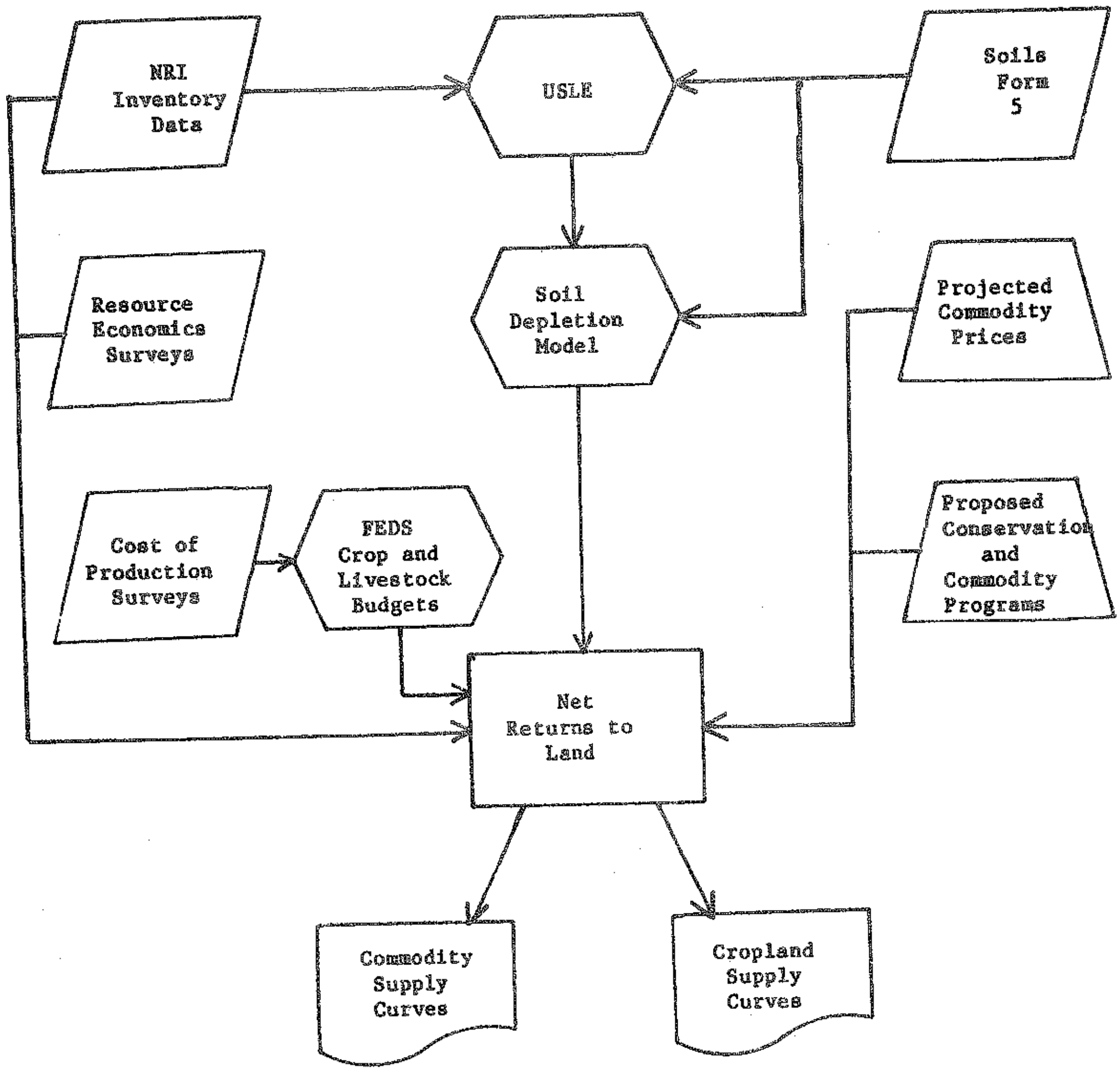
Changes in quality of land resources could be assessed as well as changes in quantity of land by incorporating results from soil depletion estimating procedures. Erosion rates associated with crop practices at each point could be applied to productivity depletion curves estimated from soil properties recorded in the Soils Form 5 record corresponding to the soil at each point (11).

