SOILOSS – a history of its development and application.

Colin J Rosewell, September 2021

This article describes the development and use of the SOILOSS soil erosion prediction model. The latest version of the software and supporting documents are stored on the NSW Government SEED web-based Portal.

https://datasets.seed.nsw.gov.au/dataset/soiloss

What started it all?

In 1975/76 the surveys conducted as part of the District Technical Manual Program revealed a major soil erosion problem in the lower Namoi valley (Junor et al, 1979). By 1984 it was described as a 'crisis' (Anon, 1984).This resulted from a large increase in the area of grassland being brought into cultivation and being subject to sheet and rill erosion. From 1945 to 1975 the area of the lower Namoi valley affected by both sheet and gully erosion increased from 32% to 52%. Additionally, the normal cropping practice for winter cereals was to burn the stubble after harvest and cultivate for weed control during the fallow exposing bare soil to high intensity rain in January and February.

Alternative crop stubble and tillage management practices for crop land were under investigation and were being advocated for use, but the uptake was slow. Crop farmers faced with tighter margins needed better advice on the effectiveness of erosion control practices and the economic cost of soil erosion (Edwards and Charman, 1980).

What options were available?

In the United States there had been continuing development of the Universal Soil Loss Equation (USLE) as an erosion prediction tool. The latest revision of the USLE was published in 1978 (Wischmeier and Smith, 1978) just after the retirement of the senior author, Walter Wischmeier. He visited Australia in 1979 and cautioned against the adoption of the USLE without evaluation of the rainfall and soil factors.

The Universal Soil Loss Equation is:

$A = R \times K \times L \times S \times C \times P$

where A is the computed soil loss per unit area, expressed in the units selected for K and for the period selected for R. In practice these are usually so selected that they compute A in tons per acre per year.

R, the rainfall and run-off factor, is the number of rainfall erosion index units, plus a factor for run-off from snowmelt or applied water where such run-off is significant.

K. the soil erodibility factor, is the soil loss rate per erosion index unit for a specified soil as measured on a unit plot, which is defined as a 72.6 feet (22.1 metre) length of uniform 9 percent slope continuously in clean-tilled fallow.

L, the slope-length factor, is the ratio of soil loss from the field slope length to that from a 72.6 feet (22.1 metre) length under identical conditions.

S. the slope-steepness factor, is the ratio of soil loss from the field slope gradient to that from a *D* percent stupe under identical conditions.

C, the cover and management factor, is the ratio of soil loss from an area with specified cover and management to that from an identical area in continuous clean-tilled Fallow.

P, the support practice factor, is the ratio of soil loss with a support practice like contouring, strip cropping or terracing to that with straight row farming up and down the slope.

The plan.

In mid-1979 the Australian Standing Committee on Soil Conservation convened a Working Party to establish national research priorities for soil erosion. The Working Party arrived at several general conclusions including the following:

1. That there is a need for a soil loss prediction method as an aid for conservation land use planning in Eastern Australia.
2. That the USLE is the most suitable base for soil loss prediction in Eastern Australia in the short to medium term.
3. That the USLE requires further evaluation and refinement particularly for the soil and rainfall factors.
4. That process-orientated research relating the effect of rainfall/runoff on soil loss be supported with a view to developing an improved soil loss prediction model in the long term.

The Standing Committee on Soil Conservation decided to evaluate the USLE for Australian conditions. This evaluation includes three major aspects.

1. The analysis of the data from the Runoff and Soil Loss plots operated on the Soil Conservation Research Centres.
2. Evaluation of the rainfall erosivity factor.
3. Evaluation of the soil erodibility factor.

Commencing at Cowra in 1943, a series of plot trials were initiated to measure the effect of varying land management practices on surface runoff and soil loss. Data were recorded for varying periods, some more than thirty years, resulting in at least 4,500 plot-years of record. The National Soil Conservation Program provided funding to analyse the data. Results of this work were reported by Edwards (1987).

The Reserve Bank's Rural Credits Development Fund sponsored research on adapting the USLE to New South Wales by providing funds in 1976 for a project to measure rainfall drop-size at Gunnedah using a Distrometer. The Bureau of Meteorology supplied a Distrometer for measurements at Cowra. These measurements were supported by rainfall drop-size data from Bureau Distrometers at Brisbane and Melbourne. The output from the Distrometer at Gunnedah was recorded on a purpose-built micro-computer data logger to avoid the recording losses experienced by the standard recording equipment. Two years of observation at Gunnedah using two methods of recording the data provided a correction equation for use on the Cowra, Brisbane, and Melbourne data. Measurements at Gunnedah continued until 1982 to provide the longest period of measurement anywhere in the world. An equation was developed (Rosewell, 1983, 1986) to allow the estimation of rainfall energy from rainfall intensity records. This work also demonstrated that the energy of rain in eastern Australia is sufficiently like that in the United States to allow the use in Australia of the rainfall component of the USLE.

