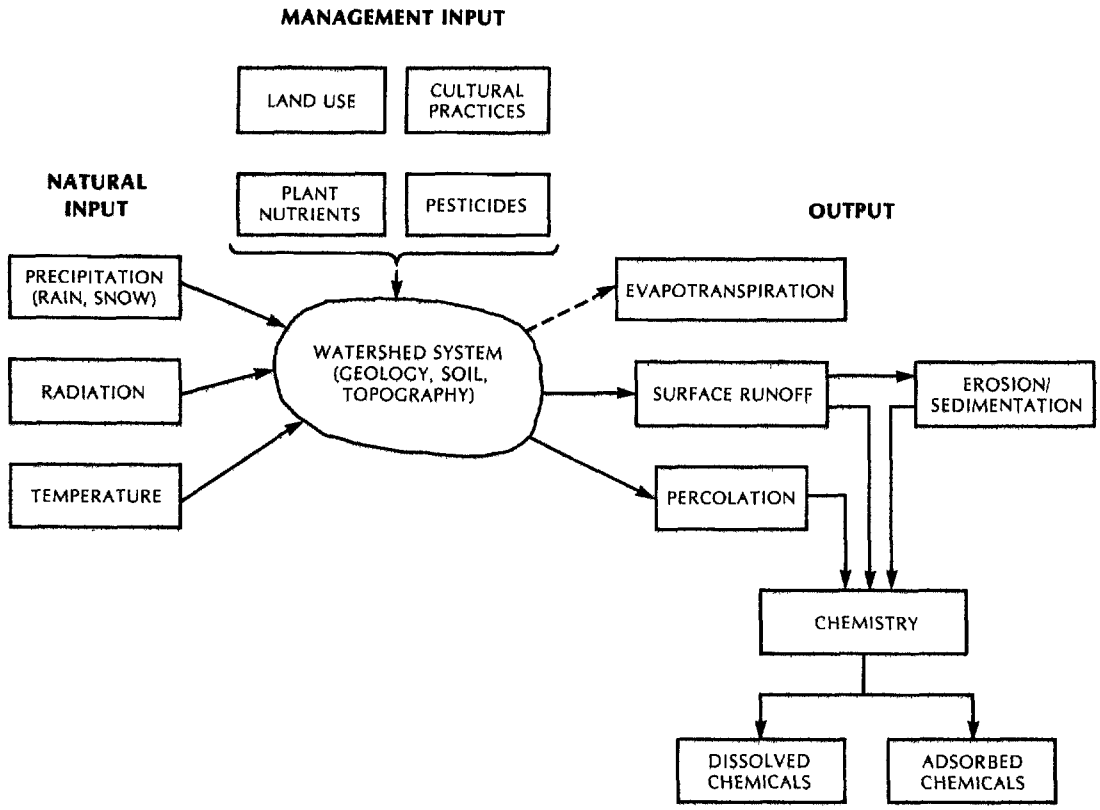
CREAMS

A Field Scale Model for Chemicals, Runoff, and Erosion From Agricultural Management Systems



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ABSTRACT

Knisel, Walter G., editor. CREAMS: A Field-Scale Model for Chemicals, Runoff, and Erosion from Agricultural Management Systems. U.S. Department of Agriculture, Conservation Research Report No. 26, 640 pp., illus.

This publication describes a mathematical model developed to evaluate nonpoint source pollution from field-sized areas. CREAMS consists of three components: hydrology, erosion/sedimentation, and chemistry. The publication is presented in three volumes: Volume I, model documentation, describes the concepts of each of the model components; Volume II, user manual, describes the model application and selection of parameter values; Volume III, supporting documentation, provides additional data and parameter information.

Keywords: hydrology, erosion, sediment transport, plant nutrient transport, pesticide transport, mathematical model, nonpoint source pollution, agricultural management.

PREFACE

Section 208 of PL 92-500, the 1972 amendments of the Clean Water Act, placed emphasis on nonpoint-source pollution. Planning required by this legislation needed methods to assess nonpoint-source pollution under various management practices for selecting Best Management Practices (BMP's) to reduce nonpoint pollution to acceptable levels.

