Analytic Took and Data Bases for Determining the Effects of National Policies on Land productivity

0TA's analysis indicates that one pressing short-term need is to develop mathematical models that can estimate the effects of Federal, State, and local policies on land productivity. Knowing the probable impacts of education programs, cost-sharing, tax incentives, subsidies, regulations, and other measures could help the Nation shape effective policies to check cropland and rangeland degradation.

Mathematical models provide a documentable, explicit, and replicable method to analyze the effects of an act ion or series of actions on a complex system. Models use equations to represent relationships among components of an agricultural system. They reduce system to their most important elements and estimate how changes in one or more components of the system will affect other components. Models can be particularly useful to compare the expected effects of different policy options.

The alternative to model-based analysis is intuit ion-the use of mental models. Even though mathematical models often appear bewilderingly complex, mental models can be equally [or more) complex. Mental models cannot, however, be as explicit nor can they be replicated by other analysts.

Mathmetical models cannot replace the judgment of experienced people. They also cannot analyze cause-effect relationships that cannot be quantified. For an individual farm or ranch, the operator's mental model may predict more accurately than a mathematical model. However, when numerous de-(csionrnakers are involved, as is the case with policymaking and program administration, it becomes difficult to rely on mental models. Mental models of complex systems can seldom be as explicit *or* objective as mathematical models, and so are less valuable tools for policy makers.

Different mental models are difficult or impossible to compare. Thus when policymaking is based on mental models of complex interactions, as is the case with most current agricultural policy, the ideas championed by the more articulate or more powerful analyst are likely to prevail, whether or not they are the most accurate, M a the matical models on the other hand, can undergo rigorous testing for internal consistency and for consistency with historical data. Further, different models can be compared.

Two major model types are used to analyze agricultural policy: *econometric models* and systems *simulation models.* Econometric models are based on widely accepted principles of economic behavior—for instance, that individuals. firms, and industrial sectors will continue to increase their use of an input until the cost of purchasing it equals the price received for the output it produces. These models have been developed extensively. Many are mathematically complex and costly to run, Because they are based primarily on economic analysis, they typically are used to describe one-way, cause-effect relationships, or "open" systems, but economic models can be designed to account for some feedbacks.

Econometric models generally arc quite sensitive to errors in the data used in their equations. Their strength lies in their ability to consider the economic basis of behaviors at many levels, from individual producers to that of the national economy. Such models can break down, or "disaggregate, ' their anaIysis to account for differences in variables such as soil types, farm operations, and local economies, and then reintegrate the outcomes to National, State, or regional levels.

Systems simulation models are valuable primarily for their breadth and integrative capabilities. These models are well suited to analyze nonmonetary benefits and costs, including changes in qualities such as wildlife habitat quality, water quality or changes in plant genetic resources. They generally are not used for detailed analysis of the economic implications of actions or policies.

Systems simulations have one particular advantage for studying land productivity. Changes in the behavior of a system can be simulated using "feedback loops"-a mechanism that relates changes in the cause-effect variablcs of a system to changes in the system's underlying modes of behavior. Feedback loops are useful to reflect, for example, that both soil enhancement and soil degradation are processes in which this year's change causes a greater change next year. A positive feedback loop can model the concept that erosion is a self-perpetuating process—i.e., that continuing erosion makes topsoil increasingly erodible. * Conversely, a negative feedback loop will describe the stabilizing effects of land conservation practices.

Just as no single farming technology can solve all conservation-related problems, no single modeling technique can provide all the information necessary for policy analysis. But they can provide decision-makers with valuable guidance. Systems and econometric models have different capabilities and their results need to be linked to provide comprehensive information on questions relating to land productivity and policy. Because individual universities tend to specialize in developing and advancing one particular modeling approach, attempts to combine the strengths of different modeling methods have been limited.

Necessary Elements for a Poiicy Analysis Model

A model capable of assessing the effects of agricultural technologies on land productivity must include the following elements:

- *Representation of the Natural System,* The major physical, chemical, and biological processes must be represented and causally linked. It is not sufficient to represent erosion rates alone. Mechanisms to show both increasing and decreasing productivity must be included to determine the sustained land productivity level for any technology mix.
- *Explicit Linkage of Technologies to Natural System Elements.* At whatever level of detail a policy study is made, the direction and magnitude of the effect of each class of technology must be identified.
- *The Macroeconomics of Technology Choice.* The economics of an operator's technology choice, which determine the magnitude of use and the economic conditions under which the technology may tend to proliferate, must be analyzed. The analysis should not presume that perfect, unbiased information is available to farmers.
- *The Interaction of the Technology and Changing Social Values.* Changes in farmers' planning horizons, * how such changes affect technology choice, and the relationship between planning horizons and social and economic trends must be included.

