CHAPTER FIVE

C factor: Cover-Management

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The cover-management factor (C) represents the effects of vegetation, management, and erosion-control practices on soil loss. As with other RUSLE factors, the C value is a ratio comparing the existing surface conditions at a site to the standard conditions of the unit plot as defined in earlier chapters.

The C factor represents the effect of plants, soil covers, soil biomass (roots and incorporated residue), and soil-disturbing activities on soil loss. RUSLE uses a sub-factor method to compute soil-loss ratios (SLR), which are the ratios of soil loss at any given time in the cover-management sequence to soil loss from the standard condition. The sub-factors used to compute a soil-loss ratio value are prior land use, canopy cover, surface cover, surface roughness, and soil moisture. The C value is the average soil-loss ratio weighted by the distribution of rainfall EI (energy x intensity) during the year.

C-Factor Options

There are two C-factor options in RUSLE, a time-invariant option and a time-variant option. The time-invariant option is used when the conditions described by the C factor remain constant or do not change sufficiently over time to change soil-loss rates, such as on most rangeland or pastureland.

The time-variant option is used when there are changes in vegetation and soil conditions that significantly affect soil-loss rates. Such conditions may occur in at least three ways. For reclaimed prime agricultural lands, crop rotation may be utilized consisting of a particular sequence of operations and crops that are repeated on an annual or longer cycle. The number of years in the rotation is entered into the RUSLE program, together with the operations and crops in chronological order. RUSLE computes sub-factor values for 15-day periods throughout the period of rotation and provides and overall rotational C value.

The time-variant option for rotation also may be used for a pasture or range land where the vegetation varies significantly during the year. In the Spring, the canopy and new roots systems develop, while in late Summer, the canopy decreases due to the leaf-fall that adds litter to the soil surface and the roots slough that adds biomass to the soil. A one-year rotation captures this natural annual cycle of vegetation changes. The time invariant option cannot account for the accumulation of litter on the surface or the accumulation of biomass in the soil.

The time-variant option also may be used to account for changes in conditions during the first few years after revegetation of a reclaimed site. Here, "zero" years is designated as the period of rotation. With a "zero" years rotation, the initial surface and soil conditions must be carefully set using an appropriate operation, such as a tandem disk to create a freshly-disturbed soil. No soil-disturbing operation is used for a "cut" soil condition. However, for a "cut" soil the root biomass remains in the soil if the depth of the cut is not below the root zone. This condition can be simulated by the establishment and killing of a plant cover that provides no cover, but leaves a root biomass in the soil following the killing operation.

Both the time-invariant and the time-variant options can be used when developing a reclamation plan for surface mining or construction sites. The time-invariant option would be used to document the conditions prior to disturbance, when mining or construction is planned on rangeland or permanent pasture. To develop a reclamation plan, the time-variant option would be used to describe conditions during the first few years following reclamation. During this period, the conditions affecting soil loss, such as canopy cover, surface cover, surface roughness, and soil consolidation will be changing. Soil consolidation is to the result of physical and biological processes that cause aggregation of soil particles that, in turn, reduce soil erodibility. After a few years, when these conditions become relatively stable, the time-invariant option could be used to describe post-reclamation conditions.

C Sub-factors

Data from the three databases (VEG, OPERATIONS, and CITY) and from user inputs, are used by the RUSLE program to derive the five C sub-factor values. These five values are then multiplied together by the RUSLE program to arrive at the C value for a specified management period. The sub-factors are prior land use (PLU), canopy cover (CC), surface cover (SC), surface roughness (SR), and antecedent soil moisture (SM). Each sub-factor value can range from slightly greater than 1 (indicating no reduction in soil-loss rates) to 0 (indicating that no soil loss will occur). Only prior land use, canopy cover, surface cover, and surface roughness will be discussed here because the soil-moisture sub-factor applies only to lands in the Northwest Wheat and Range Region of the U.S.; detailed discussion of the particular characteristics of this region and the manner by which they are addressed in RUSLE are available in AH-703 (Renard et al., 1997).

Prior Land Use

The prior land-use sub-factor (PLU) reflects the effects of soil loosening by tillage or other deep disturbance, and soil biomass (incorporated residue and plant roots) on soil-loss rates. These variables interact to give the PLU factor. For example, land that is plowed from meadow or pasture is only about 25 percent as erodible as land under continuous cropping. This is due to the effects of the vegetation incorporated by tillage and the stable soil aggregates formed under sod. Conversely, for reclaimed prime agricultural lands in a corn-soybeans rotation, the soil is about 40 percent more erodible in the year following soybeans than if it had been planted to corn due to lower soil biomass.

The PLU factor would be high (approaching 1) during and immediately following mining and construction because the topsoil is often stripped and stockpiled during mining operations, causing a decrease in the incorporated biomass. Tillage or other soil disturbance makes the soil more erodible because the soil is less consolidated, and stable aggregates are reduced in size. Soil disturbance associated with mining or construction activities also reduce stable-aggregate size and reduce the soil s ability to resist erosive forces. This reduction of aggregate size is offset somewhat by increases in the surface roughness, that slows runoff, increases infiltration, and traps sediment transported by overland flow. Maintaining or creating roughness is an effective method of reducing soil-loss rates, which is accounted for in the roughness sub-factor. Biomass and organic-matter losses are minimized when topsoil and the upper subsoil material is handled separately, not mixed with deeper soil material, and hauled directly to and spread on the final-graded reclamation surface. After soil-disturbing activities cease, the soil begins to consolidate again. If no further disturbance takes place, the soil is assumed to be fully consolidated after approximately seven years in the Eastern United States while consolidation may take longer in the Western United States, perhaps 20 years. The time required for consolidation is largely a function of rainfall amount and characteristics. Annual rainfall totals are low in many parts of the West, and so more time is required to achieve consolidation.

Canopy Cover

Canopy cover is the vegetative cover above the soil surface that intercepts raindrops but does not contact the soil surface. Any portion of a plant touching the soil surface is considered surface cover as discussed below. The two characteristics of canopy are utilized in the RUSLE calculations: (1) the percent of surface covered by the canopy, and (2) the height within the canopy from which intercepted rain drops re-form into water droplets and fall to the ground; this fall distance is known as the "effective fall height." Open spaces in a canopy, whether within the perimeter of a plant canopy or between adjacent plants, are not considered as canopy. When measuring or estimating canopy cover, planners should try to get a birds-eye view of the area.