Expertise by the staff of the Science and Education Administration-Agricultural Research (SEA-AR) in soil and water management research, along with the high priority needs of action agencies, prompted SEA's National Program Staff (NPS) to develop plans for a concerted national effort to assemble mathematical models for evaluating nonpoint-source pollution. Staff scientists met with planners in action agencies to determine their needs for such models. A. R. Robinson, D. A. Farrell, and J. Lunin, all of the NPS, and J. C. Lance, temporarily assigned to this staff, planned the mechanism for a national project. The plans were approved by C. W. Carlson, Associate Administrator of Agricultural Research, and a request was made to T. W. Edminster, Administrator of Agricultural Research, for unassigned program funds to initiate the project. T. W. Edminster and R. J. McCracken, then the Assistant Administrator, made funds available for this important project.

The project coordinator and Technical Work Group met with the Steering Committee (NPS scientists) at Beltsville, Md., in October 1977, to initiate a national project to develop mathematical models for evaluating nonpoint-source pollution. On February 14-16, 1978, a workshop was held at Arlington, Tex., to assemble SEA-AR scientists interested in participating in this project. The workshop was to:

> ...(1) review, refine, and adopt an approach, (2) select group leaders (lead scientists), (3) plot the course of action and set the time table..., (4) assign tasks (to) investigate specific components of the system to be considered...

To develop a model quickly, participants at the workshop determined that existing physically based models, or those that could be readily modified and improved, would be assembled into a package to estimate runoff, sediment, plant nutrient, and pesticide movement in a field.

Lead scientists identified for the four components are:

Hydrology---------A. D. Nicks, Chickasha, Okla.
Erosion-----------G. R. Foster, Lafayette, Ind.
Plant nutrients---M. H. Frere, Chickasha, Okla. (New Orleans, La.)
Pesticides--------R. A. Leonard, Athens, Ga.

The hydrology component was further represented by two options lead by R. E. Smith, Fort Collins, Colo., and J. R. Williams, Temple, Tex. J. D. Nowlin,

Purdue University, Lafayette, Ind., working with SEA-AR under cooperative agreement, programmed the model concepts.

The lead scientists drew upon material provided by other contributors to develop and document the model. These contributors are acknowledged throughout the publication.

Scientists in SEA-AR worked together to assemble state-of-the-art mathematical models to evaluate nonpoint-source pollution for field-scale areas. pesults of these efforts have culminated in an operational continuous simulation model. This publication documents and provides a user manual for the model named CREAMS - a field scale model for Chemicals, Runoff, and Erosion from Agricultural Management Systems.

The CREAMS model was developed using units common for the individual components. That is, customary units in the hydrology and erosion/sedimentation fields are English units, whereas metric units are common in chemistry. Rainfall data available from the National Weather Service and SEA-AR are reported in inches. Temperature data are generally in degrees Fahrenheit. Runoff, percolation, soil water, and evapotranspiration are generally reported in inches. Erosion/sedimentation data are generally reported in pounds per acre or tons per acre. Plant nutrient and pesticide losses are reported in milligrams per liter and kilograms per hectare. Model input, output, and operations were structured accordingly. Although the CREAMS model has the potential for international use, the principal users will be action agencies and consulting firms in the United States and the model, therefore, contains mixed or customary units. Users are cautioned, however, against indiscriminately modifying model components without a complete understanding of the units of operations. This version will be improved over the next several months to provide a more comprehensive model and will incorporate consistent English or metric units for user option specification.

The purpose of this publication is to provide a complete package for potential users of the model. It is divided into three main divisions. Volume I, model documentation, presents the concepts of model components. Volume II, user manual, provides information on selection of parameter values and model operation. Volume III, supporting documentation, provides the user additional information to obtain parameter values.

Results of sensitivity analysis for each component are included in the publication to indicate effects of errors in parameter estimation. This enables the user to be aware of potential difficulties resulting from inaccuracies in individual parameters.

The results of considerable testing of the components using data available from SEA-AR research locations are included. Users should be aware of two significant points: (1) Statements of model accuracy in the publication are made realistically based upon the scientist's evaluation of the mathematical representation of the real-world system and his scientific knowledge of the range and confidence in parameter estimation, and (2) ranges of conditions considered appropriate for application of the model are given in the publication.

