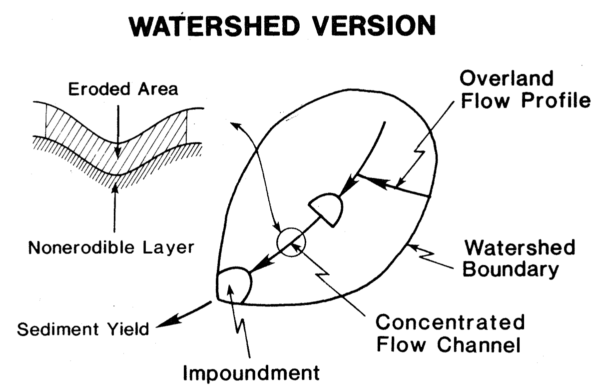
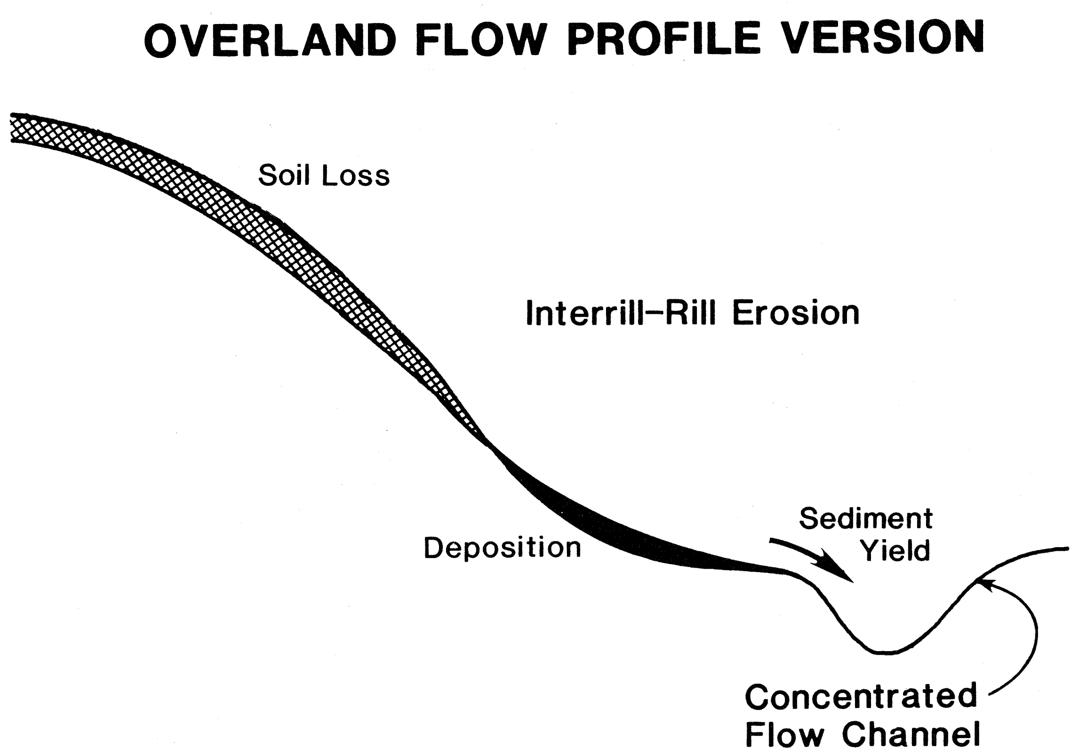
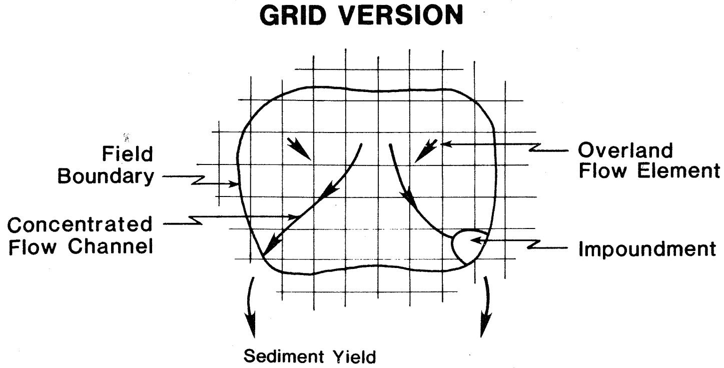
USER REQUIREMENTS

USDA–Water Erosion Prediction Project (WEPP)







USDA - Agricultural Research Service
USDA - Soil Conservation Service
USDA - Forest Service
USDI - Bureau of Land Management

PREFACE

For over a quarter century, federal and state agencies, private industry, and individuals have used the Universal Soil Loss Equation (USLE) to evaluate soil erosion caused by water. However, new environmental concerns, new erosion modeling applications, and the Food Security Act of 1985 now require enhanced capabilities. In addition to USLE's estimates of sheet and rill erosion, estimates are needed for erosion by concentrated flow, sediment delivery to locations on the landscape, and locations and amounts of deposition along the landscape and in waterways. Modern erosion theory, experimental research, computer technology, and availability of databases provide the potential for a significant advancement in erosion prediction technology.

The Water Erosion Prediction Project (WEPP) is a joint effort of several federal agencies and their cooperators. This Project will provide agencies with a new generation, process-oriented technology for estimating erosion by water. At the beginning of the Project, user needs were evaluated to develop these User Requirements that describe the functions and features that the new technology is to embody.

The following federal agencies are the principal cooperators in WEPP, support the Project, and concur with the User Requirements:

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USER REQUIREMENTS

USDA-WATER EROSION PREDICTION PROJECT (WEPP)

Draft 6.3

September 1, 1987

Compiled by
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Cooperating Agencies:

USDA-Agricultural Research Service
USDA-Soil Conservation Service
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National Soil Erosion Research Laboratory
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ABSTRACT

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The objective of the USDA-Water Erosion Prediction Project (WEPP) is to develop new generation water erosion prediction technology for use by the USDA-Soil Conservation Service, USDA-Forest Service, USDI-Bureau of Land Management, and other organizations involved in soil and water conservation and environmental planning and assessment. This improved erosion prediction technology is to be based on modern hydrologic and erosion science, process oriented, and conceptually a significant improvement over the Universal Soil Loss Equation (USLE). The model and computer programs implementing the model are to run on computers available in local offices of the user agencies. The first version of the technology, described in these User Requirements, is scheduled for delivery in 1989. Subsequently, the technology will undergo extensive testing and evaluation by user groups while research continues to develop and refine relationships in the model. Delivery of the version intended for wide use is expected in 1992. The technology, expected to have a life cycle of about 20 years, is to be modular so that new research findings can be incorporated without major revisions to the model.

Research to develop the technology will include laboratory and field studies on more than 75 cropland, rangeland, and forestland soils and site conditions across the US. This experimental research will be conducted to understand how inherent soil properties and those modified by climate and land use affect infiltration and erodibility. These studies will provide parameter values needed to ensure that the WEPP erosion prediction technology will apply across a broad range of climates, soils, topographies, and land uses.

The major applications for this technology are in conservation planning, project planning, and inventories and assessments. The model, which applies to field-sized areas, will be in three versions: a landscape profile (hillslope) version that applies to landscape profiles similar to those for the USLE except that the WEPP model considers depositional areas, a small watershed version that uses a representative landscape profile and considers waterways within the application area, and a grid version that computes sediment movement at all points and in all waterways over a field-sized area. The models is to describe the influence of climate, soil, topography, cover-management, and supporting practices on erosion, deposition, sediment yield, and sediment characteristics. Operational requirements for the model include: that it runs quickly on the computer and be easily used, broadly applicable, robust, and valid.

PROCESS USED TO DEVELOP USER REQUIREMENTS

These User Requirements are a compilation of input from many sources in the cooperating agencies. Six major drafts of the User Requirements were written and reviewed. As a part of the process, members of the WEPP Core Team visited each of the four USDA-Soil Conservation Service Technical Centers (SCS) to receive first hand input from representatives of all levels of SCS. Erosion prediction committees, technical steering committees, and individuals in all of the cooperating agencies provided major input to the User Requirements. Discussions at WEPP Core Team meeting resolved differences between user expectations and the project's ability to meet certain potential requirements.

CONTENTS

USER REQUIREMENTS

USDA-Water Erosion Prediction Project (WEPP)
Draft 6.3

1. INTRODUCTION:

The objective of this project is:

To develop new generation water erosion prediction technology for use by the USDA-Soil Conservation Service USDA-Forest Service, and USDI-Bureau of Land Management, and other organizations involved in soil and water conservation and environmental planning and assessment.

In particular, the project will develop improved erosion prediction technology based on modern hydrologic and erosion science that will be process oriented and conceptually a significant improvement over the Universal Soil Loss Equation (USLE). If the project is fully successful, the user will choose the technology developed by this project over the USLE.

The target group for the new technology is all current USLE users and specifically USDA-Soil Conservation Service (SCS). Field personnel within SCS are the expected primary users group although many others within and outside of SCS will be interested in the technology. A major secondary group of expected users is personnel in the USDI-Bureau of Land Management (BLM) and USDA-Forest Service (FS). Other agencies including the USDA-Extension Service, U.S. Department of Energy, U.S. Environmental Protection Agency, U.S. Federal Highway Administration, and various state and local agencies are also prospective users of this new erosion prediction technology.

The USLE is by far the most widely used method for predicting sheet and rill erosion. The origin and form of the equation evolved from A.W. Zingg's 1940 equation for the effect of slope length and steepness on erosion. The USLE is a lumped model since it does not define separate factor relationships for the fundamental hydrologic processes of rainfall, infiltration, and runoff and the fundamental erosional processes of detachment by raindrop impact, detachment by flow, transport by rain splash, transport by flow, and deposition by flow. Furthermore, the USLE is empirical, depends on a large mass of data for its relationships, and is very much a "black box" model. Both its empirical origin and lumped equation structure severely limit the potential for increased accuracy and major improvement. Scientifically the USLE is considered to be mature technology.

When the USLE was developed more than 20 years ago, it had to be a simple mathematical expression so that it could be solved with the computational equipment available at the time. However, small, computers are now readily available that can solve complex mathematical relationships quickly and easily in the field, local office, and even the farmer's home. Thus users now have the potential for using erosion prediction technology based on modern science of hydrologic and erosional processes that was impractical two decades ago. The objective of this project is to convert fundamental and available knowledge from these sciences to a form that the user can conveniently apply as an alternative to the USLE.

The output of this project may be a family of models and computer programs rather than a single model and program. This document defines the requirements that must be met to ensure that the model(s) meet the users' expectations and can be applied as anticipated. The delivered model(s) is expected to meet these requirements, and conversely, if the model(s) meets these requirements, the project will be judged as having delivered the intended product. Similarly, scientists and other technical specialists wishing to directly contribute to the model(s) are expected to provide information that meets the User Requirements.

The target date for completion of the project defined by this User Requirements document is August 1989. However, the prediction technology including the required input values for all potential applications will not be complete at that time, and therefore additional research and development will be required beyond 1989. The situation is analogous to the development of the USLE, which became available soon after 1960. Even though the USLE was usable at its introduction, research continued that expanded the applicability and accuracy of the USLE within its original structure. In the same way, the prediction procedure developed by this project will provide a structure that will accommodate future development and application to a broad range of conditions. When the model(s) is delivered in 1989, parameter values will be provided so that the model(s) will be usable for selected "key" situations of major importance.

Development of this erosion prediction technology will be a multi-agency and multi-discipline effort. A Core Team that has been formally appointed to lead the development is:

L.J. Lane, ARS, Tucson, AZ
(Project Leader)
E.E. Alberts, ARS, Columbia, MS
J.E. Gilley, ARS, Lincoln, NE
J.M. Laflen, ARS, W. Lafayette, IN
A.D. Nicks, ARS, Durant, OK
W.J. Rawls, ARS, Beltsville, MD
J.R. Simanton, ARS, Tucson, AZ
L.T. West, ARS, W. Lafayette, IN

H.D. Fox, SCS, Tucson, AZ
C.S. Holzhey, SCS, Lincoln, NE
D.L. Schertz, SCS, Washington, D.C.
G.A. Weesies, SCS, W. Lafayette, IN

E.R. Burroughs, FS, Moscow, ID
J.O. Nordin, FS, Washington, D.C.

G.D. Wingate, BLM, Susanville, CA

In addition, J. M. Bradford, ARS, W. Lafayette, IN and K. G. Renard, ARS, Tucson, AZ have been appointed as Resource Specialists to the Core Team in the soils and rangeland areas, respectively. The work is overseen by the ARS Erosion Prediction Technology Committee chaired by K. G. Renard, by the ARS National Program Staff represented by W. D. Kemper, Beltsville, MD, and by the SCS Erosion Prediction Committee chaired by K. W. Flach, Washington, D. C. A companion project led by L. J. Hagan, ARS, Manhattan, KS, is underway to develop new technology to estimate soil erosion by wind.

2. *GENERAL APPLICATIONS*

The primary identified user of the erosion prediction technology being developed by this project will be the USDA-Soil Conservation Service (SCS) at all levels of its operations including the local field office (District), Area Office, State Office, National Technical Center, and National Headquarters. The principal SCS user however will be the local field office. Another major identified user will be the USDI-Bureau of Land Management (BLM), which will use the technology principally at its field office level and the USDA-Forest Service (FS) at its Forest and District office levels. The needs of other potential users will be accommodated to the degree that their requirements match those listed in this document.

2.1 SCS Applications

Most SCS applications fall within the categories of: (a) conservation planning, (b) project planning, and (c) inventory and assessment.

2.1.1 Conservation Planning In SCS conservation planning, the major application of this erosion prediction technology is to predict sheet and rill erosion, concentrated flow erosion, and sediment yield at specific field sites. These predictions are made for existing conditions and for a proposed set of alternative conservation practices to provide erosion estimates used to guide the selection of a resource management (soil conservation) system for the specific site. A resource management system is usually being chosen to control: (a) erosion to a tolerable rate for productivity maintenance, (b) on-site deposition to prevent excessive adverse effects from deposition, (c) sediment yield from fields to allowable rates that prevent excessive off-site sedimentation, and (d) sediment yield from fields to prevent excessive degradation of off-site water quality.

Conservation planning in SCS occurs at the field office level, and it usually takes place in the field with the conservationist working directly with the land user. Not only does the prediction procedure provide the erosion estimates needed to develop the conservation plan, it is a communication tool that helps the conservationist describe the erosion process and how soil conservation practices work to control erosion. Thus the technology must be based on concepts and principles that can be easily understood and described by the conservationist to the client. In this application, the major need is to provide "accurate" estimates using as few resources as possible and to maximize the quality and quantity of service that SCS field personnel provide to clients.

2.1.2 Project Planning In SCS project planning, the prediction technology is used most frequently as a tool to help: (a) determine the erosion control measures and their distribution over a project area needed to meet specific project objectives, (b) estimate sediment yield and sediment characteristics needed to design off-site water conveyance and impoundment structures and to evaluate off-site impacts from sedimentation, and (c) estimate sediment yield and sediment characteristics needed to develop erosion control plans for improvements in downstream water quality. The prediction procedure is applied in the office using field data collected by field personnel, and the application may be more computer intensive than for conservation planning. Comparing project planning to conservation planning, project planning allows: (a) more expenditure of time and effort for collecting input data, (b) more emphasis on detail for representative subareas where computed results are expanded to the entire project area, (c) more emphasis on sediment yield from fields, and (d) greater use of interdisciplinary teams, although field personnel typically collect field data for input.

2.1.3 Inventory and Assessment As opposed to planning, which considers "what if" questions, SCS inventory and assessment activities are concerned with determining erosion and sediment yield for the present state. Also, rather than application to specific fields, watersheds, and project areas, the analysis is usually computing erosion and sediment yield at selected sample points and areas and aggregating these results for county, regional, state, and national areal units. The technology is usually applied in a "national" office where considerable computer and data base resources are available. The inputs frequently come from existing data bases (e.g., climatic and soil files), remotely sensed data, and surveys conducted by field office personnel. The use of the technology and the analysis is usually conducted by and under the direction of an SCS national assessment staff.

2.2 BLM Applications

Most of the BLM applications are by field office personnel needing erosion estimates to develop range management plans that will reduce sheet-rill erosion, concentrated flow erosion, and sediment yield to acceptable levels to prevent excessive loss of the productive capacity of rangeland soils and to prevent excessive off-site sedimentation. Development of range management plans includes evaluating the effects of livestock grazing systems and rangeland improvements such as vegetation conversions, brush control, mechanical/tillage treatments, and seedings on erosion. This planning activity is similar to SCS's conservation planning.

Other important applications are in Watershed Activity Planning and Watershed Condition Analysis. Watershed Activity Planning is directly analogous to SCS Project Planning and leads to watershed improvement projects. Watershed Analysis is analogous to SCS Inventory and Assessment and is usually conducted on a Resource Area or District scale.

The BLM requires technology that is easy to use in areas where little supporting climatic, soil. land use, and intensity of land use data may be available. The need is also to have a tool that is relatively simple and easy to use, comparable to the SCS conservation planning needs.

