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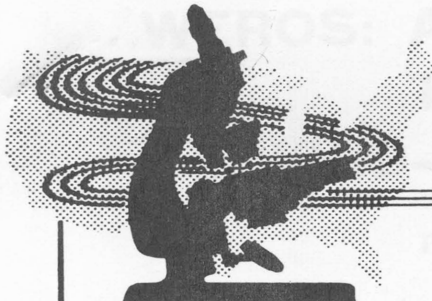

WEROS: A FORTRAN IV PROGRAM TO SOLVE THE WIND-EROSION EQUATION

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WEROS: A FORTRAN IV PROGRAM TO SOLVE THE WIND-EROSION EQUATION[1]

P. S. Fisher and E. L. Skidmore[2]

Soil blowing is a serious problem in arid and semiarid regions, including sandy areas in the United States. In 30 years of research, W. S. Chepil (1, 2) and his associates (4, 5) delineated major factors influencing the amount of soil that wind will erode from a given agricultural field.[3] They expressed these factors in a wind-erosion equation:

$$E = f(I',K',C',L',V)$$

where E is the potential average annual soil loss for the specified conditions of erodibility, I'; roughness, K'; climatic factor, C'; field length, L'; and equivalent vegetative cover, V. To facilitate use of this equation to predict soil loss more effectively, and hence to control erosion with appropriate practices, we wrote a Fortran IV[4] program WEROS (Wind Erosion) capable of solving the equation quickly and accurately. Besides predicting amount of soil loss by wind, WEROS (through high-speed calculation) has made it easier to visualize the problem in reverse; that is, one can specify (in the program) the tolerable limits of soil erosion, and the program then can determine conditions for controlling soil loss within those limits. Thus, using WEROS one can easily study the various factors altering soil loss.

This report has two sections. The first presents two examples, one on predicting soil loss and the other on conditions for controlling soil loss. Each example includes information needed to use WEROS on any similar problem. The second section describes WEROS as a computer program, along with some relevant program procedures. To understand the examples, the reader should be familiar with information in references (4) and (5).

PART 1: HOW TO USE WEROS

Example 1: Obtaining the soil-erosion amount from specified conditions.

Suppose we want to know the potential soil loss based on existing conditions. We begin with the form in figure 1. Some items in this form are not pertinent to this particular problem. For example, the units are English; therefore, the box for metric units is not checked. Similarly, item 2, windward knoll slope, does not apply and is left blank. In general, any item on the form having an indicated default option may be left blank, resulting in use of the default option. However, all items without options (Nos. 1, 4, 5, 6, 7) must contain some information for WEROS to obtain an answer. Information that does not apply can be left blank, implying a value of zero for numerical items, and "does-not-apply" for checked items. Item 8 (left blank here) pertains only when form 2 (fig. 2) follows. Form 2 specifies the information that WEROS uses to search for some condition to obtain the prespecified potential soil loss; it will be discussed in example 2.

Data on form 1 are punched on four cards in fields, each 10 columns wide. Thus, each card will contain eight items located anywhere in the field. Each item will be punched with an explicit scale or decimal point or left blank as applicable. Figure 3 shows the data cards prepared to represent the specified data for this problem. The numerical values are represented explicitly; the

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[2] Assistant professor, statistics and computer science, Kansas State University, and soil scientist, Southern Plains Branch, Soil and Water Conservation Research Division, ARS, Manhattan, Kans., respectively.

[3] Underlined numbers in parentheses refer to items listed in List of References, p. 13.

[4] Fortran IV is one of the most widely used programing languages for communicating with a computer.

FORM 1 FOR COMPUTER SOLUTION OF WIND EROSION EQUATION

If the information for this form has metric units, check ☐.

1. Percentage of soil aggregates greater than 0.84 mm. 10%.

2. Windward knoll slope, less 500 feet_____%.

   a. From top of knoll ☐

   b. From upper 1/3 ☐
   Default I_s = 1

3. Fill in the appropriate (not more than one entry):

   a. Ridge height_____(in. or cm.)
   Ridge spacing_____(in. or cm.)

   b. Ridge roughness factor _____(dimensionless)

   c. Field is smooth ☐ or rough ☑. Default K' = 1.

4. The climatic factor is 100 %.

5. Fill in the following:

   a. The angle of deviation of prevailing wind erosion direction from right angles to field strip is 0 degrees.

   b. Preponderance of wind erosion forces in prevailing wind erosion direction is 2.

   c. Height of barrier _____(ft. or m.)

   d. Field width 320 (ft. or m.). Default = 5,000 feet.

6. Quantity of vegetative cover 1600 (lbs./acre or kg./ha.)

7. Type of vegetative cover (check all correct responses):

   a. Small grain stubble ☐

      1. Flat ☐
      2. Standing ☐

   b. Small grain crops in seedling or stooling stage ☐

      1. Furrow ☐
      2. Smooth ☐

   c. Sorghum stubble ☑

      1. Flat ☐
      2. Standing ☑
      3. Height 12 (in. or cm.)

8. Check if Form 2 follows ☐.

Figure 1.—Form 1 containing the specified information for example 1.

FORM 2 FOR COMPUTER SOLUTION OF WIND EROSION EQUATION

If the information for this form has metric units, check ☐

1. What is tolerable amount of wind erosion (tons/acre/year or metric tons/ha./year)?

   Lower limit 5 Upper limit 5 Increment ____

2. Check the blank opposite the variable under investigation. Check the box opposite the variable specified and specify this variable by entering appropriate values.

   ✓ ☐ a. Soil cloddiness (percentage of aggregates greater than 0.84 mm.)