Magnetic tapes of the computer model can be furnished to anyone interested in using the model. A user, in turn, can send a magnetic tape to the project

coordinator and the program will be taped along with a set of test data, parameter values, and summary output. These data will enable users to be sure the model is operating properly on their respective computer systems. A tape can be generated for CDC or IBM computers and the user should specify the system when requesting the program.

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National Program Staff scientists who make up the Steering Committee for the project, D. A. Farrell, J. Lunin, J. C. Lance, and A. R. Robinson, are recognized for their technical support.

The Technical Work Group, D. G. DeCoursey, E. T. Engman, L. D. Meyer, M. H. Frere, and R. A. Leonard, is recognized for planning and conducting a workshop at Arlington, Tex., to initiate the modeling effort.

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W. E. Modenhauer, SEA-AR, and G. W. Isaacs, Agricultural Engineering Department, Purdue University, Lafayette, Ind., are recognized for providing J. D. Nowlin for computer programming assistance.

The following scientists participated in the workshop at Arlington, Tex., in 1978 and contributed ideas, direction, and data as well as completed task assignments that led to the model development.

C. V. Alonso, Oxford, Miss.
A. P. Barnett, Watkinsville, Ga.
J. V. Bonta, Coshocton, Ohio
A. J. Bowie, Oxford, Miss.
D. L. Chery, Athens, Ga.
K. R. Cooley, Phoenix, Ariz.
D. G. DeCoursey, Oxford, Miss.
E. T. Engman, Beltsville, Md.
G. R. Foster, Lafayette, Ind.
M. H. Frere, Chickasha, Okla.
W. R. Hamon, Coshocton, Ohio
C. L. Hanson, Boise, Idaho
A. T. Hjelmfelt, Columbia, Mo.
D. E. Kissel, Temple, Tex.
W. G. Knisel, Tucson, Ariz.
J. M. Laflen, Ames, Iowa
J. C. Lance, Beltsville, Md.
L. J. Lane, Tucson, Ariz.
W. E. Larson, St. Paul, Minn.
R. A. Leonard, Athens, Ga.
C. E. Murphree, Oxford, Miss.
C. K. Mutchler, Oxford, Miss.
R. G. Nash, Beltsville, Md.
E. L. Neff, Sidney, Mont.
A. D. Nicks, Chickasha, Okla.
C. A. Onstad, Morris, Minn.
L. B. Owens, Coshocton, Ohio
R. F. Piest, Columbia, Mo.
H. B. Pionke, Univ. Park, Penn.
W. J. Rawls, Beltsville, Md.
C. W. Richardson, Temple, Tex.
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M. J. M. Romkens, Oxford, Miss.
K. E. Saxton, Pullman, Wash.
E. H. Seely, Chickasha, Okla.
D. E. Smika, Akron, Colo.
R. E. Smith, Fort Collins, Colo.
S. J. Smith, Durant, Okla.
W. F. Spencer, Riverside, Calif.
D. R. Timmons, Morris, Minn.

D. K. McCool, Pullman, Wash.
L. L. McDowell, Oxford, Miss.
R. G. Menzel, Durant, Okla.
L. D. Meyer, Oxford, Miss.
R. D. Wauchope, Stoneville, Miss.
J. R. Williams, Temple, Tex.
G. H. Willis, Baton Rouge, La.
R. A. Young, Morris, Minn.

J. B. Burford and Jane DeLashmutt of the Water Data Laboratory, Beltsville, Md., helped obtain and format data for testing the hydrologic components of the model.

USDA-Soil Conservation Service personnel critiqued the model in a technology transfer workshop at the South Technical Service Center, Fort Worth, Tex. John Burt, Gary Margheim, E. C. Nicholas, and S. J. Robbins helped arrange the workshop and provided input to improve the model. Margheim obtained SCS funds for the SEA-AR model testing and technology transfer.

B. C. Dysart, III, and R. C. Warner, Environmental Systems Engineering Department, Clemson University, Clemson, S.C., are acknowledged for their comments and suggestions on the erosion component. Their application in South Carolina enabled improvements of the erosion component.

CONTENTS

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This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been or remain registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

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