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SOIL EROSION - SOIL PRODUCTIVITY:

A LOOK TO THE FUTURE

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Erosion and Soil Productivity

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SOIL EROSION - SOIL PRODUCTIVITY:

A LOOK TO THE FUTURE

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History has shown that disregard for the future effects of soil erosion on productivity has resulted in disastrous consequences for many nations. Great empires fell, millions perished, and land productivity was irrecoverably lost (Bennett, 1939; Lowdermilk, 1948). Could the same fate befall our nation and our world as a whole, or do we now have the technology to overcome any abuses to our soil and related resources? Our future and the future of our descendants are at stake (see Resources for the Future, 1984), so these matters are of crucial importance.

In his thought-provoking book for the Worldwatch Institute, Building a Sustainable Society, Lester Brown (1981) contends that civilization cannot survive the continuing wholesale loss of topsoil, with its associated impact on food production. Other experts agree that soil erosion will intensify future food problems, and some foresee an international food crisis that will make other past resource crises seem minor. The recent famine in eastern Africa, exacerbated by past land abuses and the resultant desertification, grimly illustrates the cruel consequences of disregard for proper soil management. Certainly, consideration of the effect of soil erosion on productivity at this Symposium was not only appropriate, but vital.

This Symposium differed from others because its focus was on the technical aspects of our theme rather than the policy aspects, dominant as the latter often seem. A wealth of information was presented and is published in this proceedings. We need to heed these reports and build on them to assure that our nation and the world as a whole will have a future that is safe, abundant, and healthy for all humanity.

The task of looking toward the future in the area of this subject, as in any area, is quite a challenge. However, to the best of our ability, we explore the current status of knowledge about the effects of soil erosion on productivity, identify those matters that merit increased attention, acknowledge related issues that may affect future technology on this topic, and speculate on how and why our efforts will have an important impact.

CURRENT KNOWLEDGE AND EFFORTS TO QUANTIFY THE EFFECT OF SOIL EROSION ON PRODUCTIVITY

The effect of soil erosion on productivity has long been recognized as a problem in agricultural production (Nat'l SE/SP Planning Comm., 1981). From the 1930s through the early 1950s, crop yield experiments on land with variable past erosion were an important part of soil conservation research.

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However, that early research involved crop varieties, fertility practices, tillage operations, and pest control methods that differed from those used today. Furthermore, research techniques that were used made it difficult to extrapolate results to conditions different from those of the studies.

Nevertheless, the results were so conclusive that most erosion research then shifted to measurements of erosion rates for different conditions and to development of erosion-control practices. Only during recent years has research in this area reemerged, primarily because of Public Law 95-192, the Soil and Water Resources Conservation Act of 1977 (RCA). RCA gave special emphasis to the need for better quantifying erosion-induced productivity losses, their economic consequences for modern agriculture, and their short- and long-term impacts on our nation's ability to produce food, fiber, and feed.

RCA specified that USDA make an appraisal of our nation's soil and water resources on private lands every 5 years. For the initial RCA appraisal in 1980, an empirical crop yield - soil loss relationship based on statistical data was used (Hagen and Dyke, 1980). This first attempt to develop a nationally applicable mathematical model sparked great interest in improving the crop yield - soil loss relationship. A workshop of federal agency personnel was held in Washington, D. C. during February 1980, and a research planning committee was appointed soon thereafter. As one of their first efforts, this National Soil Erosion - Soil Productivity Research Planning Committee (1981) reported the status of knowledge and activity concerning the effect of erosion on productivity at the start of this decade. That report summarized past studies, referenced most pertinent literature, and described ongoing and needed research.

To respond to research needed for implementing RCA, the Agricultural Research Service initiated a coordination effort with personnel of the Economic Research Service, Soil Conservation Service, various state agricultural experiment stations, and other interested agencies. It began with a planning workshop at Lafayette, IN in September 1981. Research planning was divided into four thrust areas: (1) mechanics of wind and water erosion (to better understand and describe the causative problem), (2) erosion/productivity experimentation (to experimentally investigate the relationships), (3) erosion/productivity modeling (to develop improved means of expressing the relationship mathematically), and (4) conservation tillage technology (to improve this farming methodology because of its perceived potential to maintain productivity while controlling erosion). Tasks were defined, scientists were identified to work on the tasks individually or as teams, and deadlines were set. Details of this 1981 workshop are contained in a mimeographed report, and a updated progress report was prepared in May 1983[1]. This planning effort was undertaken to foster cohesiveness and completeness of the research while attempting to keep all participants aware of work planned by others and approaches being taken. Many of the reports at this Symposium described research by persons participating in the 1981 workshop.