In addition to these elements, some additional characteristics of a useful policy decision model include:

- The planning horizon of the model must be at least a generation to register significant trends in soil productivity and long-term social and economic consequences.
- Any formal model should explicitly portray the important feedback effects occurring throughout the system.
- A useful, understandable model for national policy analysis must necessarily be aggregate, testing generic types of technologies and policies. For implementation purposes, it may be necessary to examine policies at the regional level. The high degree of variation even within regions means that "representative" data sets would likely have to be constructed.

State of the Art of Mathematical Models

Iowa State University Linear Programing Model

The most advanced of the current agricultural policy models is the Iowa State University Linear Programing (ISU-LP) Model. The model projects factor* * demands, crop and livestock output, farm income, and some environmental effects for 105 producing areas, 28 market regions, and 8 major zones in the United States. Designed to minimize the cost of crop and livestock production, model projections are based on estimates of total demand, subject to such constraints as crop rotation requirements, limitations on water supply, and conservation practices.

*The soil erosion "feedback" loop is often overlooked in analyses of the economics of erosion, but its significance may be great. For example, 30 inches of topsoil would take 450 years to erode completely away if net erosion were a steady l/l5th inch per year. However, it would take only 171 years if the net erosion rate is l\15 inch/year at the beginning of the analysis and each year's rate is just 1 percent greater than the preceding year's If the rate of increase were 10 percent a year, the 30 inches of soil would last only 40 years.

* Planning horizon—A farmer's planning horizon is the length of time he considers when making an investment of his capital, labor, or land resources, It may be as short as one crop season or as long as his children's lifetimes. The term includes the concept of discounted value that the farmer places on future income or future costs compared to present income or costs. The terms "planning period, " "payback period, " and "time horizon" are often used interchangeably with "planning horizon, "

* * Factor: A good or service used in the process of production, thus factor demand is the demand for an input to production.

The model's chief environmental projection is to estimate the erosion resulting from a given crop rotation, management practice, and geographical setting, as calculated by the universal soil loss equation. The model can test the cost of a given conservation policy and will calculate resulting shifts in such things as crop patterns, factor inputs, and transportation requirements.

U.S. Department of Agriculture (USDA) analysts chose the IS U-LP Model to provide information about future resource needs in the congressionally mandated RCA report (USDA-RCA, 1980). The report was produced in response to provisions in the Soil and Water Resources Conservation Act of 1977 (RCA), directing the Secretary of Agriculture to carry out a continuing appraisal of the soil, water, and related resources of the Nation.

Yield/Soil Loss Simulator

In order to expand the capabilities of the ISU-LP Model for dealing with causes and consequences of changes in land productivity, a USDA team developed an additional model-the Yield / Soil Loss Simulator (Y / SL)-specifically for the RCA analysis. The Y / SL model permitted USDA analysts to forecast changes in crop yield resulting from soil losses associated with various cropping and management practices. The model calculated effects of water erosion and conservation practices on soil depth and linked expected future yields to rates of change in soil depth.

The resulting analyses for the RCA report are the best and most comprehensive available; still, they fall short of the goal set by Congress for USDA's appraisal of the agricultural resource base. Substantial questions have been raised about the accuracy of the Y / SL modeI's characterization of the relationship between soil depth and yield (Benbrook, 1980). Effects on productivity such as changes in soil texture and water-holding capacity are not accounted for, nor can they be incorporated into the model with existing data. Comparisons of Y / SL estimated crop yield reductions per inch of eroded soil with actual studies show Y / SL loss estimates to be relatively conservative.

The ISU-LP Model, as supplemented by Y / SL, is the most complete representation of technological impacts on productivity available. However, it does not analyze the dynamics of natural soil systems nor the effects of technologies on the components of intrinsic productivity. It cannot account adequately for causal interactions among: 1) factors besides soil depth that comprise land productivity, 2) processes besides water erosion that cause changes in productivity, 3) technologies besides conservation practices that increase or decrease rates of change in productivity, 4) farmers' decisions regarding choice and implementaton of technologies, 5) social and economic factors that influence the farmers' planning horizons and the technology choice options, and 6) Government programs that affect, directly or indirectly, farmers' decisions (USDA-RCA, 1980; Benbrook, 1980; Picardi, 1981).