The effective fall height is measured from the ground up to the level within the canopy from which the majority of water droplets fall. The effective fall height of a canopy varies with the vegetation type, the density of the canopy, and the architecture of the plants. **Figure 5-1** illustrates different canopy shapes and shows where the average fall height occurs in these canopies. If the plant canopy has a pyramid shape, with most of the leaves toward the bottom of the canopy, then the average drop fall occurs toward the bottom of the pyramid. If the plant canopy is round or oval, then the average drop fall occurs toward the center of the canopy. If the plant canopy has an inverted pyramid shape, with most of the leaves toward the top of the canopy, then the average drop fall occurs toward the top of the canopy.

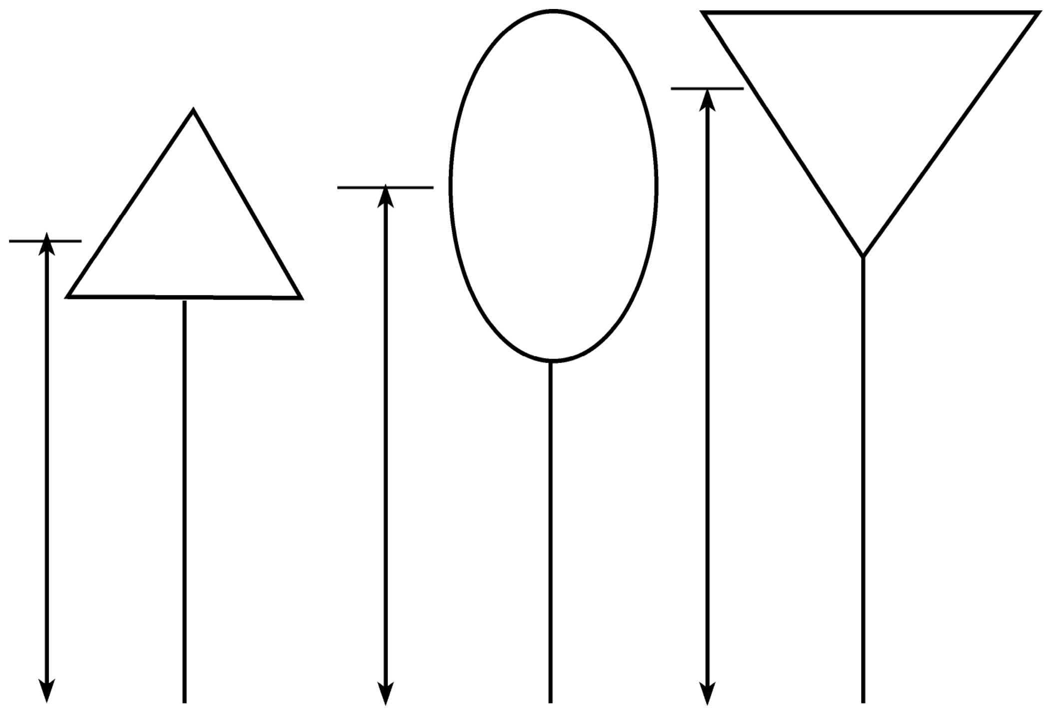

Figure 5-1. Fall heights from canopies of different shape

In plant communities that have more than one type of vegetation composing the canopy, such as on rangeland with a mixture of grasses, shrubs, and trees, the user should try to visualize the height from which most of the water drops would fall. If the majority of the canopy is composed of grasses and forbs, then that would be the type of canopy to use in estimating the effective fall height. If shrubs and small trees dominate and grasses are sparse, then the shrub and tree canopy would be used to estimate the effective fall height.

The canopy cover of reclaimed lands can vary throughout the year, especially on pasture or rangeland, or on lands revegetated with a large percentage of deciduous trees and shrubs. Leaf loss from these plants can significantly reduce canopy cover. The canopy-cover sub-factor for various combinations of percent cover is illustrated in **Figure 5-2**.