In March 1983, the American Society of Agronomy (ASA) sponsored the Soil Erosion and Crop Productivity Symposium in Denver, CO. That symposium provided an overview of the relationship between soil erosion, crop production and other relevant issues related to maintaining high-yielding agricultural lands. Speakers presented a historical perspective on erosion research, methods for erosion control, and discussions of soil productivity as well as the issues associated with public policy and economics. Seven papers addressed regional problems associated with erosion and productivity. These presentations will be published by ASA in mid 1985 as the book, Soil

[1]Both available from K. G. Kenard, USDA-ARS, Southwest Rangeland Watershed Research Center, 2000 E. Allen Road, Tucson, AZ 85719.

Erosion and Crop Productivity. ASA also held a special session on the effect of erosion on productivity at its 1983 Annual Meeting in Washington, D. C. Many of the reports given at such meetings are published in professional journals such as the Soil Science Society of America Journal, Transactions of the American Society of Agricultural Engineers, and Journal of Soil and Water Conservation.

Conservation tillage technology has been the focus of many past meetings including a recent conference on soil microbiology in Seattle, WA during March 1984 that dealt with microbiological problems encountered in conservation tillage cropping systems.[2] Another conference, "Conservation Tillage — Strategies for the Future" was held in Nashville, TN during October 1984 to discuss key issues and implications of this conservation practice. Many reports about conservation tillage are published in professional journals, including a special issue on this topic in the May-June 1983 Journal of Soil and Water Conservation.

Several regional research committees, made up primarily of scientists at land-grant universities, are pursuing research on the effect of soil erosion on productivity. In Southern Regional Project S-174, yields of major crops are measured on plots of varying natural or simulated erosion, and extensive climatic, soil water, soil properties, and nutrient status measurements are made at the plot sites. In the north central region, Project NC-174 includes work on this topic. A physically based mathematical model will be calibrated and refined to evaluate the effect of erosion on productivity for corn and small grain, using data from experiments on one or more benchmark soils in each state. Measurements for the model are planned on both eroded and noneroded sites for each soil.

Probably, the most dramatic change in research methodology during the past few decades has been the use of mathematical models. The techniques of model building have closely paralleled advances in computer hardware. Modelers can now conceptualize complex systems and emulate prototype situations with algorithms to levels of detail that are almost impossible to measure experimentally. Thus, data to test a model such as EPIC (Williams, et al., 1984) in its entirety are not presently available. The tremendous potential of models for comprehensive (in both time and space) evaluations of the effect of soil erosion on productivity has fostered major efforts to parameterize existing models, and in other instances, to develop and validate new models.

PRIORITIES FOR FUTURE RESEARCH

Research on both wind- and water-induced soil erosion effects on productivity needs to be expanded to provide information that will improve our overall understanding of the processes involved and enable us to maintain or increase current soil productivity levels. In our opinion, research is especially needed on the following topics; therefore we feel these topics should receive future priority.

Fragile Soils

Studies of soils where erosion is likely to create serious productivity problems in a relatively short time deserve special priority. These soils, appropriately termed fragile, have relatively shallow subsurface features with physical and/or chemical properties that restrict plant rooting depths.

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[2]Work Planning Conference of Soil Microbiological Issues as Related to Conservation Tillage. Mimeographed report available from L. E. Elliott, ARS-USDA, 215 Johnson Hall, Washington State University, Pullman, WA 99164.

Thus, lack of adequate soil water storage becomes an increasingly limiting factor as the soil profile depth decreases due to progressive erosion. Examples of limiting features include: fragipans, argillic horizons relatively high in clay (claypans), plinthite, natric and petrocalcic horizons, and impervious parent material or bedrock that occurs at relatively shallow depths below the soil surface. Soils with these characteristics represent a major portion of the cultivated land in most regions of the United States. Some of the effects of these features have been investigated (Frye et al., 1983; Langdale et al., 1979; Perkins and Kaihulla, 1981), but additional data are needed, especially for purposes of documenting the problem and predicting when cultivation of these soils will no longer be economically feasible.

