The Wind Erosion Prediction System

WEPS 1.0

User Manual DRAFT

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Preface and Acknowledgments

Preface

Wind erosion is a serious problem on agricultural lands throughout the United States as well as the world. The ability to accurately predict soil loss by wind is essential for, among other things, conservation planning, natural resource inventories, and reducing air pollution from wind blown sources. The Wind Erosion Equation (WEQ) is currently widely used for assessing average annual soil loss by wind from agricultural fields. The primary user of WEQ is the United States Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS). When WEQ was developed more than 35 years ago, it was necessary to make it a simple mathematical expression, readily solvable with the computational tools available. Since its inception, there have been a number of efforts to improve the accuracy, ease of application, and range of WEQ. Despite these efforts, the structure of WEQ precludes adaptation to many problems.

The USDA appointed a team of scientists to take a leading role in combining the latest wind erosion science and technology with databases and computers, to develop what should be a significant advancement in wind erosion prediction technology. The Wind Erosion Prediction System (WEPS) incorporates this new technology and is designed to be a replacement for WEQ.

Unlike WEQ, WEPS is a process-based, continuous, daily time-step model that simulates weather, field conditions, management, and erosion. WEPS 1.0 consists of the WEPS science model with a user friendly program that has the capability of simulating spatial and temporal variability of field conditions and soil loss/deposition within a field. WEPS 1.0 can also simulate simple field shapes and barriers on the field boundaries. The saltation/creep, suspension, and PM10 components of eroding material also can be reported separately by direction in WEPS 1.0. WEPS 1.0 is designed to be used under a wide range of conditions in the U.S. and is adaptable to other parts of the world. For further information regarding WEPS contact:

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Finally, acknowledgment is made of the many other individuals who have made this release of WEPS possible by reviewing this document and those who contributed through fundamental research on which many of the underlying concepts of WEPS are based.

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INTRODUCTION

WEPS
WIND EROSION PREDICTION SYSTEM

Introduction

How to Use This Document

The Wind Erosion Prediction System or 'WEPS' is a process based, daily time-step, wind erosion simulation model. It represents the latest in wind erosion prediction technology and is designed to provide wind erosion soil loss estimates from cultivated, agricultural fields. WEPS 1.0 consists of the computer implementation of WEPS science with a user interface designed to provide a easy to use methods of providing inputs to the model and obtaining output reports.

The WEPS 1.0 User Manual is designed to provide information to different levels of users. The minimum computer requirements and the steps to install WEPS on your computer (Chapter 1) are described below. Those users who are completely new to WEPS should start with the "Beginners Guide" (Chapter 2). It is recommended that, as a minimum preparation to use WEPS, the user should read the "Overview of the Wind Erosion Prediction System". Once WEPS has been installed on your computer, the user should learn how to make a simple simulation run using the "Quick Start for WEPS 1.0". For users interested in more details of the science behind WEPS, the chapter titled "Science - How WEPS Simulates Wind Erosion" (Chapter 3) is recommended. A more detailed description of the science of the WEPS model is available in the "WEPS Technical Description" which is available from WERU. More experienced users should become familiar with "How to Operate WEPS" (Chapter 4), which goes into detail of how to use all of the capabilities of WEPS 1.0. These details are also available in the 'Online Help', accessible through the WEPS 1.0 interface screen. Example problems are contained in Chapter 5, "Using WEPS in Conservation Planning". This section guides the user through exercises which describe how to use WEPS to design conservation systems. An index to the WEPS User Manual is available in Chapter 6. Finally, the "Appendices" Chapter 7 contains a suggested outline for training others how to use WEPS. The Appendices also contain the text for the WEPS tutorials which are available on CD-ROM. These texts will be useful for those who are not able to listen to the audio portion of the tutorials and want to 'read along'.

Throughout this manual, the "user" refers to the person(s) using WEPS 1.0 to set up and make a simulation run. "Operator" refers to the producer or land manager whose actual field is being simulated with WEPS. This manual contains many graphics which are examples of what can be seen on the computer screen using WEPS. In addition, WEPS will continually be improved and the screens may change. Therefore, the user may or may not see the exact same screens as those illustrated in this manual.

Minimum Computer Requirements

The minimum requirements to install and operate WEPS1.0 are: A personal computer (PC) with Windows 95/98 (48 Mb RAM) or Windows NT (64 Mb RAM); Windows 2000 (192 Mb RAM); 128 MHz Pentium; 100 Mb free disk space on the hard drive; a CR-ROM drive for installation; and a VGA color monitor with a minimum screen resolution if 800 x 600 pixels. Contact WERU if you need assistance.

Installation

Insert the WEPS1.0 CD into the CD-ROM drive. Click [Start] [Run] and enter {w:/setup} where "w" represents the drive letter for your CD-ROM drive. Follow the instructions on the screen. NOTE: See the "readme" file for up-to-date installation instructions for this CD-ROM.

WEPS1.0 is also available for download on the WERU web site at http://www.weru.ksu.edu/weps. Follow the link for WEPS download and fill out the WEPS Download Registration form. By filling out the registration form, WERU will provide notices of updates to the model. The download file consists of an executable file which will install WEPS onto your computer. Contact WERU if you need assistance at:

Phone: 785-532-6495
E-mail: weps@weru.ksu.edu .

BEGINNERS GUIDE

WEPS

WIND EROSION PREDICTION SYSTEM

An Overview of the Wind Erosion Prediction System

Introduction

The Wind Erosion Prediction System (WEPS) is a process-based, daily time-step model that simulates weather, field conditions, and erosion. WEPS development is in response to customer requests for improved wind erosion technology. It is intended to replace the predominately empirical Wind Erosion Equation (WEQ) (Woodruff and Siddoway, 1965) as a prediction tool for those who plan soil conservation systems, conduct environmental planning, or assess offsite impacts caused by wind erosion.

WEPS development involves an ARS-led, national, multi disciplinary team of scientists. It has a multi-agency commitment consisting of the Agricultural Research Service (ARS), Natural Resource Conservation Service (NRCS), and Forest Service (FS) from the U.S. Department of Agriculture, along with the Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers, and Bureau of Land Management (BLM).

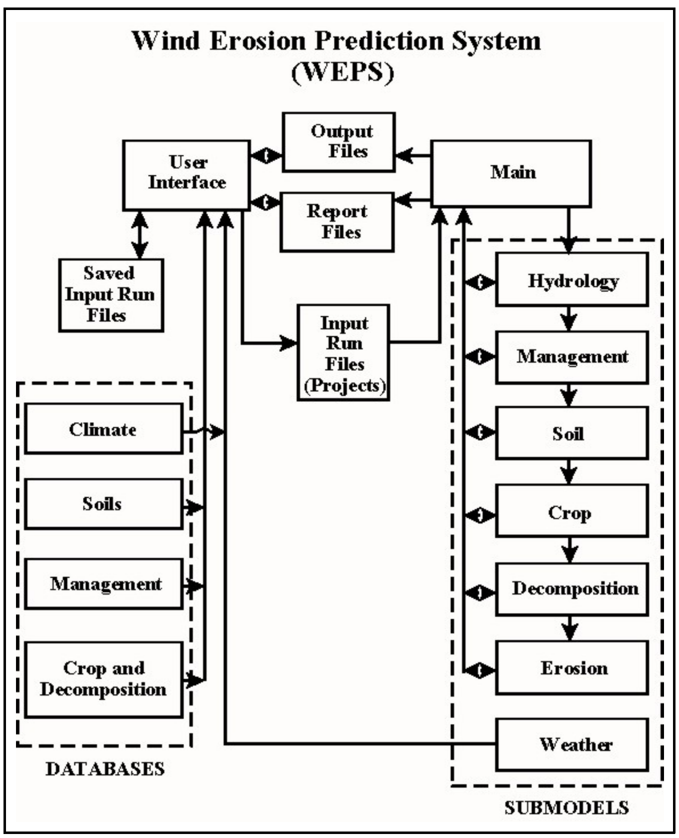

Figure 2.1. Structure of the WEPS model.

Objectives

The purposes of WEPS are to improve assessment of soil loss by wind from agricultural fields and to provide new capabilities such as assessing plant damage, calculating suspension loss, and estimating PM-10 emissions from the field.

Background

Soil erosion by wind is initiated when the wind speed exceeds the saltation threshold speed for a given soil and biomass condition. After initiation, the duration and severity of an erosion event depend on the wind speed and the evolution of the surface condition. Because WEPS is a continuous, daily time-step model, it simulates not only the basic wind erosion processes, but also the processes that modify a soil's susceptibility to wind erosion.

The structure of WEPS is modular and consists of a user-interface, a MAIN (supervisory) routine, seven submodels, and four databases (Fig. 2.1). The user-interface is used to create input files with information from the databases and the weather generator. In a practical application, new input files usually will be created by using previous input files as templates modified within the user-interface.

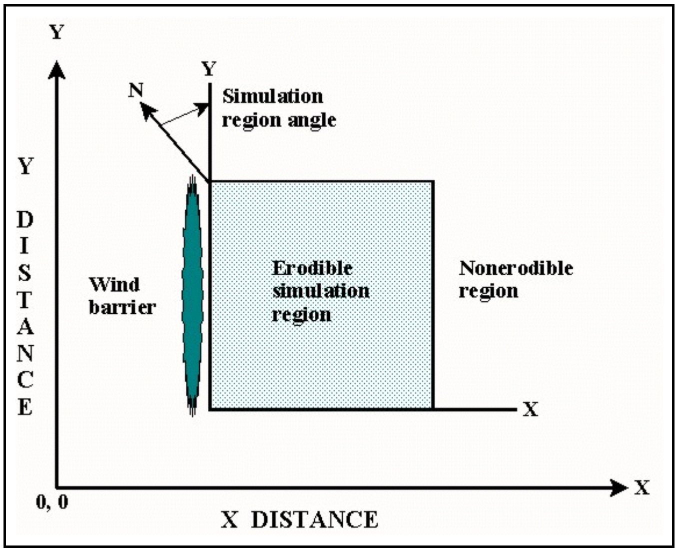

Figure 2.2. WEPS simulation geometries.

Simulation Region

In WEPS, the simulation region is a field (Fig. 2.2). Users must input the geometry of the simulation region. Initial conditions must also be specified for the surface and soil layers. WEPS can output soil loss/deposition over user-selected time intervals from a user-specified simulation region. WEPS also provides users with individual soil loss components of creep-saltation, suspension, and PM-10 size fractions. The soil loss components are particularly useful as an aid in estimating off-site impacts of wind erosion.

Discrete Time and Space

The time step is controlled by the main program. To reduce computation time, a daily time step is used in WEPS, except for selected subroutines in the HYDROLOGY and EROSION submodels, which use hourly or subhourly time steps. Submodels are called by the MAIN program (Tatarko, 1995) in the order shown in Fig. 1. Each individual submodel controls the sequence of calculations within itself. However, in MANAGEMENT, field operations are simulated sequentially according to the order in which they appear in the management plan. Management plans usually cover at least a single year and may cover multiple years. The management plan can be initiated on any given day of the year, typically when there is no growing crop. WEPS simulates conditions and soil loss on homogeneous simulation regions. "Homogeneous" means that the soil type, biomass, and management are similar over a subregion.

Weather Simulated from Climate Databases

WEPS requires wind speed and direction to simulate the process of soil erosion by wind. These and other weather variables are needed to drive temporal changes in hydrology, soil erodibility, crop growth, and residue decomposition in WEPS. The weather generator consists of the programs WINDGEN and CLIGEN (Tatarko et al., 1995).

WINDGEN simulates wind speed and direction for WEPS (Skidmore and Tatarko, 1990; Wagner et al., 1992). It was developed specifically for use with WEPS and stochastically simulates wind direction and subdaily wind speeds when needed. A compact database (Skidmore and Tatarko, 1990, 1991) developed for WINDGEN and was derived from historical monthly summaries of wind speed and wind direction contained in the Wind Energy Resource Information System (WERIS) database at the National Climatic Data Center in Asheville, North Carolina.

CLIGEN is the weather generator developed for the Water Erosion Prediction Project (WEPP) erosion model (Nicks et al., 1987). It is used with WEPS to generate an average annual air temperature as well as daily precipitation, maximum and minimum temperatures, solar radiation, and dew point temperature. Average daily air temperature and elevation for the site are used to calculate average daily air density within WEPS. CLIGEN and its database are described fully in the WEPP documentation (Nicks and Lane, 1989).

Field Conditions Simulated

The HYDROLOGY submodel (Durar and Skidmore, 1995) estimates soil surface wetness; accounts for changes in soil temperature; and maintains a soil-water balance based on daily amounts of snow melt, runoff, infiltration, deep percolation, soil evaporation, and plant transpiration. Snow melt depends on maximum daily air temperature and initial snow water content. Runoff is calculated from rainfall rate greater than infiltration, adjusted for ponding and surface flow velocity. Water is infiltrated and distributed according to Darcy's Law. Potential evapotranspiration is calculated using a revised combination method of Van Bavel. Total daily potential evapotranspiration then is partitioned, based on crop leaf area index, into potential soil evaporation and plant transpiration. Hourly potential soil evaporation rates are estimated from the daily value based on soil water availability.

A soil's aggregation and surface state can dramatically affect susceptibility to wind erosion. Thus, changes in soil and surface temporal properties are simulated daily by the WEPS SOIL submodel (Hagen et al., 1995b) in response to various weather processes like wetting/drying, freeze/drying, freeze/thawing, precipitation amount and intensity, and time. Soil layer properties such as bulk density, aggregate size distribution, and dry aggregate density are maintained on a daily basis. Surface properties, such as random and oriented roughness, crust generation, coverage fraction, density, stability, and thickness, and loose erodible material on crusted surfaces also are accounted for in the SOIL submodel.

The presence of live biomass on the soil surface influences the quantity of soil that can be removed by wind erosion. Therefore, the CROP submodel (Retta and Armbrust, 1995) simulates the growth of crop plants. The crop growth model was adapted from the Erosion Productivity Calculator (EPIC) crop growth model (Williams et al., 1990), which simulates a variety of crops and plant communities while accounting for nutrient (not available in WEPS 1.0) and water stresses. It calculates daily production of masses of roots, leaves, stems, and reproductive organs and also leaf and stem areas. Additional capabilities and modifications have been incorporated into the CROP submodel to meet the need for predicting effects of a growing crop on wind erosion. Some of the factors that affect wind erosion are the flexibility and arrangement of individual plant parts, distribution of plant parts by height, and number of plants per unit area (Shaw and Periera, 1982). Thus, leaves and stems are accounted for separately because: 1) stems of young seedlings are roughly 10 times more effective than leaves, on a per-unit-area basis, in depleting wind energy; 2) leaves are more sensitive to sandblast damage than are stems; and 3) decomposition rates of stems and leaves are different.

The DECOMPOSITION submodel (Steiner et al., 1995) for WEPS simulates the decrease in crop residue biomass from microbial activity. The decomposition process is modeled as a first order reaction, with temperature and moisture as driving variables. Standing residue is significantly more effective than flat residue at reducing wind energy at the soil surface. Hence, it is maintained separately from flat residue, and the conversion from standing to flat is simulated. The quantities of biomass remaining after harvest are partitioned into standing, surface, buried, and root pools with belowground biomass decomposition calculated for each soil layer. Because crop residue decomposition varies by type and changes with residue age, each pool is subdivided further into 1) the most recently harvested crop pool, 2) the penultimate crop pool, and 3) a "generic" crop pool that contains all older residue mass.

WEPS is expected to reflect the effects of various management practices upon wind erosion, and that is done by the MANAGEMENT submodel (Wagner and Ding, 1995). All major management operation classes are represented, such as primary and secondary tillage, cultivation, planting/seeding, harvesting, irrigation, fertilization, burning, and grazing. Each individual operation is simulated within the MANAGEMENT submodel as a series of physical processes. Those processes include 1) soil mass manipulation (changes in aggregate size distribution, soil porosity, mixing soil and residue by depth, and soil layer inversion); 2) surface modification (creation or destruction of ridges and/or dikes that form oriented surface roughness, changes in surface random roughness, and destruction of surface crusts); 3) biomass manipulation (burying and resurfacing residue, cutting standing residue, flattening standing residue, killing live crop biomass, and biomass removal); and 4) soil amendments (fertilization (not available in WEPS 1.0), planting, and irrigation).

Erosion Processes Simulated

The EROSION submodel (Hagen, 1995) decides if erosion can occur based on the current soil surface roughness (oriented and random), flat and standing biomass, aggregate size distribution, crust and rock cover, loose erodible material on a crust, and soil surface wetness. If the maximum daily wind speed reaches 8 m/s at 10m and snow depth is less than 20mm, the surface condition is evaluated on a subhourly basis to determine if erosion can occur. The EROSION submodel simulation performs the following functions: 1) calculates friction velocities based on the aerodynamic roughness of the surface, 2) calculates static threshold friction velocities, 3) computes soil loss/deposition within each grid cell, and 4) updates soil surface variables to reflect changes in soil surface "state" caused by erosion.

Summary Comparison of WEPS and WEQ

Users of wind erosion prediction technology encounter a wide range of challenging environmental problems that require solutions. WEQ was unable to meet some of these needs. After extensive consultations with users, the WEPS structure was designed with the capabilities to meet the needs identified. As such, WEPS represents new technology and is not merely an improvement and recoding of WEQ technology. Also, WEPS contains many simplifications to maintain reasonable computation times. Because many users are familiar with WEQ, a brief comparison of WEPS and WEQ follows to facilitate understanding of WEPS modeling techniques.

WEQ predicts average erosion along line-transects across the field, whereas WEPS treats the field as two-dimensional. The WEPS EROSION submodel simulates soil loss/deposition for grid areas over the entire simulation region. This feature allows users to "look inside" by specifying arbitrary accounting regions within the simulation region and, thus, obtain results averaged over selected grid areas within the accounting region (not available in WEPS 1.0).

WEQ predicts only long-term, average, soil loss. WEPS calculates on a daily basis and allows users to specify the output intervals. Thus, users can obtain outputs ranging from single storms to multiple years. By simulating for multiple years, the probability of various levels of erosion during any period of the year also can be determined.

The largest contrast between the two technologies is that WEPS simulates a wide range of processes to describe field surface conditions and wind erosion, whereas WEQ depends on users to input correct estimates of the field surface conditions. Unfortunately, erosion does not vary linearly with residue cover and other temporal field conditions. Therefore, simply specifying average field conditions as inputs likely will not yield the best estimates of long-term average erosion.

The WEQ contains no feedback loop that modifies the field in response to weather or erosion. In WEPS, the driving forces of weather cause surface temporal properties of the field to change. Thus, in a year with high rainfall, the field soil roughness may be reduced below average, while above average biomass production prevents erosion. However, in a drought year, biomass and aggregate size may both be below average, but tillage ridges may then be the primary control against soil erosion.

The modeling techniques used to simulate processes in WEPS vary. The WEATHER submodel generates stochastic simulated weather variables. Mechanistic and statistical generally relations are used to represent processes in the other submodels. However, a structured design methodology was used. First, the major wind erosion processes, such as emission, abrasion, and trapping were identified. Next, the individual temporal soil and biomass properties that affect the wind erosion processes were selected. Then, WEPS submodels were designed to simulate the general processes that control both the surface temporal properties and the erosion processes. Finally, parameters from the databases were used to make the simulation of various processes unique for specific soil, crop, and management actions.

Implementation

The current WEPS model is coded in FORTRAN conforming to the ANSI FORTRAN 77 and Fortran 95 standard. The coding guidelines used, with some minor modifications for WEPS, are outlined in the "Water Erosion Prediction Project (WEPP) Fortran-77 Coding Convention" (Carey et al., 1989). The model can be run in both a DOS and Unix environment. WEPS science code and implementation is documented fully in the WEPS Technical Description (Hagen et al., 1995a).

WEPS Updates

The WEPS model is continually being improved with periodic updates. The USDA-ARS Wind Erosion Research Unit (WERU) has established several means for obtaining the latest release of the WEPS model, databases, documents, and other related information as they become available.

For users with Internet access, WERU has established a World Wide Web site. The URL for WEPS downloads is: *http://weru.ksu.edu/weps*. This site contains all the information WEPS. Specific WEPS information also can be obtained through E-Mail at: *weps@weru.ksu.edu* .

Users without Internet access can obtain WEPS update information by contacting:

USDA-ARS, NPA
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Quick Start for WEPS 1.0

WEPS is a complicated model with a potential for numerous inputs. However, for simple simulations, WEPS can be quite easy to operate. The following quick start guide will describe how to make a simple simulation run.

Double left click on the Weps1.0 icon on the computer screen 'desktop'. Note: the NRCS standard is to start WEPS from the 'Start Menu' (e.g., "Start > Programs > USDA Applications > WEPS > WEPS1.0"). You will briefly see the Weps1.0 'Splash' window, then the WEPS1.0 main screen will appear.

<u>A Simple Simulation</u>
For a simple simulation, WEPS1.0 needs only four types of information.

1. Describe the simulation field geometry.
    a. Select the field dimensions.
        i. Type in the specific X-Length and Y-Length field dimensions on the left panel of the WEPS main interface screen.

    b. Select field orientation.
        i. Enter the specific field orientation in the "Orient." box within the left panel.

    c. Select any barriers if present.
        i. Click on the add barrier button in the left pan el. Then use the mouse to locate the barrier on the field border. Clicking the mouse will 'fix' the barrier to the desired border. The user may then select the barrier properties and type in the left panel.

2. Select a field location (for weather files).
    a. In the right panel of the window which is labeled 'Location Info', use the mouse to select a State and County from the drop down menus ▾. The closest weather stations to the center of the selected county will be loaded.

3. Select a soil.
    a. In the bottom panel of the window which is labeled 'Soil:', use the mouse to select a soil from the drop down menu ▾.

4. Select a management scenario.
    a. In the bottom panel of the window which is labeled 'Management:', use the mouse to select a crop rotation from the drop down menu ▾.

Once these four items are complete, click the ‘Run’ button on the tool bar at the top of the screen. You will then see indicators that WEPS1.0 is running. When the simulation run is finished, the output screen will appear. If WEPS encounters an error during a simulation run, a screen appears (‘Report a Bug’) which allows you to report the error to WERU. The user will be prompted to enter an e-mail address and a short message. If you are connected to the Internet at the time of the error, clicking ‘OK’ will e-mail the report to WERU along with al files necessary to duplicate the error so that it can be addressed.

Output Summary

The Output Summary for a simulation run will automatically display at the conclusion of a simulation run.

<u>WEPS Output Tabs</u>

Output screens for WEPS1.0 are arranged in a spreadsheet fashion. Several types of output are available and can be viewed by clicking on the appropriate tab at the top of the ‘Output Summary’ window. The various tabs are described below. Each tab screen can be printed by clicking the ‘Print this Report’ button Print this Report at the bottom of each screen. A description of what information is contained in each column and row is obtained by clicking the ‘Help on row/col’ button at the bottom of each tab screen.

‘Wind Erosion Summary’ Tab

The Wind Erosion Summary screen displays a simple summary of wind erosion soil loss in terms of average annual losses for each rotation year and for the entire simulation run.

‘Output Details’ Tab

The Output Details screen displays a detailed output report with all of the major reporting information available with the current version of WEPS. A description of the information contained in each column and row is given below.

The **columns** of the Output Details Tab have the following information.

Date - This column contains the date of the last day for which the row information is reported. Items in each row represent values from the end of the previous period to the current date (day/month/rotation year).

Operation - This column contains the management operation which occurred on the specified date.

Field Loss

Average Total - This column contains the total soil loss for the period (see ‘Date’ column description above), averaged across the field as well as averaged over the number of simulation years in each rotation year (kg/m^2 or tons/acre).

Standard Deviation - This column contains the standard deviation of the values in the average total column (kg/m^2 or tons/acre). {remove in the future}

Average Creep+Salt. - This column contains the total creep plus saltation loss for the period, averaged across the field grid areas, as well as averaged over the number of simulation years in each year of the crop rotation (kg/m^2 or tons/acre).

Average Susp. - This column contains the total suspension loss for the period, averaged across the field grid areas as well as averaged over the number of simulation years in each rotation year (kg/m^2 or tons/acre).

Average PM10 - This column contains the PM10 soil loss for the period, averaged across the field grid areas as well as averaged over the number of simulation years in each rotation year (kg/m^2 or tons/acre).

Mass passing Field Boundary

Creep+Saltation - These columns ☐ contain the mass per unit boundary length of creep plus saltation size material which passed the field boundary for each direction (kg/m or tons/1000 ft).

Suspension - These columns ☐ contain the mass per unit boundary length of suspension size material which passed the field boundary for each direction (kg/m or tons/1000 ft).

PM10 - These columns ☐ contain the mass per unit boundary length of PM10 size material which passed the field boundary for each direction (kg/m or tons/1000 ft).

Weather

Average Total Precip. - This column contains the total precipitation for the period averaged over the simulation years in each year of the crop rotation (mm or inches).

Average Wind Energy >8 m/s - This column contains the average daily wind energy for the period for winds greater than 8 m/s, averaged over the simulation years in each year of the crop rotation (KJ/day).

Average Surface Conditions on Date
Crop Vegetation (Live)

Canopy Cover - This column contains the fraction of live crop biomass cover (vertical view) at the period end, averaged over the simulation years for the period listed (fraction).

Standing Silhouette - This column contains the standing silhouette area index of live plants expressed on a fraction basis. These values are the standing silhouette area per area of soil surface. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Above Ground Mass - This column contains the total live crop biomass (dry weight basis), above ground, at the period end, averaged over the simulation years for the period listed (kg/m^2 or lbs/acre).

Crop Residue (Dead)

Flat Cover - This column contains the amount of flat dead cover on the soil surface, expressed as a fraction. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Standing Silhouette - This column contains the standing silhouette area index of dead plants expressed on a fraction basis. These values are the standing silhouette area per area of soil surface. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Flat Mass - This column contains the amount of flat dead biomass (dry weight basis) on the soil surface. These are values at the period end averaged over the simulation years in each rotation year (kg/m^2 or lbs/acre).

Standing Mass - This column contains the amount of standing dead biomass (dry weight basis) on the soil surface. These are values at the period end averaged over the simulation years in each rotation year (kg/m^2 or lbs/acre).

Live and Dead Biomass

Flat Cover - This column contains the amount of flat cover from live (canopy cover) and dead (flat cover) biomass on the soil surface expressed on a fraction basis. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Standing Silhouette - This column contains the standing silhouette area index of live and dead plants expressed on a fraction basis. These values are the standing silhouette area per area of soil surface. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Flat Mass - This column contains the amount of flat live (dry weight basis) and dead biomass on the soil surface. These are values at the period end averaged over the simulation years in each rotation year (kg/m^2 or lbs/acre).

Standing Mass - This column contains the amount of standing live and dead biomass (dry weight basis). These are values at the period end averaged over the simulation years in each rotation year (kg/m^2 or lbs/acre).

Roughness
Oriented
Ridge Orientation - This column contains orientation of the ridges with zero degrees (0°) representing north/south ridges.

Ridge Height - This column contains the height of ridges. This is the value at the period end averaged over the simulation years in each rotation year (mm or inches).

Ridge Spacing - This column contains the spacing between ridges. This is the value at the period end averaged over the simulation years in each rotation year (mm or inches).

Random
Roughness - This column contains the standard deviation of the soil surface random roughness. This is the value at the period end averaged over the simulation years in each rotation year (mm or inches).

The **rows** in the Output Details Tab vary depending on the number of cropping years in the rotation and the number of management operations in each year of the rotation.

Each year of the rotation has output displayed for the fifteenth and the last day of each month as well as for each management operation date. This output allows the user to view the erosion and other output for each year of the rotation. At the end of each year in the rotation is a row which contains the average annual value for that rotation year.

The last row in the output form contains the average annual values for the complete crop rotation.

Exiting WEPS 1.0

To exit WEPS 1.0, click “Project” on the menu bar at the top of the main screen, then click “Exit”. You will be asked if you want to save your project. Clicking ‘Yes’ will bring up a file save box. You will also be asked to confirm if you really want to exit WEPS 1.0.

SCIENCE

HOW WEPS SIMULATES WIND EROSION

Interface

This section describes the WEPS 1.0 User Interface program implementation and how it interacts with the WEPS science model. The WEPS 'science' model refers to the computer code and executable program that performs the actual calculations of field conditions and erosion processes for a simulation run. A simple flow diagram of the WEPS science model and User Interface is shown in Figure 3.1. A detailed description of how to operate the WEPS 1.0 User Interface is described later in this document (Chapter 4, 'How to Operate WEPS').

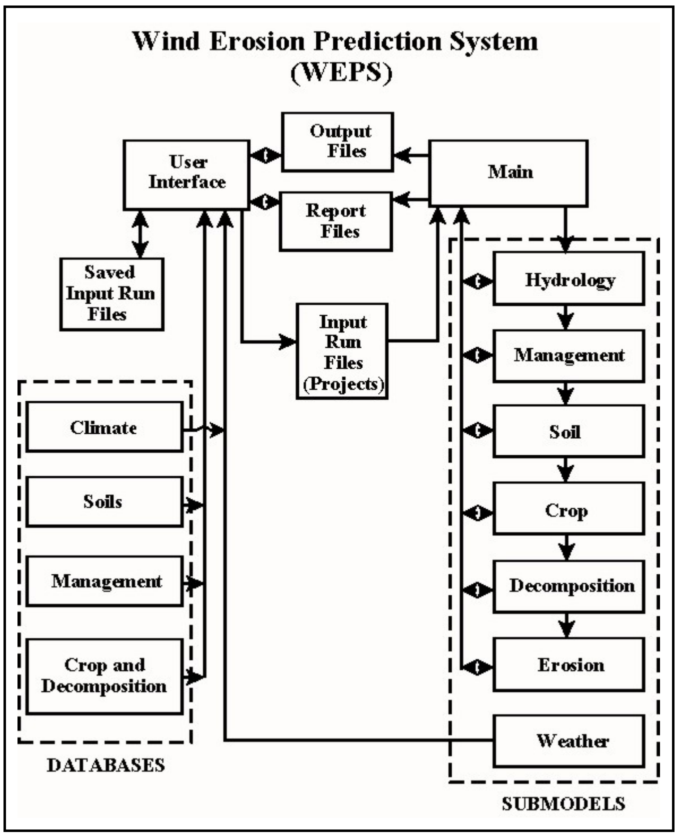

Figure 3.1. A flow diagram of the WEPS science model and User Interface.

A simplified description of the science model is provided later in this chapter. The "WEPS Technical Description" provides a more detailed description of the science behind WEPS and is available from WERU. The current WEPS science model is coded in FORTRAN conforming to the ANSI FORTRAN 77 and Fortran 95 standard. The inputs to the science model reside in a series of ASCII input files. These input files are: a Windgen file (*.win), a Cligen file (*.cli), an initial field conditions file (*.ifc), a management file (*.man), and a run file (weps.run). The science model can be executed from the command line. When WEPS is executed, the science model reads the input files accesses necessary databases, calls each submodel daily and performs the simulation, and writes output files. The output is written to one or more ASCII files. Although building the input files by hand, executing the model on the command line, and interpreting the output files can be time consuming and confusing, the WEPS 1.0 User Interface simplifies this process.

The WEPS 1.0 User Interface is written in Java. The interface can be thought of as a 'shell' of 'wrapper' around the science model which does not affect the execution of the science model. Through the interface program, the user can easily enter the information necessary to create and edit the input files. A description of how to enter this information is given later in this document (Chapter 4, ‘How to Operate WEPS’). Once the field, location, soil, and management are described, pressing the ‘Run’ button performs a series of commands to execute the science model. The interface first calls the Cligen and Windgen weather generators which create the Windgen and Cligen files for the simulation. Then the WEPS science model is called and executed as described above. When the science model is finished, the interface reads and displays the output file.

Main Program

The MAIN program is that portion of the science model that controls the initialization and execution of a WEPS simulation run. It calls subroutines that read input data and outputs the general report. In addition, MAIN calls submodels on a daily basis, which update the field conditions. If the maximum wind speed for the day exceeds a set velocity great enough to cause soil movement (i.e., 8 m/s), MAIN then calls the EROSION submodel to simulate erosion processes. The current version of WEPS reads in the climate data produced by the WEATHER submodel; performs daily simulation of the hydrologic and soil conditions, crop growth, and residue decomposition; and accounts for management effects. Finally, the model determines soil erosion by wind for the desired simulation period.

Program Description

The current version of MAIN requires the following files for a WEPS simulation run: a) a simulation run file which describes the field shape and barriers, simulation period, location of other input files, and types of output ; b) an initial field conditions file which describes soil conditions at the start of a simulation; d) a tillage/management file which describes the management system; and e) two climate files, one each in the CLIGEN and WINDGEN formats, that provide climate data on a daily basis.

The MAIN program begins by initializing local variables and then calls the subroutine INPUT which reads the simulation run file and the initial field conditions file. The simulation then is executed as a daily loop that controls the counters for the current day and an embedded subregion loop. The model can perform any length of simulation on a daily time step. However, WEPS performs a simulation for one rotation cycle to initialize surface conditions before simulations of wind erosion are performed. For each simulation day, the daily weather is read from the CLIGEN and WINDGEN data files. As some of the submodels are executed, summary information may be compiled for output. All submodels except EROSION are called within the subregion loop. Once field conditions are updated, if maximum wind speed for the day exceeds a set minimum (i.e., 8 m/s), the EROSION submodel then is called to determine threshold conditions and compute soil erosion. Finally, the MAIN program calls subroutine BOOKEEPING to account for field conditions and soil loss for periods throughout the rotation. CALTOT is then called, which outputs a series of user-selected output forms with general information about the simulation run.

Submo dels

Weather Submodel

Introduction

The Wind Erosion Prediction System (WEPS) requires wind speed and direction in order to simulate the process of soil erosion by wind. These and other weather variables are also needed to drive temporal changes in hydrology, soil erodibility, crop growth, and residue decomposition in WEPS. The weather generator of WEPS consists of the separate programs WINDGEN and CLIGEN and simulates the needed weather variables on a daily basis and wind speed on an hourly basis.

