STEEP

A MODEL FOR CONSERVATION AND ENVIRONMENTAL RESEARCH

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INTRODUCTION

Soil erosion continues to be a major problem in the Pacific Northwest wheat region. Each year erosion losses amount to millions of tons of top soil eroded from its croplands. In some cases where farmers use conventional farming practices as much as 12 bushels of top soil are eroded annually for each bushel of wheat produced. Average annual erosion rates in the Palouse region of Pacific Northwest range from 10 to in excess of 30 tons per acre (approximately 1/8 inch of top soil) using conventional farming practices. Each year approximately one third of this eroded soil is washed into streams and other water bodies. This sediment adversely affects many ecosystems and the use of water for industrial and recreational purposes.

Soil erosion impacts 10 million acres of cropland in the Columbia Plateau and Palouse-Nez Perce prairies, Columbia Basin, Snake River Plains, and the Willamette-Puget Sound Valleys in Idaho, Oregon and Washington. Annual soil erosion in the Columbia River drainage system at the time the STEEP program was implemented in 1975 was estimated at 110 million tons annually. Of this amount approximately 30 million tons annually were deposited in Pacific Northwest streams, rivers, lakes, reservoirs, and harbors. The resulting build up of silt in reservoirs is projected to shorten the life of hydroelectric and irrigation facilities, and has deteriorated the water quality in these water bodies. In addition, removing silt from highways and roadside ditches costs Pacific Northwest taxpayers millions of dollars in property taxes annually. The other consequence of erosion has been that large acreages of cropland on which the topsoil has been eroded have had their productivity significantly reduced by the loss of topsoil.

People are becoming more sensitive to the serious consequences of soil erosion, its threat to the environment, and the economic security of the region. The capability of farmers to maintain productivity at current levels will depend in large part on their ability to prevent the depletion of organic matter in these soils and future losses of topsoil. The causes of erosion in the Pacific Northwest result from a combination of factors that include: 1) a winter precipitation climate with a large amount of frozen soil runoff, 2) the steep and irregular topography, and 3) crop management systems that leave the soil bare going into the winter rainy season. Management is especially a problem with fall seeded wheat, particularly when it is planted on summer fallow or harvested dry field pea ground.

