Overview of RUSLE2

**RUSLE2 Components**

**RUSLE2** includes several components. One major RUSLE2 component is the **computer program** that solves the many **mathematical equations** used by RUSLE2. A very important part of the RUSLE2 computer program is its **interface** that connects the user to RUSLE2. Another major component of RUSLE2 is its **database**, which is a large collection of input data values. The user selects entries from the database to describe site-specific field conditions. The other major component of RUSLE2 is the **mathematical equations, scientific knowledge, and technical judgment** on which RUSLE2 is scientifically based.

**RUSLE2 Estimates Rill and Interrill Erosion**

RUSLE2 estimates rates of **rill and interrill soil erosion** caused by **rainfall** and its associated **overland flow**. **Detachment** (separation of soil particles from the soil mass) by surface runoff erodes small channels (**rills**) across the hillslope. Erosion that occurs in these channels is called rill erosion. Erosion on the areas between the rills, the **interrill areas**, is called interrill erosion. Detachment on interrill areas is by the impact of raindrops and waterdrops falling from vegetation. The detached particles (**sediment**) produced on interrill areas is transported laterally by thin flow to the rill areas where surface runoff **transports**the sediment downslope to **concentrated flow areas**(channels).

**Factors Affecting Erosion**

The four major factors of **climate, soil, topography**, and **landuse** determine rates of rill and interrill erosion. A RUSLE2 user applies RUSLE2 to a specific site by describing field conditions at the site for these four factors. RUSLE2 uses this field description to compute erosion estimates.

**Land Use Independence**

RUSLE2 is **land use independent**. It is based on equations that describe how basic features like plant yield, vegetative canopy and rooting patterns, surface roughness, mechanical soil disturbance, amount of biomass on the soil surface and in the upper layer of soil, and related factors affect rill and interrill erosion. The RUSLE2 user conveniently selects information in the RUSLE2 database to describe these variables at a specific field site. The RUSLE2 user is not required to collect field data on these variables.

RUSLE2 takes advantage of the fact that erosion is directly related to the **forces applied to the soil**by **erosive agents**in relation to the **soil’s resisting forces**regardless of the land use. RUSLE2 can be applied to cropland, rangeland, disturbed forestland, mined land, construction sites, reclaimed land, landfills, military training sites, parks, and any land where mineral soil is exposed to the direct forces of waterdrop impact and surface runoff generated by rainfall intensity being greater than the infiltration rate of water into the soil.

**Running RUSLE2**

RUSLE2 is very easy to use. With the exception of topography, the RUSLE2 user describes the site-specific field conditions by selecting database entries from menus. When a menu selection is made, RUSLE2 “pulls” values stored in the RUSLE2 database and uses them as input values to compute erosion. The user enters site-specific values for slope length and steepness to represent topography.

**Overview of Major Factors**

**Climate**: The most important climatic variable used by RUSLE2 is rainfall **erosivity**, which is related to rainfall amount (how much it rains) and intensity (how hard it rains). Another important climatic variable is temperature because temperature and precipitation together determine the longevity of biological materials like crop residue and applied mulch used to control erosion. Climate varies by location, and choosing a location in RUSLE2 chooses the erosivity, precipitation, and temperature values needed to apply RUSLE2 at a particular site.

**Soils**: Soils vary in their inherent **erodibility** as measured in a standard test involving a “**unitplot**.” A unit plot is 72.6 ft (22.1 m) long on a 9% slope and is maintained in continuous tilled fallow (no vegetation) using periodic tillage up and down slope to leave a “seedbed-like” soil condition. The USDA-NRCS has assigned soil erodibility values for most cropland and similar soils across the US. RUSLE2 includes a procedure for estimating soil erodibility for highly disturbed soils at construction sites and reclaimed mined land. The RUSLE2 user typically selects a soil by soil-map unit name from a list of soils in the RUSLE2 database.

**Topography**: **Slope length, steepness**, and **shape** are the topographic characteristics that most affect rill and interrill erosion. Site-specific values are entered for these variables. See the section on Definitions for additional information concerning these variables.

**Land Use**: Land use is the single most important factor affecting rill and interrill erosion because type of land use and land use condition are features that can be most easily changed to reduce excessive erosion. RUSLE2 uses the combination of **cover-management (cultural) practices and support practices** to describe land use.