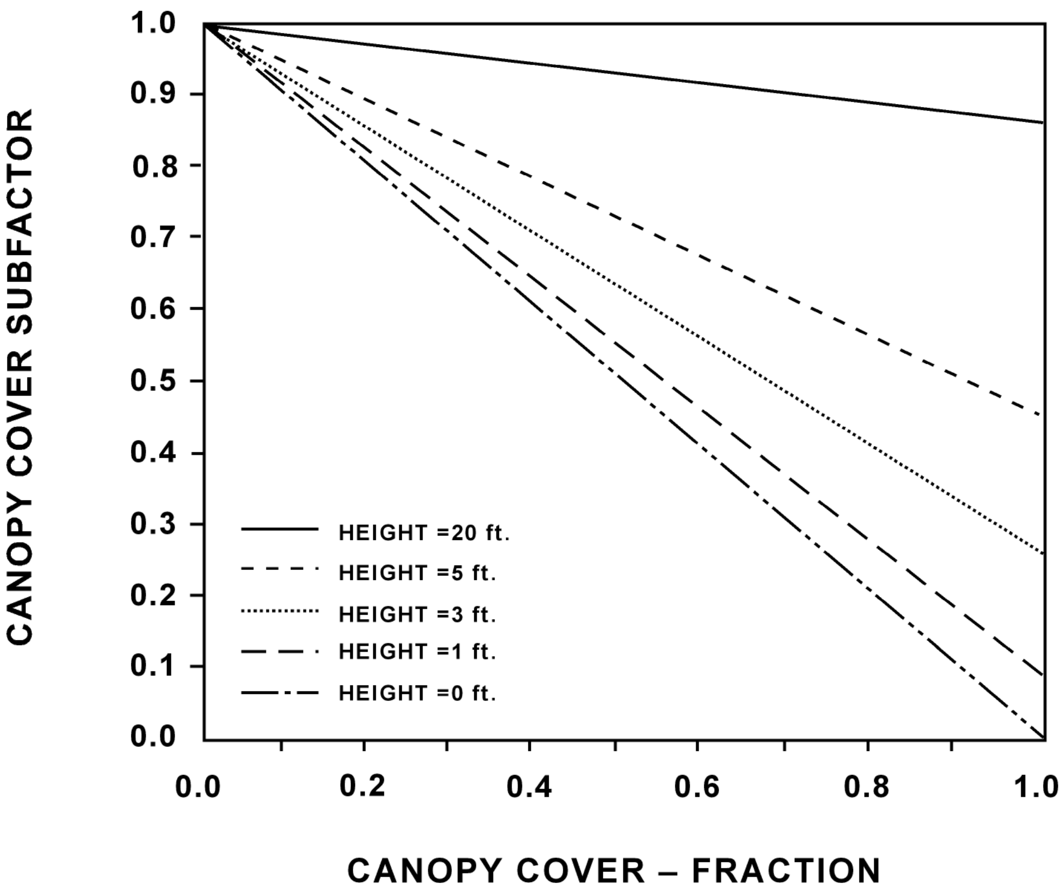

Figure 5-2. Relationship of percent canopy cover to the RUSLE canopy cover sub-factor

Surface Cover

Surface cover is material in contact with the soil that both intercepts raindrops and slows surface runoff. It includes all types of cover, such as mulches and rock fragments, live vegetation in contact with the soil surface, cryptogamic crusts (which are formed by mosses or fungi in the soil), and plant litter. To be effective, surface cover must be anchored to the surface or of sufficient size so that it is not blown away by wind or washed away by runoff. RUSLE takes into account the overlap of surface covers and rock, if both are present. The percent rock cover is entered through the K-factor screen and transferred to the C-factor computations.

The effectiveness of surface cover, such as mulch, varies depending on several factors, including the dominant type of soil erosion occurring on the slope, the slope gradient, the extent of contact between the surface cover and the soil, and the type of surface-cover material itself. In general, surface cover does a better job of reducing rill erosion rates than it does in reducing interrill erosion rates (Foster, 1982). Therefore, if erosion of a bare soil is primarily due to rilling, the addition of a given amount of cover material will reduce erosion more than if the same amount of cover material were placed on a soil that erodes primarily by interrill erosion processes.

On steep hillslopes (greater than 10% gradient) more of the total erosion often results from rill rather than interrill processes. Conversely, on flatter hillslopes (less than 3% gradient), more of the total erosion often results from interrill rather than rill processes. Again, because surface cover reduces the rill erosion rates more than the interrill erosion rates, a given amount of cover material results in a greater reduction in soil loss on steep slopes than on flat hillslopes.

The RUSLE user is asked to select a land use from which RUSLE computes a "b value" that reflects the effectiveness of the surface cover in reducing soil-loss rates. As the effectiveness of the surface cover increases, the b value increases. Because rilling often is the major erosion process on steep hillslopes, and surface cover is more effective in reducing rill erosion than interrill erosion, b values generally increase for most land uses as hillslope gradient increases. The exception to this generalization is for disturbed land where the surface cover is not in full contact with the soil surface or is not anchored to the soil surface by growing vegetation, by stems from previous vegetation. In this case, the effectiveness of surface cover is assumed to increase with hillslope gradient up to a maximum value and then to decrease with additional increases in gradient. Although RUSLE allows direct input of b values, the program should be used to compute the b value based on hillslope gradient, surface cover, and general land use**.** **Table 5-1** provides typical b values for various situations. Further discussion of b values is provided in AH-703.

The effectiveness of the surface cover depends on good contact between the soil and the cover material, and on the cover remaining in place. If the cover, whether straw mulch or manufactured materials, does not make full contact with the soil, is perched above the soil by clods, or stays suspended above depressional areas, severe rill erosion can occur beneath it. Therefore, mulch must be placed to ensure maximum contact with the soil.

Based on research by Meyer et al., 1971, 1972, mulch on construction sites is less effective than on agricultural land. Therefore, a relatively low b value is used in the program when mulch is placed on subsoil, even when properly applied, because the contact and bonding between the mulch and subsoil is assumed to be less effective than the contact and bonding between the mulch and topsoil. The smallest b value is used when the contact is fair, but not good, between the mulch and the soil, because there remains vulnerable soil beneath the cover. Mulch should always be anchored to the soil to ensure that runoff or wind does not remove the material.

As noted above, mulch consisting of long fibers, such as straw, may bridge above the soil surface by resting on clods or over depressions, thus reducing contact with the soil. Gravel mulches tend to fit into depressions and around clods, resulting in better contact with the soil than straw mulch. Therefore, a higher b value is used for gravel materials on construction sites than is used for straw. Of course, the use of gravel materials precludes virtually all post-reclamation land uses.

Table 5-1. General situations represented by b values used in RUSLE

b = 0.025	Situations where **bare-soil** rill erosion is low relative to interrill erosion, such as: flat slopes (<2%), short slopes (<15 feet), and soils that are so highly cohesive that little rill erosion occurs. This would also apply to permanent pasture on fine-textured soils where runoff is unaffected by cover or biomass. This value is also used on steep construction sites where the contact between the mulch and the soil surface is less than optimal with rill erosion occurring beneath the mulch, but the mulch does not fail entirely.
b = 0.035	A mid-range value that should be used for typical medium-textured soils that are regularly disturbed or tilled, for typical construction and for permanent pasture on coarse-textured soils.
b = 0.045	Coarse rangeland soils in areas with low rainfall.
b = 0.050	Situations where the bare-soil rill erosion is high relative to interrill erosion, such as: steep slopes, long slopes, and soils easily eroded by overland flow, e.g., thawing soils, soils high in silt, highly-disturbed soils, coarse-textured soils, and the soils of no-till agricultural lands.

Wind and water can displace mulch, leaving much less surface cover than was originally applied. The mulch cover input for RUSLE must reflect the actual mulch cover that remains in place. Crimping, netting, or tackifiers can be used to help secure the mulch.

Another important consideration is that organic mulch materials, such as straw, decompose through time. The loss of cover by decomposition is calculated within RUSLE as discussed in AH-703. Adjustments should be made based on the amount of cover that exists during the critical period when the R values are the highest.