THE STEEP PROGRAM

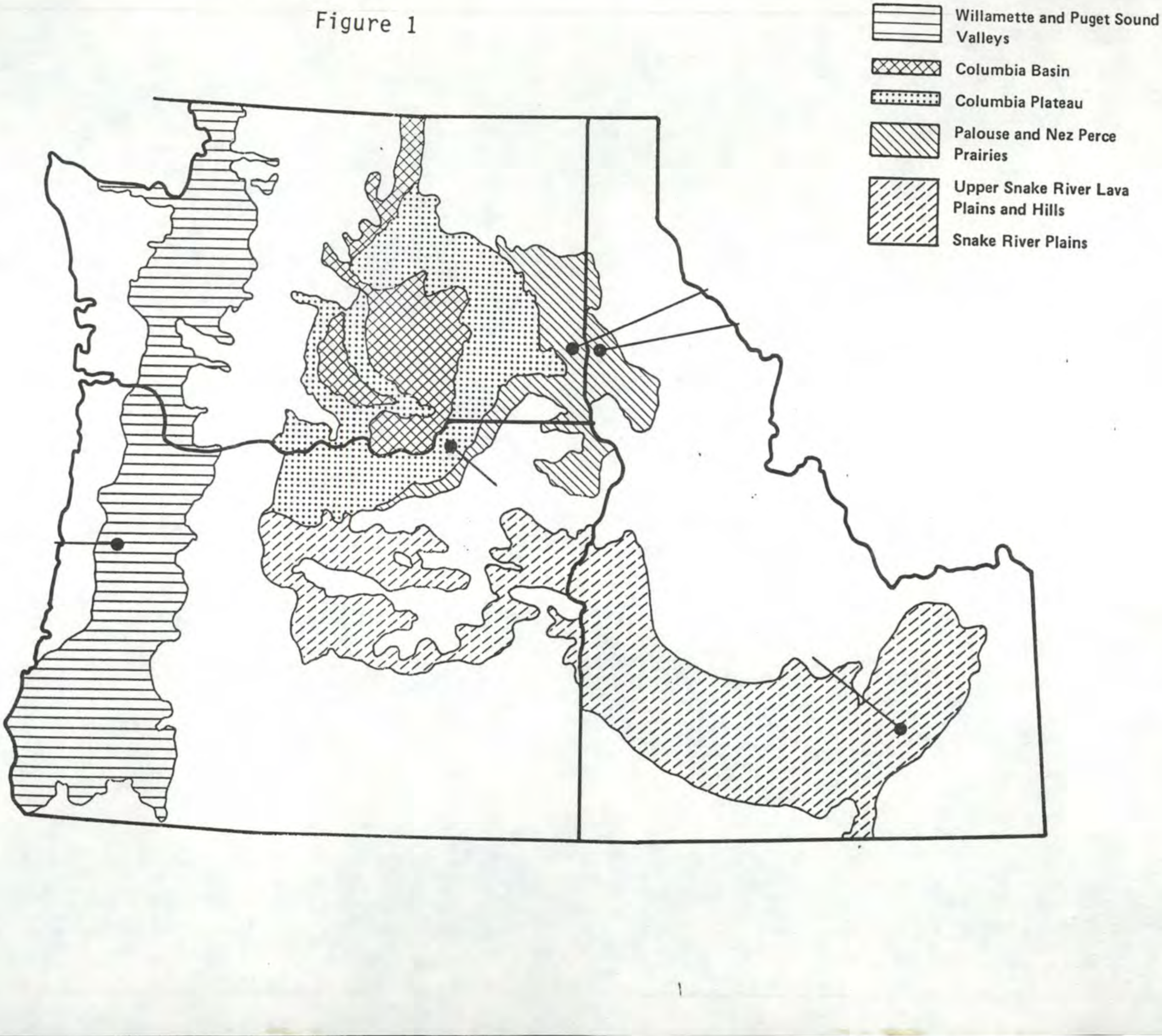
STEEP (SOLUTIONS TO ECONOMIC AND ENVIRONMENTAL PROBLEMS) is a research program designed to develop coordinated and integrated erosion control strategies and practices for the three Pacific Northwest states (Oldenstadt et al., 1982; Miller and Oldenstadt, 1987; Michalson, 1982). The idea was to establish a new approach to addressing the erosion problems in the region (Figure 1). Soil erosion and water pollution could be significantly reduced by integrating new and improved crop management practices, plant types, pest control methods, and socioeconomic principles into farming systems to achieve sustainable crop production, and a stable economic environment for farmers. The motivation for this research approach has come primarily from grain producers and their organizations. They organized the project, provided financial support, obtained Congressional funding, and continue to support and monitor its progress.

Since its inception, a variety of research and extension programs have been developed which involve cooperation between the three Pacific Northwest Land Grant Universities and the U.S.D.A. Agricultural Research Service research facilities at Aberdeen, Idaho, Pendelton, Oregon, and Pullman, Washington. Funds for STEEP research have been made available each year since 1976 by a USDA-CSRS special grant to the Agricultural Experiment Stations in Idaho, Oregon, and Washington, and by annual appropriations to the USDA-Agricultural Research Service. Researchers in the SAES have to compete for funding under this program on an individual project basis. The projects which are funded are also subject to oversight by a regional coordinating committee which helps to set research priorities, and guards against the duplication of research efforts. The CSRS and ARS funds have also been supplemented by grants from SCS, agricultural industry, and the commodity commissions in the Pacific Northwest.

One of the issues which STEEP addresses is the need to develop long term research efforts which can maintain continuity of research effort, and which permit the interaction of several disciplines to solve erosion problems. The research projects which are submitted are all subject to peer review. This is done to ensure that the research is targeted at high priority areas, and is of high quality. The overall benefit of the STEEP effort has been that researchers have been able to concentrate on addressing erosion problems on a multi-year basis. It ensures a consistent research effort which in the long term has paid off in terms of research output. This output has consisted of publications dealing with solutions to conceptual problems, professional papers and journal articles, research bulletins, extension publications, software programs, conservation practices, machinery designs, new varieties of wheat, and the development of alternative crops for the region. As a part of this process a consistent effort has been made to provide information to the farmers in the region.