Cover-management practices affect both the forces applied to the soil by erosive agents and the susceptibility of the soil to detachment. For a given land use like cropland, important features include the crops that are grown, yield level, and the type of tillage system such as clean, reduced, or no till. Important features on a construction site include whether or not the land is bare, the soil material is a cut or fill, mulch has been applied, or the slope has been recently reseeded. Important features on range and reclaimed land include the native or seeded vegetation, production level, and degree of ecological maturity. The description of any cover-management practice is created, named, and stored in the RUSLE2 database. When RUSLE2 is run, the cover-management practice that fits the site-specific field condition is selected from the menu of choices. Changes can be made in key variables such as production (yield) level or mulch application rate so that the practice fits the local climate, soil, and other conditions.

Support practices include ridging (e.g., contouring), vegetative strips and barriers (e.g., buffer strips, strip cropping, fabric fence, gravel bags), runoff interceptors (e.g., terraces, diversions), and small impoundments (e.g., sediment basins, impoundment terraces). These practices reduce erosion primarily by reducing the erosivity of surface runoff and by causing deposition. Support practices are selected from a list of these practices in the RUSLE2 database. Site-specific information, such as the location of a diversion on the hillslope, is entered as required for each practice.

How RUSLE2 Computes Rill and Interrill Erosion

**Uses Conservation of Mass Principle**

**RUSLE2**uses the **conservation of mass** principle to compute estimates of rill and interrill erosion. This principle can be illustrated by considering a segment of the overland-flow path.



If **rill erosion** occurs within the segment, the amount of sediment leaving the segment (**sediment load**) = the amount of segment that enters the segment from upslope + the amount of sediment produced by interrill erosion within the segment + the sediment detached within the segment by rill erosion. If **deposition** occurs within the segment, the sediment load leaving the segment = the sediment load that enters the segment from upslope + the amount of sediment produced by interrill erosion within the segment - the sediment deposited within the segment. If net **detachment** occurs by both rill and interrill erosion, the sediment load increases along the slope, which is typical for **uniform**, **convex**, and **mildly concave** slopes. If net deposition occurs, the sediment load decreases along the slope in the depositional area, which is typical of **strongly concave** slopes. In contrast to the USLE and most applications of RUSLE1, RUSLE2 can be applied to **concave** and **complex** slopes where deposition occurs. Thus, RUSLE2 can compute **sediment yield** from hillslopes where deposition occurs.

**Detachment or Transport Limiting Principle**

The other basic computational principle is that RUSLE2 computes detachment by flow when the transport capacity of the runoff exceeds the sediment load in the flow. Conversely, RUSLE2 computes deposition when the sediment load is greater than **transport capacity**. The principle is like a bucket. A bucket can’t carry more than its capacity.

**Computing Net Detachment**

RUSLE2 computes net detachment each day using a variation of the familiar USLE factors:

a = r k l S c p

where: a = net detachment (mass/unit area), r = erosivity factor, k = soil erodibility factor, l = slope length factor, S = slope steepness factor, c = cover-management factor, and p = supporting practices factor. The lower case symbols represent daily values. Upper case symbols used in the USLE and RUSLE1 represent annual values. Each factor, except the slope steepness factor S, in equation 1 changes as environmental conditions change daily and as cover-management conditions changes with specific events, like a soil-disturbing operation. **Although the values used for each factor are daily values, they represent long-term average conditions for that day.**

The key element in this equation is the product of rk, which produces a daily sediment production estimate for unit-plot conditions. The variables r and k have units so that the product rk has **absolute units**of mass/area. The other variables in equation 1 adjust the unit-plot sediment production value to reflect differences between unit-plot conditions and site-specific field conditions. The factors l, S, c, and p are **ratios**of sediment production from the given field condition to unit-plot conditions and do not have units.

**Computing Deposition**

Deposition is computed with the equation:

D = (Vf/q) (Tc –g )

where: D = deposition rate (mass/unit area), Vf = fall velocity of the sediment, q = runoff rate, Tc = transport capacity of the runoff, and g = sediment load (mass/ unit width). RUSLE2 divides the sediment load into **five sediment classes** (primary clay, silt, and sand, small aggregates, large aggregates) that vary in size and density. The distribution of the sediment load among these classes depends on soil texture and the amount of upslope deposition. When RUSLE2 computes deposition, it computes how deposition enriches the sediment load in fine particles. The sand and large aggregate particles are deposited first while the clay, silt, and small aggregate particles travel further downstream before being deposited. Whereas detachment is a nonselective process, deposition is a highly selective process.

