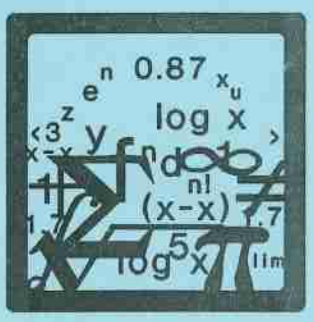
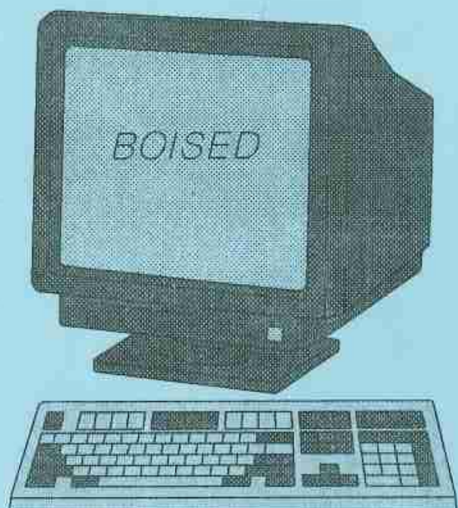
HARDY

BOISED User's Guide and Program Documentation





Boise National Forest

Graphics Added

-- Updated --

December 1991

(Version 3.01)

BOISED User's Guide
and
Program Documentation

Prepared by

Lyn Reinig
Hydrologist

Ron L.Beveridge
Computer Programmer Analyst

John P. Potyondy
Forest Hydrologist

Fred M. Hernandez
Computer Programmer

Boise National Forest

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Preface

When you can measure what you are speaking about, and express it in numbers, you know something about it; when you cannot express it in numbers, your knowledge is of a meager, unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science.

Wm. Thompson, Lord Kelvin, 1894

Any sufficiently advanced technology is indistinguishable from magic.

Clarke's Third Law

BOISED USER'S GUIDE
and
PROGRAM DOCUMENTATION

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INTRODUCTION

Program Development History

The BOISED computer program is an operational sediment prediction model used on the Boise and Payette National Forests. It is based on the conceptual model described in the publication entitled "Guide For Predicting Sediment Yields From Forested Watersheds" (1) published in October 1981 by the Northern and Intermountain Regions of the USDA Forest Service (hereafter referred to as the R-1/R-4 Guide). BOISED is operational on the Data General system and was adapted by Ron Beveridge and Gene Cole (3/86) from the SALSED program developed by Robert Hennes, Salmon National Forest, for the Hewlett Packard 9845 computer (2). BOISED has gone through several revisions and continues to be refined as new data become available or as new analysis needs are identified. The current version of the program documented in this user's guide is Version 3.01.

Program Overview and Application

BOISED is the operational sediment yield model used by the Boise and Payette National Forests to evaluate alternative land management scenarios. The model is a local adaptation of the sediment yield model developed by the Northern and Intermountain Regions of the U.S. Forest Service for application to forested watersheds associated with the Idaho Batholith. The procedure provides for estimation of on-site erosion, delivery to stream channels, and routing of sediment downstream to critical reaches where interpretation of sediment impact to water quality and fish habitat can be made.

The model is applied to watersheds stratified using "landtypes," which are units of land with similar landform, geologic, soil, and vegetative characteristics. Dominant erosion processes, including surface and mass erosion, are evaluated for each landtype in a watershed to provide estimates of natural sediment yields for undisturbed watersheds and sediment yields resulting from management activities. Erosion and sediment yield data from research are extrapolated to areas with similar characteristics to predict the effects of alternative watershed disturbances including road construction, timber harvest, and forest fire. The model predicts changes in erosion over time and adjustments are made to fit the model to varying geologic parent materials.

Factors considered to model erosion due to road construction include the type of road construction, the area disturbed by construction activities, road gradient, the intensity of road use, and erosion mitigation practices, such as surfacing or mulching of fill slopes. Factors considered to model erosion due to timber harvest include the type of harvest, the area cut, the logging system, and the slope of the terrain. Factors considered to model erosion due to fire include the area burned, the slope of the terrain, and fire intensity.

The efficiency of a landtype to deliver eroded material to stream channels as sediment is evaluated for each landtype and sediment is routed through the watershed. Factors evaluated to determine sediment delivery to stream channels include distance, slope steepness, shape, roughness, and degree of slope dissection. For basins larger than one square mile, sediment is routed to downstream locations using a delivery ratio approach.

The model produces quantified estimates of average annual sediment yields for the undisturbed condition, past activities, and activities proposed in the future. While it is inappropriate to use the model as a highly reliable predictor of absolute quantities of sediment delivered to streams at specific times, it is appropriate to use model results for comparison of alternative management scenarios within a watershed. The procedure is commonly used in the preparation of environmental assessments and impact statements as a tool to evaluate the effects of alternative timber harvest activities, road locations and design, and the application of erosion mitigation practices.

Quantitative values, or factors, are required at each step in the calculation. The R-1/R-4 Guides supply values that can be used if local values have not been developed. However, the decision as to what values and factors to use in actual calculations is left to the professional judgment of the specialist making the prediction.

User of the BOISED model must be well acquainted with the concepts, process, assumptions, and cautions described in the R1/R4 Guides. Generally, the program should only be used by qualified hydrologists and soil scientists since extensive judgement is required for proper application. A conceptual description of BOISED including many of the equations programmed into BOISED are described in the paper "A Procedure for Estimating Sediment Yield from Forested Watersheds" by John Potyondy, Gene

Cole, and Walt Megahan which is included as Appendix A. A mass erosion component, not included in the R1/R4 Guides, has been incorporated into BOISED. It is described fully in Appendix B.

The BOISED program is intended to be used as a tool to aid in predicting the cumulative yield of sediment from road construction, road management, silvicultural activities, and fire within small forested watersheds approximately 1 to 50 square miles). Model outputs are expressed as average annual yields of total sediment from a watershed. The units used are tons per year. The yields predicted are average annual natural yield and average annual management-induced yield for each year included in the analysis.

It cannot be stated too strongly that it is inappropriate to use the product of the BOISED computer program as highly reliable predictions of absolute sediment quantities. The only appropriate use of BOISED is for developing a **quantitative index** of cumulative sediment yield from different management proposals within a watershed.

The BOISED computer model should not be used as a substitute for monitoring of fish habitat, stream conditions or management practices. It is important to recognize that BOISED model outputs cannot be monitored on an annual basis. This is because the model predicts average annual conditions and these, by definition, cannot be measured. Actual sediment yields for individual years may exceed modeled values by an order of magnitude or more. The model can only be validated in a broad general sense involving a commitment to the collection of long-term data of around 10 years. Consequently, users must accept model results with a certain degree of faith recognizing that model outputs should only be used to compare alternatives management scenarios.

Appendices are included in this user guide to provide more detailed information concerning analysis steps and how factors involved in using the BOISED program were derived. References will be made to the appropriate appendix section throughout this guide.

BOISED ANALYSIS STEPS

Delineation of Watershed of Concern

The BOISED program is intended for use with watersheds in the range of 1 to approximately 50 square miles. The routing component of the model becomes increasingly questionable with larger watersheds.

The primary considerations in determining which watershed to delineate are as follows:

1. The watershed covers the area tributary to streams in which cumulative effects are of concern.
2. The watershed is within the size range for which the BOISED program is intended.

On the Boise NF, forest watersheds and Boise Data Base (BOIBASE) compartments or aggregates of more than one compartment are convenient watersheds and should be used, if they meet the above criteria. Landtype composition and landtype acreages are readily available from BOIBASE for these units.

The 1:24,000 topographic quadrangles are recommended base maps for delineating watersheds and for inventorying and recording information.

Estimating Sediment Yield Under Present Conditions

This step requires the inventory of past land disturbing activities that are still influencing sediment yield. These activities are:

Road construction and use.
Fire
Logging

While inventorying road and logging information it is useful to gather information on other significant sediment yielding activities and conditions such as areas of livestock use that have significantly reduced ground cover. Also include any other uses that significantly influence erosion, such as water ditches, special use structures, large parking lots, ski runs, mining disturbance, and heavy off-road vehicle use. Even though the BOISED program doesn't address sediment from these uses, their sediment contribution can be estimated using other methods and manually added to the yield calculated by BOISED.

Road Inventories. The first source of road information is the District transportation map available from the District Engineer or the Transportation planner in the SO. To accurately model present sediment yield, all roads that have ever been constructed and which still exist need to be determined. Excellent information sources include 1:24,000 topographic quadrangles and recent aerial photographs. Recent aerial photographs are the most reliable source. Existing identifiable roads can be placed on the 1:24,000 scale base map on which watersheds are delineated.

The type of construction activity, number of years since construction or reconstruction, width, and management class information can usually be obtained from District personnel. Sample data entry worksheets are included as Appendix C.

Logging Inventories. Obtain maps of past timber sales. To accurately model present sediment yield, determine all logging within the past 6 years. District TMA or sale administrator can usually supply these maps and correct them as needed to reflect actual logging acres, dates, and yarding/harvest type. This can be placed on the base map, overlays, etc. List the cutting unit number you wish to assign, the landtype, the harvest method, and the acres cut over on a worksheet from which the information can be entered into the BOISED program. Sample data entry worksheets are included as Appendix C.

Fire Inventories. The District Fire Management Officer (FMO) can tell you if an area of the watershed has been burned. To accurately model present sediment yield, determine all fires occurring in the past 4 years. Outline the area on the base map, determine acreage by landtype, and estimate intensity of the fire (with help of FMO). The worksheets in Appendix C can be used to summarize the information.

Estimating Sediment Yield for Alternatives

This job follows the same general methods as estimating sediment yield under present conditions. In this case however, the conditions are obtained from descriptions of each alternative and by field review of the areas involved.

PROGRAM EXECUTION

Program Description

The BOISED programs are written in Data General BASIC and compiled for use on any Data General MV series of computers. BOISED currently consists of five programs, BOISED.PR (main menu), BOISED_CALC.PR (calculations), BOISED_EDIT.PR (edits), BOISED_PRNT.PR (data file printing and viewing), and BOISED_PLOT.PR (plots). In addition two data files, named BOISED_DEFAULTS and LANDTYPES, are required for operation. A copy of each of these files will be provide with the software but they must be modified to match local conditions. The BOISED_DEFAULTS file contains all the default values used by the programs such as default road widths and mitigation coefficients. The LANDTYPES file contains landtype information the programs need to calculate erosion values. A complete description of the LANDTYPES data file and the BOISED_DEFAULTS file are included as Appendix D. Appendix E contains a detailed description of how the date for the LANDTYPES file was derived on the Boise National Forest.

Persons interested in obtaining copies of the BOISED program for loading on a Data General system should contact Informations Systems, Boise National Forest Supervisors office.

Program Execution and Operation

When the command **BOISED** is entered from the IS command line the BOISED main menu (Figure 1) is displayed. The main menu lists the names of watershed files in alphabetical order, their last date of modification, the file size (in blocks), and assigns a document number to each. Each watershed file contains the input data needed to run BOISED. In the upper left corner of the screen, the DG drawer and folder containing the files are identified.

- Figure 1 - Main Boised Menu -

BOISE NATIONAL FOREST SEDIMENT MODEL

Drawer: WATERSHEDS — Revision 03.01.01
Folder: DISTRICT

Doc. Num.	Watershed File Name	Date last Modified	File Size	Plot File
1	**PINE**	**DEC 7,90**	**8**	Y
2	PINE ORIG	DEC 7,90	8	N
3	SIXMILE	JAN 10,91	5	N
4	STOLLE 6	NOV 13,90	10	N

Pick one:
(1. **View**, 2. Calculate, 3. Edit, 4. Create, 5. Delete, 6. Rename File,
7. Print, 8. Plot, 9. Move/Duplicate) **1**
Document Number:

The last line is being displayed

Function Keys - Various function keys or key combinations are valid at the main BOISED menu and other BOISED windows. These keys are similar to standard Data General conventions and are described below.

[F1] Execute - When pressed this key accepts all default values displayed on the current screen without having to NL every data field entry.

[F3] Previous Screen - displays the previous ten watershed files on the screen or the first ten if less than ten are prior to current position.

[F4] Next Screen - displays the next ten watershed files on the screen or the last ten if less than ten are remaining.

[F11] Cancel/Exit - either exits the program or window currently being displayed. If no window is being displayed, the prompt "Do you wish to cancel/exit?" is asked, enter Y to exit the program.

[Shift/F11] Backfield - moves back a data field to the last entry. This key is most useful for correcting errors.

[NL] New Line - moves to next data entry field on the screen .

Nine options for selection are listed at the bottom of the screen similar to standard Data General menus, these are **1) View** file data, **2) Calculate** sediment yields, **3) Edit** file data, **4) Create** a new file, **5) Delete** a file, **6) Rename a File, 7) Print** file data, **8) Plot** file data, and **9) Move/Duplicate** file data.

When the desired option (1-9) and the desired document number are selected and NEW LINE (NL) pressed, the option window (figure 2) appears with the selected action displayed at the top. This is a check for the user to be sure the correct action and file have been selected before proceeding. If the wrong file or option has been selected, press N in response to "Correct file?" and the main screen returns. Answer Y to "Execute" and the program continues.

-Figure 2 - Option Window -

View File
File Name:**PINE**
Project:**PINE CREEK**
Alternative:**ALT1**
Data validity date:**89/07/29**
Correct File?**Y**   Execute?

Menu option choices are explained below.

#1 View - for viewing data in a file.

When this option is selected and the file verified, the watershed data file is read, formatted and displayed on the screen. The **HOLD** key needs to be used to stop the display in order to read the data since the file scrolls forward until the end of the file is reached. When the end of the file has been displayed the viewer is returned to the main screen.

#2 Calculate - for calculating sediment yields.

When this option is selected and the file verified, the next prompt is:

Do you need to make changes prior to calculation?

If no changes to the data are needed prior to running the calculations, press N. If more information needs to be added or changed, press Y. If you enter a Y, the Edit program (see #3) executes to allow data modification. Then the modified data is passed to the calculation program. It is important to remember that changes to the data file made at this point are **NOT** saved. They are **ONLY** used for this calculation run. This option allows you to make minor changes to the file and evaluate alternatives quickly without having to create additional data files.

If you need to make permanent corrections to the data file, select #3 Edit. (See #3 on next page for this information)

If a N (no) is entered or after the changes are made to the file the calculation window (figure 3) is displayed at the bottom of the screen.

- Figure 3 - Calculation Window -

CEO Printer name? LPT______	**Save PRINT file (Y/N):N**	**Save PLOT file (Y/N):N**	
Base Year: 1991	**Batch Process (Y/N):Y** after 18:00		**Execute? Y**

CEO Printer Name: Any valid CEO printer name works, however output requires 132 column print. The printer name **NONE** will allow the calculation to run but not print the output file. **LPT** (default) will send output to the system printer.

Save PRINT file: Output files are normally deleted after printing unless a response of **Y** is entered here. This saves the output in a file named with the following format: **WATERSHED_NAME.ALTERNATIVE.PRT**, where Watershed_Name comes from the Boised Main menu and Alternative Name is the alternative name assigned in the Option window. If you save several output files for the same watershed, be sure to give each one a unique name to avoid overwritting files by changimg the alternative name for each run. [Note: Watershed name + alternative must not be over 30 characters long or an error will occur since output file names cannot exceed 35 characters.]

Save PLOT file: Same as print file except that the extension **.PLT** is appended to a saved file which is used to plot sediment summary graphs.

Base year: Base year is used to specify the years of output that the user wishes to have printed. The BOISED summary output table displays sediment yield data for a 50 year time period from 19 years before the base year to 30 years after the base year. Activity sediment yields for logging, roading, and fire are displayed for the first three decades beginning with the year after the base year. For example, selecting a base year of 1960 displays detailed logging, roading, and fire sediment yields for decade 1 (1961-70), decade 2 (1971-1980), and decade 3 (1981-1990). The summary table displays sediment yields from year 1941 through 1990. Multiple runs, specifying different base years, are required to show output for other time periods.

Batch Process: BOISED calculations can be done in batch or demand mode. If you answer N to Batch Process, BOISED_CALC.PR executes immediately and you will have to wait until the calculations are completed before you can continue. If you say Y, you will be prompted for the time to begin the run (default is 18:00). If you enter a time that has already past, the job begins processing immediately. Generally, you will select a time in the future to reduce impacting the computer during high use periods. If you are making multiple runs of any single watershed, be sure to stagger batch execution times since BOISED creates temporary files using the watershed name. If batch runs overlap, output files are deleted before they get a chance to print. Depending on the capabilities and use of your system, large files can take several minutes to up to an hour to run. This is why batching your request is valuable unless you must have the run immediately.

#3 Edit - editing an existing file.

This selection allows you to add, correct, or delete data in existing files. The editor flips between "View" and "Edit" mode (adding and insert are edit mode). When called up, the Edit screen (figure 4) displays 10 data records at a time in a format similar to the way they appear in the data file with default values left blank in the record. You can use a variety of function keys to position yourself at the line you wish to edit (NL to go forward; Shift/Backfield to go backward, or Shift/Go To to go to an record number). The line to be edited is highlighted. The CTRL/VIEW/EDIT keys are used to toggle from view to edit mode. When you go to edit mode the line being edited is displayed at the bottom of the screen on the "edit line". Above the edit line are short descriptors of the types of information you will be prompted for by the program. The values from the active (highlighted) record (or computer generated default values) are displayed below the descriptors. Below the edit line, a short description of data entry options is displayed, telling you the values that will be accepted by the program. These change each time you move the cursor to a different data field. An error message is displayed near the bottom if you attempt to enter an invalid entry. As you enter data, values from the previous record (or defaults generated by the program) appear on the edit line to facilitate data entry.

- Figure 4 - Edit Screen -

```
                         BOISED EDIT - Rev 03.01.01 Editing

Watershed: PINE
Project: PINE CREEK      Alternative: ALT1                              Validity Date: 89/07/29
     1   1               120E2            10.0
     2   1               120C11         1860.0
     3   2     2068      120C11           90.0    1979 1
     4   2     2068      120C11          120.0    1980 5
     5   3     6-43      120C11           30.0    1981 3
     6   4A   10004A     120C11   1.1      1.1    1970 1                      2 2 4
     7   4A   10004B     120C11   1.1      2.3    1950 1                      2 2 4
     8   4A   10004B     120C11   1.1      2.3    1981 3                      2 2 4
     9   4A   10304      120E2    1.2      3.4    1981 1                      2 2 4
    10   4A   10304      120E2    1.2      3.4    1981 2                      2 2 4
   Card  Unit      LSI DATA        Dist                                   ROAD
   Type  ID    SS  Landtype  GEF   Area   Year  Code  SDR  MSDR  Width  Use  Grd  Mit
   _1              120E2     1.2   10.0

CARD TYPE- valid entries are:
     1 - Landtype data records                3 - Fire/Burn data records
     2 - Cutting Unit data records            4A - Road data records
  There are 35 more lines to be displayed
```

Data values and input requirements are discussed in greater detail later in this section.

Function Keys - Various function keys or key combinations are accepted by the edit program (and the update option to the calculate program). Many of the keys function differently depending on if the VIEW or EDIT mode is active. These keys are described below.

> **[F1] Execute** - (Edit mode) current record and all data values are accepted and verified without having to NL every data field entry. Incorrect data values cause the execute to halt and a valid entry must be entered.

[F2] Command - (View or Edit mode) calls the COMMAND window (figure 5) which allows you to perform one of four functions described below:

- Figure 5 - Command Window -

```
                 COMMANDS

HEADER - Edit Header Information
MITS   - Edit Mitigation Coef. Info
SORTS  - Sort records by Card/ID/LT/YR
ABORT  - Exit and OMIT edit Changes


What Command?          (Press NL to EXIT)
```

HEADER - displays in the window and allows change of header information: Project, Alternative and Data validity date.

MITS - displays in the window existing Mitigation Coefficient data in the form **1 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00**

System Default Values

Where the first line is the record number (**1**) and coefficient values for years 1-10 (**1.00**). The second line is the Remarks associated with this record.

You can **1) Edit 2) Create 3) Delete** records. A maximum of 9 sets of coefficients are allowed per data file. If a set of coefficients are deleted, sets with higher record numbers are renumbered and the values in the data file adjusted accordingly. Additional information on mitigation coefficients is discussed under Road Data Requirements and in Appendix J.

SORT - sorts records by Card, ID, Landtype and activity year. After sorting, the records are redisplayed.

ABORT - allows a way out of the file without keeping any changes made in the current editing session. A good way out if something goes wrong and you do not want to retain the changes.

[F3] Previous Screen - (View mode) moves back ten records in the data file.

[F4] Next Screen - (View mode) moves forward 10 records in the data file.

[Shift/F4] Begin/End Line - (Edit mode) moves the cursor to the beginning or end of a line just as in CEO, however, no data values will be checked as the cursor moves from end to end. Use EXECUTE if you need data fields checked and verified.

[Shift/F5] Go To - (View mode) moves to the line number entered or will accept FIRST or LAST.

[CTRL/F5] View/Edit - (View or Edit mode) toggles between view and edit mode. In the View mode you can move around the file until you find the records you wish to edit then press VIEW/EDIT to edit records. To return to a view mode, press this key again.

[F6] Insert - (View mode) used to insert data to an existing file, the insert is made preceding the current line. To exit the insert mode press INSERT again. CANCEL/EXIT will omit inserted data.

[Shift/F6] Find - (View mode) locates the first occurrence of any entered data string, either numbers and/or characters (i.e., Road ID or Landtype).

[F9] Delete - (View or Edit mode) This key can be used when you have a record (line of data) that you no longer wish to have in a file. It is best to be in view mode since multiple records can be easily tagged for deletion. In either mode, position yourself on the desired record and press delete. The word delete appears at the end of the line. The line has been "flagged" and will be deleted when you exit the current working session. If you change your mind after you press delete, simply press delete again and the flag will be removed.

[F11] Cancel/Exit - (View or Edit Mode) In the Edit mode, with the cursor on any field except field 1, the F11 key returns the user to the first data field and reset all fields to the original values. If already on field one, F11 exits the edit mode and returns to view mode. In View mode, the prompt: **Do you wish to cancel/exit?** will be displayed and a "Y" will allow you to exit the edit program. Before leaving, the question: **Do you need to keep the original as a backup file?** is asked. A "Y" keeps the original file as a backup file with the extension ".BU" on the end.

[Shift/F11] Backfield - (View or Edit mode) In the View mode this key allows you to move your current position up one record on the screen. In the Edit mode, it moves you back one data field. This key is most useful for correcting errors while entering data.

[NL] New Line - (View or Edit mode) In View mode, New Line will move you down one line. In Edit mode, the cursor advances to the next data field.

#4 Create - creating a file.

This selection permits you to create a new file. A block similar to that illustrated in Figure 6 appears in the middle of the screen. Information needed for the create block includes:

> **File name** - Watershed name or what ever you choose to call the data. The extension .WRC will automatically be appended to the filename. Any blanks in the name, automatically have the underscore symbol (_) inserted in the filename. [Note: Data files run by BOISED must have the extension .WRC appended as part of the filename.]
> **Project Name** - A combination of 0-16 characters or spaces, such as a timber sale name.
> **Alternative name** - Should be filled in since BOISED uses the Alternative Name for the .PRT output filename. Remember the watershed name and alternative name must not exceed 30 characters.
> **Data validity date (YY/MM/DD)** - This is the date data are known to be correct. The program uses the current date for new data files (users can override these values) and retains the previously created dates for existing data files. This date can and should be changed as data files are updated. Procedures for changing any of the header information (use the COMMAND key) are discussed in #3 Edit.

- Figure 6 - Create Window -

Create File

Watershed:______________________________
Project:_______________
Alternative:_______________
Data Validity date (YY/MM/DD)**91/02/18**

Execute?

Upon completion of this information the user will be in the Edit program (#3) in the Adding Records mode.

#5 Delete - deleting a file. This selection permits you to delete a file. A block asking you if you have the correct file appears on the screen. If you type Y, the file is deleted. If you have the wrong document number, type N or hit the CANCEL/EXIT KEY to return to the main menu.

#6 Rename file - To rename an existing file, once the block asking if this is the correct file appears, type Y. The next prompt will be:

Enter NEW watershed name:

Once this is completed, press NEW LINE and the file name will be changed.

#7 Print - This function permits you to make a printout on the laser or other printer of the information contained in a file. After showing you the standard block to verify that the correct file has been selected, the next prompt will be:

Printer name:
Copies: **Execute?**

Any valid CEO printer name will be accepted.

#8 PLOT - Assuming you have a plot file on your working directiory, this option will allow you to create three different plots which can be view on a graphics terminal or printed on a laser printer.

From the Boised main menu on the far right column titled Plot file a (Y or N) should be display for each watershed. Select the watershed that you want plot. If you select a watershed that has no plot file, the following message will be display at the bottom of the screen

You do not have any PLOT FILES for this WATERSHED. You need to run option 2. Calculate to create one. Remember to anser [Yes] if you want to save plot file.

If the watershed has one or more plot files, one of two options will take place.

a) If you have two or more plot files for the same watershed, the following screen (figure 8-1) will be display:

```
                          BOISED_PLOT              Revision: 03.01.01

   Watershed: PINE

   Doc.                                            Creation
   Num.                   Alternative              Date
   --------------------------------------------------------------------
   1                      ALT1                     MAY. 23, 91
   2                      ALT2                     JUL.  9, 91

   ====================================================================

   Enter the ALT number to be Plot:1

   The last line is being displayed
```

figure 8-1

Once the correct ALT plot file is selected, the following insert screen (figure 8-2) will appear inside the present screen:

```
                FILE TO BE PLOT
Watershed:
Alternative:
Creation Date:

                 Execute [Y/N]?:Y
```

figure 8-2

If correct file information is displayed, press NL, otherwise press CANCEL/EXIT to back to previous screen for another selection.

After selecting correct file, the following message and screen (figure 8-3) will be display:

Reading in Data ... One moment Please ..

```
                PLOT MENU FOR

               WATERSHED NAME
1. YR vs. %_Over_Natural
2. YR vs. Log_Fire_Road_Total
3. YR vs. Induce_&_Natural

Select type of Plot :1
```

figure 8-3

Here the user can select from three options. No matter which option the user selects, the following screen (figure 8-4) will be display. The user will be asked to answer a couple of questions to customize the plots.

INPUT SCREEN

The default Grapth titles are: **FIRST TITLE LINE**
SECOND TITLE LINE

Would you like to change them [Y/N]:Y

Do you want to display the Graph on your screen [Y/N]:Y

Do you want to print the Graph on a laser printer [Y/N]:Y

figure 8-4

Should the user decide to change the titles, the program will ask for two title lines. The user has the option of providing one or both lines of information.

If the user wants to view the graph on the screen, the following message will be display at the bottom of the screen:

Accessing Trendview Software ... One moment Please ..

Otherwise the user will be asked if he/she wants to print the graph on a **LASER** printer. If the user answers yes, he/she will have to provided a **valid laser queue name**. After the program creates a Binary file to print, the program will display the following:

Press NewLine to continue
Press NewLine to continue

The user MUST press newline so the program can queue to the laser printer.

If the user answers no, the program will go back to the first screen (figure 8-1).

#9 Move/duplicate - is a function that is not operational at this time.

Data Requirements

Once you have created or entered the watershed file you plan to work on, data entry can begin. The screen looks something like the one displayed in Figure 4.

The BOISED program generates default values for many variables such as the geologic erosion factor and sediment delivery ratios. The user may change these values during data entry. Any default values which are changed, will be displayed in printouts and in the data file and screen.

Note: There are two options for entering and editing data. One is to use the BOISED program directly as described. Experienced users can generally speed up data editing, however, by using the Data General SED Editor and its capabilities. This poses some risks since error checking is not in effect and changed default values are not displayed. Only experienced users who fully understand the operation of BOISED should attempt to edit files in this manner. To call up files with the SED Editor, be sure to append the extension .WRC to the watershed filename and also to insert the underline character (_) in place of any blanks in filenames.

Data are identified as one of 4 card types. These are:

- 1 - Landtype data records
- 2 - Cutting units data records
- 3 - Fire/Burn data records
- 4A - Road data records

Data can be entered in any order. The program automatically sorts all records by card type number when you enter a data entry session. Use the Command function and its sort option if you wish to sort records before exiting edit mode.

Data required for each card type is described under Data Requirements.

Data Input Termination

The CANCEL/EXIT key can always be used to terminate data input or editing. The program checks to verify that you really wish to terminate.

If this was an edit session for an existing file you will be asked the following question:

Do you need to keep the original as a backup file?

If you say N, you will be immediately returned to the main menu screen. If you say Y, you will also be returned to the main menu screen, however, a backup will be created by the program. It will have the same filename with the extension .BU added to the end of the name. For example, an original watershed file named CLEAR_CREEK.WRC would have a backup named CLEAR_CREEK.WRC.BU created. The backup file will not appear on your screen of watershed data files but will simply be stored in your directory. Exit BOISED and use the command line command FS to get a complete list of original and backup files.

Card Type 1 - Landtype Data

A landtype data base file must be created from which the BOISED program obtains various landtype values needed for program calculations. User's on the Boise or Payette National Forests Data General systems need not create a Landtype Data Base since they already exist. Other users wishing to use the program will need to create a Landtype Data Base in the format required by the program. See Appendices D and E for more information on the Landtype Data Bases.

The BOISED model requires that watersheds be stratified by landtype (or some other type of homogeneous hydrologic response unit). The acres in each landtype within the study watershed must be known prior to initiating the program. These can be readily obtained from BOIBASE compartments on the Boise National Forest (BNF) by requesting a printout listing acreages for each landtype within the compartments included within the study watershed. It is convenient to outline the study watershed to follow compartment lines whenever reasonable to do so. Compartment boundaries normally follow watershed divides.

If compartment boundaries do not follow watershed boundaries, acreage information will have to be generated manually by using a planimeter or digitizing the area of interest.

Four data items are needed to complete a landtype data record:

1. Card Type
2. Soil Survey Identifier
3. Landtype
4. Acreage.

The card type for landtype data is 1. The soil survey identifier is a character entry of up to 6 characters. Usually this field is left blank. The landtype identifier is a character entry of up to 6 characters. For a landtype identifier to be accepted as valid, it must exist on the landtype data base (See Appendix D) previously discussed. If soil survey identifiers are used, the soil survey and landtype identifier combinations must exist in the data base for entries to be valid. Acres of landtype is an integer or decimal number of up to 6 digits based on the number of acres this landtype occupies in the watershed.

During data input, the screen automatically displays values entered for the previous screen to speedup data entry. This allows the user to change values as needed or simply press NL for any value not requiring change. After each value has been entered and NL pressed, the entry is checked for validity by comparing it to landtypes in the landtype data base file. Incorrect values are cleared from the screen and a message appears at the bottom indicating which entry is incorrect. A valid landtype (one existing in the landtype data base) must be entered before the program will continue.

Landtypes are also checked in the data base to see if the entered soil survey/ landtype combination exists. If each landtype identifier is unique, the soil survey entry may be left blank. The soil survey code has been included to allow for situations where a specific landtype identifier may have different characteristics based on the soil survey used to define its attributes.

If the program is in a data input or edit modes, the last values entered will reappear to be displayed as default values ready for the next landtype to be entered. When all the landtype data has been entered, the user can move on to entering other data by simply entering a new card type.

Card Type 2 - Timber Harvest Data

The following information is needed for any timber harvest activity:
- Cutting unit identification (optional)
- Landtype in which cutting occurs.
- Acreage cut
- Year of harvest
- Harvest method - clearcut (CC) or selection (SEL).
- Yarding method - cable, helicopter (aerial), skyline, or tractor.

All timber harvest data must be entered as card type 2. Each line of an entry will need the information described below:

Unit ID - This is optional and can be any combination of up to 6 characters or digits used to identify the cutting unit. Identifiers are displayed on the calculation output to assist data interpretation. Using the number of a stand or unit can make finding a particular area easier at a later date. However, many people lump all stands with similar logging and harvest methods in a given landtype together to facilitate data entry. In this case, the unit ID is simply a number and not a true identifier.

Landtypes - must be valid landtype identifiers as described previously. If a landtype is entered that was not previously entered in the Landtype section (Card type 1), a warning will be displayed and the user will be asked to correct it. A valid entry must be entered for data entry to continue.

Geologic Erosion Factor (GEF) - generated by the program from the landtype data base file. Usually, you will leave this value as it is (NL over it), however, the value can be changed at this time. Changed values will be displayed on the screen.

Acres - The number of acres treated can be an integer or decimal value.

Year of harvest - The year the activity occurred is entered in 4-digits, for example, 1978, 2005, or 1945. Years from 1800 up to 2200 are allowed. Activities are assumed to take place at the beginning of the year with sediment produced at the end of the same year.

Harvest Code - This shows the harvest and logging method used when treating this stand. The codes are shown below and appear at the bottom of the screen:

1=CC/TR	2=CC/CB	3=CC/SKY	4=CC/AER
5=SEL/TR	6=SEL/CB	7=SEL/SKY	8=SEL/AER
CC=Clearcut	SEL=Select	tree marking	TR=Tractor
CB=Cable	SKY=Skyline	AER=Helicopter	

Surface Erosion Sediment Delivery Ratio (SDR) - generated by the program as described in Appendix J. Usually, you will leave this value as it is (NL over it), however, the value can be changed at this time. Changed values will be displayed on the screen.

Cutting unit data will continue to be displayed until the user moves onto a new card type.

Card Type 3 - Fire Data

The following information is needed to model past and future fires:

- Landtype on which the fire occurred.
- Acres burned
- Year of fire occurrence
- Fire Intensity - high, moderate, or low.

Fire/burn data is entered as card type 3. Each line of an entry requires the following information:

Unit ID - This is optional and can be any combination of up to 6 characters or digits used to identify the burn unit. Identifiers are displayed on the calculation output to assist data interpretation.

Landtypes - must be valid landtype identifiers as described previously. If a landtype is entered that was not previously entered in the Landtype section (Card type 1), a warning will be displayed and the user will be asked to correct it. A valid entry must be entered for data entry to continue.

Geologic Erosion Factor (GEF) - generated by the program from the landtype data base file. Usually, you will leave this value as it is (NL over it), however, the value can be changed at this time. Changed values will be displayed on the screen.

Acres - The number of acres burned can be integer or decimal value.

Year of Burn/Fire - The year the fire occurred entered in 4-digits, such as 1978, 1990, or 1945. Years from 1800 up to 2200 are allowed. Activities are assumed to take place at the beginning of the year with sediment produced at the end of the same year.

Fire Intensity Code - Three intensity levels, defined in Appendix G, are allowed:

1 = Low Intensity
2 = Moderate Intensity
3 = High Intensity

Surface Erosion Sediment Delivery Ratio (SDR) - generated by the program as described in Appendix J. Usually, you will leave this value as it is (NL over it), however, the value can be changed at this time. Changed values will be displayed on the screen.

Card Type 4A - **Road Data**

Information is needed for both existing and proposed roads within the study watershed. The following information is required:

Landtype on which the road exists or will exist.
Miles of road.
Year of road construction and/or reconstruction activity.
Type of road construction activity.
Road width disturbed by construction activity.
Type of use or management the road has received or is expected to receive.
Road gradient.
Erosion mitigation factor.

All road information is entered as Card Type 4A and must include the following:

Unit ID - The road number can be any combination of 1-6 characters or digits used to identify the road. It will be displayed on the calculation output. The use of Forest Service road numbers is strongly recommended.

Landtypes - must be valid landtype identifiers as described previously. If a landtype is entered that was not previously entered in the Landtype section, a warning will be displayed and the user will be asked to correct it. A valid entry must be entered for data entry to continue.

Geologic Erosion Factor (GEF) - generated by the program from the landtype data base file. Usually, you will leave this value as it is (NL over it), however, the value can be changed at this time. Changed values will be displayed on the screen.