Rates of Soil Formation

Future soil productivity depends on the maintenance of A-horizons and rooting zones that are thick enough to provide most plant growth requirements. Therefore, any comprehensive study relating future declines in productivity with continued soil losses should account for the soil formation factor, as it relates to the rate at which soils regenerate the materials lost to erosion. Estimates of soil formation rates derived from such research would also help in establishing more accurate soil loss tolerance values. For a detailed discussion of this topic, refer to Hall, et al. (1982).

Variability of Soil Water and Productivity

Much more information is needed to describe changes in soil water status with progressive erosion and the consequent effects on production. The lack of available soil water due to inadequate intake rate or storage capacity is often the primary factor limiting production, particularly on moderately to severely eroded soils. Soil water data are needed for a variety of soils with different degrees of past erosion, especially those with restricted rooting depths. The spatial variability for these soils in terms of standard soil water characterization parameters and crop yields should be measured as a function of slope and past erosion. Yields within farm fields may vary appreciably due to differential erosion and deposition associated with differences in landforms and/or previous land use. In such instances, point estimates may lead to incorrect conclusions concerning the integrated effect of these processes on productivity. Additionally, field water balances need to be monitored to determine how the water content of soil profiles occurring on differentially eroded slopes is affected by the various addition and depletion factors of the water balance equation.

Effect of Deposition on Productivity

Detailed studies which measure the effect of both soil erosion and deposition along a slope on yields are rare. Therefore, data are needed which show the net effect of erosion on productivity within a given field or small watershed. Information needed includes: (1) the effect of deposition on yields when it occurs prior to seedling emergence or in the early stages of seedling growth; and (2) the extent to which yield increases that are generally observed on thicker profiles formed by deposition on downslope positions compensate for yield reductions due to erosion upslope. Additionally, similar data are needed for floodplain areas where sediment deposits on a more massive scale.

Evaluation of Experimental Procedures

Some research should be directed toward improvement of laboratory and field experimental procedures. The methods used to estimate depths of past erosion or assign an erosion class to a given research site merit special attention. Results from naturally eroded versus scalped sites and from farm fields versus carefully controlled experimental field plots should be assessed. The advantages and shortcomings of each technique need to be clearly defined. Also, analytical laboratory procedures used for chemical characterization of eroded soil samples should be investigated, particularly those used to determine plant nutrient requirements. Since soil test extraction techniques for fertilizer recommendations were developed using samples from the more fertile, relatively uneroded sites, a determination is needed concerning whether they or other extraction methods are appropriate for use on samples of less productive, eroded soils.

Restoring Productivity of Eroded Soils

Although protection of our highly productive land must be of greatest concern, the requirements for reestablishment or maintenance of productivity on eroded soils should be investigated for at least the major cropland soils subject to erosion throughout the United States. This research would determine if and how crop yield limitations on eroded soils can be overcome, and the costs involved. Special attention should be given to isolating those adverse effects of erosion that can be overcome by increased fertilization rates, alternative land uses, different residue management practices, crop varieties, and pest control methods from those that cannot. We must recognize where damage is permanent, identify the limiting factors, and determine how to deal with the consequences.

Conservation Tillage

The previously mentioned report from the conference on soil microbiology[2] discussed unsolved problems of conservation tillage:

> "These include poor plant vigor and growth, residue management problems, soilborne diseases, and plant nutrient management and use efficiency. Most of these problems are not unique to conservation tillage systems; however, we have learned to cope with them to a degree with current tillage systems. When systems are changed, the problems tend to be magnified because we do not understand the underlying principles governing the causes and effects and the changes in the soil environment. We must develop a data base so that soil-plant-biological nutrient relationships can be predicted when tillage and residue management systems are changed."

Additional research needs in conservation tillage are discussed by Ritchie and Follett (1983).

Validation of Models

Models to describe the effect of erosion on productivity such as EPIC have not been tested in their entirety because of the lack of necessary data. Validation data are needed to test such complex models and also to verify specific algorithms that have been tested only regionally. As a more specific illustration, EPIC's generalized plant growth routine, used for a wide variety of crops, involves selection of parameter values which may vary both temporally and spatially. Parameters like the optimal and base temperature for plant growth, the parameter which converts energy to biomass, and the nutrient conversion parameters are likely different for corn grown in Minnesota versus Georgia. Data for these evaluations are not available. Finally, the EPIC model as used in the 1985 RCA assessment has recognized problems handling some conditions encountered in agricultural practices that need to be corrected using findings from research that may or may not have been completed.