WINDGEN is the program that simulates wind speed and direction for WEPS (Skidmore and Tatarko, 1990; Wagner et al., 1992). It was developed specifically for use with WEPS and stochastically simulates wind direction and subdaily (e.g., hourly) wind speed on a daily basis.

CLIGEN is the weather generator developed for the Water Erosion Prediction Project (WEPP) family of erosion models (Nicks et al., 1987). It is used by WEPS to generate an average annual air temperature as well as daily precipitation, maximum and minimum temperature, solar radiation, and dew point temperature. Average daily air temperature and elevation for the site are used to calculate average daily air density within WEPS. Those interested in CLIGEN and how it simulates these variables should consult the WEPP documentation (Nicks and Lane, 1989). Both CLIGEN and WINDGEN are executed together under the WEPS 1.0 user interface.

Wind Simulation

Prediction of wind speed and direction, like most meteorological variables, is extremely difficult. Even with advanced technology, such as sophisticated numerical models and super computers, using climatological means is only as accurate as predicting meteorological variables a few days in advance (Tribbia and Anthes, 1987). Therefore, we resort to historical statistical information about most meteorological variables and use stochastic techniques to determine likelihood of various levels of those variables. We developed a stochastic wind simulator to furnish wind direction and wind speed as needed by the Wind Erosion Prediction System described by Hagen (1991).

Although the development of the WINDGEN database and wind generator is described by Skidmore and Tatarko (1990, 1991), we give here some of the details. Our database was created from historical monthly summaries of wind speed and wind direction. Two-parameter Weibull (Takle and Brown, 1978; Corotis et al., 1978) curves were fit to the monthly summary direction and speed distribution data. Historical wind data requires a detailed station history and a sufficient period of record (5 years minimum) to be suitable for wind simulation in WEPS. Therefore the coverage of historical wind stations is sparse in some areas of the United States.

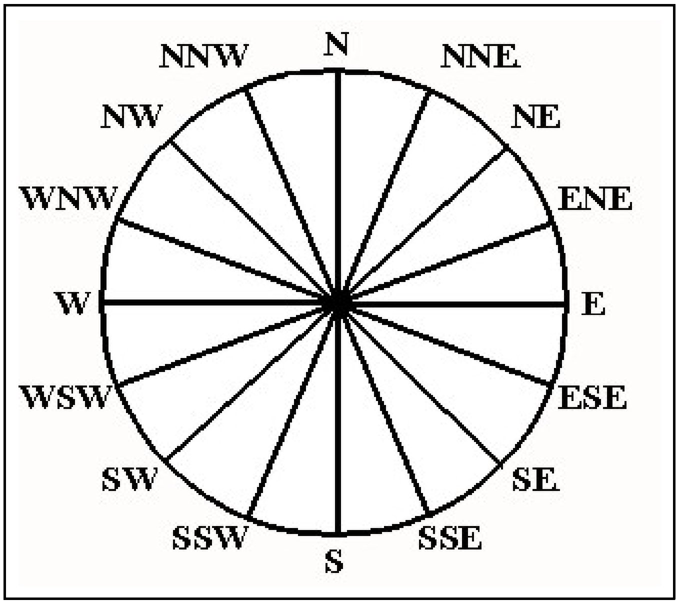

Figure 3.2. The sixteen cardinal directions used for wind direction in WEPS.

WINDGEN first determines the wind direction for the day based upon a random number selected between 0 and 1. Since the wind direction distribution in the WINDGEN database specifies the fraction of the time the wind comes from each of the 16 cardinal directions (Fig. 3.2) for each month, a cumulative frequency distribution curve is created and scaled to range from 0 to 1. Thus, the random number selected determines the wind direction for that day.

WINDGEN then determines the 24 hourly wind speeds for the day. That is done by selecting 24 random numbers between 0 and 1. These random numbers are then compared to the scaled monthly cumulative wind speed distribution for this day's direction to obtain the 24 hourly wind speeds for that day. The generator performs a few additional steps to ensure that it doesn't over or under estimate the long-term average wind speed (energy) that the summarized historical wind data reflects and to group higher hourly wind speeds together in the same day rather than just randomly distributing them across several days. It also ensures that "calm" hours (hourly wind speeds less than 1 m/s) are accurately reflected in the generated wind data series.

After the 24 hourly wind speeds have been selected, WINDGEN then determines the maximum hourly wind speed for the day and sets it to the "hour of maximum wind speed" available in the database for the current month. It then distributes the 24 hourly wind speeds such that the next two highest hourly wind speeds are adjacent to the highest hourly wind speed, the next two highest are then set adjacent to the previous two, etc. Thus, WINDGEN attempts to "build" a daily wind speed distribution which mimics the daily cycle of the wind speed increasing during the day until the "hour of maximum wind speed", and then decreasing after that hour again.

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Hydrology Submodel

The HYDROLOGY submodel of the Wind Erosion Prediction System (WEPS) uses inputs generated by other WEPS submodels such as WEATHER, CROP, SOIL, MANAGEMENT, and DECOMPOSITION to predict the water content in the various layers of the soil profile and at the soil-atmosphere interface throughout the simulation period. Accurate simulation by the other WEPS submodels requires prediction of the daily changes in soil water profiles. However, estimating soil wetness at the soil-atmosphere interface is emphasized, because it significantly influences the susceptibility of the soil to wind erosion.

The HYDROLOGY submodel of WEPS maintains a continuous, daily, soil water balance using the equation:

$$SWC = SWCI + (PRCP + DIRG) + SNOW - RUNOFF - ETA - DPRC \quad \textbf{(3.1)}$$

where SWC is the amount of water on the soil profile in any given day (mm), SWCI is the initial amount of water in the soil profile (mm), PRCP is the amount of daily precipitation (mm), DIRG is the amount of daily irrigation (mm), SNOW is the daily snow melt minus daily snow accumulation (mm), RUNOFF is the amount of daily surface runoff (mm), ETA is the amount of daily actual evapotranspiration (mm), and DPRC is the amount of daily deep percolation (mm).

The amount of daily precipitation (PRCP) is partitioned between rainfall and snowfall on the basis of the average daily air temperature. If the average daily temperature is 0°C or below, the precipitation takes the form of snowfall; otherwise, it takes the form of rainfall.

The snow term (SNOW) can be either positive, equaling the daily snow melt, or negative, equaling the daily snow accumulation. The melted snow is treated as rainfall and added to the precipitation term in Equation 3.1 when accounting for daily runoff and infiltration. On the other hand, the accumulated snow is subtracted from the daily precipitation during the estimation of the daily soil water balance with Equation 3.1.

Simulation of soil-water dynamics on a daily basis by the HYDROLOGY submodel involves three major sequences. First, the submodel partitions the total amount of water available from precipitation, irrigation, and/or snow melt into surface runoff and infiltration. The submodel stores the daily amount of water available for infiltration into the soil profile. Second, the submodel determines the influence of ambient climatic conditions by calculating the potential evapotranspiration. Third, the submodel redistributes soil water in the soil profile on an hourly basis, which provides hourly estimations of water content in the soil profile. The submodel estimates the actual rate of evapotranspiration by adjusting the potential rate on the basis of soil water availability. Deep percolation from the soil profile is estimated to be equal to the conductivity of the lowermost simulation layer, assuming a unit hydraulic gradient.

The HYDROLOGY submodel estimates surface runoff and infiltration for each simulation day that has precipitation and/or irrigation. The submodel estimates the daily amount of water available for infiltration into the soil by subtracting the amount of daily surface runoff from the amount of daily precipitation, snow melt, and/or irrigation. The infiltration water is stored in the uppermost simulation layer, until its water content reaches field capacity. Any excess water then is added to the succeeding lower layer, where it is stored with the same maximum storage restriction. This is repeated until complete water storage is obtained. Any excess water that flows out from the lowermost simulation layer becomes a part of a deep percolation.

Potential evapotranspiration is calculated using a revised version of Penman's combination method (Van Bavel, 1966). The total daily rate of potential evapotranspiration then is partitioned on the basis of the plant leaf area index into potential soil evaporation and potential plant transpiration. The potential rate of soil evaporation is adjusted to account for the effect of plant residues in the simulation region. Furthermore, the daily potential rates of soil evaporation and plant transpiration are adjusted to actual rates on the basis of water availability in the soil profile.

The HYDROLOGY submodel uses a simplified forward finite-difference technique to redistribute soil water with the one-dimensional Darcy equation for water flow. The time step of the soil water redistribution is 1 hour, which allows for an hourly estimation of soil wetness as needed for WEPS. Knowledge of the relationship between unsaturated hydraulic conductivity and soil water content is required for solving the governing transport equations of water movement through the soil. The submodel uses Campbell's (1974) method to calculate the unsaturated hydraulic conductivity of the soil from the more readily available soil water characteristic curve and saturated hydraulic conductivity data. Because water release curve data of the soil are not always available, the submodel provides alternative options to estimate the hydraulic parameters of the water release curve that are needed as inputs to run the soil water redistribution segment of the submodel.

The HYDROLOGY submodel predicts on an hourly basis soil wetness at the soil-atmosphere interface by using a combination of two techniques. The submodel extrapolates water content to the soil surface from the three uppermost simulation layers. A numerical solution known as Cramer's rule (Miller, 1982) is used to obtain an estimate of the extrapolated water content at the soil surface by solving the three simultaneous equations that describe the relationship between water content and soil depth for the three uppermost simulation layers. The submodel also interpolates the functional relationship between surface-soil wetness and the hourly evaporation ratio.

References

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Management Submodel

Introduction
WEPS is expected to reflect effects of various management practices upon wind erosion. The diversity of current practices applied to cropland by land managers makes this a daunting task. However, WEPS must adequately simulate typical cultural practices to accurately assess their affects upon wind erosion control. The MANAGEMENT submodel is assigned the task of handling the cultural practices applied by land managers which affect the soil/surface "state" within WEPS.

Purpose
All cultural practices applied by land managers are by definition "human initiated". These human-controlled processes affecting the soil and field surface "state" are initiated by typical management practices such as tillage operations, planting, harvesting, irrigation, etc. Therefore, the purpose of the MANAGEMENT submodel is to model what are considered the *major* human-controllable actions that can affect the "system state" within WEPS, in particular the system state variables defining the temporal soil and surface conditions.

Objectives
The MANAGEMENT submodel objectives are:

1. To model the primary human-initiated processes that can affect a site's susceptibility to wind erosion.

2. To provide the framework necessary to process a list of specified human-initiated actions, i.e., the cultural practices applied to a field such as a tillage/crop rotation sequence.

Keeping with the WEPS philosophy, The MANAGEMENT submodel simulates processes via a physical basis if possible, incorporates the conservation of mass and energy concepts, and uses a minimum number of parameters with readily available and/or attainable values.

Assumptions and Limitations
Several assumptions and limitations have been imposed on the MANAGEMENT submodel. The reasons vary from simply limiting the scope of the submodel, to inadequate knowledge of specific processes that may have a significant impact on the soil and/or surface. Here is the list of current assumptions and limitations, provided in no particular order, that impact the MANAGEMENT submodel.

1. Total soil water content within the current tillage zone is assumed to be unaffected by a tillage operation. The HYDROLOGY submodel is expected to handle changes in surface water content and therefore appropriately represent the usual rapid drying of the surface layer following tillage.

2. Tillage speed is not included as an independent variable affecting how a tillage operation modifies the soil and surface. A "typical" tillage speed is assumed for each tillage operation upon which the affects upon the soil and surface are based. Future versions of the MANAGEMENT submodel may incorporate tillage speed if sufficient data becomes available to model its effects upon the soil and surface.

3. Tillage depth is assumed to not influence how a tillage operation affects the soil and surface except for determining which soil layers are directly affected by a tillage operation. Again, the MANAGEMENT submodel may be extended to incorporate tillage depth effects if sufficient data becomes available in the future.

4. Effects of tillage operations on soil layers below the tillage depth are not considered, i.e., subsoil compaction below the tillage zone due to tillage. This will be addressed in a future release of the MANAGEMENT submodel.

5. Effects of a management operation are assumed homogeneous within a subregion. Effects due to tractor tires will not be considered. Certain zone-related tillage operations, such as row cultivator, will be treated in a manner such that the result will be "averaged" or "equivalent" values which represent the homogeneous region.

6. Emergency tillage, for wind erosion prevention or control, and strip cropping practices is considered in WEPS by specifying multiple separate, non-contiguous homogeneous subregions.

7. Ridge and dike geometric specifications (oriented roughness) will be provided by the user. If the tillage depth specified is not sufficient to create or destroy them (for a particular tillage operation that does so), the MANAGEMENT submodel will modify the tillage depth accordingly to obtain the desired ridge and/or dike specifications. Tillage operations that do not modify the current ridge and/or dike specifications will not do so (i.e., ridge tillage equipment).

8. Soil tillage depths will be adjusted to the nearest soil layer boundary. This will ensure that the most recent tillage operation modifications on the soil "state" are adequately represented. In the future, soil layer boundaries may be adjusted appropriately to accommodate tillage depths that would split a soil layer, i.e., a new layer boundary would be created at the prescribed tillage depth.

9. Aggregate stability and aggregate density are assumed to be unaffected by tillage operations. This decision is based on limited field data analysis. Future research may provide statistically significant affects that could then be modeled. These properties may still change among soil layers within the tillage zone due to aggregate mixing among layers caused by tillage operations.

Submodel Description

The approach taken within the MANAGEMENT submodel to deal with the variety of land management actions was to:

1. Identify the primary physical processes involved.

2. Represent individual management operations as a sequence of those primary physical processes.

3. Develop a MANAGEMENT file format allowing the input of user-specified sequences of management operations, i.e., a management practices/crop rotation file.

All operations modeled within the MANAGEMENT submodel fall within the following defined management categories as listed in Table 3.1.

Table 3.1. Management operation classes.

Operation Class	Description
Primary tillage	Tillage performed to primarily reduce surface residue, increase short-term infiltration rates, loosen subsoil hardpans, and control weed growth. Usually after-harvest tillage operations fall in this category.
Secondary tillage	Tillage typically performed in preparation for seeding or planting operations. Usually these operations are intended to smooth the soil surface, reduce the average aggregate size, and control weed growth if present.
Cultivation	Tillage specifically designed to eliminate weed growth after crop germination.
Planting/Seeding	Operations required to plant or seed a crop into a field.
Harvesting	Operation to remove biomass from a field. Biomass removed may be grain, root material, or the entire above ground biomass.
Irrigation	The artificial application or addition of water to the soil.
Fertilization	The application or addition of specific nutrients to a soil.
Burning	The removal of surface biomass with fire.
Grazing	The removal of surface biomass via livestock.

When a management or tillage operation is performed, it is simulated through a group of individual physical processes that represent the total effects of that operation. The basic individual physical processes to be modeled within the MANAGEMENT submodel of

WEPS have been grouped according to the target of their actions and outlined in Table 3.2.

Table 3.2. MANAGEMENT submodel processes.

Action	Process	Description
Soil Mass Manipulation	Crush	The application of forces to the soil to modify the soil aggregate structure by breaking down soil aggregates.
	Loosen/ Compact	The process of decreasing soil bulk density and increasing porosity (incorporation of air) or the inverse process of increasing soil bulk density by removing air from the soil.
	Mix	The process of uniting or blending of soil layer properties, including biomass.
	Invert	The reversing of the vertical order of occurrence of soil layers within the current specified tillage zone.
Surface Manipulation	Ridge/Dike	The process of creating or destroying ridges and/or dikes (oriented surface roughness).
	Roughen	The process of modifying the random surface roughness.
	Crust	The process of modifying the soil surface crust characteristics.
Biomass Manipulation	Bury/Lift	The process of moving above ground biomass into the soil or the inverse process of bringing buried biomass to the surface.
	Cut	The process of cutting standing biomass to a prescribed height.
	Drop	The process of moving a portion of the standing biomass to the soil surface.
	Kill	The death of live biomass.
	Remove	The removal of biomass from the system (harvest, grazing, and burning).
Soil Amendments	Fertilize	Addition of nutrients to the soil.
	Plant	Addition of seeds/plants to the soil.
	Irrigate	Addition of water to the soil.

The underlying philosophy behind the MANAGEMENT submodel was to attempt to develop physical law based representations, if possible, for each of the chosen physical processes. These processes are assumed to be independent with respect to each other and are to be simulated sequentially, even though many of them occur simultaneously in the real world. The order they are initiated in the submodel is dependent upon the specific operation.

The list of management operations performed for a given management plan (crop rotation or cyclical management practices) on a homogeneous region (subregion) is specified in a MANAGEMENT input file. The MANAGEMENT submodel checks on a daily basis for any operations to be performed on that day. If operations are needed, the MANAGEMENT submodel will execute the specified routines required to simulate the effects of those operations as instructed in the MANAGEMENT input file. When the last operation is performed for that particular crop rotation cycle, the same sequence will be repeated for the next year(s) of simulation.

A single MANAGEMENT input file may include multiple management operation lists, one for each subregion being simulated.

Crop Submodel

Introduction

The primary purpose of the WEPS plant growth submodel (CROP) is to obtain realistic estimates of plant growth so that the influence of vegetative cover on soil loss by wind erosion can be properly evaluated. The CROP submodel (Retta and Armbrust, 1995), was adapted from the Erosion Productivity Impact Calculator (EPIC) crop growth model (Williams, et.al, 1990). Additional capabilities and modifications have been developed and incorporated into the CROP submodel to meet the need for predicting effects of a growing crop on wind erosion. Young seedlings provide some protection from wind erosion. However, not all plant parts are equally effective. Stems of young plants, on a per-unit area basis, are roughly 10 times more effective than leaves in depleting wind energy. Other differences between leaves and stems are that, leaves are more sensitive to sandblast damage than are stems; and leaf and stem residues decompose at different rates. To properly account for these differences the CROP submodel gives daily estimates of leaf and stem growth in mass and area. At harvest, the 'grain' is removed and the 'straw' may consist of leaves, stems, and 'chaff'. In most case the leaf and 'chaff' residue is short-lived and only the stem residue may provide protection on a longer-term basis. The CROP submodel gives estimates of the amount of leaf, stem, 'grain', and 'chaff' mass produced on a daily basis. An important consideration is the effect of plant density on the amount of cover provided by growing seedlings during the early vegetative growth period. Many management practices leave the soil vulnerable to the forces of wind erosion prior to seeding until the growing plants develop sufficient cover. During the period from emergence to the development of adequate cover, the amount of cover is directly proportional to the number of seedlings per unit area. The higher the number of plants per unit area the greater the cover provided by the growing vegetation. To account for the differences in cover due to initial plant density, the leaf and stem area indexes at emergence (which are used by the EROSION submodel in computations of soil loss) are calculated by multiplying the initial areas per plant by the number of seedlings per unit area. Thus the greater the number of seedlings per unit area at emergence, the greater the protection provided by the young seedlings from wind erosion. The CROP submodel uses data inputs of plant, weather, hydrology, and management to estimate leaf mass, stem mass, reproductive mass, yield mass, 'chaff' mass, and root mass of 'live' plants (crops) on a daily basis. Other plant characteristics estimated daily are: root mass by soil layer, rooting depth, plant height, and canopy cover.

Phenological development

Phenological development of the crop is based on growing-degree-day (GDD) accumulation. The crop parameter file for CROP contains, for each crop, the potential GDDs from planting to physiological maturity and the relative GDDs from planting to emergence, to the start of the reproductive phase, and to the start of leaf senescence. CROP uses the same procedures as EPIC for simulating annual or perennial plants, and winter or summer crops. Annual plants 'grow' from planting to the date when the accumulated GDDs equal the potential GDDs for the crop. For annual winter crops, such as wheat, GDD accumulation (therefore growth) does not occur during the period of dormancy. Perennial crops maintain their root systems throughout the year, although the plant may become dormant after a frost. After the end of dormancy, plants start growing when the average daily air temperature exceeds the base temperature of the plant. For established alfalfa, a value of the average GDD between consecutive cuts is needed.

Emergence
Emergence occurs when the GDD accumulation from date of planting equals 6% of the seasonal GDD. CROP does not account for effects of soil temperature, soil water, soil crusting, soil strength, seeding depth, soil removal or deposition caused by wind erosion, which can influence germination, seedling emergence, survival, and growth.

Biomass Production
Shortwave radiation at the top of the canopy is multiplied by the factor C to estimate the amount of photosynthetically active radiation (PAR).

Growth Constraints
Potential growth and yield seldom are achieved, because of stress caused by suboptimal conditions. The CROP submodel adjusts daily biomass and area growth for water, temperature, and nutrient stresses. Water, temperature, and nutrient stress factors range from 0, where no growth will occur, to 1 for no limitation in growth. For any simulation day, the minimum value of the water, nutrient, or temperature stress factor adjusts daily produced biomass.

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Residue Decomposition Submodel

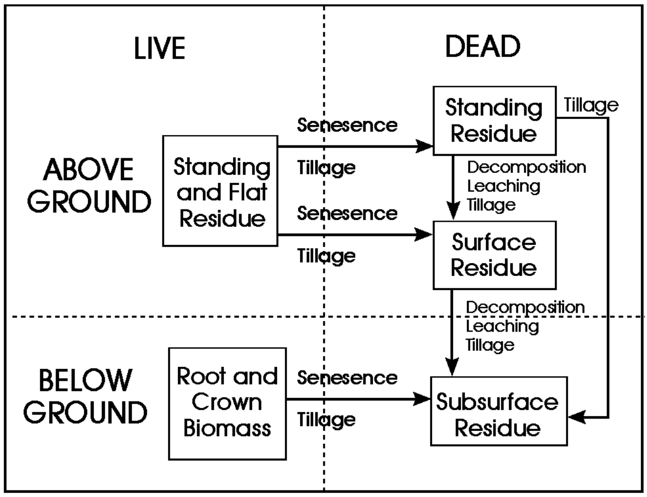

Figure 3.3. Biomass distribution and transfer between residue pools.

Model Overview
The DECOMPOSITION submodel simulates the decrease in crop residue biomass due to microbial activity. The decomposition process is modeled as a first order reaction with temperature and moisture as driving variables. The total quantities of biomass remaining after harvest are partitioned between standing, surface, buried, and root pools. Below ground biomass decomposition is calculated for each soil layer. Figure 3.3 depicts the distribution of biomass between residue pools.

Since residue decomposition can require a long period of time, crop residue biomass from sequential harvests are accounted for in separate data pools using an indexing variable (IAGE). Standing, surface, buried, and root biomass from the most recently harvested crop will be indexed IAGE = 1, biomass from the penultimate crop IAGE = 2, and for surface biomass a third pool will be accounted for as IAGE = 3. On a day of harvest, any biomass remaining from a previous crop is moved into the older age pools and residue from the current crop are indexed IAGE = 1. Decomposition rates for biomass pools one and two will be appropriate for the specific crops while biomass pool three will have a decomposition rate that reflects a slow rate of decomposition.

Decomposition
The general decomposition equation is a simple first order rate loss equation:

$$M_t = M_o * \exp^{-k\,CUMDD} \tag{3.2}$$

where M_t is the present quantity of biomass (kg m^{-2}) in the standing, surface, buried, or root pools; M_o is the initial biomass (kg m^{-2}); k is a crop specific rate constant used to calculate residue biomass changes (day^{-1}); and CUMDD is a weighted-time variable calculated from functions of temperature and moisture. Optimum moisture and temperature conditions result in the accumulation of 1 decomposition day for each day of the simulation. When moisture or temperature limit the rate of decomposition, the minimum of the moisture or temperature functions is used to accumulate a fraction of a decomposition day.

Residual moisture in the residues is considered to decrease by 60 % each day following the wetting event. Both precipitation and soil moisture influence the moisture of surface residues.

Changes in Standing Residue Biomass and Population

Standing residue losses occur from both microbial and physical actions. Physical transfers of crop residues from the standing biomass pool will reduce both the population size and biomass. When the changes occur due to physical forces such as wind, snow, gravity, or wheel traffic the transfer is to the surface pool. Tillage may result in redistribution to both the surface and buried pools. A daily estimate of the standing population is required in order to evaluate stem area index (SAI) and its influence on aerodynamic resistance (Steiner et al, 1994). The equation used to predict residue cover from flat residue is from Gregory (1982).

Modifying Variables Due to Tillage Operations

On a day of tillage, the distribution of residues will change between standing, flat and buried components depending on the tillage implement being used. The MANAGEMENT submodel will need to update the current biomass for each position (standing, surface, buried, and root) in each of the three age pools (1, 2, 3). Soil surface cover is then updated from the amount of biomass remaining in the surface and standing pools.

Crop Residue Decomposition Submodel Summary

1. Initialize decomposition variables for standing, surface, buried, and root biomass. Initialize decomposition rate constants for old residues.

2. At harvest:

    a. Transfer residue biomass, stem numbers, decomposition days, decomposition rates and cover factors from younger to older age pools.

    b. Check MANAGEMENT to see if the harvest process buried residues.

    c. Put mass and stem information for harvested crop into IAGE = 1 pools.

    d. Initialize decomposition rates and cover factor variables for harvested crop.

3. Daily:

    a. Test for harvest or tillage date.

    b. Calculate temperature and moisture functions and accumulate decomposition days.

c. Calculate change in biomass for residue pools

- standing residue mass
- surface residue mass
- below ground residue mass
- root residue mass

d. Calculate transfer of standing residue mass to surface residue mass and update standing and surface biomass.

e. Compute vertical and horizontal residue cover.

References

Gregory, J. M. 1982. Soil cover prediction with various amounts and types of residue. Trans. ASAE. 28:98-101, 105.

Steiner, J. L., H. H. Schomberg, C. L. Douglas, Jr., and A. L. Black. 1994. Standing stem persistence in no-tillage small-grain fields. Agron. J. 86:76-81.

Soil Submodel

Introduction

All the soil properties that control soil wind erodibility vary with time. Hence, the objective of the soil submodel is to simulate these temporal soil properties on a daily basis in response to various driving processes. On days when wind erosion or management activities occur, the Erosion and Management submodels may also update some of the same temporal variables. The driving processes that change soil temporal properties are mostly weather related, and hence, the sequence of occurrence of individual driving processes is highly variable. Thus, the submodel must be able to update the soil variables given an arbitrary driving process and the soil conditions for the prior day. The purpose of this paper is to provide a brief overview of the major processes that are simulated, and the temporal variables that are updated by the soil submodel. For an in-depth discussion of the equations used in the Soil submodel, see the Soil Submodel Technical Document (Hagen et al., 1995).

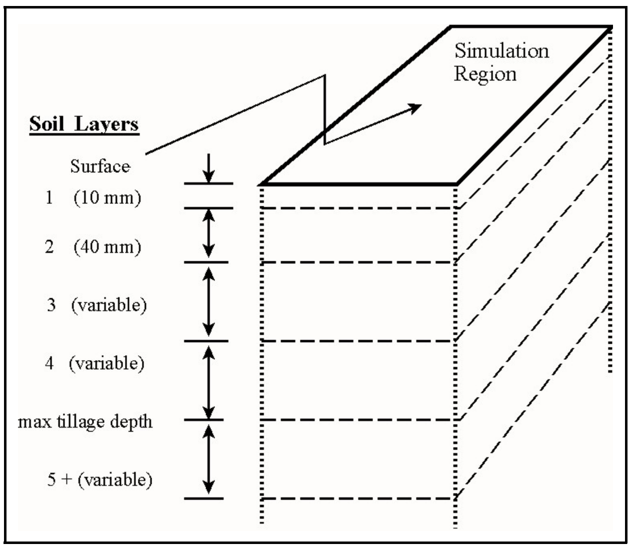

Figure 3.4. Diagram representing the spatial domain of the Soil submodel.

Spatial Regime

In the Soil submodel, the spatial regime is considered to be uniform in the horizontal direction over the simulation region, but non-uniform in the vertical direction (Fig. 3.4). Hence, the vertical direction is divided into layers in each soil profile. Some of the layer boundaries are selected to coincide with the layers determined by the NRCS Soil Survey of each soil. Layers one and two are initially set at 10 and 40 mm (0.39 and 1.57 inches), respectively, to allow simulation of sharp gradients in temporal soil properties near the surface.

Soil Layering Scheme

The hydrology and crop sub-models of WEPS depend upon the soil being stratified by layers. Hydrology moves water up and down within the soil based upon the relative wetness of adjacent layers. Crop estimates plant growth based upon several factors, one of the most important being availability of water within the root zone. It is important that WEPS keep track of now how much water is available at various soil depths. Hence, WEPS views the soil as a series of layers, each layer possibly having distinct physical characteristics but this is not necessary.

WEPS divides the soil into layers based upon National Soil Information System (NASIS) input data. The layering scheme respects the underlying NASIS data. That is, no NASIS layers are combined when creating WEPS layers. Much of the complexity of the layering process is due to the creation of the very thin top layers. The design criteria are:

10. Preserve NASIS layering, i.e. a WEPS layer cannot cross a NASIS layer boundary.

11. Try to get the first three layers to be 10, 40 and 50 mm.

12. Preserve the relative sizes, 1:4:5:5, of the top layers if the absolute size cannot be attained.

13. Divide the remaining layers into relatively uniform thicknesses, somewhat thinner at the top and thicker as depth increases.

Processes Simulated and Variables Updated

The processes simulated and the variables updated are summarized in Table 3.3. The effect of the processes on roughness is always to reduce the roughness. In contrast, many of the other variables either increase or decrease in value depending upon the prior-day value, soil intrinsic properties and the driving process. To simulate the dry stability and aggregate size distribution, for a wide range of soils, these variables were first normalized using mean and standard deviation of the variables for each soil series to give a range from 0 to 1 for each variable. The driving processes were then applied to the normalized ranges to determine the change in the normalized variable. Finally, the updated normalized values were converted to the real values of these variables.

Table 3.3. Soil submodel variable and process matrix.

	Surface Processes			Layer Processes		
Soil Temporal Variables	Rain	Sprinkler Irrigation	Snow Melt	Wet/dry	Freeze/thaw	Freeze/dry
Roughness:						
Ridge Height	X	X	X			
Dike Height	X	X	X			
Random	X	X	X			
Crust:						
Depth	X	X	X			
Cover fraction	X	X	X			
Density	X	X	X			
Stability	X	X	X	X	X	X
Loose mass	X	X	X			
Loose cover	X	X	X			
Aggregates:						
Size distribution	X	X	X	X	X	X
Dry stability	X	X	X	X	X	X
Density	X	X	X	X	X	X
Layers:						
Bulk density	X	X	X			

In summary, the Soil submodel outputs updated values on a daily basis for each of the variable listed in Table 1 in response to the occurrence of the various driving processes.

References

Hagen, L.J., T.M. Zobeck, E.L. Skidmore, and I. Elminyawi. 1995b. WEPS technical documentation: soil submodel. SWCS WEPP/WEPS Symposium. Ankeny, IA

Erosion Submodel

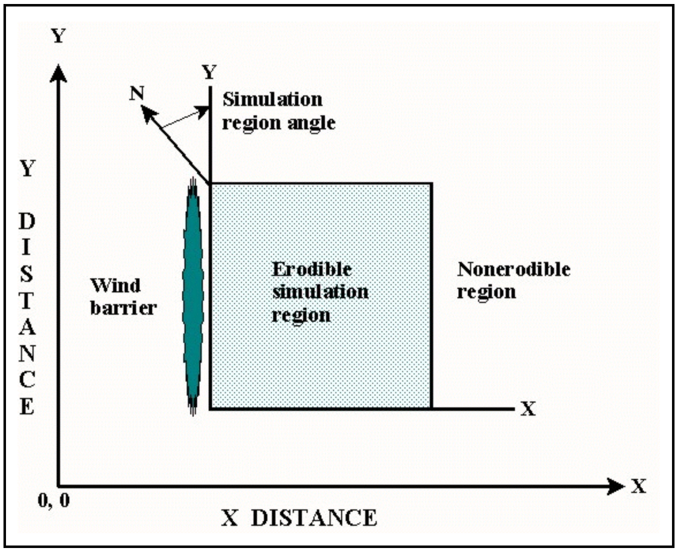

Figure 3.5. Schematic of simulation region geometry. Field orientation, end points of barriers, and opposite corners of the rectangular simulation region are input to the Erosion submodel.

Introduction

The objective of the erosion submodel is to simulate the components of soil loss/deposition over a rectangular field in response to wind speed , wind direction, field orientation, and surface conditions on a sub-hourly basis (Fig. 3.5). In WEPS 1.0 barriers maybe placed on any or all field boundaries. When barriers are present, the wind speed is reduced in the sheltered area on both the upwind and downwind sides of the barriers. The submodel determines the threshold friction velocity at which erosion can begin for each surface condition. When wind speeds exceed the threshold, the submodel calculates the loss/deposition over a series of individual grid cells representing the field. The soil/loss deposition is divided into components of saltation/creep and suspension, because each has different transport modes, as well as off-site impacts. Finally, the field surface is periodically updated to simulate the changes caused by erosion. The purpose of this paper is to provide users with a brief overview of the submodel. For an in-depth description of the equations used in this submodel, see the WEPS Erosion Submodel Technical Description (Hagen, 1995).

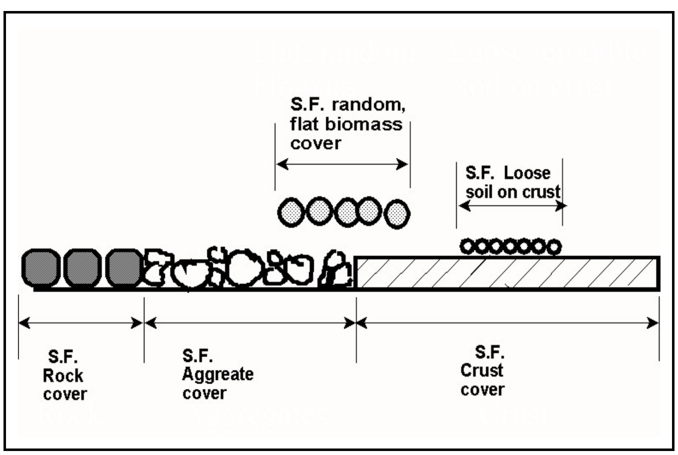

Figure 3.6. Diagram illustrating components of flat surface cover inputs to the Erosion submodel.