Sometimes mulch is not evenly spread, resulting in some areas with reduced cover. The conservative way to apply RUSLE is to estimate the soil loss for the area having the lowest cover and to use that estimated soil loss for the entire area. An average soil-loss rate may be obtained for the site by computing the soil loss separately for areas with different amounts of surface cover. A weighted soil-loss rate is then computed based on the percentage of the total area that each sub-area represents. The reason that average surface cover is not used to estimate an average erosion rate is that the equation describing the effect of surface cover on soil loss is non-linear, so that the average surface cover does not give an accurate representation of the actual soil loss.

Table 5-2 provides C values for several combinations of mulch type, percent slope, and soil conditions. Because of the interactive nature of the variables in RUSLE, the program always should be used to compute C values for specific applications; the values in **Table 5-2** are intended only as examples. The placed topsoil and subsoil are direct-hauled or stockpiled soil spread on the surface much like fill material. The stripped topsoil is the remaining topsoil horizon following partial removal by grading operations. In this case, the topsoil has not been stripped down to the subsoil horizon and still contains some organic matter and rootlets. These soils are assumed to be well-prepared to ensure optimum contact between the soil and the mulch material. It also is assumed that the mulch is uniformly distributed on the hillslope, and it is assumed that the mulch is effectively anchored by crimping, netting, or tackifier so that it is not displaced by wind or water.

The C values in **Table 5-2** were computed for a site near Lexington, KY with a 150 foot hillslope. The "placed topsoil" and "placed subsoil" were assumed to be dumped and bladed on March 15 followed immediately by a surface cover. It is assumed that there was no initial vegetation on the site. The C values in the table represent the first three-month period during which time a vegetation cover was established on the surface. If no vegetation cover was established for the entire year, a C value of 0.08 for the first three months becomes a value of 0.14 for the year.

Also, the C values depend on when the mulch is applied to the surface. For example, if the surface material is dumped and bladed with the mulch applied on June 15, the C value for the first three months is 0.09, slightly higher than the C value when the mulch is applied in March. The value for the year is 0.12, slightly lower than the C value when the mulch is applied in March. The differences reflect the climatic regime of the location. These C values and those in **Table 5-2** will vary with location. Hence, the RUSLE program should be used to provide customized C values for a particular site.

The potential for mulch failure can be estimated using the procedure described by Foster, et al., 1982. When the shear stress imposed by a surface flow exceeds the shear strength of a mulch material, the mulch may be displaced or rilling begins beneath the mulch; in either case, the mulch ceases to protect the soil surface. A properly designed erosion-control system is one in which the mulch does not fail to protect the soil. Graphs provided by Foster et al., 1982 can be used to estimate the conditions under which mulch failure may occur. The relations upon which those graphs are based have not been included in the RUSLE program because they have not been extensively tested under actual field conditions. The procedure provided by Foster et al., 1982 employs the data inputs used by the RUSLE program and simple graphs and so could provide valuable guidance in situations where the potential for mulch failure must be evaluated.

Table 5-2. C factor values for mulch under disturbed-land conditions

Type of Mulch	Gradient (%)	Placed Topsoil	Subsoil	Stripped Topsoil
Straw, 2 tons/acre, 91% cover at placement, 84% cover at 3 months	1	0.10	0.10	0.09
	6	0.07	0.08	0.06
	15	0.06	0.08	0.04
	30	0.07	0.10	0.04
	50	0.08	0.11	0.03
Straw, 1 ton/acre. 69% cover at placement, 50% cover at 3 months	1	0.24	0.24	0.23
	6	0.18	0.20	0.16
	15	0.18	0.20	0.14
	30	0.18	0.24	0.12
	50	0.20	0.26	0.12
Straw, ½ ton/acre, 36% cover	1	0.35	0.35	0.34
	6	0.29	0.31	0.26
	15	0.28	0.32	0.23
	30	0.29	0.35	0.22
	50	0.30	0.38	0.21
Straw, 2 tons/acre, 20% rock fragment on soil before placement of mulch	1	0.09	0.09	0.09
	6	0.06	0.07	0.05
	15	0.06	0.08	0.04
	30	0.06	0.09	0.03
	50	0.07	0.10	0.03
Straw, 1/2 tons/acre, 20% rock fragment on soil before placement of mulch	1	0.24	0.24	0.23
	6	0.18	0.20	0.16
	15	0.18	0.20	0.14
	30	0.18	0.24	0.12
	50	0.20	0.26	0.12
Gravel, 135 tons/acre, 90% cover	1	0.08	0.08	0.08
	6	0.05	0.05	0.05
	15	0.04	0.04	0.04
	30	0.03	0.03	0.03
	50	0.03	0.03	0.03

Notes:
Soil is assumed to have been placed as a fill or to have been disturbed. Values would be lower for a cut slope.

The soil is assumed to have been well prepared to ensure optimum contact between the soil and the mulch and the mulch is assumed to have been anchored by crimping or a similar operation. A netting, tackifier, or something similar has been used to keep in the mulch in place so that it is blown away by wind.

The mulch is assumed to have evenly and uniformly placed.

The mulch is assumed not fail even by mulch movement or erosion beneath the mulch. The potential for mulch failure can be determined using the procedure described in Foster, G. R., C. B. Johnson, and W. C. Moldenhauer. 1982. Hydraulics of failure of unanchored cornstalk and wheat straw mulches for erosion control. Trans. ASAE. 940-947.

There are several ways to estimate the percent surface cover. **Figure 5-3** shows a graphic representation of percent cover. This can be used to help you visualize the amount of mulch or rock cover for a particular site. Your local NRCS office may have sets of photographs that show varying levels of vegetation covers. Surface cover can be measured quickly in the field using the line-transect or point-frame methods.