2.3 FS Applications

Two branches of the USDA-Forest Service are potential users of this erosion prediction technology. The branches are the National Forests and the State and Private divisions of the FS. The State and Private division of the FS advises state and local governmental agencies and private organizations and individuals. The principal FS users will be resource specialists at the Forest and District level. Applications by the FS are similar to those of SCS, but vary slightly because of specific direction for management of Federal lands. Categories include: (a) project planning and assessment, (b) forest planning, and (c) conservation planning.

2.3.1 Project Planning and Assessment In the FS, project planning is generally conducted under the guidance of the National Environmental Policy Act, the Multiple-Use Sustained-Yield Act, and the National Forest Management Act of 1976. These acts established procedures for evaluating resource management actions.

Most projects within the FS are evaluated by an interdisciplinary team of resource specialists. Jointly, they review major issues, list management concerns, develop alternatives, collect necessary resource information, and evaluate the alternatives. The preferred alternative is selected by the appropriate line officer. All decisions are subject to public review and appeal. Often it is the process that is appealed.

Types of projects include, but are not limited to: range allotment planning, range improvements, road construction, mineral exploration and development, timber harvest, reforestation, wildlife habitat improvement projects, developed recreation sites, trails, prescribed fire, wildfire restoration, off road vehicle use, borrow sites, and land exchanges.

Most projects involve activities that do not recur annually. Often they require disturbance for a certain period followed by restoration and then a long period of limited or no activity.

2.3.2 Forest Planning The National Forest Mangement Act of 1976 required all Forests to develop and evaluate alternative levels and mixes of land management activities. Activities were scheduled for 10 years, with projections for five decades. Modeling of erosion and sediment was included in many Forest Plans. Sediment values were also used in some cases to evaluate mangement effects on other resources, such as fisheries. Long-term monitoring is required to ensure compliance with legal requirements and to evaluate assumptions. Environmental Impact Statements are prepared for each Forest Plan.

Erosion and sediment estimates are made for response areas within each Forest. The results need to reflect impacts of management alternatives over large land areas. Results should also reflect changes over time.

2.3.3 Conservation Planning This application concerns evaluating the use of specific practices, which is often accomplished by the FS watershed specialist acting as an In-Service consultant to Ranger Districts. Quick answers are needed in the field with limited input information. "Ball park" estimates should be possible without the use of a computer.

Also included in this application is training of non-watershed personnel.

3. GENERAL REQUIREMENTS

3.1 Size Area

The erosion prediction procedure from this project is to apply to "field-sized" areas or conservation treatment units. Although the size of a particular field to which the procedure applies will vary with degree of complexity within a field, the maximum size "field" is about a section (640 acres) although an area as large as 2,000 acres is needed for some rangeland applications. On very complex areas, the "field" may be much smaller than 640 acres. The procedure will not apply to areas having incised, permanent channels such as classical gullies and stream channels. The channels that the procedure is to include are those farmed over and known as concentrated flow or "cropland ephemeral gullies." Also, the procedure is to apply to constructed waterways like terrace channels and grassed waterways. In rangeland and forest applications, "fields" can include gullies up to the size of typical concentrated flow gullies in 640 acre cropland fields. These channels are about 3 to 6 ft wide by about 3 ft deep. The procedure is not to apply to headcut erosion, sloughing of gully sidewalls, or the effects of seepage on erosion in concentrated flow channels.

3.2 Required Erosion, Deposition, and Sediment Yield Estimates

The procedure is to compute: (a) sheet-rill erosion and deposition by overland flow along selected landscape profiles or over an entire field, (b) concentrated flow (ephemeral gully) erosion along selected channels or over the entire channel network within a field, and (c) sediment yield and its sediment characteristics from selected watersheds within the field or at all outlet points from the field. To meet these requirements, the procedure is to include three basic versions: (a) a representative landscape profile version, (b) a watershed version, and (c) a grid version that covers the entire field.

In these User Requirements, "fineness" refers to sediment characteristics. In general, fineness can be an enrichment ratio based on specific surface area. However, at the request of the user, the procedure is to compute erosion, deposition, and transport for a minimum of five sediment particle classes that can vary by diameter, density, and composition by primary particles and organic matter.

Estimates from the water erosion prediction procedure should be in a form with respect to space and time that they can be combined with estimates from wind erosion prediction procedures to support evaluations of the combined effects of wind and water erosion. This requirement can be met by computing average annual erosion rates at any point in the field.

3.3 Major Factors

The procedure is to describe the influence on erosion, deposition, and sediment yield of the major factors: (a) climate, (b) soil, (c) topography, (d) cover-management, and (e) supporting practices. The last two factors describe land use.

3.4 Applicability

Ultimately the procedure is to apply to all U.S. locations including Alaska, Hawaii, and Puerto Rico. Furthermore, the procedure should be developed with the goal that it will apply worldwide. The procedure is to be process based to meet this broad range of applicability. In particular, the effects of cropping and management will be described by a component structure based on canopy, ground cover, roughness, soil consolidation, and similar components. This project will provide the basic relationships to meet this requirement, but field application of the procedure will depend on the availability of parameter values. This project will determine parameter values for a set of "key" soils, crops, management, tillage, and supporting practices specified in a later section.

3.5 Other General Requirements

The prediction technology must be easily used with easily understood guidelines. Also, it must use minimal and easily obtained inputs, which are specified in a later section. When applied to conservation planning, the procedure must be portable for use in the office, truck, field, or client's house. The procedure when implemented on a computer should be accessible by telephone if the user desires special features or data not available in a "standard" field version.

4. REQUIREMENTS FOR MAJOR FACTORS AFFECTING EROSION

4.1 Climate

4.1.1 Erosive Agents The procedure is to compute erosion, deposition, and sediment yield caused by: (a) impacting waterdrops from rainfall or sprinkler irrigation and (b) surface flow from rainfall, sprinkler or surface irrigation, or snowmelt, including runoff from snowbanks. The procedure should also compute erosion of thawing soil.

4.1.2 Frequency of Estimates At the choice of the user, values will be computed on the following basis: (a) long term, average annual, (b) distribution by crop stages or seasons over an average or typical year, (c) frequency distribution of annual amounts, (d) frequency distribution by month, (e) frequency distribution by event, (f) single design storm, and (g) continuous simulation. These computations may assume time invariant soil, topographic, and land use conditions except in cases where the cover conditions consistently change over a period, like recovery following a disturbance in a forest. The continuous simulation option is not expected to be used in conservation planning.

4.1.3 Climatic (Weather) Inputs Climatic (weather) inputs can be, but are not limited to values: (a) generated by a stochastic (random) weather generator, (b) obtained from historical weather records, or (c) derived from design storm characteristics including additions of water by sprinkler or surface irrigation. In any case, the climatic inputs shall be retrievable from a prerecorded record that can be directly accessed by the computer program implementing the procedure, and use of the procedure shall require no action by the user when the procedure is applied within specified geographic regions. An objective is to use a minimum number of storms in a given application. Direct use of long term, daily, or storm-by-storm historical weather data is least desirable. In the case of design storms, the maximum information that should be expected from the user is: (a) storm amount, (b) average intensity, (c) ratio of peak intensity to average intensity, and (d) time to peak. When design storms are used, the user is to have the capability of choosing parameter values for existing conditions such as soil moisture.

The FS and the BLM collect weather information at a great number of sites, both remotely and at manned stations. This information is maintained in the Administrative Forest Fire Information and Retrieval Management System (AFFIRMS) and National Fire Weather Data Library (NFWDF). The ideal situation would be for the user to be able to select data from a nearby site, and then, through a simple model, have the data modified for any change in elevation and aspect.

4.2 Soil

The procedure must apply to a list of "key" soils as agreed to by SCS, BLM, FS, and ARS.

4.2.1 Soil Criteria The "key" soils should include a cross section of U.S. soils having a range of properties thought to affect erodibility by raindrop impact and surface flow, sediment properties at the point of detachment, infiltration, and antecedent soil moisture. The procedure must deal with eroded and uneroded soil phases. The criteria for selecting specific soils for the "key" soils list is: (a) values of important properties are uniformly spread over their range, (b) inclusion of at least five soils within the textural classifications of sandy loam, loamy sand, and sand (group of soils where runoff limits erosion) and at least five soils within the textural classifications of sandy clay, silty clay, and clay (group of soils where detachment limits erosion), (c) inclusion of several soils with major erosion problems, (d) inclusion of range soils, and (e) inclusion of soils susceptible to both water and wind erosion.

Selection of soils should consider differences among soils according to their separate susceptibilities to interrill erosion and rill erosion and according to characteristics of their sediment at the point of detachment that are important in transport and deposition processes. Ideally the soils on the "key" soils list would reflect a range of soil properties that affect soil erodibility and transportability indices. These properties could include: (a) texture, (b) organic matter, (c) aggregate size and stability, (d) soil structure, (e) bulk density, (f) soil surface shear strength, (g) crust thickness and penetration resistance, (h) water retention, (i) Fe and Al oxides, (j) Na, Mg, Ca, and K contents, (k) salinity characteristics, (l) acidity, (m) cation exchange capacity, (n) clay mineralogy, and (o) morphology of soil particles at and near the soil surface. Those properties important in determining "base" erodibility values are ones that are assumed to be time-invariant and are not affected by land use with the exception of properties like aggregate size and stability, susceptibility to crusting, soil strength, and bulk density. These and similar properties must be determined for a "standard" condition. A more detailed and orderly listing of soil properties important to soil erodibility is given in Appendix 1.

The Soils Lists given in Appendix 2 reflect a consideration of these criteria and a range of these properties. The Lists represent those soils that when limited to about 20 to 30 cropland, range, and forest soils would be ones that provide a range of characteristics and are ones for which the users would most want soil erodibility values when the WEPP model is delivered in August 1989.

The key soils must include a cross section of soils characteristic of mountainous rangeland and forestland. The number of soils evaluated will be limited but should represent a wide range in geographic location, geomorphic situation, vegetative community, elevation, climatic conditions, management, and rock fragment content. Slopes between 20 and 75 percent should be represented.

4.2.2 Soil Input Values for the important time-invariant soil properties needed by the procedure should be prerecorded, and their input to the procedure shall require no action by the user other than to specify a soil survey mapping unit. The required properties could be available in a soils data base that may be remote from the office site. However, over time, the required soils data base needed by a local office should be available on the field office computer. The field user should be able to optionally change soil properties from those given in the data base, if on-site conditions indicate that a change is desirable. The user can also specify different soils at different locations in the field.

4.3 Topography

4.3.1 Types of Topographic Representations Topography is to be considered in three ways. One form of the procedure is the one that applies to a given landscape profile. This profile is chosen by the user in much the same way that a landscape profile is chosen to apply the USLE. The difference is that slope length would be the distance from the origin of overland flow to a concentrated flow channel or waterbody rather than end at a depositional area. This application, referred to as the *profile* version, considers sheet and rill erosion, but not concentrated flow erosion. The second version is the *watershed* version, which applies to a given watershed within the field. It considers sheet-rill erosion and deposition by overland flow, erosion and deposition by concentrated flow channels, and deposition in impoundments. The *watershed* version applies to selected watersheds within the field being analyzed, and it does not refer to a version that can apply to large complex watersheds. The third version, the *grid* version, completely covers the field with grid elements and computes sheet and rill erosion and deposition by overland flow for each grid, erosion and deposition by concentrated flow along each concentrated flow channel within each grid, deposition in each impoundment within the field, and sediment yield at all outlet points from the field.

4.3.2 Profile Version The profile version is applied to landscape profiles selected by the user.

4.3.2.1 Output: The profile version is to compute: (a) net erosion or deposition, (b) rill erosion or deposition by flow, (c) interrill erosion,

(d) fineness of the eroded or deposited sediment, (see Section 3.2 for a definition of fineness), (e) sediment load, and (f) fineness of the sediment load. As a minimum, this version outputs average soil loss for the slope length (sediment yield/unit of slope length). Erosion rate for the erosional parts of the profile and deposition rate for the depositional parts of the slope are to be computed for slope length segments located along the slope length as specified by user input. The procedure must have the capability to store results from individual profiles within a field and to use these values to compute weighted averages for the field based on the fraction of the field that each profile represents.

4.3.2.2 Input: The user will have two options to specify characteristics of the landscape profile. The options are: (a) to specify a slope length, average steepness, location of the major inflection point, degree of curvature of the upper slope, and degree of curvature of the lower slope and (b) locations and slope steepnesses along the profile. These features are indicated in Figure 1 of Appendix 3.

4.3.3 Watershed Version To apply the watershed version, the user chooses a watershed within the field to apply the model. This version must at least apply to the situations shown in Figures 2 through 5 of Appendix 3. Symmetry between subwatersheds may be assumed.

4.3.3.1 Output: The outputs for the slope length profile portion of the watershed version is the same information produced by the profile version. The output for the concentrated flow portion is to be the same as that for the profile portion except that output is by channel reach rather than by slope length segment.

4.3.3.2 Input: Inputs for the profile portion of the watershed version are to be the same as those for the profile version. Inputs for the concentrated flow portion are to be: (a) channel cross section properties, (b) locations along the channel and grades at those locations, (c) information on the outlet control to the channel, and (d) drainage areas at the upper and lower ends of the channels. The channel outlet control will consider backwater from: (a) uniform flow in the last reach of the channel or uniform flow in a specific outlet channel at the end of the given channel, (b) critical depth at the end of the channel, or (c) a natural or constructed outlet control with a known rating curve. The input for a within-field impoundment will be the sideslopes that form the basin or coefficients for an area-depth curve and simple information on the rating function that describes flow out of the impoundment.

4.3.4 Grid Version The grid version describes erosion and sediment movement in grids that can cover entire regular or irregularly shaped fields with boundaries that may not coincide with watershed boundaries as shown in Figure 6 of Appendix 3.

4.3.4.1 Output: The outputs will be the same as those for the watershed version except that the values are based on grid areas rather than on slope length or channel reach segments.

4.3.4.2 Input: The input to the grid model will be slope steepness and direction for each grid and the grade and direction of a channel reach within a grid. Properties of channel cross sections and channel outlet controls will be input like those in the watershed version. Topographic field data needed to analyze a 640 acre field should be obtainable within eight hours by three people. As an alternative to collecting field data, the procedure shall accept data derived from 2 ft contour maps or maps with a greater contour interval provided an adequate definition of the slope profiles and concentrated flow paths can be determined.

4.3.5 Resolution The procedure is to use a minimum number of slope length and channel reach segments. The minimum should be that needed to provide the detail of output information requested by the user and that needed for satisfactory computational accuracy. Satisfactory computational accuracy is achieved when computed values are within 10 percent of their "exact" values. The purpose of this requirement is to minimize run time while maintaining satisfactory computational accuracy.

4.3.6 Spatial Variability The procedure is to allow infiltration, soil erodibility, and other soil factor values to vary as soil mapping units vary and crop yield varies along a landscape profile, along a concentrated flow channel profile, and over a field. The procedure must be able to accommodate at least 10 combinations of land use situations[1] for a profile, channel, or field and

1 A land use situation or condition is defined by differences in crop, tillage, or sequence in a rotation that have a significant effect on erosion.

ten strips, each having a different land use condition, in strip-type situations. Some of the most complex strip cropping situations are illustrated in Appendix 4. In addition to dealing with "conventional" strip cropping, the procedure is to consider skip-row farming common to some cotton farming systems where four rows of crop are alternated with two blank rows and other similar combinations are used. Also, the procedure is to accommodate the different land use situations indicated in Figures 2 through 5 of Appendix 3.

4.4 Land Use

4.4.1 Land Uses Considered by Prediction Procedure The land uses to be considered by the erosion prediction procedure produced by this project include: cropland; vegetable land; hayland; pastureland; orchards; vineyards; nurseries; rangeland; disturbed forest land; construction sites; road surfaces, cuts, and fills; surface mines; hazardous waste sites; recreational; and other land uses where surface flow occurs over the entire area and erosional processes are only slightly affected by "partial area" hydrology as illustrated in Appendix 5. These lands may be non-irrigated, sprinkler irrigated, or surface irrigated. This project will provide the basic relationships from a component analysis to describe the important factors of land use that affect erosion. Although parameter values unique to the land uses listed above may be required, this project will directly provide only those for the "key" land uses described below. Scientists contributing to the project on their own may provide some of the additional parameter values.

4.4.1.1 Cropland: The procedure as delivered in 1989 is to work satisfactorily for: the rowcrops of corn, soybeans, sorghum, and cotton; small grain; hayland that may be periodically cultivated; and pastureland that is occasionally renovated. The procedure as delivered in 1989 also will apply to other land uses such as vegetable crops, orchards, vineyards, and close grown legumes, but using parameter values based on judgement rather than data from specific field experiments on those practices. The procedure is to apply to all land uses as satisfactorily as does the USLE, recognizing that the USLE is applied to many situations without supporting experimental data.