Road Miles - The number of miles of road within a landtype. It can be any decimal number less than 1,000. Include specified as well as constructed temporary roads. Do not include skid trails which are considered part of cutting unit erosion. Note that the screen displays "Dist Area" on the information descriptor lines but requested miles as the proper unit under the edit line.

Year of Construction/Reconstruction - The year activity occurred is entered in 4-digits as 1978, 1990, or 1945. Years from 1800 up to 2200 are allowed. Activities are assumed to take place at the beginning of the year with sediment produced at the end of the same year.

Construction Type Code - A code from 1 to 4 representing the type of construction activity. 1 = New/Existing, 2 = Heavy reconstruction, 3 = Light Reconstruction, and 4 = Reclaimed. See Appendix H for specific definitions.

The program allows for an unlimited number of reconstruction of an existing road. Two important rules need to be followed pertaining to reconstructed and reclaimed roads:

(1) You cannot reconstruct a road segment that has never been built. BOISED, as in real life, will only let you reconstruct a road that has previously been built. Even though you may only wish to model the reconstruction impact of a road, you will need to have the computer "build" the road first. If you have no idea of when the road was constructed, fool the computer by coding road construction for some time in the past, such as 1900. This is necessary so that the model calculates sediment correctly. Failure to account for this is one of the most common BOISED data entry errors. The editor does not screen for this error. The error will be detected during calculation and result in a crash. If you get a data coding error which highlights card type 4A, check the highlighted record and the one preceding it to verify that the road in question has indeed been constructed, that is, in the sorted data file, code 1 for a new road should always precede a code 2, 3, or 4 for a reconstructed or reclaimed road.

(2) Every new road/reconstructed road combination must have a unique road number/landtype associated with it. This is required because the program uses the road ID and landtype identifiers to keep track of which roads are being reconstructed. If only new roads are being constructed, identical combinations are not a problem. As an illustration consider the following two hypothetical situations:

	DATA EXAMPLE 1			DATA EXAMPLE 2		
	Road ID	**Landtype**	**Type Code**	**Road ID**	**Landtype**	**Type Code**
(1)	A123	122	1 New	A123	122	1 New
(2)	A123	122	3 L. Recon.	A123	122	3 L. Recon.
(3)	A123	109	1 New	A123	109	1 New
(4)	A123	109	3 L. Recon.	A123	109	3 L. Recon.
(5)	A123	122	1 New	A123X	122	1 New
(6)	A123	122	3 L. Recon.	A123X	122	3 L. Recon.

Data Example 1 will crash because road ID/landtype combination A123/122 in lines 5 and 6 are the same as the road ID/landtype combination in lines 1 and 2. Data Example 2 will work because and X has been added to the road ID in lines 5 and 6 to make it unique. Usually, the best way to "trick" the program is to add a variable to the Road identifier. This is another of the more common errors. Check for unique road ID/landtype combinations when a calculation run crashes.

Surface Erosion Sediment Delivery Ratio (SDR) - generated by the program as described in Appendix J. Usually, you will leave this value as it is (NL over it), however, the value can be changed at this time. Changed values will be displayed on the screen.

Mass Erosion Sediment Delivery Ratio (MSDR) - delivery ratios for mass erosion are calculated separate from the delivery of surface eroded sediment. The default value is generated by the program using the relationship described in Appendix B. Usually, you will leave this value as it is (NL over it), however, the value can be changed at this time. Changed values will be displayed on the screen.

Road Disturbed Width - This is a number generated by the program based on the average slope of the landtype on which the road is constructed. It includes the horizontal distance from the top of the cut slope, across the road tread and any ditches, to the base of the fill slope. Current road widths are based on construction methods (typical cut slopes, fill slopes, and road widths) used after approximately 1980 on the Boise National Forest. Users must generally increase road widths for all construction prior to 1980 or significant underestimation of sediment yield will occur. The default value generated by the program can be overridden by the user at the time of data entry. All road widths less than 1,000 feet will be accepted by the program. See Appendix I for a complete discussion of assumptions used to calculate road widths.

Road Use/Management Code - A value between 1 and 4 where 1 = Heavy Use, 2 = Light Use, 3 = a road Closed to traffic, and 4 = a road Obliterated (reclaimed) by ripping and the re-establishment of vegetation. See Appendix H for complete definitions.

Road Gradient Class - A code from 1-3 corresponding to average percent road gradient where 1 = less than 5%, 2 = 5-10%, and 3 = average road gradient greater than 10%. See Appendix H for additional information concerning this code.

Erosion Mitigation Factor - An expression of the amount of surface erosion reduction attained through the use of various onsite mitigation practices. The factor is structured so that a value of 1.0 implies no reduction in erosion (100% of calculated erosion is assumed to be delivered to stream channels). A factor of 0.2, by contrast, implies an 80 percent reduction in erosion (20% of calculated erosion is assumed to be delivered to stream channels). A default value of 1.0 (no mitigation) will be used unless the user overrides the value. For Boise National Forest granitics the 1.0 mitigation factor assumes dry seeding of cut and fill slopes as the only erosion mitigation practice, other than standard road drainage design, applied to disturbed areas. See Appendix J for a list of mitigation factors used on the Boise National Forest as well as a discussion of how to develop factors. Users have two options for changing mitigation factors in the program: (1) Type over the value for each line, or (2) build additional mitigation tables using the Command line and its mitigation factor builder (refer back to Figure 5 for a discussion). The second choice is preferred if a set of factors are to be used more than once. Up to nine additional mitigation factor tables can be constructed. Each is identified by number and can be assigned to any road segment by simply entering its number identifier. Tables can be created, edited, and deleted by following the prompts after calling up the MITS option by pressing the Command key (F2) in edit mode. Mitigation factors appear as card type 4C in the watershed data file.

PROGRAM OUTPUT

For Boise NF Supervisors Office DG system users, the printed output is normally sent to the high speed printer, draft printer, or other printer specified by the user. Users at other locations will have to identify the location of the printer to which the output is to be sent.

Examples of printed output are included in Appendix N. Please refer to the examples as you read the following explanations.

Natural Sediment Yield and Deposition Threshold

This section shows the watershed name, project name, and alternatives across the top and provides a table listing each landtype within the watershed and the respective acres, square miles, natural sediment yield, total landtype natural sediment yield, average landtype slope, surface and mass sediment delivery ratios, and the geologic erosion factor assigned to each landtype. Columns are totaled where appropriate.

Following the table are calculated values that may need some explanation.

Channel sediment routing coefficient is a sediment routing value based on the relationship of watershed area to the amount of sediment routed as described in the R-1/R-4 Sediment guides. A coefficient of .71 means that 71 percent of the sediment delivered to first order channels is expected to be delivered to the lowest point in the watershed. It is based only on the size of the watershed and assumes that all sediment delivered to first order channels is routed to the mouth of the watershed in the year of the activity. We know this is not precisely true and that sediment tends to move during high flow years. The basic research for this coefficient is rather sparse, and individual watersheds can vary considerably from these average values.

Total natural sediment rate to critical reach is the total natural sediment multiplied by the watershed coefficient. The critical reach is assumed to be the mouth of the watershed being modeled.

Average natural sediment yield is the total natural sediment rate divided by the square miles within the watershed (tons/square mile/year). This value represents sediment delivery to first order drainages.

Average natural sediment yield to the critical reach is the total natural sediment rate to critical reach divided by the square miles within the watershed (tons/square mile/year). This value represents sediment delivered to the mouth of the watershed.

Deposition Threshold Calculations: A geomorphic threshold, or the point at which channel equilibrium is observably altered as evidenced by accelerated deposition of bed materials, loss of channel capacity, and changes in substrate particle size distribution, serves as one reference point for interpreting levels of acceptable change. Data from 65 watersheds on the Clearwater National Forest indicates these changes in sediment yield increase to range from 50 to 350 percent over natural, with 150 percent being a rough average. Threshold calculations in BOISED are determined from an equation derived from Figure 2 of the publication, "Systematic Watershed Analysis Procedure for Clearwater National Forest" by Dale Wilson, Rick Patten, and Walter Megahan which is included as Appendix L. Users are cautioned to carefully read the source document before using these threshold concepts and then to use them only as possible preliminary indicators of possible stream channel disequilibrium.

It is generally recognized that sediment increases which result in observable changes in stream characteristics are detrimental to fisheries. The development of relationships between sediment yield increases and effects on fish habitat and fish populations, however, have met with limited success (Chapman and McLeod, 1987). Based on this, the Boise National Forest currently employs a more pragmatic empirical approach to establishing sediment yield increase thresholds. Sediment producing activities from the early 1900's to the present were modeled for 51 watersheds to estimate the magnitude of past sediment yield increases. In general, maximum sediment yield increases occurred 25 to 30 years ago between 1960 and 1965. Maximum average annual increases averaged about 200 percent over natural and ranged as high as 715 percent. Assuming that current fisheries habitat conditions and fish populations are a direct result of past average increases in sediment of up to 200 percent, a 50 percent reduction, or a threshold of 100 percent over natural was selected as the maximum allowable sediment yield increase on the Boise National Forest for future land-disturbing activities in the Boise National Forest Land and Resource Management Plan. The standard is applied to the mouth of third order watersheds. By reducing the magnitude of future impacts compared to the past, improvement to fish habitat and water quality are expected to occur.

Threshold represents a red flag warning that unacceptable stream channel changes are likely to occur under the modeled scenario. All of these relationships have not yet been verified with field data for the Boise and Payette National Forests. The question of acceptable levels of sediment increase is a difficult one and any thresholds should not be accepted lightly due to the serious consequences either to the environment or commodity production, Be prepared to defend and explain the rationale for any thresholds that are adopted!

Timber Harvest Sediment Yield Section

The next section provides a table of estimated sediment production from logging. A table is produced for each of the first three decades following the specified current year. Each entry identifies the cutting unit ID, landtype, year of harvest, logging method, sediment delivery ratio, area of the unit, and the sediment production for individual years. Totals by year are provided at the bottom of each page.

Fire Sediment Yield Section

The next section provides a table of estimated sediment production from fire. A table is produced for each of the first three decades following the specified current year. Each entry identifies the unit ID, landtype, year of burning, fire intensity, sediment delivery ratio, area of the burn, and the sediment production for individual years. Totals by year are provided at the bottom of each page.

Roading Sediment Yield Section

The next section provides a table of estimated sediment production from road construction activities. A table is produced for each of the first three decades following the specified current year. Each entry identifies the road number, landtype, year, type of construction followed by the road management class, disturbed area of the road, and the sediment production for individual years. Totals by year are provided at the bottom of each page.

The next section provides a more detailed summary of road characteristics modeled. In addition to items already mentioned, each road segment's geologic erosion factor, surface and mass erosion delivery ratios, gradient class, disturbed width in feet and area, and the mitigation coefficient table assigned is displayed. The table is followed by a printout of mitigation coefficient tables used by the run. Note that the road miles column does not include reconstructed roads in the total.

Sediment Yield Summary Table

The sediment yield summary table is the most useful output table for most users. It summarizes sediment yield from all sources on one handy page. Refer to Appendix N for an example. A brief explanation for each follows:

1. Shows the year of activity. The current year is highlighted by parallel dotted lines.

2. Sediment Production for Each Year - Logging. These are tons per year average annual sediment yield estimates unrouted.

3. Sediment Production for Each Year - Fire. These are tons per year average annual sediment yield estimates unrouted.

4. Sediment Production for Each Year - Roading. Totals for all roading activity by year in tons per year average annual sediment production.

5. Total Delivered Sediment. Sum of columns 2, 3, and 4. It shows total management-induced (logging+fire+roading) sediment delivered to first order channels. This value and the values for the preceding columns assumes that sediment from logging units, fire, and roads is delivered to the stream system the same year erosion occurs. Be aware of this assumption in interpreting the results of this output.

6. Total Management-Induced Sediment at Mouth. This is column 4 multiplied by the channel sediment routing coefficient shown on page 1 of the printout. The user is cautioned that the routing coefficient, based on the relationship described in the R-1/R-4 Sediment Guide, is a very broad based value derived from the average of many stream systems, and may not accurately reflect sediment transport characteristics of the particular stream system in question.

7. Total Sediment at Mouth. This is the total amount of management-induced plus natural sediment production multiplied by the routing coefficient.

8. Annual Percent Increase Over Natural Sediment. Calculated as total sediment minus natural sediment divided by natural sediment times 100. This displays the projected sediment yield for any single year. Users are cautioned that this value is especially sensitive to watershed size with small watersheds exhibiting extremely large values due to size alone.

9. 3-Year Running Mean Percent Increase Over Natural Sediment. Same as column 8 except that a running mean is calculated. Note that years one and two of the display are in error. Some people feel that sediment increases are more properly interpreted based on a 3-year period of time rather than on an individual year basis, that is, impacts should persist for a period of year before they become significant.

10. Tons Deposited. Column 7 minus the value for "The threshold sediment to the critical reach" shown at the top of the page. The user must decide whether the assumptions used to develop geomorphic thresholds are appropriate for the watershed in question.

11. Tons Accumulated. This is the accumulated total of each year's Tons deposited as shown in column 10.

12. Percent of Stream Energy Threshold Consumed. Column 7 divided by the value for threshold to the critical reach shown at top of the page. When this value exceeds 100 percent, deposition is assumed to begin.

V. REFERENCES

Arnold, J.F. 1988. A procedure for estimating natural sediment yields and geologic erosion factors for the Boise National Forest. Boise National Forest, Unpublished manuscript, 21 p.

Hennes, R.W. 1985. SALSED Documentation. Salmon National Forest, Intermountain Region. (unpublished).

Hennes, R.W. and J.P. Potyondy. 1985. User's Guide to R1R4SED - A Computerized Version of the R1/R4 Sediment Yield Model. Intermountain Region, Range and Watershed Management. 13+ p.

Megahan, W. F. 1976. Tables of geometry for low-standard roads for watershed management considerations, slope staking, and end areas. USDA Forest Service Gen. Tech. Rpt. INT-32. Int. For. and Range Exp. Sta., Boise, Idaho.

Megahan, W.F., N.F. Day and T.M. Bliss. 1978. Landslide occurrence in the western and central Rocky Mountain Physiographic Province in Idaho *In* Forest soils and land use, (Ed). Proceedings of the Fifth North American Forest Soil conference, Colorado State University, Fort Collins, CO.

Megahan, W.F., and P.N. King. 1985. Identification of critical areas on forest lands for control of nonpoint sources of pollution. Environmental Management, Vol 9, No. 1, pp. 7-18.

Potyondy, J.P, G.F. Cole, and W.F. Megahan. 1991. A procedure for estimating sediment yield from forested watersheds. Pp 46-54, Section 12, Vol. 2 *in* Interagency Committee on Water Data, Subcommittee on Sedimentation. Proceedings of the Fifth Interagency Sedimentation Conference, Las Vegas, Nevada, 1991, March 18-21.

U.S. Forest Service. 1980. An approach to water resources evaluation nonpoint sources-silviculture (WRENSS), a procedural handbook. U.S. Environmental Protection Agency, Athens, Georgia, EPA-600/8-80-012, August 1980.

U.S. Forest Service. 1981. Guide for predicting sediment yields from forested watersheds. Northern and Intermountain Regions, Soil and Water Management. 42 p. Cline, R., G. Cole, W. Megahan, R. Patten and J. Potyondy. 1981. Guide for predicting sediment yields from forested watersheds. U.S. Forest Service, Northern and Intermountain Regions, Missoula, Montana and Ogden, Utah.

U.S. Forest Service. 1983. Guide for predicting Salmonid response to sediment yields in Idaho Batholith watersheds. Northern and Intermountain Regions, Wildlife Managment. 50 p.

Wilson, D., R. Patten, and W.F. Megahan. 1982. Systematic Watershed Analysis Procedure for the Clearwater National Forest. National Academy of Science, National Research Council, Transportation Research Board, Transportation Research Record 892. 1982: 50-56. Washington, D.C.

KEY TO LANDTYPE ASSOCIATIONS AND LANDTYPES
ON THE BOISE NATIONAL FOREST

Prepared By
George Wendt and Timothy Bliss, Soil Scientists
Boise National Forest
February 5, 1976

FOREWARD

This key was developed as an aid for those persons interested in gaining a better understanding of the relationships among the landtypes and landtype associations mapped on the Boise National Forest. Part I contains definitions for five broad geomorphic land groups based on the geologic process and rock type which gave rise to the soils found on each land group. In Part II each geomorphic land group is separated into landtype associations (represented by a capital letter and an arabic numeral, as F3, V4, D1) and landtypes (represented by a three-digit number, usually followed by a lower case letter, or a hyphenated one or two digit number, or both, as 104, 111x, 136-7, 109a-1, 120b-13).

The following two lists contain definitions for the three-digit numbers and for the lower case letters which modify them. The hyphenated one or two digit number usually describes different soil combinations.

101 Alluvial Lands, including Meadow Land

102 Terrace Lands

103 Glacial Outwash Lands

104 Valley Train Lands

105 Alluvial Fan Lands

106 Moraine Lands, including Lateral and End Moraine Lands

107 Toe Slope Lands

108 Glacial Plastered Mountain Slope Land

109 Cryoplanated (Upland, Ridge Lands, Mountain Slopes, Steep Headland, Basin Land)

110 Cirque Basin Lands

111 Glacial Trough Lands, including Steep Headlands

112 River Spur Lands

113 Rocky Ridge Land

114 Subalpine Rim Land

115 Rocky Glacial Scoured Mountain Slope Land

120 Mountain Slope Lands, including Steep Headlands

121 Basin Lands

122 Oversteepened Canyon Lands

123 Faulted Bench Lands

125 Benchy Mountain Slope Land

131 Dissected Dip Slope Lands

133 Scarp Slope Lands

134 Benchy Plateau Slope Land

135 Mesa Scarp Slope Lands

136 Basalt Plain Lands, Cinder Cone, Volcanic Flow Land, Basalt Rockland, Rolling Lava Plain, Dissected Plateau Land

140 Mountain Slope Lands (with remnant lacustrine deposits)

141 Basin Land (" " " ")

143 Faulted Bench Lands (" " " ")

a = Weakly Dissected: >1500 ft. between stream dissections on mountain slopes.

b = Moderately Dissected: 500-1500 ft. between stream dissections.

c = Strongly Dissected: <500 ft. between stream dissections.

d = Steep Headlands

e = Maturely Dissected: Characterized by moderate to well weathered bedrock and rounded fluvial topography.

g = Rejuvenated: Significant fluvial action reinitiated, usually due to uplifting and steepening of slopes.

n = Basin

x = Scoured: Due to glacial action.

Most of the landtypes are unique to the association under which they appear. (Exceptions are starred with explanations sometimes appearing in parenthesis.) Yet, each landtype does contain some inclusions and has a range of characteristics which allows it to vary across the Forest.

Also, note that the Districts on which each landtype appears are listed to the right of the landtype number in the key.

The key was not extended to differentiate among the landtypes because such an extension would greatly lengthen this document. Besides, the landtype name is fairly self-explanatory and anyone requiring additional information is expected to study the soil hydrologic reconnaissance reports. Detailed descriptions and pictures of the landtypes and landtype associations are contained therein.

PART I - GEOMORPHIC LAND GROUPS

A. Soils Derived from Intrusive Granitic (and Metamorphic) Rocks:

1. Soils formed on glaciated landscapes... Glaciated Lands
2. Other soils formed on landscapes dominantly influenced by cold glacial climates; i.e., frost churned and normally at elevations >6000 ft. ... Cryic Lands
3. Other soils formed on landscapes dominantly affected by erosive fluvial (water) action... Fluvial Lands

B. Other Soils Derived from Extrusive Volcanic Rocks:

Soils formed on flows and cones... Volcanic Lands

C. Other Soils Derived from Water and Ice Transported Geologic Materials:

Soils formed in moraine, outwash and other alluvium... Depositional Land

PART II - LANDTYPE ASSOCIATIONS AND LANDTYPES

A. Glaciated Lands

1. Glaciated lands with U-shaped valleys... p.32

Glaciated Granitic Trough Lands (G2)

*a.	Valley train land	(104-2) ⁄ 104	D1 - D6
b.	Glacial plastered mountain slope land	⁄ 108	D2, D4, D5
c.	Weakly dissected glacial trough land	⁄ 111a	D1 - D6
		⁄ 111a-1	D1 - D6
d.	Moderately dissected glacial trough land	⁄ 111b	D2 - D6
		111b-1	D2, D4, D.
e.	Strongly dissected glacial trough land	111c	D2, D4 -
		111c-3	D4

*f. Steep rocky glacial headland (111d-2) 111d D4

*g. Steep benchy glacial headland 111d-3 D6

h. Rejuvenated glacial trough land 111g D6

*i. Scoured glacial trough land 111x D2 - D4

j. Rocky glacial scoured mountain slopes (115-1) 115 D4

2. Other glaciated lands, especially cirque basins and associated headlands... p. 30 Glaciated Granitic Headlands (G1)

a. Cirque basin land 110 D2 - D4, D6

b. Scoured cirque basin land 110x D1 - D6

*c. Steep rocky glacial headland 111d D2, D4

*d. Steep benchy glacial headland 111d-3 D3, D5, D6

*e. Scoured glacial trough land 111x D2, D3, D5

f. Rocky ridge land 113 D1 - D6

*g. Subalpine rim land (inclusion) 114 D5

B. Cryic Lands

1. Cryic lands consisting mostly of mountain slopes affected significantly by fluvial processes... p. 12

Rejuvenated Cryoplanated Mountain Slope Lands (C2)

a. Cryoplanated ridge land (109a, 109a-1) 109-2 D1 - D6

109-5 D6

b. Weakly dissected cryoplanated mountain slopes 109a-1 D1-D3, D5,

c. Moderately dissected cryoplanated mountain slopes (109b-1) 109b D1 - D6

d. Strongly dissected cryoplanated mountain slopes 109c D1 - D6

e. Cryoplanated headland (109e-1) 109d-1 D1-D3, D5, I

f. Rejuvenated cryoplanated mountain slopes 109g D1, D2

109g-1 D1

2. Other cryic lands, including ridges, uplands and basins, little affected by fluvial processes... (p.10) p.30 Cryoplanated Granitic Uplands (C1)

a. Cryoplanated upland (109, 109b) 109-9 D4 - D6

b. Cryoplanated basin land (109d-2) 109n-1 D4 - D6

*c. Subalpine rim land (114-2) 114 D4

C. Fluvial Lands

1. Fluvial lands which have a moderate to high mass wasting potential due to pockets of heavier than normal soils formed in remnant lacustrine deposits... (p.26

Mass Wasting Fluvial Lands (F6)

a. Moderately dissected mountain slope land	140b-2	D2
	140b-3	D2, D3
b. Strongly dissected mountain slope land	140c-1	D2
	140c-2	D2
	140c-3	D2, D3
c. Maturely dissected mountain slope land	140e-1	D2, D3
	140e-2	D3
d. Basin land	141	D2
e. Faulted bench land	143	D2, D3
f. Strongly dissected faulted bench land	143c	D3

2. Other fluvial lands adjacent to canyons with live streams, with shallow, parallel 1st and 2nd order drainages, and with slopes dominantly > 60%... p. 24

Steep Granitic Canyon Slopes (F5)

a.	Oversteepened canyon land	122	D3 - D5
		122-4	D1 - D6
b.	Rocky oversteepened canyon land	122-1	D1, D2, D4,
c.	Oversteepened canyon land-Xeric soils	122-8	D1, D6
*d.	Steep rocky headland	120d-2	D4
*e.	Steep headland	120d-3	D1
*	Xeric soils	120d-4	D1

3. Other fluvial lands which are faulted with a bench or basin-like appearance, with or without deep stream dissections... no F5

Structurally Controlled Granitic Fluvial Lands (F:

a.	River spur land	112	D4
		112-1	D4, D5
b.	Basin land	121	D3, D4, D6
c.	Maturely dissected basin land	121e	D2 - D6
		121e-1	D1, D5
d.	Faulted bench land	123	D4
		123-1	D2, D4, D5
		123-3	D2, D3, D6
	Xeric Soils	123-2	D2
e.	Moderately dissected faulted bench land	123b	D1
		123b-1	D1
f.	Strongly dissected faulted bench land	123c	D1, D3, D5

4. Other fluvial lands with xeric (dry) soils, but not cryic, such that the forest crown density is < 20%. Slopes are short to long at 20% to 50% and drainages are parallel to dendritic... p.28

Xeric Granitic Fluvial Lands (F7)

*a. Weakly dissected mountain slope land		120a-8 D6
*b. Moderately dissected mountain slope land	(120b-11, 120b-12)	120b-3 D1 - D3
	Volcanics?)	120b-5 D6
c. Strongly dissected mountain slope land		120c-2 D6
		120c-8 D1 - D3, D6
		120c-12 D6
*d. Steep headland		120d-4 D1 - D3, D6
e. Maturely dissected mountain slope land,		
	Low Relief	120e-5 D1
	High Relief	120e-6 D1, D2, D6
	Moderate Relief	120e-7 D2

(Landtypes 120a-8 and 120b-3 are included in F1 on D5 because of the absence of an F7 unit)

5. Other fluvial lands with well rounded ridge tops and drainageways and fine-meshed dendritic stream pattern over well weathered bedrock ..

p.20 Mature Relief Fluvial Lands (F2)

a. Maturely dissected mountain slope land		
	Low Relief	120e D3 - D6
	High Relief	120e-1 D3 - D5
	Moderate Relief	120e-2 D1, D3, D6

(Some mature lands are xeric and are found under F7, or are lacustrine and are found under F6)

6. Other fluvial lands with strongly dissected slopes, with V-shaped drainages and with relatively narrow sharp ridges... p. 22

Strongly Dissected Granitic Fluvial Lands (F4)

a. Strongly dissected mountain slope land...

		120c	D3 - D6
north aspect		120c-1	D3 - D5
		120c-3	D1 - D6
north aspect	(120c-9)	120c-11	D1-D3, D5, D6

b. Steep rocky headland	120d	D4
*	120d-2	D2, D5
*c. Steep headland	120d-3	D2, D3, D5, D6

7. Other fluvial lands with weakly to moderately dissected slopes and V-shaped drainages... (p. 18)

Fluvial Granitic Lands (F1)

a. Weakly dissected mountain slope land	120a	D4, D6
	120a-1	D6
	120a-2	D2 - D4

b. Moderately dissected mountain slope land...

northerly aspects	120b	D4
soft bedrock	120b-1	D4
northerly aspects	120b-4	D1 - D6
southerly aspects	120b-6	D1-D3, D5, D6
	120b-10	D6
	120b-13	D6
	120b-2	D4

c. Weakly dissected mountain slope land

* (Inclusion)	Xeric soils	120a-8	D5

d. Moderately dissected mountain slope land

* (Inclusion)	Xeric soils	120b-3	D5

D. Volcanic Lands

1. Volcanic lands which show evidence of recent geologic activity by the presence of volcanic flows and cinder cones... no PS

Recent Volcanic Lands (V3)

a. Cinder cone		136-5	D1
b. Volcanic flow land		136-6	D1

2. Other volcanic flow lands (basaltic) which have been faulted and tilted from 30% to 50%, with scarp slopes up to 70%... p. 40

Structurally Controlled Basalt Lands (V5)

a. Dissected dip slopes		131-2	D6
	Xeric soils	131-3	D6
b. Smooth scarp slopes		133a-3	D6
c. Moderately dissected scarp slopes		133b	D6
d. Strongly dissected scarp slopes		133c-1	D6

3. Other volcanic lands with soils formed on the relatively flat Snake River basalt flows... p. 36 Basalt Plains (V2)

a. Basalt Plain	Xeric soils	136-1	D1, D2
	Xeric soils	136-2	D1
		136-3	D1
b. Basalt rockland	Xeric soils	136-7	D1

4. Other volcanic lands which are flat to rolling and have soils formed from silicic volcanic rock underlain by granite... p. 38

Silicic Volcanic Lands (V4)

a.	Benchy mountain slope land		125	D1
b.	Mesa Scarp Slopes		135-3	D1
		Xeric soils	135-2	D1
c.	Rolling lava plain	Xeric soils	136-4	D1
d.	Dissected plateau land	Xeric soils	136-8	D1

5. Other volcanic lands, with both steep and/or benchy escarpments, and which have been and/or are being cut by active streams in the Boise River drainage... p. 34

Basalt Canyon Lands (V1)

a.	Benchy plateau slopes	134-3	D1
b.	Mesa scarp slopes	135-1	D1, D2

E. <u>Depositional Lands</u>

1. Depositional lands resulting from glacial action, as morainal deposits and glacial outwash... p. 14

Moraine and Outwash Lands (D1)

a.	Glacial outwash land			103	D4, D5
b.		Low relief		103-1	D5
c.	Moraine land, undifferentiated			106	D2, D4, D5
d.	Lateral moraine land		(106a)	106-2	D2, D4, D5
e.	End moraine land		(106b)	106-4	D4
*f.	Valley train land (inclusion)		(104-2)	104	D4
g.	Meadow land				
*		Undifferentiated soils	(101a)	101-3	D4, D5

2. Other depositional lands... p-16		Alluvial Lands (D2)	
a. Alluvial land undifferentiated soils		101	D1 - D6
	Low gradient	101-2	D1
*b. Meadow land - undifferentiated soils (inclusion)		101-3	D6
c. Terrace land		102	D1, D2, D , D6
d. Alluvial fan land		105	D4, D5
	Xeric soils	105-4	D1 - D3
	Xeric soils	105-5	D1, D2, D
e. Toe slope land		107	D4
	(Basalt)	107-1	D2, D6
		107-2	D6

Lty	NSY	Dist Wdth
101		14.8
102		14.8
104		16.6
~~104~~		
107		25.6
109		25.6
110		17.6
113		49.1
114		33.8
121		20.3
122		46.4
123		25.6
105-5		16.6
109-1		25.6
109-5		23.0
109-9		20.3
109a-1		33.8
109b		25.6
109b-1		25.6
109c		29.7
109d-1		39.9
109n-1		25.6
110x		17.6
111a		36.9
111a-1		36.9
111b		36.9
111b-1	50	36.9
111c		25.6
111d	60	43.6
111d-3	55	29.7
111g	60	43.6
111x	50	33.8
120a		33.8
120a-2		29.7
120b		36.9
120b-1	50	29.7
120b-13		33.8
120b-2		33.8
120b-4		29.7
120b-6		25.6
120c	80	36.9
120c-1	58	43.6
120c-11		33.8
120c-12		36.9
120c-2	74	36.9
120c-3	78	41.8
120c-8	87	43.6
120d	95	39.9
120d-3	85	36.9
120d-4	110	36.9
120e		20.3
120e1		29.7
121e		23.0
122-4	120	46.4
123-3		25.6
D01-1	12	15.6
D01-11	12	15.6
G06-1	12	16.6
G06-2	12	19.0
G16-1	12	16.6
G16-2	30	23.0
S09-1	90	39.9
S09-11	50	39.9
S09-12	50	39.9
S09-2	120	39.9
S09-3	90	36.9
S20-1	30	33.8
S30-1	30	25.6
S30-12	30	29.7

```
Function    DW    (AVG SLOPE, DW)

If  AVG SLOPE < 10   Then

        DW =

  ElseIf  AVG SLOPE = 15   Then

          DW =

  Else If   AVG SLOPE = 20   Then

          DW =
```

Appendix

A

Paper:

A Procedure for Estimating Sediment Yields from Forested Watersheds

by

John P. Potyondy
Gene F. Cole
Walter F. Megahan

Fifth Interagency Sedimentation Conference

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A PROCEDURE FOR ESTIMATING SEDIMENT YIELDS FROM FORESTED WATERSHEDS

by John P. Potyondy, Forest Hydrologist, USDA Forest Service, Boise National Forest, Boise, Idaho.
Gene F. Cole, Forest Hydrologist (Retired), USDA Forest Service, Boise National Forest, Boise, Idaho.
Walter F. Megahan, Research Hydrologist, USDA Forest Service, Intermountain Forest and Range Experiment Station, Boise, Idaho

ABSTRACT

BOISED is the operational sediment yield model used by the Boise National Forest to evaluate the sediment impact from alternative land management scenarios. The model is a local adaptation of the sediment yield model developed by the Northern and Intermountain Regions of the U.S. Forest Service for application to forested watersheds associated with the Idaho Batholith. The procedure is commonly used in the preparation of environmental assessments and impact statements as a tool to evaluate the effects of alternative timber harvest activities, road locations and design, and the application of erosion mitigation practices. The procedure provides for estimation of on-site erosion, delivery to stream channels, and routing of sediment downstream to critical reaches where interpretation of sediment impact to water quality and fish habitat can be made.

The model produces quantified estimates of average annual sediment yields for the undisturbed condition, past activities, and activities proposed in the future. Management activities which can be modeled include road construction, timber harvest, and fire. While it is inappropriate to use the model as a highly reliable predictor of absolute quantities of sediment delivered to streams at specific times, it is appropriate to use model results for comparison of alternative management scenarios within a watershed. Because the model considers both on-site erosion and downstream sediment yield, application of best management practices for the protection of water quality and beneficial uses can be evaluated.

INTRODUCTION

The National Environmental Policy Act of 1969 (42 U.S.C. 4321) is one of the most far-reaching pieces of legislation to affect National Forests. Among other things, it mandates interdisciplinary planning and the use of analytical procedures so that the impacts of alternative courses of action can be made more explicit and visible to the public prior to decisionmaking.

Various procedures have been developed to estimate the effects of alternative soil disturbing practices on soil erosion (Wischmeier and Smith, 1978, Curtis and Darrach, 1977, Darrach and Curtis, 1978). Unfortunately, these methods have limited application in much of the mountainous West because they were developed on agricultural lands and are not well adapted to erosional processes common to forested watersheds.

A procedure has been developed on the Boise National Forest for predicting the cumulative effects of alternative land management practices, including road construction, timber harvest, and forest fire, on increasing sediment yield from forested watersheds. The procedure is encapsulated in a computer model named BOISED (Unpublished user guide by Boise National Forest, in preparation) and is patterned after the USDA Forest Service Regions 1 and 4 Sediment Yield Model (Cline, et. al., 1981). Although developed principally for watersheds associated with the Idaho Batholith, the processes described can be adapted to other forested areas provided some base research sediment yield data exists.

The BOISED model simplifies for analysis an extremely complex physical system and was developed from empirical data supplemented by extrapolation based on professional judgement and our current understanding of erosion and sediment transport processes on forested lands. In general, the procedure estimates on-site erosion from the time of its genesis until it decreases to pre-activity levels, modifies the amount of erosion according to general land unit characteristics, delivers the eroded material to the stream system, and routes the eroded material through the watershed to downstream sites where interpretation of effects are made. The systematic analysis tool is not generally recommended for watersheds greater than 50 square miles. All values are expressed in terms of average annual yields.

WATERSHED STRATIFICATION

Average annual erosion rates are estimated for homogeneous response units delineated according to hierarchical land systems inventory concepts described by Wertz and Arnold (1972). The basic unit for the procedure is the "landtype" defined as an area of land with similar landform, parent material, soil, and vegetation characteristics. Landtypes typically range in size from about 40 to several hundred acres. Landtypes are ideal for sediment modeling because many of the factors influencing slope hydrology and sediment delivery from slopes to streams are used to delineate landtypes. Among these are factors such as slope shape, gradient, roughness, dissection by drainageways, and the average distance to active drainageways. Specifics of landtype mapping for the Boise National Forest are fully described elsewhere (Wendt, et. al., 1975).

NATURAL SEDIMENT YIELD

Average annual natural sediment yield, expressed as tons per square mile of watershed area per year, serves as the beginning point for describing the undisturbed condition and as a baseline against which to interpret the magnitude of average annual management induced sediment yield increases. Most natural sediment yield from the Idaho Batholith comes from in-channel erosion of banks and stored sediment. The primary source of supply is assumed to be natural mass slope erosion processes (slumps and slides, debris avalanche-debris flow failures, and soil creep).