Under the combined research and the extension programs related to STEEP it has been possible to develop conservation systems that reduce the amount of erosion significantly on Pacific Northwest farms. Many of the conservation strategies developed have been incorporated into the SCS planning process for conservation compliance which is directed toward reducing erosion in the region to "T" levels. The achievement of "T" levels of erosion would reduce annual soil loss from 12 to over 20 tons per acre on cropland when these conservation practices are applied in the three state region. The research team (approximately 70 scientists) has repeatedly demonstrated its ability to work together to solve erosion problems. Present research deals with a number of problems ranging from the implementing of no-till farming for small grains and legumes, evaluating new crops and varieties adaptable for conservation tillage, and determining farmers social attitudes concerning the severity of the erosion problem on their farms and in the area they are farming in. The development of new conservation systems for the region has involved University and USDA-ARS scientists from 10

Figure 1


Willamette and Puget Sound Valleys
Columbia Basin
Columbia Plateau
Palouse and Nez Perce Prairies
Upper Snake River Lava Plains and Hills
Snake River Plains

disciplines. These scientists interact to develop consistent sets of data and models for practices that are compatible with conservation management systems in the region.

The STEEP effort has worked to develop and utilize new and improved systems of conservation management in which tillage methods, crop rotations, plant types and methods of plant protection are integrated into complete management systems that minimize erosion without adversely affecting costs and levels of production. There are three main research approaches for erosion control: 1) developing conservation cropping systems along with plant types that can produce profitable yields in trashy, hard soil seedbeds; and 2) develop early fall planting methods for winter wheat and barley for increased ground cover before winter; and 3) research on the erosion-runoff process and erosion-runoff prediction with emphasis on frozen and thawing soils. Emphasis is also given to the control of diseases, weeds, insects, and rodents and to socioeconomic factors in the development of these systems.

STEEP OBJECTIVES

The STEEP research effort is organized into six major objectives (Michalson, 1982, Oldenstadt et al.. 1982). Under each objective there are several sub-objectives (not listed here). Each sub-objective covers a specific research topic which is integrated into the conservation management systems being developed. A brief description of the main objectives follows.

1. TILLAGE AND PLANT MANAGEMENT.

To develop combinations for tillage and residue management, cropping, and pest control systems to control erosion and maintain and/or increase crop production.

2. PLANT DESIGN.

To develop crop cultivars having morphological and rooting characteristics that reduce erosion, and the maintain food (feed) production when grown in conservation cropping systems.

3. EROSION AND RUNOFF PREDICTION.

To improve the understanding and prediction of erosion runoff processes as affected by climate, topography, soils, tillage, and crop management; and to use this information in on farm decision making for planing conservation control applications.

4. PEST CONTROL.

To integrate the control of weeds, diseases, rodents, and insects into plant management systems to minimize the impacts of changing cropping environments related to erosion control.

5. SOCIOECONOMICS OF EROSION CONTROL.

To estimate the economic and social impacts of using improved erosion control practices on farm organizations, costs and incomes, net income, and on maintaining short and long term agricultural productivity in the region.

6. INTEGRATED TECHNOLOGY TRANSFER RESEARCH.

To develop methods and systems to provide decision support models and software, published materials, to extension agents and specialists, soil conservationists, and producers.

All of the objectives have a common goal, i.e., development of farming systems for control of soil erosion. Each objective contributes in a special way to achieve this goal and is a link in the over all project. The objectives and/or sub-objectives are revised as necessary as new problems occur in the process of changing tillage and cropping systems.

ORGANIZATION AND MANAGEMENT OF THE RESEARCH PROGRAM

The research team has repeatedly demonstrated its ability to work together over the past 14 years. Efforts are made to ensure that the solutions developed are practical and workable. The combined effort, tied together by the objectives, coordination among agencies, and scientists, and the availability of supplemental funding has demonstrated a high degree of success. A coordinating committee comprised of six scientists, one extension specialist, and a representative from USDA-SCS has the responsibility for organizing annual reporting sessions. These sessions serve as a mechanism for monitoring progress for the wheat industry and interested federal and state agencies, and to facilitate interaction among the participating scientists. Scientists are encouraged to submit research proposals in their area of interest within the six objectives. these are passed though departmental channels, and the research administrators may call on the Coordinating Committee to review and prioritize the individual proposals and provide recommendations on funding. Research grants are usually made for a three year periods after which they are terminated or extensively revised. This turnover provides opportunity for more scientists to participate in the program and also provides a means to maintain a balance in the needed disciplines.