4.4.1.2 Rangeland: The procedure will consider: grasslands, brushland, savanna, tundra, sagebrush lands, salt-desert shrublands, Southwest semi-desert grasslands, lands, deserts, pinjon-juniper woodlands, chaparral, and badlands. Rangelands can be highly nonuniform in microtopography and vegetation and a range site can have 15 to 20 separate species of plants. Rangelands are diverse and vary greatly as a result of natural processes that occurred over many years. The procedure is to be able to account for natural differences in rangelands as well as differences caused by specific grazing, vegetative, and mechanical management practices. The procedure is to work for rangelands common to all of the U.S, including steep, mountainous rangelands and alpine areas.

4.4.1.3 Disturbed forestlands: The procedure is to apply to forest lands where overland flow occurs and usual hydrologic procedures used to describe overland flow hydrology can be reasonably applied. Overland flow does not occur in many undisturbed forests and thus this procedure would not apply to those situations. However, the procedure is expected to apply in common forest activities where harvesting, road construction and maintenance, site preparation, burning, grazing, mining, and other activities have disturbed the cover and exposed mineral soil enough that overland flow occurs. The procedure is also expected to apply in undisturbed forests where overland flow occurs.

4.4.1.4 Management and tillage systems: On cultivated land, the procedure will accommodate: (a) clean tillage systems (e.g., moldboard plow, disk, field cultivate, plant, harvest); (b) conservation tillage systems (e.g., no-till, ridge till) identified by residue level, degree of disturbance, ridge height, and other factors; (c) solid seeded, low residue crops; (d) crop rotations with durations at least through ten years [See Appendices 4 and 6 for some atypical rotations.] (e) multiple (double, triple) cropping; (f) intercropping, (g) manure additions, (h) silage and residue removal, (i) mulching, (j) winter cover crops, (k) winter grazing, and (l) up to five hay cuttings. On rangeland, the management systems that the procedure is to describe include: (a) grazing management, (b) brush management, (c) range seeding, and (d) conversion to and from rangeland. On forest land, it is to consider typical practices.

4.4.1.5 Supporting (mechanical) practices: These practices for any land use include: (a) contouring, (b) ridging, (c) bedding, (d) hillside ditches, (e) furrow diking, (f) terraces (level, gradient, and tile outlet), (g) diversions, (h) strip cropping, (i) divided slopes; (j) grass buffer strips, (k) subsoiling and ripping, (l) land imprinting, (m) root plowing, (n) pitting, (o) chaining, (p) tree grubbing, and (q) prescribed burning and other fire. Other practices having an impact on erosion control that are to be considered include: (a) controlled traffic, (b) water and sediment control basins, (c) small impoundments (d) grassed waterways, (e) surface drains, (f) tile drains, (g) surge irrigation, and (h) irrigation reorganization such as changing length of run and slope.

4.4.2 Representation of Land Use Effects A component method will be used to represent the effects of land use on erosion and deposition. The components considered to be most important are: (a) canopy; (b) ground cover (including crop residue, stems and leaves, growing plants touching the soil, rock fragments, and surface litter); (c) surface roughness (random and oriented -- tillage marks); (d) incorporated residue (short term mechanical and long term effects); (e) below ground biomass (incorporated residue and roots); (f) land use residual (e.g., soybean and meadow effects); (g) seasonal (crop growth and soil effects other than antecedent soil moisture and soil thawing); (h) soil thawing; (i) soil consolidation; (k) tillage (type, pulverization, and recency); and (l) wetting, drying, traffic, and other recent events affecting soil erodibility.

4.4.3 Major Land Use Modules The major modules of the procedure needed to describe land use will include: (a) crop growth, (b) tillage, (c) residue decomposition, (d) grazing and (d) supporting practices.

4.4.3.1 Crop module: This module is expected to estimate: (a) canopy cover percentage and height with time, (b) residue mass and coverage at harvest, and (c) below ground biomass per unit area and its distribution with depth and time. These growth characteristics will be described by nondimensional growth curves identified by major crop type. The user is to have the option of changing these curves, and plant growth will be sensitive to environmental conditions in the continuous simulation mode of operation. For input, the user will enter the names of the crops in a rotation. Planting and harvest dates, fertility level, yield, and cropping history would be entered if actual values differ significantly from typical local values that have been prerecorded in a database. The procedure will use prestored values to the fullest extent possible, but the user may change default values, including those listed above plus expected crop height, maximum canopy cover percentage, ratio of residue mass to grain yield, and ratio of root biomass to grain yield.

4.4.3.2 Tillage module: The tillage module, which represents soil disturbing activities, will estimate: (a) surface roughness, bulk density, and aggregate size at the time of tillage as a function of implement properties, soil texture and organic matter, production level, and moisture content at time of tillage; (b) changes in roughness, bulk density, and aggregate size with time as a function of soil texture and organic matter, cover-management, rainfall, freezing/thawing (overwintering), and erosion; and (c) burial of residue and its distribution with depth as a function of soil and implement properties. The user will have the option to choose input by: (a) name of tillage operation, which will use prestored information or (b) properties and time of the tillage operation, which will include "base" roughness value for a standard condition, degree of pulverization, depth of tillage, residue covered for a standard condition, ridge and row spacings, and ridge height.

4.4.3.3 Residue decomposition module: The residue decomposition module is to estimate: (a) mass and percent cover of residue including forest litter and logging slash, on the soil surface at any time and (b) mass and distribution with depth of residue, roots, and other biomaterials in the soil at any time. The module is to distinguish among major differences according to soil, climate, crop, and tillage. In particular, the component is to be driven by: (a) soil temperature, (b) soil texture, (c) soil moisture, and (d) type of residue. User inputs to drive this component will be taken from those listed for the other land use modules.

4.4.3.4 Grazing module: This module is to estimate the removal of above ground biomass and changes in soil properties such as density and roughness that affect infiltration and erosion caused by animal grazing and traffic. Other secondary effects such as loss of below ground biomass and surface ground cover would also be computed.

4.4.3.5 Supporting practices module: Most supporting practices affect erosion by either reducing runoff, redirecting it, or directly reducing the hydraulic forces of the flow. The procedure is to accommodate increased infiltration and the resulting runoff reduction. Runoff redirection is to be considered by flow path definition in the topographic inputs. The procedure is to accommodate at least two flow path configurations that may occur any number of times during a cropping rotation. These flow path configurations are defined by the user as input. The effect of practices like strip cropping and grass strips are to be analyzed by their effect on infiltration, runoff rate and amount, and the reduction of runoff's shear stress acting on the soil caused by an increase in hydraulic roughness.

5. *OPERATIONAL REQUIREMENTS*

The primary application of this erosion prediction technology will be by field personnel who will be using the procedure as a tool to assist land managers in making soil conservation decisions. Major factors important to these users are: (a) computational time, (b) ease of use, (c) applicability to the broad range of conditions typically encountered in field programs, (d) robustness, (e) validity, and (f) ease of explanation to client.

5.1 Computational Time

Developers of the procedure are to strive for computational efficiency and to have the procedure operate as quickly as possible. The procedure is to compute the frequency distribution of annual soil loss values for the profile version at the rate of one management practice per minute and one practice per two minutes for the watershed version running a single overland flow profile and a single concentrated flow channel. The rate can be proportionally slower for more complex systems. Also, not more than 30 minutes per farm of actual user time (computer time can be longer) is to be required in the office to prepare and assemble needed information before going to the field. Once in the field, no more time can be used to collect and assemble input information than would be required for the USLE when the profile version is used. The criteria to be used by the developers for judging the acceptability of an internal simplification in the procedure are: (a) does the planning or assessment decision change -- if not, use the procedure that requires the least resources -- and do computed values for the primary output variable change more than 10 percent -- if they do, is the change of consequence?

5.2 Ease of Use

The procedure shall be easy to use, especially for the infrequent user, by accepting simple inputs that are commonly available and understood by personnel in the local field office. It should require little structured training or support. Also, it shall be flexible and accept inputs on increasing detailed and complex levels if the user determines that more detail is needed or that default values need changing. The user shall not have to directly manipulate any mathematical equations to use the procedure; all mathematical manipulations shall be done by a computer program. The procedure is to be designed so that a maximum amount of computations can be made once-and-for-all and stored for repeated use. Likewise, the procedure shall be constructed so that data files specific to a given local area (a county or sub-county unit) can be prepared and stored locally so that the field office user only has to search and retrieve minimal data with each application. In so far as possible, the procedure shall use data and data files used in other SCS, BLM, and FS applications, and it should be compatible with Geographic Information Systems (GIS). The output should display in an easily understood form the consequence of alternative management options.

5.3 Applicable to Broad Range of Conditions

The procedure, within the limits defined by this document, must apply to all sheet-rill erosion problems that local field office personnel encounter. In particular, it must apply to all conditions covered by the USLE plus additional ones. Similarly, this requirement also applies to all concentrated flow erosion situations, but the procedure is not for hydraulic design of waterways.

5.4 Robustness

The procedure must tolerate out-of-range input data and combinations of inputs that might cause problems. The procedure should use asymptotic, "well behaved" functions to avoid extremely incorrect values and the procedure unexpectedly "blowing up." See the Appendix 7 for an example. It must tolerate applications for which it is not intended. However, the procedure must alert the user to these excesses, alert for loss of accuracy when inputs are over simplified such as for slope shape, and check for incorrect data entries. The procedure should alert the user to the possibility of obtaining "additional" information with more detailed inputs.

5.5 Validity

The procedure must be sufficiently accurate to lead to the planning and assessment decision that would be made in the large majority of cases when full information is available. However, more than accuracy is to be considered in establishing the validity of the procedure. The procedure is to be validated, and the validation process and its results are to be documented. The prediction procedure is expected to be composed of a number of modules. Each major module is to be individually validated, and the procedure is to be validated as a package.

5.5.1 Validation Criteria Validation is to be based on the procedure meeting all of the following criteria. (a) The model is valid if it serves its intended purpose as defined by these specific User Requirements. (b) The model is based on scientific principles and represents a reasonable expression of current scientific understanding of erosion processes that can be used in an applied procedure. (c) The procedure gives expected responses that appear reasonable. For example, the output varies qualitatively with ground cover (or any variable or combination of variables) in the way that is commonly accepted by erosion experts. (d) The model gives results that are more useful for agency program objectives than those given by the USLE and applies to situations not appropriate for the USLE. These situations include deposition in furrows, especially as influenced by plant residue in the furrows; nonuniform distribution of cover between ridges and furrows; the acceleration of rill erosion above a critical steepness; the variation in slope length, slope steepness, ground cover, and contouring relationships with climate, soil, topography, and land use; erosion by surface irrigation; deposition on concave slopes; and concentrated flow erosion. (e) The model provides a reasonable representation of data covering the range of conditions of the "key" situations described above. (f) Judgements on the "goodness of fit" of the estimates from the procedure to observed data are to be based on the data sets as a whole and not on a few specific and isolated data sets. Quantitative measures of the "goodness of fits" will be calculated and presented, but a specific quantitative level of accuracy figure is not being required because of the great variation in the experimental data that will be used in validation. However, the results are to be at least as good with respect to observed data and known relationships as those from the USLE. (g) The model is able to "stand up" in public hearings of management plans and assessments.

5.6 Ease of Explanation

The procedure is to be based on a set of principles and concepts that can be explained by local field personnel to the client. The procedure is to be developed so that the user can easily demonstrate how the major factors of climate, soil, topography, and land use affect erosion.

6. IMPLEMENTATION OF PROCEDURE

The procedure described above must be implemented in some mathematical form that allows it to be used. The procedure will be conceptualized and described with logic and mathematical expressions to form a model, which will be coded in a computer program. A record and description of these activities is to be delivered.

6.1 Model Considerations

6.1.1 Structure The model is to be based on the fundamental erosion processes of: (a) interrill erosion (principally detachment by raindrop impact and lateral transport by thin flow), (b) rill and concentrated flow erosion (detachment by flow), (c) sediment transport by flow, (d) deposition by flow, (e) deposition in impoundments, and concentrated flow hydraulics. The model is expected to include major modules for: (a) climate generation; (b) snow accumulation, (c) snowmelt, (d) infiltration, (e) runoff, (f) soil temperature, (g) erosion, (h) soil moisture, (i) crop growth, (j) plant residue, and (k) tillage. Implicit in all of these modules except for the climate module is the central role of soil and soil properties. Although the model will include these modules, it is NOT intended to be used specifically as a model for crop yield, water quality, soil moisture, runoff, stochastic (random) climate variables, wind erosion, or erosion and sediment yield from classical gullies, stream channels, or large complex watersheds.

6.1.2 Hydrologic Elements Hydrologically, the model is to apply to conditions where overland flow is significant, and runoff and erosion is not dominated by "partial area" hydrology. The model will consider lateral subsurface flow and baseflow using a simple travel time approach that takes position on the landscape into account. It will consider vertical water movement in the root zone and tile drainage only to the extent needed to compute surface runoff sufficiently accurate for erosion computations. The hydrologic elements will be: (a) overland flow (broad sheet flow and concentrated flow in "furrows"), (b) concentrated flow in major natural and constructed waterways (ephemeral gullies plowed over within the crop rotation, terrace and diversion channels, grassed waterways, and rangeland gullies comparable to within-field concentrated flow channels), (c) small impoundments (underground tile outlet terrace impoundments, level terraces without outlets, water and sediment control basins, within-field natural impoundments, farm ponds, and other similar within-field structures and features), (d) simple return, lateral, and base flow, and (e) simple tile drainage.

6.1.3 Family of Models A family of models is permissible to meet the entirety of the user requirements. All of the models in the family are intended for use by SCS, FS, and BLM; research models are not permissible in the family. Commonality within the family and with other models is to be maintained where reasonable. In so far as possible, relationships used in simplified versions in the family are to be derived from those in the most detailed version. This statement of commonality implies that when parameter values representing the assumptions used to derive the simplified relationships are input into the detailed relationships, they will give the same result as the simple ones for a given situation. Commonality in so far as possible is to be maintained with components of other models where particular dominant algorithms are emerging. The model and its coding are to be modular to make changing of model modules or submodules simple and easy. Inputs are to be common across this family of models and with other models in wide use in SCS in so far as possible.

6.1.4 Similarities with Other Models Since this model will have several features that are similar to those in existing models produced by ARS and others that are being used by SCS, SCS has asked for a brief description of several of these models. Similarities of this model with other models having similar components are described in Appendix 8. A model is like a tool in a tool chest. While a pair of pliers can sometimes be used as a wrench, a wrench of the proper design and size (i.e., the proper tool for the job) is usually chosen to tighten bolts. Similarly, this prediction model is to be developed as the best tool for predicting erosion by the field user. Other models are better for other purposes, e.g., EPIC for estimating the impact of erosion on productivity.

6.1.5 Modification of Model Modules The various modules or model subcomponents are to be constructed so that they can be easily maintained and replaced. Also, the modules are to be constructed in a way to facilitate their use in combination with other models.

6.2 Coding

The main requirements presently identified for the coding is that the model and its code will follow a structured design. The model will be programmed using structured programming procedures. The program must be developed in the programming languages of FORTRAN 77 or C, and machine dependent routines are to be avoided to enhance transportability. The language and other requirements related to programming are to be developed during further discussions with SCS, FS, and BLM. Also, mnemonic variable names will be used. Additional details are to be developed on computer requirements such as data base management, menu vs. command driven, and input and output screens.

6.3 Documentation

The main delivered product from the project will be a computer program and documentation transferred on tape, floppy disk, or electronically between computers. However, written documentation is to accompany the computer file. The documentation will describe the governing logic and mathematical relationships on which the model is built, validation of the model, information needed to install the computer program, description of inputs and how to obtain them, and instructions on how to run the program and use the model. Also, information needed to maintain the model and its code will also be provided. "User" type documentation will be jointly developed by ARS and the user agencies.