The potential hazard of natural mass soil movement can be estimated by evaluating site characteristics such as slope gradient, soil depth, subsurface drainage, soil texture, bedding structure and orientation, surface slope configuration, and precipitation input. A procedure for doing so is documented in the WRENSS Handbook (USDA Forest Service, 1980). This procedure was modified to reflect Boise National Forest conditions by changing weighting factors and adding new factors as appropriate (Unpublished report by J.F. Arnold, 1988).

Local sediment yield data was obtained from the USDA Intermountain Forest and Range Experiment Station's Tailholt-Circle End and Silver Creek Study Areas. Sediment yield measured at the mouths of twelve small granitic watersheds having slopes with gradients near 60 percent and ranging in size from 0.15 to 2.5 square miles, averaged 25 tons per square mile per year (Megahan, 1975; unpublished data, Intermountain Research Station, Boise, Idaho).

Mass erosion hazard ratings were determined for each of the measured watersheds and for each landtype on the Boise National Forest. A curve was constructed to estimate natural sediment yield from the hazard rating by assigning the lowest range of expected sediment yield (10 tons/mile^2/year) to the landtype with the lowest hazard rating and the highest yield (100 tons/mile^2/year) to the landtype with the highest hazard rating. Ratings for landtypes on the study watersheds and the corresponding measured sediment yields defined the middle range of the curve. Using the curve, natural sediment was estimated for each landtype based on the landtype's mass erosion hazard rating.

Computationally, total natural sediment for a watershed is the sum of the natural sediment yield for each landtype times its area. These values provide estimates of natural in-channel sediment yield for watersheds representative of the size from which the original data was collected averaging one square mile in size. As watershed size increases, unit area sediment yield decreases. The decrease is due to losses caused by sediment storage in tributary channels, floodplains, and behind organic debris. To account for this loss, a channel routing coefficient, using a relationship developed by Roehl (1962) is used. Roehl's relationship has been adjusted to provide a coefficient of 1.0 for one square mile watersheds as follows:

$$C = A^{-0.18}$$

where: C = channel routing coefficient; A = watershed area (square miles).

The channel routing coefficient is applied whenever watersheds greater than one square mile are modeled to correct for storage losses within the watershed.

SEDIMENT FROM SURFACE EROSION

Management-induced sediment generated from surface erosion processes is modeled independently from management-induced mass erosion. Mass erosion processes are an acceleration over natural sediment rates, while surface erosion is created by management activities.

Basic surface erosion rates (Table 1) were derived from research data for new road construction, logging, and fire (Cline et. al., 1982). Basic erosion rates for road reconstruction and road management were estimated based on the relative amount of soil disturbance compared to new construction.

Heavy reconstruction means the entire existing road surface is completely disturbed, cut slopes receive significant disturbance, and fill slopes minor disturbance. Light reconstruction involves minor excavation and disturbance of cut and fill slopes. Heavy use is defined as more than five vehicles per day. Light use averages less than 5 vehicles per day. Closed roads are generally gated to prevent traffic and are not surface bladed annually. Obliterated roads have natural drainageways restored and are revegetated. Closures and obliterations are assumed to take place during the fourth year following disturbance.

Table 1. Basic surface erosion rates for standard practices in tons per square mile of disturbance per year.

PRACTICE	Years Since Activity Occurred 1	2	3	4	5	6	6+
Fire	550	120	25	5	0	0	0
Logging	340	180	140	90	40	20	0
New Road/Heavy Use	67,500	18,000	7,000	7,000	7,000	7,000	7,000
New Road/Light Use	67,500	18,000	5,000	5,000	5,000	5,000	5,000
New Road/Closed	67,500	18,000	5,000	3,000	2,000	1,250	1,250
New Road/Obliterated	67,500	18,000	5,000	1,000	500	250	250
Heavy Reconst/Heavy Use	18,000	10,000	7,000	7,000	7,000	7,000	7,000
Heavy Reconst/Light Use	18,000	5,000	5,000	5,000	5,000	5,000	5,000
Heavy Reconst/Closed	18,000	5,000	5,000	3,000	2,000	1,250	1,250
Heavy Reconst/Obliterated	18,000	5,000	5,000	1,000	500	250	250
Light Reconst/Heavy Use	9,000	7,000	7,000	7,000	7,000	7,000	7,000
Light Reconst/Light Use	9,000	5,000	5,000	5,000	5,000	5,000	5,000
Light Reconst/Closed	9,000	5,000	5,000	3,000	2,000	1,250	1,250
Light Reconst/Obliterated	9,000	5,000	5,000	1,000	500	250	250

When a proposed disturbance deviates from the standard practice used to define the basic rates, erosion rates are modified by multiplying by appropriate factors based on the deviation from the standard.

Road Construction

Computationally, total erosion from a uniform road segment within one landtype for any year is calculated as:

(BASIC ROAD EROSION RATE) times (DISTURBED AREA) times (GEOLOGIC EROSION FACTOR) times (ROAD GRADIENT FACTOR) times (MITIGATION FACTOR) times (SLOPE SEDIMENT DELIVERY FACTOR)

where:

BASIC ROAD EROSION RATE = erosion in tons per square mile of disturbed area per year (Table 1). The standard road is assumed to be a maintained, 16 foot wide, native material road with a sustained grade of 5 to 7 percent, constructed on grantic material on a 50 percent side slope.
DISTURBED AREA = the total area disturbed by road construction expressed in square miles. The disturbed area of the road prism includes road subgrade, cut and fill slopes, ditches, berms, turnouts, and any other construction features that may be present. Tables of geometry for low standard roads, such as those developed by Megahan (1976) are useful to determine total disturbed area.
GEOLOGIC EROSION FACTOR = a coefficient applied to management-induced surface erosion to account for the relative difference in erodability based on geologic parent material. On the Boise National Forest, weathered granitics are assigned a value of 1.0; basalts have a value of 0.42.
ROAD GRADIENT FACTOR = a coefficient use to correct for gradients other than the standard. Gradients from 5 to 9.9 percent are assigned a value of 1.0; gradients less than 5 percent are assigned 0.5; gradients 10 percent or greater are assigned a value of 1.5.
MITIGATION FACTOR = a coefficient used to express the percent reduction in erosion due to the application of erosion control practices. Included are vegetative measures, such as seeding and mulching of cut and fill slopes, as

well as physical measures, such as gravelling and the placement of filter windrows. Combinations of practices are commonly employed. The mitigation effectiveness of many road erosion control practices has been documented by Burroughs and King (1988).

SLOPE SEDIMENT DELIVERY FACTOR = a coefficient used to express the percent of on-site erosion which reaches active drainageways. A modification of a procedure developed by the Forest Service (U.S. Forest Service, 1980) is used. Variables include slope steepness, shape, dissection, and distance to active drainageways (Reinig, et. al., in preparation). Delivery efficiencies generally are less than 20 percent.

Logging

Computationally, total erosion due to logging on a landtype for any year is calculated as:

(BASIC LOGGING EROSION RATE) times (GEOLOGIC EROSION FACTOR) times (DISTURBED AREA) times (LOGGING SYSTEM FACTOR) times (LAND UNIT SLOPE FACTOR) times (SLOPE SEDIMENT DELIVERY FACTOR)

where (factors not previously defined):

BASIC LOGGING EROSION RATE = Erosion in tons per square mile per year for the standard logging system which is clearcut with tractor yarding (Table 1). Temporary roads and skid trails within the harvest area and which have erosion control practices employed are assumed to be part of the standard practice.

DISTURBED AREA = the total area harvested.

LOGGING SYSTEM FACTOR = a coefficient used to express relative erodability of various logging systems and silvicultural prescriptions based on the amount of bare soil exposed (Table 2)

Table 2. Logging system factors for alternative logging systems and silvicultural prescriptions.

SILVICULTURAL PRESCRIPTION	LOGGING YARDING SYSTEM			
	Tractor	Cable	Skyline	Aerial
Clearcutting	1.00	0.62	0.33	0.19
Selection	0.71	0.43	0.29	0.14

LAND UNIT SLOPE FACTOR = a coefficient used to increase or decrease erosion for slopes other than 45 percent. The factor is adapted from the slope factor relationship of the Universal Soil Loss Equation scaled so that slopes of 45 have a factor of 1.0, slopes of 75 percent have a factor of 2.0, and flat surfaces have a factor of 0.5.

Fire

Computationally, total erosion due to fire on a landtype for any year is calculated as:

(BASIC FIRE EROSION RATE) times (GEOLOGIC EROSION FACTOR) times (DISTURBED AREA) times (FIRE INTENSITY FACTOR) times (LAND UNIT SLOPE FACTOR) times (SLOPE SEDIMENT DELIVERY FACTOR) where (factors not previously defined):

BASIC FIRE EROSION RATE = Erosion in tons per square mile per year for the standard fire which is assumed to have burned at high intensity on a side slope of 45 percent consuming at least 40 percent of standing vegetation (Table 1).
DISTURBED AREA - the total area actually burned.
FIRE INTENSITY FACTOR - a coefficient used to express relative erodability assigned to low, medium, and high fire intensity classes as defined in the Forest Service Burned-Area Emergency Rehabilitation Handbook (FSH 2509.13). High equals 1.0, medium equals 0.5, and low equals 0.2

SEDIMENT FROM MASS EROSION

Debris avalanche-debris slide slope failures are the major categories of mass erosion occurring on the Boise National Forest based on published and unpublished data from a landslide inventory conducted in Idaho (Megahan, et. al., 1978; Unpublished data, Intermountain Research Station, Boise, Idaho). The frequency of these slope failures in various parts of the world average about 140 times greater per unit area of road than undisturbed slopes, whereas clearcutting increases slope failure frequency an average of only 7 times (Megahan and King, 1985). Studies consistently indicate that debris avalanche-debris slide slope failures are limited to slopes greater than 45 percent with a maximum frequency of occurrence at about 70 percent. For these reasons, only new road construction on landtypes with average slopes greater than or equal to 45 percent are assumed to accelerate mass erosion processes. Provisions are made to exclude landtypes on steep slopes known to be unstable and landtypes on gentler slopes known to be susceptible to slope failure due to other factors.

Using the inventory data cited, total mass erosion during a 20 year period was tabulated and then divided by the total miles of road construction during the same time period and by the average natural sediment yield for the study area to yield an acceleration factor as a function of natural sediment yield. A cumulative frequency curve of age versus slide frequency was constructed to derive acceleration factors for individual years (Table 3).

Table 3. On-site Mass Erosion Acceleration Factors.

Road Age (years)	Accel. Factor	Road Age (years)	Accel. Factor	Road Age (years)	Accel. Factor	Road Age (years)	Accel. Factor
1	44	6	51	11	25	16	6
2	76	7	44	12	19	17	6
3	82	8	38	13	13	18	6
4	63	9	32	14	13	19	3
5	63	10	25	15	13	20+	3

Since the data used to derive acceleration factors represents on-site erosion, a delivery factor had to be developed for each landtype. Because mass erosion delivery processes are inherently different from surface erosion delivery processes, a mass erosion delivery ratio patterned after a graphical relationship found in the WRENSS Handbook (U.S. Forest Service, 1980) for debris avalanche-debris flows was used.

Computationally, management-induced mass erosion for new roads constructed on landtypes with average slopes of 45 percent or greater is calculated as:

MASS EROSION (new roads) = (NATURAL SEDIMENT YIELD) times (DISTURBED AREA)
times (MASS EROSION DELIVERY FACTOR)
times (ON-SITE MASS EROSION ACCELERATION FACTOR)

where:

NATURAL SEDIMENT YIELD = the sediment yield from an undisturbed landtype expressed in tons per square mile per year.
DISTURBED AREA = the total area disturbed by road construction as previously defined.
MASS EROSION DELIVERY FACTOR = a decimal fraction expressing the percentage of on-site mass erosion material delivered to the nearest first or higher order drainage.
ON-SITE MASS EROSION ACCELERATION FACTOR = a dimensionless multiplier from Table 3.

PROCEDURE APPLICATION

By varying either the amount, location, anmd timing of management activities or the application of erosion mitigation practices, the mix of activities which keeps sediment impacts within acceptable limits can be identified. This is normally done during the environmental assessment phase of project level planning to provide the decisionmaker and public with a reasonable assessment of probable impacts.

Sediment yield outputs from the model are normally expressed as a percent increase over the natural condition. An example of a typical application of the model to a 7 square mile watershed is shown in Figure 1.

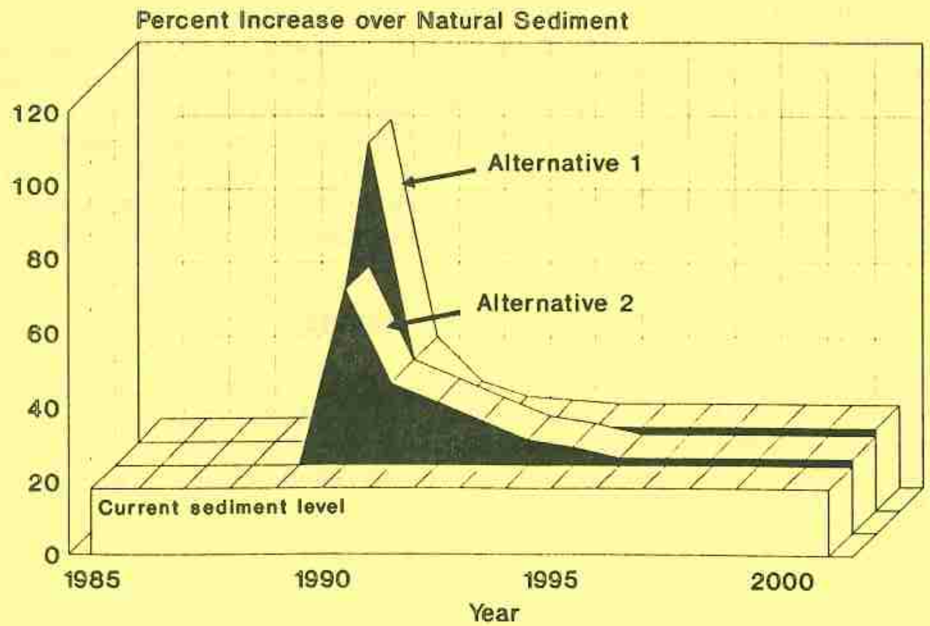

Figure 1. Example of a typical application of the procedure.

The example assumes 9 miles of existing road which produces the current 18 percent increase over natural followed by alternatives which construct 5 miles of new road in 1990 and harvest 450 acres of timber by selection methods in 1991. The time dependence of sediment response to these activities is readily apparent. Alternative 1 assumes all construction takes place in one year followed by timber harvest the next year. Sediment yield peaks at 100 percent over natural. Alternative 2 employs a higher degree of erosion mitigation and defers some road construction into 1991. Peak sediment yield is reduced to 65 percent over natural and remains high for a slightly longer period of years. Sediment yields in both alternatives do not return to predisturbance conditions due to long term surface erosion from added roads. Based on reduced peak and long term sediment yields, Alternative 2 is clearly the environmentally preferred alternative.

A geomorphic threshold, or the point at which channel equilibrium is observably altered as evidenced by accelerated deposition of bed materials, loss of channel capacity, and changes in substrate particle size distribution, serves as one reference point for interpreting levels of acceptable change. Data from 65 watersheds on the Clearwater National Forest (Wilson, et. al., 1982) indicates these changes in sediment yield increase to range from 50 to 350 percent over natural, with 150 percent being a rough average. It is generally recognized that sediment increases which result in observable changes in stream characteristiscs are deterimental to fisheries. The development of relationships between sediment yield increases and effects on fish habitat and fish populations, however, have met with limited success (Chapman and McLeod, 1987). Based on this, the Boise National Forest employed a more pragmatic empirical approach to establishing sediment yield increase thresholds. Sediment producing activities from the early 1900's to the present were modeled for 51 watersheds to estimate the magnitude of past sediment yield increases. In general, maximum sediment yield increases occurred 25 to 30 years ago between 1960 and 1965. Maximum average annual increases averaged about 200 percent over natural and ranged as high as 715 percent. Assuming that current fisheries habitat conditions and fish populations are a direct result of past average increases in sediment of up to 200 percent, a 50 percent reduction, or a threshold of 100 percent over natural was selected as the maximum allowable sediment yield increase on the Boise National Forest for future land-disturbing activities. By reducing the magnitude of future impacts compared to the past, improvement to fish habitat and water quality are expected to occur. The procedures described in this paper will be used to define acceptable levels of activities and specific on-site erosion mitigation practices to achieve these goals.

ACKNOWLEDGEMENTS

The authors wish to recognize and express their thanks to the numerous hydrologists and soil scientists working on National Forests in the Intermountain and Northern Regions of the Forest Service who have contributed to the development and improvement of the R1/R4 Sediment Yield Model and the BOISED Model.

REFERENCES

Burroughs, E.R., and J.C. King, 1989, Reduction of soil erosion on forest roads. Gen, Tech. Rep. INT-264, Ogden, Utah, USDA Forest Service, Intermountain Research Station.

Chapman, D.W., and K.P. McLeod, 1987. Development of criteria for fine sediment in the northern Rockies ecoregion. U.S. Environmental Protection Agency, Seattle, Washington, EPA-910/9-87-162, April 1987.

Cline, R., G. Cole, W. Megahan, R. Patten and J. Potyondy, 1981, Guide for predicting sediment yields from forested watersheds. U.S. Forest Service, Northern and Intermountain Regions, Missoula, Montana and Ogden, Utah.

Curtis, N.M., and A.G. Darrach, 1977, Estimating sheet-rill erosion and sediment yield on disturbed western forest and woodlands. Tech. Note Woodland - No. 10, USDA SCS West Tech. Serv. Center, Portland, Oregon.

Darrach, A.G., and N.M. Curtis, 1978, Estimating sheet-rill erosion and sediment yield on rural and forest highways. Tech. Note Woodland - No. 12, USDA SCS West Tech. Serv. Center, Portland, Oregon.

Megahan, W.F., 1975, Sedimentation in relation to logging activities in the mountains of central Idaho. In Present and Prospective Technology for Predicting Sediment Yields and Sources, Proc. Sediment-Yield Workshop. USDA Sediment Lab., Oxford, Miss., Nov. 28-30, 1972. U.S. Agric. Res. Serv. Rpt. ARS-S-40, 1975, 285 p.

Megahan, W.F., 1976, Tables of geometry for low-standard roads for watershed management considerations, slope staking, and end areas. Technical Report INT-32. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah.

Megahan, W.F., N.F. Day and T.M. Bliss, 1978. Landslide occurrence in the western and central Rocky Mountain Physiographic Provence in Idaho In Forest soils and land use, (Ed). Proceedings of the Fifth North American Forest Soil Conference, Colorado State University, Fort Collins, CO.

Megahan, W.F., and P.N. King, 1985, Identification of critical areas on forest lands for control of nonpoint sources of pollution. Environmental Management, Vol 9, No. 1, pp. 7-18.

Roehl, J.W., 1962, Sediment source areas, delivery ratios, and influencing morphological factors. Commission of Land Erosion, International Assoc. of Scientific Hydrology, Reading, Berkshire, England, Pub. 59, pp. 202-213.

U.S. Forest Service, 1980, An approach to water resources evaluation nonpoint sources-silviculture (WRENSS), a procedural handbook. U.S. Environmental Protection Agency, Athens, Georgia, EPA-600/8-80-012, August 1980.

Wendt, G.E., R.A. Thompson, and K.N. Larson, 1975, Land systems inventory, Boise National Forest, Idaho: A basic inventory for planning and management. USDA Forest Service, Intermountain Region, Ogden, Utah.

Wertz, W.A., and J.F. Arnold, 1972, Land systems inventory. USDA Forest Service, Intermountain Region, Ogden, Utah.

Wilson, D., R. Patten, and W.F. Megahan, 1982, Systematic watershed analysis procedure for Clearwater National Forest. Leachates: Terrain Analysis, National Academy of Sciences, Transportation Research Council, Transportation Research Board, Trans. Res. Rec. 892:50-56, Washington, DC.

Wischmeier, W.H., and D.D. Smith, 1978, Predicting rainfall erosion losses--A guide to conservation planning. Agric. Handbook 537, USDA Science and Educ. Admin., U.S. Govt. Printing Office, Washington, DC.

Appendix B

Mass Erosion Component of BOISED

APPENDIX B

MASS EROSION COMPONENT OF BOISED

The basic premise for quantifying sediment from mass erosion processes is that management activities accelerate natural mass erosion processes. The mass erosion methodology developed here is patterned after the mass erosion portion of the systematic watershed analysis procedure developed by the Clearwater National Forest (Wilson, et. al 1982) and procedures for quantifying soil mass movement found in Chapter 5 of WRENSS (U.S. Forest Service 1980). Basic data for the methodology is derived from published and unpublished data from a landslide inventory conducted on the Clearwater and Boise National Forests (Megahan et al. 1978).

Mass erosion refers to the movement of numerous soil particles en masse, primarily under the influence of gravity. WRENSS classifies mass erosion into two categories: (1) deep-seated slump-earthflows, and (2) shallow debris avalanche-debris flows. Only debris avalanche-debris flow slope failures are modeled because the vast majority (72%) of the slope failures inventoried fell into this category.

Road construction and timber harvest increases the occurrence of debris avalanche-debris flows slope failures. Frequencies for this category of slope failure from studies in various parts of the world average about 140 times greater per unit area of road than undisturbed slopes, whereas clearcutting increased slope failure frequency an average of seven times (Megahan and King 1985). In this model, only road-related increases in mass erosion are included because of their relatively greater significance compared to that of clearcut areas.

Studies consistently show that debris avalanche-debris slide slope failures are limited to slopes greater than 45 percent to 55 percent with a maximum frequency of occurrence at about 70 percent. For this reason, mass erosion will generally be modeled only for landtypes with average slopes greater than or equal to 45 percent. Provision is made for inclusion of landtypes with average slopes less than 45 percent that are known to be highly susceptible to slope failure. Similarly, stable landtypes situated at slopes greater than the critical gradient can be excluded from the model.

Mass erosion will be applied to new road construction for individual landtypes using the following equation:

MASS EROSION (new roads) = (NATURAL SEDIMENT YIELD) times [(DISTURBED AREA)
times (MASS EROSION DELIVERY RATIO)
times (ON-SITE MASS EROSION ACCELERATION FACTOR)]

where: NATURAL SEDIMENT YIELD = sediment yield from an undisturbed landtype expressed in tons/square mile/year; DISTURBED AREA = total area disturbed by road construction expressed in square miles; MASS EROSION DELIVERY RATIO = a decimal fraction expressing the percentage of on-site mass erosion material delivered to the nearest first or higher order drainage; ON-SITE MASS EROSION ACCELERATION FACTOR = a dimensionless multiplier obtained by dividing the tons of road caused on-site mass erosion by the average natural sediment yield.

The disturbed area of the road prism includes road subgrade, cut and fill slopes, ditches, berms, turnouts, and any other construction features that may be present. Tables of geometry for low standard roads, such as those developed by Megahan (1976) are useful to determine total disturbed area.

Natural sediment yield is determined for each landtype using procedures outlined in the "Guide for Predicting Sediment Yields from Forested Watersheds" (Cline, et al. 1981) and further refined for Boise National Forest landtypes by John Arnold as described in Appendix E.

The mass erosion delivery ratio is determined from a graphical relationship found in WRENSS (Chapter 5, Figure V.11, page V.43; see also figure in Appendix K). The mass erosion delivery ratio is different from that used to delivery surface erosion material to streams. A delivery ratio is included because the data used to calculate the acceleration factor are on-site, undelivered soil quantitiies. Inclusion of a delivery factor, which varies by landtype as a function of average landtype slope and slope roughness, incorporates landform physical features into the model at the landtype level.

Mass erosion acceleration factors were determined from a slope failure study which included the Clearwater and Boise National Forests and is generally representative of the Northern Rocky Mountain physiographic province (Megahan et al. 1978). Only road-related slope failures occurring on grantic soils were tabulated to develop the acceleration factors used in this model.

The acceleration factor was determined by tabulating the total volume of road-related mass erosion material moved during a twenty years period within the 309 square mile Middle Fork of the Payette River drainage on the Boise National Forest (Unpublished data from Megahan et al. 1978). Of the 789 slope failures tallied within the Middle Fork of the Payette River, 451 were road-related, 38 were not road associated, and the remaining 300 were not classified as to source of failure. Total slope failure volume, converted to units of weight, for the 451 road-related events equalled 90,687 tons. This weight was prorated assuming the same ratio of road-related to non-road-related slope failures for the unclassified failures as for the inventoried portion to yield an estimated total weight of mass erosion material of 146,324 tons. Miles of road construction for the same twenty year period was determined from a data base compiled by the Emmett Ranger District of the Boise National Forest (Reinig, personal communication). A total of 393 miles of road had been constructed encompassing 5.64 square miles of disturbed area. An average sediment yield of 41 tons per square mile per year was calculated for the drainage using the landtype data base from the Emmett Ranger District.

The following calculations were performed to determine acceleration factors:

Total weight of mass erosion material moved per square mile of road = 146,324 tons divided by 5.64 square miles = 25,944 tons per square mile over 20 years. Dividing by natural sediment yield (25,944/41) results in an acceleration factor of 633 for a twenty year period, or an average annual acceleration factor of 32 for undelivered sediment.

Since slope failure occurrence is not uniform over time, the 20-year acceleration factor (633) was distributed over time. The frequency of road-related slope failures for the Middle Fork of the Payette River and the grantic portion of the study area on the Clearwater National Forest was tabulated by age of the road at the time of failure occurrence. From the data, 228 road-related slope failures on grantitics were able to be classified according to age; 152 on the Middle Fork of the Payette River and 76 on the Clearwater National Forest portion of the inventory. A cumulative frequency distribution of age versus slope failure frequency for a 20 year period was developed, plotted on probability logarithmic graph paper, and a smooth curve graphically fit to the data. The following acceleration factors were selected from the graph:

Road Age (Years)	Acceleration Factor	Road Age (years)	Acceleration Factor
1	44	11	25
2	76	12	19
3	82	13	13
4	63	14	13
5	63	15	13
6	51	16	6
7	44	17	6
8	38	18	6
9	32	19	3
10	25	20+	3

An acceleration factor of 3 times natural sediment yield is assumed to continue as long as the road is in place. Some of the inventory data, going back as much as 50 years for some cases, indicates that increased rates of road-related accelerated mass erosion persist over time.

Live roots /

Guide for landslide prone in PNW (Green Book)

1) Aerial Photo Analysis

2) Coarse-angular / sub-angular ([illegible])

Review partial cut areas

REFERENCES:

Cline, R., G. Cole, W. Megahan, R. Patten and J. Potyondy. 1981. Guide for predicting sediment yields from forested watersheds. U.S. Forest Service, Northern and Intermountain Regions, Missoula, Montana and Ogden, Utah.

Megahan, W.F. 1976. Tables of geometry for low-standard roads for watershed management considerations, slope staking, and end areas. Technical Report INT-32. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah.

Megahan, W.F., N.F. Day and T.M. Bliss. 1978. Landslide occurrence in the western and central Rocky Mountain Physiographic Province in Idaho <u>In</u> Forest soils and land use, (Ed). Proceedings of the Fifth North American Forest Soil Conference, Colorado State University, Fort Collins, CO.

Megahan, W.F., and P.N. King. 1985. Identification of critical areas on forest lands for control of nonpoint sources of pollution. Environmental Management, Vol 9, No. 1, pp. 7-18.

U.S. Forest Service. 1980. An approach to water resources evaluation nonpoint sources-silviculture (WRENSS), a procedural handbook. U.S. Environmental Protection Agency, Athens, Georgia, EPA-600/8-80-012, August 1980.

Wilson, D., R. Patten, and W.F. Megahan. 1982. Systematic watershed analysis procedure for Clearwater National Forest. Leachates: Terrain Analysis, National Academy of Sciences, Transportation Research Council, Transportation Research Board, Trans. Res. Rec. 892:50-56, Washington, DC.

Gonsior & Gardner, 1971

Appendix C

Data Input Worksheets

LANDTYPES

Drainage______________

Watershed______________

Subwatershed___________

LANDTYPE	ACRES	LANDTYPE	ACRES

CUTTING UNIT DATA

Boise National Forest

Prepared by___________

NAME_________________________

Watershed Name:_______________

Sub-Watershed Name:_______________

LANDTYPE	UNIT#	LOGGING SYSTEM/ TREATMENT TYPE	ACRES	YEAR

LOGGING SYSTEM TYPE

1-CC/TR 2-CC/CB 3-CC/SKY 4-CC/AER

5-SEL/TR 6-SEL/CB 7-SEL/SKY 8-SEL/SER

CC-Clear Cut SEL-Select tree marking TR-Tractor

CB-Cable SKY-Skyline AER-Helicopter

FIRE DATA

Boise National Forest

Prepared by______________

NAME________________________________

Watershed Name:____________________

Sub-Watershed Name:________________

LANDTYPE	UNIT ID	FIRE INTENSITY CLASS	ACRES	YEAR	MITIGATION

Intensity Classes: Low/Mod/High

Page__of__

ROAD CONSTRUCTION DATA CODING FORM

Boise National Forest

Prepared by________
Date_______________

Drainage ________________
Watershed ________________

Subwatershed________________
Subwatershed #______________

LANDTYPE	ROAD NUMBER	ROAD LENGTH MILES	I CONSTR TYPE YEAR ACTIVITY	II MGMT CLASS	III GRADIENT CLASS

I	II	III
1-New/existing	1-heavy	1-0-5%
2-Heavy recon	2-light	2-5-10%
3-Light recon	3-closed	3-10%
4-Reclaimed	4-obliterated	

Appendix D

Boise National Forest

Landtype Data Base and BOISED Default Files

APPENDIX D

Landtype Database (LANDTYPES) & BOISED Data Defaults File (BOISED_DEFAULTS)

LANDTYPE DATA BASE FILE

The landtype data base file named LANDTYPES must be created before BOISED can be run. It is simply a flat file consisting of one record for each landtype. Data included in each record are:

1. Soil survey identifier (optional)
2. Landtype identifier
3. Geological erosion factor
4. Natural sediment yield (tons per square mile per year)
5. Average landtype slope (percent)
6. Slope shape code (straight/concave/convex/benchy)
7. Dissection code (strong/moderate/weak)
8. Roughness code (smooth/light/moderate/heavy)
9. Distance code (<100 feet, 100-200, 200-800, >800 feet)
10. Mass erosion inclusion factor (1=include mass erosion)

The following definitions apply to slope dissection:

Strong - drainageways are spaced less than 500 feet apart if shallow or moderately deep, or 500 to 1000 feet apart if deep.
Moderate - drainageways are spaced 500 to 1500 feet apart if shallow or moderately deep, or more than 1500 feet apart if deep.
Weak - drainageways are spaced more than 1500 feet apart.

The following guidelines apply to slope roughness:

Smooth - slopes very lightly vegetated.
Light - slopes have moderate amounts of forest vegetation.
Moderate - slopes have heavy forest vegetation.
Heavy - slopes have frequent large boulders, outcrops, or hummocks.

