An ARS Retiree Looks at USDA Water Resource Programs

Kenneth G. Renard

Abstract

ARS scientists and engineers have been developing natural resource models to assist action agencies with programs to manage and rectify environmental concerns at various time and spatial scales. Past efforts are reviewed and comments offered on future needs.

Keywords: natural resource models, water, watersheds, simulation, historical development

Introduction

The paper will be directed toward water initiatives needed in USDA but not including USFS programs because the author is not familiar with that work. As an 'outside observer,' a new emphasis to USDA water programs is long overdue. Although USDA was a strong participant (and past leader) in Federal water programs, this is no longer true (in my opinion). The reason for this change may include: 1) the populous is now urban and does not recognize that most water originates from agricultural and forest lands, 2) food is too plentiful to warrant additional funding, and 3) USDA leadership is production-oriented (food and fiber) with only minimal environmental concerns.

Historical Programs

PL 566 programs

Most past funding impetus came to USDA in response to problem needs. Certainly the small watershed programs in the 1930's and later associated with flood-control activities (funded under Public Law 566) on upland watersheds, set a strong precedent in USDA for conservation activity. The famous (or infamous) curve numbers produced by SCS personnel in 1957 for estimating flood peaks from rural watersheds is widely used even in the 21st century. This technology (curve numbers, design rainfall data and land uses) has been cussed/discussed/revised in the ensuing years but still remains a favorite design procedure for water problems and specifically flood peak estimation (Stewart et al. 1975, ASCE 1996).

Senate document '59

Following the creation of ARS in 1953-54, soil and water conservation research programs that had originated in SCS, were slow to expand. The US Senate Appropriations Committee in 1959 produced a report on needed research based on citizen input. The report stressed the urgent need to determine water (and soil) problems of regional and national need for protecting the nations natural resources. The hearings and input at them from a number of users, led to *new perspectives for USDA.*

The needs report stated that "Special attention should be given to hydrologic research on agricultural watersheds." Six regional watershed centers were identified as needed supplement original SCS watersheds and to quantify geographic and cultural differences in areas of the U.S. These six new centers funded over a few years and added to iriginal SCS watersheds have provided fundamental technology for hydrologic and erosion/ sedimentation problems. A national hydrology and an erosion and sedimentation laboratory complemented the regional centers.

Parallel to the aforementioned laboratories was the need for laboratories to research specific problems (e.g. Water Conservation Laboratory, etc.) which have helped the SCS/NRCS implement conservation programs with individual farmers and ranchers for the wide range of soil and water resource programs. Over the ensuing period, funding of these research locations has become a major concern as problems change and inflation erodes available resources.

Renard is retired (currently a Collaborator) as a Hydraulic Engineer from the USDA-ARS, Southwest Watershed Research Center, Tucson, AZ 85719. E-mail: krenard@tucson.ars.ag.gov.

Specific collaborative efforts

With an established infrastructure to pursue research and provide needed data, ARS began a program of mathematical model development to assist SCS/now NRCS and others with program solutions for specific problems. The personnel assembled at ARS research locations represented differing scientific expertise to address specific problems. The earliest collaborative efforts addressed erosion problems associated with wind and water. The timeline for programs discussed subsequently is presented in Figure 1.

The USLE (Universal Soil Loss Equation) resulted from plot data sent to Indiana and analyzed by Wischmeier and Smith (1965). That technology was updated (Wischmeier and Smith 1978) and used by the SCS in numerous environmental assessments. The technology is essential to farm conservation plans involving water erosion and plans to reduce soil loss.

In somewhat of a parallel approach, the Wind Erosion Equation was published as a USDA Handbook by Skidmore and Woodruff (1968). The technology is widely used for wind erosion prediction and control. Although specific funding for both pieces of technology was part of continuing basic ARS funding, it soon became evident that such funding was insufficient to address emerging new concerns and that new monetary resources were needed.

Water Pollution (Stewart et al. 1975)

The EPA funded collaborative research with ARS to assess water pollution from cropland (Stewart et al. 1975). For this effort, ARS scientists were assigned to represent a discipline and diverse geographic location. The resulting reports were widely used to assess pollution from farmlands of the U.S. To my knowledge this effort was unique because it represented the first such federal interagency effort of this kind.