7. APPENDIX 1 - IMPORTANT SOIL PROPERTIES AFFECTING SOIL ERODIBILITY

I. Measurements on Disturbed Soil Samples (Sieved and/or Ground)

A. Time Invariant Properties

1. Primary clay
2. Primary silt
3. Primary sand
4. Coarse fragments
5. Carbon (Organic matter)
6. Total nitrogen
7. Iron
8. Aluminum
9. Silicon
10. Extractable bases
11. Soluble cations
12. Cation exchange capacity
13. Carbonates
14. Acidity
15. Soil consistency (Aterburg limits)

B. Aggregate Properties

1. Dry aggregate size
2. Aggregate stability indices

C. Mineralogical and Morphological Properties

1. Description and relative abundance of clay minerals
2. Description and relative abundance of amorphous materials
3. Morphology of coarse silt and sand primary particles
4. Morphology of coarse silt and sand-sized aggregates
5. Qualitative description of aggregation mechanics (e.g., abundance of fine root hairs, fungal hyhae)

D. Properties of Remolded Cores

1. Infiltration related properties

a. Moisture-tension relationship
b. Saturated hydraulic conductivity
c. Unsaturated hydraulic conductivity
d. Hydrophobic and hydrophillic conditions
e. Rock fragments

2. Erosion related properties

a. Cohesion and friction angle
b. Detachment by impact of single drop
c. Shear strength by fall cone
d. Shear strength by direct shear
e. Penetration resistance

II. *In-situ* Soil Measurements Associated with Field Erodibility Testing

A. Interrill erodibility tests

1. Depth of Ap horizon
2. Bulk density
3. Microrelief
4. Shear strength

a. Fall cone
b. Penetration resistance

5. Crust characteristics

a. Thickness
b. Rupture resistance

6. Antecedent soil moisture

B. Rill erodibility tests

1. Depth of Ap horizon
2. Bulk density
3. Shear strength

a. Fall cone
b. Torvane
c. Penetration resistance

8. APPENDIX 2 - SOILS LIST

I. Cropland Soils (List 4.0)

A. Table 8.1: List of Cropland Soils.

Category I (Highest Priority)

1. Abilene (TX)	- fine, mixed, thermic Pachic Argiustoll
2. Anselmo (NE)	- coarse-loamy, mixed, mesic Typic Haplustoll
3. Bonifay (FL)	- loamy, siliceous, thermic Grossarenic Plinthic Paleudult
4. Cecil (NC)	- clayey, kaolinitic, thermic Typic Hapludult
5. Forman (ND)	- fine-loamy, mixed Udic Argiboroll
6. Frederick (VA)	- clayey, mixed, mesic Typic Paleudult
7. Grenada (MS)	- fine-silty, mixed, themic Glossic Fragiudalf
8. Heiden (TX)	- fine, montmorillonitic, thermic Udic Chromustert
9. Keith (NE)	- fine-silty, mixed, mesic Aridic Argiustoll
10. Miami (IN)	- fine-loamy, mixed, mesic Typic Hapludalf
11. Pierre (SD)	- very-fine, montmorillonitic, mesic Ustertic Camborthid
12. Monona (IA)	- fine-silty, mixed, mesic Typic Hapludoll
13. Palouse (WA)	- fine-silty, mixed, mesic Pachic Ultic Haploxeroll
14. Ramona (CA)	- fine-loamy, mixed, thermic Typic Haploxeralf
15. Salinas (CA)	- fine-loamy, mixed, thermic Pachic Haploxeroll
16. Sverdrup (MN)	- sandy, mixed Udic Haploboroll
17. Tifton (GA)	- fine-loamy, siliceous, thermic Plinthic Paleudult
18. Walla Walla (WA)	- coarse-silty, mixed, mesic Typic Haploxeroll
19. Williams (ND)	- fine-loamy, mixed Typic Argiboroll
20. Woodward (OK)	- coarse-silty, mixed, thermic Typic Ustochrept

Category II (Lower Priority)

1. Balcom (CA)	- fine-loamy, mixed, thermic Calcixerollic Xerochrept
2. Chester (MD)	- fine-loamy, mixed, mesic Typic Hapludult
3. Clarion (IA)	- fine-loamy, mixed, mesic Typic Hapludoll
4. Davidson (GA)	- clayey, kaolinitic, thermic Rhodic Paleudult
5. Dunkird (NY)	- fine-silty, mixed, mesic Glossoboric Hapludalf
6. Mexico (MO)	- fine, montmorillonitic, mesic Udollic Ochraqualf
7. Morley (IL)	- fine, illitic, mesic Typic Hapludalf
8. Portneuf (ID)	- coarse-silty, mixed, mesic Durixerollic Calciorthid
9. Sharpsburg (IA)	- fine, montmorillonitic, mesic Typic Argiudoll
10. Zahl (ND)	- fine-loamy, mixed Entic Haploboroll

B. Table 8.2. Arrangement of Cropland Soils by Order and Suborder.

Order	Suborder: Warm Soils — Moist	Warm Soils — Wet	Warm Soils — Dry	Cool Soils — Moist
Alfisols (6)	**Udalfs** Dunkirk Grenada Miami Morley	**Aqualfs** Mexico	**Xeralfs** Ramona	
Aridisols (2)			**Orthids** Pierre Portneuf	
Inceptisols (2)	**Ochrepts** Balcom Woodward			
Mollisols (13)	**Udolls** Clarion Monona Sharpsburg		**Ustolls** Abilene Anselmo Keith **Xerolls** Palouse Salinas Walla Walla	**Borolls** Forman Severdrup Williams Zahl
Ultisols (6)	**Udults** Bonifay Cecil Chester Davidson Frederick Tifton			
Vertisols (1)			**Usterts** Heiden	

C. Table 8.3: Arrangement of Cropland Soils by Texture.

Sand	Silt loam	Loam	Sandy clay loam
Bonifay	Chester	Balcom	Davidson
	Grenada	Clarion	Dunkirk
Loamy sand	Keith	Williams	
Sverdrup	Mexico	Woodward	**Clay loam**
Tifton	Miami	Zahl	Abilene
	Monona		Forman
Sandy loam	Palouse	**Silty clay loam**	Morley
Anselmo	Portneuf	Frederick	Salinas
Cecil	Walla Walla		
Ramona	Sharpsburg		**Clay**
			Heiden
			Pierre

II. Rangeland Erodibility Soils (List 2.0)

These rangeland soils have been identified as target soils having a range of soil properties that make them important for determining erodibility values. Unlike cropland, erosion on rangeland must be studied as a combination of soil and site conditions. This list was developed primarily from soil erodibility considerations. The following list in section III gives soil/site combinations that have been chosen for WEPP experiments where both soil and site conditions were considered along with operational factors such as availability of water.

A. Table 8.4: List of Rangeland Erodibility Soils.

1.	Amarillo (TX)	- fine-loamy, mixed, thermic Aridic Paleustalf
2.	Bainville (MT)	- fine-silty, mixed (calcareous), mesic Ustic Torriorthent
3.	Blazon (WY)	- loamy, mixed (calcareous), frigid, shallow Ustic Torriorthent
4.	Cave (AZ)	- loamy, mixed, thermic, shallow Typic Paleorthid
5.	Colby (KS)	- fine-silty, mixed (calcareous), mesic Ustic Torriorthent
6.	Lucien (OK)	- loamy, mixed, thermic, shallow Typic Haplustoll
7.	Lucky Star (UT)	- loamy-skeletal, mixed Cryic Paleboroll
8.	Mohave (AZ)	- fine-loamy, mixed, thermic Typic Haplargid
9.	Morton (ND)	- fine-silty, mixed Typic Argiboroll
10.	Nannyton (ID)	- fine-loamy, mixed, mesic Typic Haplargid
11.	Parleys (UT)	- fine-silty, mixed, mesic Calcic Argixeroll
12.	Pierre (SD)	- very-fine, montmorillonitic, mesic Ustertic Camborthid
13.	Pratt (KS)	- sandy, mixed, thermic Psammentic Haplustalf
14.	Summit (OK)	- fine, montmorillonitic, thermic Vertic Argiudoll
15.	Tarrant (TX)	- clayey-skeletal, montmorillonitic, thermic Lithic Calciustoll
16.	Tillman (TX)	- fine, mixed, thermic Typic Paleustoll
17.	Vebar (ND)	- coarse-loamy, mixed Typic Haploboroll
18.	Venable (CO)	- fine-loamy, mixed Cumulic Cryaquoll
19.	Vernon (TX)	- fine, mixed, thermic Typic Ustochrept
20.	Vista (CA)	- coarse-loamy, mixed, thermic Typic Xerochrept

B. Table 8.5: Arrangement of Rangeland Erodibility Soils by Order and Suborder.

	Suborder			
	Warm Soils		Cool Soils	
Order	Moist	Wet	Dry	Moist
Aplfisols (2)		**Aqualfs**	**Ustalfs** Amarillo Pratt	
Aridisols (4)			**Argids** Mohave Nannyton **Orthids** Cave Pierre	
Entisols (3)			**Orthents** Bainville Blazon Colby	
Inceptisols (2)	**Ochrepts** Vernon Vista			
Mollisols (9)	**Udolls** Summit	**Aquolls** Venable	**Ustolls** Lucien Tarrant Tillman **Xerolls** Parleys	**Borolls** Lucky Star Morton Vebar

C. Table 8.6: Arrangement of Rangeland Erodibility Soils by Texture.

Loamy sand	**Loam**	**Clay loam**
Pratt	Cave (gravelly)	Blason
	Lucien	
Sandy loam	Nannyton (gravelly)	**Silty clay loam**
Amarillo		Summit
Mohave	**Silt loam**	
Vebar	Bainville	**Clay**
Venable	Colby	Pierre
Vista	Lucky Star (gravelly)	Tarrant
	Morton	Vernon
	Parleys	
	Tillman	

III. Rangeland soil/site combinations for evaluation of erodibility and cover/management effects

A. Table 8.7: List of Rangeland Soil/site Combination Soils

1. Bernardo (AZ)	- fine, mixed, thermic Ustollic Haplargid
2. Deaver (CO)	- fine, montmorillonitic (calcareous), mesic Typic Torriortent
3. Declo (ID)	- coarse-loamy, mixed, mesic Xerollic Calciorthid
4. Glasgow (ID)	- fine, montmorillonitic, mesic Xerollic Haplargid
5. Grant (OK)	- fine-silty, mixed, thermic Udic Argiustoll
6. Hackroy (NM)	- clayey, mixed, mesic Lithic Aridic Haplustalf
7. Nannyton (ID)	- fine-loamy, mixed, mesic Typic Haplargid
8. NSD-Area 11 (NV)*	- loamy-skeletal, mixed, thermic Typic Durorthid
9. NSD-Mercury (NV)*	- loamy-skeletal, mixed, thermic Typic Haplargid
10. NSD-Walnut Gulch (AZ)*	- coarse-loamy, mixed thermic Ustollic Calciorthid
11. Petescreek (CA)	- fine-loamy, mixed, frigid Pachic Agixeroll
12. Pierre (SD)	- very-fine, montmorillonitic, mesic Ustertic Cambothid
13. Pratt (OK)	- sandy, mixed, thermic Psammentic Haplustalf
14. Purves (TX)	- clayey, montmorillonitic, thermic Lithic Calciustoll
15. Querencia (NM)	- fine-loamy, mixed, thermic Ustollic Camborthid
16. Searla (ID)	- loamy-skeletal, mixed, frigid Calcic Agrixeroll
17. Shano (WA)	- coarse-silty, mixed, mesic Xerollic Camborthid
18. Vida (MT)	- fine-loamy, mixed Typic Argiboroll
19. Woodward (OK)	- coarse-silty, mixed, thermic Typic Ustochrept

*NSD - No Series Designated. Series names have not been assigned to these sites. The name following NSD refers to the location of the site.

B. Table 8.8. Arrangement of Rangeland Soil/site Combinations by Soil Order and Suborder.

Order	Suborder: Warm Soils — Dry	Suborder: Cool Soils — Moist
Alfisols (2)	**Ustalfs** Hackroy Pratt	
Aridisols (10)	**Argids** Bernardo Glasgow Nannyton NSD-Mercury	
	Orthids Declo NSD-Area 11 NSD-Walnut Gulch Pierre Querencia Shano	
Entisols (1)	**Orthents** Deaver	
Inceptisols (1)	**Ochrepts** Woodward	
Mollisols (5)	**Ustolls** Grant Purves	**Borolls** Vida
	Xerolls Petescreek Searla	

C. Table 8.9: Arrangement of Range Soil/site Combination Soils by Surface Texture.

Loamy Sand
Pratt

Silt Loam
Grant
Shano
Woodward

Sandy Loam
Declo
Hackroy
NSD-Area 11 (gravelly)
NSD-Walnut Gulch (gravelly)
Querencia

Loam
Glasgow
Nannyton
NSD-Mercury (gravelly)
Petescreek (gravelly)
Searla (gravelly)

Clay Loam
Bernardo
Vida

Silty Clay
Deaver

Clay
Pierre
Purves (gravelly)

IV. Forest Land Mountainous Rangeland Soils

A. Table 8.10: List of Forest Land Mountainous Rangeland Soils.

Category I (Highest Priority)

1.	Aiken (CA)	- clayey, oxidic, mesic Xeric Haplohumult
2.	Auburn (CA)	- loamy, mixed, thermic Ruptic-lithic Xerochrept
3.	Awhahnee (CA)	- coarse-loamy, mixed thermic Mollic Haploxeralf
4.	Berks (PA)	- loamy-skeletal, mixed, mesic, Typic Dystrochrept
5.	Boise (ID)	- sandy-skeletal, mixed Typic Cryoboroll
6.	Clarksville (AR)	- loamy-skeletal, siliceous, mesic, Typic Paleudult
7.	Edneyville (NC)	- fine-loamy, mixed, mesic, Typic Hapludult
8.	Gogebic (MI)	- coarse-loamy, mixed, frigid, Alfic Fragiorthod
9.	Granile (CO)	- loamy-skeletal, mixed, Typic Cryoboralf
10.	Legault (CO)	- sandy-skeletal, mixed, Typic Cryochrept
11.	Nathrop (CO)	- loamy-skeletal, mixed, Argic Cryoboroll
12.	Neuns (CA)	- loamy-skeletal, mixed, mesic Dystric Xerochrept
13.	Owen Creek (WY)	- fine, montmorillonitic, Argic Cryoboroll
14.	Smithdale (MS)	- fine-loamy, siliceous, thermic, Typci Hapludult
15.	Tolo (OR)	- medial/loamy, mixed, frigid, Typic Vitrandept
16.	Tunbridge (VT)	- coarse-loamy, mixed, frigid, Typic Haplorthod
17.	Waca (CA)	- medial-skeletal, frigid Andic Xerumbrept.
18.	Wellston (OH)	- fine-silty, mixed, mesic, Ultic Hapludalf

Category II (Lower Priority)

1.	Adel (MT)	- fine-loamy, mixed Pachic Cryoboroll
2.	Cecil (NC)	- clayey, kaolinitic, thermic Typic Hapludult
3.	Cieneba (CA)	- loamy, mixed, nonacid, thermic, shallow Typic Xerorthent
4.	Cookport (WV)	- fine-loamy, mixed, mesic, Aquic Fragiudult
5.	Grenada (MS)	- fine-silty, mixed, thermic, Glossic Fragidualf
6.	Karta (AK)	- loamy-skeletal, mixed Humic Cryorthod
7.	Marlow (NH)	- coarse-loamy, mixed, frigid, Typic Haplorthod
8.	Rubicon (MI)	- sandy, mixed, frigid, Entic Haplorthod
9.	Sitka (AK)	- medial, Humic Cryorthod
10.	Wiekert (PA)	- loamy-skeletal, mixed, mesic, Lithic Dystrochrept

B. Table 8.11: Arrangement of Forest Land Mountainous Rangeland Soils by Order and Suborder.

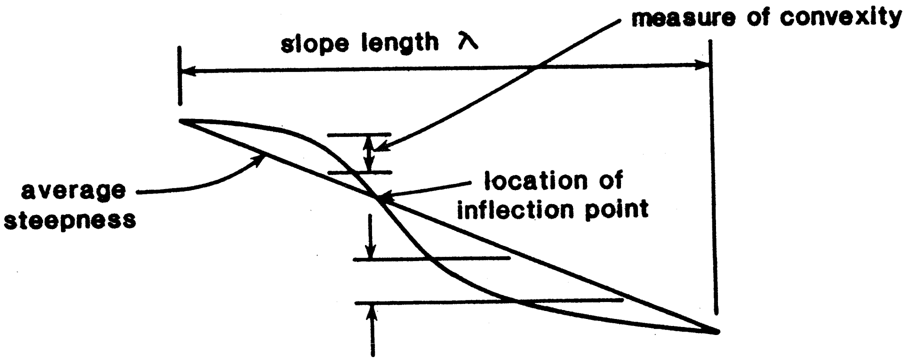
Order	Suborder: Warm Soils, Moist	Suborder: Cool Soils, Moist
Alfisols (4)	**Udalfs** Grenada Wellston **Xeralfs** Awhahnee	**Boralfs** Granile
Entisols (1)	**Orthents** Cieneba	
Inceptisols (7)	**Andepts** Tolo **Ochrepts** Auburn Becks Legault Neuns Weikert **Umbrepts** Waca	
Mollisols (4)		**Borolls** Adel Boise Mathrop Owen Creek
Spodosols (6)	**Orthods** Gogebic Karta Marlow Rubicon Sitka Tunbridge	
Ultisols (6)	**Humults** Aiken **Udults** Cecil Clarksville Cookport Edneyville Smithdale	

C. Table 8.12: Arrangement of Forest Land Mountainous Rangeland Soils by Surface Texture.

Loamy Sand	**Loam**	**Sandy Loam**
Boise	Adel	Awhahnee
Legault (stony)	Aiken	Cecil
Rubicon	Auburn	Cieneba
	Cookport	Edneyville
Silt Loam	Karta (gravelly)	Gogebic
Berks	Nathrop (stony)	Granile (gravelly)
Clarksville (very cherty)	Neuns (gravelly)	Marlow
Grenada		Smithdale
Owen Creek	**Medial***	Tunbridge
Tolo	Sitka	Waca (cobbly)
Weikert (channery)		
Wellston		

*Medial Volcanic derived; loamy by field texture; <60% ash, cinders, and pumice.