A complete list of the Boise NF LANDTYPE data file follows:

BOISE NATIONAL FOREST LANDTYPE DATA BASE

Landtype	GEF	NSR	SL	S	R	D	d	M
101	0.8	3	5	1	1	3	2	0
1012	0.8	3	5	1	1	3	2	0
1013	0.8	3	5	1	2	3	2	0
101A	0.8	3	5	1	2	3	2	0
102	0.8	3	5	1	2	3	2	0
103	0.8	3	10	2	3	3	3	0
1031	0.8	3	5	2	2	3	3	0
104	0.8	3	15	2	3	3	2	0
1042	0.8	3	10	2	3	3	2	0
105	0.8	3	15	2	3	3	2	0
1054	0.8	12	20	3	1	3	2	0
1055	0.8	10	15	3	1	3	2	0
106	0.9	8	10	4	3	3	3	0
1062	0.9	11	25	3	3	3	3	0
106B	0.9	3	20	3	3	3	3	0
107	1.0	16	40	2	3	3	2	0
1071	1.0	18	20	2	2	3	2	0
1072	1.0	20	25	2	2	3	2	0
108	0.8	18	45	4	3	3	3	1
109	0.9	20	35	3	3	3	3	0
1092	0.9	25	35	3	1	3	4	0
1095	0.9	20	35	3	2	3	3	0
1099	0.9	25	30	3	3	3	3	0
109A	0.9	40	35	3	1	3	3	0
109A1	0.9	30	50	3	2	3	3	1
109B	0.9	35	40	3	2	2	3	0
109B1	0.9	30	40	3	2	2	3	0
109C	0.9	35	45	3	2	1	3	1
109D1	0.9	94	60	1	2	1	2	1
109D2	0.9	26	20	2	3	1	2	0
109E	0.9	15	45	1	2	1	2	1
109G	0.9	42	50	1	2	1	3	1
109G1	0.9	49	60	3	2	1	3	1
109N1	0.9	34	40	3	3	1	2	0
110	0.8	5	15	2	3	3	2	0
110X	0.8	5	20	2	3	3	2	0
111A	0.8	20	55	2	3	3	3	1
111A1	0.8	25	55	2	2	3	3	1
111A2	0.8	20	45	2	2	3	3	1
111A3	0.8	20	40	2	3	3	3	0
111B	0.8	30	55	2	2	2	3	1
111B1	0.8	50	55	2	2	2	3	1
111B2	0.8	30	50	2	2	2	3	1
111C	0.8	40	55	2	2	1	3	1
111C3	0.8	45	45	2	2	1	3	1
111D	0.8	60	70	4	4	1	3	1
111D2	0.8	55	60	2	4	1	3	1
111D3	0.8	55	45	4	4	1	3	1
111G	0.8	60	55	1	2	2	3	1
111X	0.8	50	75	2	2	1	3	1
111X1	0.8	55	50	2	2	1	3	1

Landtype = landtype identifier.
GEF = geologic erosion factor.
NSR = natural sediment yield in tons per square mile per year.
SL = average slope in percent.
S = Slope shape code
- 1 = Straight
- 2 = Concave
- 3 = Convex
- 4 = Benchy

R = Slope Roughness code
- 1 = Smooth
- 2 = Light
- 3 = Moderate
- 4 = Heavy

D = Slope Dissection
- 1 = Strong
- 2 = Moderate
- 3 = Weak

d = Slope Distance
- 1 = less than 100 feet
- 2 = 100-200 feet
- 3 = 200-800 feet
- 4 = more than 800 feet

M = mass erosion inclusion factor
- 1 = mass erosion will be calculated
- 0 = mass erosion will be set equalt to zero (excluded)

Migrate to PC/Applix

Landtype	GEF	NSR	SL	S	R	D	d	M
112	0.8	75	55	1	2	2	2	1
1121	0.8	75	35	3	2	3	2	0
113	0.8	5	75	1	3	3	4	1
1131	0.8	3	55	3	3	3	4	1
114	0.8	18	45	3	2	3	4	1
1142	0.8	20	40	3	2	3	4	0
115	0.8	25	55	4	3	3	3	1
120A	1.0	25	50	1	3	3	3	1
120A1	1.0	30	45	1	3	3	3	1
120A2	1.0	25	45	3	3	3	3	1
120A8	1.0	32	50	1	1	3	3	1
120B	1.1	35	55	1	3	2	3	1
120B1	1.2	50	45	1	2	2	3	1
120B2	1.1	35	50	1	3	2	3	1
120B3	1.1	50	55	1	1	2	3	1
120B4	1.1	40	45	1	3	2	3	1
120B5	0.6	30	50	3	2	2	3	1
120B6	1.1	38	40	1	3	2	3	0
120B10	.42	36	45	1	2	2	3	0
120B13	1.1	38	50	3	3	2	3	1
120B14	.42	20	60	3	2	2	3	1
120C	1.1	80	55	1	3	1	3	1
120C1	1.1	58	60	1	3	1	3	1
120C2	1.1	74	55	1	1	1	3	1
120C3	1.1	78	65	1	2	1	3	1
120C8	1.1	87	60	1	1	1	3	1
120C11	1.1	45	50	1	3	1	3	1
120D	1.1	95	70	1	2	1	3	1
120D2	1.1	125	75	1	3	1	3	1
120D3	1.1	85	65	1	2	1	3	1
120D4	1.1	110	65	1	1	1	3	1
120E	1.2	20	30	2	3	2	2	0
120E1	1.2	30	45	3	3	2	3	1
120E2	1.2	23	40	3	2	2	3	0
120E3	1.2	20	40	3	3	2	3	0
120E5	1.2	20	30	2	1	2	3	0
120E6	1.2	35	40	1	1	2	3	0
120E7	1.2	25	40	2	1	2	3	0
121	1.2	27	30	2	3	2	2	0
121E	1.2	27	35	2	3	2	2	0
121E1	1.2	23	20	2	3	2	2	0
122	1.1	135	75	1	1	2	3	1
1221	1.1	140	75	1	2	1	3	1
1222	1.1	135	75	1	3	1	3	1
1224	1.1	120	75	1	3	1	3	1
1225	1.1	135	80	1	3	1	3	1
1228	1.1	130	70	1	1	2	3	1
123	1.1	25	40	1	3	2	3	0
1231	1.1	18	15	1	3	3	3	0
1232	1.1	29	55	3	2	2	3	1
1233	1.1	30	40	3	3	3	3	0
123B	1.1	21	25	2	3	2	2	0
123B1	1.1	30	40	3	2	2	3	0

Mass wasting Criteria

NSR - > 50

slopes - 40 to 75 %

slope shape - concave (no mother cover)

glaciated landforms more

Landtype	GEF	NSR	SL	S	R	D	d	M
123C	1.1	58	55	1	3	1	3	1
125	.30	25	50	4	3	3	3	1
1312	.42	5	40	3	3	2	3	0
1313	.42	8	40	3	1	2	3	0
133A3	.42	4	55	2	2	3	3	1
133B	.42	10	55	2	2	2	3	1
133C1	.42	20	55	2	2	1	3	1
1343	.42	15	40	4	3	3	3	0
1351	.42	11	70	1	4	3	3	1
1352	.42	18	40	1	2	3	3	0
1353	.42	16	45	4	3	3	3	1
1361	.42	3	10	1	2	3	3	0
1362	.42	3	15	1	2	3	3	0
1363	.42	3	15	1	3	3	3	0
1365	.42	3	45	3	3	3	3	1
1366	.42	3	25	2	4	3	2	0
1367	.42	3	5	3	4	3	3	0
1368	.42	3	35	3	1	3	3	0
140B2	.75	3	45	1	2	2	3	1
140B3	.75	58	55	1	1	2	3	1
140C1	.75	44	50	1	3	1	3	1
140C2	.75	50	55	1	2	1	3	1
140C3	.75	75	60	1	1	1	3	1
140E1	.75	18	40	2	2	2	3	0
140E2	.75	28	50	2	3	2	3	1
141	.75	25	45	2	3	2	2	1
143	.75	35	50	1	3	3	3	1
143C	.75	49	55	1	2	1	3	1
D011	1.0	12	10	1	1	3	1	0
D0111	1.0	12	10	1	1	3	2	0
D0112	1.0	12	25	2	2	3	2	0
D013	1.0	12	5	1	2	3	2	0
D021	1.0	12	15	2	4	3	2	0
D031	1.0	12	5	1	2	3	2	0
D032	1.0	12	5	1	2	3	2	0
D081	1.0	12	10	1	1	3	2	0
D082	1.0	30	35	1	1	3	1	0
D1010	1.0	12	15	2	2	3	2	0
D102	1.0	12	50	4	2	3	2	0
D131	1.0	12	5	1	2	3	2	0
G061	1.0	12	15	2	3	3	2	0
G062	1.0	12	25	2	3	3	2	0
G131	1.0	12	15	1	3	3	2	0
G161	1.0	12	15	4	3	3	2	0
G162	1.0	30	35	4	3	3	1	0
S052	1.0	30	50	2	2	3	2	1
S081	1.0	12	45	2	3	2	1	1
S091	1.0	90	60	2	3	1	1	1
S0911	1.0	50	60	2	3	1	1	1
S0912	1.0	50	70	1	2	1	1	1
S0914	1.0	30	55	2	3	2	2	1
S092	1.0	120	70	1	3	1	1	1
S093	1.0	90	55	1	3	1	1	1

Landtype	GEF	NSR	SL	S	R	D	d	M
S181	1.0	12	20	2	4	3	1	0
S1811	1.0	30	60	1	4	3	1	1
S1812	1.0	30	70	1	3	2	1	1
S182	1.0	30	70	1	3	2	1	1
S201	1.0	30	50	2	3	1	1	1
S211	1.0	30	55	2	2	1	1	1
S2810	1.0	12	50	2	2	2	1	0
S301	1.0	30	40	2	3	1	1	0
S3012	1.0	30	45	2	3	1	1	1
V011	0.42	12	10	2	1	3	1	0
V111	0.42	12	10	1	1	3	1	0

FOREST PLANNING CAPABILITY ZONES

Landtype	GEF	NSR	SL	S	R	D	d	M
CZ1	0.42	12	15	2	2	3	3	0
CZ2	1.0	57	60	2	2	1	3	1
CZ3	1.0	26	55	2	2	1	3	1
CZ4	0.7	42	55	2	2	2	3	1
CZ5	1.0	27	55	2	3	1	3	1
CZ6	1.0	23	55	2	2	2	3	1
CZ7	1.0	104	65	2	2	1	3	1
CZ8	1.0	21	35	2	2	1	3	0
CZ9	0.7	21	45	2	2	2	3	0
CZ10	1.0	48	60	2	2	1	3	1
CZ11	1.0	92	60	2	2	1	3	1
CZ12	1.0	29	50	2	2	1	3	1
CZ13	0.42	13	45	2	2	3	3	0
CZ14	1.0	25	55	2	2	2	3	1
CZ15	0.7	20	50	2	2	2	3	1
CZ16	0.7	12	45	2	2	2	3	0
CZ17	0.7	10	15	2	2	2	3	0

BOISED DEFAULTS DATA FILE

Listed below is a copy of the BOISED_DEFAULTS data file as it is maintained in the computer. The file must remain in this format. Do not add extra lines.

```
rem   **** ROAD WIDTH DATA ****
14,15.6,17.6,20.3,25.6,33.8,39.9,43.6,49.1,999,999
1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0
rem   **** Surface sediment delivery data ****
0,2,3.9,5.2,7,9,12.1,17,25.2,36,51.2,
0,1.5,2.6,4.6,5,6.5,9,12.9,18.3,25.5,40.5,
0,1.5,2.6,4.6,5,6.5,9,12.9,18.3,25.5,40.5,
0,1,1.6,2.1,2.9,3.3,5.0,8.0,11.2,18,31
0,0,0,0,0,0,0,0,0,0,0
.59,1.0,1.31,1.89,.71,1.0,1.33,.33,.65,1.0,2.0
rem  **** Data for cutting unit types ****
"CC/TR","CC/CB","CC/SKY","CC/AER","SEL/TR","SEL/CB","SEL/SKY","SEL/AER" rem
**** MEAF factor data ****
44,76,82,63,63,51,44,38,32,25,25,19,13,13,13,6,6,6,3,3 rem  **** Basic Road
Erosion Rates for HEAVY - LIGHT - CLOSE - OBLIT 7000,5000,1250,250
67500,18000,18000,9000
67500,18000,18000,9000
67500,18000,5000,1000,1000
18000,5000,5000,1000,1000
9000,5000,5000,1000,1000
67500,18000,5000,500,500
18000,5000,5000,500,500
9000,5000,5000,500,500
rem **** Basic Logging Erosion Rates ****
340,180,140,90,40,20,0,0
1,.62,.33,.19,.71,.43,.29,.14
rem **** Basic Fire Erosion Rates ****
550,120,25,5,0,0,0,0
.2,.5,1.0,1
"Low","Medium","High","  "
```

Listed below is a copy of the BOISED_DEFAULTS data file with the individual sections split and detailed. When modifying this file do not remove the rem line and do not add extra lines to the file.

```
rem    **** ROAD WIDTH DATA ****
14,15.6,17.6,20.3,25.6,33.8,39.9,43.6,49.1,999,999
1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0
```

Road width data consists of two lines. Line one is the default road width distance for each slope increment as listed below:

Slope:	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Value:	14	15.6	17.6	20.3	25.6	33.8	39.9	43.6	49.1	999	999

Values for slopes between these defaults are computed from the next lower and higher value, for example, 5% = 14.8 or 14+.5*(15.6-14.0)

Line two are the default Erosion Mitigation Coefficients for the first 10 years. In this case each year is 1.0.

```
rem    **** SEDIMENT DELIVERY COEFFICIENTS ****
0,2,3.9,5.2,7,9,12.1,17,25.2,36,51.2,
0,1.5,2.6,4.6,5,6.5,9,12.9,18.3,25.5,40.5,
0,1.5,2.6,4.6,5,6.5,9,12.9,18.3,25.5,40.5,
0,1,1.6,2.1,2.9,3.3,5.0,8.0,11.2,18,31
0,0,0,0,0,0,0,0,0,0,0
0.59,1.0,1.31,1.89,.70,1.0,1.33,.33,.65,1.0,2.0
```

Surface sediment delivery values from the graphs shown in Appendix K are shown here. The first four lines of sediment delivery data are read into array CVRT. Line 5 is read into the array CADD and line 6 is read into CDIV. The numbers in lines 1 through 4 are percent sediment delivered arrayed in percent classes: 0, 10, 20, 30, 40, 50, 50, 70, 80, 90, 100. Line 1 is for straight slopes, 2 is for concave slopes, 3 is for convex slopes, and 4 is for benchy slopes. Line 5 values are all equal to 0. Line 6 is arrayed as follows:

```
Line 6 - Value 1: Roughness  - Smooth
         Value 2:            - Light
         Value 3:            - Moderate
         Value 4:            - Heavy
         Value 5: Dissection - Strong
         Value 6:            - Moderate
         Value 7:            - Weak
         Value 8: Distance   - <100 feet
         Value 9:            - 100-200 feet
         Value 10:           - 200-800 feet
         Value 11:           - > 800 feet
```

Values in line 6 are slopes of graphs relating sediment delivery from the previous calculation to the new sediment delivery calculated. See figures in Appendix K.

```
rem **** Data for cutting unit types ****
"CC/TR","CC/CB","CC/SKY","CC/AER","SEL/TR","SEL/CB","SEL/SKY","SEL/AER"
```

Cutting unit types are used in output files to give descriptions to cutting unit codes as listed below:

Types:	CC/TR	CC/CB	CC/SKY	CC/AER	SEL/TR	SEL/CB	SEL/SKY	SEL/AER
Codes:	1	2	3	4	5	6	7	8

```
rem **** MEAF factor data ****
44,76,82,63,63,51,44,38,32,25,25,19,13,13,13,6,6,6,3,3
```

The Mass Erosion Acceleration Factor assigned for each year are listed above. These factors correspond to the first 20 years of erosion with the year 20 factor used for all years greater than 20.

Factors:	44	76	82	63	63	51	44	38	32	25	25	19	13	13	13	6	6	6	3	3
Year:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+

```
rem **** Basic Road Erosion Rates for HEAVY - LIGHT - CLOSE - OBLIT
7000,5000,1250,250
67500,18000,18000,9000
67500,18000,18000,9000
67500,18000,5000,1000,1000
18000,5000,5000,1000,1000
9000,5000,5000,1000,1000
67500,18000,5000,500,500
18000,5000,5000,500,500
9000,5000,5000,500,500
```

The first line of the Basic Road Erosion Rates is the default value for each road use array, using the following association.

Basic Erosion Values:	7000	5000	1250	250
Road Use Array:	Heavy	Light	Close	Oblit

The next 2 lines replace the base values with the following data:

	New Rd/Yr 1	New Rd/Yr 2	Hvy Recon/Yr 1	Lt Recon/Yr 1
Heavy Use:	67500	18000	18000	9000
Light Use:	67500	18000	18000	9000

The next 6 lines replace the base values with the following data:

	Year 1	Year 2	Year 3	Year 4	Year 5
Closed/New Rd	67500	18000	5000	1000	1000
Closed/Hvy Recon	18000	5000	5000	1000	1000
Closed/Lt Recon	9000	5000	5000	1000	1000
Oblit./New Rd	67500	18000	5000	500	500
Oblit./Hvy Recon	18000	5000	5000	500	500
Oblit./Lt Recon	9000	5000	5000	500	500

```
rem **** Basic Logging Erosion Rates ****
340,180,140,90,40,20,0,0
1,.62,.33,.19,.71,.43,.29,.14
```

The first line of data are the Basic Logging Erosion Rates and are placed in an array to correspond to years in the following relationship:

Basic Rate:	340	180	140	90	40	20	0	0
Year:	1	2	3	4	5	6	7	8

The next line is the Logging type factor and is used as a multiplier of the basic logging rates with the following relationship:

Type Factor:	1	.62	.33	.19	.71	.43	.29	.14
Logging Type:	CC/TR	CC/CB	CC/SKY	CC/AER	SEL/TR	SEL/CB	SEL/SKY	SEL/AER

```
rem **** Basic Fire Erosion Rates ****
550,120,25,5,0,0,0,0
.2,.5,1.0,1
"Low","Medium","High","  "
```

The first line of data are the Basic Fire Erosion Rates and are placed in an array to correspond to years in the following relationship:

Basic Rate:	550	120	25	5	0	0	0	0
Year:	1	2	3	4	5	6	7	8

The next two lines are the Fire intensity factors and the intensity descriptor. The intensity factor is used as a multiplier of the basic Fire rates with the following relationship:

Intensity Factor:	.2	.5	1.0	1
Intensity:	Low	Medium	High	" "

The last value 1 has a corresponding blank description to be used at a later date if needed.

Appendix

E

Boise

National Forest

Natural Sediment Yields and Geologic Erosion Factors

A PROCEDURE FOR ESTIMATING
NATURAL SEDIMENT YIELDS
AND
GEOLOGIC EROSION FACTORS
FOR
THE BOISE NATIONAL FOREST

By

John F. Arnold
of
Arnold Associates
Environmental Consultants
6708 Holiday Drive
Boise, Idaho 83709
(208) 375-6678

March 1988

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FORWARD

Use of Models - The Challenge

A major concern of Forest Service specialists and land managers is the risk land management agencies take when they use numbers with absolute values (like tons/square mile/year of sediment) to operate predictive models (such as BOISED) which are really nothing more than relative models. Using absolute values to many means that we are dealing with absolute models. It should be clearly stated and restated that the state-of-the-art in the fields of hydrology and sedimentation do not permit the use of absolute models. Quantitative terms are used only to operate relative models.

The knowledge to develop good relative models which fit many years of land management experience and research exists. But, the state-of-the-art in the fields of hydrology and sedimentation analysis is not to the point where accurate prediction can be made in terms of quantitative amounts. This fact, however, should not prevent land managers from using existing relative models of natural mountain slope performance and comparing that performance with similarly developed models under disturbed conditions. Although, absolute terms like tons per square mile per year are used in both models, the relative proportional difference between disturbed and undisturbed conditions has a reliability that is accurate enough to support management prescriptions.

Changes in sediment yields from timber management activities and its associated road building can be measured by orders of magnitudes. Consequently, the size of such differences make precise predictions unnecessary in order to make decisions required to meet stated management objectives.

The practicality and reliability of using relative models needs to be clearly understood as a legitimate way to address the sedimentation problem. If the methodologies for estimating natural and disturbed sediment rates are used in a consistent fashion, realistic estimates of sedimentation effects from proposed management are achievable.

INTRODUCTION

The BOISED Sediment Yield Model is used extensively by the Boise and Payette National Forests in Forest Planning and project level environmental assessments. BOISED is patterned after the R1/R4 Sediment Yield Model (Cline, et. al., 1981), however, BOISED needs to be refined to reflect local conditions and land characteristics.

This report documents the procedure developed for determining two key components of the model: (1) natural sediment yields and (2) geologic erosion factors. Specific values are developed for each of the landtypes used by the Boise National Forest. Results of the analysis will be used to improve the BOISED Sediment Yield Model.

BOISED documentation is contained in a draft BOISED User's Guide (Cole, 1986) which broadly explains model assumptions. Natural sediment rates and geologic erosion factors are used in the current version of BOISED, but documentation of the rationale behind their selection is sparse. Consequently, this contract was designed to first of all develop a procedure for determining natural erosion rates and geologic erosion factors and secondly to provide a documented record of how those estimates were made.

BACKGROUND

The R1/R4 Sediment Guide (Cline et. al., 1981) documents the rationale and assumptions applicable to the R1/R4 Sediment Yield Model. A natural sediment yield of 25 tons per square mile per year is presented as the average condition for fluvial granitic slopes with gradients near 60 percent. This value is derived from landtypes on small study watersheds within the Intermountain Forest and Range Experiment Station's Silver Creek study area. Before using the sediment model, users are encouraged to use local sediment data or identify landtypes on their Forest with similar characteristics for extrapolation.

A procedure for extrapolation is provided in the R1/R4 Guide to assist those who may not be able to develop a methodology on their own. It is based on a functional relationship between natural sediment rates measured at Silver Creek and a mass erosion hazard rating described in the WRENSS Handbook (U.S. Forest Service, 1980). This relationship is valid because mass slope erosion processes are the dominant source of supply of eroded material in undisturbed forested watersheds. Modification of this approach for use on the Boise National Forest is discussed in this report.

Since the R1/R4 Sediment Yield Model was designed to be used in granitic watersheds a method had to be found to allow use of the model in other geologies. The geologic erosion factor is a coefficient applied to management-induced erosion causing activities to modify basic erosion rates for road construction, timber harvest, and fire for areas underlain by bedrock other than granitics. The R1/R4 Guide presents a table of geologic erosion factors for a variety of rock types.

Specific geologic erosion factors for the Boise National Forest are discussed in this report. When geologic erosion factors were examined, it soon became apparent that assignment of one geologic erosion factor (GEF) to all granitics on the Boise National Forest, regardless of their degree of weathering, would lead to faulty sediment predictions. Therefore, a range of geologic erosion factors were derived for granitics and other geologies found on the Boise National Forest and adjacent areas.

ANALYSIS PROCEDURES

A. NATURAL SEDIMENT YIELDS

1. Original Estimates of Natural Sediment Yield

In the late 1960's, original estimates of sediment yield on the Boise National Forest for both natural and accelerated sedimentation rates for the various landtypes were based on data gathered by analysis of the various studies, investigations, research results, and observations made in the South Fork of the Salmon River drainage.

Use of the information is outlined in the January 1968 report, "South Fork Salmon River Special Survey - Soils and Hydrology" (Arnold and Lundeen, 1968). Natural sedimentation rates in the 1968 South Fork Salmon River Report were also used in Soil Hydrologic Reconnaissance reports for the Krassel Ranger District on the Payette National Forest and for granitic landtypes on adjacent districts on the Boise National Forest.

What was not defined in the above reports were landtype characteristics and other assumptions used as the basis for judging natural rates assigned to the various landtypes in the extrapolation process. These factors and the underlying rationale that was used to estimate natural sedimentation rates is explained below.

Natural sedimentation rates are a function of slope forming processes. Slope forming processes are extremely complex and it is important to realize that most of the processes function to one degree or another on any given mountain slope. The challenge is to recognize which processes assume dominant roles. This makes developing practical estimating procedures easier because all processes need not be evaluated . . . only the dominant or limiting ones.

Mass wasting processes are the chief processes by which materials move downslope on undisturbed slopes having coarse-textured noncohesive soils; especially on forest lands. Soil creep (both wet and dry) occurs almost constantly. Soil creep is the process which loads up ephemeral draws on slopes which in turn are "blown out", mainly as debris torrents, periodically. These may occur as a result of climatic events, changes in vegetation (generally fire induced), slope manipulation (mainly road building), or seismic events which may occur when soils have high moisture contents.

Saturated soil conditions, mainly from protracted rain-on-snow events, also causes minor onslope failures. These small spoon-shaped slides are prone to surface erosion from overland flow once exposed. On River Break Lands (landtype 122), especially those with southerly aspects, and Steep Rocky Headlands (landtype 120d), surface erosion must also be considered in determining natural sedimentation rates.

Soils on a variety of landtypes which have had heavy grazing use (especially sheep use) may be in a condition where surface erosion (mainly sheet and rill) occurs in significant proportions. This situation is particularly important on old driveways and on the more gently sloping ridge lands (often 109 landtypes) where sheep were intentionally confined for "bucking" (breeding) purposes. The resulting eroded material was moved for short distances on the slope, generally having the effort of accelerating the rate at which draws were loaded, making them more susceptible to periodic blowout. Such loading naturally occurs due to soil creep in undisturbed conditions loading draws with sediment and and making it available for transport when large climatic events occur.

Natural surface erosion contributions are most significant on non-forest or partly-forest lands and are not likely to change appreciably in any single planning period (10 years or less). In contrast, slope disturbance associated with timber harvest and road construction can significantly influence mass wasting processes (soil-creep, debris slides, and torrents), and can be the most important factors in determining sedimentation rates on forest lands. These concepts are identical to those used in the R1/R4 Sediment Yield Guide.

Original sediment yield estimates were made by evaluating available measured data in terms of the kinds of landtypes from which measurement studies, surveys, and investigations had been made. This information was then extrapolated to other landtypes on the basis of comparison of landtype characteristics. This was accomplished through specific onsite observations of landtypes which represented the highest to the lowest end of the sedimentation potential spectrum.

Most of these field observations and estimates were the result of interdisciplinary efforts (soils-hydrology-geology-geomorphology). Final estimates were reviewed by almost everyone that was concerned and available.

Neither the terminology, nor the more systematic methodology of the WRENSS approach (U.S. Forest Service, 1980; Chapter 5) for evaluating mass wasting hazard were available at the time. However, landscape characteristics and factors similar to those listed in WRENSS were considered in making the original estimates. The approximate weighted order of their importance as they were considered to make the original estimates is listed below.

1. Slope gradient.

2. Slope characteristics (degree of dissection, internal and external relief, shape, and configuration).

3. Bedrock (kind and degree of weathering and fracturing).

4. Soil texture, depth, and stoniness (surface and in profile).

5. Climate, precipitation and other special events like rain-on-snow or high intensity summer storms.

6. Potential vegetative cover types (consider aspect and elevation).

7. Presence of buffers to landtypes and streams.

The above characteristics were used to interpret the relative rates with which materials moved downslope and the efficiency with which they were delivered to perennial streams.

Additionally, natural sediment yield values used in the original estimates made in the Soil Hydrologic Reconnaissance Reports for both the Boise and Payette National Forests were based on the following assumption and interpretation.

1. The LOWEST CLASS of sediment production was estimated (from interdisciplinary observations) to be between one and five tons/square mile/year. Cirque Basin Lands (landtype 110) represents this lowest class.

2. Measured data from the Circle End and Tailholt Study watersheds represented the MEDIUM CLASS with sediment production rate of 18 to 31 tons/square mile/year. Landtypes in these drainages are mainly Moderately (landtype 120b) to Strongly Dissected (landtype 120c) Stream Cut Lands with minor amounts of Headlands (landtype 120d).

3. The HIGHEST CLASS of sediment production was estimated to come from River Break Lands (landtype 122). This landtype was estimated to produce about two times the sediment of the lands in Circle End and Tailholt due to steeper slopes and a higher proportion of surface erosion. The average annual rate is 50 tons/square mile/year. These lands are also at elevations where rain-on-snow events are likely to occur. River Break Lands are highly efficient in sediment delivery because first and second order ephemeral drainageways drain directly into fifth and sixth order live streams. Due to this, an estimate of 200 tons/square mile/year was made for River Break Lands. In reviewing the rationale for establishing the rate of 200 tons/square mile/year for the River Breaks Lands, a complete justification was not found. This is discussed in the next section.

The original interpretations were made before the initiation of the Silver Creek studies or the development of the R1/R4 Sediment Yield Guide. Recent research regarding sediment yields from undisturbed watersheds had to be evaluated to put estimating procedures in their proper perspective.

2. The Sedimentation From Surface Erosion Problem

Even though mass wasting processes are identified as the chief determining factors in generating sediment on undisturbed forest lands by this work and in the R1/R4 Sediment Yield Guide, a rationale for estimating natural yield due to surface erosion becomes necessary when considering non-forest and partly forest lands. This factor becomes especially important on landtypes with finer textured soils or with soils having textural B horizons.

However, present technology does not permit methodologies to predict in any accurate way erosion and/or sediment yield from soils on mountain slopes. The so-called Universal Soil Loss Equation (USLE) has not been made to work as yet on mountain slopes (although continuing efforts are being made).

For this project the U.S. Forest Service Inherent Erosion Rating Method (U.S. Forest Service, 1979) was revised. The revision expresses Inherent Erosion Hazard in terms of ranges of numerical indexes as opposed to five classes (I through V). Indices are then related to a numerical range of sediment yields expressed in tons/square mile/year. On the largely basalt Weiser District numerical values from sedimentation were derived from information in the 1977 USGS Water Information Bulletin No. 44.

The Inherent Erosion Hazard (I.E.H.) is based on the Soil Erodibility Index and the topographic hazard (expressed as percent slope).

$$\text{I.E.H.} = \frac{\text{Soil Erodibility Index (S.E.I.)} + \%\ \text{slope}}{2}$$

The soil erodibility index ((S.E.I.) is determined by adjusting the Detachability Index (D.I.) (See Appendix AA, Exhibit I) for coarse fragments and multiplying the adjusted figure by the profile permeability rating (P.P.R.) (See Appendix AA, Exhibit 2).

$$\text{S.E.I.} = \text{D.I.}\ (1.00 - \%\ \text{Surface fragments}) \times \text{P.P.R.}$$

The topographic hazard is based on percent slope.

An example may be appropriate to illustrate the various calculations.

Assume a detachability index of 6, 30 percent surface coarse fragments, a profile permeability index of 8, and a slope of 70 percent.

$$\text{S.E.I.} = \text{D.I.}\ (1.00 - \%\ \text{Surface Coarse Fragments}) \times \text{P.P.R.}$$

$$\text{I.E.H.} = \frac{\text{S.E.T.} + \%\ \text{slope}}{2} = \frac{6\ (1.00 - .30) \times 8 + 70}{2}$$

$$\text{I.E.H.} = \frac{33.6 + .70}{2} = \frac{103.6}{2} = 51.8,\ \text{rounded off to } 52.$$

The above approach was used for a number of reasons:

1. Inherent Erosion Hazard Ratings and supporting characteristics are given in existing soil-hydrologic reports.
2. Other methods would require data not yet generated by existing surveys.
3. The method proposed is parallel in concept to that proposed by the WRENSS methodology which deals with the sediment producing potential from mass wasting and to the methods used to estimate sedimentation from land use activities.

The following table shows ranges of estimated sediment yield from surface erosion for grantics and volcanics. The sourcce of the numbers reported here are the sedimentation studies on the Weiser River and Clayton's surface erosion studies (unpublished) in the Silver Creek Study area.

RELATING INHERENT EROSION HAZARD RATING TO SEDIMENT
(Delivery Factor Must Be Applied)
(Tons/square mile/year)
Inherent Erosion Hazard Rating

Proposed Index	Original Class Ratings	Volcanics	Granitics (including phyllites, schists and border zone rocks
<10	I Low	5 - 10	5 - 25
10 - 20	II Moderately Low	10 - 20	25 - 50
20 - 40	III Medium	30 - 50	50 - 75
40 - 60	IV Moderately High	50 - 100	75 - 100
>60 - 200	V High	100 - 150	100 - 150

Sediment yield from surface erosion processes is a significant factor on some some non-forested and partly forested landtypes. In most cases mass wasting is the dominant process on forest lands and the surface erosion component does not need to be factored in.

3. Re-Analysis of Natural Sediment Yields

The first step in the re-analysis was to review research results and guidelines developed since the original estimates were made in the late 1960's. Chief sources of information were the Intermountain Research station's Silver Creek studies and the R1/R4 Sediment Yield Guide (Cline et. al., 1981). Much of the information in the R1/R4 Sediment Guide is taken from the Forest Service/EPA WRENSS Handbook (U.S. Forest Service, 1980).

The functional relationship between natural sediment yield and the mass erosion hazard rating contained in the WRENSS Handbook as described in the R1/R4 Sediment Guide was examined as a beginning point for determining natural sediment yield throughout the Boise National Forest. Debris avalanche-debris flows were selected as the dominant mass movement process because of the shallow, noncohesive nature of granitic soils and the importance subsurface flow concentration has on mass erosion processes. Factors used in WRENSS to estimate the natural hazard of debris avalanche-debris flow failures were modified to more closely reflect conditions appropriate to Boise National Forest landtype and climatic conditions. The Boise National Forest Modified WRENSS Procedure including factors and weights assigned to each is shown in Appendix A. Appendix B contains a form that can be used to evaluate individual landtypes. The process used to develop and verify the Modified WRENSS Procedure against research data is discussed below.

Silver Creek research results benchmark natural sediment yield rates upon which the R1/R4 Sediment Yield Model is based. The average natural sediment yield value of 25 tons/square mile/year is reported in the R1/R4 Guide as being mostly in the 120c-11 landtype (Strongly Dissected Mountain Slope Land - southerly aspect) with minor amounts in the 120c landtype (Strongly Dissected Mountain Slope Land - northerly aspect). This characterization caused a concern because personal experience elsewhere and work on the South Fork of the Salmon River and slide studies indicated that the natural erosion rate for a 120c-11 to be somewhat higher. Also, the Silver Creek area has many unique characteristics which are atypical in many ways from other fluvial landtypes in the Idaho Batholith.

Major differences include:

1. A higher proportion of rock weathering classes 5, 6, and 7 compared to the Idaho Batholith in general. (See Intermountain General Technical Report INT-2, "Practical Grain Size, Fracturing Density, and Weathering Classification of Intrusive Rocks of the Idaho Batholith" (Clayton and Arnold, 1972) for description of weathering classes. Generally, the higher the number the greater the degree of weathering.)

2. Strong structural control which roughly bisects the east slope draining into Silver Creek. This structural control imposed during the formation of the Silver Creek basin appears to have reduced slope gradients in the upper portion and only slightly rejuvenated the lower

slopes. This basin effect is unlike that found elsewhere on the Batholith where most fluvial mountain slopes have been rejuvenated through uplift and/or stream entrenchment.

3. The dominantly fine grained character of the sands and lack of coarse fragments in the soil is different from the Batholith in general.

Because of these concerns, a field visit was made to Silver Creek to review slope characteristics in terms of their sediment producing characteristics. As a result of this trip and subsequent analysis and discussion, several conclusions were reached.

1. The upper portions of the unit are actually Moderately Dissected Headlands. The drainage below the headlands appears to function more like a 120b (Moderately Dissected Mountain Slope Land) unit than a 120c-11 (Strongly Dissected Mountain Slope Land)unit. These kinds of lands (120b) were interpreted to produce roughly 25 tons/square mile/year by the South Fork of the Salmon River study.

2. The lower portions of the study area, formerly mapped as landtype 123-3 (Faulted Bench Land), although it has a roughly parallel drainage, the entry to the next drainage is roughly at a 45 degree angle, thus taking on some dentritic characteristics.

3. It is also apparent that the incipient onslope drainageways are generally shorter in length than usual on most 120c-11 units.

The thrust of comments 1 and 2 is that the drainage of the area is fairly well integrated in that there is little, if any, skipping of stream orders as is usually the case in 120c-11 landtypes. Such an integration of drainage patterns ameliorates energies of runoff and sedimentation. In effect, the lower portion function is similar to a high relief Maturely Dissected Mountain Slope Land (120e). The 120e unit was interpreted by the South Fork Salmon River Study to have roughly a 20 tons/square mile/year natural sediment yield. If the higher relief and somewhat more efficient drainage pattern is taken into account, 25 tons appears to be a reasonable sediment yield to expect.

One of the things that comes out of the field review is the inherent danger of taking information generalized at a broad level and applying it to an area as small as the study watersheds in the Silver Creek Study Area. It is unrealistic to expect predicted interpretations to match with results measured at the small watershed level without a characterization effort (stratification, delineation, description and interpretation) at a commensurate level.

To assure that proper use was being made of Silver Creek sedimentation studies, additional analysis of recent data was done. The following steps were taken:

1. Converted the most recent compilation of sediment measurements (Clayton and Megahan, 1986) taken on four small watersheds in the Silver Creek Study Area from kilograms/hectare/year to tons/square mile/year:

Watershed	Average Sediment Yield (Tons/mi^2/year)
Control Creek	35
Cabin Creek	32
D Creek	43
C Creek	40

2. Mapped Silver Creek landtypes on 1:15,840 scale after reviewing the original Soil Hydrologic Reconnaissance Surveys of the Cascade and Emmett Ranger Districts together with a detailed soil survey made by Jim Clayton of Control, Cabin, and No Name Creeks.

3. Made an estimate of slope gradients of the units mapped using:
   a. The stereo image.
   b. 1" = 1,000' scale topographic map.
   c. Slope measurements actually taken on the ground on various experimental plots.

The topographic map did not adequately show the steepness of ephemeral draws on side slopes. It took a closer stereoscopic look at experimental plot sites to get a truer feel for slope gradients. The dominant slope was used to characterize each landtype.

4. From isohyetal maps and unpublished Silver Creek data, reviewed climatic data including runoff and precipitation. Annual total precipitation is between 35 to 50 inches at elevations ranging from 5,000 to 6,000 feet. Summer showers are common. Rainfall intensities up to 0.5 inch per hour for 30 minutesintensities can be expected almost annually. Rain-on-snow events that could cause road fill failures appear to be a 10-year event. Small rain-on-snow events are common, especially at mid-elevations.

5. Determined the proportional amount each landtype occupies in a particular watershed using a digital planimeter.

6. Rated mass erosion hazard for landtypes within each watershed using a preliminary version of the Modified WRENS Procedure (See Appendices A and B) considering mass erosion and surface erosion sources.

7. Evaluated mass erosion to include soil creep, debris slides, debris torrents, and elevation effects.

8. Estimated surface erosion as necessary. Only three of four landtypes were considered to produce significant amounts of sediment from surface erosion. Sources of the amounts were taken from unpublished slope erosion plot data from Silver Creek (Jim Clayton, personal communication). Clayton's studies indicated delivery rates of surface eroded materials to be relatively low for granitic soils with 5 to 10 percent of onsite erosion usually delivered to drainageways. By comparison of characteristics, a delivery rate of 20 percent was interpreted as a maximum in the Silver Creek area. (Delivery rates higher than 20 percent can occur on over-steepened unbuffered landtypes immediately adjacent to live streams.)

9. Natural erosion rates were estimated from available data and extrapolation for each landtype using the preliminary modified WRENSS form.

10. The proportional amount of sediment contributed by each landtype was determined by multiplying the percent area occupied by each landtype. These results were totaled and compared to the measured average. (Results for C Creek indicated that this watershed may be an anomoly. Possible explanations may be: leakage through a strong fault on the northern edge of the watershed, and/or leakage through highly fractured pegmatite dikes or through more highly fractured bedrock.)

11. Modified the preliminary WRENSS Procedure. Modifications took several approximations, but ended with the following changes:

a. Changes in hazard rating weighting factors were made. This was brought about by consideration of a number of different factors and to retain the relative strength of slope gradient and climatic factors.

b. Specific changes made to the debris-avalanche debris torrent factors included:

(1) Five slope classes rather than three are used.