**Mathematical Integration of Equations**

Solving erosion equations involves a mathematical integration process. RUSLE2 uses a complete integration procedure while both the USLE and RUSLE1 use approximations. RUSLE2 multiplies daily factor values and adds those values to compute annual erosion. In contrast, the USLE and RUSLE1 first integrate the individual factors and then multiplies those values to compute annual erosion. The USLE and RUSLE1 approximations, which are less accurate than the RUSLE2 computations, can account for a difference of up to 20% difference in erosion estimates between RUSLE2 and the USLE or RUSLE1.

The approximations used in the USLE and RUSLE1 were required so that those equations could be implemented in a “paper” version. Although RUSLE2 can compute values for the familiar annual K, L, C, and P factors, those factors are not used in RUSLE2 and are not typically displayed in the RUSLE2 output.

**Factors Used in Erosion Equations in RUSLE2**

**r factor: Annual erosivity R** is the sum of the daily r values. The R factor represents the erosivity of the climate at a particular location. An average annual value of R is determined from historical weather records using erosivity values determined for individual storms. The erosivity of an individual storm is computed as the product of the storm's total energy, which is closely related to storm amount, and the storm's maximum 30-minute intensity. Erosivity range from less than 8 (US customary units) in the western US to about 700 for New Orleans. All other factors being the same, soil loss is 100 times greater at New Orleans, Louisiana than at Las Vegas, Nevada. (**RUSLE2 can also work in metric units as well as US customary units**.)

The required erosivity information has been placed in the RUSLE2 database for individual U.S. counties in the eastern US where erosivity does not vary spatially over the county and by precipitation zone and specific locations in counties in the western US where erosivity varies spatially because of elevation or other effects. A similar organization of the climate data can be used for RUSLE2 applications outside of the U.S.

**k factor**: In RUSLE2, the upper case K represents the **base soil erodibility** as determined using the **soil erodibility nomograph**. The lower case k represents the soil erodibility factor value on a given day during the year. RUSLE2 computes temporal values of soil erodibility as a function of temperature and precipitation. The K factor is an empirical measure of soil erodibility as affected by **intrinsic soil properties**. Erosion measurements based on unit-plot conditions were used to experimentally determine the values for K used to derive the soil erodibility nomograph.

The K factor is a measure of soil erodibility under the standard unit-plot condition. Land use, such as that involving plant roots and incorporation of organic material into the soil affects, soil erodibility, but such effects are considered in the cover-management c factor. The K factor represents the combination of detachability of the soil, runoff potential of the soil, and the transportability of the sediment eroded from the soil.

The main soil properties affecting K are soil texture, including the amount of very fine sand in addition to the usual sand, silt, and clay percentage used to describe soil texture; organic matter; structure; and runoff potential as related to permeability of the soil profile. In general terms, high clay soils have low K values because theses soils are resistant to detachment. High sand soils have low K values because these soils have high infiltration rates and reduced runoff, and sediment eroded from these soils is not easily transported. Silt loam soils have moderate to high K values because soil particles are moderate to easily detached, infiltration is moderate to low producing moderate to high runoff, and the sediment is moderate to easily transported. Silt soils have the highest K values because these soils readily crust producing high runoff. Also, soil particles from silt soils are easily detached, and the sediment is easily transported.

This mixture of effects illustrates that **K is empirical**. It is not a soil property but is defined by **RUSLE definitions**. The definition for K, and for all RUSLE factors as well, must be carefully observed to achieve accurate results. For example, using K to account for reduced soil loss from incorporation of manure is not proper and produces incorrect results.

**lS factor**: The l and S factors jointly represent the effect of **slope length, steepness**, and **shape** on sediment production. The lowercase ‘l’ in RUSLE2 represents how the slope length factor varies daily as cover-management conditions vary. The upper case L represents an annual value that has been weighted based on the distribution of erosivity during the year. The S factor does not vary during the year in RUSLE2.