   Lower limit ____ Upper limit ____ Increment ____

   ___ ☐ b. Soil ridge roughness factor (dimensionless)

   Lower limit ____ Upper limit ____ Increment ____

   ___ ☐ c. Quantity of vegetative cover (lbs./acre or kg./ha.)

   Lower limit ____ Upper limit ____ Increment ____

   ___ ☐ d. Barrier height (ft. or m.)

   Lower limit ____ Upper limit ____ Increment ____

   ___ ☐ e. Field width (ft. of m.)

   Lower limit ____ Upper limit ____ Increment ____

   ___ ☑ f. Climatic factor (percent)

   Lower limit 10 Upper limit 100 Increment 10

3. The program searches the conditions necessary to limit potential soil loss to amount specified in item 1, ± ____%. Default = 5%.

Figure 2.—Form containing the specified information for example 2.

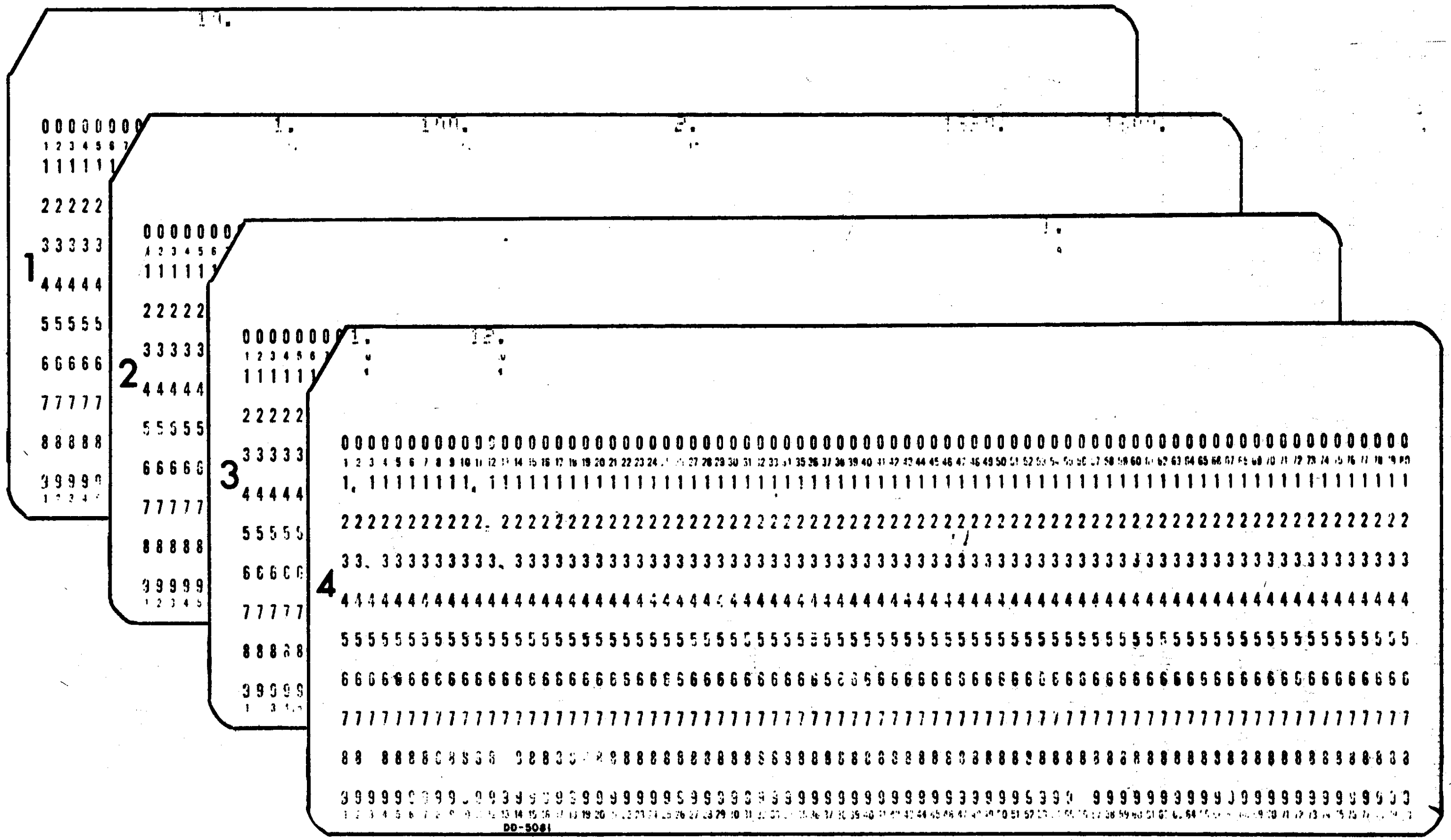


Figure 3.—The four data cards representing information contained on form 1 (fig. 1).

checks on the form are represented on the cards by a "1." Item number or numbers given below each 10-column field correspond to the applicable numbers on form 1.

Data cards are then placed at the back of the program, and with the proper control cards (those required by the particular computer installation) in place, the program can be executed.

The output from WEROS, shown in figure 4, consists of three basic items: (1) A brief copy of the input data; (2) the calculated answer; and (3) identification information (that is, example 1). The input data as printed out agrees with the conditions we specified initially for this problem, and the answer is given as 28 tons/acre/year or 63 metric tons/hectare/year.

To understand the mechanics of this procedure; that is, use of data cards and interpreting information as it is reproduced by the computer, the following information is pertinent. As shown in figure 4, under "INPUT," the units, when presented, are given in the English system. However, in no way is the card input limited to English units; in fact, if the box denoting metric units is checked, metric units must be given for all items or answers will be incorrect. Also the number 0. appearing in figure 3 beside various entries denotes either that the item is not applicable, or that its value is 0.. The No. 1. has the same function; that is, it means that the item marked is applicable, or that its value is 1.. Consider, for example, the entry "CLIMATIC FACTOR." The value given is 1. (fig. 4), which means 100 percent, and in this case, it is the literal value of the climatic factor used. However, under ridge roughness (item 3, fig. 1) a 1. appears next to the entry "OR ROUGH," which signifies that the field under consideration is rough. Another anomaly appears as part of the last entry. Under "SORGHUM STUBBLE" and next to "OR STANDING" is the number pair, "1. 12.". The 1. again tells us that we are concerned with standing sorghum stubble; 12. denotes, in inches, the height of the stubble.