General Comments Regarding Future Research

Various topics were omitted from the foregoing list that certainly merit future research; we included only those of the highest priority. Furthermore, the listed items are not discrete research entities; most erosion/productivity studies will likely encompass several of these topics plus other research areas as well. We especially want to stress the importance of fundamental research, to better understand the basic processes involved, as a major component of any research program to control soil erosion and enhance soil productivity.

In regard to future research efforts, the benefits from continued national coordination of erosion/productivity research and the importance of effective transfer of pertinent technology to users deserve special emphasis. Interagency cooperation and interaction among researchers in this field need to be continued. An awareness of other studies and research techniques can improve the productivity and efficiency of individual research studies, and also, major program gaps can be identified and overlaps avoided. Furthermore, individual research efforts can be better coordinated to focus on critical issues, and the overall effort can be viewed from a systems approach rather than as individual studies. Futhermore, technology gained from this research must be efficiently conveyed to those who need it, including farmers, decision makers, and other scientists. The excellence of our research efforts will be diminished should we fail. However, through the successful transfer of needed erosion/productivity technology, these efforts have the potential to be a major factor influencing world-wide policy decisions related to soil conservation and agricultural production.

NONTECHNICAL ISSUES THAT WILL IMPACT ON THE IMPORTANCE OF FUTURE EFFORTS TO BETTER DEFINE THE EFFECT OF SOIL EROSION ON PRODUCTIVITY

As professionals concerned about the production of food, fiber, and feed and especially about the effect of soil erosion on such production, we are very interested in the future importance of improved technology in this area and prospects for support of research on this topic. Is the effect of erosion on productivity a topic that will soon go away as it did after the 1930s and 40s, or is it here to stay this time? The answer will depend on many factors, few of which we can or will influence significantly. Some of the important "nontechnical" issues and their possible impacts follow.

National and International Factors

We operate in a world where major national and international developments often affect us and our work. Some will have a great impact on crop production demands.

Population Trends: Experts project an annual population growth of about 1% in the United States and other industrial nations and 2 1/2% in developing nations (Calhoun, 1979). By the year 2000, world population will be between 6 and 8 billion persons, and it may exceed 25 billion during the next 100 years. The United Nations Food and Agriculture Organization (FAO) has estimated that worldwide agricultural production needs to increase by 60% between 1980 and the year 2000 (Dudal, 1981). Most of this increase will have to come from land that is already being cultivated, and it will also have to compensate for any decrease in productivity on current cropland due to erosion, salinization, lack of irrigation water, waterlogging, and pollution.

Energy Availability and Cost: The energy situation can affect crop production and erosion control in many ways. High fuel costs discourage intensive cultivation and encourage reduced-tillage methods such as no-till, a soil conserving practice. Energy costs increase costs of many pesticides and fertilizers that are used extensively in crop production. Since most of the soil's nitrogen is in the near-surface part of the profile, topsoil losses by erosion and reductions in nitrogen usage would reduce crop production. In the USA alone, annual soil-nitrogen losses from erosion amount to more than $600,000,000, and the annual total for all plant nutrients is over a billion dollars (Larson et al., 1983). Any increase in production costs leaves less money available for erosion control practices, and shortages of energy might preclude construction of conservation practices that require major earthmoving.

Economic Situation: Our national economic situation has a major impact on the availability of public and private funds for production aids, soil conservation practices, and research. Internationally, the United States has been relying heavily on agricultural exports (about $30,000,000,000 per year) to improve our "balance of payments" and thereby counteract our massive imports of oil and durable goods. High commodity prices encourage cropping of marginal lands that are subject to serious erosion and rapid loss of productivity.

Legislation: Significant legislation has been enacted during recent years that impacts on erosion and its effect on productivity. Section 208 of PL 92-500 was aimed toward reduced nonpoint source pollution, and eroded soil, the greatest pollutant by volume (Robinson, 1971), was a major target. About the same time and since, several states passed erosion, runoff, and sediment control laws aimed at combating land uses that caused serious offsite problems. The 1977 RCA focused on soil as a production resource rather than as a pollutant (USDA, 1980). The effect of erosion on productivity is a major concern of RCA, and the act requires a continuing appraisal of our nation's natural resources every 5 years.