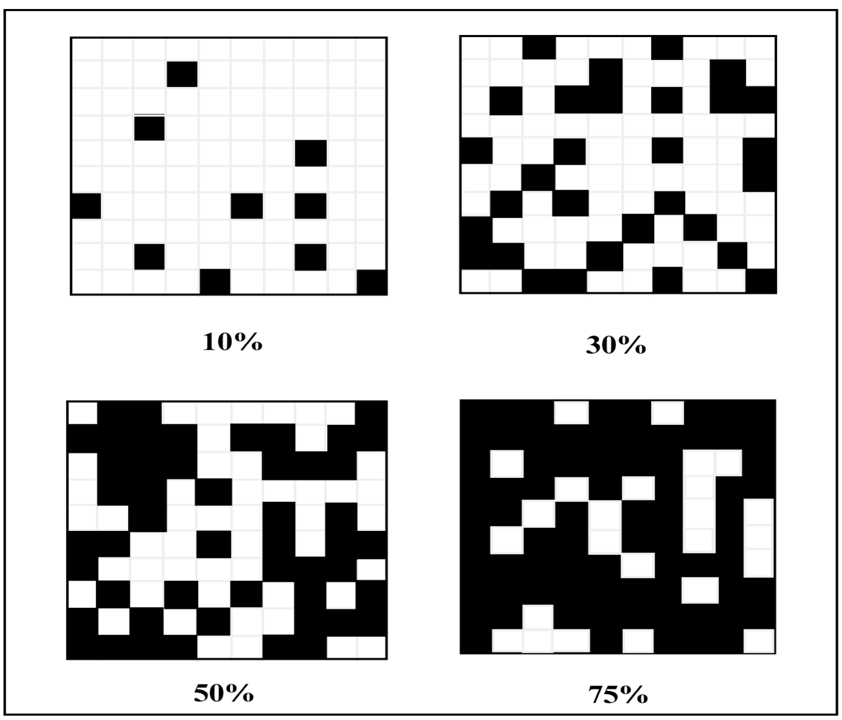

Figure 5-3. Graphic representation of varying percent surface cover

Measuring surface cover by the line-transect method: For ease of calculation and adequate accuracy, use a 100-foot measuring tape or a cord with 100 points marked on it with knots or other easily-visible marks. If the cover has any obvious orientation, stretch the cord or tape along the ground at a 45° angle to that orientation. Then walk along the cord and look directly down on each mark. Count the number of marks that have a piece of plant residue or other cover under it, and total them for the transect. Only count cover that is larger than 0.25 - 0.40 in size. If you are using a tape, look at the edge of the tape at each foot mark for cover. Always look on the same side of the tape. Repeat this procedure four or five times over the area, choosing locations that are representative of the area as a whole. The average number of cover hits is the percent cover for the area.

Figure 5-4 shows surface-cover, sub-factor values for varying cover levels. The three curves in this figure also illustrate how the effectiveness of surface cover in reducing soil-loss rates varies with the relative amounts of rill and interrill erosion as represented by the three different b values. The curve with a b value of 0.025 represents the effectiveness of a surface cover when the ratio of rill to interrill erosion is low for bare soil conditions. The curve with a b value of 0.050 represents the effectiveness of a surface cover when the ratio of rill to interrill erosion is high for bare soil conditions.

RUSLE can add cover after a harvest operation on reclaimed agricultural land, using the residue yield ratio in the VEG database. RUSLE can also accommodate the "external" addition of mulch materials, such as straw, in the computations of C values.

During the reclamation process, surface cover could be added as straw mulch, excelsior blankets, or other types of mulching materials. Unfortunately, there is a paucity of systematically collected field data relating applications of these products to soil loss that can be used to calibrate sub-factor values for RUSLE. In many cases, the RUSLE users must rely on their professional judgement based upon experience. Additional research is greatly needed to establish the soil-loss rates for various manufactured products, various application rates, and various site conditions.

Manufactured erosion-control products affect rill and interrill erosion processes in the same way as covers of natural materials. The same properties considered in an evaluation of straw mulch, for example, should be considered when using RUSLE to compute a C value for manufactured products. The important material properties are: (1) the percent of the soil surface covered, (2) the mass of the applied material, and (3) the rate at which the material decomposes. Another important variable is the nature of the contact between the mulch material and the soil surface. If the material bridges across the microtopography of the surface, a *disturbed land use with no rock cover* should be chosen from the general land use menu. If the material closely conforms to the soil surface, following the microtopography, then choose the *disturbed land use with rock cover* option from the menu.

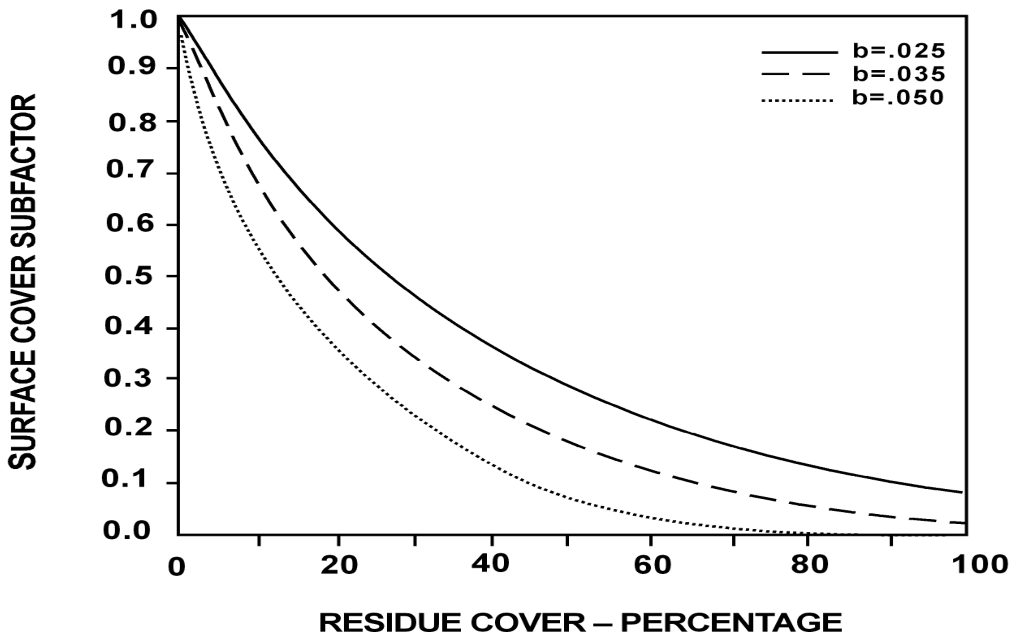

Figure 5-4. Relationship between percent residue cover and the RUSLE surface cover sub-factor.