Returning to form 1 (fig. 1) and fig. 3, all percentage data are to be punched on the cards as percentages, not as decimals. For example, in figure 3 the first card contains an entry for the percentage of soil aggregates larger than 0.84 mm.; the value given, 10 percent, is punched 10. on the data card. Those entries not applying or having a value of 0 can be represented by a blank or empty field on the data card. Last, nothing other than numbers and their accompanying decimal points should appear on the data cards.

Example 2: Obtaining a specified condition to control erosion when tolerable soil loss has been specified.

Consider a problem with these specifications:

1. From a specified field, we wish to allow a soil loss of approximately 5 tons/acre/year.

2. The field is smooth.

3. The preponderance of wind-erosion forces in the prevailing wind-erosion direction is 2, while the angle of the prevailing wind-erosion direction from right angles to the field strip is 20 degrees.

```
OUTPUT


THE ANSWER IS    28.1999    TONS/ACRE/YEAR   OR      63.2129    MET TONS/HA/YEAR

           INPUT
           PERCENTAGE OF SOIL AGGREGATES 10.0
           WINDWARD KNOLL SLOPE  0.0
           A.   0.        B.   0.
           RIDGE HT 0.00  IN.          RIDGE SPACING   0.00  IN.
           RIDGE ROUGHNESS  0.0
           SMOOTH    0.     OR ROUGH   1.
           CLIMATIC FACTOR   1.0
           WIND ANGLE  0.0
           WIND FORCE   2.00
           HEIGH OF BARRIER (FT)     0.0
           FIELD WIDTH (FT)  1320.0
           VEGETATIVE COVER (LBS/ACRE)  1600.0
           SMALL GRAIN STUBBLE    0.
               FLAT   0.     OR STANDING   0.
           SMALL GRAIN SEEDLING OR STOOLING   0.
               FURROW   0.     OR SMOOTH   0.
           SORGHUM STUBBLE
               FLAT   0.     OR STANDING   1.  12.



CASE NUMBER =     1
```

Figure 4.—Output of WEROS after processing the information of example 1, as specified on the cards shown in figure 3.

4. The field is 1,480 feet wide.

5. It has no vegetative cover.

Using those specifications, suppose we investigate the effect of climatic factor on the percentage of soil aggregates greater than 0.84 mm. required to limit soil loss to a specified amount. That is, for different climatic factors what percentage of soil aggregates greater than 0.84 mm. is needed to keep wind erosion to the level of 5 tons/acre/year? Let us examine climatic factors, with an increment value of 10, ranging from a low of 10 to a high of 100.

Form 1 can be completed as shown in figure 5; however, this time item 8 must be checked. That signifies to WEROS that what follows is a data card applying to the search part of the program and supplying the necessary information to obtain the required answer.

With item 8 of form 1 checked, we now complete form 2 as shown in figure 2. Again the units are in English, so the first box on the form is left blank. As specified, we are interested in a soil loss of approximately 5 tons; therefore, in item 1, we will supply 5. for both the lower and the upper limits, leaving the increment blank.

In item 2 we are interested in the effect of climatic factor on soil cloddiness, so we check the blank in part a and the box in part f, here supplying the lower (10.) and upper (100.) limits of the climatic factor and its increment (10.).

Item 3 allows us to adjust the tolerance on soil-loss limits recorded in item 2. That is, if item 3 is left blank, the program will accept an answer for soil cloddiness that under the specified climatic condition will be in the range of 5 tons/acre/year ± 5 percent, or 4.75 to 5.25 tons/acre/year, but if one wishes an answer to any other degree of accuracy that value can be placed in item 3. For this problem, the 5 percent limit is deemed acceptable.

Figure 6 shows the data cards prepared for this problem. The first four cards, representing information on form 1, have been punched as specified in the previous example. The fifth card, representing information on form 2, contains at most 10 punched numbers, each number being allowed five columns. The first five columns contain either a blank or the right justified number "1," depending on whether English or metric units are used. The next three sets of five columns (columns 6-20) contain the lower, upper, and incremental values for soil loss, respectively; each of the three numbers includes a decimal point and can be located anywhere in its designated 5-column field. The next two fields (columns 21-30) contain information for item 2; the first number is, for this example, a "1," right justified, denoting that the first entry of item 2 is the variable we wish to determine. The second field of 5 columns contains a "6," right justified, signifying that entry "f" (sixth entry, climatic factor) is the one that will vary. The next three fields (columns 31-45) contain the numbers representing lower, upper, and incremental values of the climatic factor as specified; the values should include a decimal point and may be located anywhere in their respective fields. If no decimal is given, the program automatically places a decimal one digit to the left of the last digit in the field.

To instruct the computer to print out each iteration of the search, add 1,000 to the increment value. The increment value (the "10" of fig. 2), then, is punched as 10,100 as shown in figure 6. The program interprets this as 1,010.0 and will extract the increment value. It sets a switch for this case and prints out each iteration of the search as shown in figure 7.

The output from this problem (shown in fig. 7) consists of the important input parameters and their values as described in the last section. The identification "CASE NUMBER = 2" is included to indicate this was the second problem run. The next row shown pertains to data on form 2; that is, we are looking for 1 (soil cloddiness) using 6 (climatic factor) where the values of 6 range from a low of 0.1 to a high of 1. by increments of 0.1 or in percentages 10, 100, 10, respectively. The next item indicates amount of soil loss specified for the conditions specified in the preceding line—in this case, 5 tons/acre/year.

Because the increment value of 0.1 was punched on the card as 10,001, the next five rows are printed out to show the search number (that is, each try of the program to find the proper soil-cloddiness value). The second entry on each of these five lines contains information that prevents the program from continuing indefinitely without converging to an answer. In general, if the next guess does not improve the answer, then, the "improvement-counter" is incremented. If five consecutive non-improvements are recorded, the search will terminate. The program will then proceed to the next case, be it a new set of data or just the increment of a current parameter. This counter is used primarily when a set of conditions is given in which no answer is possible, and with our example, that could occur if the percentage of soil cloddiness needed to control soil erosion happened to be outside the range of the soil-cloddiness table.

