APPENDIX D. PARAMETER VALUES FOR MAJOR AGRICULTURAL CROPS AND TILLAGE OPERATIONS

The following information and data are to be used to prepare data files for crops and tillage operations used in application of RUSLE to cropland. Data presented for the crops and tillage operations represent "core" values that are to be used as starting points. Procedures are given that can be used to adjust the core values to represent conditions that differ from those described by the core data. Guidelines are also given on how to develop parameter values for crops and tillage operations not listed in the tables by extracting data from the literature or by comparing characteristics of the given crop or operation to crops and operations listed in the "core" data.

Data presented in the following tables were developed by the USDA Agricultural Research Service (ARS) and the Natural Resources Conservation Service (NRCS) for use by NRCS in its national implementation of RUSLE. The values and procedures are based on a review of data in the literature and on the judgment of numerous technical specialists in NRCS and the ARS RUSLE development team.

Use of these values and procedures can greatly help to ensure consistency in the application of RUSLE. If you get inconsistent results with RUSLE, first make checks using "core" values. Then carefully evaluate adjustments to the "core" values to ensure that reasonable adjustments have been made and that RUSLE is responding as expected to each adjustment.

Procedure for Adjusting Values for a "Core" Crop

If RUSLE is being applied to a crop included in the "core" data but the yield differs from the yield of the core crop, adjustments to the parameter values given for the core crop in table 5-1 or 5-2 are needed.

Residue:Yield Ratio

RUSLE has been designed to use a constant residue:yield ratio over the range of yields given in table D-1. If the yield of the given crop falls outside of the range given for the core crop, the residue:yield ratio can be varied with yield. In general, assumption of a constant residue:yield ratio for yields above the upper limit is acceptable. However, this ratio increases significantly as yield

decreases below the lower limit. If the residue:yield ratio is varied as a function of yield outside of the given range, the ratios should be chosen to match the constant ratio value at the upper and lower limits.

The residue:yield ratios given in table D-1 are based on commonly accepted, typical values for this ratio. However, this ratio can vary with crop variety, region, and other factors. A value for this ratio can be selected that differs from the "core" value given in table D-1, but the assumption of a constant value must be observed within the yield range given in table D-1.

Root Mass

Root biomass is adjusted using multiplication factors in table D-2 where root biomass is assumed to be linearly adjusted as a function of aboveground biomass. If yield is within the range where the residue:yield ratio is assumed to be constant, root biomass can be adjusted linearly with yield. One way to make the adjustment is to first determine the multiplication factor based on a ratio of the aboveground biomass. Each root biomass value for the core crop can be multiplied by this factor to determine values for the given crop.[3] The procedure is illustrated in table D-3.

Canopy

Canopy cover (percentage) is adjusted according to the square root (0.5 power) of the ratio of aboveground biomass for the given crop to that for the core crop. The multiplication factors are given in table D-2. If the resulting canopy value exceeds 100%, a value of 100% should be assigned to the canopy value. If the yield is within the range where a constant residue:yield is assumed, yield values can be used to form the ratio of biomass values to determine a multiplication factor. All canopy values of the core crop are multiplied by the adjustment factor to obtain the new set of canopy values. The procedure is illustrated in table D-3.

Effective Fall Height

Effective fall height is adjusted according to the 0.2 power of the ratio of aboveground biomass for the given crop to that for the core crop. The multiplication factors are given in table D-2. If the yield is within the range

[3]The following guide should be used in rounding numbers. Root biomass values are rounded to nearest 10 lb/acre per 4 in depth, canopy percentage to nearest 5 percent, and fall height to the nearest 0.1 ft.

where a constant residue:yield is assumed, yield values can be used to form the ratio of biomass values to determine a multiplication factor. All effective fall height values of the core crop are multiplied by the adjustment factor to obtain the new set of canopy values. The procedure is illustrated in table D-3.