CREAMS/GLEAMS

The need for computer technology to assist with problem solutions led ARS to designate a team to assist with non-point pollution problems (Chemicals, Runoff, Erosion and Agricultural Management Systems). When the agency asked for volunteers in 1979, a large number of scientists responded. Computer software was developed to predict the hydrology-erosion-chemical losses from different land uses and physiographic regions of U.S. (Knisel et al.1980). This analytical model set a prescription for several computer efforts that followed. Again SCS, the technology user, adopted the model with ARS scientists and engineers to address specific USDA needs. Although specific **new resources** to support the effort were minimal, it encouraged ARS staff members for future such research. The model developed by Knisel

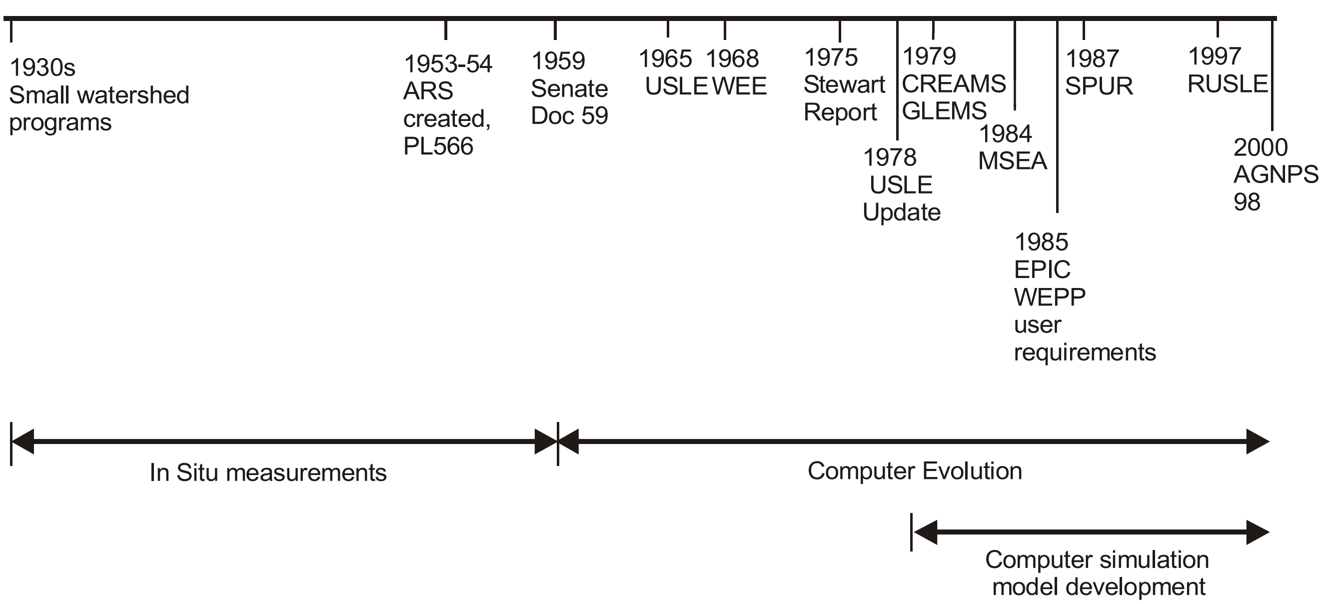

Figure 1. Timeline of simulation models and programs.

and associates generated interest among the international community.

EPIC (Erosion Productivity Impact Calculator)

Environmental concerns evolved in USDA in the early 1980s to predict/manage the effects of soil erosion on long-term production of food and fiber from U.S. land resources. Again in response to a SCS request for assistance, an ARS team was designated to provide analytical assistance for model development. Concurrent with the software model developed, field experiments were designed across the country to assist with quantifying the impacts of erosion on food and fiber production. SCS made many model simulations in the U.S. to quantify erosion impacts across agricultural production areas. The analytical model, called EPIC (Williams and Renard 1985) has been and continues to be used for soil-erosion resource assessment in the U.S.

SPUR

Building on the success of EPIC, ARS assembled a new team in 1986 to develop technology for **S**imulation of the **P**roduction and **U**tilization of **R**angelands, and specifically grazing impacts on the hydrology-erosion-environmental conditions of the western U.S. (Wight 1987). Again some limited additional funds were available to assist with this effort. In contrast to other model efforts, this model was less restrictive area wise. Also important to this effort, was the inclusion of animal and range plant scientists who broadened the model to include animal conditions.