Surface Conditions Needed as Inputs

Surface roughness is represented by both random roughness and oriented roughness. The parameters used are standard deviation of the surface heights for random roughness and the height and spacing of ridges for oriented roughness.

Surface cover is represented on three levels (Fig. 3.6). In the first level, surface rock, aggregates and crust comprise 100 percent of the cover.

In the second level, the parameter is the fraction of the crusted surface covered with loose, erodible soil. When there is no crust, this parameter is always zero. In the third level, the parameter is the fraction of total surface covered by flat, random biomass.

The aggregate density and size distribution are input parameters that indicate soil mobility. The dry mechanical stability of the clods/crust are input parameters that indicate their resistance to abrasion from impacts by eroding soil. Surface soil wetness is also input and used to increase the threshold friction velocity at which erosion begins.

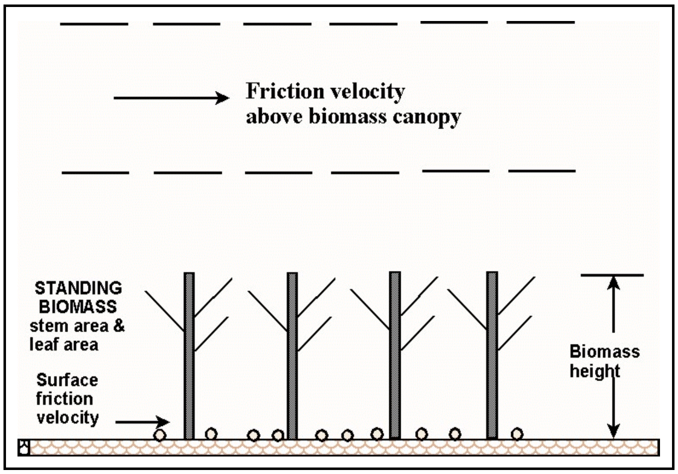

Figure 3.7. Diagram illustrating friction velocity above standing biomass that is reduced by drag of stems and leaves to the surface friction velocity below the standing biomass.

Uniformly distributed, standing biomass is 5 to 10 times more effective in controlling wind erosion than flat biomass, and thus, is treated separately. The wind friction velocity above standing biomass is depleted by the leaves and stems to obtain the surface friction velocity at the surface that is used to drive erosion (Fig. 3.7). Leaves are represented by a leaf area index and stems by a stem silhouette area index in the input parameters.

Erosion Processes Simulated

Soil transport during wind erosion occurs in three modes: creep-size aggregates, 0.84-2.0 mm (0.033 - 0.079 in.) in diameter roll along the surface, saltation-size aggregates, 0.10 - 0.84 mm (0.004 - 0.033 in.) in diameter hop over the surface, and suspension-size aggregates, < 0.01 mm (0.004 in.) in diameter move above the surface in the turbulent flow. Obviously, variations in friction velocity, aggregate density and sediment load may change the mass of aggregates moving in a given mode. Saltation and creep are simulated together, because they have a limited transport capacity that depends mainly upon friction velocity and surface roughness. The suspension component is simulated with no upper limit on its transport capacity at the field scale. A portion of the suspension component also is simulated as PM-10, i.e., particulate matter less than 10 micrometers (0.0004 in.) in diameter that is regulated as a health hazard.

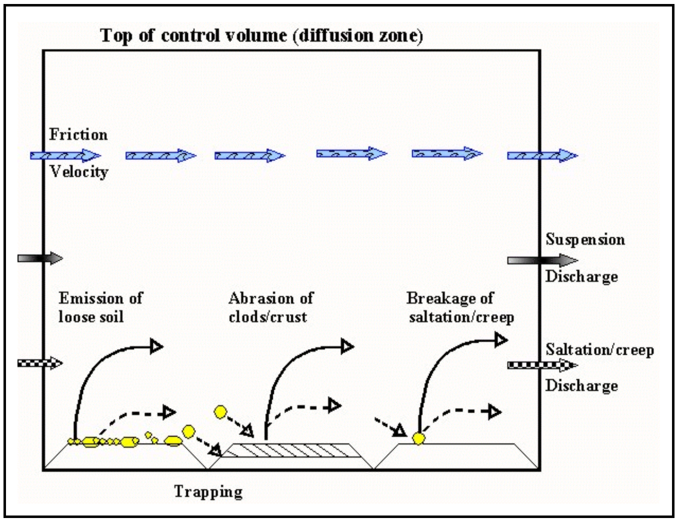

Figure 3.8. Diagram illustrating processes simulated by the Erosion submodel on a bare soil surface in an individual grid cell.

Multiple, physical erosion processes are simulated in the erosion submodel, and these are illustrated for a single grid cell in Fig. 3.8. The two sources of eroding soil are emission of loose soil and entrainment of soil abraded from clods and crust. These sources are apportioned between saltation/creep and suspension components based on the process and soil characteristics. Three processes deplete the amount of moving saltation/creep. These include trapping in surface depressions, interception by plant stems/leaves, and breakage of saltation/creep to suspension-size.

Simulation of surface rearrangement is accomplished by allowing emissions to deplete the loose soil and armor the surface in the upwind field area. In contrast, processes such as abrasion of the protruding aggregates and trapping in depressions dominate in downwind areas and lead to smoothing the surface and a build-up of loose saltation/creep. A build-up of saltation/creep often occurs, because the transport capacity may be satisfied, but abrasion of clods/crust continues to create additional saltation/creep-size soil.

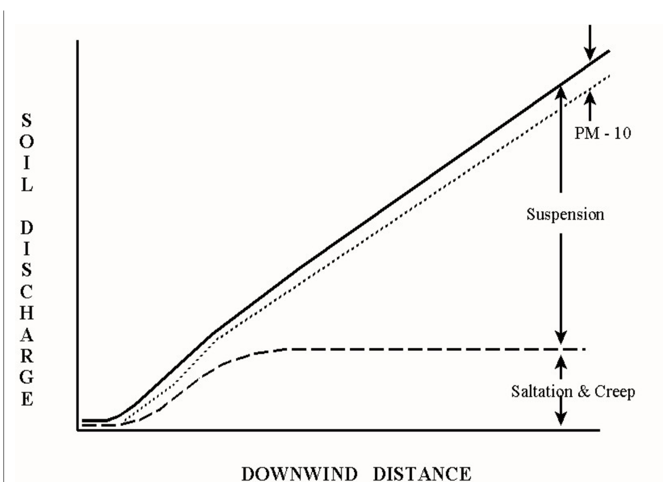

Figure 3.9. Diagram illustrating downwind transport capacity for saltation & creep, but a continuing increase in transported mass of suspension-size soil downwind.

Typical behavior of the downwind soil discharge simulated along a line transect for the saltation/creep and suspension components is illustrated in Fig. 3.9. The suspension component keeps increasing with downwind distance even though saltation/creep reaches transport capacity. This is because the sources for suspension-size soil are usually active over the entire field. These sources include emissions from impacts on loose soil, abrasion from clods/crust, and breakage from impacting saltation/creep-size aggregates.

Moreover, the suspension component has a transport capacity many times larger than that of saltation/creep, so on large fields it is the ‘freightliner’ for moving soil and saltation/creep is merely the ‘pickup truck’.

Outputs

The Erosion submodel calculates total, suspension, and PM-10 soil loss/deposition at each grid cell in the field. The grid cell data are summarized in other parts of WEPS and reported to users as averages over the field for selected periods. The submodel also calculates the components of soil discharge crossing each field boundary. These are reported to users based on the size ranges of aggregates as saltation/creep, suspension, and PM-10. These latter outputs are useful for evaluating off-site impacts in any given direction from the eroding field.

References

Hagen, L.J. 1995. Wind Erosion Prediction System (WEPS) Technical Description: Erosion submodel. IN Proc. of the WEPP/WEPS Symposium. Soil and Water Conserv. Soc., Des Moines, IA.

Databases

Weather Database

Introduction

The Wind Erosion Prediction System (WEPS) requires wind speed and direction in order to simulate the process of soil erosion by wind. These and other weather variables are also needed to drive temporal changes in hydrology, soil erodibility, crop growth, and residue decomposition in WEPS. The weather generator of WEPS consists of the programs WINDGEN and CLIGEN as well as a user interface and it is capable of simulating the needed weather variables on a daily basis and wind speed on a subdaily basis.

WINDGEN is the program that simulates wind speed and direction for WEPS (Skidmore and Tatarko, 1990; Wagner et al., 1992). It was developed specifically for use with WEPS and stochastically simulates wind direction and maximum and minimum wind speed on a daily basis. In addition, WINDGEN provides the hour at which the maximum wind speed occurs for each day based on historical records. Subdaily wind speeds are generated from within WEPS by the subroutine 'calcwu'.

CLIGEN is the weather generator developed for the Water Erosion Prediction Project (WEPP) family of erosion models (Nicks et al., 1987). It is used with WEPS to generate an average annual air temperature as well as daily precipitation, maximum and minimum temperature, solar radiation, and dew point temperature. Average daily air temperature and elevation for the site are used to calculate average daily air density within WEPS. CLIGEN will not be described in this document. However, those interested in CLIGEN and how it simulates these variables should consult the WEPP documentation (Nicks and Lane, 1989). Both CLIGEN and WINDGEN may be executed separately from the command line, or they may be executed together under a menu driven program called 'CLI_WIND'. This is a stand-alone program that allows the generation of weather output from CLIGEN and WINDGEN through a user-friendly menu-driven interface.

Windgen Development

Prediction of wind speed and direction, like most meteorological variables, is extremely difficult. Even with advanced technology, such as sophisticated numerical models and super computers, using climatological means is only as accurate as predicting meteorological variables a few days in advance (Tribbia and Anthes, 1987). Therefore, we resort to historical statistical information about most meteorological variables and use stochastic techniques to determine likelihood of various levels of those variables.

Various models have been used to describe wind speed distribution. A glance at a frequency versus wind speed histogram shows that the distribution is not best described by the familiar normal distribution. Distributions that have been used to describe wind speed include the one -parameter Rayleigh (Hennessey, 1977; Corotis et al., 1978), the two parameter gamma (Nicks and Lane, 1989), and the two-parameter Weibull (Takle and Brown, 1978; Corotis et al., 1978). The Weibull is undoubtedly the most widely used model of common wind behavior representing wind speed distributions.

We developed a stochastic wind simulator to furnish wind direction and wind speed as needed by the Wind Erosion Prediction System described by Hagen (1991).

Compact Database

One important requirement of a wind simulator for wind erosion modeling is to develop a compact database. Although described elsewhere (Skidmore and Tatarko, 1990, 1991), we give here some of the details of creating the compact database. Our database was created from historical monthly summaries of wind speed and wind direction contained in the extensive Wind Energy Resource Information System (WERIS) database at the National Climatic Data Center, Asheville, North Carolina (NCC TD 9793). The WERIS database is described further in Appendix C of Elliot et al. (1986). Data were extracted from WERIS tables and, in some cases, analyzed further to create a database suitable for our needs.

We used data from WERIS, joint wind speed/direction frequency by month (e.g., Table 3.4), to calculate scale and shape parameters of the Weibull distribution function for each of the 16 cardinal wind directions by month.

The cumulative Weibull distribution function F(u) and the probability density function f(u) are defined by:

$$F(u) = 1 - \exp[-(u/c)^k] \qquad \textbf{(3.3)}$$

and

$$f(u) = dF(u)/du = (k/c)(u/c)^{k-1} \exp[-(u/c)^k] \qquad \textbf{(3.4)}$$

where u is wind speed, c is scale parameter (units of velocity), and k is shape parameter (dimensionless) (Apt, 1976). Because anemometer heights varied from location to location, all wind speeds (e.g., Column 1, Table 3.4) were adjusted to a 10 m reference height according to the following:

$$u_2 = u_1(z_2/z_1)^{1/7} \qquad \textbf{(3.5)}$$

where u1 and u2 are wind speeds at heights z_1 and z_2, respectively (Elliot, 1979).

Table 3.4. Monthly joint wind speed/direction frequency values.

Wind Speed (m/s)	Wind Direction																	
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm	Total
Calm	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.7	1.7
1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	.3	.1	.1	.0	.1	.1	.2	.1	.3	.1	.5	.5	.6	.4	.5	.2	.0	4.1
3	.7	.3	.5	.4	.9	.4	.6	.5	.9	.4	1.1	1.1	1.5	.8	.7	.3	.0	11.1
4	1.0	.6	.8	.4	1.1	.9	1.0	.8	1.9	.6	.8	1.2	1.6	1.2	.7	.5	.0	15.1
5	.9	.6	.8	.5	.9	.9	1.0	1.3	2.1	.9	1.2	1.2	1.6	.5	.4	.5	.0	15.4
6	.7	.7	.6	.4	.6	.5	.9	.6	1.6	1.0	1.1	1.2	.7	.6	.3	.5	.0	12.2
7	1.0	.6	.6	.4	.2	.5	.4	.5	1.6	1.0	1.4	.8	.7	.5	.3	.2	.0	10.0
8	1.0	.6	.8	.2	.5	.3	.6	.3	1.4	1.2	1.0	.6	.7	.4	.4	.2	.0	10.1
9	.8	.4	.6	.2	.3	.1	.2	.4	1.0	.8	.7	.6	.6	.4	.2	.3	.0	7.6
10	.3	.4	.2	.2	.1	.0	.1	.2	.8	.4	.2	.3	.4	.3	.1	.1	.0	4.3
11	.3	.4	.1	.1	.0	.0	.1	.1	.5	.2	.3	.3	.5	.1	.1	.1	.0	3.1
12	.2	.1	.0	.0	.0	.0	.0	.1	.0	.1	.1	.2	.4	.1	.1	.0	.0	1.6
13	.2	.1	.0	.0	.0	.0	.0	.0	.0	.8	.2	.1	.3	.2	.1	.1	.0	1.3
14	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.1	.2	.1	.1	.0	.0	.7
15	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.1	.0	.0	.0	.0	.0	.5
16	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.1	.0	.0	.0	.0	.2
17	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.1
18	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1
19	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1
20	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
21-25	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
26-30	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
31-35	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
36-40	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
41-up	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total	7.8	4.8	5.1	2.9	4.9	3.8	5.1	4.9	12.2	6.8	8.9	8.5	9.9	5.7	4.0	3.0	1.7	100.0
Avg	6.9	7.0	6.1	6.0	5.1	5.2	5.5	5.9	6.2	6.7	6.4	6.2	6.4	6.2	5.6	6.3	.0	6.1

Table 12c of WERIS for March, Lubbock, TX

The calm periods were eliminated, and the frequency of wind in each speed group was normalized to give a total of 1.0 for each of the 16 cardinal directions (e.g., 1 = North, 2 = NNE, 3 = NE, . . . 16 = NNW). Thus,

$$F_1(u) = [(F(u) - F_0)/(1 - F_0)] = 1 - \exp[(u/c)^k] \quad \textbf{(3.6)}$$

where $F_1(u)$ is the cumulative distribution with the calm periods eliminated, and F_0 is the frequency of the calm periods. The scale and shape parameters were calculated by the method of least squares applied to the cumulative distribution function (Eqn. [3.6]). Equation [3.6] was rewritten as:

$$1 - F_1(u) = \exp[-(u/c)^k] \quad \textbf{(3.7)}$$

Then by taking the logarithm twice, this becomes:

$$\ln[-\ln(1 - F_1(u))] = -k \ln c + k \ln u \quad \textbf{(3.8)}$$

If we let $y = \ln[-\ln(1 - F_1(u))]$, $a = -k \ln c$, $b = k$, and $x = \ln u$, Equation [3.8] may be rewritten as:

$$y = a + bx \tag{3.9}$$

$F_1(u)$ was calculated from information in tables like Table 3.9 for each wind speed group to determine y and x in Equation [3.9]. This gave the information needed to use a standard method of least squares to determine the Weibull scale and shape parameters. To recover the real distribution, we can rewrite Equation [3.6] as:

$$F_1(u) = F_0 + (1 - F_0)(1 - \exp[-(u/c)^k]) \tag{3.10}$$

Wind direction distribution for each location was summarized by month from the "TOTAL" row near the bottom of Table 3.9 for each location.

Other pertinent data, obtained from the Wind Energy Resource Atlas of the United States (Elliot et al., 1986), included latitude, longitude, city, state, location name, Weather Bureau Army Navy (WBAN) number, agency responsible for the weather station, period of record, anemometer height and location, and number of observations per 24-hour period.

We eliminated WERIS sites from our database if they represented less than 5 years of data, the anemometer height was not known, or fewer than 8 observations were taken per day. Where more than one satisfactory observation period/site remained in a metropolis, we picked the site with the best combination of the following: (1) maximum number of hours per day observations were taken, (2) longest period of record, (3) 1 hourly versus 3 hourly observations, and (4) best location of anemometer (ground mast > beacon tower > roof top > unknown location). The WINDGEN database currently consists of statistical parameters for 672 locations in the United States.

From WERIS , we obtained a ratio of maximum/minimum mean hourly wind speed and hour of maximum wind speed by month (e.g., Table 3.5). Tables 3.5, 3.6, 3.7, and 3.8 give examples of wind information we compiled into a compact database.

Table 3.5. Ratio of maximum to minimum hourly wind speed (max/min) and hour of maximum wind speed.

	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
max/min	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.7	1.5	1.6	1.6	1.5
hour max	15	12	15	15	18	18	18	15	15	15	12	15

Values from WERIS Table 5 for Lubbock, TX (Skidmore and Tatarko, 1991) where Month 1 = January.

Table 3.6. Wind direction distribution by month in percent.

Wind Direction	Month 1	2	3	4	5	6	7	8	9	10	11	12
1	8.2	9.7	7.8	5.5	5.3	3.1	2.3	2.9	5.9	6.3	8.8	9.0
2	5.0	4.9	4.8	3.6	3.7	2.2	1.5	2.6	4.8	5.0	4.4	4.8
3	5.0	5.9	5.1	4.1	4.1	3.2	3.9	4.2	6.3	5.3	4.8	4.7
4	3.8	4.2	2.9	4.5	4.8	4.1	3.8	4.7	4.9	4.1	3.1	3.1
5	4.0	4.3	4.9	5.3	5.9	5.0	5.9	6.7	6.3	4.3	4.4	2.2
6	3.1	3.8	3.8	4.7	6.6	6.1	5.7	6.3	5.7	3.0	3.2	1.9
7	3.3	3.8	5.1	6.5	10.5	10.4	10.0	9.7	7.5	4.2	3.4	2.1
8	2.9	3.3	4.9	4.9	8.3	9.5	11.6	14.9	13.6	9.0	5.4	3.7
9	9.8	8.7	12.2	16.4	16.4	26.8	27.4	24.1	18.6	19.7	11.7	9.4
10	6.0	5.7	6.8	6.5	6.9	9.2	8.8	7.2	7.9	9.6	7.5	7.4
11	9.6	8.5	8.9	7.7	7.3	5.9	5.9	5.1	6.2	8.2	9.9	10.1
12	9.6	9.3	8.5	7.9	4.7	3.4	2.4	2.8	3.5	6.0	9.0	9.8
13	12.3	10.8	9.9	6.7	5.1	3.3	2.0	1.7	3.5	6.1	9.0	11.8
14	6.3	6.2	5.7	4.6	3.0	1.5	1.0	1.1	1.7	3.2	5.1	7.7
15	4.7	4.9	4.0	3.4	2.6	1.6	0.8	1.1	2.0	3.0	4.3	5.3
16	3.8	3.4	3.0	3.0	1.8	1.1	0.6	1.1	2.1	2.9	3.0	4.0
17	2.7	2.7	1.7	1.4	1.8	1.5	3.1	5.0	4.0	3.6	4.8	4.3

Directions are clockwise with 1 = north and Month 1 = January. Direction 17 represents calm periods. Values for Lubbock, TX (Skidmore and Tatarko, 1991).

Table 3.7. Weibull shape parameters by month and direction.

Wind Direction	Month 1	2	3	4	5	6	7	8	9	10	11	12
1	2.5	2.5	2.7	2.6	2.8	2.3	2.2	2.6	2.3	2.5	2.7	2.7
2	2.8	2.4	3.2	2.9	2.8	2.7	3.2	2.3	3.1	2.8	2.7	2.6
3	2.8	3.1	3.3	2.8	2.7	2.9	2.8	3.3	3.2	3.3	3.0	3.2
4	3.9	3.4	3.0	3.5	3.0	2.6	2.8	2.9	3.2	3.1	2.7	3.2
5	3.1	3.2	3.3	2.9	3.0	3.4	3.1	3.2	3.3	3.0	3.6	2.8
6	3.4	3.6	3.9	3.3	3.6	4.4	3.7	3.9	3.3	3.5	3.6	5.1
7	3.7	3.3	3.3	3.3	3.4	3.6	3.5	3.5	3.9	4.1	3.6	5.4
8	3.2	4.1	3.3	3.5	3.3	3.5	3.8	3.7	3.5	2.9	3.0	4.5
9	2.9	3.2	3.6	3.3	3.3	3.7	3.7	3.7	3.4	3.3	3.3	3.2
10	3.1	3.5	3.7	3.7	3.2	3.5	3.9	3.6	4.0	3.2	3.5	3.2
11	3.4	3.2	2.7	3.2	3.2	3.0	3.5	3.0	3.4	3.0	3.2	3.2
12	2.5	2.6	2.5	2.4	2.5	2.9	3.4	3.6	3.0	2.7	2.6	2.6
13	2.1	2.4	2.2	2.5	2.6	2.2	3.3	3.1	3.0	2.4	2.2	2.2
14	2.1	2.2	2.3	2.5	2.4	3.6	4.1	3.5	2.6	2.4	1.8	2.0
15	2.4	2.6	2.2	2.5	2.5	3.1	3.3	2.9	2.9	2.0	2.2	2.3
16	2.2	2.6	2.7	2.3	2.8	3.3	2.6	3.5	2.5	2.1	2.4	2.4
17	2.6	2.6	2.7	2.9	3.0	3.1	3.3	3.2	3.0	2.7	2.6	2.6

The directions are clockwise starting with 1=north. Direction 17 is for total wind. Values are for Lubbock, TX (Skidmore and Tatarko, 1991).

Table 3.8. Weibull scale parameters by month and direction in m/s.

Wind Direction	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1	8.0	8.2	8.8	8.3	8.0	7.6	5.8	5.0	6.4	7.5	7.5	7.9
2	8.2	9.2	9.0	8.6	8.3	7.6	6.0	5.7	7.3	7.5	6.7	8.1
3	6.6	7.8	8.0	8.3	7.9	7.2	5.8	5.8	5.9	7.0	6.5	6.8
4	6.5	6.5	7.8	6.9	7.3	6.3	5.9	5.2	5.3	6.2	5.7	6.3
5	6.0	6.3	6.7	6.4	6.6	6.3	5.2	4.8	4.6	5.2	5.0	5.0
6	5.3	6.4	6.8	7.1	7.1	6.2	5.3	5.0	5.2	5.1	5.1	4.2
7	5.5	6.4	7.2	7.2	7.4	6.8	6.0	5.5	5.5	5.3	4.8	5.2
8	5.9	6.1	7.5	8.5	8.0	7.5	6.3	5.8	5.9	6.2	5.8	5.2
9	6.2	7.0	7.9	8.5	8.1	8.0	6.8	6.5	6.5	6.6	6.2	6.5
10	7.2	7.2	8.7	8.5	8.1	7.7	6.9	6.5	6.9	6.9	6.9	7.4
11	7.3	7.6	8.2	8.4	7.6	6.9	6.1	5.9	6.1	6.2	6.5	6.9
12	6.5	7.0	8.0	8.6	7.8	7.0	5.4	5.0	5.2	5.9	6.4	6.0
13	6.7	6.8	8.3	8.8	7.2	6.4	4.9	4.4	5.3	5.1	6.3	6.4
14	7.1	7.2	7.8	8.1	7.0	5.6	4.3	4.2	4.6	5.1	6.0	6.9
15	6.1	6.1	7.2	7.2	7.1	5.3	4.6	4.5	4.4	4.9	6.4	6.5
16	7.1	7.7	7.7	8.3	6.6	5.7	4.8	3.9	4.9	6.4	7.1	7.2
17	6.8	7.3	8.1	8.2	7.7	7.3	6.3	5.8	5.9	6.3	6.4	6.7

Directions are clockwise starting with 1=north. Direction 17 is for total wind. Values for Lubbock, TX. Wind speed adjusted to height of 10 meters (Skidmore and Tatarko, 1991).

Following is an example WINDGEN database record for Goodland, Kansas.

<u>Example WINDGEN database entry for Goodland, Kansas.</u>

```
# 23065 USA KS GOODLAND
39 22 N 101 42 W 1112 19500609 19640322 ARW
  2.4  2.8  2.6  2.2  2.5  2.4  3.7  3.5  3.3  2.9  3.1  3.1
  7.7  8.2 10.1  9.4  6.8  5.6  4.7  4.5  6.3  7.2  7.0  6.2
  4.6  4.0  5.7  5.6  5.8  5.1  4.9  4.6  6.2  4.9  3.8  2.8
  2.3  2.9  3.5  4.0  5.8  5.9  5.1  4.5  3.8  3.7  2.2  1.7
  1.3  1.6  2.5  3.2  4.4  4.3  3.4  3.4  3.6  1.6  1.1  1.1
  1.1  1.1  1.9  2.6  3.2  3.4  3.5  2.8  2.9  1.5  1.0  0.8
  1.8  2.4  3.7  5.2  6.2  5.9  6.7  5.1  4.4  3.3  1.8  1.5
  2.5  3.9  6.0  6.3  8.2  9.0 11.2  9.7  6.0  5.4  3.3  2.6
  5.8  7.2  8.2 10.5 12.9 14.0 16.8 17.2 14.0 11.2  5.1  4.6
  6.0  6.9  7.2  9.4 11.0 13.4 13.6 13.4 14.8 10.4  7.2  5.2
  4.7  4.5  4.7  6.2  5.7  8.3  7.6  8.3  8.2  6.3  6.0  4.4
  8.2  7.2  5.5  5.0  4.3  5.0  5.3  6.2  5.9  6.9  8.3  8.7
 16.3 11.8  7.9  5.9  5.6  4.0  3.4  4.0  5.0  8.9 13.8 15.4
  6.6  5.5  3.6  2.5  1.9  1.5  1.4  2.2  2.4  4.0  5.5  7.3
  8.7  7.7  5.7  4.2  3.8  2.8  2.3  2.9  3.0  5.8  9.3 11.2
 10.6 10.8  8.7  7.7  5.8  4.2  2.9  3.6  4.7  7.2  9.0 12.1
  9.4 11.5 12.3 10.2  6.2  5.2  3.5  4.1  5.7  8.9 12.4 11.4
  7.89  8.11  8.61  8.15  7.03  6.53  5.89  5.88  6.50  6.72  7.77  7.16
  6.99  7.07  7.26  6.83  6.49  6.60  6.21  5.64  6.48  5.78  6.82  6.01
  5.08  5.36  6.08  5.90  6.26  6.16  5.91  5.44  5.13  5.35  5.23  4.85
  4.86  4.36  5.89  6.16  6.70  6.32  6.01  5.20  5.80  4.62  4.50  4.39
  4.40  4.30  5.59  5.56  5.51  5.88  5.21  4.86  5.47  4.50  4.34  4.50
  4.58  5.26  5.67  6.19  6.64  6.59  5.74  5.58  5.31  4.45  4.21  4.50
  5.01  5.73  6.85  6.85  7.14  6.65  6.22  6.00  5.47  5.80  5.60  5.82
  5.99  6.41  7.42  8.13  7.82  7.80  6.80  6.91  7.17  6.94  6.39  6.19
  6.26  6.63  7.65  8.12  7.76  7.83  6.98  6.83  7.47  7.24  6.72  6.37
  6.14  6.64  7.31  7.50  7.25  8.03  6.75  6.48  6.94  6.81  6.88  6.77
  5.62  5.23  6.28  5.95  5.81  5.93  5.37  5.20  5.28  5.25  5.78  5.89
  5.18  5.18  5.42  5.22  5.22  5.07  4.31  4.28  4.35  4.82  5.02  5.13
  4.71  4.49  4.89  4.62  4.06  3.55  3.16  3.28  3.97  4.09  4.43  4.70
  5.27  5.39  6.09  6.00  5.37  5.34  4.19  4.52  4.19  4.72  5.67  5.66
  6.77  6.93  7.86  7.93  7.27  5.70  4.41  4.56  5.29  6.08  6.70  6.65
  8.05  8.71  9.67  9.10  7.41  6.81  5.84  5.85  6.85  7.52  8.27  8.51
  2.32  2.41  2.29  2.70  2.43  2.41  2.37  2.43  2.47  2.69  2.64  2.48
  2.82  2.51  2.59  2.54  2.83  2.55  2.43  2.67  2.48  2.77  2.47  2.97
  3.07  2.87  2.56  2.88  2.61  2.57  2.40  2.37  2.82  2.82  2.79  2.69
  3.60  4.00  3.27  2.36  2.45  2.67  2.84  2.68  3.03  3.50  2.95  2.84
  4.04  2.58  2.91  3.06  2.56  2.65  2.47  2.76  2.83  3.67  2.65  3.77
  3.36  3.02  2.86  2.52  2.56  2.56  2.50  2.64  2.75  3.08  3.60  3.67
  2.53  2.74  2.79  2.60  2.61  2.74  2.70  2.68  2.85  2.86  2.27  2.52
  3.14  3.02  2.91  2.93  2.97  2.81  3.15  3.06  3.15  2.97  2.99  2.88
  3.20  2.74  2.71  2.85  2.62  3.01  3.23  3.08  3.14  3.00  2.99  3.27
  3.48  2.78  2.67  3.02  2.67  3.10  3.16  2.84  3.32  2.80  2.96  2.66
  3.26  3.23  2.78  2.90  2.69  2.84  2.74  2.99  3.11  3.43  3.06  3.35
  3.84  3.42  3.36  3.24  3.37  2.62  3.34  2.97  3.67  4.03  4.12  3.94
  3.36  3.37  2.67  3.16  3.09  3.08  2.96  4.30  2.95  3.17  3.63  3.63
  3.17  3.18  2.29  2.62  2.67  2.59  2.39  2.64  2.94  2.94  2.96  3.01
  2.42  2.32  2.20  2.16  2.07  2.32  2.60  2.53  2.12  2.24  2.16  2.35
  2.45  2.50  2.42  2.39  2.58  2.40  2.25  2.34  2.37  2.56  2.49  2.50
  1.4  1.4  1.3  1.4  1.4  1.4  1.6  1.6  1.3  1.4  1.4  1.4
   12   12   11   14   15   15   17   17   15   13   12   13
```

<u>Meaning of each item in the preceding example:</u>

line number	Item	Meaning
1	#	Starting mark
	23065	A unique number (WBAN) associated with the WERIS (Wind Energy Resource Information System) database site
	USA	Country
	KS	State
	Goodland	Name of the site
2	*39 22 N*	Latitude of the location (39° 22' N)
	101 42 W	Longitude of the location (101° 42' W)
	1112	Elevation (m)
	19500609	Beginning record date (yyyymmdd)
	19640322	Ending record date (yyyymmdd)
	ARW	A three letter code containing record information:

first letter *A* -- # of observation/day

A	24
B	19-23
C	12-18
D	5-11
E	4
F	Less than 3
G	Greater than 24
U	Unknown

second letter *R* -- Anemometer location

R	Roof-top
G	Ground mast
B	Beacon tower

E	Estimated Wind, no anemometer
O	Other
U	Unknown

third letter	*W* -- Recording agency
A	Air Force
D	US Department of Agriculture
E	Experiment Station
N	Navy
W	Weather Service
F	FAA
O	Other
U	Unknown

3-18 2.4 ... Wind direction distribution by month (column) and direction (16 rows).

19 *9.4* ... Percent of time calm (no wind) by month.

20-35 *7.89* ... Weibull scale parameter by month (column) and direction (16 rows), C (m/s).

36-51 *2.32* ... Weibull shape parameter by month (column) and direction (16 rows), K.

52 1.4 ... The average ratio of maximum mean hourly to minimum mean hourly observed wind speeds by month.

53 12 ... Average hour of maximum wind speed by month.

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Soil Database

The soil database for WEPS is derived from the National Soil Information System (NASIS) developed and maintained by the USDA-NRCS. Below is a list of the data elements which are obtained from NASIS and a brief description of each.