Measurement of soil loss from unit plots maintained under continuous tilled bare fallow commenced at Inverell in 1977 and at three other sites in the early 1980s. These data were used to determine the soil erodibility factor (K) for use in the USLE (Armstrong, 1990, Rosewell, 1992a). Subsequently, the data from New South Wales and from sites in Queensland were used to show that, with slight modifications, the USLE soil erodibility nomograph could provide useful estimates of the soil erodibility factor from laboratory data, (Loch and Rosewell, 1992).

The Wheat Research Council provided funds in 1984 for Rosewell to visit the United States Department of Agriculture, Agriculture Research Service (USDA ARS) laboratories that were working on the revised USLE (RUSLE). Two objectives were to gather advice on estimating the C-factor for the USLE in NSW and to see what was happening with computer-based decision support systems (Rosewell, 1985a, 1985b, 1986). The work at Gunnedah on the rainfall factor was also shared with ARS counterparts resulting in the equation to estimate rainfall energy being adopted for RUSLE (Renard et.al., 1997)

The Hiccup.

In 1987, Soil Conservation Service Management proposed to stop all research into erosion prediction as it was considered to be "technology not required at that time". This prompted efforts to demonstrate to regional staff the use of soil erosion prediction technology based on the USLE to provide an objective method of soil erosion hazard assessment and for the selection of management practices to reduce erosion (Rosewell, 1987). Edwards assembled an information package and created a simple computer program to illustrate the application of the USLE and demonstrated it to staff in the southern regions. Rosewell demonstrated it in the northern, western, and north coast regions There was enthusiastic support for erosion prediction technology and approval was given for a 12-month project to assemble a computer-based application of the USLE with interim data for NSW crop and pasture lands.

The Fix.

Interim information was available on the magnitude and seasonal distribution of the rainfall erosivity factor; approximations of soil erodibility for a small range of soils; and the C-factor could be estimated for permanent cover from the data provided in the USDA Handbook. However, the C-factors for NSW crops and cropping practices were not available.

The developers of the USLE had suggested that subfactors could be used to estimate the C-factor for crop land. This subfactor approach was further developed by the USDA-ARS (Laflen et.al. 1985). Rosewell had discussed the methodology with those authors in 1984 and carried out research on methods to adapt it to NSW. The C-factor may be estimated from subfactors for crop height, canopy cover, ground cover, surface soil roughness, soil density, crop residue decay, residual effects of previous crops and the combination of these subfactors with the seasonal distribution of erosive rain. It was found that reasonable estimates of the subfactors could be made using simple models and actual data for a range of crops grown in NSW. The procedure was complex, and it was necessary to develop computer routines to do the calculations. The computer routines formed a module which incorporated a crop growth model, a tillage model, and a residue management and decay model. The models were calibrated using local data and tested against either published information or expert opinion. This program module became the core module of the first versions of SOILOSS.

SOILOSS V3

SOILOSS V3 software and Handbook was published (Rosewell and Edwards, 1988) with a public launch at the NSW Parliament House. The development of the SOILOSS model, its early validation and application are described in Edwards and Rosewell (1990). Further validation is reported by Rosewell (1992b, 1993).

SOILOSS V3 was written in Microsoft Basic for DOS-based IBM PCs. A key to its successful use was the development of a very simple interface with all input from the user being carefully controlled using an input routine that Rosewell had developed for commercial computer games. The software also provided easy testing of 'what-if' scenarios with 'expert' advice to the user.

At that time, SOILOSS was the first erosion prediction program to use subfactor for the estimation of the C-factor, the first implementation of the USLE to use data appropriate for NSW and the first commercially available software to implement the USLE in SI units.

Each Soil Conservation Service Region appointed a SOILOSS liaison officer. These persons attended a SOILOSS workshop and then demonstrated and promoted SOILOSS in their regions. They communicated their experiences via a SOILOSS Newsletter. SOILOSS was being used for land use planning; assessment of erosion risk on reclaimed mine land; and on land being developed for urban use. The feedback provided by users was incorporated in later versions of SOILOSS. Of particular interest was a request from High School Agriculture and Geography teachers for a version of SOILOSS compatible with Apple computers.

SOILOSS V3 used the rainfall erosivity factor calculated from the rainfall intensity data recorded on four Soil Conservation Research Centres. The seasonal distribution of erosive rain was estimated for three zones in NSW – the northern summer dominant rainfall zone; the southern winter dominant rainfall zone; and a central non seasonal zone.