(2) Slope dissection and relief (internal and external) and shape were added to get a better handle on subsurface drainage characteristics which was deleted as a separate factor.

(3) Bedrock weathering was added to account for one of the most important parameters in the Idaho Batholith.

(4) Bedrock fracturing was added because of its possible effect on water translocation.

(5) Soil depth classes were changed to fit the ranges usually encountered on the Boise and Payette National Forests.

(6) Coarse fragment consideration was added to account for understanding of water intake and translocation and resistance to movement as well as resistance to wet and dry creep.

(7) Precipitation input was changed to reflect local climate.

12. Mass erosion hazard ratings (weighted by proportional area for each landtype) are shown in Figure 1. The average hazard rating of the four watersheds was plotted against average sediment measured for the four watersheds. A curve was fitted through this point and the end points of 16 hazard rating units at 10 tons/square mile/year and a rating of 162 at 100 tons/square mile/year. These end points were established from the theoretical range of hazard rating numbers and the assumed range of 10 to 100 tons/square mile/year for natural sediment yields in the R1/R4 Sediment Yield Guide.

After several iterations changing weighting factors, the final curve relating natural sediment yields to hazard ratings for mass erosion from debris slides, debris avalanches, and debris torrents for essentially noncohesive soils on the Boise National Forest was developed (Figure 1). No changes from the curve in the R1/R4 Sediment Guide are recommended when considering mass erosion from areas where slumps and earth flow processes are dominant. (See Figure 3, page 12 of the R1/R4 Sediment Yield Guide for this curve).

13. The final Boise National Forest Modified WRENSS Procedure and weighing factors are shown in Appendix A. A convenient form for rating mass erosion hazard is included as Appendix B.

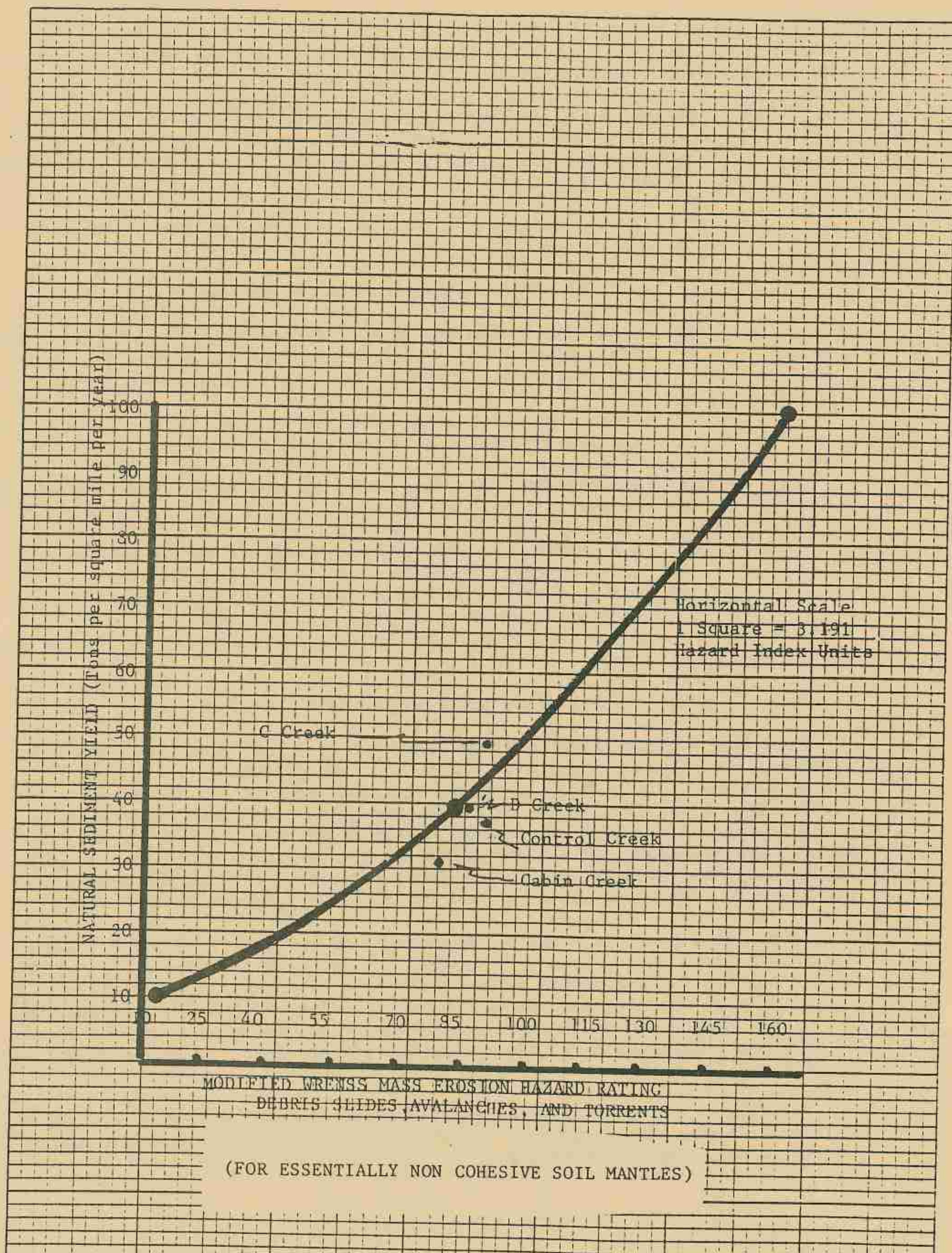


Figure 1: Relationship between natural sediment yield and mass mass erosion hazard rating for the Boise National Forest.

4. Comparison of Re-Analysis Results With Prior Estimates

A preliminary run using the Boise National Forest Modified WRENSS Procedure on Krassel Ranger District landtypes was done to see how the new estimates compared with previous sediment yield estimates. Some significant differences were apparent. The new procedure resulted in about a 25 percent reduction in total natural sediment for the survey area. These differences were discussed at some length with Soil Scientists Dean Martens (Payette National Forest) and Chuck Prentiss (Boise National Forest) and it was determined that a more detailed rerun was required.

This exercise was valuable in that it pointed out what experienced people in the field have always known . . . it is an unrealistic expectation to expect an empirical methodology using static indices to apply to all situations.

One of the basic difficulties is the problem of assigning representative index values that fit the complexity of real world landscapes. Different situations have different limiting factors in determining natural sediment yield rates. It is often a combination of only a few factors that determine sedimentation potentials. For this reason, any approach using static index number needs to be used with judgement. When adjustments are necessary, they should be supported by defined reasons (experience or research results). For example, where rain-on-snow events are known to generate large amounts of sediment, the climatic factor of 24 might be doubled. Such an increase would raise the index from 125 to 149 on a 122 landtype and increase natural sediment yield to about 120 tons/square mile/year.

All of the critical factors (other than the climatic factor) which need to be addressed when using the Modified WRENSS Procedure to more nearly matches local experience has to do with estimating sediment delivery efficiencies of slopes.

Important considerations include:

1. Skipping one or more stream orders greatly influence drainage delivery efficiencies of runoff and sedimentation.

2. Stream patterns - Parallel drainages draining at near 90 degree angles into drainageways or streams have higher delivery efficiencies than drainages entering streams at near 45 degree angles. Dendritic and rectangular patterns integrate and ameliorate energies making sediment delivery less efficient.

3. Streamside buffers - A lack of lands buffering sediment from landtype slope to live streams increase sediment delivery efficiencies. Wide, flat buffers reduce delivery.

4. The kind and amount of ground cover - On a non-forest land slope sparsely covered with annual grasses, the rate of wet and dry creep is greater than on a slope with a brush understory. Surface erosion is a more significant factor. Aspect is a tool to get a first separation of this factor. The natural occurrence of vegetation is a contributing factor to the differences in the natural erosion rates between 120b and 102b-1 as well as 120c and 120c-1 landtypes.

5. The attitude of bedrock bedding planes or dominant jointing planes can be an important consideration when combining sediment rates on some slopes. When bedrock bedding and jointing planes are roughly parallel to the slope, sediment delivery efficiencies are increased.

6. Slope shape with respect to the degree of convexity or concavity in both the plan and cross-sectional perspectives may be an important consideration, especially when comparing sedimentation delivery efficiencies of one slope with one or more other slopes. Convex slopes tend to have higher delivery efficiencies.

7. Energy dissipation factors like talus or large boulders on slopes as is the case on the toes of some glacial troughs.

A rerun of natural sediment rates of Krassel Ranger District landtypes was made using the modified WRENSS procedure. Table 1 shows a comparison of the new sediment yield estimates with the original estimates. Some rates were higher and some were lower than the original efforts, but the range, from highest to lowest showed little change.

The largest difference from the original estimates was in the landtype 122, River Breaks Land. The main cause for the difference is delivery factors were not considered in extrapolating the impacts in the form of debris slides, torrents, and slope failures resulting from the 1964-1965 rain-on-snow events.

The application of a 40 percent delivery rate for this landtype gives an annual estimate of about 130 tons/square mile/year. The Modified WRENSS analysis gives 110-140. The range reflects the need to consider local experience about the frequency of rain-on-snow events and in those cases where the landtype extends directly into live streams.

Original estimates were based primarily on sediment measurements from Circle End and Tailholt Creeks. Revised estimates arw based on a model built from Silver Creek data. The more recent data used more realistic assumptions of such things as trap efficiency and is therefore judged to be better.

The specific gravity of sediment assumed for the South Fork studies indicated that one cubic yard of sediment weighted roughly one ton. Subsequent experience indicates that sediment from granitics varies between 1.2 tons/cubic yard to 0.8 tons/cubic yard (personal communication, Walt Megahan). The variability is mainly due to variation in organic matter content. In small streams, 1.8 tons/cubic yard is probably a realistic figure. On the other hand, in streams like the South Fork Salmon River and the Seseech River, 1.2 tons/cubic yard are likely. Sediment from exposed road cuts and fills as well as road surfaces probably approach 1.2 tons/cubic yard onsite and perhaps somewhat less when delivered to live streams. Because of this variability and because of the level of reliability of predictions, 1 ton/cubic yard is used in the comparison in Table 1. More precise figures would imply an accuracy which does not exist.

Estimated total natural sediment yield for the Krassel reconnaissance survey area was about 25 percent less than that predicted by the original estimates. This difference should not change management prescriptions resulting from BOISED analysis procedures. The new estimates are recommended for estimating natural sediment yields for granitic lands on the Boise and Payette Forests.

COMPARISON OF ORIGINAL NATURAL EROSION RATE ESTIMATES WITH ESTIMATES USING PROCEDURES DEVELOPED FOR THIS PROJECT USING MODIFIED WRENS PROCEDURES (OLD KRASSEL DISTRICT)

Landtype	Symbol	Original Estimates Tons/sq.mi./yr.	Modified Estimates Tons/sq.mi./yr
Toe Slope Land	107	15	16
Glacial Plastered Mountain Slope Land	108	10	18
Weakly Glaciated Uplands	109	10	20
Thin Mantled Weakly Glaciated Uplands	109a	35	35
Moderately Dissected Weakly Glaciated Uplands	109b	30	30
Cirque Basin Land	110	3	5
Scoured Cirque Basin Land	110x	5	5
Weakly Dissected Glacial Trough Land	111a	10	20
Moderately Dissected Glacial Trough Land	111b	15	25
Strongly Dissected Glacial Trough Land	111c	50	45
Steep Rocky Cirque Head Land	111d	75	60
River Spur Land	112	100	75
Rocky Ridge Land	113	5	5
Subalpine Rim Land	114	10	18
Glacial Scoured Mountain Slope Land	115	35	32
Faulted Glacial Scoured Uplands	116	3	5
Weakly Dissected Mountain Slope Land	120a	15	22
Moderately Dissected Mountain Slope Land	120b	25	45
Moderately Dissected Thin Mountain Slope Land	120b-1	50	80
Strongly Dissected Mountain Slope Land	120c	100	
Strongly Dissected Thick Mantled Mountain Slope Land	120c-1	75	50
Steep Rocky Head Land	120d	125	95-110
Maturely Dissected Mountain Slope Land	120e	20	20
Steep Maturely Dissected Mountain Slope Land	120e-1	40	30
Structural Basin Land	121	15	15
Maturely Dissected Structural Basin Land	121e	15	20
River Breaks Land	122	200	110-140
Faulted Bench Land	123	20	20

Table 1: Comparison of natural sediment yields between original and modified WRENSS procedure.

B. GEOLOGIC EROSION FACTORS

The geologic erosion factor in the R1/R4 Sediment Yield Guide is used to modify basic erosion rates generated by man-caused activities to reflect the relative erosivity for areas underlain by bedrock other than granitics. A table of geologic erosion factors for major rock types is shown in Table 2. It contains values appearing in the R1/R4 Sediment Yield Guide as well as some value extrapolated by this author.

The surface aggregation ratio for various rock types is used as the basis for extrapolation. Surface aggregation for granitics was portrayed by Anderson (1975) to range from 71 to 149. Andre and Anderson (1961) estimated an average value of 118 for granitics. There appears to be as much variation in mean surface aggregation ratios in granitics as there is between rock types. For this reason, it appears to be more realistic to tie the geologic erosion factor to rock weathering classes.

Table 3 shows geologic erosion factors for granitic by weathering class. Weathering classes used are those proposed by Clayton and Arnold (1972) for the Idaho Batholith. Table 3 also contains a diagram of data taken from unpublished road cut slopes in the Silver Creek Study Area (Personal communication, Jim Clayton) which supports linkage between weathering class and geologic erosion factor rankings.

Table 4 shows estimated geologic erosion factors for 5 broad geologic groups found in and around the Idaho Batholith. These estimates are entirely theoretical and not based on field experience.

Table 5 shows average geologic erosion factors for a partial list of landtypes in the four main landtype association groups for Boise National Forest granitics.

Geologic erosion factors tied to weathering class are particularly useful when doing project analyses with detailed on-site information. The degree of rock weathering can vary considerably in 500 feet on a given slope. Similarly, geologic erosion factors also vary with the depth of disturbance. For example, exposed road cuts and fills on a 50 percent slope underlain by granitic bedrock in weathering class 5 would have a geologic erosion factor of 1.2 (extremely high). If, however, the same area was logged without roads and suffered only 10 percent shallowly disturbed ground, erosion from the bared soil would be more appropriately determined by other factors.

When specific onsite rock weathering information is not available, Tables 4 and 5 can be used to estimate average geologic erosion factors. The tables are intended for use as a guide only. Soil Hydrologic Reconnaissance Reports should be reviewed when possible, and verified with on the ground experience to yield a similar table for each survey area. Note that metamorphics have been broken into hard and soft categories in much the same way as sedimentary rocks, rhyolites, and quartzites have been added. The geological erosion factor for alluvium should be used with caution.

Table 2: Geologic erosion factors for major rock types.

GEOLOGIC EROSION FACTORS BY MAJOR ROCK TYPES

Rock Type	Mean Surface Aggregation Ratio	Coefficient of Variation (Percent)	Geologic Erosion Factor
Acid igneous (granitic)	118	35	1.0
Basic igneous (basalt & andesite)	49	53	.42
Serpentine	41	44	.35
Miscellaneous Metamorphic	46	50	.39
Soft Metamorphic	--	--	.70*
Schist	89	67	.75
Quartzite	--	--	.20*
Hard sediments	61	18	.52
Soft sediments	78	83	.66
Limestone	--	--	.25*
Rhylolite (including Welded Tuffs	--	--	.25*
Alluvium	124	88	1.05 1/

* Extrapolated from field observations by comparison of characteristics. John Arnold, February 1988.

1/ The figure given probably represents deposits of sands and silts. Extremely bouldery, cobbly or gravelly alluviums may be as low as .30.

Table 3: Geologic erosion factors for granitics by weathering class and diagram showing the relationship between weathering classes and surface erosion.

GEOLOGIC EROSION FACTORS FOR GRANITICS BY WEATHERING CLASS
(Including Schist, Phyllites and Border Zone Rocks)

Geologic Erosion Factor	Weather Class
.8	1 and 2
.9	3
1.0	4
1.1	5 and 7
1.2	6

SURFACE EROSION VERSUS ROCK WEATHERING CLASS
(from unpublished Silver Creek data)

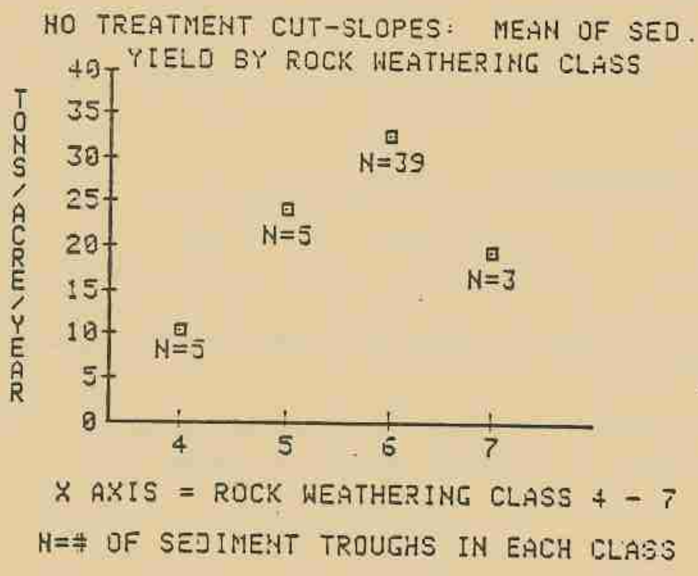


Table 4: Estimated geologic erosion factors for broad rock groups.

ESTIMATED DOMINANT GEOLOGIC EROSION FACTORS FOR THE FIVE BROAD GEOLOGIC GROUPS USED IN THE MAPPING LEGEND

Geologic Group Map Symbols	Estimated Geologic Erosion Factor
V Main Columbia River Basalts but some Andesites	.42
G Granitics (including Border Zone)	.8 to 1.2
M Schists, phyllites, Slates and some interbedded Metavolcanic and volcaniclastic Metasedimentary Rocks	.75
O Other Volcanics (especially Weathered Pyroclastics) and Sedimentary Rocks	.65
U Undifferentiated A unit established for mapping convenience for use where geology is of small importance as in broad areas of strongly glaciated uplands in a wilderness area.	.60

Table 5: Estimated geologic erosion factors for major landtype associations and landtypes.

A GUIDE TO USUAL GEOLOGIC EROSION FACTORS ESTIMATED FOR A PARTIAL LIST OF LANDTYPES IN THE FOUR MAIN LANDTYPE ASSOCIATIONS

	Usual Symbol	Usual GEF
Glaciated Lands		
Cirque Basin Lands	110	.8
Scoured Cirque Basin Lands	110x	.8
Weakly Dissected Glacial Trough	111a	.8
Moderately Dissected Glacial Trough	111b	.8
Strongly Dissected Glacial Trough	111c	.8
Steep Rocky Cirque Headlands	111d	.8
Subalpine Rim Land	114	.8
Glacial Scoured Mtn. Slopes Lands	115	.8
Faulted Scoured Uplands	116	.8
Cryic Uplands (Weakly Glaciated) Periglaciated Uplands Cryo Planated)		
Thin Mantled Weakly Glaciated Uplands	109a	1.0
Weakly Glaciated Uplands	109	.9
Moderately Dissected Weakly Glaciated Uplands	109b	.9
Fluvial Lands		
Weakly Dissected Mountain Slope Lands	120a	1.0
Moderately Dissected Mountain Slope Lands	120b*	1.0-1.2
Moderately Dissected Thin Mantled Mountain Slope Lands	120b-1	1.2
Strongly Dissected Mtn. Slope Lands	120c	1.0-1.2
Strongly Dissected Thick Mantled Mountain Slope Lands	120c-1 or 11	1.1
Steep Rocky Headland	120d*	1.0-1.2
Maturely Dissected Mtn. Slope Land	120e*	1.2
River Breaks Lands	122*	1.0-1.2
Depositional Lands (Including Toe Slope Land)	100 series	.5-1.3

* Several variations have been mapped by the various Soil Hydrologic Reconnaissance Surveys.

C. REVISED NATURAL SEDIMENT YIELD ESTIMATES AND GEOLOGIC EROSION FACTORS

The Boise National Forest Modified WRENSS Procedure described in this report was applied to all landtypes on the Boise National Forest to generate a revised listof natural sediment yields and geologic erosion factors for the BOISED sediment yield model. These values will be programmed into the BOISED model when it undergoes it next major revision scheduled for later this year.

All Boise National Forest landtypes were rated by the author and Boise National Forest Soil Scientist Chuck Prentiss using aerial photos and Soil Hydrologic Reconnaissance Survey reports. Original rating sheets are on file with the Soil Scientist. Because Soil Hydrologic Reconnaissance Surveys were essentially uncorrelated between Districts and done by different teams at different times in different physiographic subsections, landtypes for each survey were examined individually. This was done because it was suspected that landtypes with identical designations but in different survey areas might be variable enough to have different responses to management activities and sometimes different natural attributes (like natural sediment rates).

Eight survey areas were examined:

- Mountain Home Ranger District
- Boise Ranger District
- Idaho City Ranger District
- Cascade Ranger District
- Lowman Ranger District
- Emmett Ranger District
- Landmark Ranger District
- Bear Valley Ranger District

Appendix C shows the revised estimates of natural sediment yield and a range of geologic erosion factors developed for each Boise National Forest landtype for each survey area.

Appendix D shows the individual values for natural sediment yield and geologic erosion factors that will be entered into the BOISED model. Since estimated sediment yields changed significantly depending on the survey area for only a few landtypes, it was judged acceptable to assign a single natural sediment yield value to each landtype. Similarly, a midpoint for the range of geologic erosion factors was selected for entry into the computer model since computers cannot readily deal with ranges of values. BOISED model users will have the capability to override these values when doing site specific analysis if the need arises.

REFERENCES

Anderson, H.W. 1975. Sedimentation and turbidity hazards in wildlands. _In_ Watershed Management. Symposium conducted by Committee on Watershed Management of American Society of Civil Engineers. Aug. 11-13, 1975, Utah State University, Logan, Utah, p. 347-376.

Andre, J.E. and H.W. Anderson. 1961. Variation of soil erodability with geology, geographic zone, elevation, and vegetation types in northern California wildlands. Journal of Geophysical Research 66: 3351-3358.

Arnold, J.F. and L.J. Lundeen. 1968. South Fork Salmon River special survey soils and hydrology. U.S. Forest Service, Boise National Forest, Boise, Idaho. 195 p.

Clayton, J.L. and J.F. Arnold. 1972. Practical grain size, fracturing density, and weathering classification of intrusive rocks of the Idaho Batholith. USDS Forest Service General Technical Report INT-2, Ogden, Utah. 17 p.

Clayton, J.L. and W.F. Megahan. 1986. Erosional and chemical denudation rates in the southwestern Idaho Batholith. Earth Surface Processes and Landforms. 11(4): 389-400.

Cline, R, G. Cole, W. Megahan, R. Patten, and J. Potyondy. 1981. Guide for predicting sediment yields from forested watersheds. U.S. Forest Service, Northern and Intermountain Regions, Soil and Water Management, Missoula, Montana and Ogden, Utah, 42 p.

Cole, G. 1986. User's Guide for BOISED, A procedure for estimating sediment yield on the Boise and Payette National Forests. Version 1.01, Rough Draft. Boise National Forest, Boise, Idaho.

U.S. Forest Service. 1979. Procedural guide for the soil resource inventory portion of the land systems inventory. U.S. Forest Service, Intermountain Region, Ogden, Utah. 91 p.

U.S. Forest Service. 1980. An approach to water resources evaluation nonpoint sources-silviculture (WRENSS), A procedural handbook. U.S. Environmental Protection Agency, Athens, Georgia, EPA-600/8-80-012, August 1980.

APPENDIX AA

Soil Detachability
and
Soil Erodibility
Ratings

Exhibit 1

SOIL ERODIBILITY CLASSIFICATION GUIDE

I. DETACHABILITY CLASSES

	Detachability index
Surface horizon aggregates STRONGLY resistant to detachment or dispersion; aggregates dominantly GREATER THAN 2 mm. in diameter after wetting; moistened aggregates maintain their stability when washed repeatedly by a fine stream of water from a plastic wash bottle.	1 or 2
Surface horizon aggregates STRONGLY resistant to detachment or dispersion; aggregates dominantly LESS THAN 2 mm. in diameter after wetting.	3 or 4
Surface horizon aggregates MODERATELY resistant to detachment or dispersion; moistened aggregates soon become completely detached or dispersed when repeatedly washed by a fine stream of water.	5 or 6
Surface horizon aggregates WEAKLY resistant to detachment or dispersion; aggregates begin to collapse when first moistened or are readily detached with first wash of a fine stream of water from a plastic wash bottle.	7 or 8
Surface horizon NOT aggregated but is single grain; particles in a detached state.	9 or 10

Exhibit 2

PROFILE ERODABILITY RATING

Permeability of surface horizon(s)	Reduction of permeability in lower horizon(s)	Depth at which permeability reduction begins: Less than 6 inches	6 - 18 inches	18 - 36 inches	Greater than 36 inches
		Profile permeability indices			
Rapid	Little or no reduction 1/				1 or 2
	Moderate reduction 2/	5 to 7	3 or 4	2 or 3	1 or 2
	Pronounced reduction 3/	8 to 10	5 to 7	3 or 4	1 or 2
Moderately rapid	Little or no reduction				3 or 4
	Moderate reduction	7 or 8	5 or 6	4 or 5	3 or 4
	Pronounced reduction	9 or 10	7 or 8	5 or 6	3 or 4
Moderate	Little or no reduction				5 or 6
	Moderate reduction	7 or 8	6 or 7	5 or 6	5 or 6
	Pronounced reduction	9 or 10	7 or 8	6 or 7	5 or 6
Moderately slow	Little or no reduction				7 or 8
	Moderate reduction	8 or 9	7 or 8	7 or 8	7 or 8
	Pronounced reduction	9 or 10	8 or 9	7 or 8	7 or 8
Slow	Little or no reduction				9 or 10
	Moderate reduction	9 or 10	9 or 10	9 or 10	9 or 10
	Pronounced reduction	9 or 10	9 or 10	9 or 10	9 or 10

1/ Also includes those profiles whose permeability increases in the lower horizons.

2/ Commonly includes those profiles with increase of one textural class from A to B horizon; somewhat pervious substrata, etc.

3/ Commonly includes those profiles with abrupt, pronounced development in B horizon, increase of more than one textural class from A to B horizon; impervious substrata, such as hardpans, strong fragipans, slightly fractured or unfractured bedrock.

APPENDIX A

Boise National Forest
Modified WRENSS Procedure
for Estimating Natural Sediment Yields

Table of Factors and Weights

Appendix A

BOISE NATIONAL FOREST MODIFIED WRENSS PROCEDURE

Suggested weighting factors for determination of natural hazard of debris avalanche-debris flow failures.

Factor	Hazard Index and Range	Weight
Slope gradient	Very high >70%	65-76
	High 55-70%	40-65
	Medium 45-55%	20-40
	Moderately Low 30-45%	10-20
	Low <30%	0-10
Slope Dissection	c - High High density, closely spaced incipient drainage depressions < 500' apart	8
Landtype Dissection Designation	b - Medium Presence of incipient drainage depressions but widely spaced 500-1000' apart	4
	a - Low Incipient drainage depressions rare to absent > 1000' apart	1
Relief (External) Difference in elevation between bottom and top of landtype	High >2000'	5
	Moderately High 1500-2000'	4
	Medium 1000-1500'	3
	Moderately Low 500-1000'	2
	Low <500'	1
Relief (Internal) (On Slope) Difference in elevation between drainage bottom and spur ridge within a landtype (depth in entrenchment)	>200'	5
	100-200'	4
	50-100'	3
	25-50'	2
	<25'	1

Appendix A (page 2)

Factor	Hazard Index and Range	Weight
Surface Slope	High Smooth, continuous slopes unbroken by benches or rock outcrops and/or numerous breaks in canopy due to blowdowns, frequent linear or teardrop shaped even-age stands beginning at small scarps or spoon-shaped depressions indicative of old debris avalanche-debris flow activity.	5
	Medium Smooth, continuous slopes broken by occasional benches and rock outcrops. Infrequent evidence of past landslide activity.	3
	Low Slope broken by rock benches and outcrops.	1
	Medium Bedding on jointing planes are horizontal or dipping into the slope with minor jointing at angles less than the natural slope gradient. Minor surface fracturing - no faulting or shearing evident.	3
	Low Bedding on jointing planes are horizontal or dipping into the slope. Jointing and fracturing is minor - no faulting or shearing evident.	1
Bedrock Weathering 1/ Class (Granitics, Schists, Phyllites and Border Zone)	Class 7	10
	Class 6	8
	Class 5	7
	Class 4	4
	Class 3	1
	Class 2	1
	Class 1	1
Bedrock Fracturing Class	>6' between fractures (Very Low)	5
	4-6' between fractures (Low)	4
	1.5-4' between fractures (Medium)	3
	.5-1.5' between fractures (High)	2
	<.5' between fractures (Very High)	1

1/ See General Technical Report INT-2, 1972 - USDA 1972 Forest Service - Practical Grain Size, Fracturing Density, and Weathering Classification of Intrusive Rocks of the Idaho Batholith; Clayton and Arnold.

Appendix A (Page 3)

Factor	Hazard Index and Range	Weight
Soil Depth	Shallow soils, <20" Moderately deep soils 20-40" Deep soils, 40-60" Very deep, >60"	15 7 3 1
Soil Texture	High Unconsolidated, noncohesive soils and colluvial debris including sands and gravels, rock fragments, weathered granites, pumice, and noncompacted glacial tills with low silt content (<10%) and no clay.	5
	Medium Unconsolidated, noncohesive soils and colluvial debris with moderate silt content (10-20%) and minor clay (<10%).	3
	Low Fine grained, cohesive soils with greater than 20% clay sized particles or mica.	1
Rock Fragments 3/4 to 18 inches diameter	<10% 10% to 35% >35%	5 3 1
Precipitation Input*	Annual precipitation >40" Area has potential for early spring or late winter rain-on-snow events. Moderately high intensity summer storms common.	24
	Annual precipitation 30-40" Area has potential for rain-on-snow events. Moderately high intensity summer storms common.	18
	Annual precipitation 20-30"	12
	Annual precipitation <20"	5

KEY TO CHANGING 5 CLASS WEATHERING CLASSIFICATION FOR GRANITICS (SCHISTS, PHYLLITES AND BOULDER ZONE ROCKS USED IN SOIL HYDROLOGIC RECONNAISSANCE REPORTS TO FIT 7 CLASS BREAKDOWN[1/]

New Classification[1/] (7 Classes)	Old Classification (5 Classes)
1. Unweathered	1. Hand unweathered
2. Very Weakly Weathered	1. Hand unweathered
3. Weakly Weathered	2. Moderately hard, somewhat weathered (non-spalling).
4. Moderately Weathered	3. Moderately hard, but spalling.
5. Moderately Well Weathered	4. Modertely soft, moderately weathered, fracturing is often masked by grus filling fractures. Roots follow fractures.
6. Well Weathered 7. Very well weathered*	5. Soft - well weathered. Roots can penetrate matrix of rock between fractures.

* Plastic when moist due to presence of clay-sized minerals.

FRACTURING CLASS KEY OLD VS. NEW[1/]

New Density Class	Distance Between Joint Set or Fractures	Old (Fracturing Class) (As in Krassel Report)
Very Low	>6'	Massive
Low	4 to 6'	Slightly Fractured
Medium	1.5 to 4'	Moderately Fractured
High	.5 to 1.5'	Well Fractured
Very High	<.5'	Extremely Well Fractured

1/ Practical Grain Sized, Fracturing Density, and Weathering Classification of Intrusive Rocks of The Idaho Batholith. By James L. Clayton and John F. Arnold.