The search bounds, given next in these five rows, specify the lower and upper limits of the interval in which the value of cloddiness is being sought. The last two items of each row specify the result of soil loss for the value given. Thus, we read the first of these five rows of search information in figure 7 as: It is search No. 1 in the interval 2. to 80. (soil-cloddiness range), and WEROS

FORM 1 FOR COMPUTER SOLUTION OF WIND-EROSION EQUATION

If the information for this form has metric units, check ☐.

1. Percentage of soil aggregates greater than 0.84 mm. ________.

2. Windward knoll slope, less 500 feet______%.

    a. From top of knoll ☐

    b. From upper 1/3 ☐
    Default $I_s = 1$

3. Fill in the appropriate (not more than one entry):

    a. Ridge height______(in. or cm.)
    Ridge spacing ______(in. or cm.)

    b. Ridge roughness factor ______(dimensionless)

    c. Field is smooth ☑ or rough ☐. Default K' = 1.

4. The climatic factor is ______%.

5. Fill in the following:

    a. The angle of deviation of prevailing wind erosion direction from right angles to field strip is 20 degrees.

    b. Preponderance of wind erosion forces in prevailing wind erosion direction is 2.

    c. Height of barrier______(ft. or m.)

    d. Field width 1480 (ft. or m.). Default = 5,000 feet.

6. Quantity of vegetative cover ______(lbs/acre or kg./ha.)

7. Type of vegetative cover (check all correct responses):

    a. Small grain stubble ☐

        1. Flat ☐
        2. Standing ☐

    b. Small grain crops in seedling or stooling stage ☐

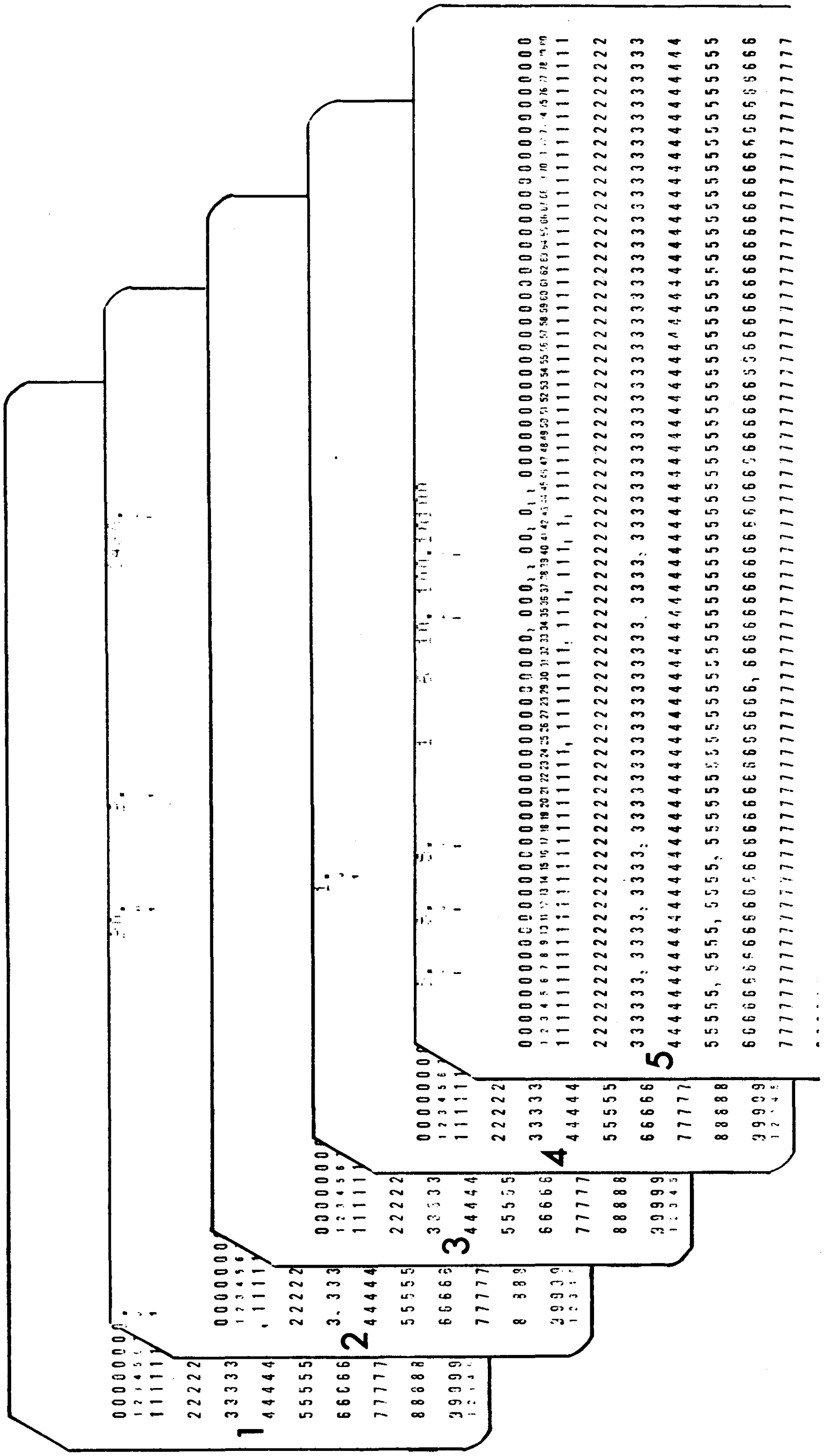
        1. Furrow ☐
        2. Smooth ☐

    c. Sorghum stubble ☐

        1. Flat ☐
        2. Standing ☐
        3. Height ______(in. or cm.)

8. Check if Form 2 follows ☑.

Figure 5.—Form 1 containing the specified information for example 2.