Header	Descriptive Name (units) - definition - data type
state	State name - character
county	County name - The name of the County - character
ssaname	Soil survey area name - The name given to the specified geographic area (e.g., soil survey area) - character
ssaid	Soil survey area symbol - A symbol that uniquely identifies a single occurrence of a particular type of area (e.g Lancaster Co., Nebraska is NE109) - character
musym	Map Unit Symbol - The symbol used uniquely identify the soil map unit in the soil survey - character
compname	Soil component name - The correlated name of the map unit - character
comppct	Soil component percent (%) - The percentage of the component of the map unit - integer
taxorder	Soil taxonomic order - The soil order of the soil component name - character
slope	Slope gradient (%) - The difference in elevation between two points - float
albedodry	Albedo of the bare dry surface soil - The estimated ratio of the incident shortwave (solar) radiation that is reflected by the air dry, less than 2 mm fraction of the soil (unitless) - float
#of_layers	Number of soil horizons or layers - integer
hzdept	Depth to top of horizon (cm) - The distance from top of the soil to the top of soil horizon - integer

hzdepb Depth to bottom of horizon (cm) - The distance from top of the soil to the base of soil horizon - integer

hzthk Thickness of soil horizon (cm) - A measurement from the top to bottom of the soil horizon - integer

texture Soil texture - An expression, based on the USDA system of particle sizes, for the relative proportions of various size groups - character

%claytotal Clay (%) - Mineral particles less than 0.002 mm in equivalent diameter as a weight percentage - float

%sandtotal Sand (%) - Mineral particles 0.05 to 2.0 mm in equivalent diameter as a weight percentage - float

%sandco Coarse sand (%) - Mineral particles 0.5 to 1.0 mm in equivalent diameter as a weight percentage - float

%sandmed Medium sand (%) - Mineral particles 0.25 to 0.5 mm in equivalent diameter as a weight percentage - float

%sandfine Fine sand (%) - Mineral particles 0.10 to 0.25 mm in equivalent diameter as a weight percentage - float

%sandvf Very fine sand (%) - Mineral particles 0.05 to 0.10 mm in equivalent diameter as a weight percentage - float

dbthirdbar Bulk density 1/3 bar (Mg/m^3) - The oven dried weight of the less than 2.0 mm soil material per unit volume at a tension of 1/3 bar - float

dbovendry Bulk density oven dry (Mg/m^3) - The oven dried weight of the less than 2.0 mm soil material per unit volume - float

wtenthbar Water 1/10 bar (%) - The amount of soil water retained at a tension pf 1/10 bar (10 kPa), expressed as a percentage of the less than 2 mm, oven-dry soil weight. If the soil is a sand, the 1/10 bar water will be listed, if not, the column is blank. - float

wthirdbar Water 1/3 bar (%) - The amount of soil water retained at a tension pf 1/3 bar (33 kPa), expressed as a percentage of the less than 2 mm, oven-dry soil weight - float

wfifteenbar Water 15 bar (%) - The amount of soil water retained at a tension pf 15 bar (1500 kPa), expressed as a percentage of the less than 2 mm, oven-dry soil weight - float

ksat Saturated hydraulic conductivity (µm/s) - The amount of water that would move vertically through a unit area of saturated soil in unit time under unit hydraulic gradient - float

cec7 Cation exchange capacity (meq/100 g) - The amount of exchangeable cations that a soil can adsorb at pH 7.0 - float. If the soil has a pH < 5.5, the column is blank, otherwise the effective cation exchange capacity will be listed.

ecec Effective Cation exchange capacity (meq/100 g) - The sum of NH4OAc extractable bases plus KCl extractable aluminum used for soils that have pH < 5.5 - float. If the soil has a pH < 5.5, the effective cation exchange capacity will be listed, if not the column is blank.

om Organic matter (%) - The amount by weight of decomposed plant and animal residue expressed as a weight percent of the soil material - float

caco3 Calcium carbonate equivalent (%) - The quantity of Carbonate (CO3) in the soil expressed as CaCO3 as a weight percentage of the < 2 mm soil - integer

ph1to1h2o Soil Reaction - pH (unitless) - A numerical expression of the relative acidity or alkalinity of a soil using the1:1 soil to water method. - float. If the soil is a mineral soil, the pH will be listed, if not, the column is blank.

ph01mcac12 Soil Reaction - pH (unitless) - A numerical expression of the relative acidity or alkalinity of a soil using the 0.01M calcium chloride method. - float. If the soil is a Histosol, the pH will be listed, if not, the column is blank.

fragvol Rock fragments by volume (%) - The volume of the horizon occupied by 2 mm or larger fraction - integer

lep Linear extensibility percent (%) - The linear expression of the volume difference of the natural soil fabric at 1/3 or 1/10 bar water content and oven dryness. The volume change is reported as a percent change for the whole soil. - float

The WEPS soil database format as downloaded from NASIS, is an ascii text file with each element being separated by the pipe (|) symbol. Each layer is on one line, with various soils listed one after another. Note that there are two places for pH and two for CEC. Only one of each of these will be populated depending on the type of soil. So only one value should is taken from the two columns to fill out the corresponding column in the ifc file. The WEPS soil interface then converts the units and generates further data elements as required by WEPS.

Crop Database

Introduction

In the WEPS plant growth submodel biomass is converted from solar radiation and partitioned to root and 'shoot' parts (Fig. 3.10). The shoot mass is partitioned into leaf, stem, and reproductive masses. Finally the reproductive mass is partitioned into grain and chaff parts. Development of the crop in WEPS is a function of the heat unit index, which is the ratio of the cumulated growing degree days at any time to the seasonal growing degree days. The crop reaches maturity when the heat unit index is 1. To perform these and other operations the WEPS plant growth model uses crop parameters. A short description of all the database parameters used in the WEPS plant growth model is below. The parameters consist of a mixture of plant growth, decomposition, and other related information used to simulate plant growth and decomposition in the WEPS model.

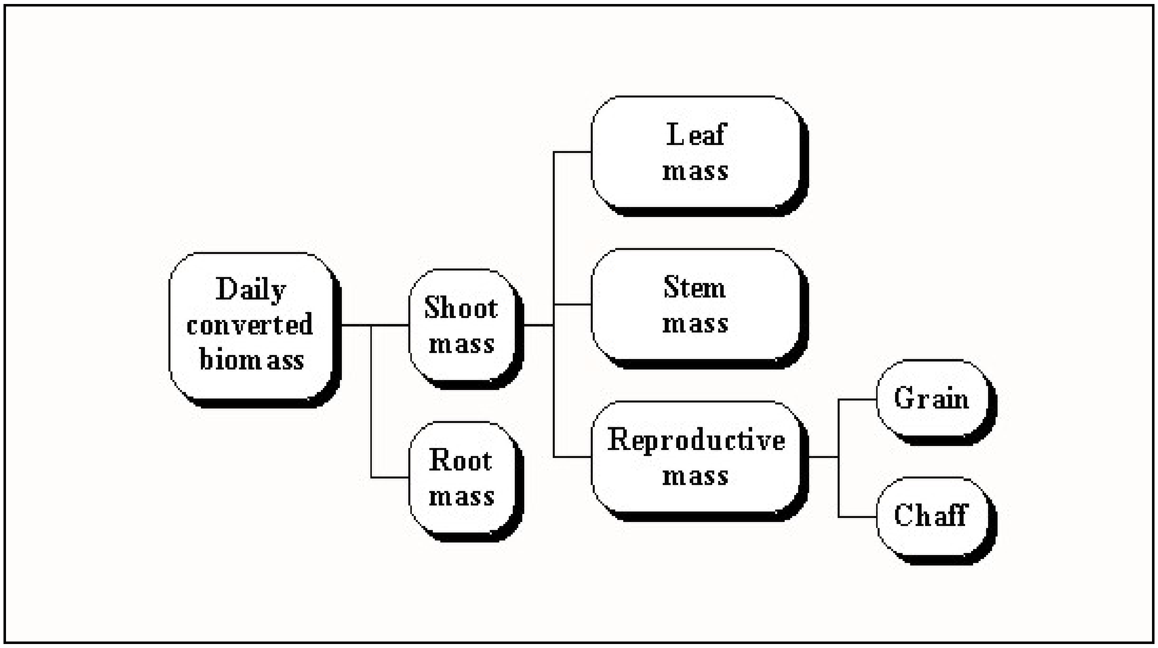
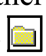


Figure 3.10. Schematic of biomass partitioning in WEPS.

Crop Parameters

Accessing the crop parameters: Many of the crop database parameters can be accessed (i.e., viewed or modified) through the WEPS crop rotation editor. Double clicking on the folder icon , on the left side of the main screen management box, will bring up the management crop rotation editor. This allows the user to modify management scenarios and save them to other file names. The crop parameter window can be accessed by clicking on the folder icon  next to a listed crop on the left side of the 'Crop' column of the MCREW window. The crop parameters are grouped in 6 tabs. Many of the parameters are assumed to be crop specific, and therefore should not be changed unless the user establishes that a parameter(s) does not work for their condition. At the top of the crop parameter window is the 'Crop Name' selection list. Clicking on the down arrow brings up a list from which to select a crop. This is a list of the common name of the crop, which may be followed by additional descriptors when there are multiple entries for the same crop. For example, 'soybeans, MG 0, 95 days' means that the name of the crop is soybeans belonging to maturity group 0 , and takes about 95 days to mature.

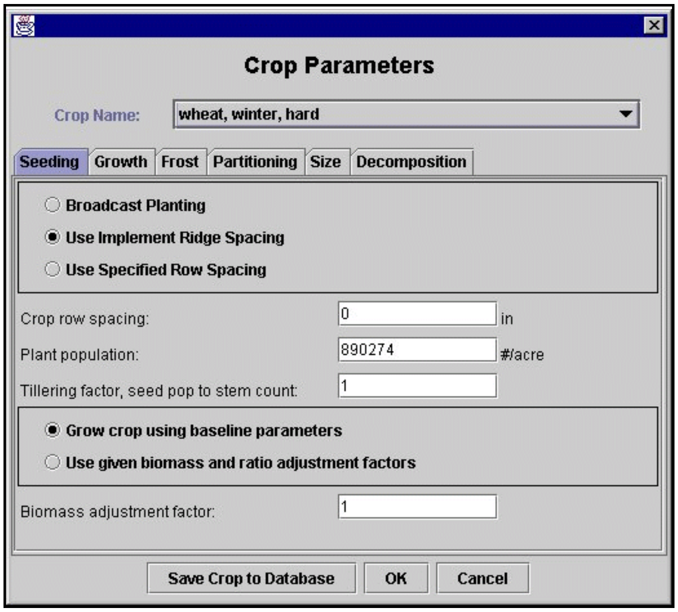


Figure 3.11. Seeding tab window.

Seeding tab (Fig 3.11): This tab has two variables, 'plant population' and 'tillering factor', that are read from the crop database. Plant population is the number of plants or seedlings per unit area. The model assumes 100% germination rate. The tillering factor is the number of tillers per plant. Normally the model is run with the 'Biomass adjustment factor' set to 1.0. However, the model can be run by entering the desired biomass adjustment factor. This choice can be made by clicking on the 'use given biomass and ratio adjustment factors' circle and entering the desired biomass adjustment factor. It is recommended that the use of a biomass adjustment factor be limited to cases when it can be demonstrated that biomass production was influenced by processes other than those simulated in the model. The default plant population (seeding rate) can be changed to suit the conditions being simulated. As mentioned above plant population density will have an impact on amount of vegetative cover, and therefore erosion rates, during the early part of the growing period. It can also have an impact on 'yield'.

Growth tab (Fig. 3.12): This tab displays ten parameters from the crop database. First the user must select the mode of calculation; whether to use the 'days to maturity'(DTM) mode, or the 'seasonal growing degree days (GDD_s)'. This is done by clicking the appropriate circle labeled 'Crop matures on average in Days shown' or 'Crop Matures in Heat Units shown'. GDD_s is the total growing degree days from planting to physiological maturity. In the GDD_s mode the user can either use the default GDD_s or supply another value. In the DTM mode the model computes GDD_s internally. A brief description of DTM follows. For annual crops DTM is the number of days from planting to physiological maturity. For perennial crops (e.g. alfalfa), DTM is the number of days from start of spring growth to physiological maturity of seed. For perennials, the date of spring planting (or start of spring

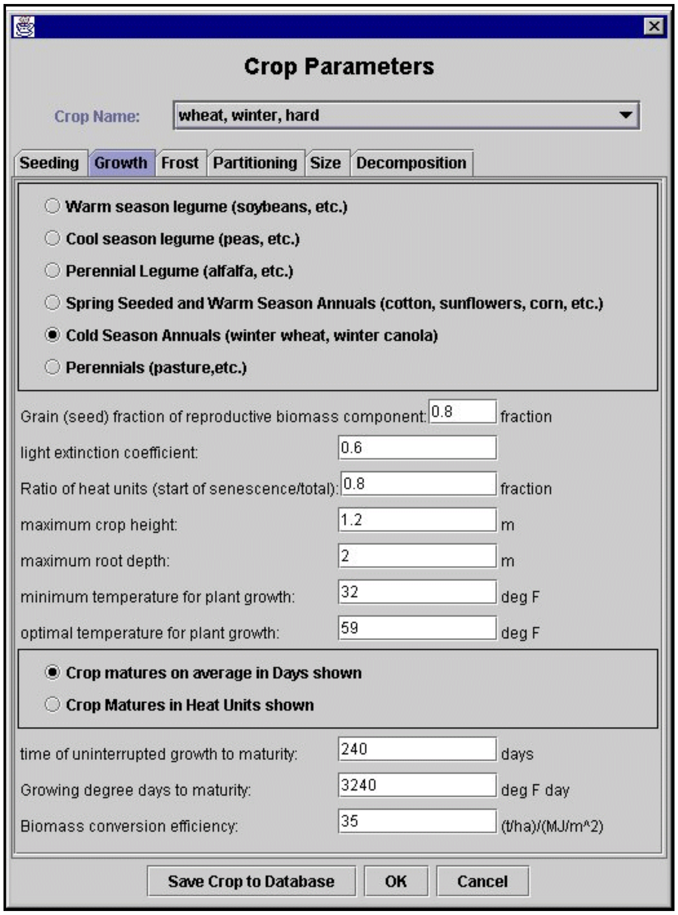


Figure 3.12. Growth tab window.

growth) is not a data entry, but calculated internally in the Crop submodel. For root and vegetable crops, DTM is the number of days from the planting/transplanting date to market 'maturity'. Similarly, for tropical fruit crops (e.g. pineapple) DTM is the number of days from planting to market maturity of fruit. For sugarcane, DTM is the number of days from planting to the time when the cane is ready for cutting. For cover crops DTM is the time from planting at the normal planting time to physiological maturity. If a user feels that the default value of DTM is either too long or too short then the user should replace it to more correctly represent the cultivar or variety being simulated. Since DTM is used in internal computations of GDD_s it determines the length of the growing season. If the user chose the GDD_s mode then the user must ensure that the default GDD_s applies to the variety being simulated. In most cases it is recommended that the DTM method should be used, most users may be more familiar with the number of days a crop may take to mature than with how many growing-degree-days a crop takes to mature. However, the GDD_s method should be used for cover crops that are planted out of season. It is recommended that most of the remaining parameters in this tab should not be changed without proper evaluation.

A brief definition of the parameters in this tab is below:

<u>Grain (seed) fraction of reproductive biomass component</u>: Harvestable fraction of reproductive biomass. For grain crops the reproductive mass is the ratio of grain mass to reproductive mass (grain/(grain+chaff)). For corn the 'chaff' will include the husk and the shank. For many field crops a value of 0.8 is used.

<u>light extinction coefficient</u>: A measure of how much of the light energy is transmitted through a canopy. This parameter is a constant in the equation used to convert light energy into biomass. Values may range from 0.3 to 0.6 for crops with upright leaves, and from 0.6

to 1.05 for crops with horizontal leaves.

Ratio of heat units (start of senescence/total): This parameter determines when senescence will start (e.g. a value of 0.8 indicates that senescence will start when 80% of the growing season is completed).

maximum crop height: The height a plant can reach under ideal growing conditions.

maximum root depth: The depth that the root of a plant can reach under ideal growing conditions.

minimum temperature for plant growth: The average daily air temperature below which the model will not allow plant growth (the temperature stress factor is 0.0).

optimal temperature for plant growth: The average daily air temperature at which the model will allow maximum growth (the temperature stress factor is 1.0).

time of uninterrupted growth to maturity: This label is misleading and should be changed to read: days from planting to physiological (or market) maturity. For annual grain crops, the average number of days from planting to maturity of seed; for vegetable, fruit and root crops, sugarcane, and tobacco it is the number of days from planting (or ratooning) to harvest; for perennials (e.g. alfalfa) it is the number of days from spring growth to maturity of seed.

Growing degree days to maturity: For annual grain crops, the average seasonal growing-degree-days from planting to maturity of seed; for vegetable, fruit and root crops, sugarcane, and tobacco it is the average seasonal growing-degree-days from planting (or ratooning) to harvest; for perennials (e.g. alfalfa) it is the average seasonal growing-degree-days from spring growth to maturity of seed.

Biomass conversion efficiency: Energy to biomass conversion parameter at ambient CO_2 levels. This parameter determines how effective a crop is in converting photosynthetically active radiation into structural biomass. This parameter may be changed based on field experimentation.

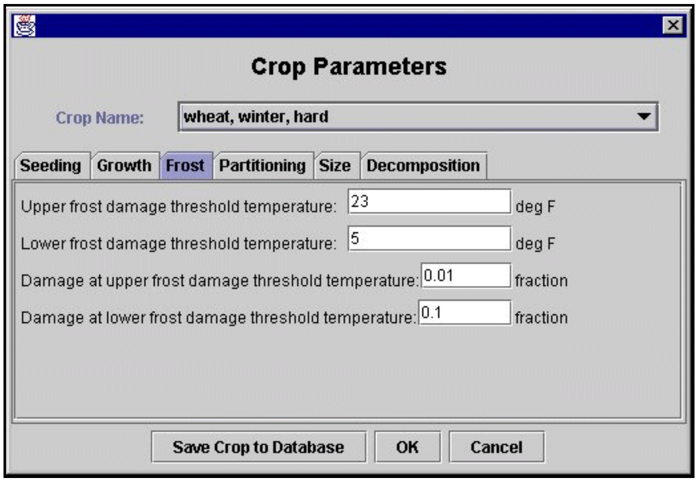


Figure 3.13. Frost tab window.

<u>Frost tab (Fig. 3.13):</u> The Crop submodel reduces green leaf area in response to frost. The frost parameters determine the shape of a sigmoid curve used in assessing rate of green leaf area reduction in response to temperatures below freezing (Fig. 3.14).

Note: Changing parameters on the 'Frost' tab is not recommended unless the user completely understands their derivation and the resulting effect of the changes. Contact WERU for more assistance.

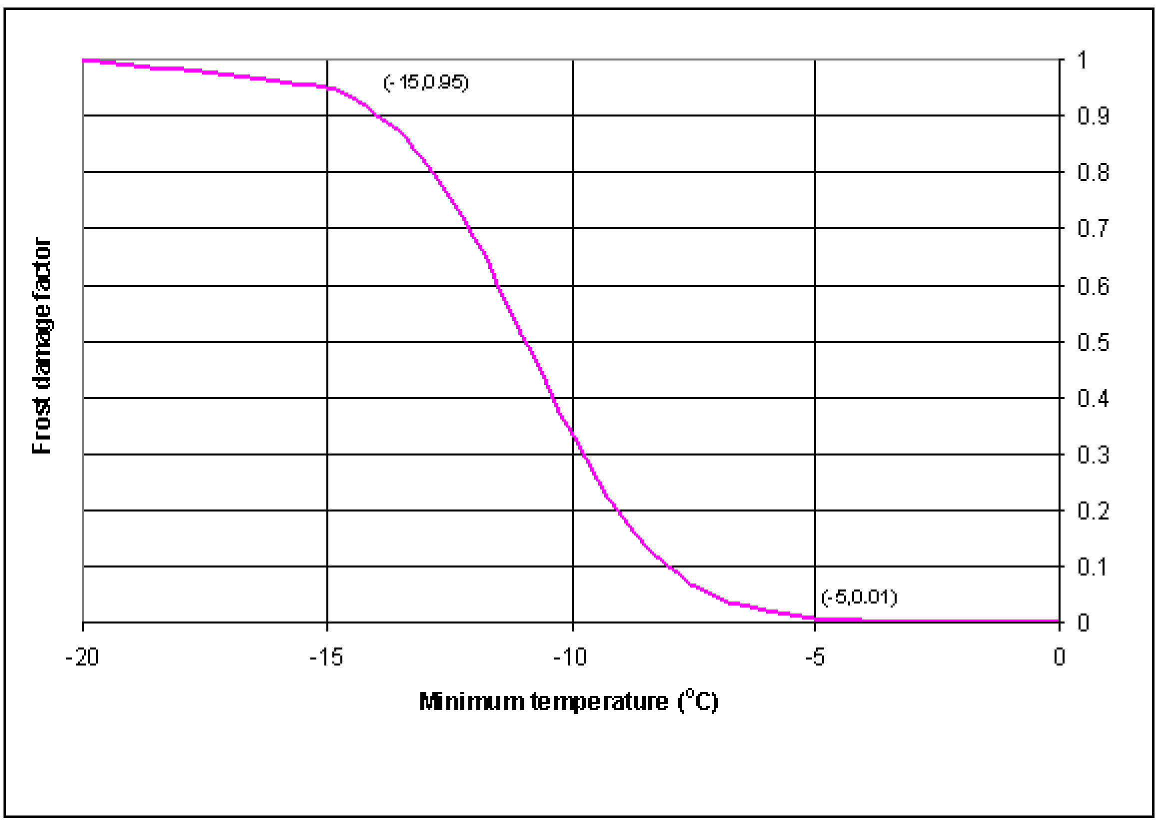


Figure 3.14. Example frost damage curve.

The frost parameters follow:

Upper frost damage threshold temperature: This label should be changed to read 'upper frost damage temperature'.

Lower frost damage threshold temperature: This label should be changed to read 'lower frost damage temperature'.

Damage at upper frost damage threshold temperature: This label should be changed to read 'relative damage at upper frost temperature'

Damage at lower frost damage threshold temperature: This label should be changed to read 'relative damage at lower frost temperature'.

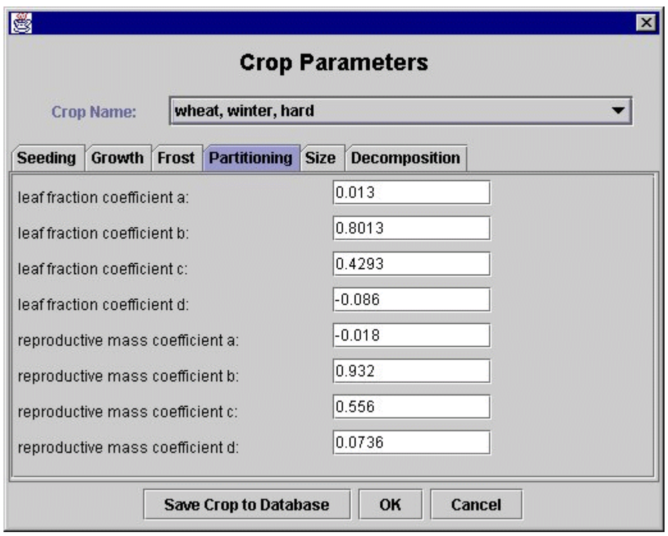


Figure 3.15. Partitioning tab window.

Partitioning tab (Fig 3.15): There 8 parameters in this tab. These parameters are the coefficients in a 4-parameter logistic function to determine partitioning of 'shoot' biomass into leaf or reproductive masses. The first 4 coefficients are for leaf and the last 4 are for reproductive (Fig. 3.16).

Note: Changing parameters on the 'Partitioning' tab is not recommended unless the user completely understands their derivation and the resulting effect of the changes. These parameters require extensive testing and or field data if new values are to be generated and used. Contact WERU for more assistance. The parameters are:

leaf fraction coefficient a: The intercept of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into leaves.

leaf fraction coefficient b: The asymptote of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into leaves.

leaf fraction coefficient c: The inflection point of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into leaves.

leaf fraction coefficient d: The inverse of the slope of a 4-parameter logistic function used in computing the fraction of daily converted ‘shoot’ (above ground) biomass that goes into leaves.

reproductive mass fraction coefficient a: The intercept of a 4-parameter logistic function used in computing the fraction of daily converted ‘shoot’ (above ground) biomass that goes into reproductive parts or yield.

reproductive mass fraction coefficient b: The asymptote of a 4-parameter logistic function used in computing the fraction of daily converted ‘shoot’ (above ground) biomass that goes into reproductive parts or yield.

reproductive mass fraction coefficient c: The inflection point of a 4-parameter logistic function used in computing the fraction of daily converted ‘shoot’ (above ground) biomass that goes into reproductive parts or yield.

reproductive mass fraction coefficient d: The inverse of the slope of a 4-parameter logistic function used in computing the fraction of daily converted ‘shoot’ (above ground) biomass that goes into reproductive parts or yield.

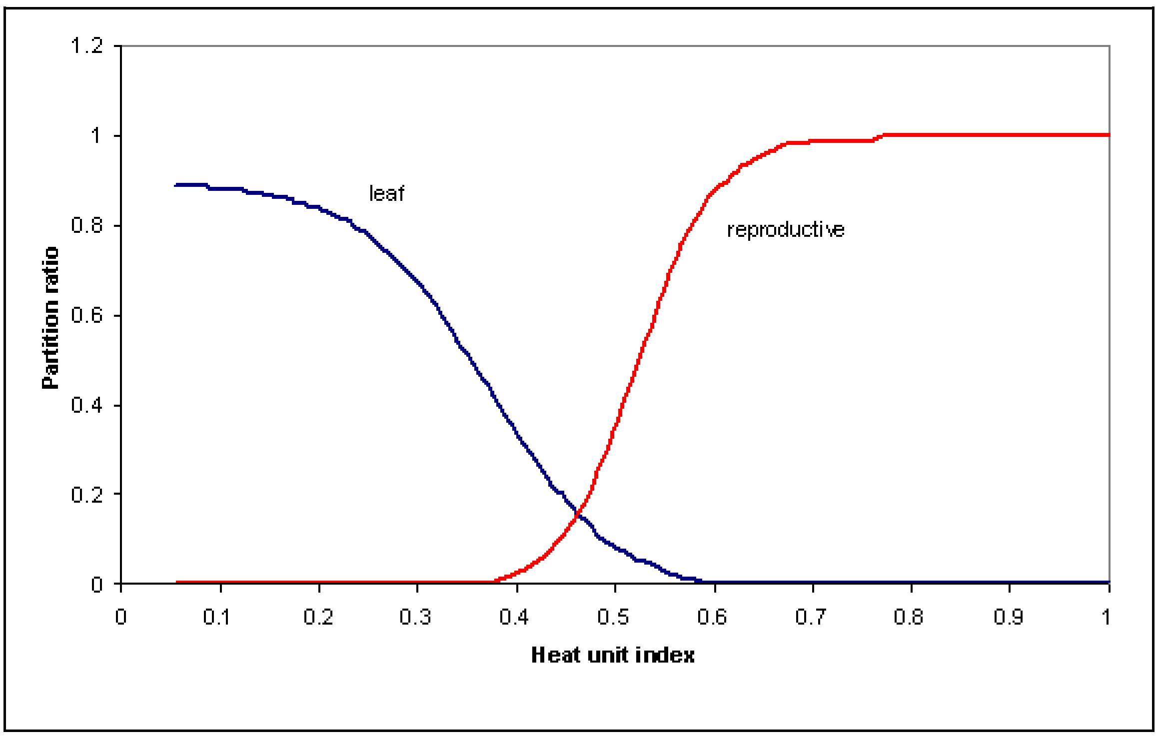


Figure 3.16. Example shoot and reproductive growth curves.

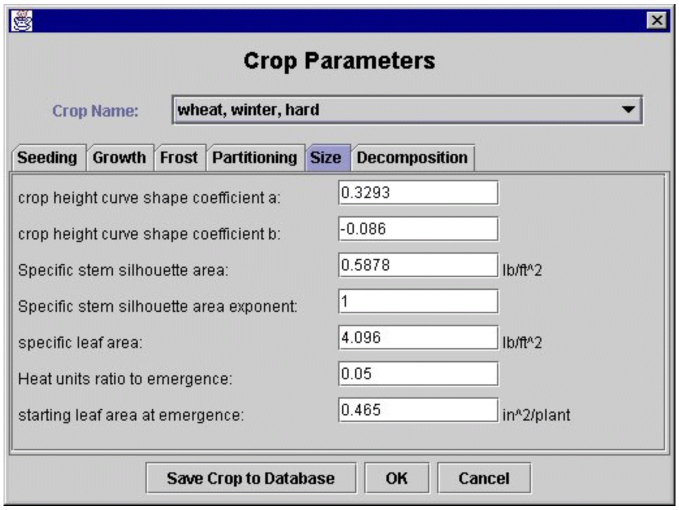


Figure 3.17. Size tab window.

Size tab (Fig 3.17): Miscellaneous types of crop architecture parameters are contained in this tab.

Note: Changing parameters on the 'Size' tab is not recommended unless the user completely understands their derivation and the resulting effect of the changes. These parameters require extensive testing and or field data if new values are to be generated and used. Contact WERU for more assistance.

The parameters are:

crop height curve shape coefficient a: The inflection point of a 2-parameter sigmoid function used to compute plant height.

crop height curve shape coefficient b: The inverse of the slope of a 2-parameter sigmoid function used to compute plant height (Fig. 3.18). These two parameters determine the potential rate of increase in plant height of a crop. The parameters are the result of assuming that plant height growth follows the growth patterns in leaf area. However, these parameters can also be derived from field measured plant height data.

Specific stem silhouette area: A slope coefficient of a power function.

Specific stem silhouette area exponent: For many crops, for which field data are available, it has been found that the relationship of stem silhouette area to its mass is strongly correlated to a 2-parameter power function. The power function is used in the model to compute stem silhouette area. The parameters are the coefficients of the power function. These parameters can be determined from field data of stem mass and stem silhouette area.

specific leaf area: The slope of a linear regression line of leaf mass vs leaf area. A zero-intercept linear function relating leaf mass to leaf area is used in the model to convert leaf mass to leaf area. This parameter can be determined from field data of leaf mass and leaf area.

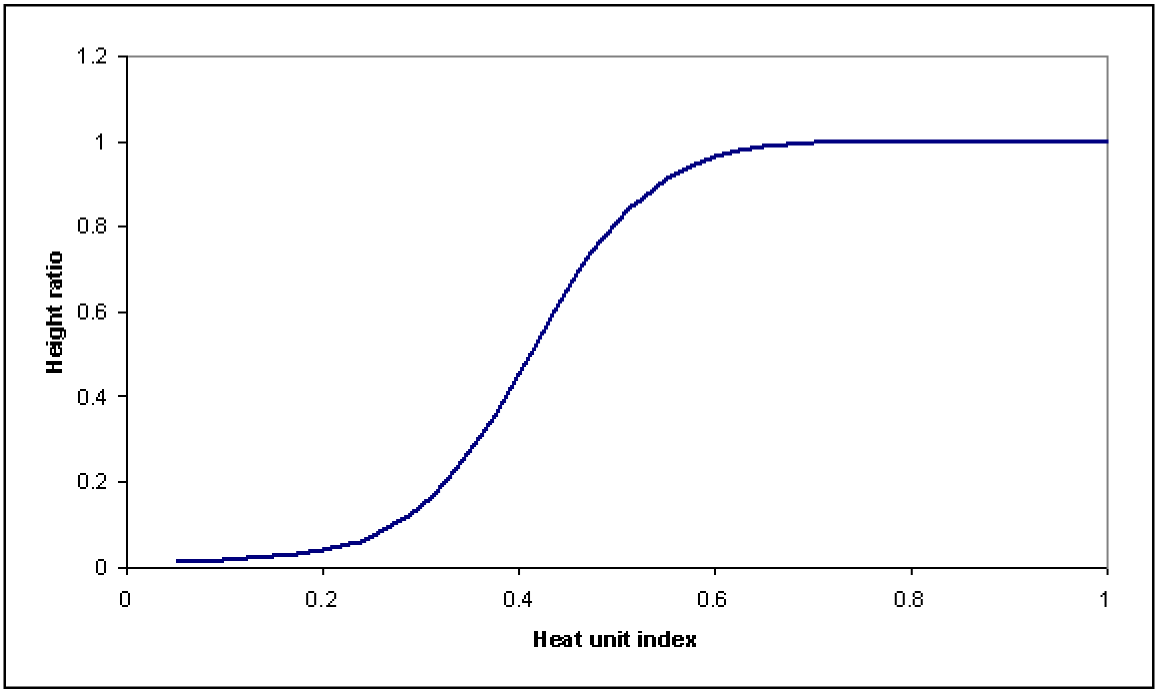


Figure 3.18. Sample graph of the function used to compute plant height.

Heat unit ratio to emergence: The relative heat units required for emergence. The model assumes that under average conditions it takes about 100 degree C days from seeding to emergence. The parameter is the ratio of degree C days from seeding to emergence to the degree C days from seeding to maturity.

starting leaf area per plant at emergence: The average estimated leaf area per plant when seedling emerges from the ground (inches^2/plant).

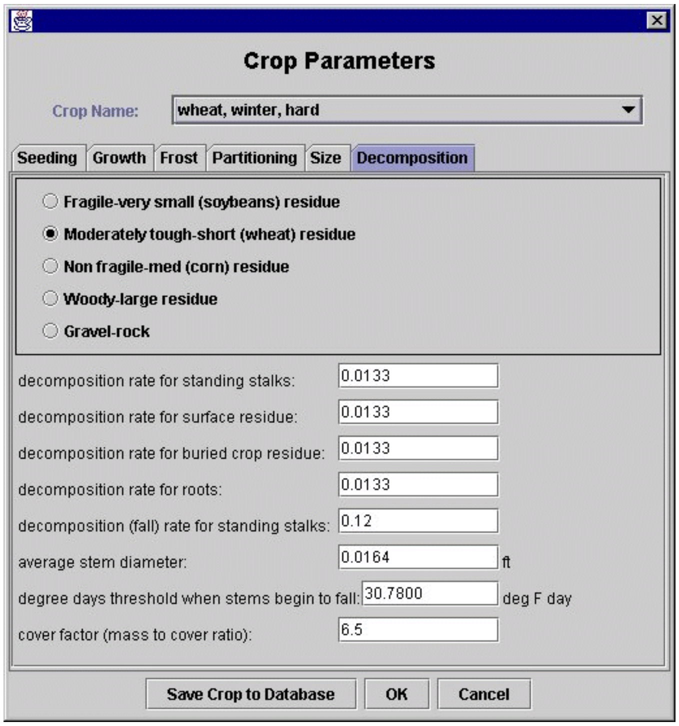


Figure 3.19. Decomposition tab window.