Efforts are under way at USDA and Iowa State University to develop more comprehensive research tools for assessing soil productivity. Recognition of the inadequacies in the Y / SL. approach has spurred the development of other models to deal with a wider variety of soil productivity processes. However, such models are primarily research tools and are probably too complex to aid in policy development. Although improvements to the Y / SL model have been suggested, the model seems to have been shelved and no substitute policy analysis tool is being developed at USDA (Benbrook, *1981).*

Phonological Models

Recently UDSA'S Science and Education Administration's Wheat Yield Group began designing a series of "phonological models" that simulate the dynamics of plant (crop) growth and how this is affected by physical and biological processes and the environment [Dyke, 1980). The models will analyze the effects of runoff, soil texture, organic matter, nutrient cycles, infiltration, and residue decomposition. No soil biota analysis is planned. In this modeling approach, agricultural technologies will be linked to the specific process that they affect instead of merely correlated with yield. The models will be crop- and soil-specific and have a 50- to 100-year" planning horizon to simulate long-term productivity changes. The models for sorghum and wheat are already operational.

This approach will be better able to capture the feedback dynamics of the natural system including nutrient cycles and organic matter dynamics. These models are intended to be linked to the ISU-LP model. If successfully merged, they will provide important feedback simulation that has been missing from the present ISU-LP structure.

A disadvantage of the phonological model is that, even though they deal only with natural systems, they are extremely complex, with over 400 subroutines, and they can only deal with one crop and one location at a time. The models are research tools more than policy analysis programs (Picardi, 1981).

However, scientists working with the phonological models hope to have them sufficiently complete by 1985 to be useful for drafting the 1985 Resources Conservation Act report.

Current Developments and Future Needs

The Center for Agricultural and Rural Development (CARD) at Iowa State University is rapidly moving to develop linked econometric and simulation models. One recently completed model estimates farmer and consumer reaction vis-a-vis such factors as changes in land and water use, production, conservation, and erosion. Estimates are provided by region and specific location, and **can** account for interregional interactions. Another model under development for the International Institute of Applied Systems Analysis relates crop production systems, conservation practices, tillage methods, etc., to livestock systems, soil loss, and yield and productivity changes over time. The model is intended to trace the effects of erosion and / or technology on yield over time.

Both academic institutions and USDA are focusing on complex, scientifically advanced modeling. This approach is likely to further the state of knowledge about the underlying processes involved in land productivity. However, the policy analysis needs of Congress and program administrators are not being met by these efforts. Two needs require particular attention:

1. Models that relate land productivity to factors beyond crop yields—i.e., benefits such as genetic diversity of resident plant species, wildlife habitat, and water quality effects. Losses in these areas have major long-term economic implications for agriculture, recreation, and human health but cannot be reliably quantified with existing techniques.
2. Quick, inexpensive models to estimate national effects of resource policy decisions that have a simple structure and clear documentation and are readily understandable not only by economists, but also by analysts trained in other disciplines. (Without this clarity, a mathematical policy model is no more explicit to most policy analysts than is a mental model.) Current models deal with regional and subregional variation but often sacrifice ease of use and cost-efficiency for richness of detail. Congressional scrutiny of alternative policy initiatives could be enhanced if models were available that focus directly on Federal program capabilities to enhance or degrade soil productivity,

Data Availability and Requirements for Further Model Development

To develop policy models, two kinds of data are needed: 1) causal interaction information describing how each element of a system affects each other element, and 2) time-series descriptive data about important variables—e.g., changes over time in levels of soil organic matter or levels of application for various technologies. Generally, to be usable in national policy models, data must also: 1) be in the form of electronically readable data sets, having national coverage, 2) have been collected in a consistent fashion or selected according to a consistent set of criteria, and 3) contain information usable for assessing technological impacts on soil productivity.

Table D-1 describes 12 major data sets that meet the latter three criteria. The sets are representative of available data but do not comprise a complete list. Although other sets contain useful data–e.g., on specific technologies, specific crops, national weather data, or regional water inventories—it is fairly certain that none is significantly better suited for assessing productivity than those listed in table D-1. The table describes the type of data included in the set but does not catalog all the information included.

The Soil Conservation Service (SCS) performs soil surveys containing a wealth of information on soil classes, subclasses, and series, and provides chemical, physical, and land-use information for 12,000 different soil types, Soil surveys have classified and located soils for 65 percent of the counties in the United States. Much of the descriptive information on soil classes has been computerized in the "Soils V" data base (table D-1, #l O); however, "Soil V" does not include geographic location data (USDA, 1979).