9. APPENDIX 3 - TOPOGRAPHIC REPRESENTATIONS

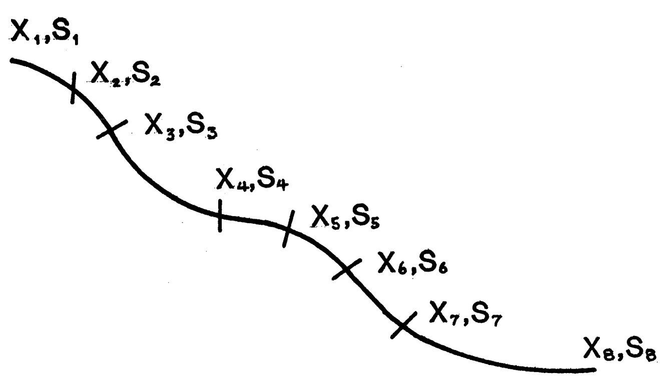


measure of concavity by perhaps slightly concave, moderately concave, strongly concave

Option 1: Specify the above general features of a landscape profile, the model would construct the necessary computational segments.

Both Options

A measure of the convergence or divergence of the landscape would be indicated.



Option 2: Specify locations and steepnesses at the locations along the slope. A linear variation of slope between points would be assumed.

Figure 9.1: Options for inputting landscape profile information.

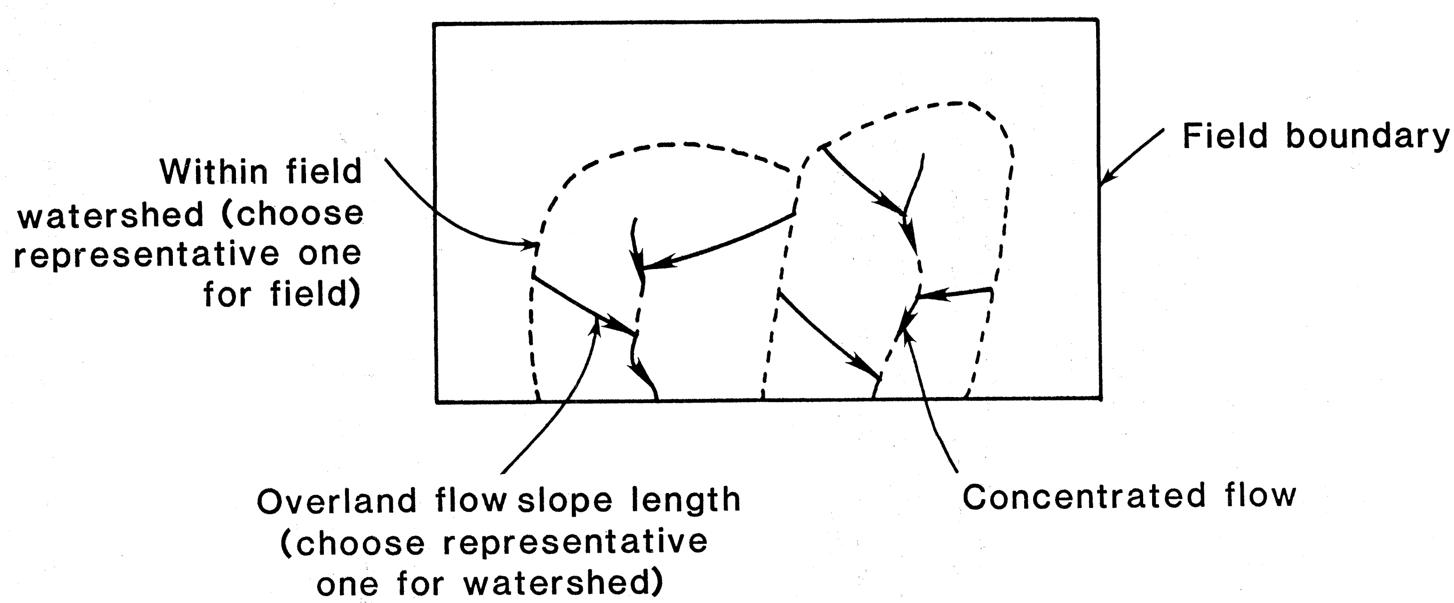


Figure 9.2: Simple first order watershed.

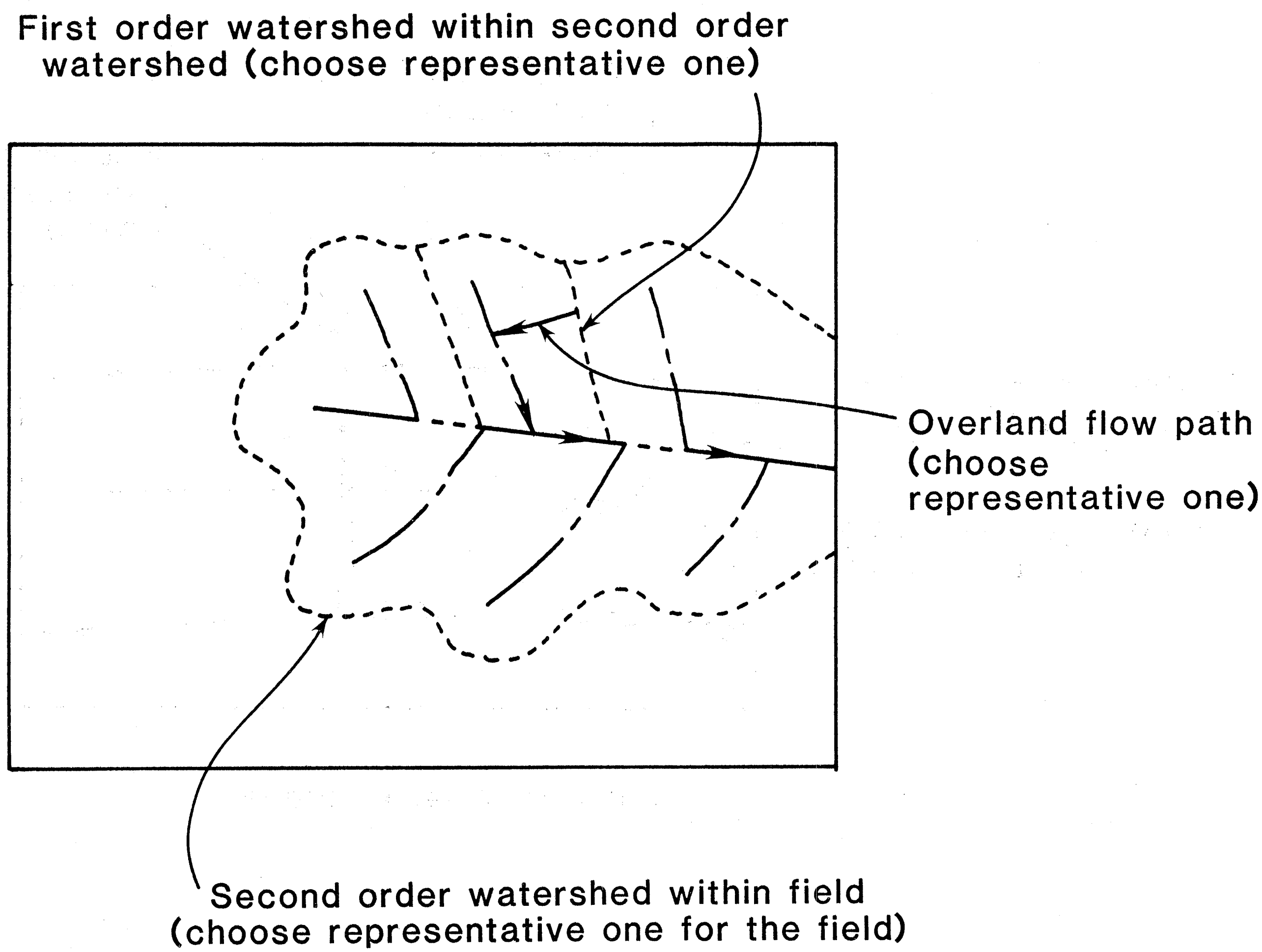


Figure 9.3a: Example second order watersheds.

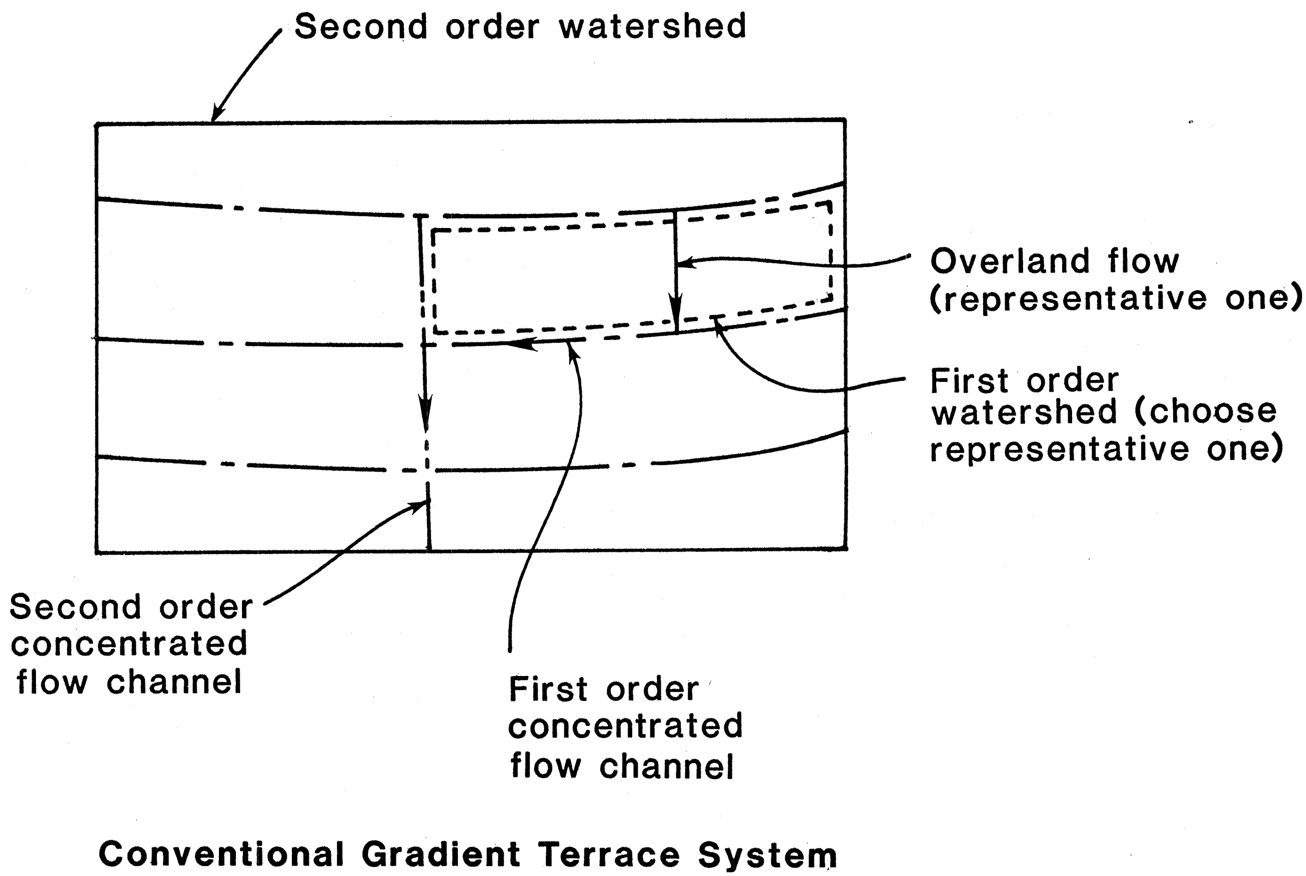


Figure 9.3b: Example second order watersheds.

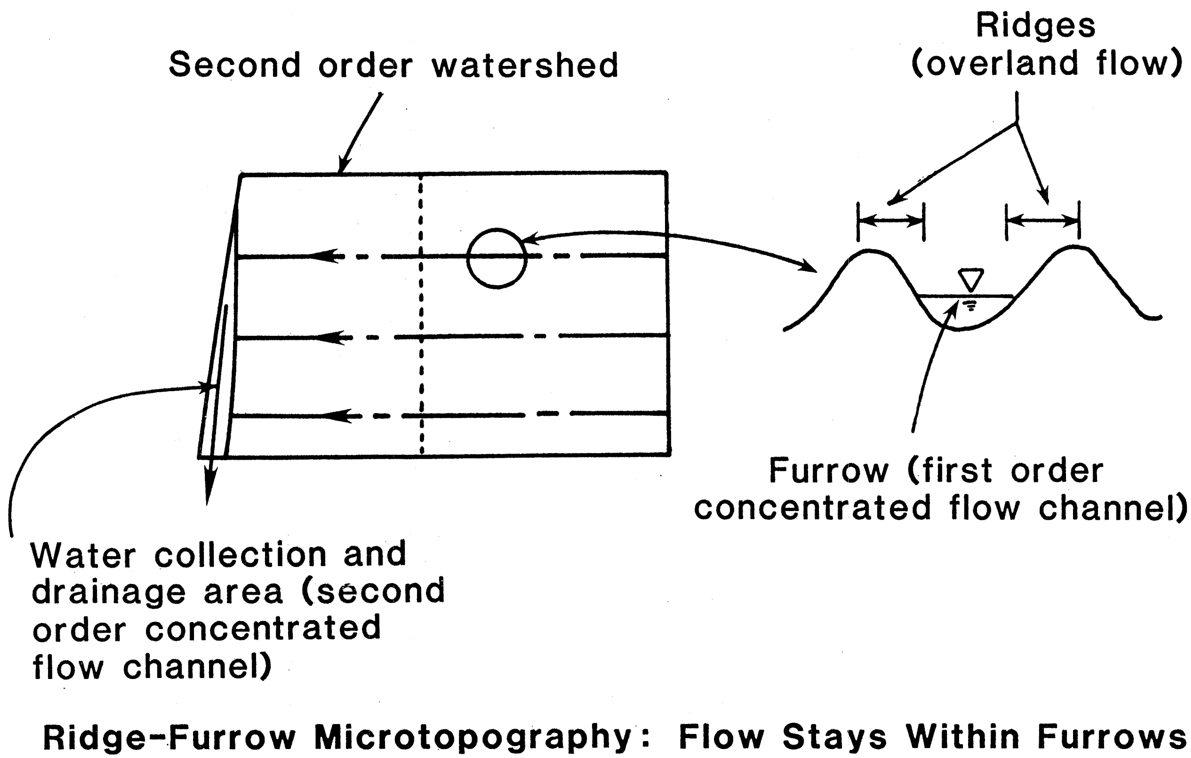
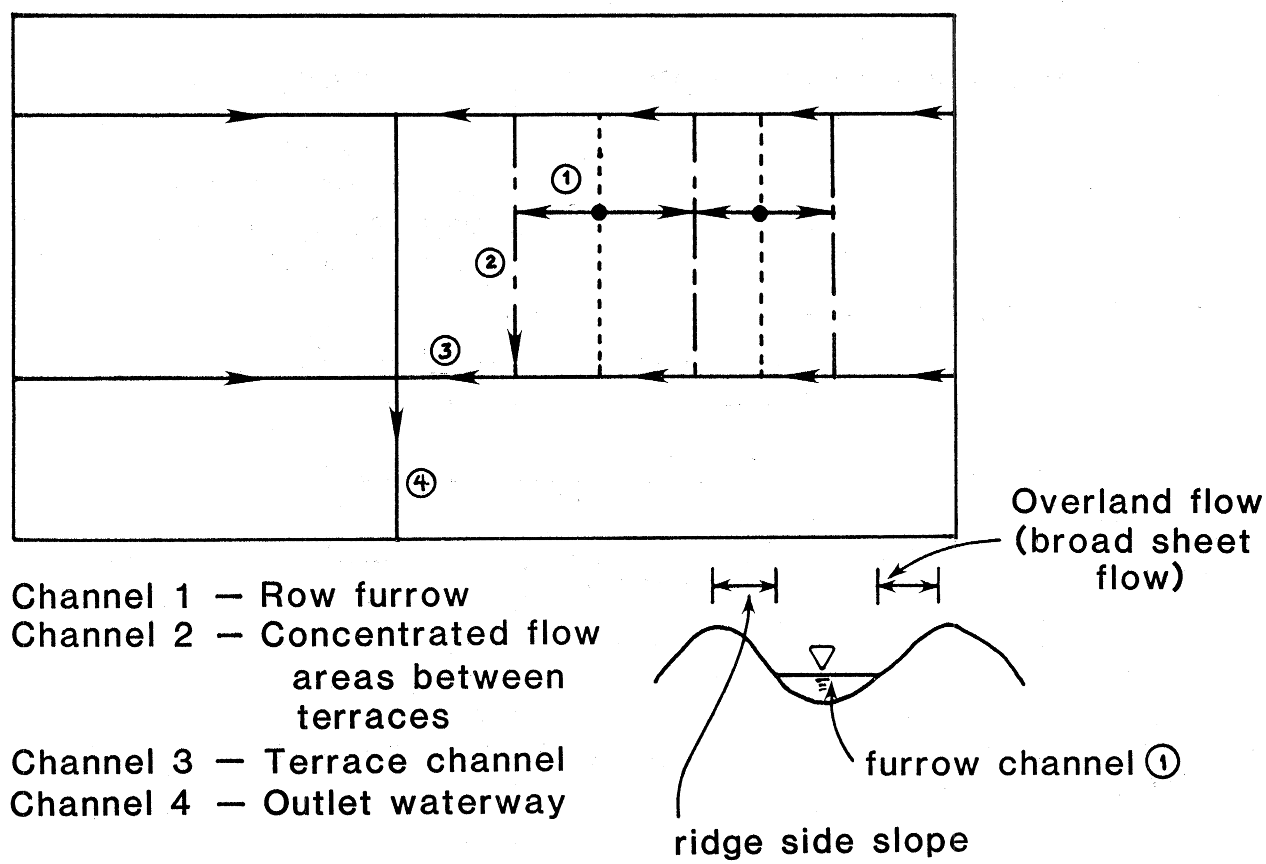
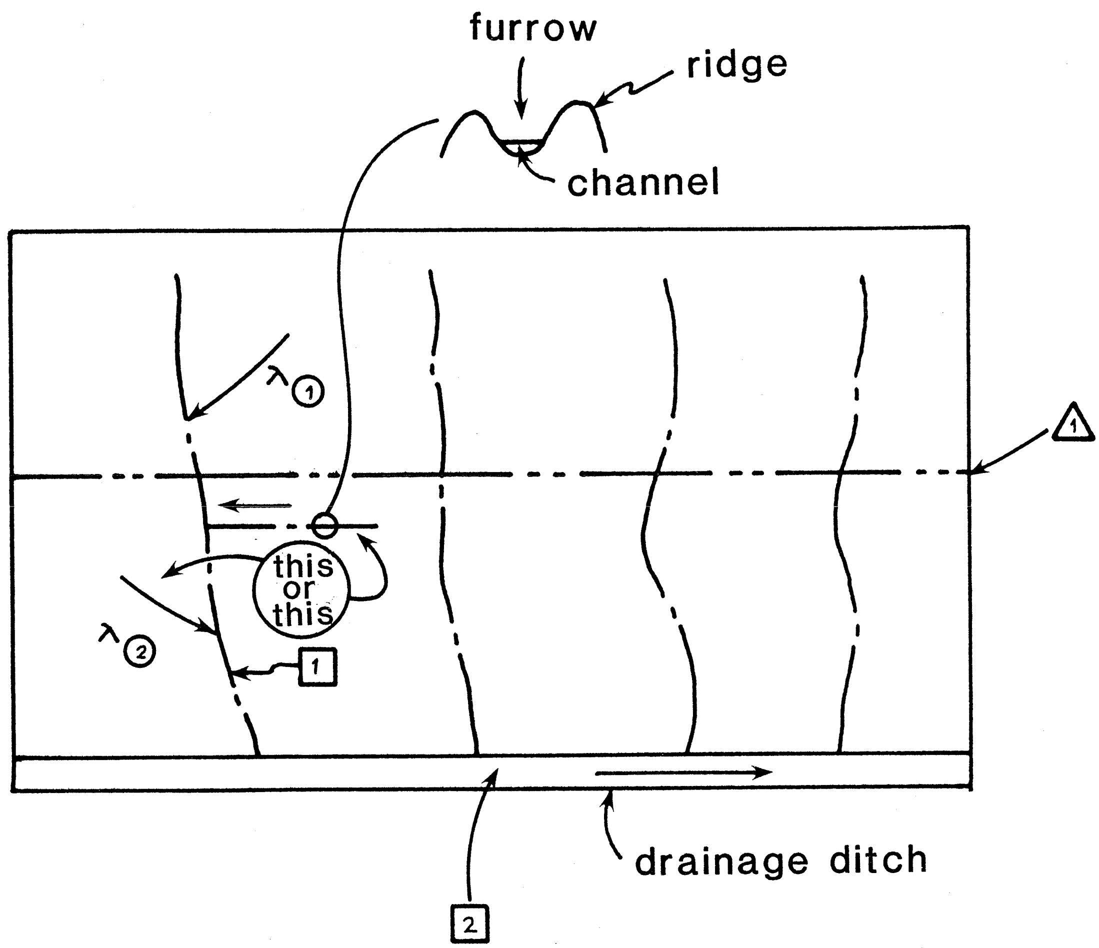