Decomposition tab (Fig 3.19): Five options are available for selecting decomposition parameters for surface and buried residue. They range from fragile to non-erodible types depending on the crop type.

Note: Changing parameters on the 'Decomposition' tab is not recommended unless the user completely understands their derivation and the resulting effect of the changes. These parameters require extensive testing and or field data if new values are to be generated and used. Contact WERU for more assistance.

Parameters for each option are:

decomposition rate for standing stalks: Standing residue mass decomposition rate (g/g/day).

decomposition rate for surface residues: Flat residue decomposition rate (g/g/day).

decomposition rate for buried crop residue: Buried residue decomposition rate (g/g/day).

decomposition rate for roots: Root residue mass decomposition rate (g/g/day).

decomposition (fall) rate for standing stalks: The rate at which standing stalks fall to a flattened (horizontal) position on the soil surface.

average stem diameter: Residue stem diameter (meters or feet).

degree days threshold when stems begin to fall: Threshold degree C days (degree C days).

cover factor (mass to cover ratio): kg m^{-2}

Management Database

HOW TO OPERATE WEPS

Details

Toolbars and Configurations

Menu Bar

This is the top line of the WEPS main screen. A brief description of each item on the menu bar is given below.

Project

The ‘Project’ menu brings up a drop down list of various operations pertaining to WEPS projects. The Project menu contains the following options:

- ‘New’ - allows user to create a new project from scratch (Ctrl+N).
- ‘Open’ - opens an existing project (Ctrl+O).
- ‘Save’ - saves the currently displayed project to its current file name (Ctrl+S).
- ‘Save As’ - saves currently displayed project.
- ‘Exit’ - exit the WEPS program.

Configuration

The ‘Configuration’ menu brings up various configuration options for WEPS. See the discussion later in this section for more details on setting WEPS configurations.

Run

This allows the user to run WEPS, view a project summary for the current project, or view output for the current or other projects. The ‘Run’ menu on the WEPS Main Screen brings up the following options:

- ‘Make a WEPS Run’ - clicking on this menu item begins a simulation.
- ‘View Reports’ has the follow submenu:
  - ‘View Current Project Summary’ - view the WEPS Project Summary screen for the current project.
  - ‘View Current Project Output’ - view the Output screen for the current project.
  - ‘View Other Project's Output’ - view the Output screen for a previously run project.

Tools

This menu contain various tools available for use with WEPS including:

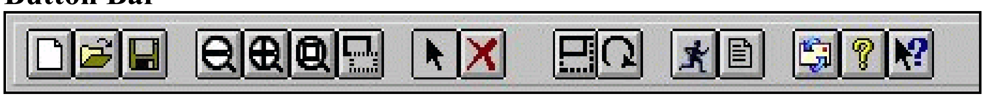
- ‘Send Email’ - send e-mail comments to WERU, providing the computer is connected to the Internet. This tool also allows the user to send the current project as an attachment. To send the project, click the check box at the bottom of the e-mail window.

Help

This menu contains help options for WEPS including:

- ‘Help Topics’ - brings up a window containing the WEPS online help system.
- ‘About WEPS 1.0’ - gives the current version of WEPS.

Button Bar



At the top of the main WEPS window (below the menu bar) is a series of buttons with icons, designed to help the user in the operation of WEPS.

Project Operations

This button allows user to create a new project from scratch. This has the same function as selecting ‘New’ under ‘Project’ on the menu bar.

This button opens an existing project. This has the same function as selecting ‘Open’ under ‘Project’ on the menu bar.

This button saves the currently displayed project to its current file name. This has the same function as selecting ‘Save’ under ‘Project’ on the menu bar.

Field Viewing


This button allows the user to ‘Zoom Out’ or shrink the view of the field on the main screen. Note that this does not shrink the field dimensions, just the view.


This button allows the user to ‘Zoom In’ or enlarge the view of the field on the main screen. Note that this does not enlarge the field dimensions, just the view.


This ‘Zoom to Fit’ button allows the user to size the view of the field to fit the main screen. Note that this does not resize the field dimensions, just the view.

This 'Move' button allows the user to move the field in the view area. The field can be repositioned on the center panel by clicking on the 'Move' button, then click and hold the mouse button over the field shape to move the field to the desired position. The move button can be used in a similar manner to move a barrier to another boundary of the field.

Select

This 'Select' button allows the user to turn off a field manipulation operation such as resizing, moving, or rotating the view of a field (see a description of these operations elsewhere in this section).

This 'Delete' button deletes "selected barriers" from the field.

Field Manipulation

This 'Resize' button allows the user to change the actual field length and width. When the button is clicked, 'handles' appear on the field borders which can be 'dragged' to resize the field dimensions. Note that as the field is resized, the X-Length and Y-Length are changed.

This 'Rotate' button allows the user to rotate the field to adjust the angle of the field. By placing the mouse cursor within the circle in the simulation region, drag the mouse to rotate the field to the desired orientation. Note that the field will only rotate in a range of ±45 degrees. By using rotate and adjusting the field length and width, the user should be able to obtain the desired field size and orientation.

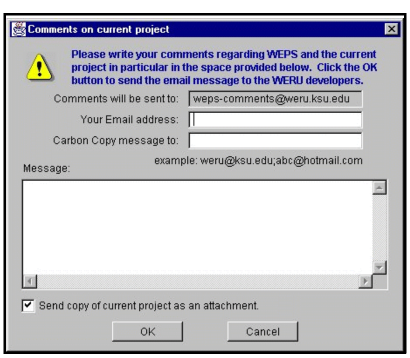
Run and View

This 'Run' button begins a simulation run.

This 'View' button allows the user to view the output window.

Help

This 'e-mail' button allows the user to e-mail comments to WERU along with the contents of the current Project, if desired. Clicking the 'e-mail' button brings up a separate window (see below).



The user should enter an e-mail address and a short message. Click the check box at the bottom of the window to attach the current project files to your e-mail. If you are connected to the Internet, clicking 'OK' will e-mail the message to WERU, along with any attached files so that your enquiry can be answered.


This ‘Question’ button allows the user to view the current version and release number of WEPS.


This ‘Context Help’ button provides help for a particular item on the WEPS screen. Clicking the ‘Context Help’ button on the tool bar and then clicking on the item on the screen for which help is desired brings up a help screen for that item.

Configuration

The ‘Configuration’ menu brings up various configuration options for WEPS.

- ‘User Settings’ which brings up a screen that allows the user to set the following:
  - Display units in either metric or English.
  - Maximum distance for climate station choice lists (kilometers or miles). Typically use the closest, but the user may want to select a station more typical of the climate for the field being simulated. An example of not selecting the closest station might occur in mountainous areas where the adjacent station does not typify the climate for the simulated field.
  - Hide "graphical scale", "lat/lon" fields, and length of WEPS run.
- ‘System Settings’ which brings up a screen that sets the following:
  - Windgen/Cligen program settings.
- ‘WEPS Developer Settings’ which brings up a submenu that has the following:
  - Alternative weather files - enter location for alternative weather files.
  - Submodel output options - select types of additional output from WEPS submodels.
  - # years for simulation runs - select total number of simulation years or the number of management rotation cycles for the simulation run.
- ‘Email Settings’ which brings up email configuration settings screen.

Describing the Field and Barriers

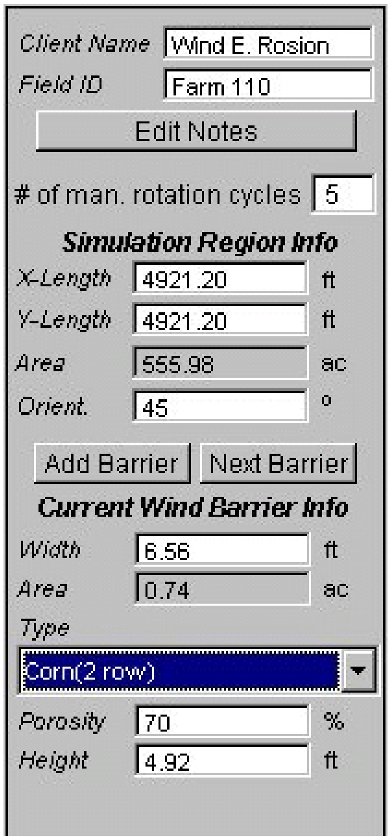


Figure 4.1. Left panel of the main WEPS screen.

Customer, field description, and barrier information for a simulation run can be entered by using the left panel of the WEPS1.0 main screen (Fig. 4.2, 1).

The 'Client Name' and 'Field ID' for the simulation run can be entered by typing the information in the windows at the top of the panel. The user may also type in additional notes for the run by clicking the 'Edit Notes' button. A window will appear in which the notes can be typed. These notes will be displayed on the Output Summary

To describe the simulation region, the field dimensions are entered as an X-Length and a Y-Length. Note that the area of the region will be displayed but can not be edited. To orient the field direction, simply type in the angle in degrees of deviation from north of the field. Note that the field will only rotate in a range of ±45 degrees. By rotating and adjusting the field length and width, the user should be able to obtain the desired field size and orientation.

If the user desires to add barriers to the field borders, click the 'Add Barrier' button. By dragging the mouse cursor, in the center panel of the WEPS screen (Fig. 4.2), position the barrier on the desired border. Then click the mouse to "fix" the barrier on the appropriate field border. Note that barriers are only allowed on the field borders in WEPS 1.0. The barrier type can then be selected from the drop down list in the left panel. To change a barrier type at a later time, click the down arrow to the right of the barrier type to bring up the list of available barriers and click on the appropriate barrier. Enter the barrier width, porosity, and height in the appropriate space. Note that the area of the barrier is displayed but cannot be edited. To remove a barrier from the field, click on the barrier to select it (notice it will be 'highlighted' when selected) then click the delete button on the tool bar at the top of the screen. One may also cycle through the barriers to select a barrier already positioned on the field by clicking the 'Next Barrier' button.

An alternative method of describing field dimensions is to manipulate the field using the tool bar and mouse. The 'Resize' button allows the user to change the field length and width as well as the barrier width. When the Resize button is clicked, then the field in the center panel of the WEPS screen (Fig. 4.2), "handles" appear on the field borders which can be "dragged" to resize the field dimensions. Note that as the field is resized, the X-Length and Y-Length and field area change. Similarly when the Resize button is clicked, then a barrier in the center panel of the WEPS screen, "handles" appear on the barrier which can be "dragged" to resize the field dimensions. Note that as the barrier width is resized, the barrier width and area change in the left panel.

The 'Rotate' button allows the user to rotate the field to adjust the angle of the field. By clicking the Rotate button, then placing the mouse cursor within the circle in the simulation region, drag the mouse to rotate the field to the desired orientation. Note that the field will only rotate in a range of ±45 degrees. By using rotate and adjusting the field length and width, the user should be able to obtain the desired field size and orientation.

Once the field has been resized and oriented using the tool bar and mouse, the 'Select' button allows the user to turn off field manipulation operations such as resizing or rotating the view of a field.

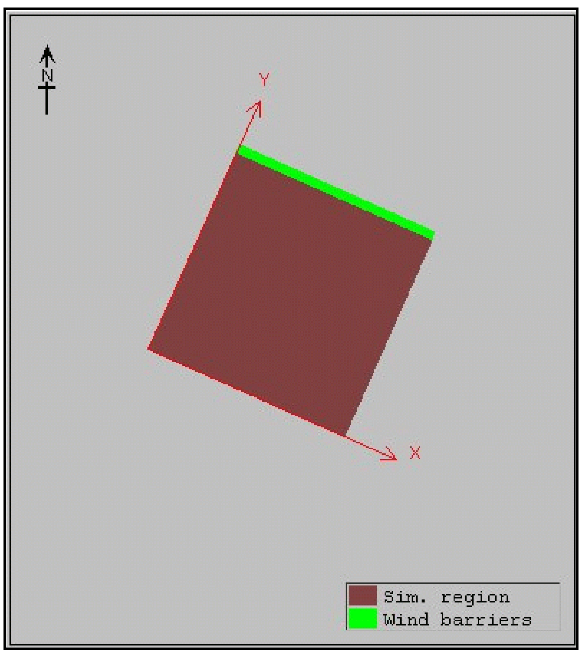


Figure 4.2. View of the field shape and barrier as input by the user.

The resulting field shape (brown) and orientation with barriers (green), if present, can be viewed in the center panel of the main WEPS screen (Fig. 4.2). Note that the barrier width is not drawn to scale relative to the field dimensions. If the field dimensions are too large or small to be viewed in the center panel, use the 'Zoom Out' , 'Zoom In' , or 'Zoom to Fit' buttons on the toolbar at the top of the screen to resize the view.

The field can be repositioned on the center panel by clicking on the 'move' button , then click and hold the mouse button over the field shape to move the field to the desired position. The move button can be used in a similar manner to move a barrier to another boundary of the field.

Creating special shapes or configurations such as circles and strip cropping are discussed under "Using WEPS for Conservation Planning".

Choosing a Location

Choosing a location within WEPS defines the physical location of the field to be simulated. In reality, this location information is used to select the weather stations (CLIGEN and WINDGEN) to be used for the simulation.

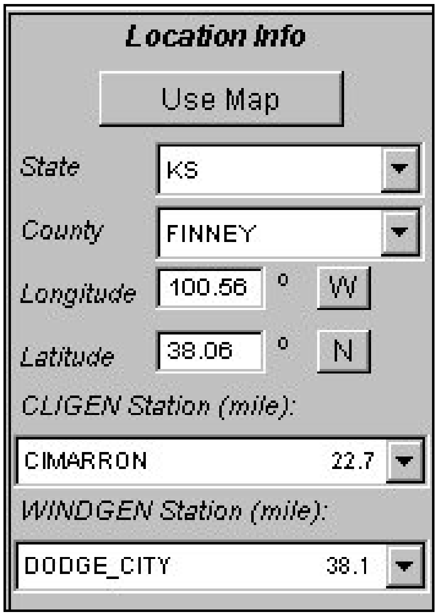


Figure 4.3. 'Location Info' panel.

Location information is entered through the rightmost panel labeled 'Location Info' on the main interface screen (Fig. 4.3). A simple method of choosing a location is to select the state and county of interest from the drop down list by clicking the down arrow to the right of the state and county. The CLIGEN and WINDGEN stations nearest to the center of the selected county will then determined by the interface and listed. The longitude and latitude of the location can also be entered, which will bring up the nearest CLIGEN and WINDGEN stations. Once the stations are displayed, the user can click on the down arrow next to the stations to bring up a list of nearby stations from which to choose an alternative station if desired. Right clicking on the listed CLIGEN or WINDGEN station name in will bring up information about the weather station. This information may be useful in determining which station best fits the location and conditions desired.

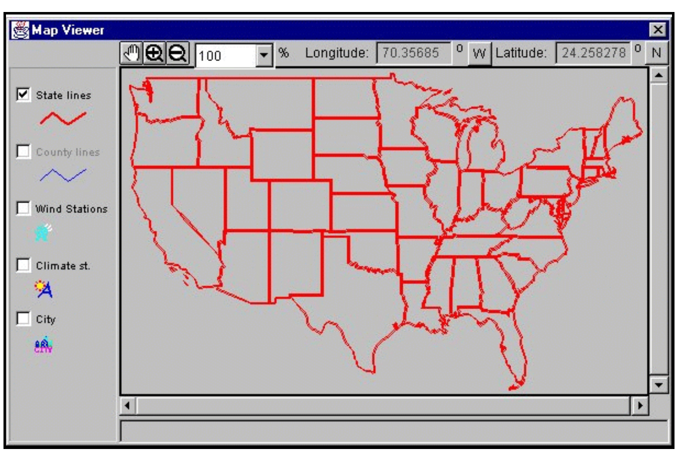


Figure 4.4. Map Viewer window.

An alternative method to choosing a location is by using the map. Clicking on the 'Use Map' button brings up 'Map Viewer' with a map of the United States (Fig. 4.4). The map can be 'zoomed' in or out by selecting a % magnification from the dropdown list at the top the map viewer screen. Alternatively, the user may increase or decrease magnification by clicking the zoom in or zoom out buttons and then clicking a location within the map window. When zoomed to greater than 100%, one can 'drag' the view of the map by clicking on the 'move' icon then holding down the left mouse button and drag the map view to the desired location. Clicking the check boxes in the left side of the Map Viewer window will display county lines (must be zoomed at 400% or greater), the location of CLIGEN stations, WINDGEN stations, and major cities on the map. Double clicking a location on the map will select the nearest CLIGEN and WINDGEN station and close the map viewer. The map viewer is a convenient way to view all of the climate stations within a state or region.

Choosing a Soil

A soil for a simulation run is selected using the 'Soil:' box on the right side of the bottom panel of the WEPS1.0 main screen (Fig. 4.5).

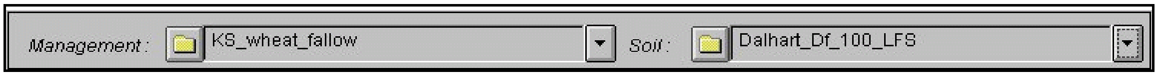


Figure 4.5. Bottom panel of the WEPS main screen with the soil box on the right.

The soil for a simulation run can be selected from a pre-generated list by clicking the down arrow on the right side of the soil box which is located in the bottom panel of the main screen (Fig. 4.5) and then select the state, county, and soil desired. The soils file are named according to the soil name, map unit symbol, component percent, and surface soil texture class (each separated by a hyphen). To view the soil data, double click on the folder icon , on the left side of the soil box. This will bring up the WEPS Soil User Interface screen (Fig. 4.6), which allows the user to view, edit, and save the soil information under a new file name. See the 'Soil Interface' help on the menu bar at the top of the WEPS Soil User Interface screen for more details.

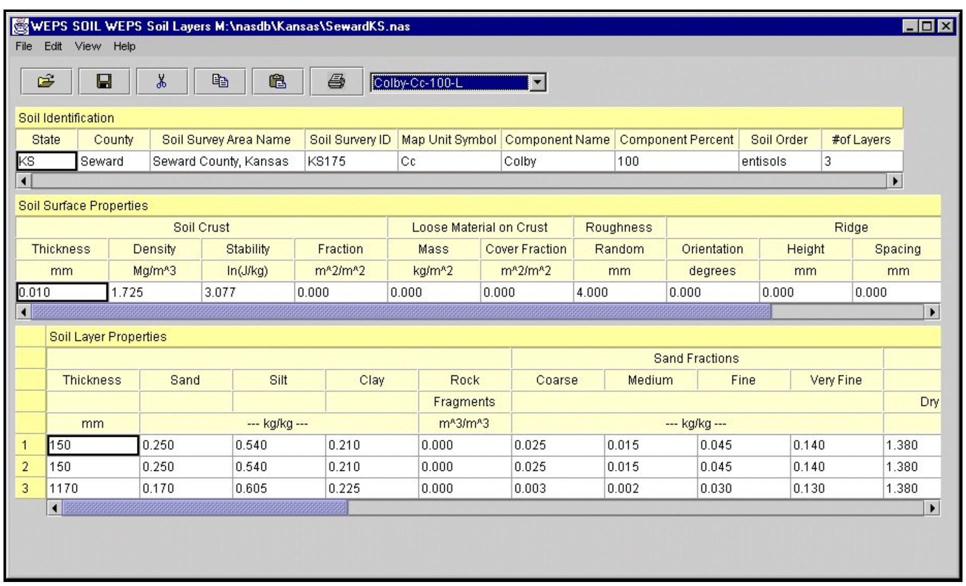


Figure 4.6. WEPS Soil User Interface screen.

Choosing and Editing a Management Rotation

Management rotation scenarios for a simulation run can be selected or a rotation editor can be opened by using the ‘Management:’ box on the right side of the bottom panel of the WEPS1.0 main screen (Fig 4.7).

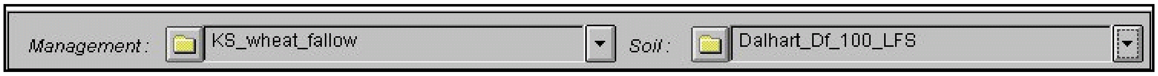


Figure 4.7. Bottom panel of the WEPS main screen with the management box on the left.

A management rotation for a simulation run can be selected from a pre-generated list by clicking the down arrow on the right side of the management box which is located in the

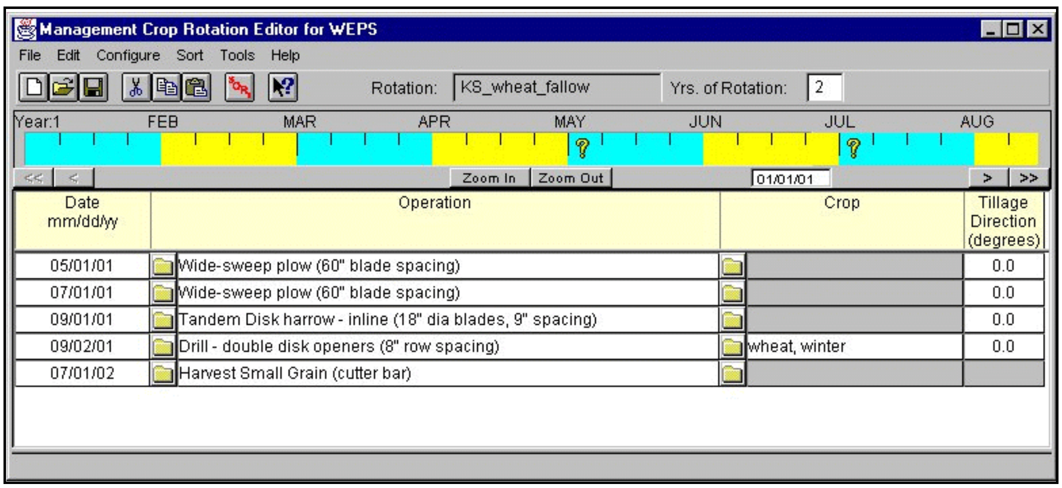


Figure 4.8. MCREW window.

bottom panel of the main screen (Fig. 4.7) and then select the management rotation desired. To open the Management Crop Rotation Editor for WEPS (MCREW), double click on the folder icon, on the left side of the management box. This will bring up the MCREW window (Fig. 4.8), which allows the user to view, edit, and save management rotation information under a new file name.

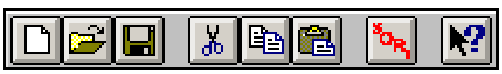
Using MCREW

MCREW is designed to allow easy creation and editing of management rotation files for WEPS. The MCREW screen consists of 5 major components:

1. Menu Toolbar

The menu toolbar consists of assorted menu options which provide access to MCREW's functions.

2. Button Toolbar

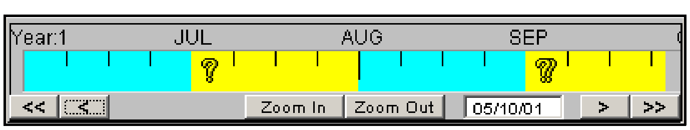


The Button toolbar consists primarily of buttons that provide quick access to some of MCREW's most common functions.

3. File Info

On the left of the icon buttons on the icon toolbar, information regarding the current management rotation file is displayed.

4. Timeline View



The Timeline View displays the sequence of operations (represented as icons) along a date timeline. Timeline View controls are available to manipulate the operation icons to adjust the dates they are associated with. All planned features for the Timeline View are not implemented yet.

5. Table View

Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
05/10/01	Planter - double disk opener:	sorghum, grain, 130 days	0.0
10/15/01	Harvest Small Grain (cutter b		
05/15/02	Wide-sweep plow (60" blade		0.0
06/25/02	Wide-sweep plow (60" blade		0.0
08/20/02	Wide-sweep plow (60" blade		0.0
09/10/02	Drill - double disk openers (8	wheat, winter, hard	0.0
07/10/03	Harvest Small Grain (cutter b		

The Table View displays the sequence of operations with their associated dates and any crops planted in a tabular format. Spreadsheet style editing functions are available to manipulate the order, selection, and removal of operations and/or crops, etc.

Opening and Saving MCREW files

In WEPS 1.0, there are two primary locations that management rotation files exist:

1. In the "Management Templates" directory.
   This is the location that complete or partial (single or multi-crop year) management rotation files are kept. Files in this directory always show up on the management rotation selection choice lists. Typically, management rotation files to be used in WEPS projects are selected from previously built management rotation files or are constructed from several partial management rotation files located in this directory.

2. Within a "WEPS project" directory.
   The management rotation file used in a WEPS run is always located in that WEPS project's directory. There can be more than one management rotation file in a WEPS project. The current management rotation file to be used when making a WEPS run is the one specified in the "weps.run" file (e.g., the one listed in the "management" input field on the WEPS main screen. Usually, management rotation files in a WEPS project are simply copies of those selected from the "Template" directory, but they may have local "project specific" modifications.

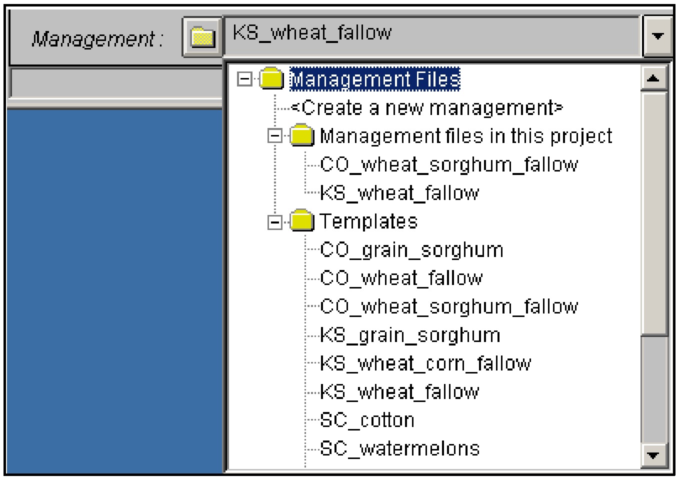


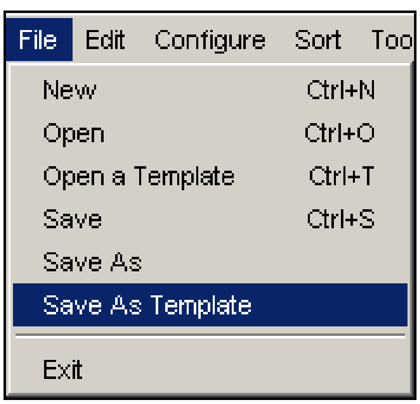
Figure 4.9. Management rotation file choice list.

The user may select a management rotation file from the Management choice list on the WEPS main screen (Fig. 4.9):

If the user makes a selection from the "Templates" node, a copy of the management rotation file will be put into the current project with the same name and become the current rotation for the project. If the user selects a previous management rotation already existing in the project ("Management files in this project" node), that file will become the current rotation for the project. If the user selects "<Create a new management>" from the list, then an empty rotation will exist for the project.

Selecting the "folder" icon opens MCREW to allow any project specific modifications to be made to the current management rotation file.

Once the user is in MCREW, rotation files can be saved in the desired location and/or other rotation files opened for editing. The "File" menu contains all of these options, with the common functions ("New", "Open", and "Save") also being available on the icon button toolbar:



- New
  Opens an empty unnamed rotation file
- Open
  Brings up an "Open File" dialog box from which the user can select the desired rotation file from those in the current project.
- Open a Template
  Brings up an "Open File" dialog box from which the user can select the desired rotation file from the "Management Templates" directory. A copy of the selected file is then added to the current WEPS project and made available for editing in MCREW.

- Save
  Saves the current project's rotation file being edited.

- Save As
  Brings up a "Save File" dialog box from which the user can specify the desired filename to save the rotation file for the current project.

- Save As Template
  Brings up a "Save File" dialog box from which the user can specify the desired filename to save the rotation file into the "Management Templates" directory.

- Exit
  Exits MCREW. If MCREW thinks that the rotation file has been modified and not saved, it will display a popup message and ask the user if they want to save it before leaving.

NOTE: Currently when one "Saves" a management rotation file for the current WEPS project, that file is not physically saved into the current project's directory until the project itself is saved via the WEPS main screen menu "Save" option or automatically prior to initiating a WEPS run. Thus, a remote possibility exists for a "saved" WEPS management rotation file to disappear if the computer crashes prior to "saving" the current project. This will be corrected in a future release.

Editing Within MCREW

A WEPS 1.0 rotation file is simply a date-ordered list of management operations. MCREW provides basic editing functionality to insert, delete, modify, and change dates for those operations. In WEPS, each operation is defined by a list of physical processes, such as residue burial, soil inversion, flattening standing residue, creation of ridges, planting a crop, etc., which are described to the model via one or more parameter values.

In it's most basic form then, one can "see" a WEPS management rotation file within MCREW via the two "views" available: 1) Timeline View and 2) the Table View. Both views show each operation and their associated date. If one selects one or more operations in either view, the other view reflects the same set of selections. For example, Fig. 4.10 shows one operation and Fig. 4.11 shows three operations selected in both the timeline (red boxes around icons) and the table view (reverse highlighted rows). Any function performed on the operation or group of operations in one view are always reflected in the other view.

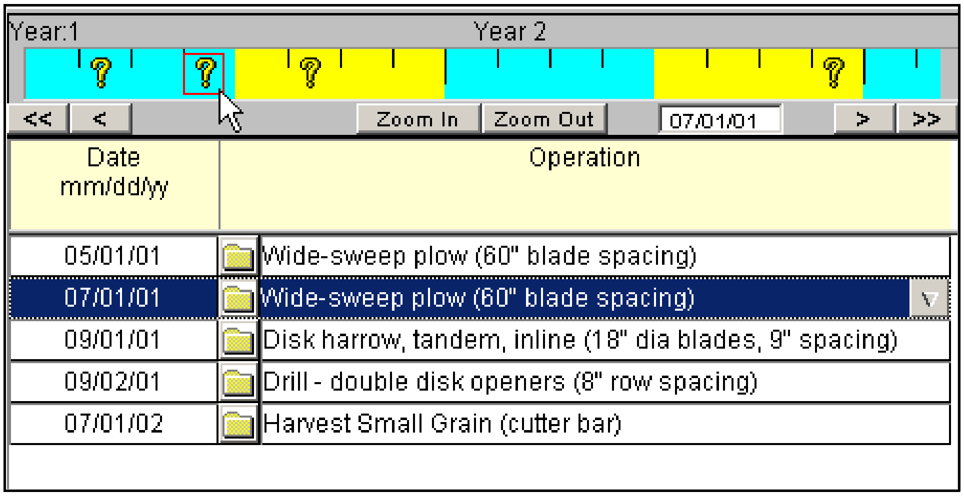


Figure 4.10. Single operation selected via mouse in timeline view with selection automatically displayed simultaneously in table view.

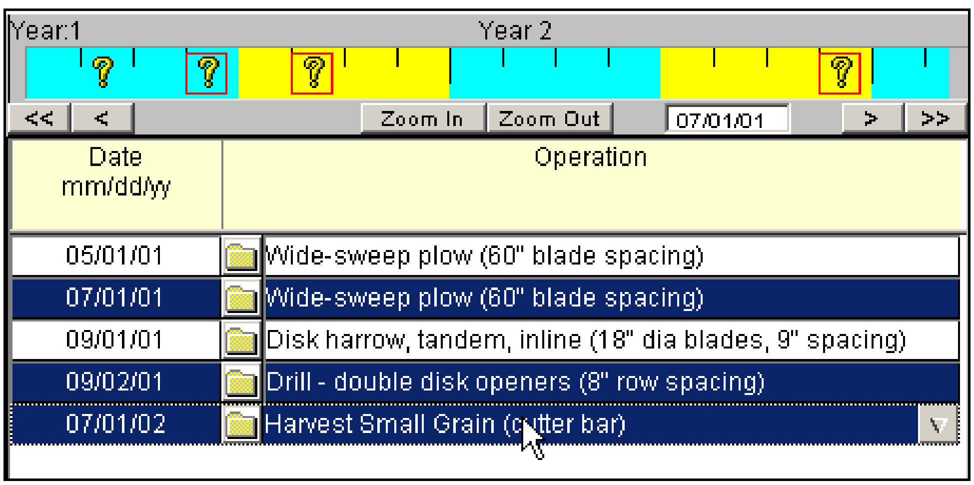


Figure 4.11. Multiple operations selected via mouse in table view with selection automatically displayed simultaneously in timeline view.

The reason there are two views of the management rotation file is that some editing functions are easier to perform in one view than the other. Before one can perform the editing functions, one must be able to first "select" one or more operations (or date in table view) to apply the desired action on them.

“Selecting” and “Editing” via the Timeline View

To select a single operation via the timeline view, one simply presses the left mouse button after placing the cursor over the icon representing the desired operation. A red box will surround the icon when it is “selected”. The date associated with the selected operation will be displayed in the timeline date field (located just to the left of the “Zoom Out” button). The user can then adjust the date of that operation by pressing and holding the left mouse button down and dragging the icon left or right along the timeline. The timeline date field will automatically display the corresponding date for that operation. When the desired operation date is found, release the mouse button.

More than one operation can be selected via the timeline view by depressing the “Control” key simultaneously with the left mouse button when the cursor is placed upon each icon representing the desired operations. Once all the icons have been selected, depress the mouse button over the icon whose operation date you want to view in the timeline date field. All operations will be moved in unison left or right on the timeline until the mouse button is released. This is a convenient way to adjust a planting (or harvesting) date that has several operations performed relative to that date without having to change each of them individually.

“Selecting”and “Editing” via the Table View

To select a single operation via the table view, one simply presses the left mouse button after placing the cursor anywhere within the row representing the desired operation. The row will be highlighted by reversing the background and foreground colors. Additional rows can be selected by two means: 1) depressing the “Control” key simultaneously with the left mouse button when the cursor is placed in each of the desired rows or 2) pressing and holding the left mouse button down and dragging the cursor across all the desired rows.