1
2
3
4
5

```
INPUT
PERCENTAGE OF SOIL AGGREGATES  0.0
WINDWARD KNOLL SLOPE  0.0
A.   0.         B.   0.
RIDGE HT 0.00  IN.          RIDGE SPACING   0.00  IN.
RIDGE ROUGHNESS  0.0
SMOOTH   1.     OR ROUGH   0.
CLIMATIC FACTOR   0.0
WIND ANGLE 20.0
WIND FORCE   2.00
HEIGH OF BARRIER (FT)     0.0
FIELD WIDTH (FT)  1480.0
VEGETATIVE COVER (LBS/ACRE)     0.0
SMALL GRAIN STUBBLE    0.
    FLAT   0.      OR STANDING   0.
SMALL GRAIN SEEDLING OR STOOLING   0.
    FURROW   0.      OR SMOOTH   0.
SORGHUM STUBBLE
    FLAT   0.      OR STANDING   0.   0.



CASE NUMBER =      2

     LOOKING FOR     1  USING     6  VALUES OF:   LOWER    0.10  UPPER    1.00  AT INCREMENTS OF:      0.10
NEXT CASE FOR E=    5.0

SEARCH NO.    1  NO. FROM LAST IMPROV.    0  SEARCH   BOUNDS     2.0000    80.0000  ANS    24.9999   FOR    2.000

SEARCH NO.    2  NO. FROM LAST IMPROV.    0  SEARCH   BOUNDS     2.0000    80.0000  ANS     4.2425   FOR   41.000

SEARCH NO.    3  NO. FROM LAST IMPROV.    0  SEARCH   BOUNDS     2.0000    41.0000  ANS     8.8926   FOR   21.500

SEARCH NO.    4  NO. FROM LAST IMPROV.    0  SEARCH   BOUNDS    21.5000    41.0000  ANS     5.4832   FOR   31.250

SEARCH NO.    5  NO. FROM LAST IMPROV.    0  SEARCH   BOUNDS    31.2500    41.0000  ANS     4.7750   FOR   36.125
NUMBER OF SEARCHES      5
GIVEN NO     6
SOUGHT  VALUE     1                    **RESULT**     36.13  (ENGLISH UNITS)         36.13  (METRIC UNITS)

SEARCH NO.    1  NO. FROM LAST IMPROV.    0  SEARCH   BOUNDS     2.0000    80.0000  ANS    49.9288   FOR    2.000

SEARCH NO.    2  NO. FROM LAST IMPROV.    0  SEARCH   BOUNDS     2.0000    80.0000  ANS     8.5636   FOR   41.000

SEARCH NO.    3  NO. FROM LAST IMPROV.    0  SEARCH   BOUNDS    41.0000    80.0000  ANS     2.5906   FOR   60.500

SEARCH NO.    4  NO. FROM LAST IMPROV.    0  SEARCH   BOUNDS    41.0000    60.5000  ANS     4.8569   FOR   50.750
NUMBER OF SEARCHES      4
GIVEN NO     6
SOUGHT  VALUE     1                    **RESULT**     50.75  (ENGLISH UNITS)         50.75  (METRIC UNITS)

SEARCH NO.    1  NO. FROM LAST IMPROV.    0  SEARCH   BOUNDS     2.0000    80.0000  ANS    74.9020   FOR    2.000
```

Figure 7.—Output of WEROS for example 2.

has tried a value of 2., yielding a soil loss of 24.999 or 25. tons/acre/year. That is far in excess of the 5 tons/acre/year specified. Therefore, the process is continued until (at the completion of the fifth search) WEROS has obtained a soil-cloddiness value of 36.125 percent, which yields a soil loss of 4.775; that is, within the 5 percent range of 5 tons/acre/year for a climatic factor of 10.

The next three lines specify the given and sought value as well as the solution. In this case, the answer for English and metric units is identical because the answer is a percentage without units. However, when the answer has units, then both the value in metric units and the value in English units will be given.

WEROS then continues this case by incrementing the climatic factor of 10 by 10 to get 20 and proceeds to compute a new soil-cloddiness factor, which it does in four searches. That value is given as 50.75 percent.

Item 1 on form 2 can specify three things. One situation investigated was the effect of varying climatic factor on soil cloddiness with soil loss specified at 5 tons/acre/year. Suppose now, we investigate a pair of factors at some specified soil loss; for example, the effect of climatic factor and soil cloddiness. We can do that by specifying the limits and an increment value. For example, suppose we apply the last problem to values of soil loss from 5 to 25 tons/acre/year at increments of 5 tons. This information should be included on the input card, and the output should contain (for the above problem) 10 answers for 5 tons, 10 for 10 tons/acre/year, and so forth for a total of 50 answers.

Then we interpret item 1 of form 2. Suppose we are now interested in the effect of climatic factor on soil cloddiness (again we could have selected any other pair) when the soil loss is specified only by a low and a high value. For example, we could allow soil loss to be specified in the range 5 to 10 tons/acre/year; then 5 would be included in the "lower" and 10 in the "upper" and the increment left blank. Thus, the example explained above is just a special case of this more general ability.

The last items of importance to the users of WEROS are: (1) Form 1 and form 2 need not specify the same type of units, and (2) when both forms are used, any information contained on the cards representing form 1, which pertains to or duplicates information given on the card representing form 2, will be disregarded. That is, if in example 2, the cards from form 1 had contained a value of 2. for the climatic factor, this value would have been ignored for the computations specified by the card representing form 2, which contains conflicting specifications for the climatic factor.

PART 2: THE PROGRAM WEROS

WEROS is written in a generally accepted implementation—an independent version of FORTRAN IV. For the most part, WEROS follows the procedure outlined by Skidmore and others (3) to obtain a solution when the problem is similar to that of example 1 of the previous part. However, the solution procedure is somewhat more complex when the problem is similar to that given in example 2 of Part 1.