APPENDIX B

Rating Form for
Boise National Forest
Modified WRENSS Procedure

MODIFIED WRENS SEDIMENTATION FACTOR ESTIMATES

John F. Arnold, Feburary 2, 1988

Landtype: ____________ Location: ____________ By: ____________ Date: ____________

	Slope Grad.	Slope Dissection	Relief Ext.	Relief Int.	Surface Slope Config.	Weathering Class (Grantics) Schists, Phyllites & Border Zone	Fractur. Class	Soil Depth	Soil Texture	Soil Coarse Fragments	Precip. Input	Index	Experience Modifiers 1/
Debris Slide, Flow, Torrent Factor													

	Slope Gradient	Subsurface Drainage Characteristics	Soil Texture	Slope Configuration	Vegetative Indicators	Precipitation Input	Experience Modifiers1/	Total Index	Delivery (%)
Slump-Earth Flow Index									

Surface Erosion Index	Percent Non-Forest	Depth to Restricting Layer	Surface Coarse Frags	Detachability Index (DI)	Permeability Index (PI)	Slope Index (SI)	Total Index2/	Tons/ Sq.Mi/. Year	Delivery Percent	Delivered Tons
Soil 1										
Soil 2										
Soil 3										
Rock Outcrop										

1/Adjustments to accommodate local knowledge and experience: Specify. ___

Notes:

	Bedrock	GEF
Geologic Erosion Factor (GEF)		

2/Total Index =

$$\frac{DI(100 - \%\ \text{Surface Crse Frags}) \times PI + SI}{2}$$

Natural Erosion Rate

- Surface ___
- Debris Slides, etc. ___
- Slump Landflow ___

TOTAL ___

APPENDIX C

Revised Natural Sediment Yields
and
Geologic Erosion Factors
for
Boise National Forest Landtypes

REVISED NATURAL SEDIMENT YIELDS AND GEOLOGIC EROSION FACTORS BY LANDTYPE

(Units are Tons/square mile/year)

Landtype Symbol	Dominant CEF	1 Mtn. Home	2 Boise	3 Idaho City	4 Cascade	5 Lowman	6 Emmett	7 Landmark	8 Bear Valley
101	.5-1.3	<5	<5	<5	<5	<5	<5	<5	
101-2	.5-1.3	<5							
101-3	.5-1.3					<5	<5		
101a	.5-1.3							<5	<5
102	.5-1.3	<5	<5		<5	<5	<5	<5	<5
103	.5-1.3				<5	<5			<5
103-1	.5-1.3					<5			<5
104	.5-1.3	<5	<5	<5	<5	<5	<5		<5
104-2	.5-1.3							<5	
105	.5-1.3				5	5			
105-4	.5-1.3	12	12	12					
105-3	.5-1.3	None	None	None	None	None	None	None	None
105-5	.5-1.3	10	10						
106	.9	8	8		<5			8	<5
106-2	.9		11			11			
106-9	.9				<5			<5	<5
106b	.9	None	None	None	None	None	None	None	None
107	1.0				16				
107-1	1.0		18				18		
107-2	1.0						20		
108	.8		18		18	18			18
109	.9				20			20	20
109-2	.9	25	25	25			25		
109-1	.9	None	None	None	None	None	None	None	None
109-5	.9						20		
109-9	.9					25	25		
109a	.9				40				40
109a-1	.9	30	30	30		30	30	30	30
109b	.9	35	35	35		35	35		
109b-1	.9							30	
109b-3	.9	None	None	None	None	None	None	None	None
109c	.9	35	35	35		35	35	35	
109d-1	.9	94	94	94		94	94		15
109d-2	.9							26	
109e	.9								15
109g	.9	42	42						
109g-1	.9	49							
109n	.9	None	None	None	None	None	None	None	None
109n-1	.9					34	34		
110	.8		5	5	5		5	5	
110-1	.8	None	None	None	None	None	None	None	None
110x	.8	5	5	5	5	5	5	5	
110x-2	.8								<5
111a	.8	20	20	20	20	20	20	20	20
111a-1	.8	25	25	25		25	25	25	25
111a-2	.8				20				
111a-3	.8				20				
111b	.8		30	30	30	30	30	30	30
111b-1	.8		50			50		50	
111b-2	.8								30

Appendix C (Page 2)

Landtype Symbol	Dominant GEF	1 Mtn. Home	2 Boise	3 Idaho City	4 Cascade	5 Lowman	6 Emmett	7 Landmark	8 Bear Valley
111c	.8		40		40	40	40		
111c-3	.8								45
111d	.8		60		60				60
111d-2	.8							55	
111d-3	.8			55		55	55		
111g	.8						60		
111x	.8		50	50		50		50	
111x-1	.8								55
112	.8				75				
112-1	.8	75				75			
113	.8		5	5	5	5	5	5	5
113-1	.8				<5				
114	.8				18	18			
114-2	.8							20	
115	.8				25				
120a	1.0				25		25		25
120a-1	1.0						30		
120a-2	1.0		25	25				25	
120a-8	1.0				32				32
120b	1.0-1.2				35				35
120b-1	1.2				50			50	50
120b-2	1.0-1.2				35				
120b-3	1.0-1.2	50	50	50		50		50	
120b-4	1.0-1.2	40	40	40		40	40	40	40
120b-5	.60						30		
120b-6	1.0-1.2	38	38	38		38	38		
120b-10	.42						36	36	
120b-13	1.0-1.2							38	
120b-14	.42							20	
120c	1.0-1.2				80	80	80		80
120c-1	1.1				58	58			
120c-2	1.0-1.2					74	74		
120c-3	1.0-1.2	68	78	78			78	78	
120c-8	1.0-1.2	82	87	92			82		
120c-11	1.1	49	40	49		49	49		
120d	1.0-1.2				95				
120d-2	1.0-1.2	125						125	
120d-3	1.0-1.2	85		85		85	85		
120d-4	1.0-1.2	110		110			110		
120e	1.2			20	20	20			
120e-1	1.2	30		30	30	30			30
120e-2	1.2	20		25					
120e-3	1.2								20
120e-5	1.2	20							
120e-6	1.2	35	35				35		
120e-7	1.2		25						
121	1.2			30	30		24		
121e	1.2		27	27	27	27	27		27
121e-1	1.2	23				23			

Appendix C (Page 3)

Landtype Symbol	Dominant GEF	1 Mtn. Home	2 Boise	3 Idaho City	4 Cascade	5 Lowman	6 Emmett	7 Landmark	8 Bear Valley
122	1.0-1.2			140	140	140			122
122-1	1.0-1.2	140	140				140		
122-2	1.0-1.2								135
122-4	1.0-1.2	120	120	120		120	120		120
122-5	1.0-1.2							135	
122-8	1.0-1.2	130					130		
123	1.0-1.2				25				
123-1	1.0-1.2		18			18		18	18
123-2	1.0-1.2		29						
123-3	1.0-.12		25				35		
123b	1.0-1.2	21							
123b-1	1.0-1.2	30							
123c	1.0-1.2	58				58			
125	.3	25							
131-2	.42						5		
131-3	.42						8		
133a-3	.42						4		
133b	.42						10		
133c-1	.42						20		
134-3	.42	15							
135-1	.42	11	11						
135-2	.42	18							
135-3	.42	16							
136-1	.42	<5	<5						
136-2	.42	<5							
136-3	.42	<5							
136-5	.42	<5							
136-6	.42	<5							
136-7	.42	<5							
136-8	.42	<5							
140b-2	.75		<5	<5					
140b-3	.75		58						
140c-1	.75		44						
140c-2	.75		50						
140c-3	.75		75	75					
140e-1	.75		18						
140e-2	.75			28					
141	.75		25						
143	.75		35	35					
143c	.75			49					

APPENDIX D

Revised Natural Sediment Yields
and
Geologic Erosion Factors
for
Boise National Forest Landtypes
as entered into the
BOISED Sediment Yield Model

REVISED NATURAL SEDIMENT YIELDS AND GEOLOGIC EROSION FACTORS
(As entered into BOISED Sediment Yield Model)

Landtype Symbol	Dominant GEF	Natural Sediment Yield (Tons/square mile/year)
101	0.8	3
101-2	0.8	3
101-3	0.8	3
101a	0.8	3
102	0.8	3
103	0.8	3
103-1	0.8	3
104	0.8	3
104-2	0.8	3
105	0.8	3
105-4	0.8	12
105-5	0.8	10
106	0.9	8
106-2	0.9	11
106-9	0.9	3
107	1.0	16
107-1	1.0	18
107-2	1.0	20
108	0.8	18
109	0.9	20
109-2	0.9	25
109-5	0.9	20
109-9	0.9	25
109a	0.9	40
109a-1	0.9	30
109b	0.9	35
109b-1	0.9	30
109c	0.9	35
109d-1	0.9	94
109d-2	0.9	26
109e	0.9	15
109g	0.9	42
109g-1	0.9	49
109n-1	0.9	34
110	0.8	5
110x	0.8	5
111a	0.8	20
111a-1	0.8	25
111a-2	0.8	20
111a-3	0.8	20
111b	0.8	30
111b-1	0.8	50
111b-2	0.8	30
111c	0.8	40
111c-3	0.8	45

Appendix D (Page 2)

Landtype Symbol	Dominant GEF	Natural Sediment Yield (Tons/Square Mile/Year)
111d	0.8	60
111d-2	0.8	55
111d-3	0.8	55
111g	0.8	60
111x	0.8	50
111x-1	0.8	55
112	0.8	75
112-1	0.8	75
113	0.8	5
113-1	0.8	3
114	0.8	18
114-2	0.8	20
115	0.8	25
120a	1.0	25
120a-1	1.0	30
120a-2	1.0	25
120a-8	1.0	32
120b	1.1	35
120b-1	1.2	50
120b-2	1.1	35
120b-3	1.1	50
120b-4	1.1	40
120b-5*	0.6	30
120b-6	1.1	38
120b-10*	.42	36
120b-13	1.1	38
120b-14*	.42	20
120c	1.1	80
120c-1	1.1	58
120c-2	1.1	74
120c-3	1.1	78
120c-8	1.1	87
120c-11	1.1	45
120d	1.1	95
120d-2	1.1	125
120d-3	1.1	85
120d-4	1.1	110
120e	1.2	20
120e-1	1.2	30
120e-2	1.2	23
120e-3	1.2	20
120e-5	1.2	20
120e-6	1.2	35
120e-7	1.2	25
121	1.2	27
121e	1.2	27
121e-1	1.2	23

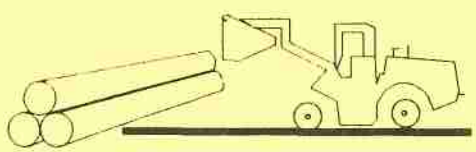
Appendix D (Page 3)

Landtype Symbol	Dominant GEF	Natural Sediment Yield (Tons/square mile/year)
122	1.1	135
122-1	1.1	140
122-2	1.1	135
122-4	1.1	120
122-5	1.1	135
122-8	1.1	130
123	1.1	25
123-1	1.1	18
123-2	1.1	29
123-3	1.1	30
123b	1.1	21
123b-1	1.1	30
123c	1.1	58
125	.30	25
131-2	.42	5
131-3	.42	8
133a-3	.42	4
133b	.42	10
133c-1	.42	20
134-3	.42	15
135-1	.42	11
135-2	.42	18
135-3	.42	16
136-1	.42	3
136-2	.42	3
136-3	.42	3
136-5	.42	3
136-6	.42	3
136-7	.42	3
136-8	.42	3
140b-2	.75	3
140b-3	.75	58
140c-1	.75	44
140c-2	.75	50
140c-3	.75	75
140e-1	.75	18
140e-2	.75	28
141	.75	25
143	.75	35
143c	.75	49

Appendix

F

Timber Harvest Codes



Basic Logging Erosion Rates

APPENDIX F

Timber Harvest Codes and Basic Logging Erosion Rates

The following rates (Tons/Mi^2/Year) are used for logging activities. All values are the same as those found in the R1/R4 Sediment Yield Guide.

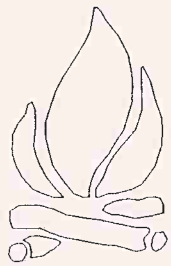
Harv Method	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
1. CC/TR	340	180	140	90	40	20
2. CC/CB	211	112	87	56	25	12
3. CC/SKY	112	59	46	30	13	7
4. CC/AER	65	34	27	17	8	4
5. SEL/TR	241	128	99	64	28	14
6. SEL/CB	146	77	60	39	17	9
7. SEL/SKY	99	52	41	26	12	6
8. SEL/AER	48	25	20	13	6	3

where: CC = clearcut logging
SEL = selection logging
TR = Tractor skidding
CB = Cable skidding
SKY = Skyline logging
AER = Helicopter logging

Appendix

G

Fire Intensity Levels



and
Basic Fire
Erosion Rates

APPENDIX G

Fire Intensity Level Definitions and Basic Fire Erosion Rates

All values are the same as those found in the R1/R4 Sediment Yield Guide.

Basic Erosion Rates For Fire
(Tons/Mi^2/year)

Year Since Fire	Fire Intensity Class: Low	Medium	High
1	110	275	550
2	24	60	120
3	5	13	25
4	1	3	5
5	0	0	0

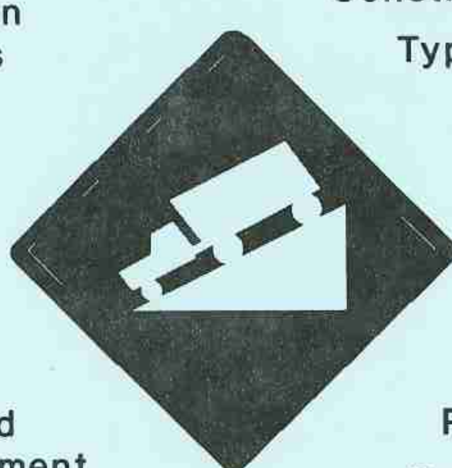
Fire intensity class is defined as follows:

Fire Intensity Class	Description
Low	Soil surface litter and humus have not been destroyed by fire. (a) Root crowns and surface roots will resprout. (b) Potential surface erosion has not changed as a result of fire
Medium	On up to 40 percent of the area, the soil surface litter and humus have been destroyed by fire and the A horizon has had intensive heating. (a) Crusting of soil surface produces accelerated surface erosion. (b) Intensively burned areas may be water repellent. (c) Root crowns and surface roots of grasses in the intensively burned area are dead and will not resprout.
High	On 40 percent or more of the area, soil surface litter and humus have been completely destroyed by fire and the A horizon has had intensive heating. (a) Crusting of soil surface produces accelerated surface erosion. (b) Intensively burned areas may be water repellent. (c) Root crowns and surface roots of grasses in the intensively burned areas are dead and will not resprout.

Appendix H

Basic Road Erosion Rates

Road Construction Types



Road Management Use Codes

Road Gradient Classes

APPENDIX H

Basic Road Erosion Rates
Road Construction Type Definitions
Management/Use Codes
and
Gradient Classes

Roading Activities. The following matrices show the basic erosion rates used in BOISED for combinations of Construction Type, Road Management, and time since activity.

Matrix 1. Existing/New Construction. Basic Erosion Rates- $Tons/Mi^2/Yr.$

Years Since Activ.	Road Use/Management Class			
	Heavy Use	Light Use	Closed	Oblit
1	67,500	67,500	67,500	67,500
2	18,000	18,000	18,000	18,000
3	7,000	5,000	5,000	5,000
4	7,000	5,000	3,000	1,000
5	7,000	5,000	2,000	500
6+	7,000	5,000	1,250	250

Matrix 2. Heavy Reconstruction. Basic Erosion Rates - $Tons/Mi^2/Yr.$

Years Since Activ.	Road Use/Management Class			
	Heavy Use	Light Use	Closed	Oblit
1	18,000	18,000	18,000	8,000
2	10,000	5,000	5,000	5,000
3	7,000	5,000	5,000	5,000
4	7,000	5,000	3,000	1,000
5	7,000	5,000	2,000	500
6+	7,000	5,000	1,250	250

Matrix 3. Light Reconstruction Basic Erosion Rates - $Tons/Mi^2/Yr.$

Years Since Activ.	Road Use/Management Class			
	Heavy Use	Light Use	Closed	Oblit
1	9,000	9,000	9,000	9,000
2	7,000	5,000	5,000	5,000
3	7,000	5,000	5,000	5,000
4	7,000	5,000	3,000	1,000
5	7,000	5,000	2,000	500
6+	7,000	5,000	1,250	250

Matrix 4. Reclaimed Road Basic Erosion Rates - $Tons/Mi^2/Yr$

Years Since Activ.	Road Use/Management Class			
	Heavy Use	Light Use	Closed	Oblit
1	-	-	-	1,000
2	-	-	-	500
3+	-	-	-	250

Road Construction Activity Definitions

New Construction: The construction of a road where no road exists, or the major reconstruction of an existing road resulting in essentially complete disturbance of cut slopes, fill slopes, and the road surface. Table values for Light Use come from the R1/R4 Sediment Yield Guide. Other values were extrapolated based on relative amounts of soil disturbance.

Heavy Reconstruction: The reconstruction of an existing road on essentially the same location of the original road. Excavation is moderate and comes from intermittent curve widening, slough removal, and turnout construction. Defective culverts are replaced and new culverts added as needed. The road surface receives complete disturbance, cut slopes significant disturbance, and fill slopes minor disturbance. Table values extrapolated based on relative amounts of soil disturbance from this activity compared to new construction.

Light Reconstruction: The smoothing and shaping of the existing road surface and minor excavation of widely spaced slough deposits. Cut slopes and fill slopes have minor disturbance. Culverts may be replaced or added. Often, existing roads have been cross ditched and these structures bladed out to provide a smooth running surface. Table values extrapolated as for heavy reconstruction.

Reclaimed: The obliteration of a road from the system, generally by ripping the road tread and seeding. Table values extrapolated by Boise NF personnel.

Road Management/Use Class Definitions.

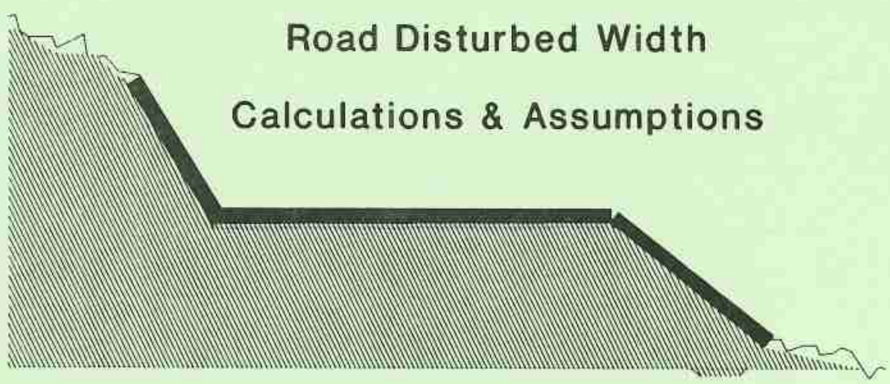
Heavy Use - more than approximately 5 vehicles average per day with road surface blading frequency averaging at least once in two years.
Light Use - less than approximately 5 vehicles a day with infrequent blading of the surface.
Closed - closed to traffic but fills and culverts in place. Not surface bladed. Basic erosion rate tables assume that the closure is implemented four years after construction.
Obliterated - culverts and bridges at drainageways removed, road surface cross ditched and revegetated, and no use by four wheeled vehicles. Basic erosion rate tables assume that the road is obliterated four years after construction. To obliterate a road sooner or reduce erosion from a closed road, code it as a **reclaimed** road and specify the year the road treatment takes place.

Road Gradient Class Definitions.

The average road gradient modifies the basic erosion rate from the "standard" rates shown above. If the average road gradient for the individual road segments entered into BOISED is known, the following adjustment factors can be used to modify the basic erosion rate. Simply enter the road gradient class at the appropriate prompt when entering road activity information.

Road Gradient Class	Adjustment Factor
1. 0 - 4.9%	0.5
2. 5 - 9.9%	1.0
3. 10%+	1.5

Appendix I



Road Disturbed Width

Calculations & Assumptions

APPENDIX I

Road Disturbed Width Calculations and Assumptions

Disturbed Area

For logging and fire activities the disturbed area, in acres, is the actual area treated. However for roading, this disturbed area is not as easily determined. Factors effecting the actual area disturbed by road activities include: gradient of slope on which the road is located; road width; slope ratio of cut slopes and fill slopes. The BOISED program calculates a default disturbed width for roads based on a set of assumed road characteristics. The program automatically adjusts road widths based on the average sideslope of the landtype on which the road is constructed. When sideslope gradient of road location differs from the average for the landtype, or the road width, design, or cut and fill ratios differ from the assumed typical road, it may be necessary to enter a different disturbed width by overriding the default value supplied by BOISED. Users must carefully evaluate road widths since roads create a disproportionately large percentage of total management-induced sediment.

The model currently only includes one road width template (NEW) to which the system defaults. Plans are underway to add a second template (OLD) which will facilitate data entry of old road systems. Both are fully described below:

(1) OLD refers to road construction as it was done on the Forest prior to 1980. Widths are generally greater than for road construction practices which were implemented roughly after 1980 (NEW).

(2) NEW refers to road construction as it is presently done on the Forest. This generally began after 1980 but specific changeover dates may vary. As a general rule, roads constructed prior to 1980 should use OLD road width defaults and roads constructed after 1980 should use NEW road width defaults. Users will need to decide what to use in specific applications.

The differences between OLD and NEW are shown below and in Figure I-1.

Road Characteristic	OLD	NEW
Basic road design	16 foot with ditch	14 foot rolled grade
	Both use "balance as you go road design"	
Road width	16 feet	14 feet
Fill slope	1.5:1	1.3:1
Cut slope (Sideslopes <60%)	1:1	0.75:1
(Sideslopes >60%	0.5:1	Full bench

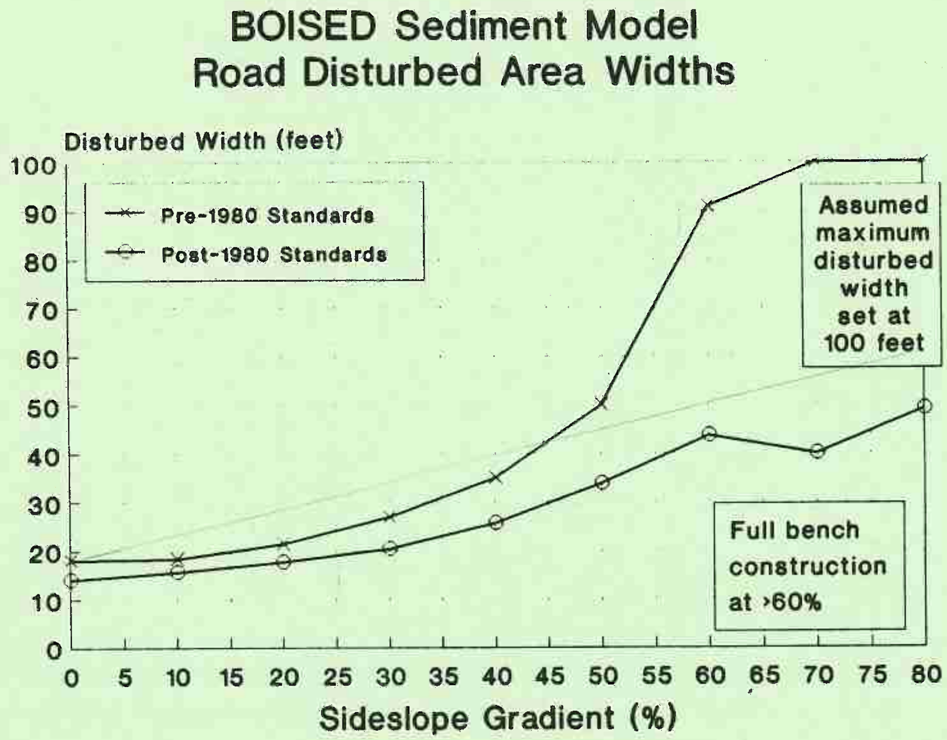
Calculation of default disturbed widths are based on the publication: Megahan, W. F., 1976. Tables of Geometry For Low-standard Roads For Watershed Management Considerations, Slope Staking, and End Areas. USDA Forest Service Gen. Tech. Rept. INT-32, Int. For. and Range Expt. Sta. All width are horizontal widths and not on the ground slope distances.

The following table lists the default disturbed widths for typical slope gradients:

Sideslope gradient(%)	OLD Disturbed Width(ft)	NEW Disturbed With(ft)
0	18.0	14.0
10	18.3	15.6
20	21.3	17.6
30	26.8	20.3
40	34.9	25.6
50	49.9	33.8
60	90.8	43.6
70	*100.0	39.9
80	*100.0	49.1

* Calculated values are much higher than those shown in the table (212 and 412 feet, respectively). The lower values are used as defaults because 100 feet appears to be an upper limit of disturbed width observed on the Forest for slopes 70 percent and greater.

30 ft Avg ?


BOISED Sediment Model
Road Disturbed Area Widths
Disturbed Width (feet)
100
90
80
70
60
50
40
30
20
10
0
Pre-1980 Standards
Post-1980 Standards
Assumed maximum disturbed width set at 100 feet
Full bench construction at >60%
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
Sideslope Gradient (%)

Appendix J

Erosion Mitigation Factors

APPENDIX J

Erosion Mitigation Factors

Mitigation is the treatment over and above the "standard practice" that is accomplished on roading activities to reduce on-site erosion. For fires, mitigation is defined as emergency burned area rehabilitation measures implemented on the burned area to reduce erosion.

The erosion mitigation factor is defined as 1 minus the expected erosion reduction expressed as a decimal. For example, a set of practices with a 30 percent reduction in erosion is assigned an erosion mitigation factor of 0.70 (e.g., 1.0 minus 0.3 = 0.7). Mitigation measures as defined here apply only to surface erosion processes. Small mass failures, less the than 10 cubic yards, are considered part of this surface erosion.

When recommending a mitigation treatment, do not be misled to believe that the effectiveness listed in mitigation factor tables will always occur. If practices are improperly implemented on the ground, effectiveness will be reduced. The combined skill of engineers, soil scientists, hydrologists, and others is needed, together with onsite knowledge, to effectively design mitigation treatments that fit. Similarly, if conditions other than the "average" occur, effectiveness may be altered either positively or negatively.

Road Mitigation Factors

Road erosion mitigation refers to the reduction of sediment moved off the entire road prism of a standard road, including the cut and fill slopes and the road travelway (including the ditch), compared to the amount of erosion which would occur in the absence of specific practices. Mitigation effects are highly variable and dependent on land type, site characteristics, design, time of application, maintenance, and location.

The basic road is defined as a single lane road with curve widening and turnouts, adequate drainage structures, all clearing slash removed from road prism, balanced construction as much as possible, including slope rounding and benching. Quality location, design, construction, and maintenance are assumed.

The document "Reduction of Soil Erosion on Forest Roads" by Edward R. Burroughs, Jr. and John G, King (USDA Forest Service, Intermountain Research Station, General Technical Report INT-264) is the basis for most of the estimation of erosion reduction used BOISED. The paper presents the expected reduction in surface erosion from selected treatments applied to forest road travelways, cut slopes, fill slopes, and ditches. Estimated erosion reduction is expressed as functions of ground cover, slope gradient, and soil properties whenever possible.

In developing mitigation coefficients for roads it is important to consider the total partitioning of erosion from the various parts of the road. For example, even though filter windrows may be 80 percent effective in terms of erosion reduction, the total reduction from the entire road disturbed width may be significantly less than 80 percent because, in the absence of specific treatments of the road tread and fill slopes, these road segments will continue to produce erosion at untreated rates. On Boise National Forest granitics, the long-term partitioning of total erosion is generally assumed to consist of 55 percent from cut slopes, 25 percent from fill slopes, and 20 percent from the travelway. These are long-term averages of segment contribution and will generally be used to calculate total erosion reduction.

Depending on site conditions, the distribution immediately following construction activities may be significantly different. In general, cut and fill slope percentages may be reversed with the major contribution coming from fill slopes immediately after construction. Furthermore, treatments may not be uniformly effective the entire length of the road. The variability of these factors and others makes determination of erosion mitigation factors difficult. For modeling purposes, long term partitioning values listed above are used. In specific cases, more detailed mitigation factors may be developed for the three years after construction assuming site specific data are available. Use of the long-term partitioning values are estimated to overestimate sediment yield 10 to 20 percent in years immediately after construction. However, given the uncertainty of sediment modeling and the data available at the planning level when models are generally run, more detailed analysis is judged to not generally be needed.

In granitic soils, stabilization of cut slopes is the most difficult erosion mitigation problem. The long-term instability of cut slopes, and our inability to effectively control erosion from them, is the major reason why the Boise National Forest is unable to reduce erosion as much as many other National Forest with different soil types where erosion reduction up to 90 percent is often possible.

Erosion mitigation factors also change over time as road practices change. For example, additional erosion reductions occur as roads are closed to traffic, water barred, or obliterated. Erosion reduction due to road closure and obliteration are already built into basic road erosion tables and should not be double counted as mitigation measures. Remember that the tables assume that closures and obliterations take place 4 years after construction. If implementation will be significantly different from assumptions described above, mitigation factors may need to be changed or road to be obliterated may be coded as reclaimed prior to the fourth year. BOISED allows the user to specify a mitigation factor for each of the first 9 years following the activity with the tenth year's factor applying to all years beyond year 10.

All possible combinations of practices and situations that may be encountered cannot be dealt with in terms of guidelines for the selection of mitigation factors. The following table displays road erosion mitigation factors for specific practices commonly used on the Boise National Forest. Model users will still need to evaluate on a site specific basis reductions expected from practices not included in the following list. Examples include location of roads in the upper, or lower, third of a slope, the use of energy dissipators at culvert outlets, and the treatment of sediment source areas. Some of these extremely effective erosion mitigation practices are difficult to model with BOISED which is structured to deal with relatively homogeneous landscapes, roads, and activities. The real world is often much more complex and the model can only deal with average situations and expected responses. For comparative analysis purposes, this level of detail is adequate.

Practice	Percent Reduction	Average Boise NF Mitigation Factor
Fill slopes		
Dry seeding	0 - 20	1.00
Filter windrows	75 - 85	0.20
Seeding, straw mulch, asphalt tackifier		
Vertical height less than 20 feet	45 - 60	0.50
Vertical height 20 to 40 feet	25 - 30	0.75
Curlex mulch	95	0.05
Curlex plus filter windrow	99	0.01
Cut slopes		
Dry seeding (3/4:1)	0 - 20	1.00
Seeding, straw mulch, asphalt tackifier		
3/4:1 slope	40	0.60
1:1 slope	75	0.25
Seeding, straw mulch		
3/4:1 slope	30	0.70
1:1 slope	40	0.60
Terracing (1:1 to 1.4:1)	85	0.15
Travelway		
Gravel	70 - 85	0.20
Gravel (road plus ditch)	90	0.10
Bituminous surface	95	0.05

The following examples illustrate calculation of erosion mitigation factors for three typical mitigation "packages" included in the Forest Plan which might be applied to typical road projects.

LOW LEVEL EROSION MITIGATION PRACTICES:

Dry seeding all cut and fill slopes as well as design for adequate road drainage. This is the "standard practice" and is assigned an erosion reduction value of zero since these practices are part of the definition of the "standard road" from which basic erosion rates derive. (Erosion mitigation factor = 1.0).

MODERATE LEVEL EROSION MITIGATION PRACTICES:

Only major sediment contributing areas are treated for erosion mitigation; not the entire length of the road. Specific practices include:

1. Placing filter windrows on the fill 100 feet each side of the drainage.
2. Placing erosion control netting for 100 feet each side of drainage on cut and fill slopes in contributing areas and around culvert inlets and outlets.

The assumption is made that 75 percent of cut slope erosion comes from contribution areas next to drainageways. Consequently, 40 percent (75% of 55%) of total cut slope erosion is attributed to the contributing area with 15 percent coming from the rest of the cut slopes in the road segment. The following table demonstrates the calculation process.

Road segment	% of Total	Activity	Activity Reduction	Total Reduction (%)
Cut slope	15	None	0 %	0.15 x 0 = 0
Contrib. Area	40	Erosion netting	60 %	0.40 x 60 = 24
Fill slope	25	Filter windrow	80 %	0.25 x 80 = 20
Road Tread	20	None	0 %	0.20 x 0 = 0
Totals	100			Weighted average reduction = 44 % Erosion mitigation factor = 0.56

HIGH LEVEL EROSION MITIGATION PRACTICES:

Same practices as Moderate Level plus:

1. Graveling entire road surface (including ditches if appropriate).
2. Scattering straw mulch (2 T/acre) on all cut and fills for entire length of road; use tackifying agent on cut slopes.

Road segment	% of Total	Activity	Activity Reduction	Total Reduction (%)
Cut slope	15	Straw mulch	35 %	0.15 x 35 = 5
Contrib. Area	40	Erosion netting	60 %	0.40 x 60 = 24
Fill slope	25	Filter windrow	80 %	0.25 x 80 = 20
Road Tread	20	Gravel	80 %	0.20 x 80 = 16
Totals	100			Weighted average reduction = 65 % Erosion mitigation factor = 0.35

Fire Mitigation Factors

Fire mitigation is defined as emergency burned area rehabilitation measures implemented on the burned area to reduce erosion.

Practice	Percent Reduction	Average Boise NF Mitigation Factor
Seeding	35	0.65
Reforestation	30	0.70
Contour Felling	75	0.25
Soil Treatment(Discing, chaining)	15	0.85
Timber Salvage (Cut and remove trees)	60	0.40
Timber Salvage (Cut and leave trees)	65	0.35
Seeding Plus:		
Reforestation	50	0.50
Contour Felling	80	0.20
Soil Treatment	40	0.60
Timber Salvage	70	0.30
Reforestation Plus:		
Timber Salvage	70	0.30
Seeding and Reforestation Plus:		
Contour Felling	85	0.15
Soil Treatment	60	0.40
Timber Salvage	75	0.25

Note: Salvage assumes tops and branches are lopped & scattered to within 2 feet of ground)

Appendix K

Sediment Delivery

Calculations
Assumptions
Graphs

Sediment Delivery Calculations, Assumptions, and Graphs

The BOISED model uses two types of sediment delivery ratios, one for surface erosion and another for mass erosion. The sediment delivery ratio is a decimal fraction expressing the percentage of on-site eroded material delivered to the nearest first or higher order drainage. Separate delivery ratios are calculated because mass erosion and surface erosion are distinctly different processes.

Mass Erosion Sediment Delivery Ratio

The mass erosion sediment delivery ratio is only applied to road construction activities on landtypes with average slopes greater than or equal to 45 percent. Provision is made to include unstable landtypes which may be susceptible to mass erosion but have slopes less than 45 percent as well as stable landtypes on steep slopes which may not exhibit mass erosion characteristics. This is done through the mass erosion inclusion factor coding done in the Landtype Data Base file.

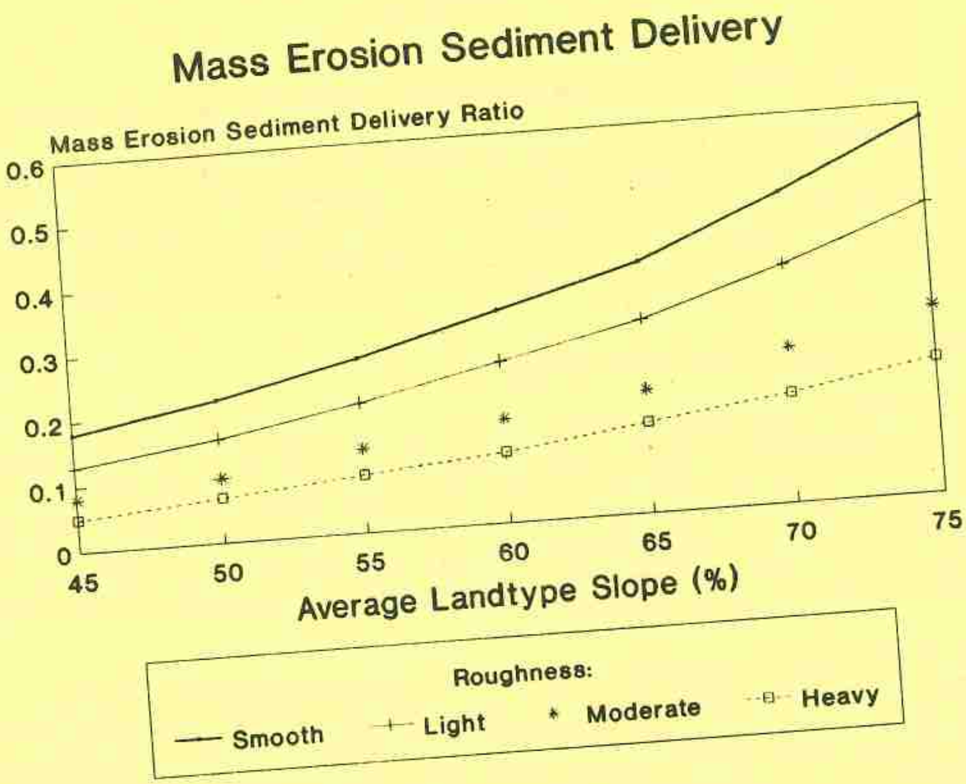
Delivery potential is based on a graphical relationship for debris avalanche-debris flow mass movements found in the WRENSS Handbook (See Appendix B). The relationship has been expanded to include the four roughness codes employed in the Landtype Data Base file (See Appendix D). In addition to heavy (which equates to the irregular slope described in WRENSS), moderate, light, and smooth slope roughness curves were added. The curves were transformed into the following equations which are programmed into BOISED. Users have the option of overriding computer generated values.

Roughness Descriptor	Code	Equation
Smooth	1	$MSDR = 3.285*EXP^{(0.0382*SLOPE)}*0.01$
Light	2	$MSDR = 2.162*EXP^{(0.0406*SLOPE)}*0.01$
Moderate	3	$MSDR = 1.278*EXP^{(0.0417*SLOPE)}*0.01$
Heavy (WRENSS Irregular)	4	$MSDR = 0.707*EXP^{(0.0454*SLOPE)}*0.01$

Where: MSDR = mass erosion sediment delivery factor as a decimal fraction;
EXP = the base of natural logarithms (e = 2.7182818); and
SLOPE = average landtype slope in percent.

The following table shows sediment delivery ratios for the four slope roughness descriptors. Figure K-1 shows the same information graphically.

Average Landtype Slope (Percent)	Mass Erosion Sediment Delivery Ratio			
	Smooth	Light	Moderate	Heavy
45	0.18	0.13	0.08	0.05
50	0.22	0.16	0.10	0.07
55	0.27	0.20	0.13	0.09
60	0.33	0.25	0.16	0.11
65	0.39	0.30	0.19	0.14
70	0.48	0.37	0.24	0.17
75	0.58	0.45	0.29	0.21


Mass Erosion Sediment Delivery
Mass Erosion Sediment Delivery Ratio
0.6
0.5
0.4
0.3
0.2
0.1
0
45
50
55
60
65
70
75
Average Landtype Slope (%)
Roughness:
Smooth
Light
Moderate
Heavy

Surface Erosion Sediment Delivery Ratio

A surface sediment delivery ratio (SDR) is assigned to each landtype in the BOISED model. It is calculated internally by the program based on five descriptive characteristics assigned for each landtype in the Land Systems Inventory process. The program assigns the same delivery ratio for all activities. If "average" conditions don't apply for a particular location, computer generated sediment delivery ratios can be changed by the user. For example, if the activity is closer to streams than the average condition, sediment deliveries can be adjusted upward.