All the selections made are also reflected in the timeline view and thus can be “edited” via the timeline functionality just mentioned. Also, the operation selections made in the timeline view can also be “edited” via the table view which will now be discussed. The table view currently has much more editing functionality implemented than the timeline view. Eventually, we plan to have all the table view editing functions made available in the timeline view as well (try a right mouse click within the timeline view).

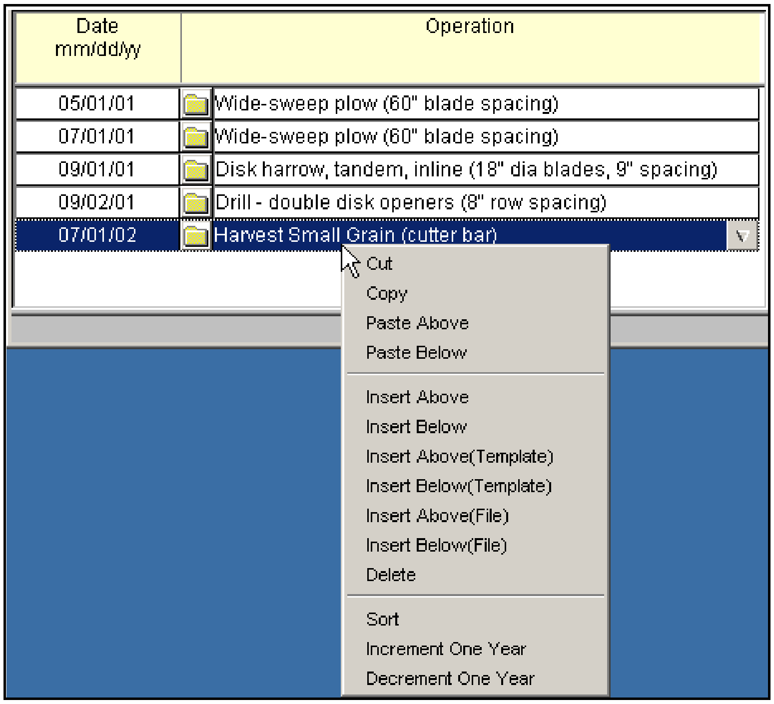


Figure 4.12. Table view drop down editing menu.

The primary editing functions available in the table view are accessible via a right mouse button drop down menu (Fig. 4.12)

The table view editing functions are:

- Cut
  Remove the currently selected operations from the rotation and store them in a temporary buffer for possible pasting back into the rotation later.

- Copy
  Copy the selected operations from the rotation and store in a temporary buffer for possible future pasting back into the rotation.

- Paste Above
  Paste the previously cut or copied operations above the selected operation (or top one if more than one is selected).

- Paste Below
  Paste the previously cut or copied operations below the selected operation (or bottom one if more than one is selected).

The "Cut" and "Copy" buttons on the toolbar can also be used for those operations. The "Paste" button is currently not functioning. (This will be remedied in the future). Ditto for these menu options under the "Edit" menu on the menu toolbar.

- Insert Above

  Insert a blank row above the selected row (or top one if more than one is selected).

- Insert Below

  Insert a blank row above the selected row (or bottom one if more than one is selected).

- Insert Above (Template)

  Selecting this option causes a dialog box to popup and present the user with a list of management operation files (complete or partial rotations), from the "Management Template" directory, for insertion above the selected operation (or top one if more than one is selected).

- Insert Below (Template)

  Selecting this option causes a dialog box to popup and present the user with a list of management operation files (complete or partial rotations), from the "Management Template" directory, for insertion below the selected operation (or bottom one if more than one is selected).

- Insert Above (File)

  Selecting this option causes a dialog box to popup and present the user with a list of management operation files (complete or partial rotations), from the "Current WEPS Project" directory, for insertion above the selected operation (or top one if more than one is selected).

- Insert Below (File)

  Selecting this option causes a dialog box to popup and present the user with a list of management operation files (complete or partial rotations), from the "Current WEPS Project" directory, for insertion below the selected operation (or bottom one if more than one is selected).

- Delete

  Permanently removes the selected operations from the rotation.

- Sort

  Sorts the list of operations based upon the dates associated with them in the table view. This function can also be performed by selecting the appropriately labeled button on the toolbar. MCREW will not allow the user to exit without the rotation file having been sorted by date first.

- Increment One Year

  Bumps the "rotation" year of the selected management operations' dates up one year. This is convenient to adjust partial rotation (single crop year) template files they are being inserted to build a new complete management rotation file.

- Decrement One Year

  Bumps the "rotation" year of the selected management operations' dates down one year.

WEPS Output

Output Summary Screen

The Output Summary screen (Fig. 4.13) for a simulation run will automatically display at the conclusion of a simulation run. If the Output Summary screen has been closed, the user can display the Output Summary screen for the current project or previously run projects by clicking the 'View' button on the WEPS main screen tool bar.

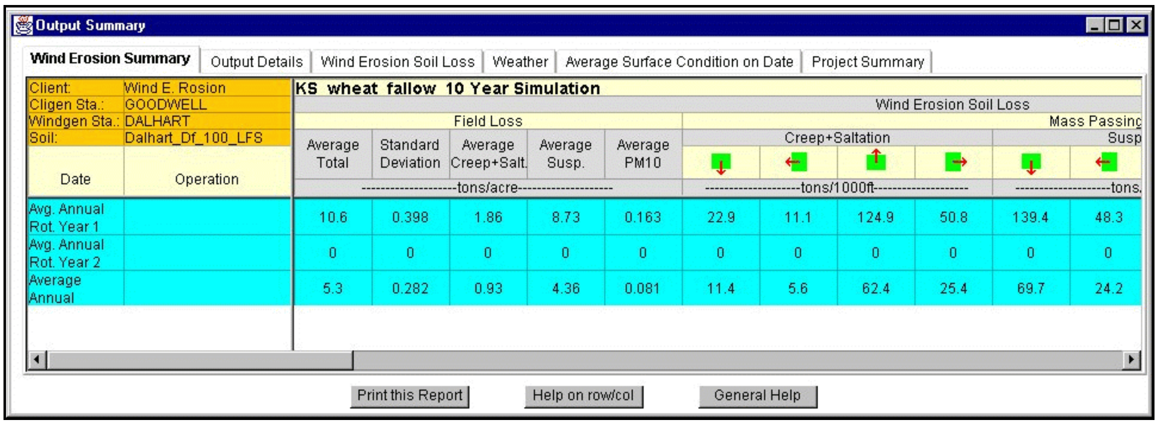


Figure 4.13. The WEPS Output Summary screen.

<u>WEPS Output Tabs</u>

Output screens for WEPS1.0 are arranged in a spreadsheet fashion. Several types of output are available and can be viewed by clicking on the appropriate tab at the top of the 'Output Summary' window. The various tabs are described below. Each tab screen can be printed by clicking the 'Print this Report' button 

at the bottom of each screen. A description of what information is contained in each column and row is obtained by clicking the 'Help on row/col' button at the bottom of each tab screen.

'Wind Erosion Summary' Tab

The Wind Erosion Summary screen displays a simple summary of wind erosion soil loss in terms of average annual losses for each rotation year as well as wind erosion soil loss for the entire simulation run in units of Tons/Acre/Year. These are the same units that was reported for soil loss with the Wind Erosion Equation.

'Output Details' Tab

The Output Details tab (Fig. 4.14) displays a detailed output report with all of the major reporting information available with the current version of WEPS. A description of the information contained in each column and row is given below.

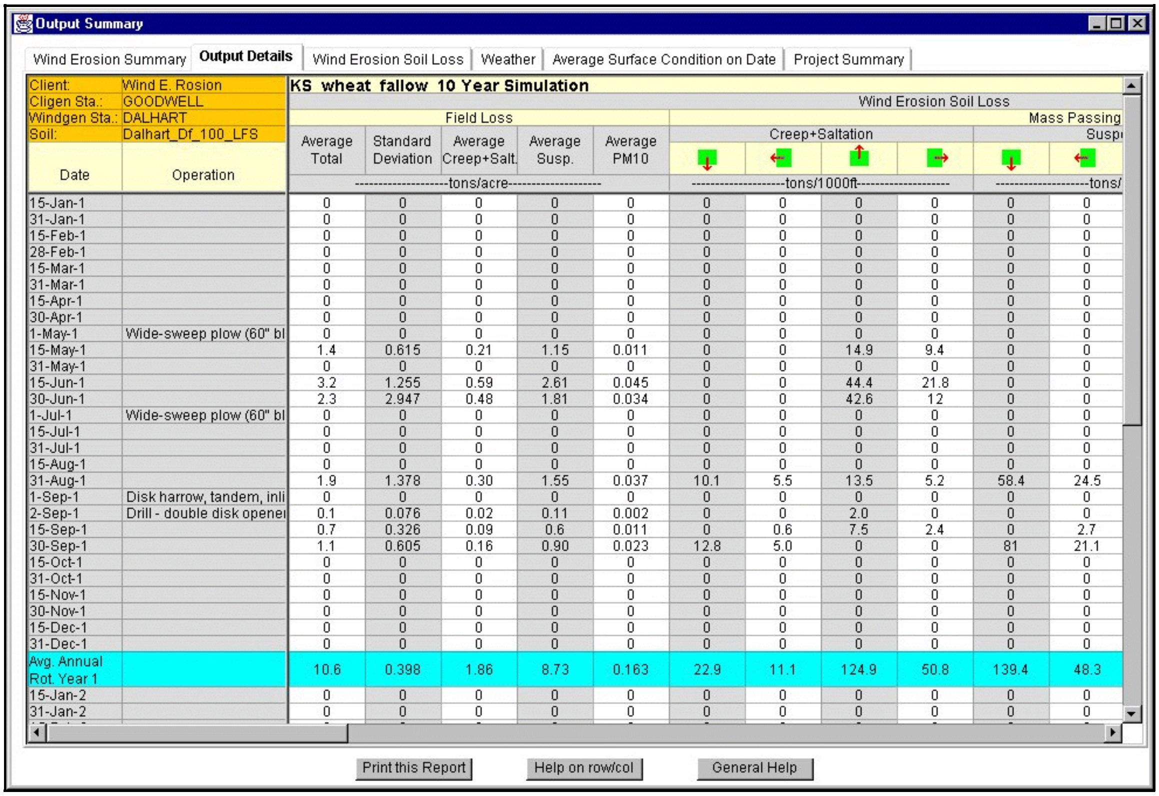


Figure 4.14. The Output Detail tab of the Output Summary screen.

The **columns** of the Output Details Tab have the following information.

Date - This column contains the date (day/month/rotation year) of the last day for which the row information is reported. Items in each row represent values from the end of the previous period to the current date.

Operation - This column contains the management operation which occurred on the specified date.

Field Loss

Average Total - This column contains the total soil loss for the period (see 'Date' column description above), averaged across the field as well as averaged over the number of simulation years in each rotation year (kg/m^2 or tons/acre).

Standard Deviation - This column contains the standard deviation of the values in the average total column (kg/m^2 or tons/acre). {to be removed in future}

Average Creep+Salt. - This column contains the total creep plus saltation loss for the period, averaged across the field grid areas, as well as averaged over the number of simulation years in each year of the crop rotation (kg/m^2 or tons/acre).

Average Susp. - This column contains the total suspension loss for the period, averaged across the field grid areas as well as averaged over the number of simulation years in each rotation year (kg/m^2 or tons/acre).

Average PM10 - This column contains the PM10 soil loss for the period, averaged across the field grid areas as well as averaged over the number of simulation years in each rotation year (kg/m^2 or tons/acre).

Mass passing Field Boundary

Creep+Saltation - These columns □ contain the mass per unit boundary length of creep plus saltation size material which passed the field boundary for each direction (kg/m or tons/1000 ft).

Suspension - These columns □ contain the mass per unit boundary length of suspension size material which passed the field boundary for each direction (kg/m or tons/1000 ft).

PM10 - These columns □ contain the mass per unit boundary length of PM10 size material which passed the field boundary for each direction (kg/m or tons/1000 ft).

Weather

Average Total Precip. - This column contains the total precipitation for the period averaged over the simulation years in each year of the crop rotation (mm or inches).

Average Wind Energy>8 m/s - This column contains the average daily wind energy for the period for winds greater than 8 m/s, averaged over the simulation years in each year of the crop rotation (KJ/day).

Average Surface Conditions on Date

Crop Vegetation (Live)

Canopy Cover - This column contains the fraction of live crop biomass cover (vertical view) at the period end, averaged over the simulation years for the period listed (fraction).

Standing Silhouette - This column contains the standing silhouette area index of live plants expressed on a fraction basis. These values are the standing silhouette area per area of soil surface. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Above Ground Mass - This column contains the total live crop biomass, above ground, at the period end, averaged over the simulation years for the period listed (kg/m^2 or lbs/acre).

Crop Residue (Dead)

Flat Cover - This column contains the amount of flat dead cover on the soil surface, expressed as a fraction. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Standing Silhouette - This column contains the standing silhouette area index of dead plants expressed on a fraction basis. These values are the standing silhouette area per area of soil surface. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Flat Mass - This column contains the amount of flat dead biomass on the soil surface. These are values at the period end averaged over the simulation years in each rotation year (kg/m^2 or lbs/acre).

Standing Mass - This column contains the amount of standing dead biomass on the soil surface. These are values at the period end averaged over the simulation years in each rotation year (kg/m^2 or lbs/acre).

Live and Dead Biomass

Flat Cover - This column contains the amount of flat cover from live (canopy cover) and dead (flat cover) biomass on the soil surface expresses on a fraction basis. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Standing Silhouette - This column contains the standing silhouette area index of live and dead plants expressed on a fraction basis. These values are the standing silhouette area per area of soil surface. These are values at the period end averaged over the simulation years in each rotation year (fraction).

Flat Mass - This column contains the amount of flat live (air dried) and dead biomass on the soil surface. These are values at the period end averaged over the simulation years in each rotation year (kg/m^2 or lbs/acre).

Standing Mass - This column contains the amount of standing live and dead biomass. These are values at the period end averaged over the simulation years in each rotation year (kg/m^2 or lbs/acre).

Roughness

Oriented

Ridge Orientation - This column contains orientation of the ridges with zero degrees (0°) representing north/south ridges.

Ridge Height - This column contains the height of ridges. This is the value at the period end averaged over the simulation years in each rotation year (mm or inches).

Ridge Spacing - This column contains the spacing between ridges. This is the value at the period end averaged over the simulation years in each rotation year (mm or inches).

Random

Roughness - This column contains the standard deviation of the soil surface random roughness. This is the value at the period end averaged over the simulation years in each rotation year (mm or inches).

The **rows** in the Output Details Tab vary depending on the number of cropping years in the rotation and the number of management operations in each year of the rotation.

Each year of the rotation has output displayed for the fifteenth and the last day of each month as well as for each management operation date. This output allows the user to view the erosion and other output for each year of the rotation. At the end of each year in the rotation is a row which contains the average annual value for that rotation year.

The last row in the output form contains the average annual values for the complete crop rotation.

‘Wind Erosion Soil Loss’ Tab

The Wind Erosion Soil Loss screen provides a summary of all the wind erosion soil loss output for the simulation run. Note that this tab screen is actually a subset of the ‘Output Details’ tab screen.

‘Weather’ Tab

The Weather screen provides a summary of some of the weather information for the simulation run. Note that this tab screen is actually a subset of the ‘Output Details’ tab screen.

‘Average Surface Conditions on Date’ Tab
The Average Surface Conditions on Date screen provides a summary of average surface conditions including crop biomass and soil roughness for the simulation run. Note that this tab screen is actually a subset of the ‘Output Details’ tab screen.

‘Project Summary’ Tab
The Project Summary screen provides a summary of the project information for a simulation run. There is also a section for user comments. This tab screen may be useful as a cover sheet for a wind erosion simulation report.

USING WEPS IN CONSERVATION PLANNING

Interpreting Outputs

Interpreting outputs of WEPS is an important part of controlling wind erosion through conservation planning. By observing how the soil loss is affected by weather and field conditions, the management operations can be adjusted to reduce soil loss. In developing new conservation plans, the user should build or modify several different scenarios and compare outputs to determine the best management to control wind erosion. Because of runtime issues, it is recommended that, for early comparisons, no more than five rotations cycles be used for a simulation. This will allow relative soil loss values for comparisons. Once one or two scenarios are selected, 20-30 rotation cycles are recommended for more accurate erosion loss estimates. The number of erosion cycles can be set by selecting "Configuration" then "WEPS Developers Options" menus on the main screen.

Date

This column contains the date of the last day for which the row information is reported (day/month/rotation year). Items in each row represent values from the end of the previous period to the current date. The date column, along with soil loss, will indicate which periods have the greatest wind erosion and are thus in need of changes of management to control wind erosion.

The **rows** in the Output Details Tab vary depending on the number of cropping years in the rotation and the number of management operations in each year of the rotation. Each year of the rotation has output displayed for the fifteenth and the last day of each month as well as for each management operation date. This output allows the user to view the erosion and other output for each year of the rotation. At the end of each year in the rotation is a row which contains the average annual value for that rotation year. The last row in the output form contains the average annual values for the complete crop rotation.

Operation

This column contains the management operation which occurred on the specified date. It is the management operation or the date of operation which most users will modify to affect field conditions and thus wind erosion.

Wind Erosion Soil Loss

The Wind Erosion Soil Loss columns provide a summary of all the wind erosion soil loss for the simulation run. The numbers in these columns are those that the user will try to affect by adjusting management dates and operations.

<u>Field Loss</u>

These columns contain the total loss of each size class for the period, averaged across the field grid areas, as well as averaged over the number of simulation years in each year of the crop rotation (kg/m^2 or tons/acre). {add creep+salt/suspension ratio discussion here}

Mass Passing Field Boundary

These columns ☐ contain the mass per unit length of various sized material which passed the field boundary for each direction (kg/m or tons/1000 ft). This information is useful in determining how much material is leaving the field in each direction. For the creep/saltation size, the material will most likely be deposited on the field boundary such as a stream, fence, ditch, or road. If deposited in a ditch, subsequent rainfall way wash the material in to waterways where it can affect water quality. If deposited on a roadway, the roadway will likely need to be cleared. For suspension and PM10 sizes, the material may travel great distances affecting air quality. The material passing each boundary may indicate that barriers may be needed on the opposite or upwind side of the field to control wind erosion. The direction of soil loss may also indicate a needed change in direction of tillage.

Weather

The Weather columns provide a summary of some of the weather information for the simulation run.

Average Total Precip.

This column contains the total precipitation for the period averaged over the simulation years in each year of the crop rotation (mm or inches). This section is useful in determining how precipitation amounts may be affecting biomass production and roughness decay.

Average Wind Energy > 8m/s

This column contains the average daily wind energy for the period for winds greater than 8 m/s, averaged over the simulation years in each year of the crop rotation (KJ/day). This will indicate which periods have the most erosive winds.

Average Surface Conditions on Date

The Average Surface Conditions on Date columns provide a summary of average surface conditions including crop biomass and soil roughness for the simulation run.

Crop Vegetation (Live)

These columns provide information on the structural configuration of live growing biomass. By observing the canopy cover, the standing silhouette area index, and the above ground mass, the user can determine which periods are not providing sufficient cover to control wind erosion.

Crop Residue (Dead)

These columns provide information on the structural configuration of dead biomass or residue. By observing the flat cover, the standing silhouette area index, the flat mass, and the standing mass, the user can determine which periods are not providing sufficient residue cover to control wind erosion.

Live and Dead Biomass

These columns provide information on the structural configuration of both the live growing biomass and the dead biomass or residue. By observing the flat cover, the standing silhouette area index, the flat mass, and the standing mass, the user can determine which periods are not providing sufficient cover to control wind erosion.

Roughness

For cropping systems that do not produce sufficient residue for erosion control (e.g., cotton), roughness management is often used to reduce wind friction velocity at the soil surface. This reduces the amount of soil detachment and transport and increases deposition and thus soil loss.

Oriented

These columns refer to regularly spaced roughness elements caused by tillage implements such as ridges, furrows and dikes. Ridge orientation, width, and height may be adjusted for periods of high soil loss to determine its effect on wind erosion. The user can also follow the roughness decay over time as result of rainfall.

Random Roughness

This column contains the standard deviation of the soil surface random roughness. This is the value at the period end, averaged over the simulation years in each rotation year (inches or mm). Random roughness is primarily the result of aggregate size distribution but is also affected by various types of tillage tools. Random roughness values for typical management operations are listed in Table 5.1. Photographs (Figs. 5.1 - 5.9) can be used as a guide to determine relative random roughness values.

Table 5.1. Random roughness values for typical management operations based on a silt loam soil (Ag. Handbook 537).

Field Operation	Random Roughness (inches)	Field Operation	Random Roughness (inches)
Chisel, sweeps	1.2	Fertilizer applicator, anhydrous knife	0.6
Chisel, straight point	1.5	Harrow, spike	0.4
Chisel, twisted shovels	1.9	Harrow, tine	0.4
Cultivator, field	0.7	Lister	0.8
Cultivator, row	0.7	Manure injector	1.5
Cultivator, ridge till	0.7	Moldboard plow	1.9
Disk, 1-way	1.2	Mulch threader	0.4
Disk, heavy plowing	1.9	Planter, no-till	0.4
Disk, Tandem	0.8	Planter, row	0.4
Drill, double disk	0.4	Rodweeder	0.4
Drill, deep furrow	0.5	Rotary hoe	0.4
Drill, no-till	0.4	Vee ripper	1.2
Drill, no-till into sod	0.3		

Figure 5.1. Random roughness of 0.25 inches (6 mm).

Figure 5.2. Random roughness of 0.40 inches (10 mm).

Figure 5.3. Random roughness of 0.65 inches (17 mm).

Figure 5.4. Random roughness of 0.75 inches (19 mm).

Figure 5.5. Random roughness of 0.85 inches (22 mm).

Figure 5.6. Random roughness of 1.05 inches (27 mm).

Figure 5.7. Random roughness of 1.60 inches (41 mm).

Figure 5.8. Random roughness of 1.70 inches (43 mm).

Figure 5.9. Random roughness of 2.15 inches (55 mm).

Special Field Configurations

Although WEPS 1.0 is designed to simulate rectangular field shapes, special field configurations such as circles or strip cropping can be simulated. By manipulating the field shape to represent a field with the same area and rotating the field along with any barriers many field shapes can be approximated.

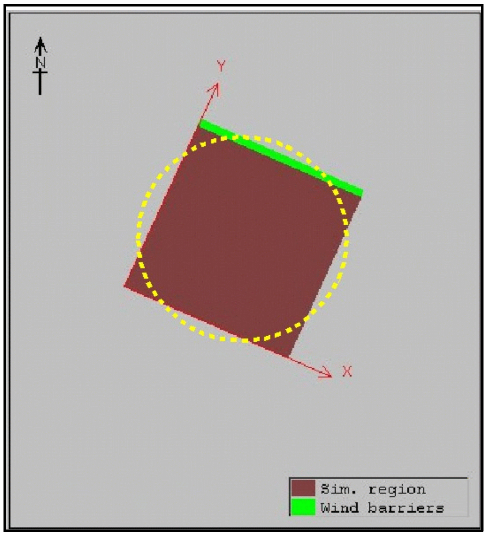


Figure 5.10. Example of using a square field shape to approximate a circle.

A circular field can be simulated using a square field of equal area. Figure 5.10 illustrates how this would be visualized. Note that the yellow dashed circle is shown here to illustrate the circular field and cannot be placed over the field within the WEPS 1.0 interface. For such fields, barriers should be added and the field rotated to best simulate the actual field configuration.

Other field shapes can also be simulated with WEPS 1.0. A half circle can be represented with a rectangle as illustrated in Figure 5.11. Figure 5.12 illustrates how an irregular field may be visualized for a filed along a stream with filter strips along the North and East sides.

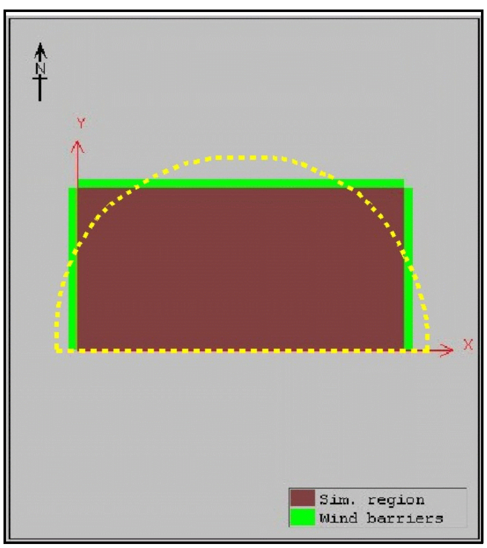


Figure 5.11. Example of using a rectangular field to simulate a half circle.

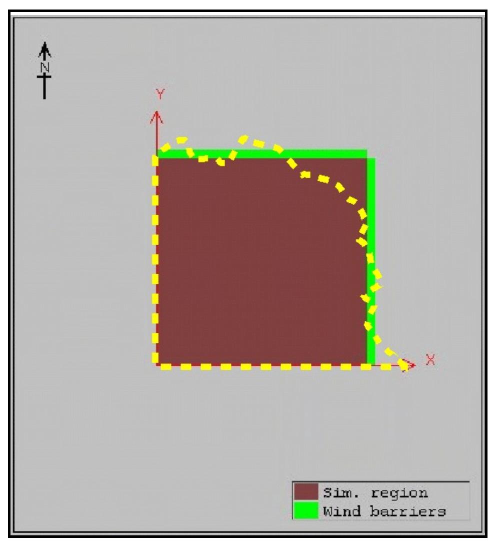


Figure 5.12. Example of using a square field to simulate a field with a stream with buffers along two sides.

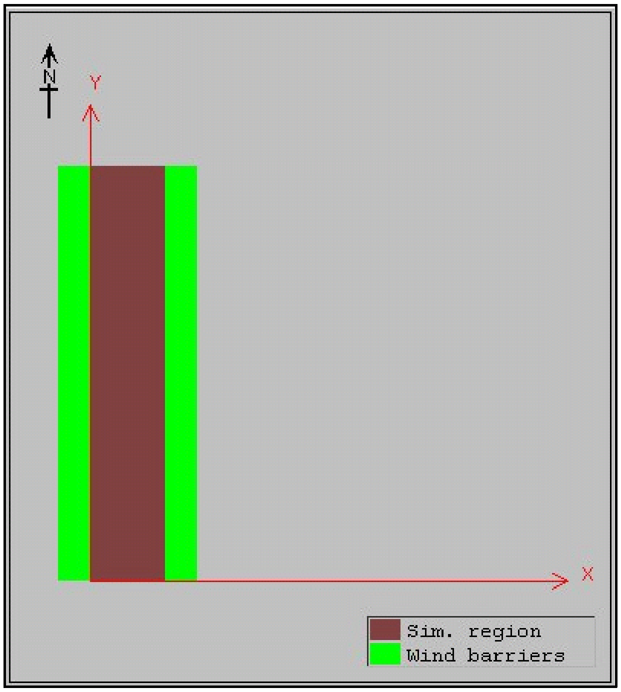


Figure 5.13. Example field layout for simulating strip cropping or grass barriers.

Fields managed for wind erosion control by strip cropping (non-contour, linear) are simulated with each strip of unique management as an individual rectangular field and the erosion losses for each strip summed. For fields managed with grass strips, the fields are simulated as individual strips with the appropriate barriers on either side. The erosion loss from one section of the field is then multiplied by the number of strips to obtain the soil loss for the entire field. Figure 5.13 illustrates a field layout for simulating strip cropping or grass barriers.

WEPS 1.0 only allows tillage in one direction (e.g., Northwest/Southeast). In other words, multiple tillage directions such as where the operator tills parallel to each border of the field, cannot be simulated with WEPS 1.0. Observing the effects tillage direction may have for the particular simulation may illustrate the need to alter tillage directions in the actual field to control wind erosion.

Using Barriers for Erosion Control in WEPS

Barriers have the effect of reducing field width by reducing wind velocity and abrasion of the downwind immobile clods, crusts, and residues along the prevailing wind erosion direction. Wind barriers of perennial or annual plants are often used for wind erosion control.

Perennial barriers are put in place for erosion control every year. They provide protection the entire year, even in the dry years that crop residues are absent, when soil aggregation is limited (no clods), or when ridges created by tillage implements are fragile become ineffective in severe wind storms. Annual barriers are used primarily to provide temporary protection during the most critical wind erosion period and can be removed and replaced every year. Artificial barriers such as snow fencing, board walls, bamboo and willow fences, earthen banks, hand-inserted straw rows and rock walls have been used for wind erosion control, but only on a very limited basis. There is usually a very high cost in material and labor to construct these barriers and their use is generally restricted to high-value crops. They can also be used in sand dune areas to aid the initial stabilization of the areas while grass and trees are being established.

Using WEPS, we can quickly determine the field edge where the greatest amount of eroded soil is leaving the field. In most cases, a field windbreak would be most effective on the upwind side of this field. Ideally, a tract of land where windbreaks are installed will be equally stripped, thus shorting the width of the field along the most erosive winds. So, along with estimating erosion with a windbreak, we will also be resizing the field.

The field will be resized down to the strip width that a producer agrees with or to other widths for demonstration purposes. We can change the field size by just typing in the field dimensions or by clicking on the resize button and then dragging the ‘Handles’ on the X and Y dimensions of the field. See the section “Describing the Field and Barriers” (Chapter 5) for more details on adding and modifying field barriers.

EVALUATING WIND EROSION PROBLEMS WITH WEPS

This is an example problem that we will use to evaluate a wind erosion problem in the Stevens Point area of central Wisconsin.

The scenario for the problem is:

- The farm is located near Stevens Point, WI in Portage County.
- The Cligen Station is Stevens Point and the Windgen Station is Wausau.
- The Soil Map Unit used in the evaluation is MfB-Mecan-100-LS.
- The original two year Cropping system is Spring Peas and Snap Beans (green).
- The field size is 2640' X2640', 160 acres.
- The WEPS evaluation of the cropping system will be run for 20 rotation cycles.

Below (Fig. 5.14) is the two year rotation of Spring Peas and Snap Beans (green) including the dates and field operations. Following evaluation of the erosion rates on the two year rotation, it has been decided to set up a three year rotation to include early potatoes.

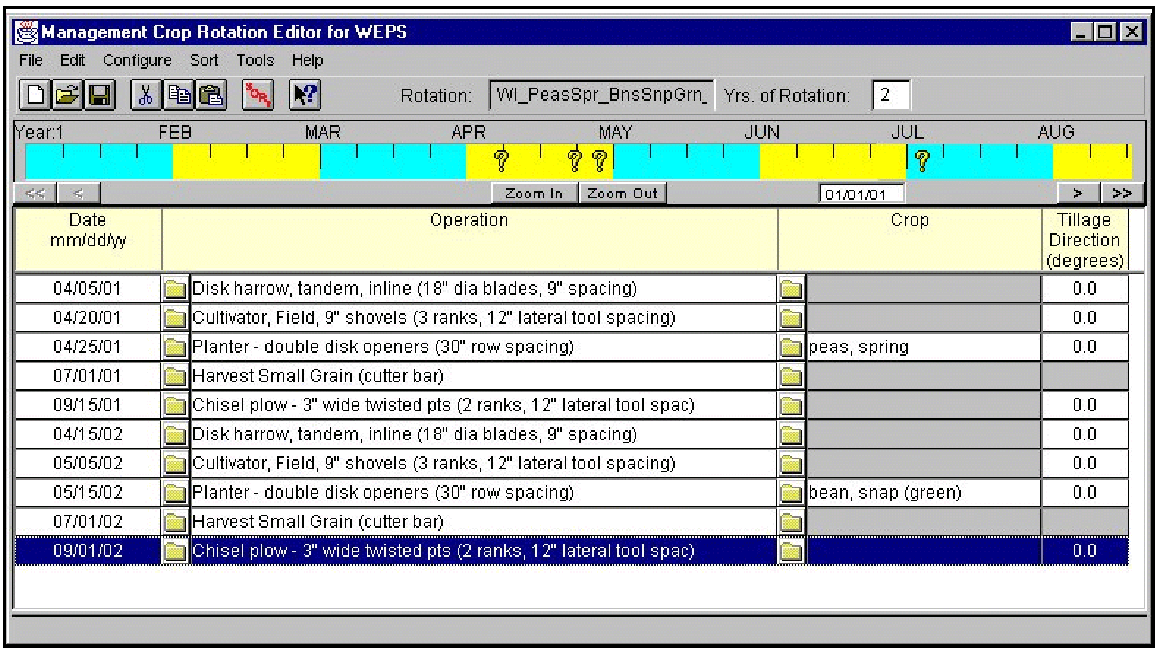
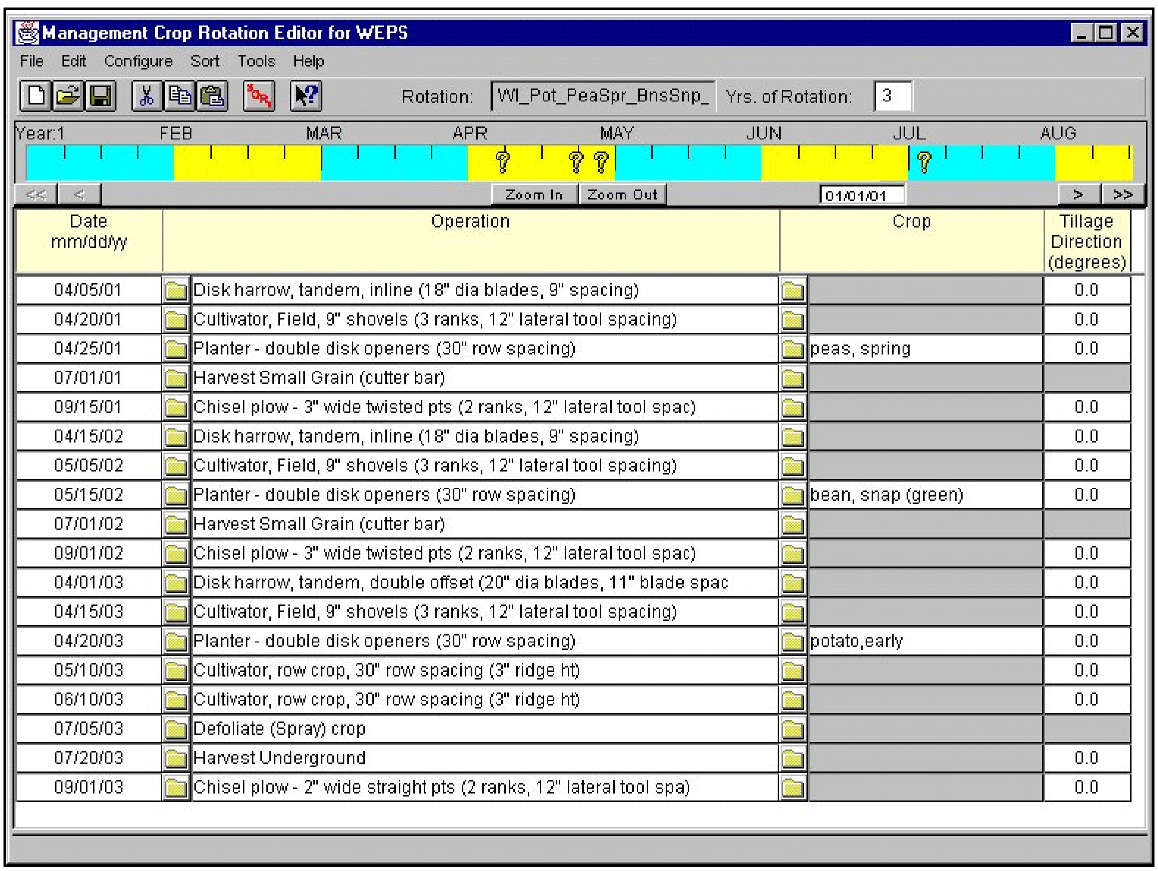


Figure 5.14. A two year rotation of spring peas and snap beans (green).