WEROS consists of 11 subroutines, each performing a major function in the solution procedure. Thus, the program can be modified and tailored easily to fit individual requirements. This modularity also contributes to understanding of functions performed in each routine. Figure 8 shows the sequence of routines as they are used to solve problems similar to examples 1 and 2 of the previous part, respectively.

The only significant difference between the two sequences (fig. 8) is the use of MAIN1 when a problem requiring a search is specified.

A brief explanation of each subroutine follows.

A. MAIN

MAIN is the controlling routine, and as shown in figure 8, it will call for the routine IPUT; it may call for the routine COMPUT or MAIN1, depending on the specification of the problem. IPUT is called to obtain data from the necessary tables and figures as contained in (4). Data representing information on form 1 are read in next, and if these data are in metric units, they will be converted to the English equivalents. Thus, all computations in WEROS are done with English units, which simplifies programing.

If method 1 (that is the procedure required to solve problems similar to example 1) is required, MAIN calls COMPUT, which will obtain the answer. The answer is printed out: then, the input data are printed, completing the required task. If, however, method 2 (that is, the procedure required to solve problems similar to example 2) is specified, then MAIN prints out the input data and calls MAIN1 to complete the problem. As each specified problem is completed, another set of data cards, representing form 1, is read in. If no such cards are found, WEROS is terminated with an error message due to an end-of-file condition. This termination procedure could easily be altered to meet the specifications of an individual system by inserting statements to check for a special terminal card.

B. INPUT

The INPUT routine consists of read statements, which read from cards, the data representing the tables and graphs used in calculating an answer. The data are stored in seven arrays as discrete values from the curves they represent. Other values that may be required are interpolated from surrounding values. We used values obtained from graphs based on the criteria that in the areas where the slopes of the curves exhibited the most rapid change, the values were taken closer together, while from the remaining areas of the graphs fewer values were used. Selecting the points in this manner permitted use of linear interpolation with a relatively small, but predictable error.

C. COMPUT

This routine controls the remaining routines and the sequence in which they are executed to obtain an answer for the specified data.

D. IPRIME

This routine calculates the value of *I*, which is soil erodibility, from the input data for the percentage of

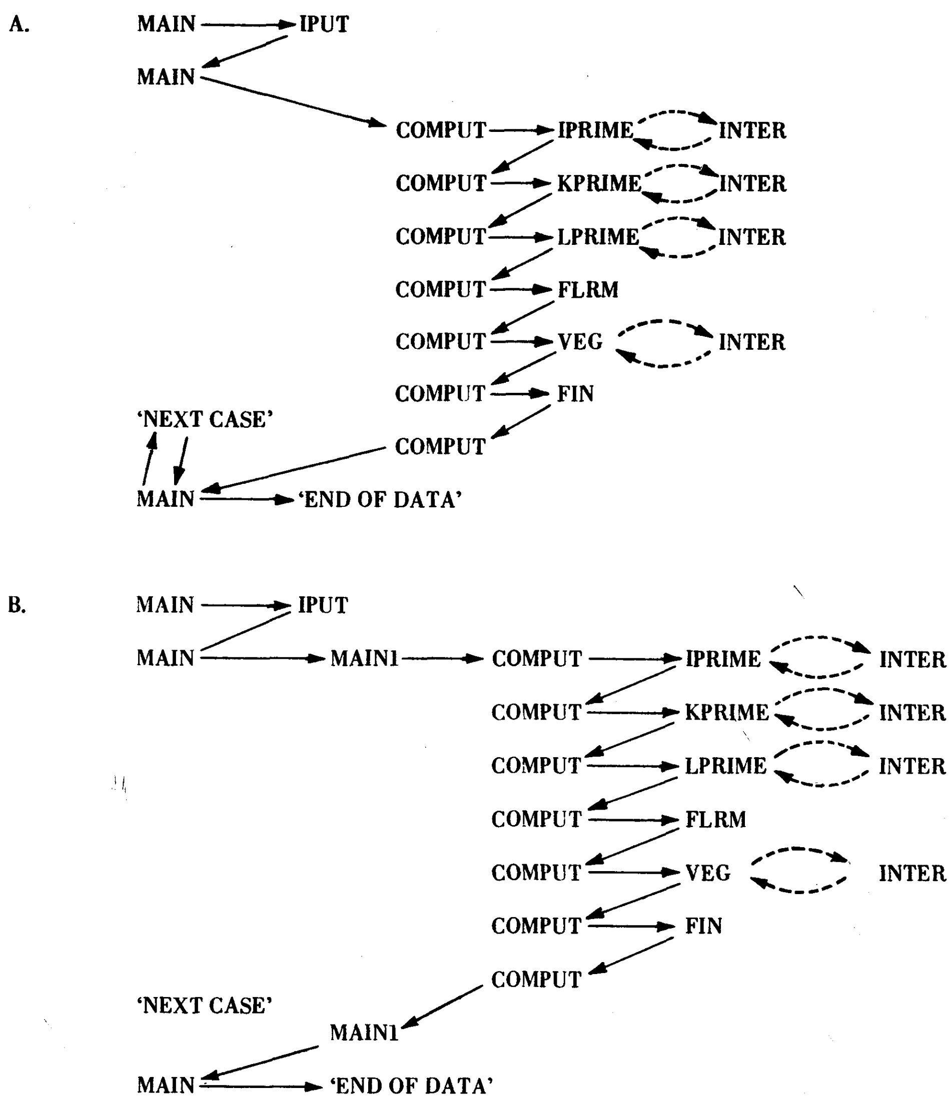


Figure 8.—Sequence of subroutines to calculate an answer to problems similar to examples A and B, respectively. The broken lines represent possible use; the solid lines, definite use.

soil fractions larger than 0.84 mm. Then, using the information on the percentage of windward knoll slope, the value of I' (soil-erodibility index) is calculated. If the percentage of windward knoll slope is given, then IPRIME will use INTER to obtain the potential soil loss for that value. If no percentage of windward knoll slope is specified, the value of 1 will be used.