RUSLE2 represents the total of rill and interrill erosion. Rill erosion increases in a downslope direction because runoff, which is the primary erosive agent for rill erosion, increases in a downslope direction. In contrast, interrill does not vary with location on the slope because it is primarily caused by raindrop impact. Therefore, the slope length factor “l” is greater for those conditions where rill erosion is greater relative to interrill erosion.

Erosion increases with slope steepness. RUSLE2 makes no differentiation between rill and interrill erosion in the S factor that computes the effect of slope steepness on soil loss. The science for the effect of slope steepness on the rill-interrill erosion ratio did not seem sufficient to adjust the S factor in RUSLE2.

Slope shape is the spatial variation of steepness along the slope. Steepness at a position on the hillslope greatly affects erosion. Erosion is greatest for **convex** slopes that are steep near the end of the slope length where runoff is greatest. Erosion is least for **concave** slopes where the upper end of the slope is steep and runoff is least. Deposition occurs on concave slopes where transport capacity of the runoff is significantly reduced as the slope flattens. Sediment yield from these slopes is less than the amount of sediment produced by erosion.

**c factor**: The c factor accounts for the effects of cover-management. The lower case c in RUSLE2 refers to the cover-management factor for each day. The upper case C refers to an average annual C factor value where the individual daily c factor values have been weighted by the distribution of erosivity during the year.

Daily c factor values are computed using the subfactor method. RUSLE2 uses subfactors for **canopy** (cover above but not in contact with the soil surface), **ground cover** (cover directly in contact with the soil surface), **surface roughness**, **time since last mechanical soil disturbance**, amount and distribution of **live and dead roots** in the soil, **organic material that has been incorporated into the soil**, **ridge height**, and **antecedent soil moisture**, which is only used in the Northwest Wheat and Range Region (NWRR). These variable change through the year as plants grow and senesce, the soil is disturbed, materials are added to the soil surface, and vegetative or other organic materials are removed or incorporated into the soil.

RUSLE2 computes the decay of organic material and the amount of standing stubble that falls each day based on properties of the material and daily precipitation and temperature at the location. RUSLE2 computes loss of surface roughness and ridge height based on daily precipitation amount and interrill erosion. RUSLE2 computes how a mechanical soil disturbance buries surface materials and distributes buried materials and dead roots in the soil.

**RUSLE2 does not model vegetative growth**. Instead, RUSLE2 makes its erosion computations based on a description of the vegetation. The user provides a description of the vegetation by making selections from the RUSLE2 database. These descriptions are stored in the RUSLE2 database and are selected by making a menu choice. Key values such as production level and crop yield can be changed to represent local conditions.

**p factor**: The lower case p refers to a daily value of the support practices factor. The upper case P is an average annual value determined from the individual daily p values weighted by the erosivity distribution or by taking the ratio of soil loss with the practice to soil loss without the practice. The effect of ridging (contouring) is taken into account by how ridge height, row grade, and runoff affect detachment and transport of sediment. The effect of barriers like vegetative strips is taken into account by how these features reduce transport capacity by slowing the runoff (e.g., vegetative retardance) and cause deposition. The effect of runoff interceptors (diversions, terraces) is taken into account by how these practices reduce slope length and cause deposition in the channels created by these interceptors. The effect of small impoundments is taken into account by how these practices deposit sediment. Deposition that occurs on concave slopes is taken into account by solving the conservation of mass equation along the flow path.

**T c transport capacity**: Transport capacity is computed as a function of runoff rate, slope steepness, and hydraulic resistance. RUSLE2 uses the 10 yr-24 hr precipitation amount and the NRCS curve number method to compute runoff. RUSLE2 computes how runoff potential changes daily as a function of cover-management conditions. RUSLE2 computes daily hydraulic roughness from the soil surface roughness, live ground cover, ground cover provided by crop residue and mulch, and vegetative retardance.

RUSLE2 Definitions

**RUSLE2** uses a specific set of definitions, partly because the disciplines involved in soil erosion have not developed a common set of definitions. Observance of RUSLE2 definitions is required to obtain proper erosion estimates from RUSLE2 and to make the proper interpretation of those estimates.