Geographic area and soil type can be linked through the two data sets: The Agricultural Research and Inventory Surveys through Areal Remote Sensing (AgRISTARS) (table D-1, #12), and the National Pedon Data System (table D-1, #6). AgRISTARS contains data on the most representative soil type in 25-mile squares for a national grid, whereas the National Pedon Data System inventories all the soils that are received by the National Soils Survey Lab in Lincoln, Nebr. Efforts are being made to coordinate the two systems by selecting the most representative soil type in each county for analysis and inclusion in the National Pedon Data System. When they are completed, these data sets are expected to serve as general resource bases for research purposes.

Table D-l.—Characteristics of Various Agricultural Data Sets Related to Soil Productivity

Data set	Date	Author	Location	Electronic	Public	FIPS[a] code	Policy models	Aggregation	Data
1 Conservation Needs Inventory (CNI)	1967"	Soil Conservation Service (Scs)	D C	Yes		Yes	None	County	Land class, present use, slope management factor, and irrigation
2 Potential Cropland Study	1977	SCS	D C	Yes	Yes	Yes	National Agricultural Lands Study (NALS)	Primary sampling unit	Potential arable cropland, present use, potential for reconversion to cropland, Universal Soil Loss Equa. tion parameters, soil and water problems
3 National Resources Inventory (N RI)	1977, 1982, ongoing	SCS	D C	Yes		Yes	NALS, RCA, lowa LP	Major land resource area	R-factor, slope, length, present use, soil class, conservation practice, treatment needs potential cropland, erodability, type irriaga-tlon, ownership, crop management, dominant problems, and associated water bodies
4 Crop Consumptive irrigation Requirements	1976	SCS	D C	Yes	Yes, public access via extension	No	Used–in ISU. LP	Crop specific in each county	Irrigation requirements net of rainfall for each crop in each county
5 Agricultural Census, OBERS	1974, 1978, 1982 every four years	Department of Commerce (DOC), ESS of DOA	D C	Yes	Limited distrtbution for labor statistics ESS data public	Yes	Inputs to NIRAP model	Water Resource Council Regions	Farm Income, production, value of farm, outputs, factor Inputs, land cropped, ırrigated land, tenure and employment
6 National Pedon Data System	Ongoing	National Soils Survey Lab, DOA	Lincoln, Nebr	Yes	Yes	Yes	None specifically	Site. specific with geographic coordina-tion	Site description slope, drainage, cul-tural uses, 7 horizon files, physical and chemical lab tests, mineralogy data, some engineering data, CIOS. est weather station, cl I mate data Most representative soils in each country being coded first
7 Yield/Soil Loss Simulator data (Y/SL)	1980	DOA SEA	D C	Yes	Yes	Yes	Yield;soil Loss Simulator Model, SEA	Soil mapping unit	240,000 observations, variety of crops, texture, slope, class, country, SCS yield, and normalized yield
8 Crop Reporting Board	Yearly	Economics &" Statistics Service, DOA	D C	Yes	Yes	Yes	Yearly crop yield projections	County	Yield data for all major crops, and factor Inputs
9 Phenological Model Data	Being devel. oped	SEA of DOA	Temple, Tex	Yes	Yes	Yes	Input to Iowa State LP model	Crop and soil type specific	Physical, chemical and botanical data relating technologies to yields, hydrology and soil class to erosion and productiviity
10 Soils v	Ongoing	SCS	D C	Series. yes Maps-no	"Yes	No	Yield/Sol~ Loss	No geographic reference	12,000 soil series records, cultural data on use suiability survey maps show soil types for loca. tions, 65 percent of country classi-fied, yield and performance ratings, cost of restoration Soil survey information such as slope, texture, capability class, use, erosion phase, and irrtgation practice
11 National Woodland Data System, Range Data System	Ongoing	SCS	Fort Collins, Colo	Yes	7	Not yet	None yet	Site specific	Growth rates of trees on specific kinds of soil for over 20,000 sites, range data system contains forage production and species composition
12 Agricultural Research and Inventory Surveys through Areal Remote Sensing, AgRISTARS	On-going	DOA SEA	Temple, Tex	Yes	Yes	Yes	Pheno. logical models	25x25 mile grid	Information on the most representa tive Soil Series in **each 25. mile** square for a National grid, soil survey i n format ton, land use, culti. vation practice, location of nearest **weather station**

a*FIPS Federal Information* processing standard code, which allows users to label data entries consistently among all Government agencies

SOURCE Off Ice of Technology Assessment

Available land inventory surveys include the Conservation Needs Inventory (1958, 1967), the Potential Croplands Interim Study (USDA, 1977), and the National Resource Inventory (NRI), which began in 1977 and will continue periodically (USDA, ESCS, 1980).