The factors used to calculate the SDR and which are included in the landtype data base file are:

1. Average Slope Steepness (percent gradient)
2. Average Slope Shape (for up and down slope profile)
3. Average Slope Dissection by drainageways (draws and streams)
4. Average Slope Roughness (boulders, vegetation, etc.)
5. Average Slope Distance from midpoint of landtype (or point of erosion) to an active drainageway (a drainageway that flows surface water at least once a year)

The final delivery ratio is determined by progressively solving a family of four curves; each time obtaining an adjusted SDR which is then used as beginning point for entering the next curve. Figures K-2 and K-3 show the four curves. Figure K-4 shows an example of how the curves are used.

A trial and error approach was used by Gene Cole to develop the curves based on Silver Creek research data. The relative effects of the factors on sediment delivery were hypothesized, plotted, and then compared to real data. Curves were then uniformly shifted up or down until calculated sediment delivery ratios for landtypes present in Silver Creek were the same as measured sediment delivery. The activity generating sediment in the Silver Creek Study Area was road construction. Therefore, delivery ratios generated by BOISED are based on delivery measured from roading. Sediment delivery from non-roading activities may be slightly overestimated due to this.

Sediment Routing

Sediment routing from first order drainages to the mouth of the watershed being modeled is handled as described in the R1/R4 Sediment Yield Guide. It is simple a function of watershed size and is calculated based on the following equation:

$$Y = AREA^{-0.18}$$

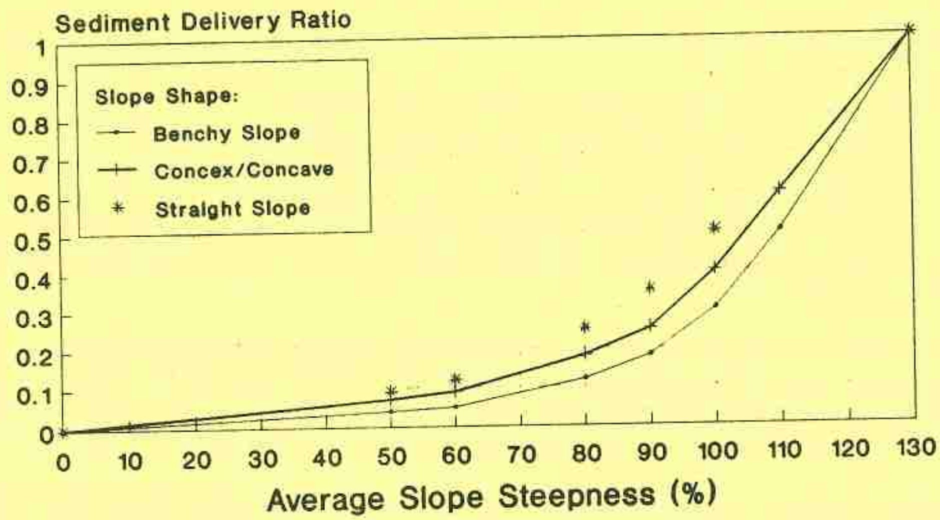
where: Y = a routing coefficient expressed as a decimal fraction which is the percent of total sediment delivered to the mouth of the watershed, and AREA = drainage area in square miles.

The following table shows routing coefficients for typical watershed sizes.

Area (Mi^2)	Routing Coefficient	Area (Mi^2)	Routing Coefficient
1	1.00	25	0.56
5	0.74	50	0.49
10	0.66	75	0.46
15	0.61	100	0.44

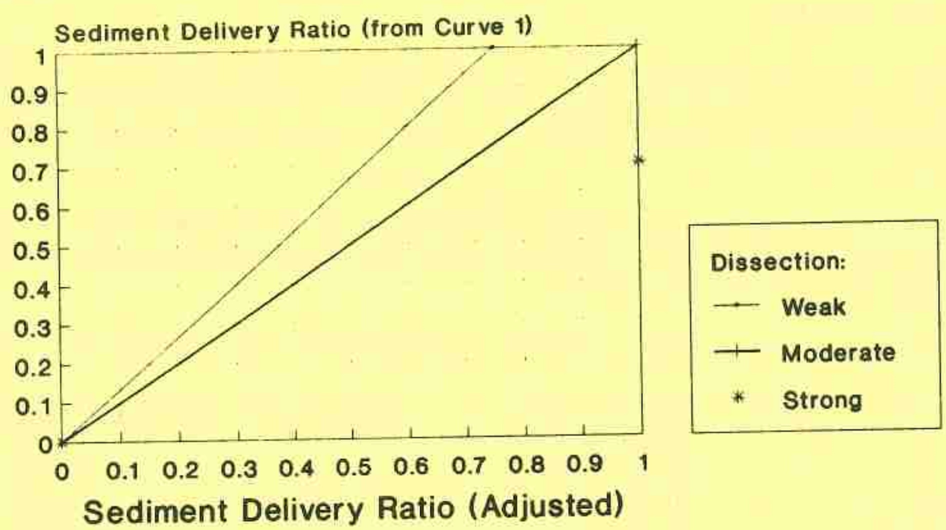
SDR CURVE 1

Sediment Delivery Ratio versus Slope Steepness and Shape



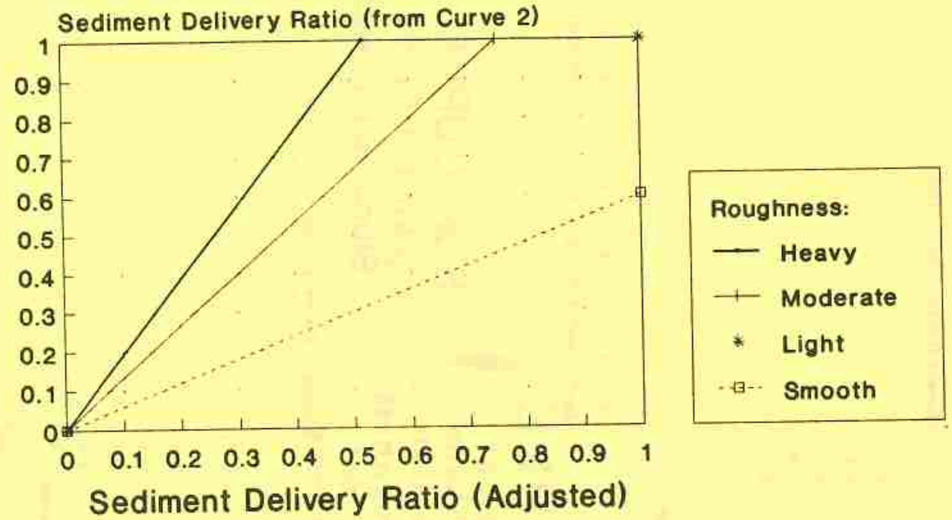
SDR CURVE 2

Adjustment Curve for Average Slope Dissection



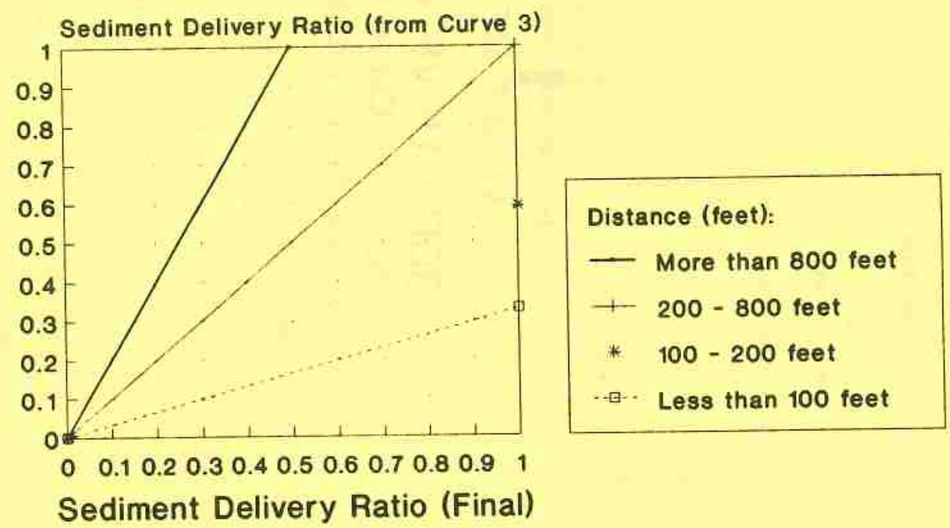
SDR CURVE 3

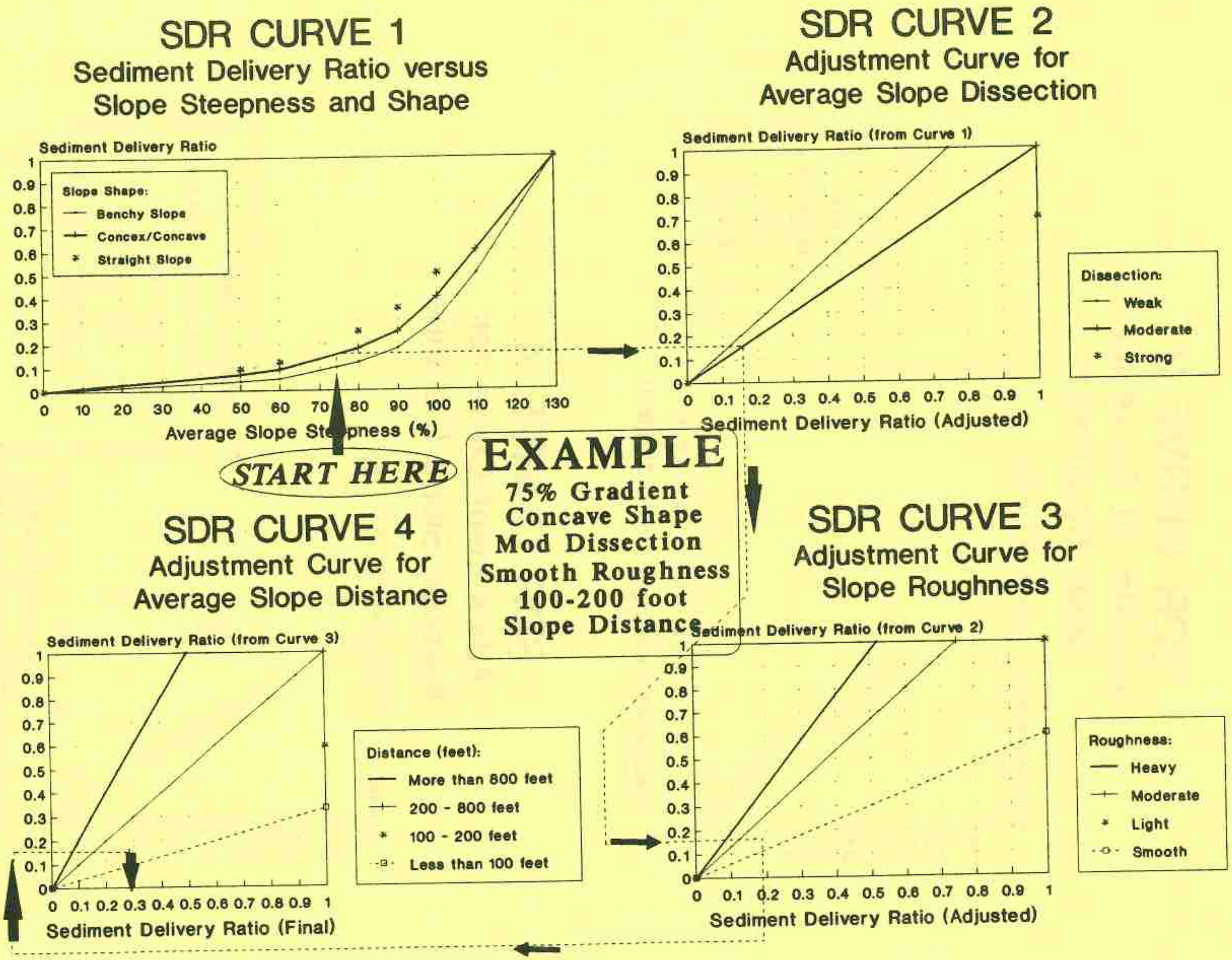
Adjustment Curve for Slope Roughness



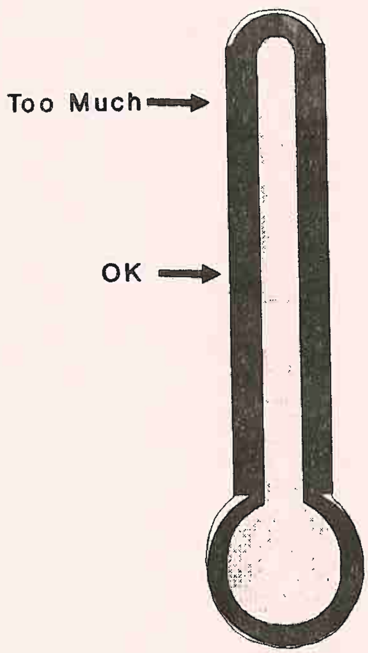
SDR CURVE 4

Adjustment Curve for Average Slope Distance




SDR CURVE 1
Sediment Delivery Ratio versus
Slope Steepness and Shape
Sediment Delivery Ratio
Slope Shape:
Benchy Slope
Concex/Concave
Straight Slope
Average Slope Steepness (%)
START HERE
SDR CURVE 2
Adjustment Curve for
Average Slope Dissection
Sediment Delivery Ratio (from Curve 1)
Dissection:
Weak
Moderate
Strong
Sediment Delivery Ratio (Adjusted)
EXAMPLE
75% Gradient
Concave Shape
Mod Dissection
Smooth Roughness
100-200 foot
Slope Distance
SDR CURVE 3
Adjustment Curve for
Slope Roughness
Sediment Delivery Ratio (from Curve 2)
Roughness:
Heavy
Moderate
Light
Smooth
Sediment Delivery Ratio (Adjusted)
SDR CURVE 4
Adjustment Curve for
Average Slope Distance
Sediment Delivery Ratio (from Curve 3)
Distance (feet):
More than 800 feet
200 - 800 feet
100 - 200 feet
Less than 100 feet
Sediment Delivery Ratio (Final)

Appendix L



Geomorphic Threshold Concepts

Paper:

Systematic Watershed Analysis Procedure for Clearwater National Forest

Systematic Watershed Analysis Procedure for Clearwater National Forest

DALE WILSON, RICK PATTEN, AND WALTER F. MEGAHAN

Natural and man-caused disturbances, including roads, may cause accelerated on-site erosion, increased downstream sedimentation, and changes in channel conditions. A procedure has been developed to estimate the magnitude of these effects on the Clearwater National Forest based on a land systems inventory that uses the "landtype", which is defined as a unit of land that has similar landform, geologic, soil, and vegetative characteristics. The dominant erosion hazards, which include surface erosion and rotational and debris landslides, are evaluated for each landtype in a watershed. The efficiency of a landtype to deliver eroded material into the channel system as sediment is also evaluated for each landtype. Erosion and sedimentation data collected locally or extrapolated from nearby areas with similar characteristics are used to estimate the erosion and sedimentation responses of road construction, timber harvest, and forest fire. Predictions can be made for undisturbed conditions and also to determine the effects of past or proposed management alternatives. Predictions are sensitive to changes in erosion over time. A relation based on analyses of 65 watersheds makes it possible to define allowable increases in sediment production based on channel equilibrium conditions. The procedure is useful to transportation planners because it provides a means to evaluate the effects of alternative road locations and road design features and allows scheduling construction over time to minimize unwanted effects.

There has been considerable interest in recent years in the effect of alternative cultural practices on water quality. On forest lands, the pollutant of primary concern is sediment, and the primary cultural practice that causes accelerated sediment is road construction (1). This is particularly true in the western United States, where accelerated sedimentation following road construction commonly results from both surface and mass erosion processes (2).

Various procedures have been developed to estimate the effects of alternative soil-disturbing practices on erosion. Most of these were developed on agricultural lands (3,4) and have subsequently been adapted to other types of soil disturbances, including construction sites and roads (5,6). Unfortunately, these methods have limited application for evaluating road erosion in much of the mountainous West because they are not adapted to snowmelt conditions, they do not consider gulley and mass erosion, and they make no provision for subsurface flow intercepted by roadcuts.

We have developed a procedure for predicting the effects of alternative watershed disturbances, which include road construction, timber harvest, and forest fire. The procedure uses a systems approach based on the landforms found in the basin, empirical data to estimate the effects of disturbance on annual surface and mass erosion, and the resulting response in both annual sediment yields and channel equilibrium conditions. By using the Clearwater National Forest procedures, responses are measured in terms of changes in annual sediment yields and channel equilibrium conditions and are usually evaluated over a period of less than 20 years.

ROLE OF LANDTYPE

The "landtype" is one stratum of the hierarchical land systems inventory described by Wertz and Arnold (7). The higher-level strata, which include physiographic provinces, sections, and subsections, are all delineated on the basis of climatic and geologic differences and are roughly classified by size as greater than 1000 mile^2, 100-1000 mile^2, and 25-100 mile^2 for each level, respectively. Further stratification requires the evaluation of additional factors, including landform, soils, and vegetation. The landtype association reflects a common genesis for a group of lands and can range in size from 10 to 25 mile^2. The basic land unit used for the watershed analysis procedure is the landtype itself, and it is defined as an area of land with similar landform, parent material, soil, and vegetation characteristics. Landtypes range from 40 to several hundred acres in size and average about 150 acres. Guidelines and additional background information on the delineation of landtypes are available elsewhere (8-11).

Landtypes and Slope Hydrology

Landtypes are used as the basic component for describing the watershed system because factors used to delineate landtypes are the same factors that influence the hydrologic function of slopes. Characteristics that describe slope hydrology, or how a slope handles water, include (a) slope shape, (b) slope length, (c) slope gradient, and (d) surface drainage characteristics (12).

When analyzing slope hydrology, it is helpful to consider how a slope disposes of water and how the above-mentioned factors influence runoff timing, as follows:

1. Slope shape: Slope shape influences whether water is dispersed or concentrated. Slope shape classes mapped include the following: (a) class 1--slopes that are convex horizontally disperse water movement in all directions; this tends to discourage concentration and decreases contributing area to streams that originate on the slope; (b) class 2--straight slopes accumulate water in straight flow paths down the slope; and (c) class 3--horizontally concave slopes concentrate water movement to common points; this increases the contributing area of streams that originate on the slope.
2. Slope length: Longer slopes tend to accumulate more water on the lower portions of the slopes.
3. Slope gradient: Steeper slopes decrease the time of concentration of slope water movement and increase flow velocities.
4. Surface drainage characteristics: Slope dissection, stream density, stream length, and entrenchment all affect time of concentration and contributing area of slope water movement.

Soil and parent material characteristics used to delineate landtypes include soil mantle depth, soil texture, soil structure, soil consistency, bedrock type, bedrock weathering, and bedrock jointing and fracturing. Each factor modifies mantle drainage and, subsequently, the subsurface water movement on slopes. Soil and bedrock characteristics can vary within a landtype but occur in a predictable pattern; thus, differences are reflected in the overall slope hydrology.

The last basic criterion that describes the landtype is vegetative habitat type (13). This also indicates basic slope hydrology by expressing relative soil moisture regimes over the slope throughout the year. Vegetative habitat types are used to define soil mantle stability through correlation with vegetative cover and vegetative recovery potential.

Delineation and Description of Landtypes

The actual landtype delineation process requires, first, delineation by landform, which is a morphological descriptor. Landform is described by slope shapes, slope length, slope gradient, etc., and landtypes are classified and mapped by aerial photograph interpretation. Field traverses that cross representative areas of each mapping unit are then taken to provide detailed site information. Patterns of landform, soils and vegetative habitat types, and general parent material characteristics are described and extrapolated over the mapped areas. The mapping units are then transferred from the aerial photographs to 1:24 000 scale topographic maps. A final, detailed landtype description is developed for each unique mapped unit and includes a general description and setting, physical landform characteristics, slope hydrologic properties, parent material, soil, and vegetation characteristics.

Landtype Erosion Hazards

Interpretations of the hazards for various kinds of erosion, including rotational mass wasting, debris avalanche, and overland flow erosion, are made for each landtype in order to define the relative sediment production potential for each area of land. Ratings for each attribute are classified relatively from very low (class 1) to very high (class 5).

Rotational Mass Wasting Hazard

Rotational mass wasting is defined as movement that occurs along internal slip surfaces (usually concave and upward) with backward tilting common. Movement is usually deep seated in response to increased subsurface water concentrations in the vicinity of the slide plane (14). Hard bedrock surfaces do not constitute the slippage plane. Criteria used in evaluating the hazard are incidence of subsurface water concentration, mantle depth, soil and bedrock characteristics, and evidence of past rotational failures. These factors are interrelated, but they are discussed individually.

Slope hydrologic characteristics describe an incidence of subsurface water concentration. Factors considered are slope shape, slope gradient, drainage density, lower-order stream characteristics, and mantle drainage characteristics. Areas with a high incidence of subsurface water concentration include stream headlands with convex-shaped slopes that change to concave shapes where large numbers of first-order streams originate. Also, subsurface water concentrates in deep-mantled, weakly dissected, over-steepened slopes (streambreaks) where almost all slope drainage is subsurface, which causes water concentrations in middle and lower slopes. An example of an area with a low incidence of subsurface water concentration would be low relief lands with a well-developed, high-density, dendritic drainage pattern.

Soil cohesive strength of the mantle also affects rotational mass wasting potential. This is evaluated by using pertinent soil and geologic characteristics such as type of bedrock and soil textural properties. For example, sandy soils developed from quartzites with large percentages of coarse fragments have much lower cohesion strength than silt loam and silty clay loam soils developed from micaceous shists.

Debris Avalanche Hazard

Debris avalanches are defined as rapid and usually sudden sliding of usually cohesionless mixtures of soil and rock material that range in depth from several inches to 4-5 ft (14). Criteria used to assess the hazard are slope gradient, slope shape, aspect, surface soil creep hazard class, and evidence of past debris avalanches such as slide scars, talus slopes, and colluvial cones or fans at the toe of the slopes.

Debris avalanches are most common on steep, concave slopes with soils susceptible to surface creep. On the Clearwater National Forest, most debris avalanches occur when the heads of draws are overloaded with sediment eroded from adjoining slopes through dry surface creep. The occurrence of a large, high-intensity hydrologic event (often rain on snow) triggers the debris avalanche.

Surface creep is the gravitational movement of solid particles dislodged by various processes such as raindrop splash, wind, frost action, and animal movement. Criteria used to assess surface creep are slope gradient, aspect, soil cohesion and coefficient of friction, soil particle size, and vegetative cover potential. Surface creep is a gravity process; therefore, slope gradient is a dominant factor. Aspect influences the frequency of freeze-thaw cycles that occur during the spring. Soil cohesion and particle size refer to surface soil properties. Loose, noncohesive soils with large particle sizes are much more susceptible to gravity movement than fine-grained cohesive soils. Vegetative cover greatly reduces surface creep by reducing surface temperature fluctuations and protecting the soil surface from particle movement.

Overland Flow Erosion Hazard

Overland flow erosion refers to erosion caused by tractive forces developed by water running over undisturbed natural surfaces bared of vegetation. This erosion occurs as sheet erosion and rilling. Factors used to rate surface erosion hazard are based on the detachability of soil particles and the potential for occurrence of overland flow and are very similar to those used for rotational mass wasting: slope shape and slope gradient, mantle depth, and soil particle detachability. Raindrop splash or overland flow is required to detach and move particles. Slopes that concentrate water have the greatest potential for overland flow (for example, steep concave slopes that concentrate runoff from a larger area into a smaller area). Landforms that exhibit this property include breaklands, stream headlands, and glacial cirque basins. Broad convex ridges have a lower potential for overland flow because runoff is dispersed over the slope.

Thin soil mantles are more likely to have overland flow than thick soil mantles that occur on similar slopes because of more limited water storage capacity. Soil particle detachability is a function of the apparent cohesion of individual soil particles within the soil matrix. For example, coarse-textured, single-grain soils are more susceptible to particle detachment than cohesive soils with strong structures.

Slope Delivery Efficiency

On-site erosion is only manifest at downstream locations as sediment if the eroded material is delivered to the stream. Thus, the ability of a given landscape to deliver sediment downslope (termed slope delivery efficiency) is an important concern. Specifically, slope delivery efficiency describes rates at which water and sediment are transported from different slopes to the water system, including ephemeral draws. Slope delivery efficiency defines the role the landtype plays in sediment production in a watershed and refers to the ratio of sediment delivered into the water system over a 5- to 10-year period.

Slope delivery efficiency for mass erosion is based on data that quantify downslope delivery of landslide material collected on more than 600 landslides on the Clearwater National Forest (15). Slope characteristics used to interpret slope delivery for each landtype are slope gradient, slope shape, slope dissection density, and internal relief. Ratings for slope delivery efficiency are made similar to erosion hazard ratings that range from very low (class 1) to very high (class 5).

SEDIMENT PREDICTION FROM FOREST MANAGEMENT PRACTICES

The hazard ratings derived for each landtype provide the basis for quantification of sediment yields from watersheds in both the undisturbed state and following alternative kinds of land use practices. The simulation technique generates probable sediment rates caused by accelerated mass erosion on each landtype from roading, logging, or fire. It also generates sediment caused by induced surface erosion from road prisms, logging, or fire. A natural sediment rate is generated to interpret the magnitude of effects with respect to a specific watershed system and its water resource values.

Basic assumptions involved in the sediment prediction process include the following:

1. Sediment yields can be simulated and used as expected annual volumes per unit area of the system routed to the mouth of the system.
2. Natural sediment yields are generated by in-channel erosion of banks and stored sediment in beds. This material is supplied principally by long-term mass movement (slumps and slides; debris avalanches, flows, and torrents; and creep) and, to a lesser degree, by natural surface erosion that is a function of catastrophic wildfires.
3. Mass erosion and surface erosion can be treated as separate processes, although in fact they are often interactive and interelated. Essentially, mass erosion is assumed to be accelerated by management activities, while surface erosion from wildfires, roads, and logging is induced or created by activities. The erosion products are delivered to the channel system by distinctly different processes: mass erosion is a colluvial or gravity process while surface erosion is moved principally by flowing water. Many of the same landtype properties are used to determine delivery efficiency for the two types of erosion processes, but the influence of those properties is different.

Natural Sediment Rate

The natural sediment rates, expressed as tons per square mile of watershed area per year, are derived from a composite on-site erosion hazard based on a weighted average of the individual on-site erosion hazards developed for each landtype. The composite on-site erosion hazard is calculated as follows:

$$\text{Composite on-site erosion hazard} = (0.4 \times \text{rotational mass wasting hazard}) + (0.4 \times \text{debris avalanche hazard}) + (0.2 \times \text{overland flow erosion hazard}) \quad (1)$$

The weighting factors are based on the fact that most natural sediment production on the Clearwater National Forest is caused by mass erosion that feeds material directly to stream channels. However, some overland flow erosion occurs following natural wildfires. Megahan and Molitor (16) found a total of 700 tons/mile² of soil loss from surface erosion after a wildfire on landscapes similar to those on the Clearwater National Forest. Soil losses were highest immediately after the burn and decreased to zero within five years in response to vegetative regrowth. The average wildfire frequency for vegetative types on the Clearwater National Forest is estimated to be about 140 years (17). Based on a wildfire erosion rate of 700 tons/mile² in 5 years and a fire frequency of 140 years, the average overland flow erosion from natural wildfire over a fire cycle is 5 tons/mile²/year. Megahan (18) reported an average annual sediment yield of 25 tons/mile²/year for undisturbed drainages similar to those on the Clearwater National Forest. About 5 tons/mile²/year or 20 percent of this is caused by long-term surface erosion from fire on the Clearwater National Forest. The remaining 80 percent is divided about equally between rotational mass wasting and debris avalanche, hence the weighting factors of 0.4 for rotational mass wasting and debris avalanche and 0.2 for surface erosion.

Watersheds with landtypes similar to those on the Clearwater National Forest have been shown to yield average annual sediment volumes that range from about 10 to 100 tons/mile²/year (18,19). Values within this range were assigned to each landtype identified on the forest based on the landtype's relative composite on-site erosion hazard. Each landtype's contribution is summed and weighted by area to account for potential sediment from all the lands in the watershed system.

This value provides an estimate of the total potential sediment for basins of similar size to the basins where the original data were collected. These study basins ranged from 0.15 to 2.5 mile² in size and averaged about 1.0 mile² (18). In order to estimate sediment yields for larger basins, it is necessary to correct for losses caused by channel storage. This is done by multiplying by a channel routing coefficient. The coefficient (C) is obtained from a relation developed by Roehl (20) by using a water shed area (A) in square miles. Roehl's original relation is adjusted to provide a coefficient of 1.0 at 1 mile² as follows:

$$C = A^{-0.18} \quad (2)$$

The procedure to estimate natural sediment yields from composite erosion hazard used on the Clearwater National Forest is adapted from a general procedure in use by the Forest Service, U.S. Department of Agriculture, in the northern Rocky Mountains (21).

Sediment from Accelerated Mass Erosion

The basic premise for quantifying sediment from mass erosion processes is that management activities accelerate natural mass erosion potential. The amount of increase is based on the landtype mass erosion hazard rating developed by using the rotational mass hazard, the debris avalanche hazard, and the slope delivery efficiency determined for a landtype, as follows:

$$\text{Landtype mass erosion hazard} = (\text{rotational mass wasting hazard}) + (\text{debris avalanche hazard}) \times (\text{slope delivery efficiency}) \quad (3)$$

Acceleration factors derived from studies in the Idaho Batholith (15) and modified by work on the Clearwater National Forest (22) are used to predict the increased risk of mass erosion due to roading, logging, or fire as a function of parent material and time after disturbance. The sediment from accelerated mass erosion is simply the landtype mass erosion hazard multiplied by the applicable acceleration factor, the area of the disturbance, and a coefficient to account for mitigation measures for roads and logging or fire intensity. The following illustrates the relation used for roads; similar relations are used for fire and logging:

Increased sediment = 20 x (landtype mass erosion hazard) x (road acceleration factor) x (area disturbed by road) x (mitigation) - 20 (4)

Sediment from Surface Erosion

Sediment derived from surface erosion is similated as an independent process with respect to mass erosion. The basic premise here is that roads, logging, and fire create, rather than accelerate, surface erosion. The methodology was developed by the Forest Service interregional task force and is documented in their report (21).

Surface erosion rates are assigned for each type of land disturbance activity, including road construction, logging, and wildfire. Assigned erosion rates are defined for each kind of disturbance and modified as needed if the disturbance is not in keeping with the definition. For example, the erosion rate for roads is based on the "basic road", which assumes a road with a 16-ft subgrade width, no surfacing, balanced construction, and no ditch.

Erosion rates are modified as the road deviates from this standard. Likewise, erosion rates are modified to account for differences in logging practices and wildfire intensity. Erosion rates also vary by landtype, elapsed time since disturbance (in years), and mitigation measures designed to reduce road erosion. Data for this effort come primarily from research conducted in Idaho (15,16, 18,23,24) supplemented by data from the West Coast (25-27). Erosion rates are in terms of tons per unit area of disturbance; therefore, the rates are multiplied by disturbed area to get total erosion for each landtype.

As with mass erosion, all soil losses caused by surface erosion are not delivered to streams because of enroute storage. A modification of a procedure developed by the Forest Service (21) is used to estimate delivery of surface-eroded material. Three variables are used to determine delivery:

1. Slope shape determines the ability to produce water for movement of sediment in the channel efficiently,
2. Slope gradient defines energy availability, and
3. Stream density represents slope length and proximity of the erosion source to the water system.

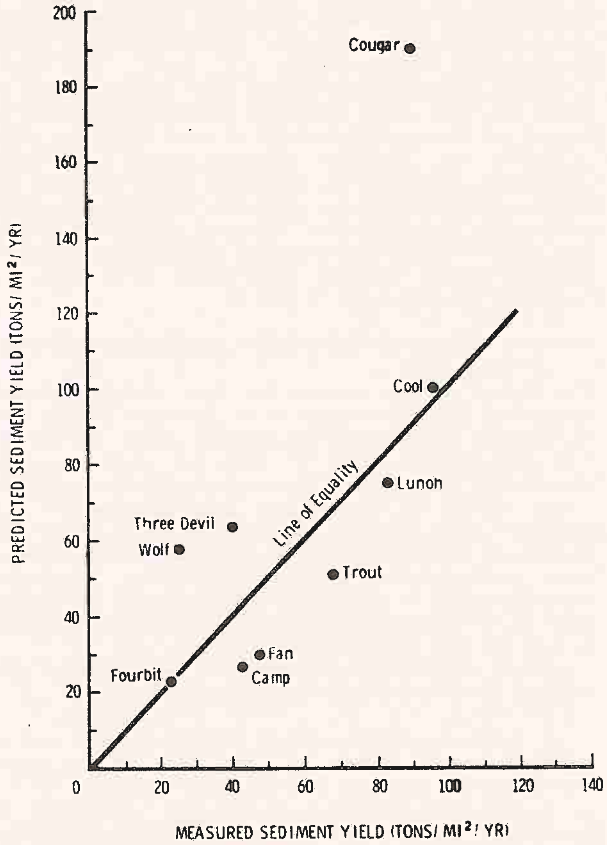
The relation used to predict surface erosion from roads is shown below; similar relations are used for fire and logging:

Increased sediment from road prism = (road base rate) x (mitigation) x (parent material erosion hazard) x (area disturbed by road) x (landtype slope delivery efficiency) (5)

PREDICTED VERSUS ACTUAL SEDIMENT YIELDS

The sediment yield prediction procedure is designed to provide average annual sediment for both natural and disturbed watersheds. This level of precision is analogous to the average annual sheet and rill erosion predictions for agricultural lands provided by the universal soil loss equation (4). In both cases, predictions for a specific year can be considerably different than actual, simply because of deviations in climatic conditions from the average.

Figure 1. Predicted versus measured average annual sediment yield.



Comparisons between actual and predicted values must be made for the average of a number of years of data to be valid.

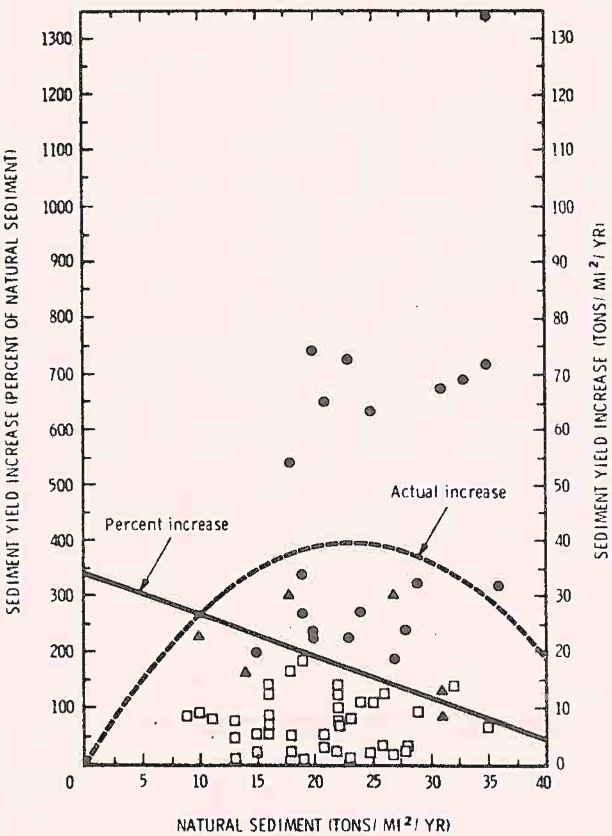
We do have relatively long-term sediment yield data for nine watersheds on the Clearwater National Forest that can be used for comparison purposes. Data consist of suspended and bed-load samples collected at irregular intervals during the year. Each annual data set ranged from about 10 to 16 samples. Individual sediment samples were prorated by time between samples to estimate annual sediment yields. A total of from six or seven years of sediment yield data are available for each watershed.