Length of Growing Season and Dormancy

Adjustments may be needed for length of growing season for crops like corn and soybeans and length of the dormancy season for crops like winter wheat. The adjustment made for length of growing season is to add or subtract days from the period of full canopy before senescence begins. Length of the dormancy period is adjusted by adding or subtracting days to the dormancy period. In the southern part of the United States, reduced growth can continue throughout the dormancy period. The core data should be adjusted to account for this effect.

Crops Not Listed Among Core Crops

Situations will arise where RUSLE will be applied to crops not listed in the core data set. Several options are available for obtaining values for these crops. Key variables are amount of aboveground biomass, amount of root biomass at harvest, amount of canopy, and fall height at harvest.

Obtain Data From the Literature

The first option involves selecting published values in the literature. Try to find as much published data as possible. Variations among the sources can be large. The ratio of aboveground biomass to root biomass is not constant during the growing season. Select the root biomass value at maturity as the starting point. Choose values during the growing season that form an S-shaped curve similar to the data shown for the core crops. The same applies for canopy and effective fall height. Choose a residue:yield ratio value that can be assumed to be constant over the mid 50% yield range of the crop.

Obtain Data From NRCS

The second option is to contact the State Agronomist in an office of the Natural Resources Conservation Service (NRCS) of the USDA. Very likely NRCS has already developed a data set for a crop that can be used directly or that can be modified.

Compare Crop Characteristics to Characteristics of a Core Crop

The third alternative is to compare characteristics of the given crop to those of a similar core crop and adjust parameter values accordingly. For example, peanuts might be compared to soybeans.

Relation of Ground Cover Percent to Mass

In many cases, ground cover is the single most important factor affecting erosion. Therefore, the single most important crop variable is amount of residue at harvest and at planting time. Table D-4 lists values for the "core" crops for relating percent ground cover to mass.

Percent ground cover is not an accurate indicator of amount of biomass when percent cover exceeds 90%, as at harvest. The exponential shape of the curve that describes the relation of residue cover to residue mass is not sensitive to mass at high percent cover values. Mass can change greatly with little detectable change in cover above 90%, especially for covers greater than 95%. However, percent cover for values less than 75% is a reliable indicator of cover mass on the surface.

Even though percent cover is the single most important variable affecting erosion, loss of residue is on a mass basis. While cover is readily measured, mass of cover is not easily measured. Soil particles must be carefully washed from the residue, and leaves and stems must be carefully recovered. Also, the residue rapidly loses mass shortly after harvest, which is not reflected in a corresponding loss of cover.

If RUSLE is using the proper mass of residue at harvest but is giving a poor estimate of cover before spring tillage, two possibilities should be checked. One is that the decomposition parameter value used to compute loss of residue is in error; the other possibility is that the relationship of residue cover to residue mass is in error.

If the residue cover after planting is not correct but was correct before the first tillage operation at planting time, the most likely cause is that the value of residue left by the tillage operation is incorrect. If the residue after planting is correct but is not correct at the end of the growing season, the decomposition parameter value is incorrect.

Be Cautious

Because erosion is sensitive to cover, care should be taken to ensure that cover values are reasonable. However, when adjustments are needed, analyze

the reason for the problem and make adjustments carefully and methodically. Sometimes the problem is not as it appears.

Decomposition Parameter Values

Loss of residue over time is computed in RUSLE as a function of temperature and rainfall. Parameter values for decomposition are given in table D-5.

Data used in RUSLE to evaluate the adequacy of the decomposition parameter values should be field measurements of the loss of residue cover. Obviously, other factors such as soilborne organisms can affect residue loss. These effects are empirically captured in the decomposition parameter values. Thus, a decomposition parameter value should be based on field measurements and not laboratory decomposition tests.

The decomposition computations in RUSLE do not consider standing stubble separate from biomass on the soil. As a consequence, RUSLE may overestimate the loss of standing stubble. However, a decomposition parameter value can be applied to the biomass in the soil that is different from the parameter value for biomass on the soil.

RUSLE does not treat the plant components of leaves, stems, and roots separately. All components are assumed to be lost at the same rate. Furthermore, RUSLE does not vary the decomposition parameter value based on the state of decomposition to consider, for example, that decomposition may initially proceed more rapidly than in later stages.