National Priorities: We Americans seem to take the availability of high quality food for granted, and we also seem to have assumed a self-imposed obligation to help feed impoverished nations who are not as fortunate. Yet, we have shown relatively little concern about excessive soil erosion and its effect on productivity. Recently, both agricultural and nonagricultural interests have shown increased concern, with concomitant state and national efforts to better control soil erosion. Future progress will depend on the priorities given to such work, including support for a strong research program in this area.

International Stability: A major cause of revolutions, riots, and other human conflict is the deterioration of the environment from causes such as excessive erosion and deforestation that affect food supplies and other necessities. Such conditions increase demands on productivity by the rest of the world. Certainly, the United States will be one of the nations most expected to help alleviate food shortages and thereby reduce hunger-related tensions throughout the world, as evidenced by the late-1984 consignment of 300,000 tons of U. S. wheat from a national emergency reserve to aid Ethiopia and other African nations.

Agricultural Factors

Within the agricultural community, numerous factors impact on the importance of how erosion affects productivity.

Agricultural Policies: Policies concerning agricultural production controls, conservation incentives, land use zoning, subsidies, and other such options influence crop production and erosion-control efforts. These policies are established in various ways and may change from time to time. Policy alternatives that are aimed toward better conservation of national soil resources are discussed by CAST (1982).

Farmer Attitudes: Concern about the effect of soil erosion on productivity by farm owners and operators seems to range from indifferent to serious, from very short-sighted to many generations in the future, and from ignorance to strong knowledgeable leadership. Unless and until very comprehensive erosion legislation is enacted, the attitudes, abilities, and economic well-being of those persons farming cropland will be dominant factors in the effectiveness of soil conservation efforts.

Crop Production Technology: The large increases in agricultural crop production during the past half century have slowed considerably, and some agriculturalists believe that yields are beginning to plateau (see Heady, 1984) because major breakthroughs are not occurring as rapidly as they once did. Major advances in crop variety improvement and pest control technology still are needed before widespread use will be made of soil-conserving cropping practices such as no-till.

The Price/Cost Squeeze: The greatest dilemma facing many farmers today is how to "make ends meet" and still properly care for their land. When costs for interest, equipment, and supplies are high and prices received for products are low, farmers cannot afford to spend much for conservation practices and pollution controls. Long-term considerations necessarily are overlooked to survive immediate economic crises.

Conversions of Cropland to Nonagricultural Uses: During recent years, approximately a half million hectares of U. S. cropland have been lost annually from agricultural production to other uses such as urban development and highways (Timmons and Curtiss, 1979). This loss is in addition to the thousands of hectares that go out of production each year due to excessive salinity, irrigation-water shortages, and serious past erosion that make cropping them unprofitable.

Alternatives to the Use of Agricultural Land for Crop Production: Some futurists question whether cropland will be necessary for future production. Alternative crop production methods, such as hydroponics, greenhouse farms, space farms, and aquaculture, are touted for crop production. These methods may someday provide a significant supplement to conventional cropland production, but their capacity to largely replace the 167 million hectares of U. S. cropland soils and billions of hectares worldwide is nowhere in the foreseeable future.

Environmental Factors

In addition to matters of the agricultural community, other factors may have an impact on agricultural productivity.

Ecological Concerns: People are understandably concerned about their health and the quality of their environment. Food quality is a high priority, as are air and water quality. Some chemical pesticides that enhance crop production have been banned, and others may be restricted or banned. Regardless of the effect on environmental quality and our ecological system, the result probably will be decreased crop production.

Offsite Damages: Some experts such as Crosson (1984) state that the offsite damages due to erosion are many times more costly than erosion's effect on productivity. Regardless, the offsite problems caused by rapid runoff plus sediment and chemicals in the runoff may strengthen efforts to control cropland runoff and reduce soil erosion. Some land currently used for cropland may have to be taken out of production or used less intensively.

The long-term benefits may be significant, but the methods used may also decrease current production.

The Net Effect, and Other Concerns

Obviously, no one can foretell the net effect of factors such as the foregoing examples on future cropland productivity. Most of these issues suggest that demands on our agricultural soils for crop production will increase, although some factors will help to alleviate such demands. One thing seems certain, both nationally and internationally: we will probably need to achieve more productivity on less land during the foreseeable future.