**Overland-Flow Path**

The basic computational unit in RUSLE2 is an **overland**-**flowpath**. The overland-flow path used in RUSLE2 is the path that runoff follows from the origin of overland flow to the point where it enters a **concentrated flow area**, defined as a channel. The topographic information entered into RUSLE2 by the user for a specific site describes the slope steepness along this path.

**Basic RUSLE2 Erosion Variables**



RUSLE2 estimates **average annual soil loss** from the **eroding portion** of the overland-flow path, **deposition** on the **depositional portion** of the path, and **sedimentload** along the overland flow path. **Sediment yield** (**delivery**) is the sediment load at the end of the overland flow path, at the outlet of terrace/diversion channels, or discharged from sediment basins that are considered in the overland flow path **(profile) r**epresentation used in a particular RUSLE2 computation. These quantities are expressed in units of mass per unit area per year.

**This sediment yield is for a site only if the RUSLE2 flow path happens to end at the site boundary.**

**Detachment** is the separation of soil particles from the soil mass. Net detachment adds sediment to the sediment load and causes sediment load to increase in a downslope direction. Deposition is the transfer of sediment from the sediment load back to the soil mass. **Local deposition** is the deposition of sediment very near to the point where the sediment was detached. Deposition of sediment eroded from soil clods in nearby depressions formed by the clods is an example of local deposition. **Remote deposition**is the deposition of sediment far from its point of origin such as deposition in a terrace channel or on the toe of a concave slope.

**Main RUSLE2 Outputs**

RUSLE2 displays the four output values of: soil loss from the eroding portion of the slope, detachment for the entire overland flow path, conservation planning soil loss, and sediment delivery (yield). **Soil loss**has a specific meaning. Soil loss is the net loss of sediment from the eroding portion of the overland-flow path. This value is used in **conservation planning**to select cover-management and support practices to control soil loss to a value less than **soil loss tolerance** or some other conservation planning criteria. **Detachment** is the total sediment production for the overland flow path length represented in a RUSLE2 computation. **Sediment delivery (yield)** is the amount of sediment leaving the flow path represented in a RUSLE2 computation. **Total deposition** for the overland-flow path, which is not displayed, is the differences between total detachment (sediment production) and sediment yield. **Conservation planning soil loss** gives partial credit to remote deposition depending on where the deposition occurs along the overland-flow path. RUSLE2 gives very little credit as “**soil saved**” for deposition that occurs near the end of the overland-flow path. Conservation planning soil loss is generally less than total detachment (sediment production) and greater than sediment yield. Full credit is taken for local deposition as soil saved.

**Topographic Descriptions**



RUSLE2 can be applied to the many illustrated profile shapes that occur on both natural and constructed hillslopes. The **USLE slope length** definition was that deposition ended the slope length. However, if the overland flow continued across the depositional area, the slope length for the lower portion of the hillslope did not begin where deposition ended but began at the top of the hillslope where runoff began. The **complex: concave-convex** hillslope illustrates such a profile. The USLE cannot be easily applied to this slope shape. Rather than use the traditional USLE slope-length definition, RUSLE2 uses an overland-flow path-length definition. The RUSLE2 overland flow path length is the distance from the origin of overland flow to where the flow enters a concentrated flow area like an ephemeral gully or a terrace channel. RUSLE2 is very easy to apply to this slope shape and requires no special considerations for slope length like the USLE.

However, RUSLE2 can also be applied to only the eroding portion of the slope to make USLE compatible soil loss estimates. In this application, the USLE slope length can be used in RUSLE2 as the distance from the origin of overland flow to the point where deposition begins on concave slopes or to a concentrated flow channel.

The recommended RUSLE2 approach is to represent the entire overland-flow path from origin of the overland flow to a concentrated flow channel. RUSLE2 automatically determines where deposition occurs as a part of its computations. RUSLE2 computes and displays the soil loss on the eroding portion of the overland-flow path, the deposition on the depositional portion of the overland-flow path, and sediment yield from the overland-flow path without any additional consideration. RUSLE2 uses the hillslope profile description entered by the user to make the appropriate computations. This application illustrates the increased power of RUSLE2 over the USLE.



A special and easy application of RUSLE2 is the cut-roadway-fill slope. The first analysis might be to assume an outward sloping roadway. In that case, the overland flow path is from the top of the cut slope to the bottom of the fill slope. If the slope of the roadway is back into the hillslope (i.e., the roadway has an adverse slope), a negative steepness is entered for the roadway and RUSLE2 automatically divides the slope into the proper overland flow path lengths.