Decomposition is related more closely to soil moisture than to the rainfall values used in RUSLE to compute loss of residue. Also, temperature varies within a day, and both temperature and rainfall vary from day to day. Monthly values in RUSLE are disaggregated into smoothed daily values for the RUSLE computations. The result is that decomposition parameter values for a given crop may need adjustment by climatic region. For example, a much larger decomposition parameter value is needed for wheat in the Northwestern Wheat and Range Region than in other parts of the United States.

Given these considerations and the limitations of the simple equations used in RUSLE to compute loss of biomass, decomposition parameter values are chosen to provide the best overall results.

Adjusting Parameter Values for Operations in the Core List

Table 5-5 contains parameter values for the core list of field implements used in many cropland operations. When an operation in the core list does not match the operation as applied in your situation, the following adjustments can be made.

Depth of Incorporation

For a given type of implement, a single value is used for depth of incorporation. For example, a value of 6 in is used for all chisel plows regardless of actual depth of tillage. Values for depth of incorporation are chosen based on information given in table D-6.

Roughness

A roughness value assigned to a tillage operation can be adjusted up or down one roughness step as shown in table D-7. For example, a moldboard plow has a roughness value of 1.9 in for its core value. It could be assigned a value of 2.3 for a clay soil that is very rough or a value of 1.5 for a sandy soil that is relatively smooth after plowing. The roughness index as used in RUSLE represents both the effects of depressional storage and the degree of pulverization.

Amount of Residue Left

Since surface cover has such a great effect on erosion, the value for the amount of residue left by an operation should be selected carefully. In general, values should be rounded to the nearest 10% or perhaps to the nearest 5%. Consideration should be given to whether the residue is fragile or nonfragile. Nonfragile residues are assumed in table 5-5. A very important consideration, especially if information is obtained from the literature, is whether or not residue mass or percent cover was used to indicate how much residue was left by the tillage operation.

Obtaining Parameter Values for Operations Not in the Core List

If a particular operation is not in the core list, values for the operation can often be obtained from the NRCS, which has developed values for an array of operations. This approach is preferred because the NRCS values have been tested and evaluated for consistency with other operations. The next best alternative is to choose values based on data in literature. The third and last desirable option is to compare characteristics of the particular operation against those of operations in the core list. If values are obtained from the literature or by comparison with operations in the core list, the following must be observed. The depth of incorporation is based on type of tillage operation as described in table D-6. The value of roughness that is assigned to a tillage operation is based on the tillage occurring in a medium-textured soil at a high level of management, meaning that large amounts of residue from a high yielding crop like corn has been routinely incorporated into the soil.

Table D-1. Residue:yield ratio and yield range over which to use a constant residue:yield ratio

Crop	Residue:yield ratio	Range[1]
Corn	1.0	50 to 150 bu(acre)$^{-1}$
Soybeans	1.5	15 to 45 bu(acre)$^{-1}$
Cotton	[2]4.5	300 to 1000 lbs(acre)$^{-1}$lint
Sorghum	1.0	40 to 90 bu(acre)$^{-1}$
Winter wheat	1.7	25 to 60 bu(acre)$^{-1}$
Spring wheat	1.3	25 to 60 bu(acre)$^{-1}$
Spring oats	2.0	30 to 80 bu(acre)$^{-1}$

[1]If yield is less than the minimum value in the range, the residue:yield ratio may need to be increased. If yield is greater than the maximum value in the range, the residue:yield ratio may need to be decreased.
[2]Value given is for shredding stalks in the fall. Use 3.0 for stalks shredded in the spring.