WEPP-WERM-RUSLE

In a 1985 USDA workshop in Indiana, future research needs in water and wind erosion were identified. Workshop participants agreed that an effort was needed to upgrade the science associated with the USLE (Wischmeier and Smith 1978) and the wind erosion prediction equation (Skidmore and Woodruff 1968). Following the workshop, plans evolved to upgrade soil erosion technology to include recent research findings and to produce digital computer technology identified as RUSLE (Renard et al. 1997). The plans also cited the need to produce technology to ultimately replace USLE (Laflen et al. 1981, Lane and Nearing eds1989). This new model which was designated WEPP (Water Erosion Prediction Project) has been delivered to NRCS (they were participants throughout the computer code development). The model receives modest use because of the large data input needs (not always available).

The initial effort to develop RUSLE was completed with the publication of Agriculture Handbook 703 (Renard et al. 1997). The implementation of the computer code in the Windows environment is nearing completion. Because of retirements, assistance for this research continues through the University of Tennessee. NRCS uses this technology in soil conservation programs throughout the United States.

The wind erosion prediction effort, known originally by initials WERM (Wind Erosion Research Model) is now designated WEPS (Wind Erosion Prediction System) (Hagen 1991) and parallels the RUSLE-WEPP activity. Mention of this work here is included because although wind is the driving force, water is an important factor. Furthermore, ARS and NRCS personnel often work with both wind and water.

New Activities and Funding Efforts

Several USDA staff members concerned with water problems have been integrating GIS technology (El-Swaify and Yakowitz 1998). These new technologies have developed such that they can be integral to continuing natural resource analytical programs. Again these new analytical techniques have been developed from existing budgets.

Water quality programs

The need to improve and conserve water resources was recognized with the Presidential Initiative on Water Quality in 1989. The initiative had the objectives of 1) protecting ground water resources from contamination; 2) developing water quality to address contamination; and 3) providing basic information to alter practices and contamination (Bush 1989). USDA responded to the Initiative by establishing interagency research and assessment with the title Management Systems Evaluation Areas (e.g. Onstad et al. 1991).

As part of the initiative, the Soil and Water Assessment Tool (SWAT) model (Arnold et al. 1995) and the Annualized Agricultural Non-Point Source (AnnAgNPS) model (Bingner and Theurer 2001) have become primary tools for planning watershed approaches for agricultural management practices. ARS recently released the second version of the Root Zone Water Quality Model (RZWQM) for determining the interaction between practices, hydrology, crop growth, and chemical fate (Ahuja et al. 1999).

Climate change programs

Climate change research has become a major activity in Federal Agencies. The amount of funding available for ARS water research continues to deteriorate. Some progress has been made to define CO_2 and temperature changes but with only minimal correlation to precipitation or water cycle changes.

Global water cycle

The USGCRP (Global Change Research Program) appointed a Water Cycle Study Group in 1999 (Hornberger et al. 2001). They identified needed water programs at the federal level. USDA bought into this program which as a blueprint for water-cycle activities in the next decade. Necessary ingredients to the initiative include 1) improved observations and measurements; 2) coordinated field, remote sensing, and modeling experiments; and 3) spatially nested regional climate models to link atmospheric, land surface, and subsurface processes. The outlook for the future appears to be strong, with the question about USDA's role. Is it likely that USDA will regain some stature in water programs?

As an outsider, I wonder whether USDA and other Federal Agencies will collaborate with Universities and Professional Societies, and State and Private groups with international connections (e.g. World Bank, UN's FAO).

Technical Considerations

USDA may need to address additional items such as those that follow. These technical issues deserve consideration as we seek to build scientific knowledge from past foundations (Helms et al. 2002).

1930-1950s: Period of field experiments

Field measurements dominated water programs during the period following the dust bowl. During this time, experimental programs were designed that produced data sets being added to, and still used today. Also, USDA had major input to water programs. SCS developed many programs in response to zealous conservationists like H.H. Bennett (a review of Bennett's work was presented at the 2001 SWCS meeting in South Carolina and excerpted in WASWC (World Association of Soil and Water Conservation Newsletter (V17:N4 dated October 2001). A new proponent with USDA ties is needed to return to earlier significance.