STEEP EXTENSION

An extension component was added to the STEEP program in 1982 to disseminate research findings and assist farmers in applying research results. One specialist is located at the Columbia Plateau Conservation Research Center at Pendleton, Oregon and the other at the University of Idaho in Moscow, Idaho. These specialists interact on a regular basis with scientists in their areas, and conduct field tours, write newsletters, do radio and TV programs, and organize grower information meetings throughout the inland Northwest. The STEEP extension component is a vital link in narrowing the gap between the generation of research information and on farm application.

STEEP has often been labeled a "growers program," meaning that individual farmers and the wheat producer organizations have provided major input in the development an operation of the research and extension programs. Not only do the growers seek support for STEEP funding, they also assist in establishing research priorities. Growers actively participate in the annual reviews in workshops. They also aid the Coordinating Committee in evaluation of existing research projects, and by suggesting new problems areas and needs for future research based on their own experiences. The growers were largely responsible for the addition of the extension component of STEEP.

The wheat grower organizations of the three states have done much to obtain the special grants funding that supports STEEP research. By pooling their resources they have been able to convince Congress of the seriousness of the erosion problem and the need for increased research on erosion control. Their efforts have been largely responsible for marshalling the resources of the various research agencies and of the agricultural industry into this high priority research area.

STEEP RESEARCH ACCOMPLISHMENTS

The STEEP program has contributed a number of major scientific and technical advancements in conservation farming since its inception. The following are a few examples of these accomplishments.

TILLAGE AND PLANT MANAGEMENT

- The yield advantages and improved efficiency of band placement of nitrogen fertilizer was established (Koehler et al., 1987).

- No-till drills have been developed with the capability to sow small grains and legumes (lentils, winter peas etc.) in moderate to heavy crop residues, and in hard dry soils. These drills have also been designed to place fertilizer and pesticides (Hyde et al., 1987).

- A crop residue decomposition model using generated residue/soil temperature-moisture inputs was developed for predicting the rate at which surface residues disappear in the field (Stroo et al., 1989).

- A wheat growth model was developed which predicts tillage and residue effects on developmental stages of wheat growth (Klepper et al., 1987).

PLANT DESIGN

- Wheat cultivars that perform best in conventional tillage management systems are the ones that perform best in conservation tillage systems (Allen and Peterson, 1987).

- Risks with early fall seeding for good overwinter ground cover have been reduced by development of wheat types with increased resistance to rusts, foot and root rots, flag smut, an snow mold (Allen and Peterson, 1987).

- Spring wheats that produce only primary tillers were found to be more desirable than secondary tiller producing varieties in the low rainfall areas of the Pacific Northwest. In these areas more spring cropping is encouraged in lieu of summer fallow to control erosion. (Konzak et al., 1987).

EROSION AND RUNOFF PREDICTION

- New factor relationships were developed for the Universal Soil Loss Equation to improve soil erosion prediction for the Pacific Northwest. These relationships are now being used by the Soil Conservation Service in farm planning applications to meet conservation compliance in the 1985 Food Security Act (McCool et al., 1987).

- a new method was developed for computing erosivity (R factor) values for rainfall characteristics using hourly rainfall data which are generally more available than the otherwise required 15 minute "break-point" rainfall data (Istok et al., 1987).

- A rill meter was developed for field measurement of erosion. This tool is the basis of the new data collection procedure needed to develop USLE-LS factor relationships for the Pacific Northwest (McCool et al., 1981).

PEST CONTROL

- Conservation tillage practices and intensive cropping to small grains was found to increase root diseases of wheat and barley (Weise et al., 1987).

- Studies determined that root diseases of wheat and/or barley in a conservation tillage system can be controlled by using a three-year crop rotation with the cereal grown only one year in 3 (Cook, 1988).

- Improved methods of herbicide management were developed for the control of annual grasses and broadleaf weeds in no-till wheat, barley and chemical fallow (Rydrych, 1987, Thill et al., 1987).

SOCIOECONOMICS AND PRODUCTIVITY RELATIONSHIPS

- The diffusion of conservation practices in the Northwest will take considerable time and depends to a large extent on changes in the context, innovation, and the characteristics of potential adopters (Dillman et al., 1987).

- STEEP research provided valuable insights for the highly erodible land protection provisions in the 1985 Food Security Act (Hoag and Young, 1985).

- Studies using farmer survey on adoption of erosion control practices showed that a) absentee landowner are not a major constraint to erosion control, b) the major constraints to erosion control appear to be factors external to the farmer himself, i.e., especially the rules imbedded in government programs; and c) over the past 10 years there has been a positive change in farmer attitudes toward erosion control as well as implementation of erosion control practices (Carlson et al., 1987, Dillman and Carlson, 1982).