Table D-2. Multiplication factors to adjust RUSLE plant data from core data

Ratio of biomass at maturity of given crop to biomass of core crop	Multiplication factor for root biomass[1]	Multiplication factor for canopy percent[2]	Multiplication factor for fall height[3]
0.1	0.1	0.32	0.63
.2	.2	.45	.72
.3	.3	.55	.79
.4	.4	.63	.83
.5	.5	.71	.87
.6	.6	.77	.90
.7	.7	.84	.93
.8	.8	.89	.96
.9	.9	.95	.98
[4]1.0	1.0	1.00	1.00
1.1	1.1	1.05	1.02
1.2	1.2	1.10	1.04
1.3	1.3	1.14	1.05
1.4	1.4	1.18	1.07
1.5	1.5	1.22	1.08
1.6	1.6	1.26	1.10
1.7	1.7	1.30	1.11
1.8	1.8	1.34	1.12
1.9	1.9	1.38	1.14
2.0	2.0	1.41	1.15

[1]Adjustment factor for roots = (M_g / M_c), where M_g is aboveground biomass for given crop and M_c is aboveground biomass for core crop.
[2]Adjustment factor for canopy percenter = $(M_g / M_c)^{0.5}$
[3] Adjustment factor for fall height = $(M_g / M_c)^{0.2}$
[4]Represents core crop

Table D-3. Data adjustment examples for root biomass, percentage of canopy cover, and fall height[1].

	Root biomass percent adjustments		Canopy percent adjustments		Fall height adjustment in feet	
Days	Core crop	Given crop	Core crop	Given Crop	Core Crop	Given Crop
30	180	110	10	10	0.5	0.4
45	350	210	50	40	1.0	0.9
60	530	320	80	60	1.7	1.5
75	840	500	100	80	2.5	2.2
90	1060	640	100	80	3.0	2.7
150	1060	640	70	55	3.0	2.7

[1]The following example is used:

- Core crop is corn at 125 bu(acre)$^{-1}$
- Given crop is corn at 75 bu(acre)$^{-1}$. Ratio of biomass at maturity for given crop to that core crop = 0.6.

Table D-4. Percent cover to mass relationship for core crops.

	Mass (lbs(acre)$^{-1}$) at various percentages of residue cover		
Crop	30	60	90
Corn	950	2400	6050
Soybeans	600	1600	—
Cotton	1600	4150	—
Sorghum	1050	2700	6750
Winter wheat	600	1550	3850
Spring oats	600	1550	3850

Table D-5. Decomposition coefficient values

Crop	Coefficient
Alfalfa	0.020
Brome grass	.017
Corn	.016
Cotton	.015
Peanuts	.015
Small grain	[1].008
Small grain cover crop killed while in vegetative stage	.017
Sorghum	.016
Soybeans	.025
Sunflowers	.016
Tobacco	.015

[1] Use 0.017 for the Northwestern Wheat and Range Region.

Table D-6. Depth of incorporation according to type of tillage operation

Operation	Depth of incorporation (in)
Primary tillage operations that invert soil, such as moldboard plow	8
Primary tillage operations that do not invert soil, such as chisel plows and heavy plowing disks	6
Operations involving widely spaced shanks that inject significant amounts of biomass into the soil, such as manure injectors	6
Secondary tillage operations involving disks, such as tandem disk	4
Bedding and ridging operations, such as listers, hippers, and similar tools (cultivators used in ridge-till cropping are not included in this category)	4
Secondary tillage operations involving shank type tools that mix the soil significantly, such as field cultivators	3
Shank type operations using widely spaced shanks where minimal mixing occurs, such as subsoilers and anhydrous fertilizer knife-type applicators	2
Secondary tillage operations and other operations that disturb only a shallow upper layer or that leave crop residue in a shallow upper layer, such as harrows, planters, row cultivators, and tools where minimal mixing occurs	2

Table D-7. Adjustments to random roughness index in inches to represent smoother and rougher surfaces than represented by "core" value

Smoother surface	Core roughness value	Rougher surface
0	0.1	0.2
0.1	.2	.4
.2	.4	.8
.4	.8	1.2
.8	1.2	1.6
1.2	1.6	2.0
1.6	2.0	2.4
2.0	2.4	2.8

Procedure: Identify a "core" roughness value. If the site specific condition is significantly smoother than the core surface, use the roughness value from the "smoother surface" column, and conversely for a rougher surface.