On reclaimed mined lands and construction sites, losses of mulch cover can occur due to removal by wind and water, grazing animals, or decomposition. In stable plant communities, such as rangelands, pasturelands, or successfully reclaimed lands, surface cover is lost primarily by decomposition, although some loss of surface cover may result from livestock trampling. In these types of plant communities, surface cover tends to remain relatively constant, because the cover that is lost by decomposition is replaced by additions of plant litter to the soil surface.

On mined lands and construction sites, highly erodible conditions exist during site preparation, mining, and construction periods when the soil is bare and highly disturbed. High C values are used to represent these conditions. **Table 5-3** gives some C values for soil loss from bare-soil conditions. Again, because of the interactive nature of the variables in RUSLE, the program always should be used to compute C values for specific applications; the values in **Table 5-3** are intended only as examples. Notice that the C value varies for "cut" or "fill" surface materials due to differences in the material characteristics. The C values are lower for the cut materials because the soil is still consolidated and more resistant to erosion. For fill materials, the soil has been loosened and soil-aggregation size has been reduced, making the soil much more susceptible to erosion processes. The "packed, smooth" condition represents a soil surface that has been bladed smooth but the traffic from the blading operation has compacted the soil. This condition differs from the highly-compacted layers resulting from motorscraper traffic during the placement of several fill material lifts. Such a highly-compacted surface should be treated as a "cut" condition rather than a "fill" condition.

The C values in **Table 5-3** were computed for a site near Lexington, KY assuming that the operation occurred on March 15. The C values are for the first three months following the operation. The C values of the "fill" practices are due almost entirely from the random roughness resulting from fill placement. There is some loss of roughness during the three months caused by erosion of the microtopographic peaks and sedimentation in the microtopographic basins.

No soil disturbing activity is assumed for the "cut" practices. The C value of 0.45 is based on the assumption in RUSLE that a consolidated soil is about 45% as erodible as a freshly disturbed soil. The difference between the value of 0.45 and the other C values for the "cut" conditions reflect the effect of "dead" root biomass on soil-loss rates. The density of the root system and biomass for the sod is assumed to be much greater than for the "weeds." These differences are taken into account in the RUSLE program.

Table 5-3. C values for bare soil at construction site

Condition	Practice	Factor
Fill	Packed, smooth	1
	Freshly disked	0.95
	Rough (Offset disk)	0.85
Cut	Below root zone	0.45
	Scalped surface (some roots remain from sod)	0.15
	Scalped surface (some roots remain from “weeds”)	0.42

After the mining or construction activity is completed, the reclamation process usually begins. Along with the application of mulch, permanent vegetation often is established by seeding. The effectiveness of the vegetative cover in reducing soil loss increases through time as the stand develops. **Table 5-4** provides some typical C values for different types and growth stages of vegetative cover. Once again, because of the interactive nature of the variables in RUSLE, the program always should be used to compute C values for specific applications; the values in **Table 5-4** are intended only as examples. Small grain cover crops (nurse crops) give quick cover and help to protect the soil until the permanent vegetation is established. Even weeds give some protection. Any type of cover will help protect the soil from the erosive forces of rainfall and runoff.

The C values in **Table 5-4** were computed for a site near Lexington, KY. The C values illustrate the difference in the effect on soil-loss rates of a cover crop, such as oats, compared to permanent vegetation, such as weeds. It is assumed that the oats are seeded into a freshly disturbed soil with no initial root biomass present in the soil. Thus, the root biomass for the first four months of oat growth is much less than for the permanent weed cover with a comparable annual above-ground production. Soil consolidation also differs between the oats and the weed covers. The soil is assumed to be fully consolidated for the weeds, whereas no consolidation is assumed for the oats. The canopy cover also differs between the oats and the weeds. The canopy develops through time for the oats, whereas the canopy cover is constant for the weeds. Even after the canopy for the oats is fully developed, the weeds are assumed to provide a higher percent canopy that the oats and the fall height for the oats is about three times that of the weeds. Finally, a litter cover is assumed for the weeds that is not assumed to exist for the oats. When all of these differences are taken into account, the C value for the permanent cover of weeds is much less than that of the newly planted oats. Of course, this does not mean that weeds are a desirable surface cover for reclaimed lands, but their presence does affect soil-loss rates. The C values in **Table 5-4** show that the grasses are much more effective in reducing soil-loss rates.

Table 5-4. C values for various types of vegetation cover

Type	Production Level (lb/acre)	C-value
Sod (bluegrass)	4000	0.001
Bromegrass	4000	0.002
Weeds	2000	0.01
	1000	0.04
	500	0.11
Oats (first four months)	5000 lb/acre at maturity	0.27
	2500 lb/acre at maturity	0.44
Oats (annual)	5000 lb/acre at maturity	0.17

Surface Roughness

Soil-disturbing operations leave two types of surface roughness: oriented and random. Oriented roughness has a recognizable pattern. The ridges and furrows left by "cat-tracking" or a chisel plow used in the preparation of a seedbed are examples of oriented roughness. Oriented roughness redirects surface runoff, and may trap some sediment. When the ridges and furrows are very nearly on the contour, runoff flows around the slope, rather than directly downslope, thus reducing the erosivity of the runoff. Oriented roughness is considered in the P factor. Random roughness is considered in the C factor.

Random roughness is defined as the standard deviation of the elevation from a plane across a tilled area after oriented roughness is taken into account. It has no recognizable pattern and is the result of clods and aggregates produced by various soil-disturbing activities. The depressions between the clods cause water to pond, slows runoff, increases infiltration, and stores sediment, all of which helps to reduce erosion rates. The amount of random roughness created by a particular operation varies with the initial condition of the site, the tillage implement and its use, soil texture, and soil moisture at the time of disturbance.

CAUTION: If any oriented roughness is present, take random-roughness measurements parallel to the oriented roughness. For example, take measurements along the top of a ridge or the bottom of a furrow, rather than perpendicular to the ridges and furrows.