- Steep research has shown that wheat yield losses due to loss of topsoil have been masked by technological progress. Such things as improved varieties, fertilizer management, and weed control. (Papendick et al., 1985, Young et al. 1985, Walker and Young, 1986).

- Economic studies have shown that in all cases studied that in the short run net income has been reduced on farms where by the use of conservation practices (Brooks and Michalson, 1983, Powell and Michalson 1985, and 1986). However, there were options and practices which minimized the short term losses incurred in the adoption of these practices.

- A computer modelling study supported by field data showed that the effect of erosion on wheat yield loss, and the anticipated payoff from future technical progress is greater on the deep soils than it is on the shallow soils (Young, 1984).

INTEGRATED TECHNOLOGY TRANSFER

- A Pacific Northwest "STEEP EXTENSION CONSERVATION FARMING UPDATE" publication is published quarterly by R. Veseth, and D. Wysocki.

- A "Pacific Northwest Conservation Tillage Handbook" (Veseth et al., 1989), and Handbook Series has also been developed and is available to farmers.

- Software user's manuals have been developed for the GMX program (Bolte, 1989).

- A rule based system is being developed for disease identification (Trent et al., in progress).

- Optimal farm plans for conservation compliance have been developed and are being used in the farm planning process (Ellis et al., 1989)

IMPACTS OF STEEP RESEARCH

The bottom line question is: to what degree have the objectives of the STEEP program been achieved? Has erosion been controlled on Pacific Northwest croplands? Has farm profitability been increased? After 14 years of STEEP erosion still occurs at unacceptable levels on Pacific Northwest croplands, and some farmers are making less money than they have in the past. Nevertheless, the benefits of STEEP are becoming evident. There has been a visible increase in the adoption of new soil conservation management technology which has been developed or refined by STEEP researchers. Much of the credit for this is related to the research on fertilizer placement as a part of the no-till drills which became commercialized in the early 1980's. Conservation methods have enabled farmers to reduced the number of tillage operations on wheat based rotations from five or more to fewer than three. These methods leave the seedbed in a rough condition and covered with residues which promotes erosion control.

A great deal has been learned about the relationships between tillage and plant diseases and how these can be controlled with residue management and crop rotations. Methods have been developed to move the pathogen infested residues away from the seed row. Crop rotation systems have also been designed to reduce adverse biological effects in no-till systems. Economic studies have shown the short and long term costs and benefits of soil conservation, and how cost-sharing aids in implementation of best management practices by defraying added short term costs which otherwise discourage their use by farmers. Overall, STEEP more than any other program has created increased public awareness of soil erosion and its consequences. It has also made growers more receptive to implementing conservation measures on their farms.

FUTURE DIRECTIONS FOR STEEP

In spite of the technological advances made by STEEP, soil erosion is still a major environmental and economic problem in the region. Developing better conservation practices and achieving more widespread application on the land remains an urgent high priority need. The mandatory conservation compliance requirements of the 1985 Food Security Act will likely speed up adoption of conservation tillage practices such as no-till etc., and many growers will be trying these practices on their farms for the first time in the next several years. Many technical problems relating to the use of these practices have not yet been solved, and consequently their final economic and social acceptability are not known. For example, many farmers will have difficulty planting and harvesting crops, and in controlling weeds, diseases, and other pest in seedbeds that are rough-tilled or contain large amounts of surface residues. These obstacles can frequently be overcome in research plots by not always on farmers fields for many reasons including lack of know-how, inadequate equipment, cost or time limitations, and variations in soil characteristics. Much remains to be done to accomplish the adoption of conservation tillage technology on the region's farms.

EMERGING ISSUES

Concerns in addition to soil erosion have now placed land stewardship in a new context. Water quality and groundwater quality will be major national issues in the 1990's. In the future increasing severe restrictions on chemical and nutrient management are likely to be legislatively mandated. Fewer agricultural chemicals will be available to farmers, particularly for minor use crops because chemical manufactures face increased registration restriction and expenses. Other issues that farmers must face include energy conservation, environmental stability, fish and wildlife protection, farm worker health, food safety, and maintaining net farm incomes. Conservation farming for erosion control affects all of these issues and concerns. For example, with current technology, conservation practices such as reduced tillage and no-till require increased use of pesticides and nitrogen fertilizer. Reduced runoff and evaporation under conservation tillage may increase infiltration and leaching of chemicals into groundwater. If this happens, the chemical intensive practices being developed today will not be acceptable in the future. Thus the concerns for efficient crop production, conservation of soil, water, and energy, and maintaining of net farm income will have to integrated with the need to safeguard human health and protect the environment.