When we expand the two year rotation to include Early Potatoes, we can add the operations, dates of operation, and the potato crop directly to the two year rotation or we can build a separate template for Early Potatoes and then insert the new template in the rotation. We recommend the option of building a separate template for Early Potatoes and then inserting it into the existing rotation. The new single year template for Early Potatoes begins when in MCREW by clicking on “File”, then click on “New” and this will drop a clean MCREW screen down. With the clean MCREW screen we enter dates and operations as instructed in the earlier section on MCREW (Chapter 4). The single year cropping scenario for early Potatoes should be saved as a template. We will save it by clicking on “file” and then “save as a template”. The list of management files will drop down and we will go to the window on the bottom of the list called “File name”, remove the * and then type in the name single crop scenario we are saving. To finalize we click “Save” on the bottom right of the window. We now have a new single year template and will add it to our two year rotation.

Below (Fig. 5.15) is the three year rotation of Early Potatoes, Spring Peas, and Snap Beans (green) including the dates and field operations. Following evaluation of the erosion rates on the three year rotation, it has been decided to set up a four year rotation to include Sweet Corn.

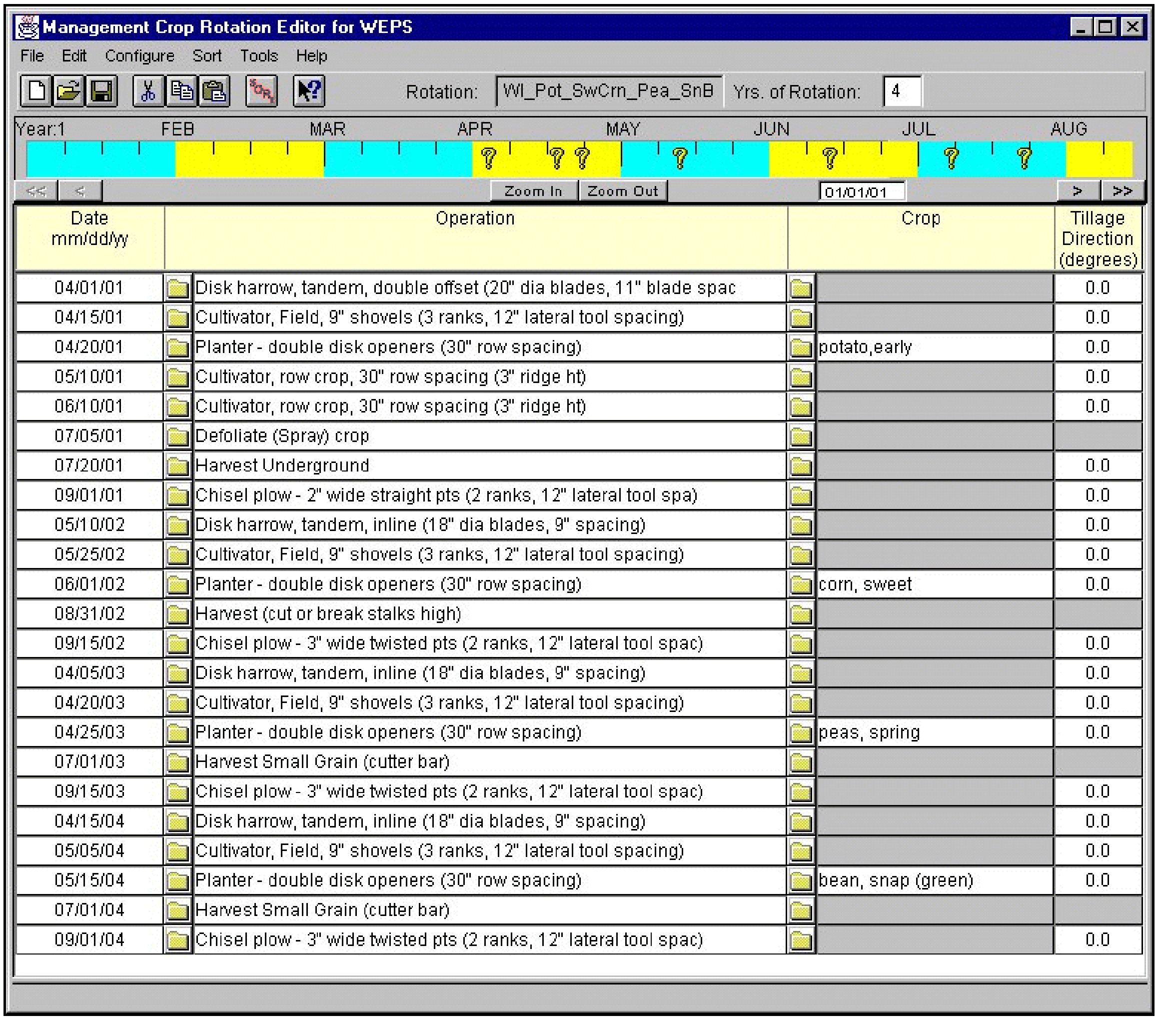


Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
04/05/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
04/20/01	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
04/25/01	Planter - double disk openers (30" row spacing)	peas, spring	0.0
07/01/01	Harvest Small Grain (cutter bar)		
09/15/01	Chisel plow - 3" wide twisted pts (2 ranks, 12" lateral tool spac)		0.0
04/15/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
05/05/02	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
05/15/02	Planter - double disk openers (30" row spacing)	bean, snap (green)	0.0
07/01/02	Harvest Small Grain (cutter bar)		
09/01/02	Chisel plow - 3" wide twisted pts (2 ranks, 12" lateral tool spac)		0.0
04/01/03	Disk harrow, tandem, double offset (20" dia blades, 11" blade spac		0.0
04/15/03	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
04/20/03	Planter - double disk openers (30" row spacing)	potato,early	0.0
05/10/03	Cultivator, row crop, 30" row spacing (3" ridge ht)		0.0
06/10/03	Cultivator, row crop, 30" row spacing (3" ridge ht)		0.0
07/05/03	Defoliate (Spray) crop		
07/20/03	Harvest Underground		0.0
09/01/03	Chisel plow - 2" wide straight pts (2 ranks, 12" lateral tool spa)		0.0

Figure 5.15. A three year rotation of early potatoes, spring peas, and snap beans (green).

When we expand the three year rotation to include Sweet Corn, we again, can add the operations, dates of operation, and the Sweet Corn crop directly to the three year rotation or we can build a separate template for Sweet Corn and insert the new template into the rotation. We again recommend the option of building a separate template for Sweet Corn and insert it into the existing rotation. Follow the same instruction used above for Early Potatoes to add Sweet Corn.

Below (Fig. 5.16) is the four year rotation of Early Potatoes, Sweet Corn, Spring Peas, and Snap Beans (green) including the dates and field operations. Following evaluation of the erosion rates on the four year rotation, it has been found acceptable.



Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
04/01/01	Disk harrow, tandem, double offset (20" dia blades, 11" blade spac		0.0
04/15/01	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
04/20/01	Planter - double disk openers (30" row spacing)	potato,early	0.0
05/10/01	Cultivator, row crop, 30" row spacing (3" ridge ht)		0.0
06/10/01	Cultivator, row crop, 30" row spacing (3" ridge ht)		0.0
07/05/01	Defoliate (Spray) crop		
07/20/01	Harvest Underground		0.0
09/01/01	Chisel plow - 2" wide straight pts (2 ranks, 12" lateral tool spa)		0.0
05/10/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
05/25/02	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
06/01/02	Planter - double disk openers (30" row spacing)	corn, sweet	0.0
08/31/02	Harvest (cut or break stalks high)		
09/15/02	Chisel plow - 3" wide twisted pts (2 ranks, 12" lateral tool spac)		0.0
04/05/03	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
04/20/03	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
04/25/03	Planter - double disk openers (30" row spacing)	peas, spring	0.0
07/01/03	Harvest Small Grain (cutter bar)		
09/15/03	Chisel plow - 3" wide twisted pts (2 ranks, 12" lateral tool spac)		0.0
04/15/04	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
05/05/04	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
05/15/04	Planter - double disk openers (30" row spacing)	bean, snap (green)	0.0
07/01/04	Harvest Small Grain (cutter bar)		
09/01/04	Chisel plow - 3" wide twisted pts (2 ranks, 12" lateral tool spac)		0.0

Figure 5.16. A four year rotation of early potatoes, sweet corn, spring peas, and snap beans (green).

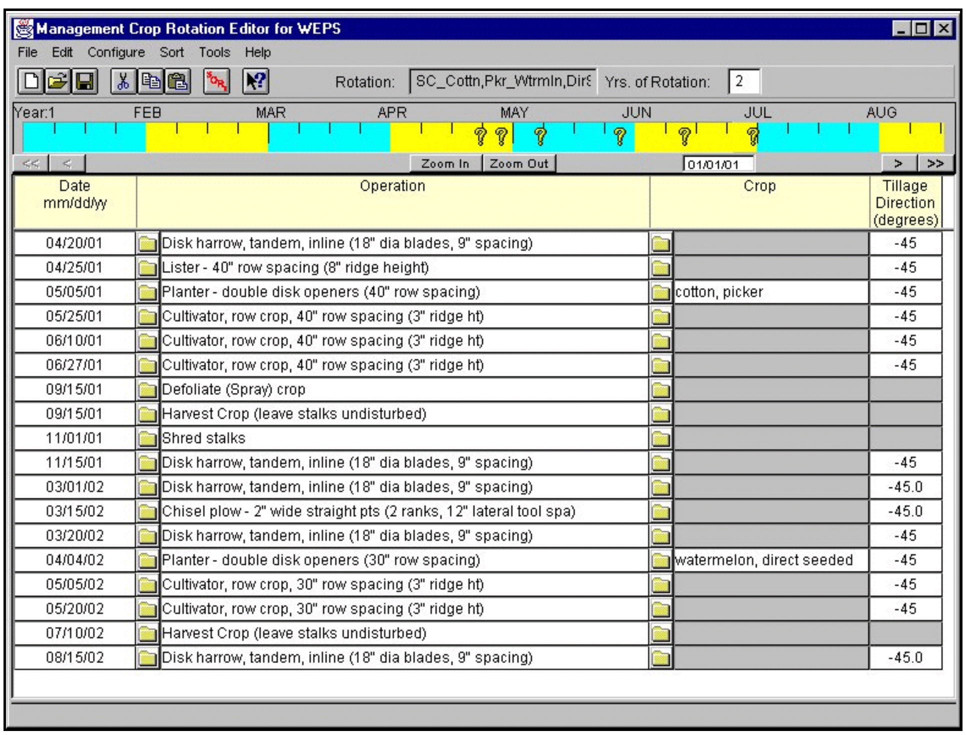
EVALUATING WIND EROSION PROBLEMS WITH WEPS

Following are some example problems that we will use to evaluate some wind erosion problems in Marlboro and Charleston Counties, South Carolina.

<u>Situation 1</u> -2 year rotation developing into a 4 year rotation

- The scenario for the problem is:
- The farm is located in **Marlboro County, SC**
- The **Cligen station is McColl** and the **Windgen station is Eastover**
- The **Soil Map Unit** used in the evaluation is**: NoA - Norfolk LS**
- The original 2 year cropping system is **Cotton and Watermelons**
- The field size is: **x axis - 3500 ft.; y axis - 2000 ft.**
- Orientation of field operations and rows is **-45 degrees**
- Operations are performed parallel to x axis
- The early WEPS evaluations will be run for **5 rotation cycles**
- **Barriers** - Woods along the NW and NE field borders (trees w/leaves 4 rows)

Below is a 2 year rotation of **upland cotton** and **watermelons**, including the dates and field operations (Fig. 5.17).



Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
04/20/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
04/25/01	Lister - 40" row spacing (8" ridge height)		-45
05/05/01	Planter - double disk openers (40" row spacing)	cotton, picker	-45
05/25/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		-45
06/10/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		-45
06/27/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		-45
09/15/01	Defoliate (Spray) crop		
09/15/01	Harvest Crop (leave stalks undisturbed)		
11/01/01	Shred stalks		
11/15/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
03/01/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45.0
03/15/02	Chisel plow - 2" wide straight pts (2 ranks, 12" lateral tool spa)		-45.0
03/20/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
04/04/02	Planter - double disk openers (30" row spacing)	watermelon, direct seeded	-45
05/05/02	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
05/20/02	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
07/10/02	Harvest Crop (leave stalks undisturbed)		
08/15/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45.0

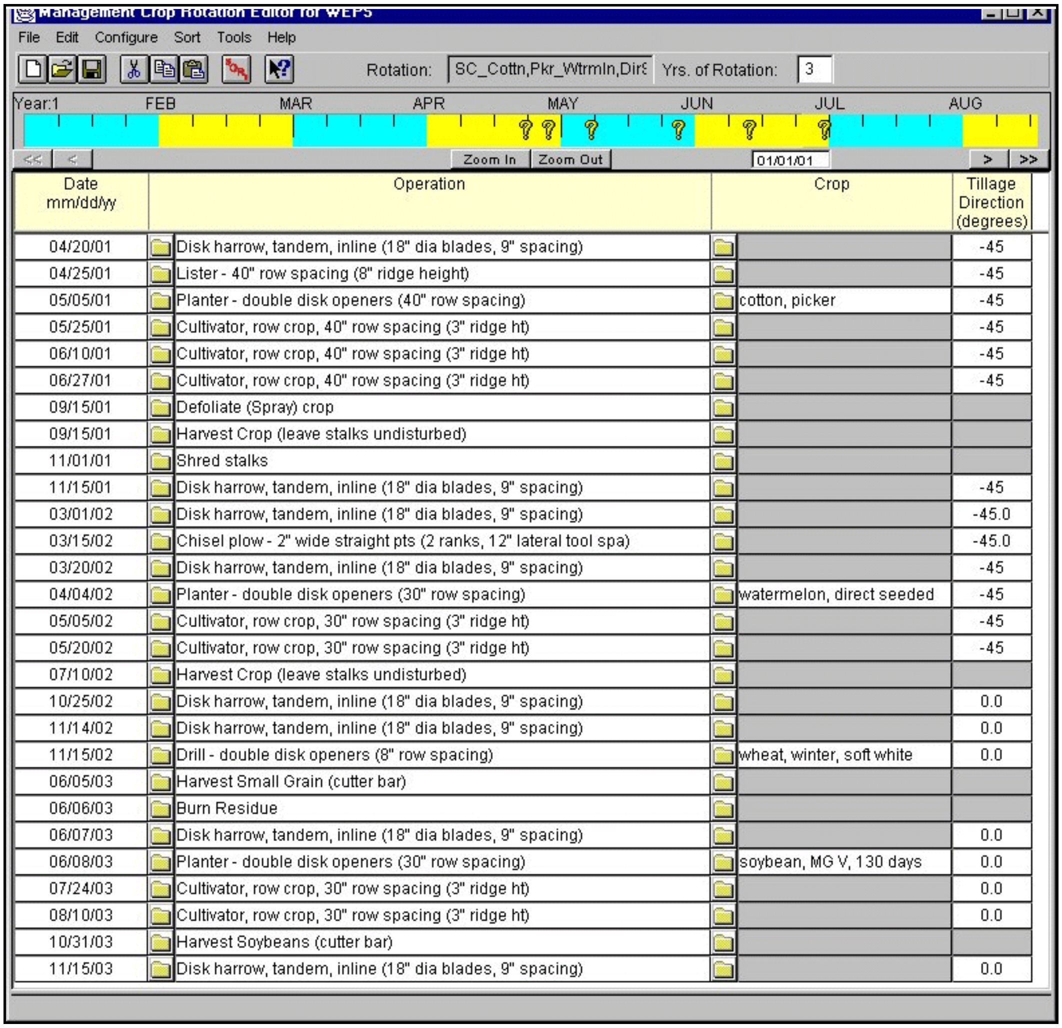
Figure 5.17. A two year rotation of upland cotton and watermelons.

***Cotton, picker** (700 lbs. lint yield)
04/10/01 Tandem disk, 18" diameter blades)
04/20/01 Tandem disk, 18" diameter blades)
04/25/01 Lister - 40" row spacing (8" ridge height)
05/05/01 Planter double disk opener (40" row spacing) – **Cotton, picker**
05/25/01 Row crop Cultivator (40" inch rows)
06/10/01 Row crop Cultivator (40" inch rows)
06/27/01 Row crop Cultivator (40" inch rows)
09/15/01 Defoliate
10/01/01 Harvest crop (leave stalks undisturbed)
11/01/01 Shred stalks

* **Watermelons**
03/01/02 Tandem disk, 18" diameter blades)
03/15/02 Chisel plow - 2" wide straight pts.
03/20/02 Tandem disk, 18" diameter blades)
04/04/02 Planter - double disk opener (48" rows) - **Watermelons**
05/05/02 Row crop Cultivator (48" inch rows)
05/20/02 Row crop Cultivator (48" inch rows)
07/10/02 Harvest crop

When we expand the 2 year rotation to include Corn, 130 day, we can add the operations, dates of operation, and the 130 day Corn crop directly to the 2 year rotation or we can build a separate template for Corn, 130 day. The new template can then be inserted into the rotation. We recommend the option of building the separate template for 130 day Corn and the template will then be available the next time you are building a rotation that includes that crop.

Below is the 3 year rotation of Cotton, picker; Watermelons; and 130 day Corn, including the field operations and the dates they were performed (Fig. 5.18).



Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
04/20/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
04/25/01	Lister - 40" row spacing (8" ridge height)		-45
05/05/01	Planter - double disk openers (40" row spacing)	cotton, picker	-45
05/25/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		-45
06/10/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		-45
06/27/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		-45
09/15/01	Defoliate (Spray) crop		
09/15/01	Harvest Crop (leave stalks undisturbed)		
11/01/01	Shred stalks		
11/15/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
03/01/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45.0
03/15/02	Chisel plow - 2" wide straight pts (2 ranks, 12" lateral tool spa)		-45.0
03/20/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
04/04/02	Planter - double disk openers (30" row spacing)	watermelon, direct seeded	-45
05/05/02	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
05/20/02	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
07/10/02	Harvest Crop (leave stalks undisturbed)		
10/25/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
11/14/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
11/15/02	Drill - double disk openers (8" row spacing)	wheat, winter, soft white	0.0
06/05/03	Harvest Small Grain (cutter bar)		
06/06/03	Burn Residue		
06/07/03	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
06/08/03	Planter - double disk openers (30" row spacing)	soybean, MG V, 130 days	0.0
07/24/03	Cultivator, row crop, 30" row spacing (3" ridge ht)		0.0
08/10/03	Cultivator, row crop, 30" row spacing (3" ridge ht)		0.0
10/31/03	Harvest Soybeans (cutter bar)		
11/15/03	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0

Figure 5.18. A three year rotation of picker cotton, watermelons, and 130 day corn.

***Cotton, picker (700 lbs. lint yield)**
04/10/01 Tandem disk, 18" diameter blades)
04/20/01 Tandem disk, 18" diameter blades)
04/25/01 Lister - 40" row spacing (8" ridge height)
05/05/01 Planter double disk opener (40" row spacing) – **Cotton, picker**
05/25/01 Row crop Cultivator (40" inch rows)
06/10/01 Row crop Cultivator (40" inch rows)
06/27/01 Row crop Cultivator (40" inch rows)

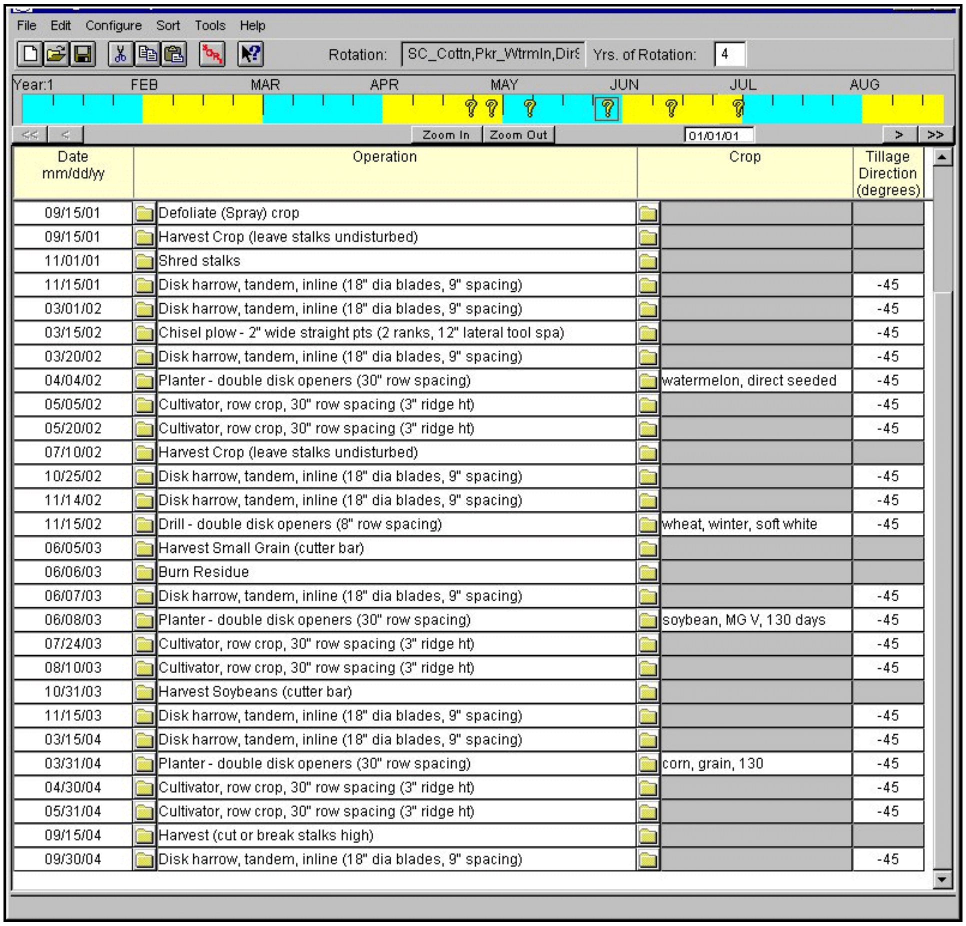
09/15/01 Defoliate
10/01/01 Harvest crop (leave stalks undisturbed)
11/01/01 shred stalks
11/15/01 Tandem disk, 18" diameter blades)

***Watermelons**
03/15/02 Chisel plow - 2" wide straight pts.
03/20/02 Tandem disk, 18" diameter blades)
04/04/02 Planter - double disk opener (48" rows) - **Watermelons**
05/05/02 Row crop Cultivator (48" inch rows)
05/20/02 Row crop Cultivator (48" inch rows)
07/10/02 Harvest crop
08/01/02 Tandem disk, 18" diameter blades)

***Wheat, winter, soft white**
10/15/02 Tandem disk, 18" diameter blades)
11/14/02 Tandem Disk 18" diameter blades)
11/15/02 Drill - double disk openers (8" rows)
06/05/03 Harvest small grain (cutter bar) – **Wheat, winter, soft white**
06/06/03 Burn residue (approximately 800 lbs of residue/acre left on surface)

***Soybeans**
06/07/03 Tandem disk, 18" blades
06/08/03 Plant, double disk openers - 30" rows - **Soybeans**
07/24/03 Row crop Cultivator (30" rows)
08/10/03 Row crop Cultivator (30" rows)
10/31/03 Harvest Soybeans, (cutter bar)
11/20/03 Tandem disk, 18" blades

Below is the 4 year rotation of picker cotton, watermelons, wheat-soybeans (double cropped); and corn, 130 day; including the field operations and the dates they were performed (Fig. 5.19).



Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
09/15/01	Defoliate (Spray) crop		
09/15/01	Harvest Crop (leave stalks undisturbed)		
11/01/01	Shred stalks		
11/15/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
03/01/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
03/15/02	Chisel plow - 2" wide straight pts (2 ranks, 12" lateral tool spa)		-45
03/20/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
04/04/02	Planter - double disk openers (30" row spacing)	watermelon, direct seeded	-45
05/05/02	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
05/20/02	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
07/10/02	Harvest Crop (leave stalks undisturbed)		
10/25/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
11/14/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
11/15/02	Drill - double disk openers (8" row spacing)	wheat, winter, soft white	-45
06/05/03	Harvest Small Grain (cutter bar)		
06/06/03	Burn Residue		
06/07/03	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
06/08/03	Planter - double disk openers (30" row spacing)	soybean, MG V, 130 days	-45
07/24/03	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
08/10/03	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
10/31/03	Harvest Soybeans (cutter bar)		
11/15/03	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
03/15/04	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
03/31/04	Planter - double disk openers (30" row spacing)	corn, grain, 130	-45
04/30/04	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
05/31/04	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
09/15/04	Harvest (cut or break stalks high)		
09/30/04	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45

Figure 5.19. A four year rotation of picker cotton, watermelons, wheat-soybeans (double cropped), and corn, 130 day.

***Cotton, picker(700 lbs. lint yield)**
04/10/01 Tandem disk, 18" diameter blades)
04/20/01 Tandem disk, 18" diameter blades)
04/25/01 Lister - 40" row spacing (8" ridge height)
05/05/01 Planter double disk opener (40" row spacing) – **Cotton, picker**
05/25/01 Row crop Cultivator (40" inch rows)
06/10/01 Row crop Cultivator (40" inch rows)
06/27/01 Row crop Cultivator (40" inch rows)
09/15/01 Defoliate

10/01/01 Harvest crop (leave stalks undisturbed)
11/01/01 shred stalks
11/15/01 Tandem disk, 18" diameter blades)
***Watermelons**
03/01/02 Chisel plow - 2" wide straight pts.
03/20/02 Tandem disk, 18" diameter blades)
04/04/02 Planter - double disk opener (48" rows) - **Watermelons**
05/05/02 Row crop Cultivator (48" inch rows)
05/20/02 Row crop Cultivator (48" inch rows)
07/10/02 Harvest crop
08/01/02 Tandem disk, 18" diameter blades)
10/01/02 Tandem disk, 18" diameter blades)

***Wheat, winter, soft white**
11/14/02 Tandem Disk 18" diameter blades)
11/15/02 Drill - double disk openers (8" rows)
06/05/03 Harvest small grain (cutter bar) – **Wheat, winter, soft white**
06/06/03 Burn residue (approximately 800 lbs of residue/acre left on surface)

***Soybeans**
06/07/03 Tandem disk, 18" blades
06/07/03 Plant, double disk openers - 30" rows - **Soybeans**
07/24/03 Row crop Cultivator (30" rows)
08/10/03 Row crop Cultivator (30" rows)
10/31/03 Harvest Soybeans (Cutter bar)
11/20/03 Tandem disk, 18" blades

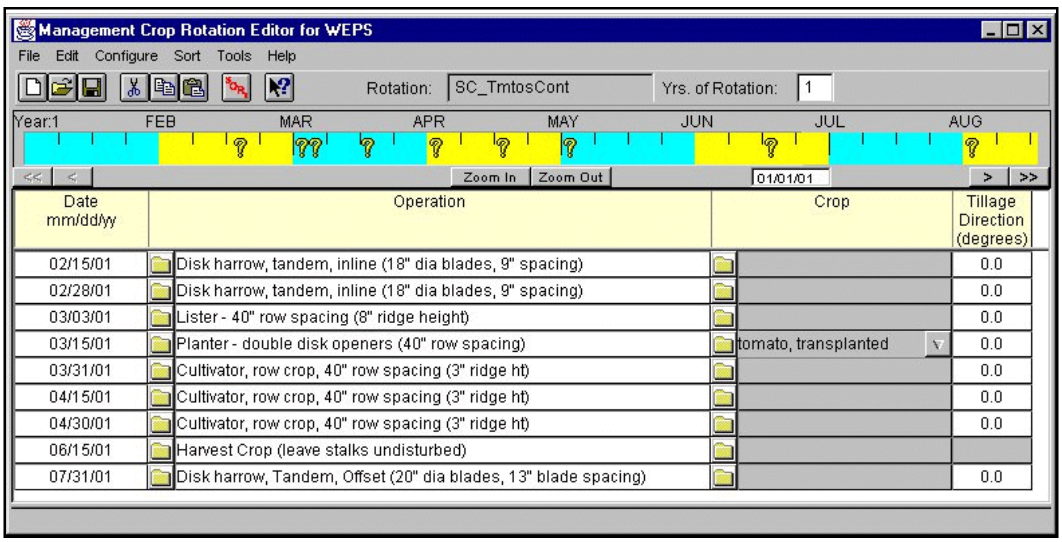
***Corn, 130 day**
03/15/04 Tandem disk, 18" diameter blades)
04/01/04 Plant, double disk openers - 30" rows - **Corn**
05/01/04 Row crop Cultivator (30" rows)
05/21/04 Row crop Cultivator (30" rows)
09/15/04 Harvest
10/15/04 Tandem disk, 18" diameter blades)

Situation 2 - Continuous Tomatoes

This is another example problem that we will use to evaluate a wind erosion problem in Charleston County, SC.

- The scenario for the problem is:
- The farm is located in **Charleston County, SC**
- The **Cligen station is Charleston** and the **Windgen station is Charleston**
- The **Soil Map Unit** used in the evaluation is: **NoA - Norfolk LS**
- The continuous cropping system is **Tomatoes**
- The **field size** is: x axis - 2000 ft.; y axis - 1500 ft.
- Orientation of field operations and rows is **-45 degrees**
- Operations are performed parallel to x axis
- The early WEPS evaluations will be run for **5 rotation cycles**
- **Barriers** - Woods along the NW and NE field borders (trees w/leaves 4 rows)

Below is the 1 year rotation of Tomatoes, including the dates and field operations (Fig. 5.20).



Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
02/15/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
02/28/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
03/03/01	Lister - 40" row spacing (8" ridge height)		0.0
03/15/01	Planter - double disk openers (40" row spacing)	tomato, transplanted	0.0
03/31/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
04/15/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
04/30/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
06/15/01	Harvest Crop (leave stalks undisturbed)		
07/31/01	Disk harrow, Tandem, Offset (20" dia blades, 13" blade spacing)		0.0

Figure 5.20. A one year rotation of tomatoes.

***Tomatoes**
02/15/01 Tandem disk, 18" diameter blades)
03/01/01 Tandem disk, 18" diameter blades)
03/03/01 Lister - 48" row spacing (8" ridge height)
03/12/01 transplant - **Tomatoes**
04/01/01 Row crop Cultivator (48" inch rows)

04/15/01 Row crop Cultivator (48" inch rows)
05/0101 Row crop Cultivator (48" inch rows
06/15/01 Harvest crop
07/25/01 Tandem disk, 18" diameter blades)

Situation 3 - Continuous Cotton

This is an example problem that we will use to evaluate a wind erosion problem in Marlboro County, SC.

- The scenario for the problem is:
- The farm is located in **Marlboro County, SC**
- The **Cligen station is McColl** and the **Windgen station is Florence**
- The **Soil Map Unit** used in the evaluation is: **FaB - Faceville LS**
- The continuous cropping system is **Cotton, picker**
- The **field size** is: x axis - 3500 ft.; y axis - 2000 ft.
- Orientation of field operations and rows is **-45 degrees**
- Operations are performed parallel to x axis
- The early WEPS evaluations will be run for **5 rotation cycles**
- **Barriers** - Woods along the NW and NE field borders (trees w/leaves 4 rows)

Below is the 1 year rotation of **Cotton, Picker** including the dates and field operations (Fig. 5.21).