A random roughness value for RUSLE can be obtained by simple field measurements. Measure the distance between the highest and lowest points on the soil surface along a furrow or ridge. The average range, determined from the average high and average low elevation measurements, is used together with **Figure 5-5** to estimate the

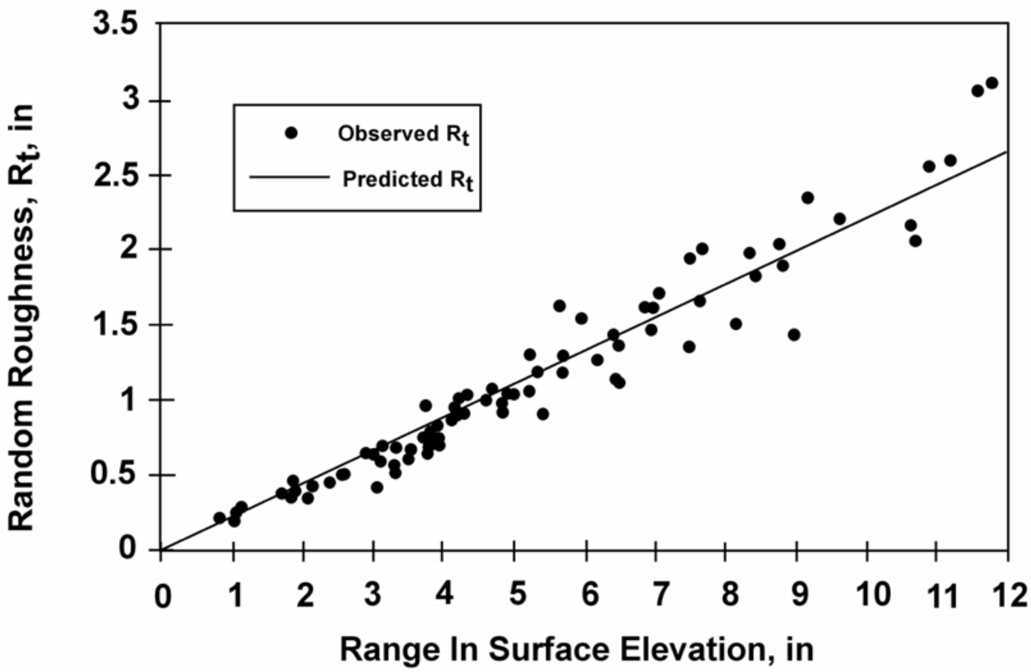

Figure 5-5 Random roughness versus range in surface elevation (Soil and Water Conservation Society, 1993)

random-roughness value. For example, if the average difference between the high and low points is 9 inches, the random-roughness value for RUSLE is 1.75 inches. **Table 5-5** provides random-roughness values for different types of rangeland communities, and

Table 5-6 provides some typical random-roughness values for various tillage implements. The values in these two table are intended only as examples; field measurements and **Figure 5-5** should be used to obtain the random-roughness values for C-factor inputs.

Table 5-5. Roughness values for rangeland field conditions (Soil and Water Conservation Society, 1993).

Condition	Random Roughness (in)
California annual grassland	0.25
Tallgrass Prairie	0.30
Clipped and bare	0.60
Pinyon/Juniper interspace	0.60
Cleared	0.70
Natural shrub	0.80
Seeded rangeland drill	0.80
Shortgrass,desert	0.80
Cleared and pitted	1.00
Mixed grass, prairie	1.00
Pitted	1.10
Sagebrush	1.10
Root-plowed	1.30

Table 5-6. Attributes of Typical Tillage Implements[1]

Field operations	Random roughness (in)	Fraction of residue left on surface (%)	Depth of incorporation (in)	Soil surface disturbed (%)
Chisel, sweeps	1.2	70	6	100
Chisel, straight point	1.5	60	6	100
Chisel, twisted shovels	1.9	45	6	100
Cultivator, field	0.7	75	3	100
Cultivator, row	0.7	80	2	85
Cultivator, ridge till	0.7	40	2	90

Field operations	Random roughness (in)	Fraction of residue left on surface (%)	Depth of incorporation (in)	Soil surface disturbed (%)
Disk, 1-way	1.2	30	4	100
Disk, heavy plowing	1.9	35	6	100
Disk, tandem	0.8	50	4	100
Drill, double disk	0.4	90	2	85
Drill, deep furrow	0.5	70	3	90
Drill, no-till	0.4	80	2	60
Drill, no-till into sod	0.3	90	2	20
Fertilizer applicator, anhydrous knife	0.6	80	2	15
Harrow, spike	0.4	80	2	100
Harrow, tine	0.4	85	2	100
Lister	0.8	20	4	100
Manure injector	1.5	50	6	40
Moldboard plow	1.9	5	8	100
Mulch treader	0.4	75	2	100
Planter, no-till	0.4	85	2	15
Planter, row	0.4	90	2	15
Rodweeder	0.4	90	2	100
Rotary hoe	0.4	85	2	100
Vee ripper	1.2	80	3	20

[1] From AH-703 - Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation

Both oriented and random roughness decrease through time. Depressions fill with sediment, and rainsplash erodes the clods, aggregates, and ridges created by tillage implements. RUSLE automatically diminishes surface roughness through time as a function of accumulated rainfall volume and rainfall energy.

Cover-Management Systems

A set of plant types, surface covers, and operations constitutes a cover-management system. The complete list of plant types, surface covers, and operations, together with the dates of planting or implementation, must be assembled for the computation of C values. For complex reclamation and production systems on reclaimed prime agricultural lands, RUSLE will accept crop-rotation sequences up to ten years in length. Additional information pertaining to the development of cover-management systems is available in Chapter 7 and in AH-703.

Caution: Developing a cover-management system for RUSLE can be a complicated task. It is imperative that plant types and operations be entered in the proper sequence to insure accurate calculation of C values. The user is strongly encouraged to participate in a RUSLE training course given by qualified instructors before trying to develop elaborate multi-step sequences for reclaimed prime agricultural lands. Check with your local NRCS office for information on available training and assistance in developing C values.