About two million acres of highly erodible land in the three Pacific Northwest states is now in the Conservation Reserve Program (CRP). This land is under 10 year contracts to grow only grass and other used not requiring tillage. Much of this land had been seriously degraded because of excessive erosion rates with the cropping systems previously used. If these land are converted back to crops after the CRP contracts expire farmers will be faced with the challenge of conserving and maintaining the accrued productivity benefits from 10 years of grass by moving to cropping systems that are more sustainable than those used prior to placing these lands in the reserve. The outcome of this post CRP transition will have a profound impact on soil erosion, water quality, farm income and the future of agriculture in the region.

STEEP II

STEEP has achieved an organizational structure and stance that makes the program ideally poised to meet production, conservation, and environmental challenges of the 1990's. It has proven ability to mobilize regional scientific and extension resources to solve regional problems. A proposal has been drafted for a new project to replace the expiring STEEP project. This project is known as STEEP II. This revised project will build on the progress and accomplishments of the original STEEP project. STEEP II seeks to coordinate a regional research and information delivery system designed to provide growers in the Pacific Northwest with advanced technologies of simultaneously controlling soil erosion and protecting water quality while achieving more cost efficient crop production and increased farm profitability.

The STEEP II program will be expanded to include water quality protection in addition to erosion control. The program will be organized around three main objectives:

1.) To obtain and integrate new technical and scientific information on soils, crop cultivars, pests, energy, and farm profitability into sustainable, farm management systems.

2.) To develop tools for assessing the impacts of farming practices on erosion and water quality.

3.) To develop and implement programs for dissemination of information and the transfer to technology to the farm.

Within these objectives considerable effort will be given to developing conservation cropping systems that will consistently produce acceptable crop yield, are adaptable to farmers in the different agronomic zones, and are environmental safe. Attention will be directed towards overcoming factors that now limit crop growth with conservation planning. Some of the factors that have been identified include increased root diseases and weed infestations associated with increased surface residues, and increased pests in wheat planted early to enhance grown cover of erosion control. Other limiting factors related to nutrient cycling an soil physical properties will also be examined.

Soil microbial properties of various tillage and cropping systems will be assessed to develop methods and principles that will prevent plant diseases, reduce the potential for nutrient leaching, and increase use efficiency of applied fertilizers and organic amendments. Increased attention will also be given to new tillage methods that complement surface residues for erosion control. Research will be conducted to explore management strategies and options for farmers on how to maximize benefits to soil productivity of CRP lands while in grass, and how to maintain these highly erodible lands in sustainable cropping systems.

Development and testing of erosion and water quality control systems will include evaluations of economic impacts at the farm and regional levels, and of social factors that limit or enhance farmer adoption of conservation practices. STEEP II will also give new emphasis to developing methodology for on-farm research and providing scientific backup to research and education projects such as those supported by the USDA-LISA (Low Input Sustainable Agriculture) program that involves working directly with growers in testing treatments on large plots or whole fields.

Erosion and water quality models will be developed as tools to evaluate impacts of conservation tillage and other management options on runoff and erosion, water conservation, and water quality. Physical and chemical process models will ultimately be incorporated with crop production models to provide an interactive link between crop production practices, erosion rates, nutrient use efficiency, and the potential for nutrient escape fro the crop root zone.

A variety of innovative approaches will be utilized for information transfer in STEEP II. These included on-farm research/demonstrations and associated field tours. decision aid computer software; newsletters; farm magazine and newspaper articles; Cooperative Extension publications; meeting presentations; conferences, symposia, and workshops; and audiovisuals.

CONCLUDING REMARKS

Nationally the momentum for conservation is present and accelerating. The STEEP program for the Pacific Northwest continues to be the best vehicle for coordinating the research and extension efforts needed to assure that national and regional goals for resource protection and economic viability are achieved. STEEP as a research/extension program has a proven track record related to organizing and accomplishing research goals in the Pacific Northwest. STEEP II will build on this foundation to help farmers meet the requirements of conservation compliance, and maintain profitable operations as agriculture moves into the next century.

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