The National Soil Conservation Program provided funds to extend this to 29 pluviograph stations in NSW. The results (Rosewell and Turner, 1992) provide a more detailed spatial and seasonal distribution of rainfall erosivity. Equations were developed for estimating the rainfall factor (R) and the 1 in 10-year storm erosivity (for use in RUSLE) from more readily available data on rainfall intensities. The procedures were packaged in the computer program RAINER (Zolotarev and Rosewell, 1993) which could be used anywhere in Australia.

SOILOSS V3 and RAINER were marketed as commercial software.

SOILOSS-High School

A significant early use of SOILOSS was for student education at High Schools, Technical Colleges and Universities. The Soil Conservation Service employed a Landcare Coordinator who worked with the Department of Education to prepare teaching material on soil erosion. A simplified version of SOILOSS was developed using Microsoft QuickBasic and released as SOILOSS-High School (Keats and Rosewell, 1993). The Department of Education converted this program for Apple computers. SOILOSS-High School was supplied free of charge to all High Schools in NSW. SOILOSS-High School was recommended for junior and secondary level in Geography, Agriculture, Design and Technology, Science, Mathematics and Computer Studies.

This version of SOILOSS was much easier to use than SOILOSS V3 and included the new length of slope (L) and steepness (S) factors from RUSLE. It was the first version used by State Forests and other Government Agencies for erosion hazard assessment. In 1995 the Department of Conservation and Land Management agreed to allow the USDA-ARS to use SOILOSS-High School as a model for a "High School Level Erosion Awareness Training Module".

SOILOSS V5.1

By 1993, the new information on rainfall erosivity (Rosewell and Turner, 1992), soil erodibility (Rosewell, 1992a; Loch and Rosewell, 1992) and the validation of SOILOSS on the crop lands of NSW lead to increasing confidence in the reliability of SOILOSS for erosion prediction. SOILOSS was being used on pasture, urban, mining and forest land. SOILOSS V5.1 was released in October 1993. The program included the new RUSLE L and S factors; new data for rainfall erosivity and its seasonal distribution; enhanced procedures for calculating the crop factor; and new procedures for assessing the effect of soil conservation works on sediment yield. The program could be installed either for use in NSW or Australia-wide with up to 12 rainfall distribution zones and up to 8 crops in each zone. The rainfall and crop data are stored in user accessible and modifiable data files. The program contains over 140 pages of on-line help and technical information (when run in a 32-bit environment). The SOILOSS handbook is itself a significant reference source. The validation of SOILOSS shows that for a range of soil loss from 0.3 t/ha/y to 143 t/ha/y, SOILOSS estimates a mean soil loss within 11% of the observed mean.

SOILOSS V5.1 was awarded third prize in the Decision Support category of the Farm Software Competition, Royal Easter Show, Sydney, 1994.

SOILOSS and its associated technology was the main vehicle for implementing Government policy on soil erosion hazard and the selection of improved management practices to reduce soil erosion on agricultural, urban and forest lands of NSW.

> 1990, Department of Housing, NSW. SOILOSS specified for use in the estimation of sheet and rill erosion on urban development sites.
>
> 1993, Standard Erosion Mitigation Guidelines for forest logging. SOILOSS used to estimate Erosion Hazard Categories.
>
> 1994, NSW Agriculture. SOILOSS specified for use in estimating the effect of pasture cover on sheet and rill erosion for state-wide Sustainable Pastures Project.
>
> 1995, Environment Protection Authority, NSW. SOILOSS specified for use in estimating the Water Pollution Hazard Category for proposed logging in State Forests.

In 1997, SOILOSS technology was used to produce the first ever map of an Australia-wide indicator of sheet and rill erosion for the Commonwealth State of the Environment Report (Rosewell, 1997).

SOILOSS V5.2

The program was updated in 2000 to version 5.2 with the addition of procedures for estimating the effect of rill/interrill ratios; improved calculation of the K-factor using a revised equation for the K-factor nomograph; and provided a table of K-factors for generic soils based on soil texture. Support for Windows 95 and 98 was added to the install program.

SOILOSS V5.3

The Namoi Catchment Management Authority commissioned an update to SOILOSS in 2005 to facilitate printing of reports under Windows XP (32-bit). The program was modified to provide an option to either save reports to text files for later viewing and printing or to redirect the DOS printer output to USB and network connected printers.

SOILOSS V5.4

Following a request from University of Canberra teaching staff, a 64-bit version of SOILOSS was created in 2019 using QB64 (a self-hosting BASIC compiler for Microsoft Windows designed to be compatible with QuickBasic). It is compatible with 64 and 32-bit operating systems but no longer has access to the Help System. The full features of SOILOSS V5.3 are only available on 64-bit machines by running the program in a virtual Windows 7 (or earlier) 32-bit environment.

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