RUSLE2 also computes the deposition that occurs in diversions and terrace channels that end an overland flow path. However, RUSLE2 does not compute the erosion that occurs in these channels if they are on a steep grade. RUSLE2 also computes deposition in small sediment basin type impoundments.

RUSLE2 computes the erosion rate (or deposition) for individual slope segments. These erosion (or deposition) values represent net sediment production (or deposition) within each segment. The ability to compute net sediment production along a slope is a very powerful RUSLE2 feature, especially for convex shaped slopes. Erosion rate at the end of a convex slope can be much greater than the average erosion rate for the entire slope.

Download RUSLE2

**RUSLE2 Templates:**

An advantage of RUSLE2 is that it can be configured to fit the application, complexity of the field conditions being represented, and individual preferences. The RUSLE2 interface templates are used to control the appearance and action of RUSLE2 as well as the required input and the output that is displayed.

RUSLE2 generates much more information than is displayed with the templates available from this site. Contact the State Agronomist if you have a special need for information available in RUSLE2 that is not being displayed by the templates available at this site.

**NRCS National RUSLE2 Database:**

The **NRCS National RUSLE2 Database** is extensive and has been carefully developed. It is the source of the database information used by NRCS field office personnel. This database is available at <http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm>.

Import information from the NRCS database as you need it rather than downloading the entire database, even for a state. If you don’t find the information in the NRCS database that you need for your application, contact your NRCS State Agronomist.

Cover-management entries in the NRCS RUSLE2 database are keyed to NRCS cropping-management zones. The NRCS cropping-management zones (CMZ) are identified on a map available on the NRCS RUSLE2 Internet site <http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm.>  To import NRCS (CMZs) into an ARS database requires two steps.  First, the CMZ must be imported into the NRCS Base database (<http://fargo.nserl.purdue.edu/RUSLE2_ftp/NRCS_Base_Database/>), and then the CMZ data must be imported from the modified base database into the ARS database with the "include all dependent files" option checked.  This two step process is needed because all the NRCS vegetation and operation descriptions are located in the NRCS base database and are not included in the individual CMZ databases.

The NRCS database is primarily for cropland applications. It also contains extensive information on climate and soils needed to apply RUSLE2 to any land use. Even though you may not be interested in the cropland data in the NRCS database, you will certainly need the climate data in the NRCS database.

If you are working with cropland soils and similar soils, you will also need the NRCS soils data from the NRCS national RUSLE2 database. The soil’s information in the NRCS database is keyed to the **NRCS Soil Survey**. Contact your local NRCS field office for a copy of a soil survey for your county. If you have NRCS soil survey information, you can create your own RUSLE2 soil entries for your working database. If you are working with highly disturbed lands, refer to the draft RUSLE2 Reference User Guide for information on how to obtain the necessary RUSLE2 soils inputs.

**User Instructions:**

A Summary RUSLE2 User Manual is available on this Internet site to get you started on using RUSLE2. A RUSLE2 User Manual with emphasis on highly disturbed land is also available from the International Erosion Control Association ( [http://www.ieca.org](http://www.ieca.org/)). Also, tutorial and other user instruction information is available from the University of Tennessee on the Internet site [www.rusle2.org](http://www.rusle2.org/). Tutorials specific to the NRCS applications are available on the NRCS RUSLE2 Internet site <http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm>.

**Overview of RUSLE2:**

A Power Point® file available for download on this Internet site, including speaker notes, provides an overview of RUSLE2. Also, a workbook giving an overview of RUSLE2 and how RUSLE2 is applied to highly disturbed land is available from the International Erosion Control Association ( [http://www.ieca.org](http://www.ieca.org/)).

**Reference User Guide:**

The Reference User Guide available for download on this Internet site is an in-depth reference guide. It is incomplete and in draft form. The final version of the Reference User Guide is expected to be available by late 2003. It uses semi-technical language to describe in detail how RUSLE2 works, how RUSLE2 represents the factors that affect soil erosion by rainfall and associated runoff, how to select RUSLE2 input values, and how to interpret RUSLE2 output.