These surveys use sampling techniques to select sites for rigorous observation by SCS personnel of existing land use, crops, irrigation, soil type, potential for reconversion to cropland from nonagricultural uses, erosion status, and needed conservation practices, Each successive inventory has become more intensive, covering a wider range of land-related concerns, and less extensive, directly surveying a smaller fraction of the land base. The data from the 1967 Conservation Needs Inventory and the 1977 NRI were used to calculate sheet and rill erosion rates for each sampled point, and these calculated rates were aggregated to indicate regional erosion rates. The 1967 sampling procedure was seriously flawed, however, and its erosion rate figures are grossly different from the 1977 figures. (For instance, the national average erosion rate from the 1967 survey is nearly twice the rate from the 1977 survey.) Thus, no time-series data are available for trend analysis. The 1982 NRI should provide the first time-series data on a national scale.

The soil surveys and national inventories provide the following kinds of information required for assessing soil productivity:

- soil type, including organic matter content and nutrients available;
- yields and crop patterns that would allow weighted average yields;
- information necessary for calculating sheet and rill erosion;
- present technology inputs recognized as conservation or irrigation practices (but not actual water application rates);
- land-use conversion rates and information relating to some of the social and economic forces affecting planning horizons and the profitability of farming;
- information about erosion problems, ownership, type of restorative treatment needed, and irrigation practices; and
- indices that allow data to be aggregated at various geographic levels.

County-specific data on yield and economic parameters are collected and computerized annually by the Crop Reporting Board at the Economics and Statistics Service (ESS) of USDA and periodically by the Department of Commerce via the Agricultural Census. Relevant types of data available from these sources include:

- yields, prices, and the values of all factor inputs in the agricultural sector for deriving marginal values of products; and
- ESS forecasts of expected prices and factor costs for estimating expected profitability.

SCS maintains a data base on crop consumptive water needs which, in conjunction with climatological data (available from the National Oceanic and Atmospheric Administration) can be used to estimate irrigation requirements. This file contains no information on actual water consumed. Moreover, no uniform nationally compiled information system on irrigation water application rates exists (Lehr, 1980), This SCS data base does include estimates of irrigation needs that could aid in determining ground water extraction rates.

Data developed to estimate coefficients for the Y/SL have been stored as an independent data set, although all of the data can be found in previously mentioned sources. Information on erosion rates, management practices, and yields is included, but these data do not appear sufficient for a causally structured model, since causal models specify that erosion rates result from changes in chemical, physical, and biological properties as well as from management practices (Hagen and Dyke, 1980).

The National Woodlands Data System quantifies production or yield response to soil type for a wide range of forest and forage species. This type of data may be used to develop yield equations for models.

The Production Records/Range Data System (RDS) is a plant materials data system with over 3,000 entries for rangelands of the Western and Southeastern United States. Most information is identified with range sites, soil series, and land capability classes to the State level. The system also records production as influenced by climate, elevation, and condition class. This information is to be computerized by 1985. It is expected to be very useful for management decisions; whether it will prove useful for a policy model of rangelands is not clear yet.

Finally, the Agricultural Research Service of USDA is developing a data base to use with the crop-specific phonological simulation models, For each major soil class and crop rotation, information modules are to be developed to simulate crop growth, soil runoff, soil texture, organic matter, nutrient levels, water infiltration, and residue decomposition. This data set will thus be the only computerized file that relates yields to soil productivity and, in turn, relates productivity to the physical, chemical, and biological processes at work. Data useful to assess land productivity will be:

- the physical, biological, or chemical impacts of a specific technology on the natural system;
- the causal mechanisms underlying erosion, organic matter accumulation, and decomposition;
- the dynamics of the nitrogen and phosphorus nutrient cycles; and
- the linkage between the natural system and runoff, which is necessary to estimate pollution loads in streams and ground water recharge.

Other relevant data sets not described here include the Soil Vegetation Inventory Method of the Bureau of Land Management; the Plant Information Network, covering Colorado, Montana, Wyoming, and North Dakota; Run Wild, covering wildlife and vegetation for Arizona and New Mexico; the Forest-Range Environment Study, containing data on forest and rangeland resources, and the National Water Data Exchange index of water-related data sets.