Such a process, shown diagrammatically in Figure 3, combines detailed information on the physical availability of land resources with an equally detailed assessment of the economic feasibility of resource utilization. It would provide information on the amount and geographic distribution of expected resource use and an estimate of erosion consequences of that pattern of use.

## Conclusions

It is easy to underrate the significance of the information sources now available for research and policy analysts. The data is

**Figure 3 -- System Components and Data Flow for Cropland Supply Response Analysis**



collected by a number of organizational units within several agencies, by specialists from diverse disciplines, for a variety of purposes. Until recently, there was little effort to coordinate or integrate these data collection efforts within USDA or unify the information mandates of Congress. Neither policymakers nor researchers have much experience in using such disaggregated data to examine national resource issues and may couch their analytical needs and plans in aggregate terms that ignore or mask the richness of detail now available.

We are confident, however, that the opportunities for detailed, comprehensive, consistent analyses done rapidly and cheaply from widely accepted data sources will prove irresistible. Agencies strive to coordinate collection efforts because the increased power of additive data bases will compensate for the occasional frustration of working across disciplines and agencies. Researchers revise and adopt tools better suited to the newly available data because doing so sheds light on areas never satisfactorily addressed before. Policymakers refine their research requests and policy proposals because the clarity and precision achieved yields better appreciation of problem causes and consequences and more effective solutions.

Above all, it is important, both for those who collect the data and those who use the data, to appreciate the evolutionary path traveled up to now by geographic data bases in USDA so that future needs and means can be anticipated and provided for.

# REFERENCES CITED


1. Batie, Sandra S. June 22, 1983. "Towards the Next Generation of Farm Policy." Hearings before the Joint Economic Committee, Agricultural Subcommittee on Conservation/Soil Erosion.
2. Bills, N.L., R.E. Heimlich and S. Stachowski. 1983. "Prime Farmland: A Pilot Study." Submitted to American Journal of Agricultural Economics.
3. Goebel, J.J. and K.O. Schmude. 1980. Statistically Designed Resource Inventories Conducted by the Soil Conservation Service. Statistical Laboratory, Iowa State University, Ames, Iowa.
4. Henderson, J.M. and R.E. Quandt. 1980. Micro-economic Theory. Third edition. McGraw-Hill, New York.
5. Hilliard, R.L. 1977. "The New York Erosion and Sediment Inventory." in Soil Erosion: Prediction and Control. Special publication No. 21, Soil Conservation Society of America, Ankeny, Iowa.
6. Inman, B. and W. Fippin. 1949. Farm Land Ownership in the U.S. Miscellaneous publication 699, USDA, Bureau of Agricultural Economics, Washington, D.C.
7. Krenz, R.D. 1975. "The USDA-ERS Firm Enterprise Data System: Capabilities and Applications." Southern J. of Agricultural Economics, 7(1): 33-38.
8. Lewis, J.A. 1980. Landownership in the U.S. USDA-ESCS Agricultural Information Bulletin, Washington, D.C.

9. Ogg, C.W., R.E. Heimlich and J.E. Hostetler. 1980. "A Modeling Approach to Making Watershed Conservation Plans." Journal of Soil and Water Conservation, 35(6): 271-274.

10. Ogg, C.W., A.B. Miller and K.C. Clayton. 1982. "Agricultural Program Integration to Achieve Soil Conservation." Submitted to American Journal of Agricultural Economics.

11. Pierce, F.J., W.E. Larson, R.H. Dowdy and W.A.P. Graham. 1983. "Productivity of Soils: Assessing Long-term Changes Due to Erosion." Journal of Soil and Water Conservation, 38(1): 39-45.

12. U.S. Department of Agriculture. 1980. Summary of Appraisal, Parts I and II and Program Report, Resources Conservation Appraisal. Washington, D.C.

13. U.S. Department of Agriculture. 1980. National Summary Evaluation of the Agricultural Conservation Program: Phase I. Washington, D.C.

14. Wischmeier, W.H. and D.D. Smith. 1978. Predicting Rainfall Erosion Losses, A Guide to Conservation Planning. Agr. Handbook 537, USDA-SEA, Washington, D.C.