Regardless of the ways that these nontechnical factors affect our future situations, humanity should be seriously concerned about the effect of soil erosion on productivity for several reasons. First, many persons in our world are still short of food and other necessities made possible by agricultural production. Worldwide, a billion people suffer from hunger and malnutrition, and 400 million live on the edge of starvation (Mayer, 1976). Until that situation is remedied, sensitive persons will be concerned about anything that adversely affects food production.

Also, the continuing loss of any important resource is a concern to most responsible persons. Even if we believe that we can compensate for a resource or do without it, we cannot be certain. It is better to fail safe, than to fail sorry! Our productive soil is our most basic natural resource for good health and well-being, so it merits our best efforts to protect its productive potential. Collectively, we are stewards of our earth, entrusted with the task of managing its resources for the future of our family - the human race.

Finally, our astounding technological achievements have brought with them some possibilities that could affect productivity on massive areas of land in the future. These include the effects of acid rain, other types of chemical or biological pollution, major climatic changes, plagues such as southern corn blight, and even catastropic nuclear accidents. Far-fetched as these may be, they are not impossible problems, based on past history. To nationally and internationally maintain a considerably greater productive capacity than needed at any particular time could be a blessing of inestimatable value.

OUR TASK AHEAD

At this National Symposium on Erosion and Soil Productivity, we acquired new information about the interrelationship of soil erosion with cropland productivity, learned of the latest techniques being used by researchers of various disciplines, improved our abilities to assess the effect of soil erosion on productivity, and became better acquainted with persons and projects that are active in this field. We obtained new resources to use professionally, but we also were challenged by important questions that remain to be answered and by complex aspects of the problem that still need to be understood. We learned how crop yields are the net result of many factors, of which productive soil is one of the key ones; yet we know that in many parts of our nation and the world, soil is the weak link in the production chain due to past erosion. We identified some things that we can do professionally to help enhance cropland productivity, but recognized that other matters usually are beyond our control. Most important, we realized anew that our successes or failures in achieving wise management of our soil resources, in controlling soil erosion, and in maintaining soil productivity can and likely will make a great difference in the quality of life that we and our descendents will enjoy in the future.

This Symposium emphasized the technical aspects of quantifying the effects of soil erosion on productivity, with less consideration of the economic, political, and sociological aspects. However, concerns of at least a subtle nature have arisen about appraising the erosion versus productivity relationship from a dominantly economic perspective. Should economic considerations, based on present conditions and knowledge, be the primary criteria for decision making? Have large-area averages been used in analyses where more specific, high-hazard data are appropriate? Are we able to fully assess the economics of erosion control efforts, as compared to the future effects of "inadequate" control? How good are economic projections, and are present-day economic conclusions being properly weighed against the food and population situations that will exist 100, 500, 1000 years in the future? The consequences of accepting a false hypothesis (that present and future food production technology will assure us of an adequate supply indefinitely, regardless of our soil conservation policies) could be devastating compared to the consequences of rejecting a true hypothesis, as perused by Libby (1983). In addition to these "Type I" and "Type II" errors, he adds a Type III error --the probability of rejecting a false hypothesis when it is too late to make any difference, a fatal hazard so well illustrated by Mishan (1977) in his analogy of a man who blissfully gains confidence in his well-being during the first 99 stories of his 100-story fall.

As we look to the future -- to our future on our earth -- one of our greatest hurdles may be to overcome the shortsighted view we have traditionally taken toward agricultural productivity, land use, and the value of our soil resources. Planning horizons are often the Year 2000, sometimes 50 years in the future, and occasionally 100 years. Yet, soil has been the basis of life on earth for thousands of years and likely will be for thousands of years in the future.

Let's put ourselves in the place of citizens of our world several hundred years from now. How would we then counsel today's land users, agricultural scientists, political decision makers, and the generations that follow them? That counsel, or our best judgment of it, should be the goal for our future actions. This means that we need to use the best we know professionally toward ensuring a world of continued productivity, to work toward making such production economically feasible while maintaining environmental quality, and to endeavor to retain our natural resources including our soil in a condition that will sustain future humanity.

Briefly, our challenge is to use our talents to provide for a future of agricultural abundance such as most of us enjoy today. What better legacy could we hope to leave to future generations?

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