Figure 9.3c: Example second order watersheds.



Each subwatershed and each channel within an order will have the same length and grade. Up through three different cover-management conditions can be specified for the channels.

Figure 9.4: Example fourth order watershed.



Profile along concentrated flow channel

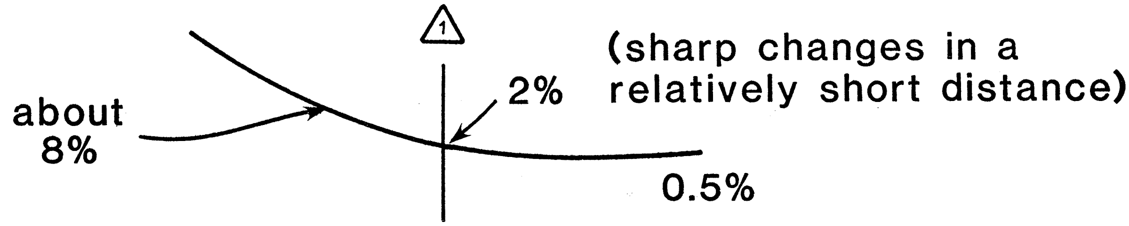


Figure 9.5a: Special topographic and land use cases that WEPP must consider.

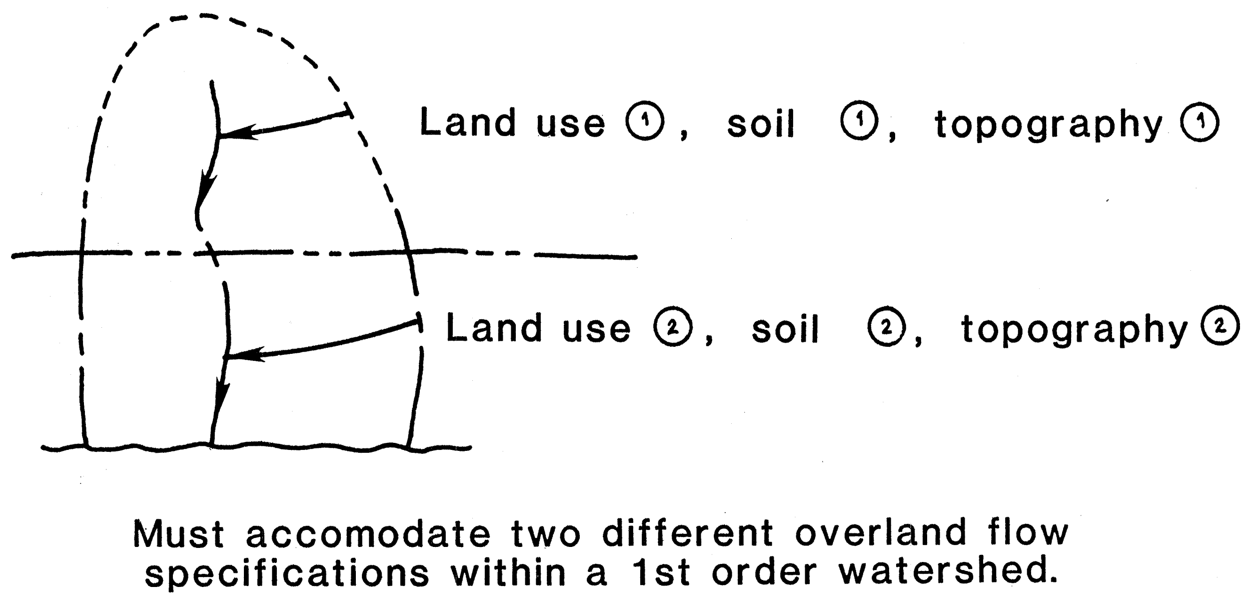
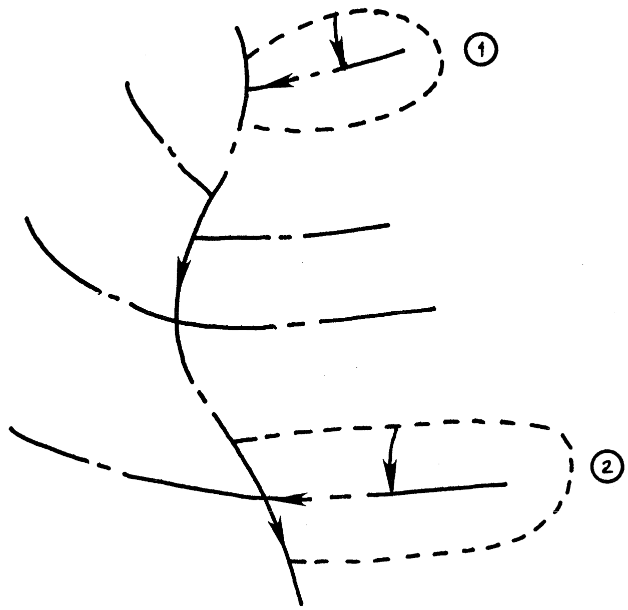
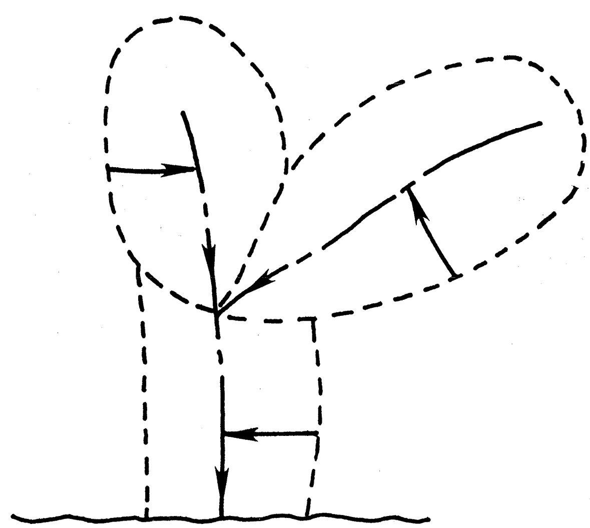


Figure 9.5b: Special topographic and land use cases that WEPP must consider (continued).



Must be able to accomodate two different 1st order watersheds within a 2nd order watershed (topography, soil, land use).



Must be able to accomodate simple, split concentrated flow channel networks. Must accomodate three different 1st order watershed specifications (soil, topography, land use).

Figure 9.5c: Special topographic and land use cases that WEPP must consider (continued).

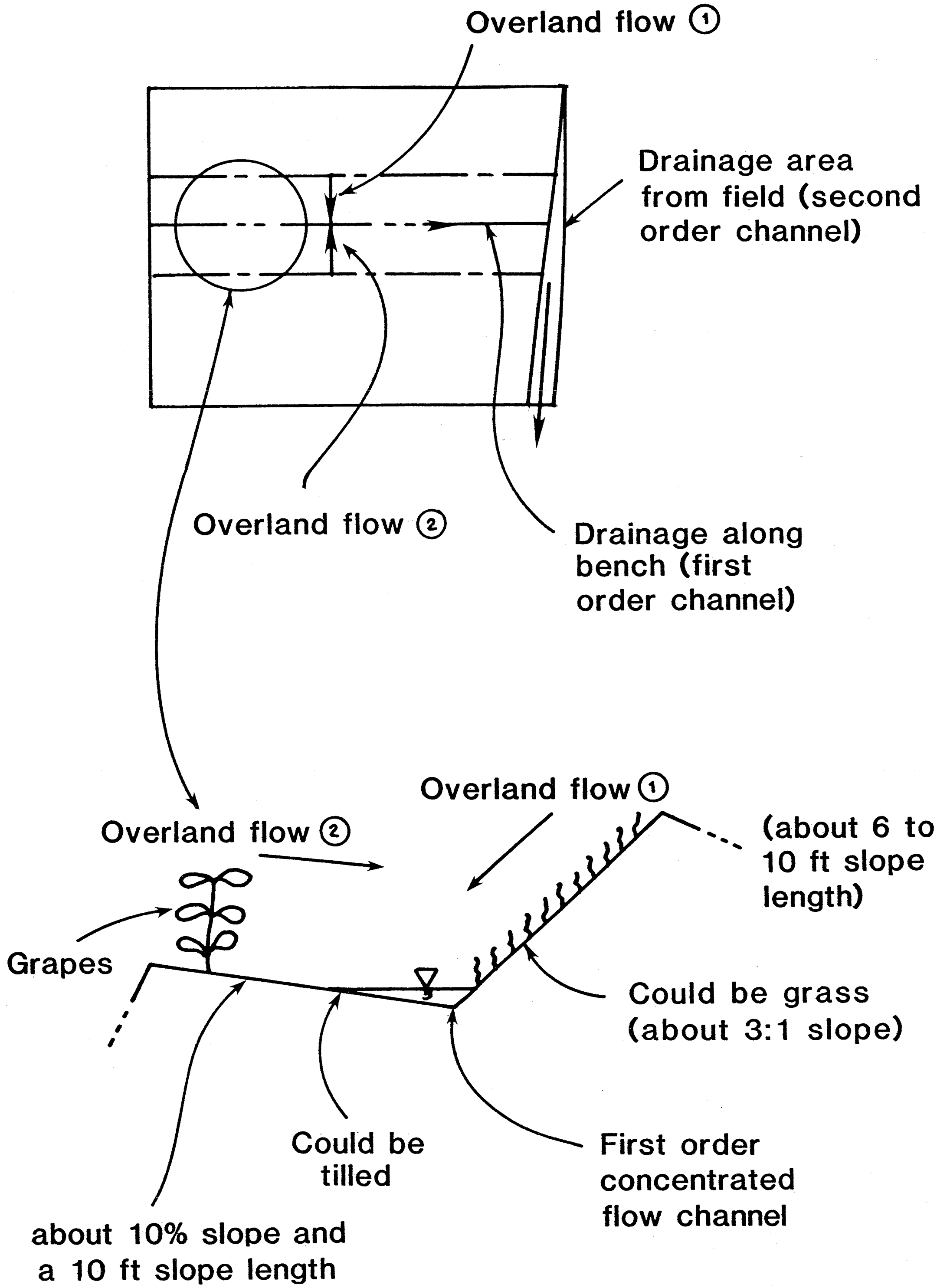
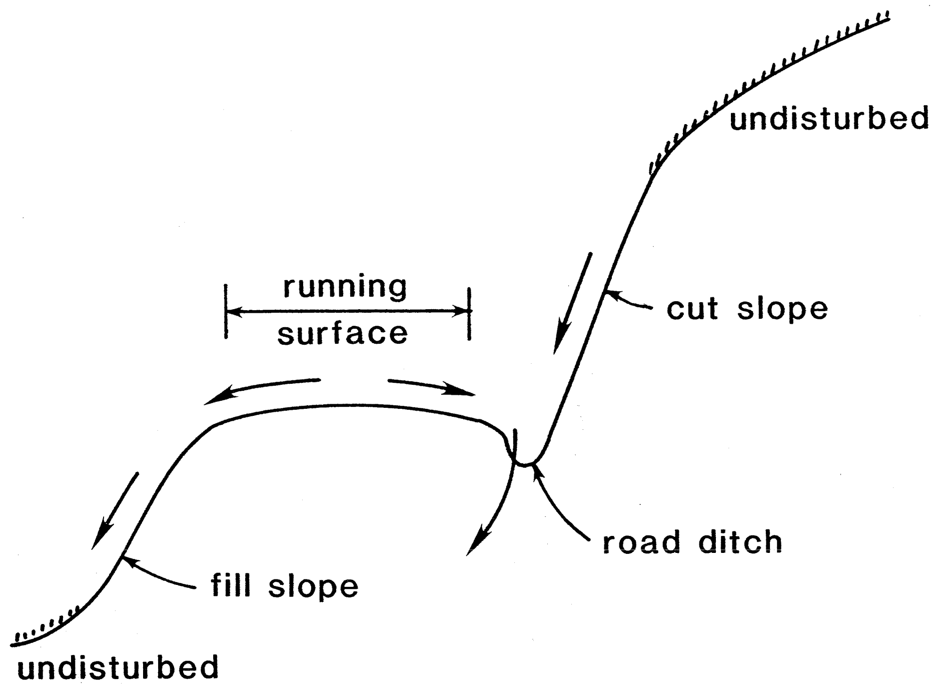
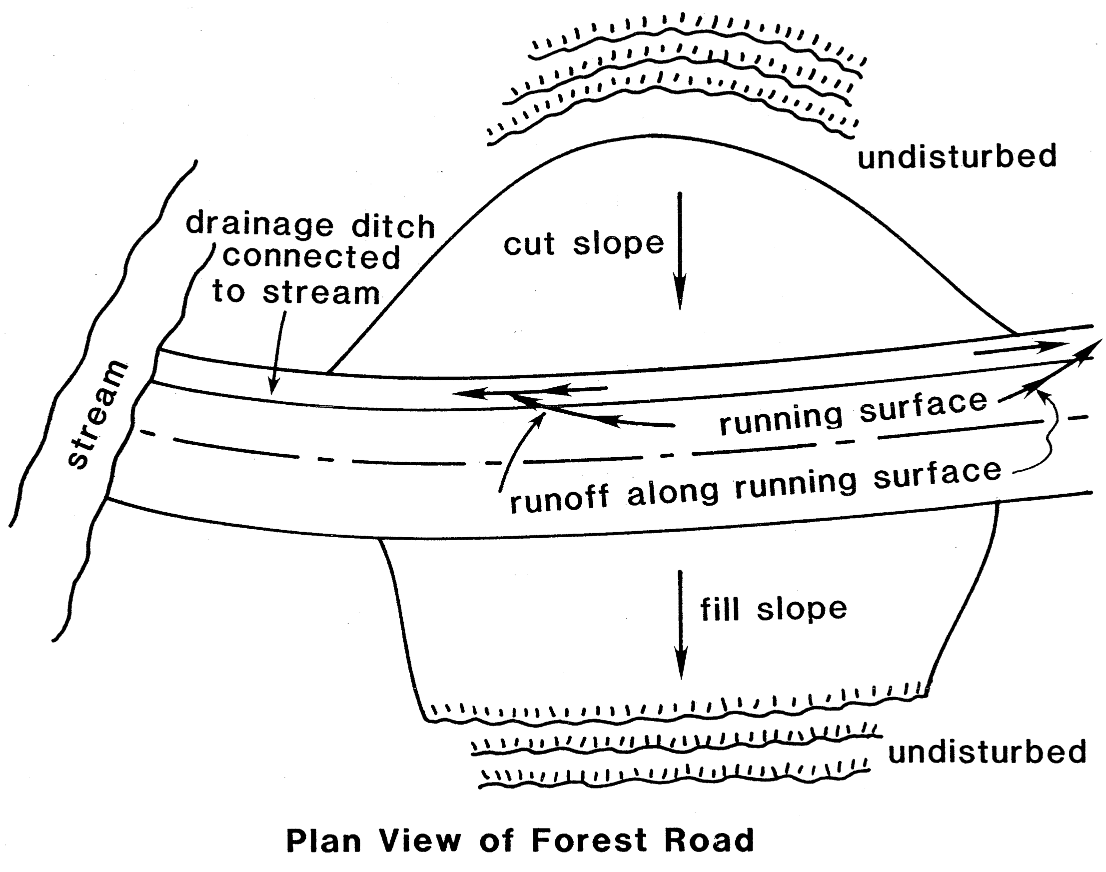


