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## Keynote

## A Perspective of the USDA Watershed Erosion and Sedimentation Research

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Erosion and sedimentation related watershed research in the USA is for the most part traceable to the calamitous events during the “Dustbowl” of the 1930s. At that time, large areas in the Plain States of the USA (Oklahoma, Kansas, Western New Mexico, eastern Colorado, and western Texas) experienced serious wind storms which removed large amounts of surface soil from plowed-up and dried-out unprotected land. While this part of the USA suffered serious agronomic and ecological damage by wind and threatened and impoverished to a catastrophic degree the livelihood of the rural population, the south-eastern part of the USA suffered severe upland area erosion problems and gullies by water from rainfall and runoff especially during severe rainstorms on cultivated unprotected sloping land. In response to these conditions, the U.S. Congress, encouraged by President Roosevelt, set in motion the legal and technical framework to address these problems. The Soil Conservation Service (SCS), a U.S. Government federal agency, was established to perform research and to recommend and assist landowners and farmers with measures to control soil loss. The primary focus was on-site monitoring and quantifying soil loss from natural runoff plots on different soil types in different agricultural practices with sloping topography. Also, sediment movement into and within the stream system and channels of agricultural watersheds was of major concern as deposited soil caused severe siltation and flooding problems. The main goal of the SCS was to conserve the soil on upland areas, stabilize streams, and prevent flooding.

In the 1940s and 1950s SCS erosion and conservation research program was initiated to include in a limited way process oriented research and to arrive at predictive relationships for the effects of hydrology, topography, soil type, and agronomic and mechanical practices. During this period the well-known Universal Soil Loss Equation (USLE), a regression based factor relationship, was developed which had a major impact on soil conservation practices and recommendations, first in the USA but soon thereafter worldwide. This relationship, in particularly its updated versions, is today the main tool for conservation management programs. In 1954 the U.S. Government assigned the research component to a newly established Agency, the Agricultural Research Service. The SCS maintained its role of implementing conservation practices at the farm and watershed level. The research area focused in particularly on the relationship between the exogenic forces of rainfall and runoff characteristics (erosivity) and the soil response to these forces (soil erodibility).

In the 1960s the USLE underlying factor relationships were further improved. The physics of erosion processes became the subject of many research projects aided by the development of rainfall simulator equipment. This equipment could shortcut many of the long-term soil erosion studies and could evaluate in a relative short time the effectiveness of soil conservation practices.

In the 1970s soil erosion mechanics on upland areas, signifying process and analytical approaches to soil erosion research, became of major interest. Similarly, the advent of computer technologies for both statistical and deterministic analyses and calculations facilitated model development of complex erosion processes. At the same time, the USLE was improved, and remained the primary conservation tool for managing upland conservation practices and stream system stabilization measures in agricultural watersheds.

In the 1980s process erosion models such as WEPP (Water Erosion Prediction Project) were developed. The premise was that a better scientific basis for predicting and controlling soil erosion would be obtained for predicting soil erosion on upland areas and for conditions inadequately covered by the USLE. Processed based research and modeling research still continues.. The USLE was updated twice in 1978 and in 2008 and became the Revised Universal Soil Loss Equation (RUSLE) with the publication of Agricultural Handbook 703 in 1997. Since that time, the recently and scientifically improved 2008 version, known as RUSLE2 can be accessed on the Home page of the National Sedimentation Laboratory. RUSLE2 has added capabilities. While the USLE can only be used in cases where erosion takes place and is not applicable when sediment deposition occurs. RUSLE 2 can be applied on upland areas with both erosion and sediment deposition problems. However, it does not address ephemeral or permanent gully erosion.

Work on channel erosion in the USDSA has not received as much emphasis as erosion on upland areas. However, substantial efforts have been made in sediment transport in the USDA. That work was mostly designed to obtain a better understanding of sediment movement in relation to flow regimes and sediment characteristics and to arrive at improved measurement techniques. Some research work was done on stream bank stability problems and protection, control structures, and sediment deposition in lakes and the stream system. Few transport relationships have been obtained. What is lacking is a better understanding of the sedimentary fluid mechanics in stream flow which appreciably may affect sediment movement as shown in shallow flow regimes on upland area.

In the 1990s and 2000nds, with digital computer technology, sophisticated numerical solutions and models have been developed that can predict to a very reasonable degree sediment movement in the stream system under complex flow regimes and geomorphic conditions. Of particular significance are the basic 1D-, 2D-, and 3D-NCCHE numerical computational models developed by the National Center for Hydro-sciences and Engineering at the University of Mississippi under the auspices of the Agricultural Research Service National Sedimentation Laboratory. These models can simulate the flow regime during dam failures of both a catastrophic (sudden collapse) and gradual nature. Likewise, these models can be used to project and determine sediment movement in the upstream and downstream sections of the stream system during and following the removal of functionally outdated dams. Of particular value in this era of climate change are the ability of these models to predict the flow regime in real time, the capability to predict the progression of flow waves in terms of height and velocity, and thus the capability of offering under certain circumstances the possibility of developing an early warning system in case of dam or levee failure. The usefulness of this capability is enhanced by the parallel development of geo-technical techniques by the National Center for Physical Acoustics of the Univ. of Mississippi to determine the stability conditions of earthen dams, to assess the potential for failure. The models also offer great potential in water quality research by following the movement of point and non-point pollutants through the watershed stream system, and estimating their abatement if combined with time dependent and natural decay rate processes. They are also very useful for Action Agency in devising policies regarding permissible discharges, evaluation of chemical hazardous conditions and spreading of pollutants in surface waters.

The weakest link in upland erosion and sedimentation research is an inadequate understanding of the effect of surface and subsurface flow on ephemeral gully and gully development.

With the development of LIDAR technology, one can now accurately assess the contribution of gullies in the erosion and sedimentation processes though research on analytical methods and the underlying physico-chemical factors need far more attention than thus far has been recognized. Perhaps, the most limiting factors to progress in soil erosion and sedimentation research are the availability of well-trained personnel in the STEM (Science, Technology, Engineering, and Mathematics) subjects and budget limits. These aspects will be discussed as well.