Missing Data

In summary, a number of national, accessible electronic data sets are available. These data sets provide some of the qualitative or quantitative information necessary for determining:

- long-term land-use change rates;
- levels of factor input use; and
- some causal factors affecting determinants of productivity such as erosion and the level of organic matter.

This data is largely descriptive, however. It should be possible to use data from the ESS Crop *Reporting* Board to estimate time-series information such as levels of factor inputs and yields. Erosion time-series data and other information from the various land inventories might be developed, although this could be a difficult task. Data are lacking for a number of important areas:

- Data on soil formation rates. Information is needed on both the rates at which the top layer of soil is enriched to become what is called "topsoil" and on the rates at which parent materials form subsoils to be able to assess long-term effects of wind and erosion.
- Data on soil fauna and flora. Biological organisms are significantly linked to rates of decomposition, tilth formation, and nitrogen fixation,
- Data on water withdrawals from aquifers. In addition, the causal linkages between chemical application and aquifer pollution have yet to be developed and organized in a way useful for policy analysis.
- Data on the socioeconomic determinants of: 1) ground water use for irrigation, and 2) reversion to dryland farming or abandonment when farmers are faced with the combined effects of water costs, pollution, subsidence, and salinization.
- Data on the links between farm profitability and farmers' planning horizons, on how these and other social factors combine to change factor inputs, and whether such changes will accelerate or slow changes in profitability.
- Data on how farmers perceive and value long-term effects of technology use on productivity.
- Data on the extent to which short-term input decisions result from social, ecological, health, and other "noneconomic" concerns.
- Data on inherent land productivity by area in the United States and on the role of inherent land productivity in total factor yields.
- Data on the cause-effect interactions between vegetative systems and the ground water system. Some individual linkages may be quantified, such as the effect of water on yields, but no information exists on important links such as how deteriorating water quality affects yields, or on how crop or range cover affects ground water recharge. Local hydrological cycles are only beginning to be modeled in sufficient detail to permit assessments of the systemwide effects of aquifer pollution and overdraft (Vanlier, 1980; Lehr, 1980).

Causal data exist on physical-chemical soil relationships for specific soils in specific regions, but it needs to be organized, standardized, and assessed in order to give reasonably accurate estimates of cause-effect dynamics for an aggregated policy model. The USDA wheat yield group at Temple, Tex., is involved in such data development for its phonological models. For actual productivity and for rates of soil formation, however, many necessary scientific experiments have yet to be done, In the area of economic decisionmaking, there is an almost total lack of data on how farmers perceive productivity y and what this means for their decisionmaking. Information is also lacking on the role of productivity in long-term decisionmaking regarding the conversion of productive cropland to other uses.

The quantitative extent to which inherent land productivity has been changing is unknown. Although it is known that productivity declines are strongly correlated with relatively high erosion rates, less is known about system changes that result in enhanced productivity.

Because of missing data in the above areas, the models that can be developed to test agricultural technologies will be incomplete, Data gaps should not, however, be used as a rationale for reducing modeling efforts. Present information is sufficient to allow models to improve current policy decision processes substantially and to facilitate the integration of production-oriented policies and programs with conservation-oriented policies and programs. Further, models can be used to identify the relative importance of missing or inadequate data to policy-related information needs. This analysis can improve the cost-effectiveness of resource inventory efforts, allowing agencies to direct data-collection resources toward the data most needed for policymaking.

Mathematical models may eventually be developed to understand various influences on inherent land productivity. Such models would also need to incorporate other elements to examine total agricultural production. Until that time, national agricultural research priorities will be set mainly from the mental models of agricultural scientists and policy experts.

In February 1981 natural resources and agricultural scientists convened a national workshop to determine research priorities for the Nation. The list of priorities that was developed is described in a publication from the Soil Science Society of America (Larson, et al., 1981). The workshop did not rank the priorities, but organized them according to subject, Areas included: sustaining soil productivity, developing conservation technology, managing water in stressed environments, protecting water quality, improving and implementing conservation policy, and assessing soil and water resources.

This OTA assessment cannot improve on the priorities identified by the more than 100 technical and policy experts who participated in that workshop. However, for the policymaking needs of Congress, OTA concludes that two of the data gaps are critically important: soil-loss tolerance and social and economic factors affecting the implementation of productivity-sustaining technologies,

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