Figure 9.5d: Special topographic and land use cases that WEPP must consider (continued).



Forest Road Cross Section



Plan View of Forest Road

Figure 9.5e: Special topographic and land use cases that WEPP must consider (continued).

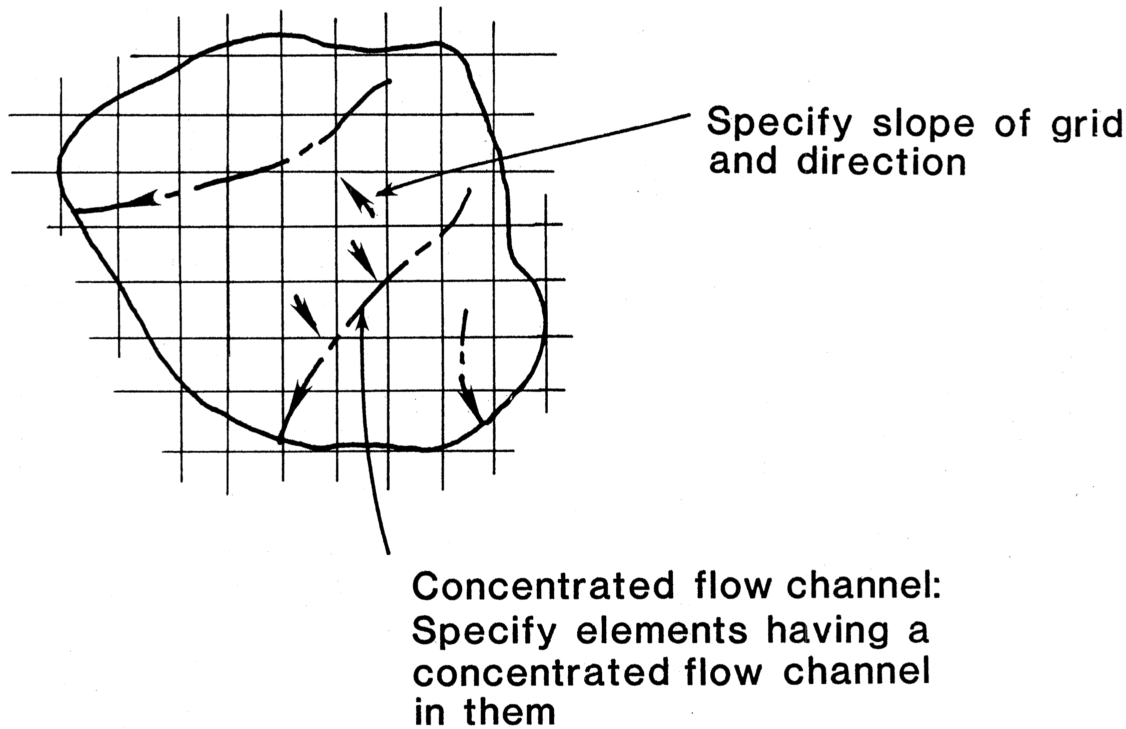


Figure 9.6: Grid element version and its representation of a field.

10. APPENDIX 4 - EXAMPLE STRIP CROPPING SYSTEMS THAT WEPP IS TO CONSIDER

Contour strip cropping systems can involve up to 10 strips in a field. A strip cropping system could involve the following:

Corn (either for grain and/or silage)

Soybeans

1st year Meadow

Established Meadow (2-4 years)

Oats

Grassed waterway or diversion

Tillage systems may include two kinds in the same year such as chisel plowing for the for crop and moldboard plowing for the oats.

See the following figures showing typical patterns of stripcropping.

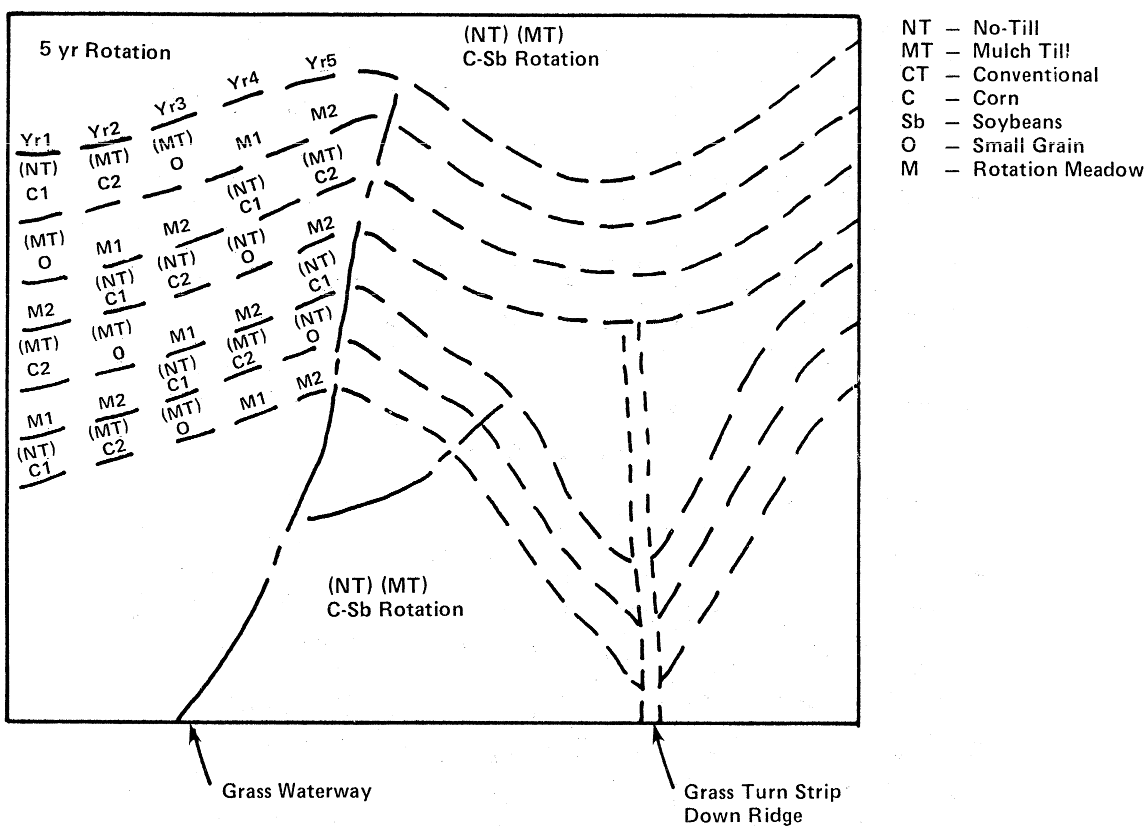


Figure 10.1a: Strip cropping and rotations.

A 6-Year Rotation of Corn, Grain, and 4 Years of Meadow by Strips in a 3-Field Arrangement

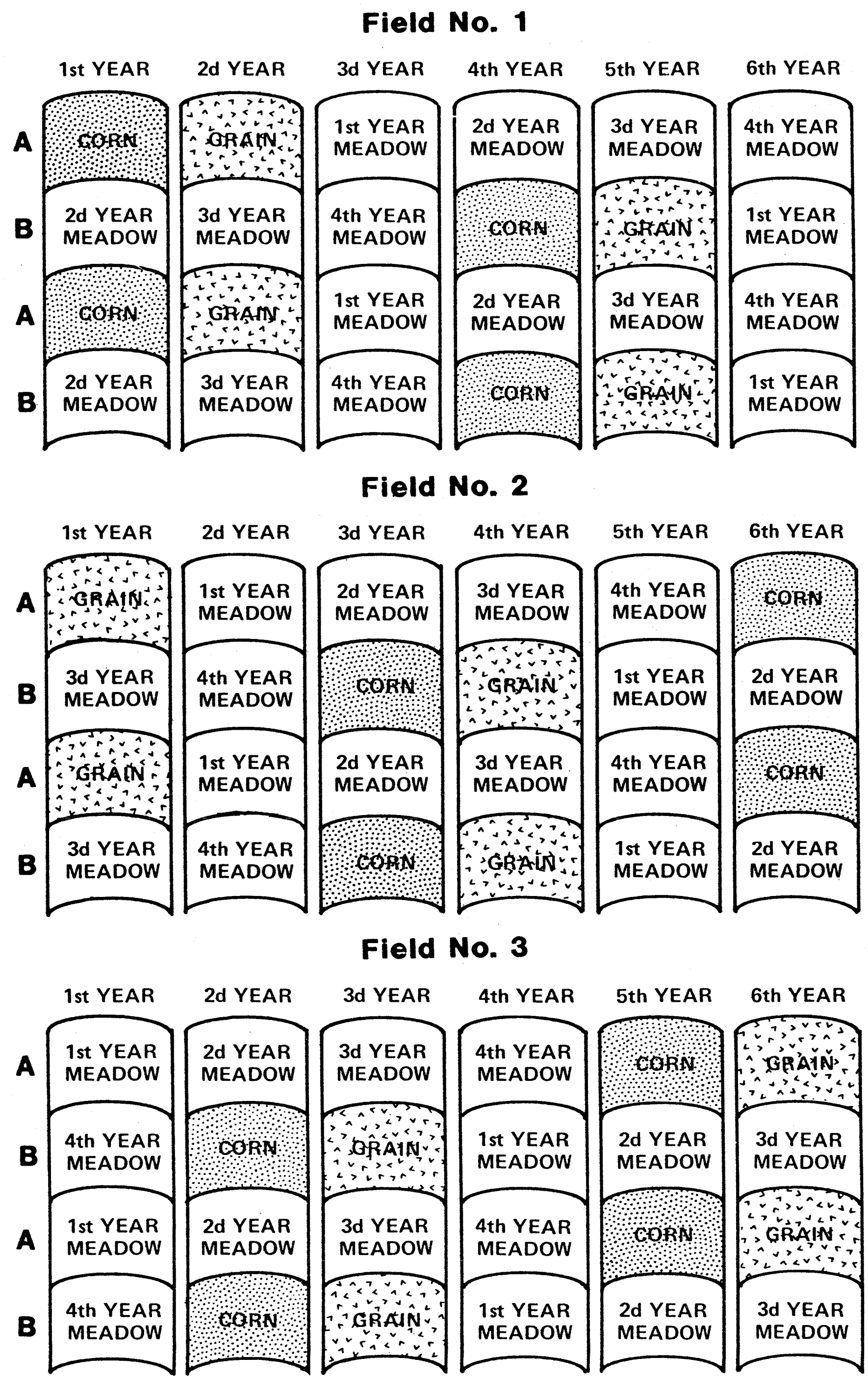


Figure 10.1b (continued): Strip cropping and rotations.

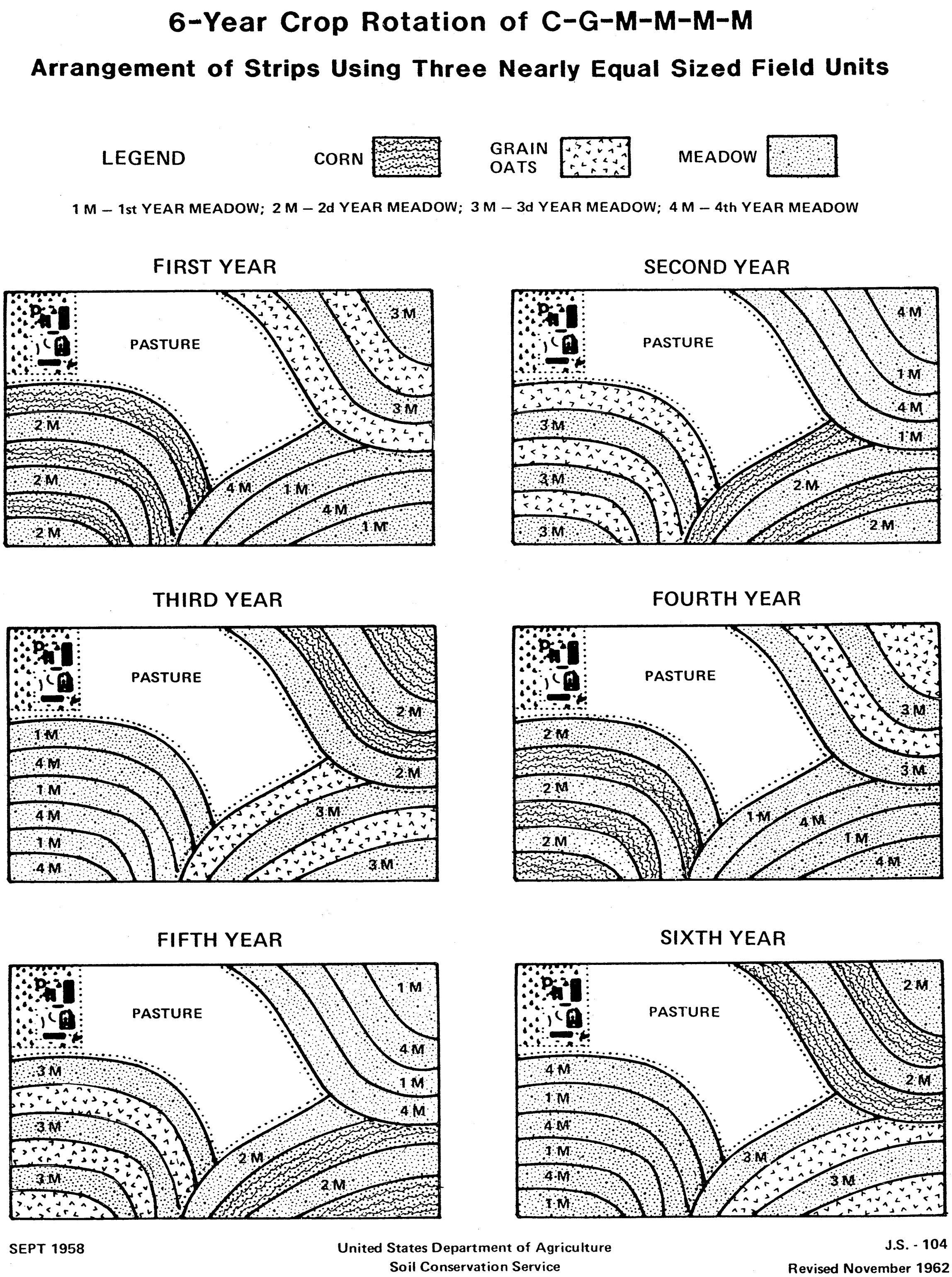
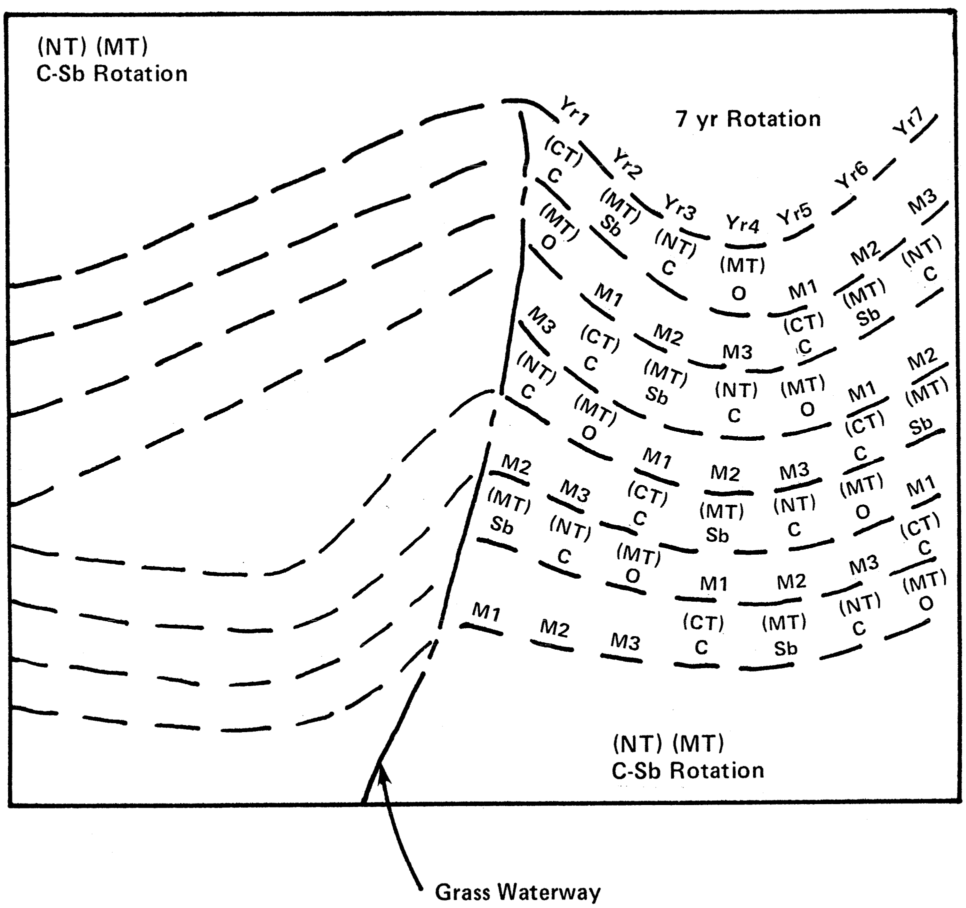