E. KPRIME

This routine determines the soil-ridge roughness factor K' from data specified for this item on form 1. If a measurement for ridge spacing and height is given, KPRIME will use INTER to interpolate a value for the soil-ridge roughness factor K'. If the field is simply smooth or rough, then KPRIME will return the value 1. or 0.5, respectively. If nothing is specified, KPRIME will assume a smooth field and return the value 1.

F. LPRIME

This routine calculates the median unsheltered travel-distance across field, L'. It involves items listed under 5 on form 1. In the worst case, three interpolations are required to obtain the median travel distance across field, from which LPRIME subtracts 10 times any barrier height to obtain unsheltered distance.

G. FLRM

This routine uses the value of L', E_2, E_3 to calculate a value of E_4 where

$$E_2 = I' K'$$
$$E_3 = E_2 C' \text{ (climatic factor).}$$

E_4 is the soil loss from a field having no vegetative cover. E_4 is expressed as

$$E_4 = I' K' C' f(L') = E_3 f(L').$$

To calculate E_4, a series of interpolations, or manipulations, of two figures are required. The manipulation, as specified in (4, 5), is impossible to do with a computer. Therefore, an equivalent procedure, explained in (3), is used. Use of the new approach requires several interpolations that cannot be included conveniently in routine INTER. Therefore, they are included within FLRM, and they follow the procedure outlined in (3).

H. VEG

This routine uses a set of nine graphs to determine the equivalent pounds of vegetative cover on a field. Here again, depending on conditions specified by form 1, one or three interpolations could be necessary. Using the specified data, VEG will use INTER to obtain the value V.

I. FIN

This routine uses the values of V (equivalent pounds per acre of vegetative cover) and E_4 to determine the answer of soil loss. The family of curves given in (*4, fig. 24*) and in (*5, fig. 10*) shows a sequence of polynomials of order one when they are graphed on a log-log scale. Being straight lines, they can be stored as a pair (x,θ), where x is $\log_{10}$ of the abscissa intersection value and θ is the acute angle between the abscissa and the line. FIN takes the logarithm of E_4 and finds the difference between this value and the point of intersection of straight line with abscissa. That difference, which represents the adjacent side of a right triangle whose hypotenuse is equivalent vegetative cover, and angle θ are used to determine the ordinate, which is the log of sought answer. If the value of V given to FIN is not one of the exact values of V on the curves, interpolation is required and two ordinate values are determined from the formula

$$y_1 = x_1 \tan\theta_1$$
$$y_2 = x_2 \tan\theta_2$$

where θ_1 and θ_2 are the angles of the preceding and following lines corresponding to the surrounding value of V, and x_1 and x_2 are the abscissa values corresponding to θ_1 and θ_2. Using the antilog of y_1 and y_2, an ordinate value y can be calculated by

$$y = y'_1 - \left(\frac{V-V_1}{V_2-V_1}\right)(y'_1 - y'_2)$$

where y'_1 and y'_2 are the antilogs of y_1 and y_2 and V_1 and V_2 are lines preceding and following V, respectively.

J. INTER

INTER is a general purpose linear-interpolation routine; it can interpolate on either abscissa or ordinate values, depending on the value of an input parameter.

K. MAIN1

This routine is used when method 2 is specified. Like MAIN, it has several functions. The first is to read in the data card representing form 2 and based on what is contained on this card, MAIN1 defines the problem to be solved. The process involves these steps:

1. Define the upper and lower limits allowed for soil loss.
2. Determine the bounds of the interval of definition for the variable being investigated and assign that variable a value equal to its lower limit.
3. Assign the initial value of the specified variable to its proper name with WEROS.
4. With this information, call COMPUT, which proceeds with the calculation already specified.
5. After an E value or answer is calculated, return to MAIN1 and check to see if it is within the necessary bounds. If it is, then continue with the next specified task. If it is not, adjust the value of the variable to a new value and call COMPUT to continue processing.

The method of search across the interval of definition for the variable being investigated is the well-known halving technique. That is, the first two points are the interval bounds; the third is the center point. The three points are used to select a new interval, which is one-half the old, and a new value, which is the midpoint of the new interval. Thus in $n > 3$ searches, WEROS is working with an interval of ½ n-2 times the length of the original interval. The number of searches generally ranges from four to six.

As explained in example 2 of Part 1, several values of E and several values of the specified variable could be given by stating a lower and an upper limit with an increment value. WEROS uses the values of E as the outer loop and the values of the specified variable as the inner loop.

CONCLUSION

Although the brief descriptions included here do not give all details of WEROS, at least function and role of each routine are specified regarding the problem-solving process embodied in the program. If source deck is desired, it can be obtained by writing to the authors. In requesting a source deck, include the type of machine facility that is available at the requesting facility to insure as little trouble as possible in getting WEROS to function correctly.

LIST OF REFERENCES

(1) Chepil, W. S., and Woodruff, N. P. Estimations of wind erodibility of farm fields. U.S. Dept. Agr. Prod. Res. Rpt. No. 25, 21 pp. March 1959.

(2) Chepil, W. S., and Woodruff, N. P. The physics of wind erosion and its control. Adv. Agron. 15:211-302. Academic Press, N. Y., 1963.

(3) Skidmore, E. L., Fisher, P. S., and Woodruff, N. P. Wind erosion equation: Computer solution and application. Soil Sci. Soc. Amer. Proc. (In press.)

(4) Skidmore, E. L., and Woodruff, N. P. Wind erosion forces in the United States and their use in predicting soil loss. U.S. Dept. Agr. Handb. No. 346, 42 pp. April 1968.

(5) Woodruff, N. P., and Siddoway, F. H. A wind erosion equation. Soil Sci. Soc. Amer. Proc. 29(5):602-608. 1965.

MISCELLANEOUS NOTES PERTAINING TO WEROS

ARRAYS REPRESENTING TABLES AND GRAPHS

The data for these ARRAYS are read from cards under control of the IPUT routine.