A reclamation plan may be quite simple or quite complex, depending on the reclamation objectives and future land uses. It is impractical to attempt to include in the RUSLE program all of the possible plant types, erosion- and sediment-control materials, and operations that might be utilized in reclamation programs throughout the United States. Furthermore, the data frequently do not exist specifically relating various plant types, materials, or operations to soil-loss rates, in which cases it is not possible to develop C values for inclusion in RUSLE. Therefore, recourse often must be given to the use of analogies based on user judgement and experience. For example, the plant types used in revegetation at a particular location may be expected to affect soil-loss rates much like coastal bermudagrass. An erosion-control material may be expected to affect soil-loss rates much like straw much applied at a rate of 2 tons per acre. An operation may be expected to affect soil-loss rates much like the use of a heavy offset disk. When new data become available relating additional plant types, materials, and operations to soil-loss rates, new C sub-factors can be added to RUSLE. The user is advised to consult with State NRCS Office to obtain existing plant type, material, and operation information for the particular area of interest and for assistance in identifying the best possible analogies for use in the C-value computations.

The C-value computations for two disturbed-land cover-management systems are provided in **Figures 5-6** and **5-7**. The site characteristics for these example are provided for comparison in **Table 5-7**. Note that the soil and topographic characteristics are the same for each site but the climatic conditions differ considerably and cover-management systems differ somewhat. For the Eastern U.S. location (Charleston, WV) the C value is 0.085, indicating that the soil-loss rate would be 8.5% of that from a bare, unit plot under the other conditions described in **Table 5-7**. For the Western U.S. location (Flagstaff, AZ) the C value is 0.07, indicating that the soil-loss rate would be 7% of that from a bare unit plot under the other conditions described in **Table 5-7**. The difference in the C values is due to the differences between the climate characteristics at these two locations and the differences in the cover-management systems.

```
                    File        Exit        Help        Screen
+-----------------< C Factor: results by operations 1.06 >--------------------+
 veg. # 1/1: winter small gr cvr        prev. veg.: winter small gr cvr
                    % res. cover    op.          date
---operation------------after op.----date---------next op.-----SLR-----%EI----
 place (dump) fill         0        3/5/1         3/6/1       0.847    0.1
 blade fill matl           0        3/6/1         3/7/1       1.06     0.1
 broadcast planter         0        3/7/1         3/7/1       0        0.0
 add straw mulch           70       3/7/1         3/5/2       0.084   99.9
---------- Rotation C Factor = 0.085 -------- Veg. C Factor = 0.085 ----------



+-----------------------< Esc Returns to C Result Menu >----------------------+
Tab  Esc F1   F3   F9   PgUp PgDn Home End
FUNC esc help cont info pgup pgdn 1st  last
```

Figure 5-6. Example C-factor value for a site in the Eastern U.S.

```
             File        Exit        Help        Screen
+-----------------< C Factor: results by operations 1.06 >--------------------+
 veg. # 1/1: grama-1st yr        prev. veg.: grama-1st yr
                    % res. cover    op.          date
---operation------------after op.----date---------next op.-----SLR-----%EI----
 place (dump) fill         0        3/15/1        3/17/1      0.846    0.0
 blade fill matl           0        3/17/1        3/18/1      1.06     0.0
 heavy offset disk         0        3/18/1        3/20/1      0.793    0.1
 range drill               0        3/20/1        3/22/1      0.896    0.1
 add straw mulch           70       3/22/1        3/15/2      0.072   99.8
--------- Rotation C Factor = 0.073 -------- Veg. C Factor = 0.073 -----------



+-----------------------< Esc Returns to C Result Menu >----------------------+
Tab  Esc F1   F3   F9   PgUp PgDn Home End
FUNC esc help cont info pgup pgdn 1st  last
```

Figure 5-7. Example C-factor value for a site in the Western U.S.

Table 5-7. Comparison of site characteristics

RUSLE Factor	Eastern United States	Western United States
Rainfall - Runoff Erosivity (R)	Charleston, WV Slope gradient = 8.65 Adjust ponding = yes (R = 140)	Flagstaff, AZ Slope gradient = 8.65 Adjust ponding = yes (R = 30)

RUSLE Factor	Eastern United States	Western United States
Soil Erodibility (K)	Silt loam Si + vfs = 65% Clay = 15% Organic matter = 0.5% Structure = 2 Permeability = 4 % Rock cover = 0 Consolidation = 7 Hydrologic group = 3 (K = 0.471)	Silt loam Si + vfs = 65% Clay = 15% Organic matter = 0.5% Structure = 2 Permeability = 4 % Rock cover = 0 Consolidation = 15 Hydrologic group = 3 (K = 0.444)
Topographic Factor (LS)	Segments = 3 Measured downslope Segments vary in length Soil texture = Silt loam General land use = 8 Gradients = 10, 15, 5% Lengths = 100, 200, 300 ft (LS = 3.50)	Segments = 3 Measured downslope Segments vary in length Soil texture = Silt loam General land use = 8 Gradients = 10, 15, 5% Lengths = 100, 200, 300 ft (LS = 3.50)
Cover - Management (C)	No Adjust for soil moisture % Rock cover = 0 b-value code = 1 Years in rotation = 0 Long-term rough = 0.24 Consolidation = 7 Winter small grain Place (dump) fill Blade fill material Broadcast planter Add straw mulch (2000lbs) (C = 0.085)	No adjust for soil moisture % Rock cover = 0 b-value code = 1 Years in rotation = 0 Long-term rough = 0.24 Consolidation = 7 Grama - 1st year Place (dump) fill Blade fill material Heavy offset disk Range drill Add straw mulch (2000lbs) (C = 0.073)

In the Midwestern part of the U.S., surface mining often takes place on prime agricultural lands. There are very specific requirements for the reclamation of these lands. Further, the post-mining land use may involve various crop-rotation patterns. It is essential that the data inputs for the computation of the C value include all of the required reclamation and cropping steps in precisely the correct sequence. The regulatory authority for mining activities and NRCS personnel can assist in the selection of the appropriate data inputs.

Sources of Information

The RUSLE program accompanying these Guidelines includes limited data sets in the CITY, OPERATIONS, and VEG databases**.** Many additional data sets have been developed by NRCS personnel during the implementation of RUSLE at the field level. Contact your State NRCS office for the latest versions of these databases.