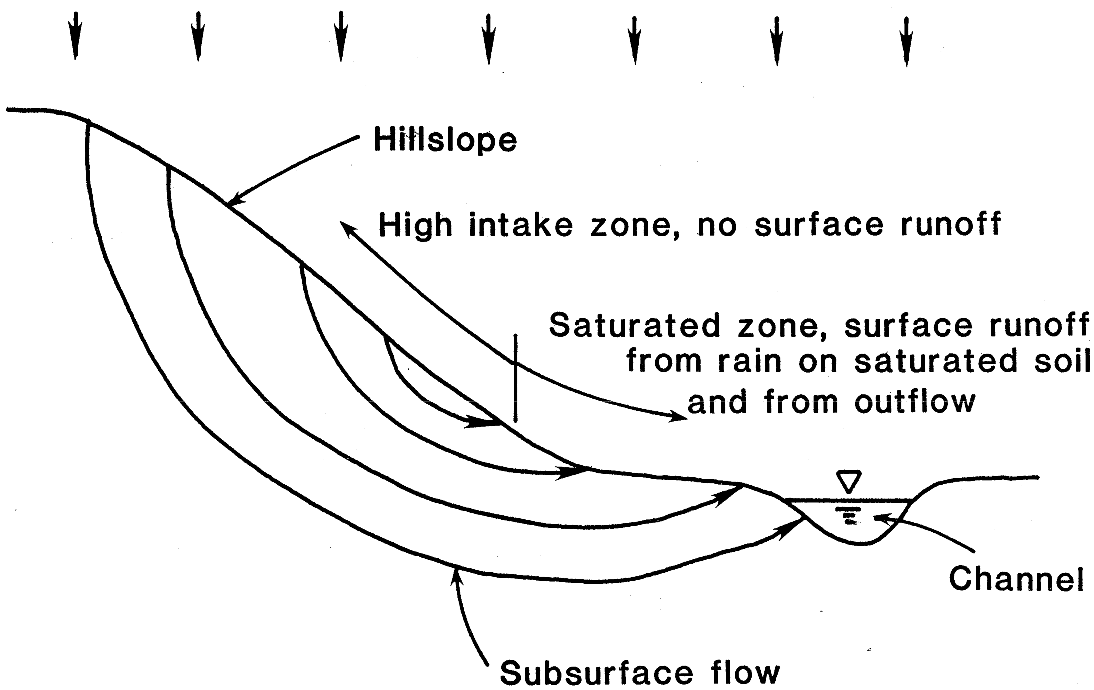
Figure 10.1c (continued): Strip cropping and rotations.



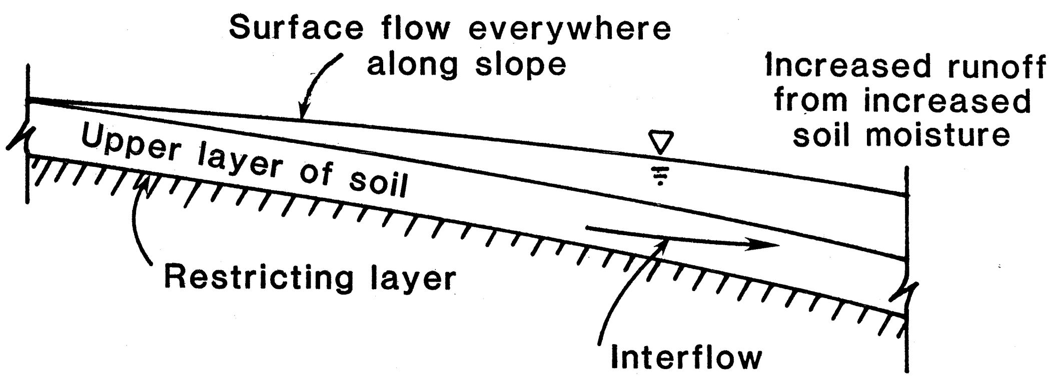
NT – No-Till
MT – Mulch Till
CT – Conventional
C – Corn
Sb – Soybeans
O – Small Grain
M – Rotation Meadow

Figure 10.1d (continued): Strip cropping and rotations.

11. APPENDIX 5 - HYDROLOGIC SITUATIONS NOT WELL TREATED BY WEPP



Partial Area Hydrology - WEPP Does NOT Apply

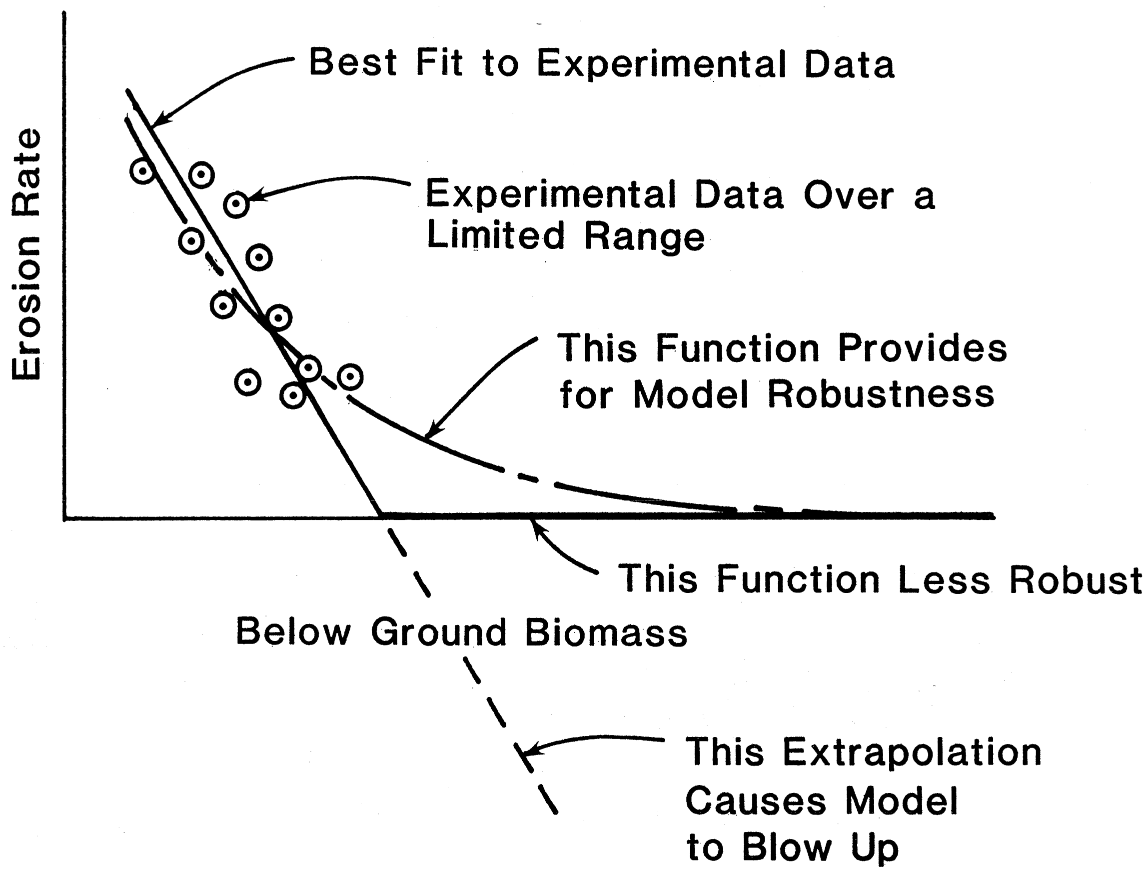


WEPP will apply but only in a simple approximate way.

12. APPENDIX 6 - SOME ATYPICAL CROP ROTATIONS

Corn (3 yrs.) - Oats (2 yrs.) - Meadow (3-5 yrs.)
Corn (3 yrs.) - Oats (1 yr.) - Meadow (4-5 yrs.)
Corn (1 yr.) - Sweet Corn (1 yr.)- Oats (1 yr.) - Meadow (3-5 yrs.)
Corn (1 yr.) - Soybeans (1 yr.) - Corn (1 yr.) - Oats (1 yr.) - Meadow (3-5 yrs.)
Corn (1 yr.) - Potatoes (2 yrs.) - Peas/snapbeans (double crop-1 yr.)

13. APPENDIX 7 - EXAMPLE OF A FUNCTION THAT ADDS ROBUSTNESS TO MODEL



14. *APPENDIX 8 - SIMILARITIES OF WEPP WITH OTHER MODELS THAT MIGHT BE USED BY SCS FOR EROSION COMPUTATIONS*

I. USLE (Universal Soil Loss Equation)

A. Principal application

1. Compute soil loss in conservation planning and inventories

2. Compute soil loss to use to estimate yield for off-site sedimentation and water quality evaluations

B. Major similarities

1. Computes sheet-rill erosion from rainfall

2. Computes average annual soil loss from eroding portions of the landscape

3. Planning and assessment tool for use by field, state, and national office agency personnel

4. Similar inputs

C. Major differences

1. Model structure

a. USLE empirical and lumped

b. WEPP process based

c. WEPP computes by storm

2. Additional computational features of WEPP

a. Deposition in furrows, on concave slopes, at edges of a land use change, and in concentrated flow channels

b. Concentrated flow erosion

c. Grid version of WEPP allows computations over a field

II. CREAMS (A Model for Chemicals, Runoff, and Erosion from Agricultural Management Systems)

A. Principal application

1. Water quality analyses for field-sized areas

B. Major similarities

1. Model structure similar but CREAMS more detailed

2. Provide similar hydrologic and erosion estimates

3. Both operate on individual storms

4. WEPP profile and watershed versions and CREAMS model field representations are the same

C. Major differences

1. User environment

a. CREAMS is not intended for day-to-day field operations

2. WEPP does not compute chemical movement

3. CREAMS algorithms are more detailed and thus more powerful

4. CREAMS uses older technology including SCS curve number runoff prediction method and USLE factors (Note: CREAMS is structured so that components can be and are being changed)

5. CREAMS is primarily intended to operate as a continuous simulation model

6. CREAMS is limited to a single crop in a "field"

7. CREAMS has no comparable "grid" model

III. EPIC (Erosion/Productivity Impact Calculator)

A. Principal application

1. Calculate the loss of crop yield from erosion

B. Major similarities

1. Model components are similar but EPIC much more detailed except for erosion component

2. Operate on individual storms

C. Major differences

1. Thrusts of models

a. EPIC emphasizes the impact of erosion on change in soil and its impact on productivity

b. Main thrust of WEPP is in its erosion estimates as affected in detail by climate, soil, topography, and land use

2. EPIC is not intended for day-to-day field operations

3. EPIC is a continuous simulation model

4. EPIC requires more detailed inputs

5. EPIC applies to a point on the landscape and thus does not consider sediment transport, deposition or concentrated flow erosion

IV. SWRRB (Simulator for Water Resources in Rural Basins)

A. Principal application

1. Efficient computation of sediment yield from small to large, complex watersheds

B. Major similarities

1. Model structure of both estimate sediment yield when SWRRB is applied to WEPP sized-areas

2. Both operate on individual storms

3. Both require similar inputs

C. Major differences

1. Model thrusts

a. SWRRB mainly is to deal with sediment yield from large, complex watersheds

b. WEPP deals in detail with erosion and deposition within a field

2. Erosion relationships in WEPP are more process based: SWRRB hydrology and erosion relationships are from the SCS curve number method and the USLE.

3. WEPP has very limited routing capability

4. WEPP is aimed to a field user

V. SPUR (Simulation of Production and Utilization of Rangelands)

A. Principal application

1. Evaluation of impact of alternative range management practices

B. Major similarities

1. Model structure

2. Both estimate sediment yield

3. Both operate on single storms

C. Major differences

1. Model thrusts

a. SPUR has an elaborate plant growth model that considers species interaction and response to environment but is limited to rangeland

b. SPUR has an animal and economics component

c. SPUR is more elaborate and has a complex watershed version

2. Erosion relationships in WEPP are more process based

3. WEPP is aimed to a field user

VI. ANSWERS (Areal Nonpoint Source Watershed Environment Response Simulation)

A. Principal application

1. Watershed planning for erosion and sediment yield control on complex watersheds

2. Water quality analysis associated with sediment associated chemicals

B. Major similarities

1. Process based

2. Event based

3. Grid topography representation

C. Major Differences

1. ANSWERS is primarily limited to single storm

2. ANSWERS has limited capability for concentrated flow erosion

3. ANSWERS is a fully dynamic model

VII. AGNPS - field scale version (Agricultural Nonpoint Source Pollution Model)

A. Principal Application

1. Analysis of nonpoint source pollution from agricultural fields

B. Major similarities

1. Grid based topographic representation

2. Process and hydrologically driven

3. Considers multiple particle classes

C. Major differences

1. AGNPS relies on older hydrologic and erosion prediction technology

2. AGPNS has limited capabilities for estimating concentrated flow erosion

VIII. SEDIMOT II (SEdimentology by DIstibuted MOdel Treatment)

A. Principal application

1. Design of sediment control structure on surface mined land

B. Major similarities

1. Process and hydrologically driven

2. Considers multiple particle classes

C. Major differences

1. Single event model

2. One option uses older hydrologic (SCS curve number) and erosion (MUSLE) prediction technology

3. Provide a more detailed analysis of impoundments and other such sediment control structures

COVER DESIGN: The logos on the cover identify the major cooperating agencies, USDA-Agricultural Research Service, Soil Conservation Service, and Forest Service and USDI-Bureau of Land Management, in the Water Erosion Prediction Project. The schematics identify the versions, landscape profile, watershed, and grid, of the WEPP model and typical features where they apply. The schematics also identify the major erosion processes and variables that the WEPP model considers. The cover for the WEPP User Requirements was designed and drawn by Rose Beghtol-Hunt, Battleground, Indiana.

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