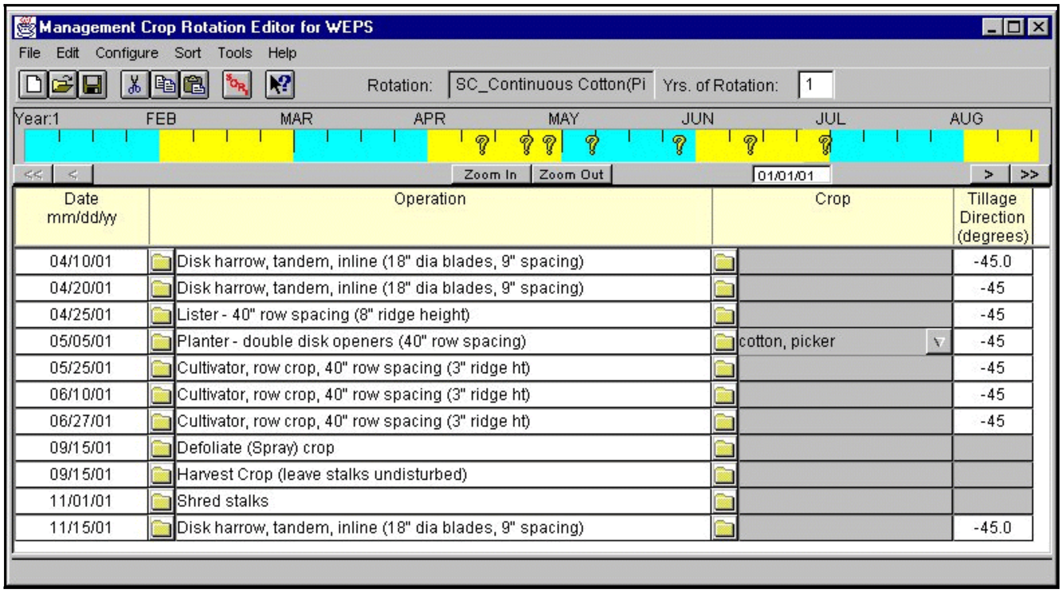


Figure 5.21. A one year rotation of picker cotton.

* **Cotton, picker** (700 lbs. lint yield)
04/10/01 Tandem disk, 18" diameter blades)
04/20/01 Tandem disk, 18" diameter blades)
04/25/01 Lister - 40" row spacing (8" ridge height)
05/05/01 Planter double disk opener (40" row spacing) – **Cotton, picker**
05/25/01 Row crop Cultivator (40" inch rows)
06/10/01 Row crop Cultivator (40" inch rows)
06/27/01 Row crop Cultivator (40" inch rows)
09/15/01 Defoliate
10/01/01 Harvest crop (leave stalks undisturbed)
11/01/01 shred stalks
11/15/01 Tandem disk, 18" diameter blades)

EVALUATING WIND EROSION PROBLEMS WITH WEPS

Following are some example problems that we will use to evaluate some wind erosion problems in Haakon County, South Dakota.

<u>Situation 1</u> -2 year rotation

The scenario for the problem is:

- The farm is located in **Haakon County, SD**
- The **Cligen station is Milesville** and the **Windgen station is Philip**
- The **Soil Map Unit** used in the evaluation is**: Craft Cv 85 VFSL**
- The original 2 year cropping system is **Winter Wheat-Fallow**
- The field size is: **x axis - 2600 ft.; y axis - 2600 ft.**
- Orientation of field operations and rows is – **North (0 or 360 degrees)**
- Operations are performed parallel to x axis
- The early WEPS evaluations will be run for **5 rotation cycles**
- Barriers - None

Below is the 2 year rotation of **Winter Wheat** and **Fallow**, including the dates and field operations (Fig. 5.22).

***Winter Wheat** (32 bu. yield) – **Fallow** (Conventional)

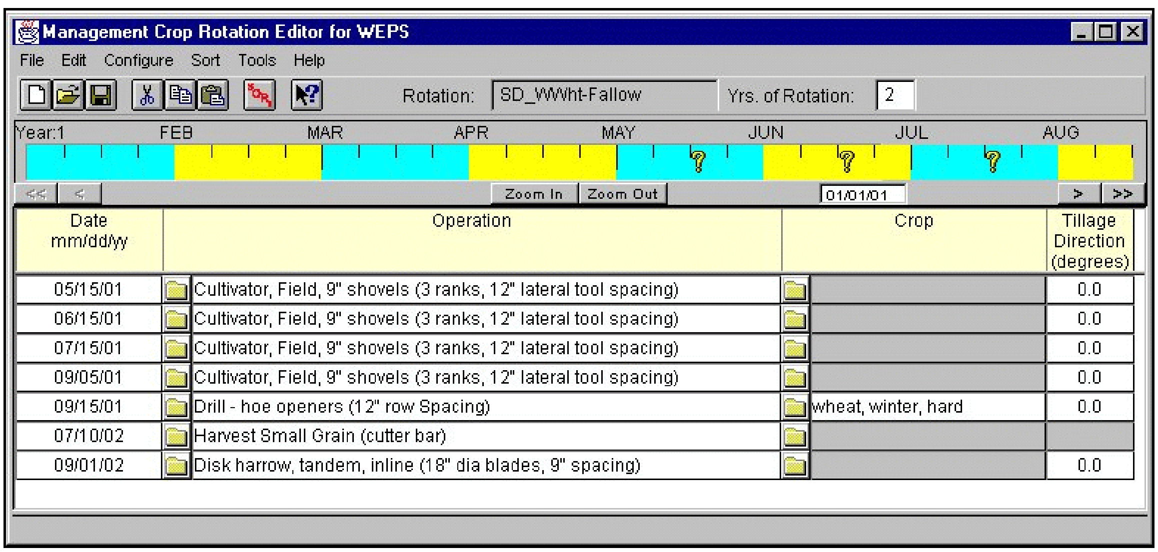


Figure 5.22. A two year rotation of winter wheat and fallow.

When we expand the 2 year rotation to include Forage Sorghum/Sudan Grass Cross (Kane) (Fig. 5.23), we can add the operations, dates of operation, and the Kane crop directly to the 2 year rotation or we can build a separate template for Kane. The new template can then be inserted into the rotation. We recommend the option of building the separate template for Kane and the template will then be available the next time you are building a rotation that includes that crop.

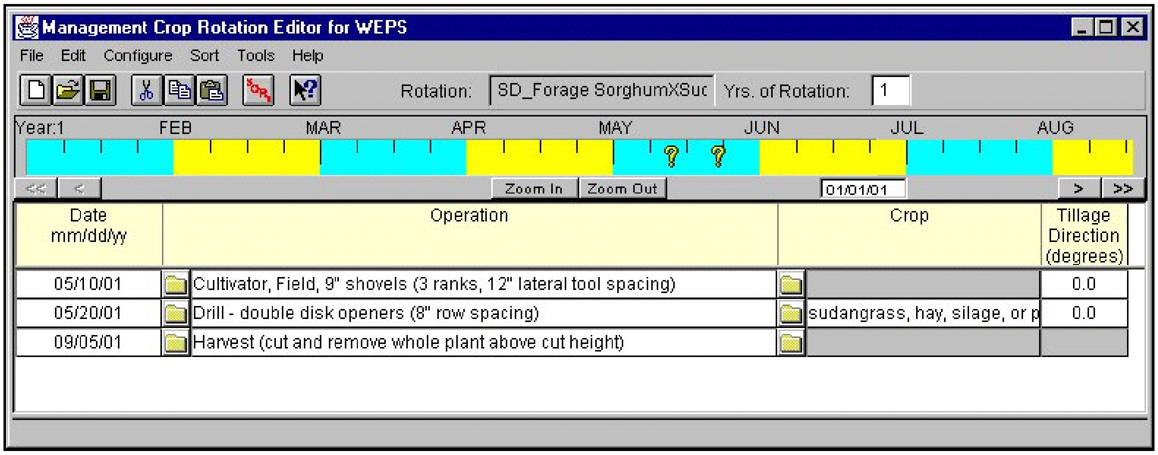
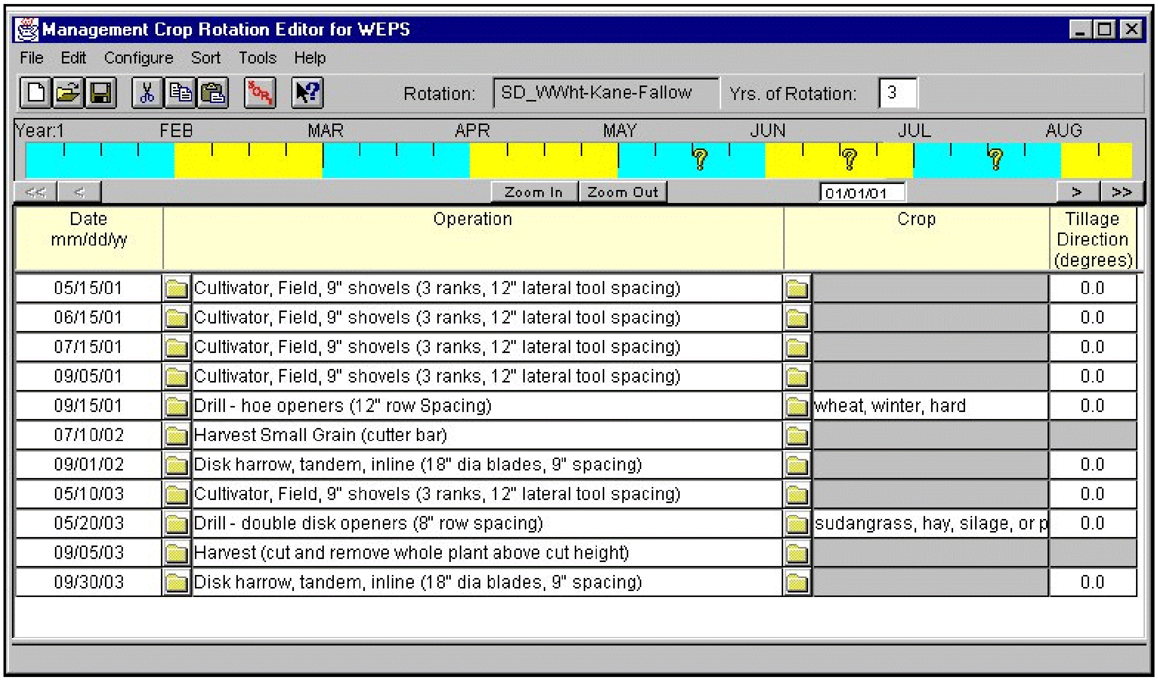


Figure 5.23. A one year rotation of forage sorghum/Sudan grass cross (kane).

Below is the 3 year rotation of Winter Wheat; Fallow; and Kane, including the field operations and the dates they were performed (Fig. 5.24).

***Winter Wheat** (32 bu. yield) – **Fallow** (Conventional) and **Kane** (~ 6000 lbs.)



Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
05/15/01	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
06/15/01	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
07/15/01	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
09/05/01	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
09/15/01	Drill - hoe openers (12" row Spacing)	wheat, winter, hard	0.0
07/10/02	Harvest Small Grain (cutter bar)		
09/01/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
05/10/03	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
05/20/03	Drill - double disk openers (8" row spacing)	sudangrass, hay, silage, or p	0.0
09/05/03	Harvest (cut and remove whole plant above cut height)		
09/30/03	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0

Figure 5.24. A three year rotation of winter wheat, fallow, and kane.

EVALUATING WIND EROSION PROBLEMS WITH WEPS

Following are some example management scenarios that we will use to evaluate a wind erosion problem in the Northwest area of Texas.

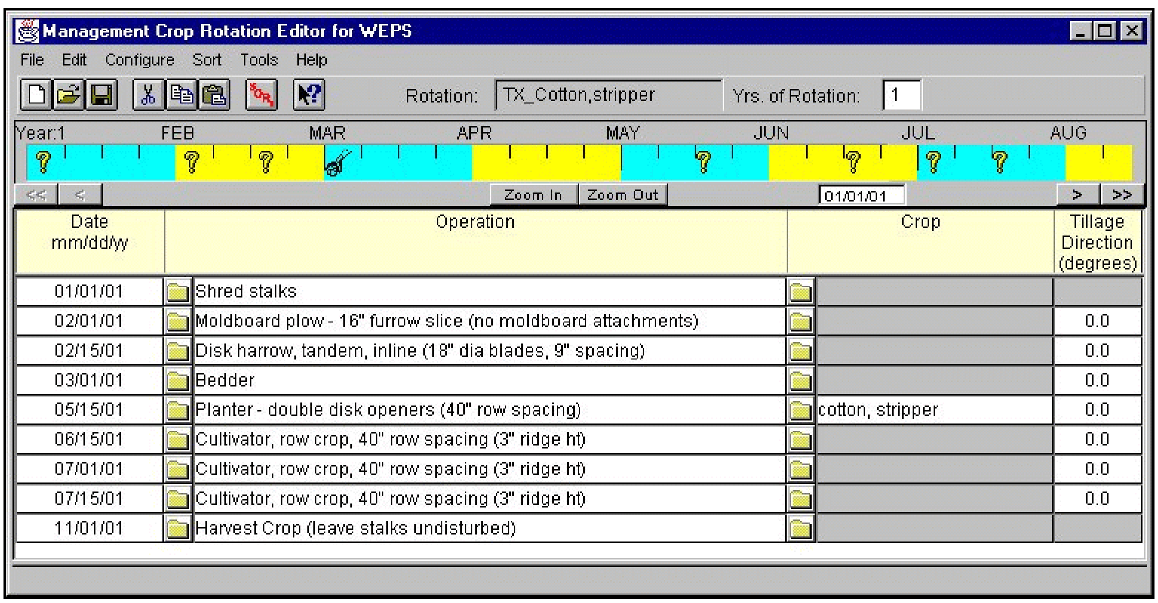
<u>Situation 1</u> – Continuos Cotton rotation

The management scenario to be evaluated is:

- The **farm** is located in **Lubbock County, TX**.
- The **Cligen Station** is Lubbock and the **Windgen Station** is Lubbock
- The **Soil Map Unit** used in the evaluation is **Amarillo_4_100_LFS**
- The original Cropping system is **Continuos Cotton, stripper**
- The **field size** is 2640' X 2640' (160 acres)
- The WEPS evaluation of the cropping system will be run for **5 rotation cycles**

Below is the **Continuos Cotton** rotation including the **dates** and **field operations** (Fig. 5.25).

Cotton (Yield of ½ Bale)



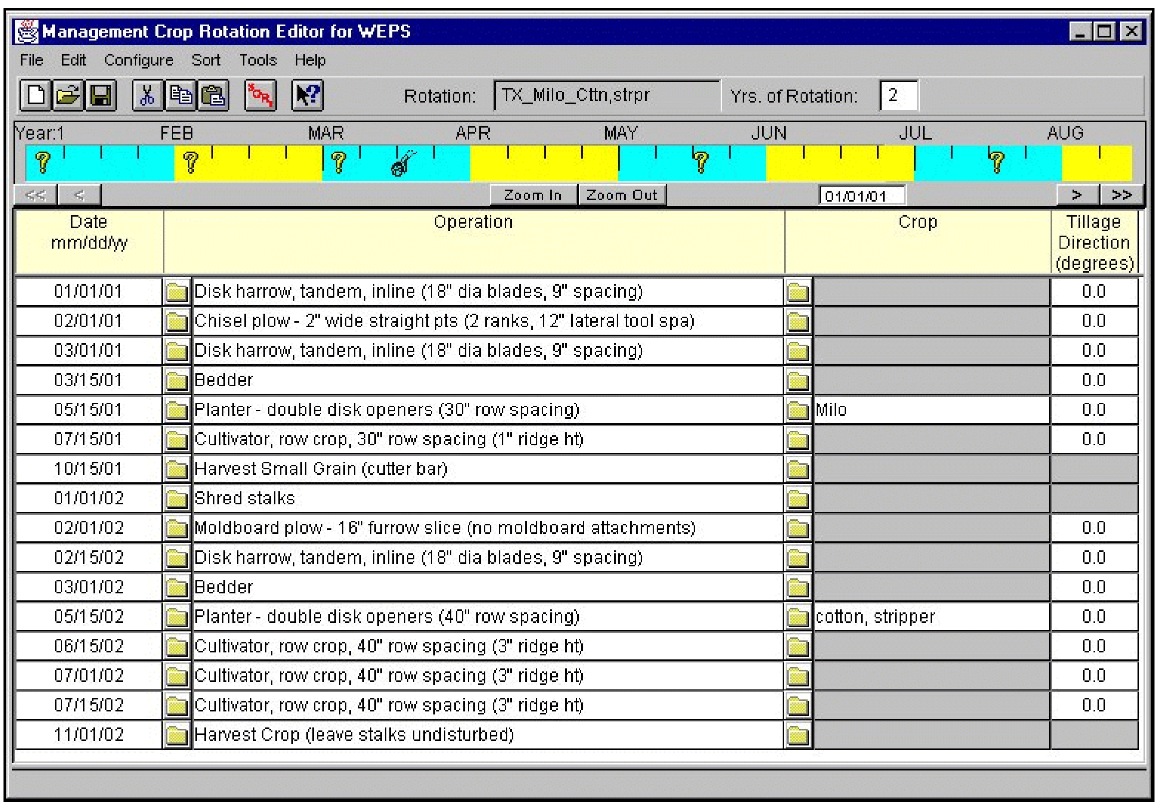
Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
01/01/01	Shred stalks		
02/01/01	Moldboard plow - 16" furrow slice (no moldboard attachments)		0.0
02/15/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
03/01/01	Bedder		0.0
05/15/01	Planter - double disk openers (40" row spacing)	cotton, stripper	0.0
06/15/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
07/01/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
07/15/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
11/01/01	Harvest Crop (leave stalks undisturbed)		

Figure 5.25. A continuos rotation of cotton.

Situation 2 – **Cotton_Milo rotation**

When we expand the 1 year cotton rotation to include **Milo**, we can add the operations, dates of operations, and the **Milo** crop directly to the original **Cotton rotation** or we can build a separate template for **Milo** and then insert the new template in the rotation. We recommend the option of building a separate template for **Milo** and then inserting it into the existing **Cotton rotation**. The new **single year template** for **Milo** begins by opening **MCREW**, clicking on **"File"**, then click on **"New"** and this will drop a clean **MCREW** screen down. With the clean **MCREW** screen we just start entering dates and operations as instructed in the earlier lessons on **MCREW**. The single year cropping scenario for **Milo** should be saved as a template. Saving a template begins by clicking on **"file"** and then **"save as a template"**. The list of dot man folders and files will drop down. Here we can open a folder before saving, or we can go directly to the window on the bottom of the list called **"File name",** remove the * and then type in the name of the new template we are saving. To finalize we click **"Save"** on the bottom right. We now have a new single year **Milo** template and will add it to our existing **Cotton scenario**.

Below is the **2 year rotation** of **Milo_Cotton**, including the dates and field operations (Fig. 5.26).

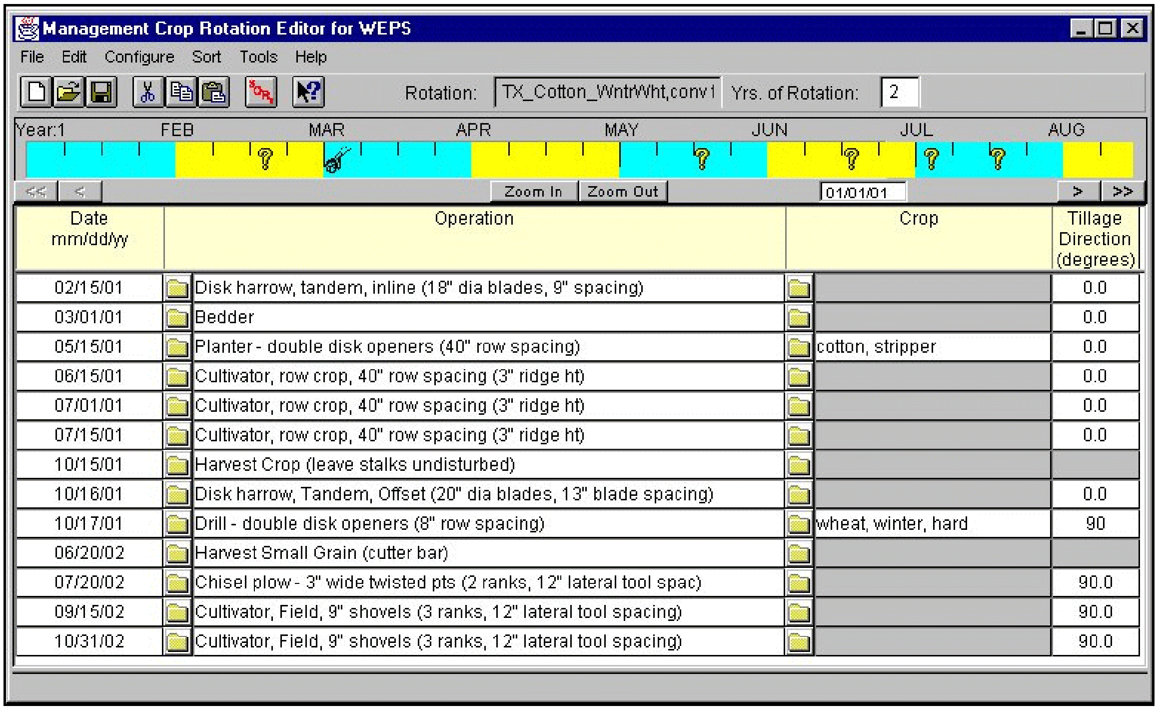


Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
01/01/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
02/01/01	Chisel plow - 2" wide straight pts (2 ranks, 12" lateral tool spa)		0.0
03/01/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
03/15/01	Bedder		0.0
05/15/01	Planter - double disk openers (30" row spacing)	Milo	0.0
07/15/01	Cultivator, row crop, 30" row spacing (1" ridge ht)		0.0
10/15/01	Harvest Small Grain (cutter bar)		
01/01/02	Shred stalks		
02/01/02	Moldboard plow - 16" furrow slice (no moldboard attachments)		0.0
02/15/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
03/01/02	Bedder		0.0
05/15/02	Planter - double disk openers (40" row spacing)	cotton, stripper	0.0
06/15/02	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
07/01/02	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
07/15/02	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
11/01/02	Harvest Crop (leave stalks undisturbed)		

Figure 5.26. A two year rotation of milo and cotton.

Situation 3 – **Cotton_Winter Wheat rotation**

Below is the 2 year rotation of **Cotton_Winter Wheat** including the dates and field operations (Fig. 5.27). We recommend the option of building the rotation using separate templates of **Cotton** and **Winter Wheat**. However, once you have a template of **Cotton_Winter Wheat**, you can use it directly from your dot man files.



Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
02/15/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
03/01/01	Bedder		0.0
05/15/01	Planter - double disk openers (40" row spacing)	cotton, stripper	0.0
06/15/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
07/01/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
07/15/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
10/15/01	Harvest Crop (leave stalks undisturbed)		
10/16/01	Disk harrow, Tandem, Offset (20" dia blades, 13" blade spacing)		0.0
10/17/01	Drill - double disk openers (8" row spacing)	wheat, winter, hard	90
06/20/02	Harvest Small Grain (cutter bar)		
07/20/02	Chisel plow - 3" wide twisted pts (2 ranks, 12" lateral tool spac)		90.0
09/15/02	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		90.0
10/31/02	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		90.0

Figure 5.27. A two year rotation of cotton and winter wheat.

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APPENDICES

Tutorials: Module 1

An Overview of WEPS

Wind erosion is a serious problem on agricultural lands throughout the United States as well as the world. The ability to accurately predict soil loss by wind is necessary for conservation planning, natural resource inventories, and quantifying potential air pollution from wind blown sources.

WEPS, the Wind Erosion Prediction System, has been developed to address this problem through a multi-agency government commitment. These agencies include: the USDA Agricultural Research Service, the USDA Natural Resources Conservation Service, the US Bureau of Land Management, the US Environmental Protection Agency, the US Forest Service, the US Army Corps of Engineers, and many universities including Kansas State University in Manhattan, Kansas.

WEQ

Wind Erosion Equation—WEQ
E = f(I,K,C,L,V)
I - soil erodibility
K - soil ridge roughness
C - climatic factor
L - field length
V - vegetative factor

The Wind Erosion Equation or WEQ was developed by the late Dr. W. S. Chepil and co-workers beginning in 1947, and first published in 1965. WEQ represented the first, and for many years, the most widely used method for assessing the average annual soil loss by wind from agricultural fields. Due to the limited science and computational tools available at that time, it was necessary to create WEQ as an empirical functional expression where the potential average annual soil loss is a function of:

- The soil erodibility
- The soil ridge roughness
- The climate
- The unsheltered distance across a field and
- The equivalent vegetative cover

WEQ is based on science and technology that is more than 35 years old, it is empirical by attempting to model response to conditions in the field as factors, and it is not easily extrapolated to areas outside the Great Plains where it was developed.

With the advanced technology of today a significant advancement in wind erosion prediction technology is now possible and overcomes the fundamental weaknesses of WEQ. The Wind Erosion Prediction System incorporates this new technology into a user-friendly computer model.

What Is WEPS?

Wind Erosion Prediction System—WEPS
Process-Based
Continuous
Daily Time-Step
Wind Erosion Model

WEPS is a process-based, continuous, daily time-step model that simulates weather, field conditions, and erosion using a simple graphical user interface. WEPS has the capability of modeling actual physical processes that are occurring in the field. As a continuous, daily, time-step model, it simulates not only the basic wind erosion processes, but also the processes that modify a soil's susceptibility to wind erosion on a daily basis. Plus, through the simulation of field barriers and varying field management practices, WEPS can accurately predict the results of these practices on soil erosion.

Factors Used In WEPS

Where are the WEQ factors in WEPS?
Example: Soil Erodibility - I Factor - WEQ
Surface Aggregation
- Size distribution
- Dry stability

Crusted Surface
- Cover fraction
- Stability and thickness
- Loose, erodible material on crust

Each of the WEQ factors is accounted for in WEPS. For example, the soil erodibility, or "I" factor of WEQ is accounted for in WEPS through modeling surface aggregation in terms of its size distribution and dry stability. The effects of crusted surfaces are modeled in terms of the fraction of the surface covered by crust, crust stability and thickness, and the amount of loose, erodible material on the crust.

Similarly, the K, C, L, and V factors of WEQ are accounted for in WEPS by multiple, complex physical processes.

Why WEPS?

Improve predictions of soil loss by wind through new technologies

WEPS has been developed to replace the older technology of WEQ and improve the overall predictions of soil loss by wind from agricultural fields.

More accurate assessment of soil loss from agricultural fields

This is done by providing more accurate assessments of soil loss from agricultural fields through process-based modeling. WEPS also meets many other needs that were previously not possible through the use of WEQ.

Aid in designing more efficient and Cost-effective erosion control systems

The simulation model makes it possible to design more efficient and cost-effective erosion control systems...and accurately predict the effects of these control systems as related to soil erosion.

Quantitative information to assist in improved management practices

Quantitative information, in addition to average annual soil loss, is provided through the detailed reports available that are important in the development of effective management practices.

Estimate suspension soil losses
Determine offsite impacts
Estimate PM-10 emissions

WEPS will also provide additional prediction capabilities, not currently available, to determine estimates of suspension soil losses, determining offsite impacts, and providing estimates of emissions of particle matter less than ten microns in size, know as PM-10.

Purpose and Goals of WEPS

Purpose and Goals
- Planning soil conservation systems
- Environmental planning and assessment evaluations
- Offsite impacts of wind erosion estimates

The goal for WEPS is to be the wind erosion tool of choice for designing sound management systems to conserve our soil, air, and water resources. Specific purposes include: the planning of soil conservation systems, providing environmental planning and assessment evaluations, and estimating offsite impacts of wind erosion.

What Does WEPS Do?

WEPS is based on erosion simulation models to accurately predict:
- Detachment
- Transport
- Deposition

WEPS simulates the erosion of a soil surface by wind as the fundamental process of soil detachment, which includes clod and crust abrasion, emission, and surface rearrangement. WEPS simulates the process of transport where particles of saltation and creep size are moved as well as suspension, which includes PM10. WEPS also simulates the process of deposition that occurs when particles are trapped in depressions or residue and as the surface is rearranged by wind erosion.

What Does WEPS Simulate?

- **Daily Weather**
- **Water Balance**
- **Crop Growth**
- **Residue Decomposition**

WEPS simulates weather on a daily basis that drives processes or causes changes in water balance or hydrology, crop growth, and residue decomposition.

Daily Changes in Temporal Field Conditions
- Soil aggregation
- Surface wetness
- Surface roughness
- Residue status (standing/flat)

WEPS simulates changes in temporal field conditions on a daily basis in terms of the soil aggregation size and strength, surface wetness, surface roughness, and how much residue is standing or flat.

Common Cultural Practices (management/land use)
- Tillage
- Planting
- Irrigation
- Harvesting
- Burning

WEPS simulates the effects of common cultural practices typical for field management and land use. These factors include tillage, planting, irrigation, harvesting, and burning.

2 Dimensional Spatial Regions
- Wind barriers
- Fields
- Uniform soil areas
- Common land use/management practices

WEPS simulates the two dimensional space of wind barriers and fields or regions which are represented as having a single soil type an common land use or management.

The WEPS Difference from WEQ

How WEPS determines soil loss compared to WEQ

WEQ makes an erosion calculation along a single, transect that represents the unsheltered distance across the field. WEPS makes calculations for many grid areas covering the entire field.

The wind speed and direction in WEQ is considered constant throughout the period being evaluated. Wind direction in WEPS varies on a daily basis and wind speed varies by the hour within the day.

Barriers in WEQ only modify the unsheltered field length. In WEPS the barrier type, height, and porosity modify the wind velocity as it travels across the field.

WEQ considers the crop and soil characteristics to remain constant throughout the period of evaluation. With WEPS, soil and crop characteristics change on a daily basis in response to climate and erosion conditions.

These differences will produce more accurate soil loss estimates as the processes simulated closely reflect the actual conditions on a daily time-step process throughout the period of evaluation.

How Is WEPS Implemented?

How is WEPS Implemented?

WEPS is implemented as a science model within a graphical user interface. The user interface allows for the creation of input run files, or "Projects", the saving of these projects, and the recall of previously saved projects. The projects created are based on the user input and the information contained in the climate, soils, management, and crop/decomposition databases.

The interface executes the science code consisting of the Main controlling program and seven submodels; Hydrology, Management, Soil, Crop, Decomposition, Erosion, and Weather. These submodels are modular in design so that they may be easily modified or replaced as better science is adopted.

The interface also allows for the selection, viewing, and printing of project output and reports.

Lets take a look at the purpose of each of the seven submodels in WEPS.

WEPS Submodels

The Weather Submodel
Drives the fundamental physical processes simulated by the other six submodels.

The WEPS weather submodel drives the fundamental physical processes simulated by the other submodels. To do this, the weather submodel simulates precipitation amount, maximum and minimum air temperature, solar radiation, dew point temperature, wind direction on a daily basis, and wind speed on an hourly basis.

The Hydrology Submodel
Models the soil water balance in response to weather and field conditions.

The purpose of the WEPS Hydrology submodel is to model soil water balance due to weather conditions and vegetation. This submodel simulates infiltration, percolation, storage, runoff, and deep drainage as well as daily evaporation and transpiration. Hourly surface wetness is used to simulate surface susceptibility to erosion.

The Soil Submodel
Models daily changes in soil surface and layer conditions in response to weather processes.

The Soil submodel is used to model daily changes in soil surface and layer conditions in response to the weather processes of wetting and drying, freezing and thawing, and freeze drying. The surface conditions considered include; roughness, crusting, aggregation stability and size, and bulk density.

The Crop Submodel
Models daily crop growth in response to weather factors and water stress.

The purpose of the Crop submodel is to model daily crop growth in response to weather factors and water stress. This submodel accounts for biomass production and partitioning, leaf and stem area growth, and plant height.

The Decomposition Submodel
Models daily decomposition of residues in response to weather.

The Decomposition submodel purpose is to model daily decomposition of standing, flat and buried residues in response to moisture conditions and temperature. The fall rate of standing residue is also modeled.

The Management Submodel

Models cultural practices which affect a site's susceptibility to wind erosion.

The WEPS Management submodel responds to cultural practices that affect a site's susceptibility to wind erosion. These responses include the effects of the manipulation of soil and biomass properties, which result from management operations.

The Erosion Submodel
Models erosion process when wind speeds exceed threshold for the surface conditions.

Finally, the purpose of the WEPS Erosion submodel is to model erosion processes when wind speeds exceed threshold for the surface conditions. It accounts for trapping and emission of eroding particles, clod and crust abrasion, and surface rearrangement in response to wind driven particle movement. The erosion submodel also simulates creep/saltation and suspension. The PM10 component of suspension is also estimated.

WEPS Interface

Field

- Size
- Shape
- Orientation

The graphical user interface makes WEPS simple to use for field simulations. Users can easily create the field size, shape and orientation.

Barriers

- Locate
- Select
- Modify

It also allows barriers to be located on the field borders and their characteristics easily selected from a drop-down menu. More specific modifications to selected characteristics may be easily made.

Climate

- Location

Soil

- Select, modify

Management
- Select, modify, build

The interface provides a simple method for the user to generate climate information by location selection. Finally, the user may select a soil and modify its properties, as well as select, modify, or build a management scenario.

Reports

The output and report options available in WEPS provide reliable and accurate information for evaluation. Information and estimates may be viewed either in summary or detail on; annual soil loss, period soil loss, saltation/creep, suspension, PM10, surface conditions, wind energy, and boundary loss.

The Benefits

The Benefits of WEPS
- Accuracy
- Weather driven
- Simulation on a daily time-step
- Estimates loss over entire field
- Reflects effects of cultural practices
- Computed erosion in 2-D space
- Multiple output options

In summary, WEPS is a process-based model that is weather driven with a daily time-step simulation. It estimates soil loss over the entire field and takes into account the effects of cultural practices, computes erosion is a 2-dimensional space, and has multiple output options for the evaluation of information.

Tutorials: Module 2

A Simple Simulation

Tutorials: Module 3

Details of Building a Simulation

Training Outline

NOTES