1960-1980s: Computer evolution

The advent of modern computers since WWII generated expanded power for data analysis. The computer development changed the way water research is performed. Increased computer speed, personal computer development, and advances in computing technology have major repercussions on water programs. Although advances have been positive, some needs remain.

1990s: Scientific expertise

Computer development continues at high levels today. The options they provide to monitor and manage water resources is significant. A problem involving student training and rewards for professional water scientists/engineers need discussion.

Students from undergraduate and graduate programs have become *computer jockeys* but they often have scant ideas on organizing and planning the collection of *in-situ* knowledge with which to populate analytical models. Often they do not know if an answer is reasonable but rather want to believe computer calculations. It is easy for me to imagine how our *in-situ* measurement technology could be enhanced. Data collection needs to take advantage of current electronic technology. In many instances, water data is being collected using equipment developed in past decades (not considering space-age technology).

The experience of serving on ARS Peer Review panels where measurements were not recongnized in individual accomplishments is disturbing. This attidude was and is restrictive to scientific progress. How can there be reliable modeling without reliable data? Academicians have similar problems. This *archaic* attitude hinders our ability to measure a system response that we now can simulate so easily, leaves major questions unanswered. How long can this continue before there is litigation resulting from unverified model applications?

Opportunities in hydrologic sciences

A blue-ribbon committee of the National Academy of Sciences (Eagleson 1991) produced a document that enumerated needs and opportunities in the hydrologic sciences. The report advocates hydrology as a distinct geoscience interactive on a range of spatial and temporal scales. Although the report has been accepted at the scientific level (in my opinion), funding and problem solving has progressed slowly because of institutional constraints. Water scientists/engineers continue to disagree over turf battles associated with hydrology (engineering, geosciences, or elsewhere)? What federal agency should lead this effort? Is it necessary to have a lead group?

Consortium of Universities for Advances in Hydrological Sciences, Inc. (CUAHSI)

The consortium was recently incorporated in the District of Columbia in 2001 (www.cuahsi.org). CUAHSI is attempting to build consensus within the university hydrologic research community for future research priorities that will be developed through the National Science Foundation (NSF). Based on National Research Council (NRC) reports, CUAHSI is proposing development of Long-Term Hydrologic Observatories (LTHOs) through major infrastructure proposals to NSF. These in parallel with NSF Long-Term Ecological Research (LTER) site concept will form the basis of the university experimental watershed program. Another key infrastructure aspect that CUAHSI is proposing is development of new measurement technology for hydrology. The LTHO's are large experimental watersheds having drainage areas between 1,000 and 100,000 km^2. The intent of CUASHI is not to replicate work of ARS, USFS, or USGS in catchments less than 1,000 km^2, but to address problems with temporal and spatial variability over large areas. It is still unclear how CUAHSI will coordinate or work with Federal hydrologic research agencies to build on existing Federal experimental watersheds or enhance Federal watershed research to include variables not currently observed in the watersheds.

Summary/Conclusions

Future progress will necessitate changes in funding duration (need longer project funding). Current funding (in academia) is generally for a few years and precludes sampling climatic extremes that are known to exist. Most water resource problems are very non linear requiring data sampling for extended periods.

We need to fully utilize computers, and scientific concepts may well be best accumulated and expressed via computer models, but first we must have well-designed field research. If we are at the proper stage, maybe it is better to say we need a good feedback loop between phenomenological research and computer analysis somewhat as astronomists do.

Water-cycle measurements historically have been made by scientists/engineers with little knowledge of modern data acquisition and storage technology. Furthermore, rewards for personnel performing such work was often treated suspiciously. Grants for such water research must include developing instrumentation. Prediction technology cannot improve without improved measurement and understanding of hydrologic processes. Personnel with advanced training in electronics/physics need to be part of the project team from its inception.

A system must be in place to recognize and reward people performing innovative efforts to improve measurement in water programs. Water activities (in USDA and elsewhere) need input from disciplines not heretofore part of the team addressing temporal and spatial variability in the water cycle. Finally, an emphasis is needed in academia to produce students with training in measurement principals and data accuracy.

Acknowledgments

Manuscript reviews and help with the preparation came from Drs. Mary Nichols, Evan Canfield, Dale Bucks, and Richard Amerman.

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