EROD	Soil erodibility I, table 3, reference 1.
RROUGH	Chart to determine soil ridge roughness factor KPRIME from the soil ridge roughness K sub R, fig. 4, reference 3; fig. 7, reference 1.
SCALE	Scale divisions of table I, reference 3.
SOLLSS	Table I, reference 2, adapted from soil loss chart - fig. 9, reference 3.
VEGCVR	Vegetative cover charts for determining equivalent vegetative cover from quantity of cover and vice versa.
WIND	Potential soil loss from knolls. Fig. 1, reference 3.
WNDERN	For determining median travel distance as a function of Rm and A. Fig. 3, reference 2.

REFERENCES

1. Skidmore, E. L., and Woodruff, N. P. 1968. Wind erosion forces in the United States and their use in predicting soil loss. U. S. Dept. of Agr. Handbook No. 346. 42 pp.

2. Skidmore, E. L., Fisher, P. S., and Woodruff, N. P. 1970. Wind erosion equation; computer solution and application. Soil Sci. Soc. Amer. Proc. 34:931-935.

3. Woodruff, N. P., and Siddoway, F. H. 1965. A wind erosion equation. Soil Sci. Soc. Amer. Proc. 29:602-608.

ROUTINES

IPUT (INPUT)	Consists of statements which read from cards, the data representing the tables and graphs used in calculations.
MAIN	Is the controlling routine.
COMPUT	Is called by either MAIN or MAIN1 and controls most of the remaining routines.
IPRIME	Calculates the value of soil erodibility, I'.
KPRIME	Determines the soil ridge roughness factor K'.
LPRIME	Calculates the median unsheltered travel distance across the field.
FLRM	Calculates the amount of soil loss (E4) from a field having no vegetative cover - interpolation routines are included.
VEG	Uses INTER to determine equivalent vegetative cover V.
FIN	Uses equivalent vegetative cover V and E4 to determine soil loss, E5.
INTER	Is a general purpose linear - interpolation routine.
MAIN1	Is used when method 2 is specified.

CODE	VARIABLE
ANG	Angle of deiration of prevailing wind erosion direction from right angles to field strip in degrees
CFCT	Climatic factor
CK1	Check 1, from top of knoll?
CK2	Check 2, from upper 1/3?
CK3	Check 3, is field smooth?
CK4	Check 4, is field rough?
CK5	Check 5, is vegetative cover small grain stubble?
CK6	Check 6, is small grain stubble flat?
CK7	Check 7, is small grain stubble standing?
CK8	Check 8, is small grain crop in seedling or stooling stage?
CK9	Check 9, is small grain crop furrowed?
CK10	Check 10, is small grain crop smooth?
CK11	Check 11, is vegetative cover sorghum stubble?
CK12	Check 12, is sorghum stubble flat?
CK13	Check 13, is sorghum stubble standing?
CK14	Check 14, does form 2 follow?
CK15	Check 15, indication of Metric or English units
FW	Field width
HT	Height of standing sorghum stubble
HTBR	Height of barrier
ICASE	Number of sets of input being processed

CODE	VARIABLE
KLSP	Windward knoll slope
PAG84	Percentage of soil aggregates greater than 0.84 MM
R	Quantity of vegetative cover
RDGHT	Ridge height
RDGRGH	Ridge roughness factor
RDGSP	Ridge spacing
WNDFRC	Preponderance of wind erosion forces in prevailing wind erosion direction

VARIABLES USED IN WEROS
ONLY WHEN FORM 2 IS USED ALSO

ALR	Lower limit of specified variable IHVE
AUI	Upper limit of specified variable IHVE
AUP	Increment limit of specified variable IHVE
IFND	Find the level of IFND variable for specified level of IHVE for potential erosion to be WEL, WEU, WEI
IHVE	Specified variable for investigation at various levels
IU	English or Metric units
PCT	Tolerance specification for search
WEI	Tolerable amount of wind erosion increment
WEL	Tolerable amount of wind erosion lower limit
WEU	Tolerable amount of wind erosion upper limit

PUNCHING DATA CARDS

<u>DATA OF FORM 1</u> are punched of four cards in fields, each 10 columns wide, each item may be located anywhere in field and punched with a decimal point or left blank.

Checks on the form are represented by "1." on the cards.

	Form	Item	Card #	Column	Type
1.	1.	Check	1	1-10	Real
2.	1.		1	11-20	Real
3.	2.		1	21-30	Real
4.	2.	a.	1	31-40	Real
5.	2.	b.	1	41-50	Real
6.	3.	a. height	1	51-60	Real
7.	3.	a. spacing	1	61-70	Real
8.	3.	b.	1	71-80	Real
9.	3.	c. smooth	2	1-10	Real
10.	3.	c. rough	2	11-20	Real
11.	4.		2	21-30	Real
12.	5.	a.	2	31-40	Real
13.	5.	b.	2	41-50	Real
14.	5.	c.	2	51-60	Real
15.	5.	d.	2	61-70	Real
16.	6.		2	71-80	Real
17.	7.	a.	3	1-10	Real
18.	7.	(1)	3	11-20	Real
19.	7.	(2)	3	21-30	Real

	Form	Item	Card #	Column	Type
20.	7.	b.	3	31-40	Real
21.	7.	(1)	3	41-50	Real
22.	7.	(2)	3	51-60	Real
23.	7.	c.	3	61-70	Real
24.	7.	(1)	3	71-80	Real
25.	7.	(2)	4	1-10	Real
26.	7.	(3)	4	11-20	Real
27.	8.		4	21-30	Real

Form 2

	Check ▱	5	1-5	Right Justified
1.	Lower Limit	5	6-10	Real (Decimal)
	Upper Limit	5	11-15	Real (Decimal)
	Increment	5	16-20	Real (Decimal)
2.	"________"	5	21-25	Right Justified
	▱	5	26-30	Right Justified
	Lower	5	31-35	Real (Decimal)
	Upper	5	36-40	Real (Decimal)
	*Increment	5	41-45	Real (Decimal)

* To instruct the computer to print out each iteration of the search, add 1000 to the increment value.