The actual versus predicted average annual sediment yields are shown in Figure 1. Most streams show relatively close agreement with little bias except Cougar Creek, where predicted values exceed actual by about 100 tons/mile^2/year. The Cougar Creek drainage contains many old roads that did not exhibit as much mass erosion as was predicted. On-the-ground inspection indicated that mitigation measures had been applied at a number of high erosion hazard situations but had not been accounted for in the prediction process. Although this comparison hardly provides a validation of the sediment estimation procedures, it does suggest that the estimates are reasonable in most cases.

CHANNEL EQUILIBRIUM

Predictions of annual sediment yields provide a convenient means for comparing watersheds and for comparing the effects of alternative land management practices over time. However, predicted sediment yields do not, in themselves, provide a means to

Figure 2. Sediment yield increase versus natural undisturbed sediment yield.



evaluate changes in channel conditions. Most streams in mountain lands in the western United States are supply limited (28). This means that more energy is available for sediment transport than there is sediment. Consequently, streams are characterized by coarse-textured beds commonly with rubble and boulder-sized materials dominating. There is limited bar development in such streams and bed forms consist primarily of nondescript accumulations of gravel and rubble materials that form the riffle and run areas found in such streams. Stream channels tend to maintain this characteristic appearance with increasing sediment loads for as long as the system is supply limited. However, eventually, sediment yields are accelerated to the point that sediment supply begins to approach transport capability. When this happens, finer bed materials begin to accumulate, as evidenced by accumulated sand particles between the coarser bed materials, development of bars, and other bed forms. Continued acceleration of sediment yields aggrades the bed further and may induce increased bank cutting, altered flow patterns, and major changes in bed forms such as formation of sand dunes, etc. Change in channel conditions are no doubt reflected in the health of the aquatic ecosystem as well.

Analyses of annual sediment yields have been made for a total of 65 watersheds on the Clearwater National Forest for both natural (undisturbed) and disturbed watershed conditions. Predictions for disturbed conditions were made by using the kinds and timing of disturbances that actually occur on each watershed. Values for the predicted maximum increase in annual sediment yield (expressed as a percentage of natural) were then plotted against the natural sediment yield (Figure 2). Channels at the mouth of each watershed were then subjectively evaluated for evidence of loss of equilibrium. Criteria used included accelerated deposition of bed materials (e.g., sand bars, dune bed forms, sand terraces along banks), loss of channel capacity (e.g., bank cutting, channel braiding), and change in substrate particle-size distribution (e.g., sand accumulations that surround gravel, rubble, and boulder material).

Each watershed represented by a point in Figure 2 was classified according to whether it was definitely out of equilibrium (solid circles), at or near equilibrium (solid triangles), or within equilibrium (open squares). An obvious grouping of data is apparent in this figure. The line shown represents the approximate envelope curve for channel equilibrium: Sediment supply exceeds available energy for watersheds above the line, whereas available energy exceeds sediment supply for watersheds below the line.

This curve provides a geomorphic basis for defining response levels of sediment increases in watersheds. Interestingly, the line is not horizontal but rather indicates that larger percentage increases in sediment can occur for watersheds with low natural sediment yields as compared with high sediment yield watersheds. This relation is clarified when the percentage changes in sediment are expressed in absolute units of tons per square mile per year (dashed curve on Figure 2). On this basis, maximum increases in sediment production can occur on watersheds where natural sediment yields equal about 20-25 tons/mile²/year. Apparently, watersheds with natural sediment yields greater than this can stand progressively less sediment increases because they are progressively nearer to equilibrium in the natural state. In contrast, watersheds with natural sediment yields less than 20-25 tons/mile²/year can stand progressively less increases in sediment because they are less capable of cleaning themselves due to limited transport energy.

PROCEDURE APPLICATIONS

These procedures make it possible to test the results of alternative land use practices on erosion, sediment yield, and channel equilibrium conditions. Erosion and sediment yield estimates are an important concern because they provide an index of potential effects on both on-site vegetation productivity and damage to downstream developments, respectively. Likewise, estimates of changes in channel equilibrium are useful because they provide an index of change to the aquatic ecosystem. By varying the kinds of practices, the time sequence of application of practices, and the various kinds of mitigation measures, we can define a mix of activities that optimizes land use benefits without causing large environmental alterations. The primary application is for project-level planning of forest management practices in a watershed system. It is an excellent tool for developing and comparing alternatives, identifying trends and recovery, scheduling activities, and recognizing potentially damaging situations.

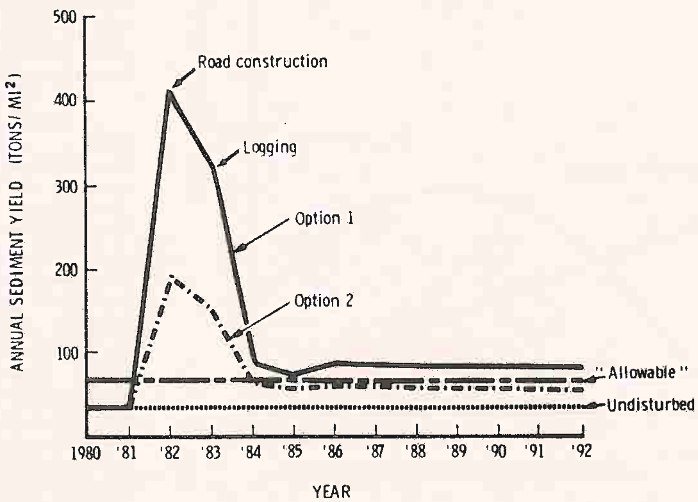
Example of Model Application

A simplified example of the application of the analysis procedures has been developed by using a representative watershed situation and landtypes found on the Clearwater National Forest. The 1000-acre watershed was developed on an old erosion surface by downcutting of the major drainage system in the area. Elevations range from 4000 to 4900 ft, and the bedrock on the watershed is granitic. Five

Table 1. Nature and amount of disturbance by landtypes for alternative timber harvest access routes.

Option	Road Length (miles)	Road Subgrade Width (ft)	Side Slope (%)	Calculated Area Disturbed by Road or Cutting Unit Area (acres)	Landtype	Type of Road Prism
1	1.0	15	25	2.4	22-G03	Balanced
	1.0	15	25	2.4	22-G03	Balanced
	0.5	15	70	1.4	61-G08	Full bench
	1.0	15	50	4.1	60-G11	Balanced
				100	22-G03	
				125	22-G03	
2	1.5	15	25	3.7	22-G03	Balanced
	1.0	15	25	2.4	22-G03	Balanced
	1.0	15	40	3.2	32-G02	Balanced
				100	22-G03	
				125	22-G03	

Figure 3. Percentage change in sediment yields for alternative road and logging practices.



different landtypes are found on the watershed.

Two options are considered in this example. Both required 3.5 miles of road construction in 1982 and logging of 225 acres of timber by using clearcutting and tractor skidding in 1983. Option 1 requires accessing the area from the bottom of the watershed and crossing the steep, high erosion hazard breaklands. Option 2 provides access from the top of the watershed and crosses the lower erosion hazard terrain. The amount and type of disturbances by landtypes are given in Table 1.

The example data were analyzed for a 10-year period following disturbance (Figure 3). The time dependence of the sediment responses is apparent. Sediment yields increase in 1981 in response to road construction. Rates decrease in 1982; however, the rate of decrease is reduced somewhat because of the logging activities. Additional decreases in sediment yield occur over time but not back to predisturbance levels because of long-term accelerated erosion on roadcuts.

According to Figure 3, increases in annual sediment yields up to about 90 percent over natural will not cause apparent channel deposition. Option 2 is clearly preferred to option 1 in terms of total increase in sediment production and duration of effects. However, other considerations may be important, depending on the nature of the uses elsewhere, the value of the water resource, and the juxtaposition of the example watershed over time and space with other watersheds in the area.

Application Elsewhere

This procedure is empirical and, as such, has limited application elsewhere. However, we feel that the principles involved can be extrapolated anywhere. An analysis procedure of this type can be designed in areas with minimal local erosion and sedimentation data by using basic principles to define relative erosion hazard ratings. These evaluations can then be used to design erosion and sediment monitoring programs that serve to update the prediction procedure. Basic requirements for implementing the watershed analysis system are as follows:

1. The dominant landforming and erosional processes of an area must be recognized,
2. The relative role of processes must be understood,
3. Landtypes or land stratification units must be designed to rate the dominant erosion processes,
4. Landtypes or land stratification units must be designed by using criteria essential to making slope delivery efficiency interpretations, and
5. The watershed system must be supply limited in the natural state.

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REFERENCES

1. Processes, Procedures, and Methods to Control Pollution Resulting from Silvicultural Activities. U.S. Environmental Protection Agency, Rept. EPA-430/9-9-73-010, 1973, 91 pp.
2. R.M. Rice, J.S. Rothacher, and W.F. Megahan. Erosion Consequences of Timber Harvesting: An Appraisal. In National Symposium on Watersheds in Transition, American Water Resources Association, Urbana, IL, 1972, pp. 321-329.
3. G.W. Musgrave. Quantitative Evaluation of Factors in Water Erosion: First Approximation. Journal of Soil and Water Conservation, Vol. 2, 1947, pp. 133-138.
4. W.H. Wischmeier and D.D. Smith. Predicting Rainfall-Erosion Losses from Cropland East of the Rocky Mountains. U.S. Department of Agriculture, Agriculture Handbook 282, 1965, 47 pp.
5. W.H. Wischmeier, C.B. Johnson, and B.V. Cross. A Soil Erodability Nomograph for Farmland and Construction Sites. Journal of Soil and Water Conservation, Vol. 26, 1971, pp. 189-193.
6. C.E. Israelsen and others. Erosion Control During Highway Construction. NCHRP, Repts. 220 and 221, April 1980.
7. W.A. Wertz and J.F. Arnold. Land Systems Inventory. Forest Service, U.S. Department of Agriculture, Intermountain Region, Ogden, UT, 1972, 12 pp.
8. G.E. Wendt, R.A. Thompson, and K.N. Larson. Land Systems Inventory, Boise National Forest, Idaho: A Basic Inventory for Planning and Management. Forest Service, U.S. Department of Agriculture, Intermountain Region, Ogden, UT, 1975.
9. Land System Inventory Guide. Forest Service, U.S. Department of Agriculture, Northern Region, Missoula, MT, Rept. R1-76-20, 1976.
10. R.W. Arnold. Strategies for Field Resource Inventories. Department of Agronomy, Cornell Univ., Ithaca, NY, Agronomy Mimeo. 79-20, 1979.
11. R.G. Cline. Landtype Mapping in Relation to Watershed Management Objectives. Proc., Interior West Watershed Management Symposium, Washington State Univ., Spokane, April 8-10, 1980, pp. 21-31.
12. M.A. Carson and M.J. Kirkby. Hillslope Form and Process. Cambridge Univ. Press, New York, Cambridge Geographical Studies 3, 1972.
13. R. Daubenmire and J.B. Daubenmire. Forest Vegetation of Eastern Washington and Northern Idaho. Washington Agriculture Experiment Station, Pullman, WA, Tech. Bull. 60, 1968, 104 pp.
14. D.J. Varnes. Landslide Types and Processes. In Landslides and Engineering Practice, HRB, Special Rept. 29, 1958, pp. 20-47.
15. W.F. Megahan, N.F. Day, and T.M. Bliss. Landslide Occurrence in the Western and Central Northern Rocky Mountain Physiographic Province in Idaho. Proc., Fifth North American Forest Soils Conference, Colorado State Univ., Ft. Collins, Aug. 1978, pp. 116-139.
16. W.F. Megahan and D.C. Molitor. Erosional Effects of Wildfire and Logging in Idaho. Proc., Watershed Management Symposium, Irrigation and Drainage Division, ASCE, Logan, UT, Aug. 11-13, 1975.
17. S.F. Arno. Forest Fire History in the Northern Rockies. Journal of Forestry, Vol. 78, No. 8, Aug. 1980, pp. 460-465.
18. W.F. Megahan. Sedimentation in Relation to Logging Activities in the Mountains of Central Idaho. In Present and Prospective Technology for Predicting Sediment Yields and Sources, Agricultural Research Service, U.S. Department of Agriculture, Rept. ARS-S-40, 1975, pp. 74-82.
19. J.F. Arnold and L.J. Lundeen. South Fork Salmon River Special Survey: Soils and Hydrology. Forest Service, U.S. Department of Agriculture, Ogden, UT, 1968, 195 pp.
20. J.W. Roehl. Sediment Source Areas, Delivery Ratios, and Influencing Morphological Factors. Commission of Land Erosion, International Association of Scientific Hydrology, Reading, Berkshire, England, Pub. 59, 1962, pp. 202-213.
21. Guide for Predicting Sediment Yields from Forested Watersheds. Forest Service, U.S. Department of Agriculture, Northern and Intermountain Regions, Missoula MT, and Ogden, UT, 1981, 49 pp.
22. D. Wilson, W.F. Megahan, W. Russell, and M. Bennett. A Systematic Watershed Analysis Procedure for the Clearwater National Forest. Proc., Analysis of Landslide Risk and Materials Engineering Workshop, Salt Lake City, Sept. 12-16, 1977, pp. 3-20.
23. W.F. Megahan. Erosion Over Time on Severely Disturbed Granitic Soils: A Model. Forest Service, U.S. Department of Agriculture, Intermountain Forest and Range Experiment Station, Ogden, UT, Res. Paper INT-156, 1974.
24. W.F. Megahan and W.J. Kidd. Effects of Logging and Logging Roads on Erosion and Sediment Deposition from Steep Terrain. Journal of Forestry, Vol. 70, No. 3, March 1972.
25. H.W. Anderson. Relative Contributions of Sediment from Source Areas and Transport Processes. In Present and Prospective Technology for Predicting Sediment Yields and Sources, Agricultural Research Service, U.S. Department of Agriculture, Rept. ARS-S-40, 1975, pp. 66-73.
26. H.W. Anderson. Sedimentation and Turbidity Hazards in Wildlands. Proc., Watershed Management, ASCE, Utah State Univ., Logan, Aug. 11-13, 1975, pp. 347-376.
27. J.E. André and H.W. Anderson. Variation of Soil Erodability with Geology, Geographic Zone, Elevation, and Vegetation Type in Northern California Wildlands. Journal of Geophysical Research, Vol. 66, 1961, pp. 3351-3358.
28. W.F. Megahan. Channel Stability and Channel Erosion Processes. Proc., Workshop on Scheduling Timber Harvest for Hydrologic Concerns, Forest Service, U.S. Department of Agriculture, Pacific Northwest Region and Pacific Northwest Forest and Range Experiment Station, Portland, OR, 1979, 18 pp.

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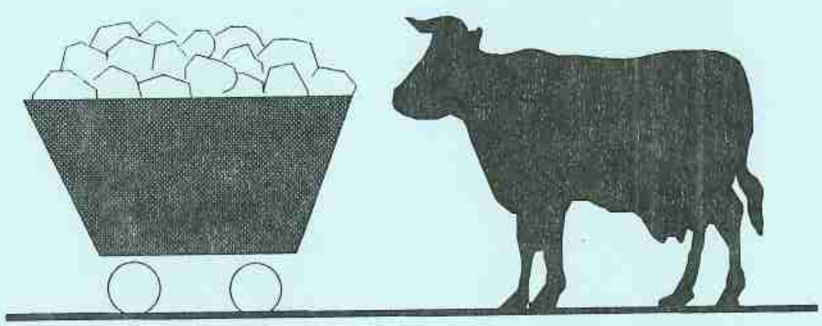
Appendix

M



Estimating Sediment Yields for Activities Other Than Logging, Roads, and Fire

APPENDIX M

Estimating Sediment Yields For Activities Other Than Logging and Roads

Concentrated Livestock and Other Activities. To estimate basic erosion rates for activities other than logging, roading and fire, estimating the average ground cover for the effected areas is a good way to begin. For livestock grazing, average annual sediment yield estimates were developed from the following two sources:

Packer, Paul E. 1953. Effects of Trampling Disturbance on Watershed Condition, Runoff, and Erosion. J. of Forestry, Vol. 51. No. 1.

Tew, Ronald K. 1973. Estimating Soil Erosion Losses From Utah Watersheds. U.S. Forest Service - Intermountain Region.

Ground cover definitions are taken from the Range Analysis Handbook, 1981 revision, Intermountain Region. The basal area of plants plus litter, rocks and erosion pavement constitute ground cover. Exceptions are mat-forming plants such as antennaria, Phlox, Silene, moss and lichens, in which case the entire plant will be counted as ground cover. Rock and erosion pavement will be counted as ground cover and its percentage will be added to that of vegetation and litter. Erosion rates are for 45 percent slopes and can be adjusted using the land unit slope factor listed later in this section.

Avg. Ground Cover (100% - Bare soil%)	Basic Erosion Rate Tons/Square mile/Year
0 - 25%	2,325
26 - 45%	525
46 - 60%	225
61 - 70%	75
71%+	0

Other Uses. Mined areas, large landings, parking areas, ski areas, etc., that are causing accelerated erosion can be inventoried, placed on map overlays, disturbed area by landtype determined, and basic erosion rates estimated by using information in this guide as reference benchmarks. Do not include this information unless the cumulative erosion and sedimentation is significant.

In some instances, the user may be able to "trick" the computer. For example, large constructed log landings, from an erosional viewpoint, are essentially the same as newly constructed roads and can be modeled as such. Numerous opportunities exist to fine tune these types of activities by altering sediment delivery and/or mitigation factors to fit real world conditions.

When data for all activities are complete, add the total from each activity to the average sediment yield for the same year from BOISED to obtain the total man-induced delivered sediment for each watershed.

Land Unit Slope Factor

This factor is applied for non-roading activities only. It is built into BOISED for logging and fire activities based on the average slope for the landtype on which the activity occurs as listed in the Landtype Data Base. It is derived from the Universal Soil Loss Equation and is simply a linear scalar to set erosion at 45 percent equal to 1 with erosion at 75 percent doubling and erosion at zero percent being cut in half. The formula is as follows:

$$\text{Land Unit Slope Factor} = \frac{[(0.43 + 0.30S + 0.043S^2) \times 0.0374] + .50}{6.613}$$

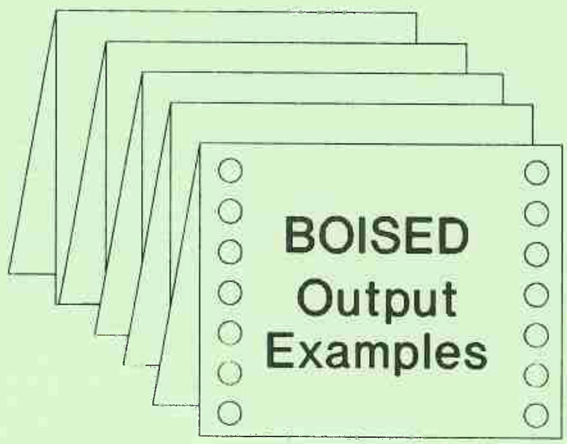
where s = average slope gradient in percent.

Examples of Land Unit Slope Factors:

Average Slope %	Land Unit Slope Factor
0	.50
10	.54
20	.63
30	.77
40	.96
50	1.20
60	1.48
70	1.81
80	2.19
90	2.63
100	3.10

When manually estimating sediment yield from activities outside of BOISED, the Land Unit Slope Factor should be applied.

Appendix N



LANDTYPES

Drainage DOLLAR CR.

Watershed

Subwatershed

DATA INPUT WORKSHEETS

LANDTYPE	ACRES	LANDTYPE	ACRES
102	30		
109A	5985		
109B	439		
120B	1306		
120B1	2501		
120C	423		
120D	309		
122	281		
SØ91	68		
S2Ø1	46		

CUTTING UNIT DATA

Boise National Forest

Prepared by J. Potyondy

NAME DOLLAR CREEK

Watershed Name: -

Sub-Watershed Name:

LANDTYPE	UNIT#	LOGGING SYSTEM/ TREATMENT TYPE	ACRES	YEAR
109A	410-302	CC/CB-2	14	1965
120B1	410-302	CC/CB-2	10	1965
109A	410-303	CC/CB-2	7	1965
120B1	410-303	CC/CB-2	7	1965
109A	410-304	CC/CB-2	16	1958
109A	410-305	SEL/CB-6	16	1958
120B1	410-306	SEL/CB-6	10	1958
120B1	410-307	SEL/CB-6	7	1958
↓	↓	↓	↓	↓
etc.	etc.	etc.	etc.	etc.

LOGGING SYSTEM TYPE

1-CC/TR 2-CC/CB 3-CC/SKY 4-CC/AER
5-SEL/TR 6-SEL/CB 7-SEL/SKY 8-SEL/SER

CC-Clear Cut SEL-Select tree marking TR-Tractor
CB-Cable SKY-Skyline AER-Helicopter

FIRE DATA

Boise National Forest

Prepared by J. Potyondy

NAME DOLLAR CREEK

Watershed Name:

Sub-Watershed Name:

LANDTYPE	UNIT ID	FIRE INTENSITY CLASS	ACRES	YEAR	MITIGATION
102		LOW	36	1989	N/A
109A		LOW	4298	1989	↓
109A		MOD	426	1989	↓
120B1		LOW	1052	1989	↓
120B1		MOD	2	1989	↓
120C		LOW	618	1989	↓
120C		MOD	6	1989	↓
122		LOW	160	1989	↓
122		MOD	14	1989	↓

Intensity Classes: Low/Mod/High

ROAD CONSTRUCTION DATA CODING FORM

Boise National Forest

Prepared by JPP
Date xx/xx/19xx

Drainage DOLLAR CREEK
Watershed

Subwatershed
Subwatershed #

LANDTYPE	ROAD NUMBER	ROAD LENGTH MILES	I CONSTR TYPE YEAR ACTIVITY	II MGMT CLASS	III GRADIENT CLASS
S091	493	0.3	1956-NEW	3	2
S091	493	0.3	1963 - LT RECON	3	2
S201	493	0.3	1956 - NEW	3	2
S201	493	0.3	1963 - LT RECON	3	2
120B	493G	3.7	1956 - NEW	3	2
120B	493G	3.7	1965 - LT RECON	3	2
120B	493G1	2.4	1956 - NEW	3	2
120 B	493G1	2.4	1963 - LT RECON	3	2
120B1	495	0.6	1956 - NEW	2	2
S091	495	1.4	1956 - NEW	2	2
S201	495	0.7	1956 - NEW	2	2
109A	495A	0.4	1963 - NEW	3	2
120 B1	495A	1.0	1956 - NEW	3	2
120 B1	495A	1.0	1963 - LT RECON	3	2
120 B 1	495A1	1.1	1963 - NEW	3	2
120B1	495A2	0.6	1956 - NEW	3	2
120B1	495A2	0.6	1963 - LT RECON	3	2
120B1	495AX	1.1	1963 - NEW	3	2
120B	495B	0.8	1957 - NEW	3	2
120 B	495B	0.8	1963 - LT REC	3	2
120B1	49BB	2.4	1957 - NEW	3	2

I	II	III
1-New/existing	1-heavy	1-0-5%
2-Heavy recon	2-light	2-5-10%
3-Light recon	3-closed	3-10%
4-Reclaimed	4-obliterated	

DATA INPUT FILE

USDA FOREST SERVICE 91/04/08
Road, Fire and Timber Harvest Sediment Model Print
Data File Listing
Revision: 03.01.01

Watershed: DOLL2 MIT
Alternative: ADJ ROAD WIDTHS

Project: PROJECTED
Data Validity Date: 10/15/90

Card Type	Unit Id.	Soil Surv	LandType	Gef	Area	Act Year	Activity	Sdr	Msdr	Road Width	Road Use	Road Grad	Mit Fac
1			102		30								
			109A		5985								
			109B		439								
			120B		1306								
			120B1		2501								
			120C		423								
			120D		309								
			122		281								
			S091		68								
			S201		46								
2	410302		109A	[.90]	14.0	1965	CC/CB	[.061]					
	410302		120B1	[1.20]	10.0	1965	CC/CB	[.080]					
	410303		109A	[.90]	7.0	1965	CC/CB	[.061]					
	410303		120B1	[1.20]	7.0	1965	CC/CB	[.080]					
	410304		109A	[.90]	16.0	1958	CC/CB	[.061]					
	410305		109A	[.90]	16.0	1958	SEL/CB	[.061]					
	410306		120B1	[1.20]	10.0	1958	SEL/CB	[.080]					
	410307		120B1	[1.20]	7.0	1958	SEL/TR	[.080]					
	410308		120B1	[1.20]	6.0	1958	SEL/CB	[.080]					
	410309		120B1	[1.20]	19.0	1965	SEL/CB	[.080]					
	410310		120B1	[1.20]	39.0	1958	SEL/TR	[.080]					
	410311		120B1	[1.20]	29.0	1958	SEL/CB	[.080]					
	410501		109A	[.90]	23.0	1965	CC/CB	[.061]					
	410502		109A	[.90]	15.0	1958	SEL/CB	[.061]					
	410502		109A	[.90]	15.0	1965	CC/CB	[.061]					
	410503		120B1	[1.20]	16.0	1965	CC/CB	[.080]					
	410504		120B1	[1.20]	22.0	1958	SEL/CB	[.080]					
	410504		120B1	[1.20]	22.0	1965	CC/CB	[.080]					
	410505		120B	[1.10]	5.0	1958	SEL/CB	[.081]					
	410505		120B	[1.10]	5.0	1965	CC/CB	[.081]					
	410505		120B1	[1.20]	6.0	1958	SEL/CB	[.080]					
	410505		120B1	[1.20]	6.0	1965	CC/CB	[.080]					
	411301		120B1	[1.20]	58.0	1958	SEL/CB	[.080]					
	411302		120B1	[1.20]	92.0	1958	SEL/TR	[.080]					
	411303		120B1	[1.20]	10.0	1958	CC/CB	[.080]					
	411304		120B1	[1.20]	7.0	1958	SEL/TR	[.080]					
	411305		120B1	[1.20]	10.0	1958	SEL/CB	[.080]					
	411306		120B1	[1.20]	12.0	1958	SEL/CB	[.080]					
	411307		109A	[.90]	4.0	1958	SEL/CB	[.061]					
	411307		120B1	[1.20]	4.0	1958	SEL/CB	[.080]					
	411502		120B1	[1.20]	30.0	1958	SEL/CB	[.080]					
	411502		120B1	[1.20]	30.0	1965	CC/CB	[.080]					

[ ] indicate DEFAULT values used by program

Watershed: DOLL2 MIT
Alternative: ADJ ROAD WIDTHS

Project: PROJECTED
Data Validity Date: 10/15/90

Card Type	Unit Id.	Soil Surv	LandType	Gef	Area	Act Year	Activity	Sdr	Msdr	Road Width	Road Use	Road Grad	Mit Fac
2	411503		120B1	[1.20]	12.0	1958	SEL/TR	[.080]					
	411503		120B1	[1.20]	12.0	1965	CC/TR	[.080]					
	411504		109A	[.90]	6.0	1965	CC/CB	[.061]					
	411504		120B1	[1.20]	6.0	1965	CC/CB	[.080]					
	411505		120B1	[1.20]	17.0	1958	SEL/TR	[.080]					
	411505		120B1	[1.20]	17.0	1965	CC/TR	[.080]					
	411506		120B1	[1.20]	32.0	1958	SEL/TR	[.080]					
	411506		120B1	[1.20]	32.0	1965	CC/TR	[.080]					
	411507		120B1	[1.20]	22.0	1958	SEL/CB	[.080]					
	411507		120B1	[1.20]	22.0	1965	CC/CB	[.080]					
	411508		120B1	[1.20]	11.0	1958	SEL/CB	[.080]					
	411508		120B1	[1.20]	11.0	1965	CC/CB	[.080]					
	411509		109A	[.90]	12.0	1958	SEL/TR	[.061]					
	411509		109A	[.90]	12.0	1965	CC/TR	[.061]					
	411509		120B1	[1.20]	12.0	1958	SEL/TR	[.080]					
	411509		120B1	[1.20]	12.0	1965	CC/TR	[.080]					
3			102	[.80]	36.0	1989	Low/Int	[.012]					
			109A	[.90]	4298.0	1989	Low/Int	[.061]					
			109A	[.90]	426.0	1989	Mode/Int	[.061]					
			120B1	[1.20]	1052.0	1989	Low/Int	[.080]					
			120B1	[1.20]	2.0	1989	Mode/Int	[.080]					
			120C	[1.10]	618.0	1989	Low/Int	[.113]					
			120C	[1.10]	6.0	1989	Mode/Int	[.113]					
			122	[1.10]	160.0	1989	Low/Int	[.358]					
			122	[1.10]	14.0	1989	Mode/Int	[.358]					
4A	493		S091	[1.00]	.30	1956	New	[.293]	[.156]	[40]	Closed	5-10%	2
	493		S091	[1.00]	.30	1963	Lt/Rec	[.293]	[.156]	[40]	Closed	5-10%	2
	493		S201	[1.00]	.30	1956	New	[.212]	[.103]	[34]	Closed	5-10%	2
	493		S201	[1.00]	.30	1963	Lt/Rec	[.212]	[.103]	[34]	Closed	5-10%	2
	493G		120B	[1.10]	3.70	1956	New	[.081]	[.127]	[37]	Closed	5-10%	2
	493G		120B	[1.10]	3.70	1965	Lt/Rec	[.081]	[.127]	[37]	Closed	5-10%	2
	493G1		120B	[1.10]	2.40	1956	New	[.081]	[.127]	[37]	Closed	5-10%	2
	493G1		120B	[1.10]	2.40	1963	Lt/Rec	[.081]	[.127]	[37]	Closed	5-10%	2
	495		120B1	[1.20]	.60	1956	New	[.080]	[.134]	[30]	Light	5-10%	2
	495		S091	[1.00]	1.40	1956	New	[.293]	[.156]	[40]	Light	5-10%	2
	495		S201	[1.00]	.70	1956	New	[.212]	[.103]	[34]	Light	5-10%	2
	495A		109A	[.90]	.40	1963	New	[.061]	[.125]	[23]	Closed	5-10%	2
	495A		120B1	[1.20]	1.00	1956	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495A		120B1	[1.20]	1.00	1963	Lt/Rec	[.080]	[.134]	[30]	Closed	5-10%	2
	495A1		120B1	[1.20]	1.10	1963	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495A2		120B1	[1.20]	.60	1956	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495A2		120B1	[1.20]	.60	1963	Lt/Rec	[.080]	[.134]	[30]	Closed	5-10%	2
	495AX		120B1	[1.20]	1.10	1963	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495B		120B	[1.10]	.80	1957	New	[.081]	[.127]	[37]	Closed	5-10%	2
	495B		120B	[1.10]	.80	1963	Lt/Rec	[.081]	[.127]	[37]	Closed	5-10%	2
	495B		120B1	[1.20]	2.40	1957	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495B1		120B	[1.10]	.40	1957	New	[.081]	[.127]	[37]	Closed	5-10%	2

[ ] Indicate DEFAULT values used by program

Watershed: DOLL2 MIT
Alternative: ADJ ROAD WIDTHS

Project: PROJECTED
Data Validity Date: 10/15/90

Card Type	Unit Id.	Soil Surv	LandType	Gef	Area	Act Year	Activity	Sdr	Msdr	Road Width	Road Use	Road Grad	Hit Fac
4A	495B1		120B	[1.10]	.40	1963	Lt/Rec	[.081]	[.127]	[37]	Closed	5-10%	2
	495B1		120B1	[1.20]	.20	1957	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495B1		120B1	[1.20]	.20	1963	Lt/Rec	[.080]	[.134]	[30]	Closed	5-10%	2
	495B2		120B	[1.10]	.10	1957	New	[.081]	[.127]	[37]	Closed	5-10%	2
	495B2		120B	[1.10]	.10	1963	Lt/Rec	[.081]	[.127]	[37]	Closed	5-10%	2
	495B2		120B1	[1.20]	.10	1957	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495B2		120B1	[1.20]	.10	1963	Lt/Rec	[.080]	[.134]	[30]	Closed	5-10%	2
	495B3		120B1	[1.20]	1.60	1957	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495B3		120B1	[1.20]	1.60	1963	Lt/Rec	[.080]	[.134]	[30]	Closed	5-10%	2
	495B4		120B	[1.10]	.20	1957	New	[.081]	[.127]	[37]	Closed	5-10%	2
	495B4		120B	[1.10]	.20	1963	Lt/Rec	[.081]	[.127]	[37]	Closed	5-10%	2
	495B4		120B1	[1.20]	.50	1963	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495B5		109A	[.90]	.20	1963	New	[.061]	[.125]	[23]	Closed	5-10%	2
	495B5		120B1	[1.20]	1.20	1963	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495B6		120B1	[1.20]	.50	1963	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495BB2		120B1	[1.20]	.40	1963	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495C		109A	[.90]	2.00	1957	New	[.061]	[.125]	[23]	Closed	5-10%	2
	495C		109A	[.90]	2.00	1963	Lt/Rec	[.061]	[.125]	[23]	Closed	5-10%	2
	495CX		109A	[.90]	.40	1963	New	[.061]	[.125]	[23]	Closed	5-10%	2
	495CY		120B1	[1.20]	1.90	1957	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495CY		120B1	[1.20]	1.90	1963	Lt/Rec	[.080]	[.134]	[30]	Closed	5-10%	2
	495E		102	[.80]	.20	1957	New	[.012]	[.026]	[15]	Closed	5-10%	2
	495E		102	[.80]	.20	1963	Lt/Rec	[.012]	[.026]	[15]	Closed	5-10%	2
	495E		109A	[.90]	.30	1957	New	[.061]	[.125]	[23]	Closed	5-10%	2
	495E		109A	[.90]	.30	1963	Lt/Rec	[.061]	[.125]	[23]	Closed	5-10%	2
	495E		120B	[1.10]	.20	1957	New	[.081]	[.127]	[37]	Closed	5-10%	2
	495E		120B	[1.10]	.20	1963	Lt/Rec	[.081]	[.127]	[37]	Closed	5-10%	2
	495E		120B1	[1.20]	.60	1957	New	[.080]	[.134]	[30]	Closed	5-10%	2
	495E		120B1	[1.20]	.60	1963	Lt/Rec	[.080]	[.134]	[30]	Closed	5-10%	2
	495E1		102	[.80]	.10	1957	New	[.012]	[.026]	[15]	Closed	5-10%	2
	495E1		102	[.80]	.10	1963	Lt/Rec	[.012]	[.026]	[15]	Closed	5-10%	2
	495E1		109A	[.90]	.60	1957	New	[.061]	[.125]	[23]	Closed	5-10%	2

[ ] indicate DEFAULT values used by program

109A - Slope = 35

Road DW =

Watershed: DOLL2 MIT
Alternative: ADJ ROAD WIDTHS

Project: PROJECTED
Data Validity Date: 10/15/90

-- MITIGATION INFORMATION --

Mit. Num.	Mitigation Coefficents (by Year) 1	2	3	4	5	6	7	8	9	10+	Remarks
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	System Default Values
2	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	High Mitigation - Forest Plan

DATA OUTPUT FILE

USDA FOREST SERVICE
ROAD, FIRE AND TIMBER HARVEST SEDIMENT MODEL

91/04/05

VERSION for BOISE/PAYETTE NATIONAL FORESTS
Revision: 03.01.02

WATERSHED: DCLL2 MIT   PROJECT: PROJECTED   ALTERNATIVE: ADJ ROAD WIDTHS   DATA VALIDITY DATE: 10/15/90

NATURAL SEDIMENT YIELD AND DEPOSITION THRESHOLD

Landtype	Acres	Square Miles	Nat Sed Yield (Tons/sq mi/yr)	Total Landtype Natural sediment (tons/yr)	Slope	Sediment Delivery Ratios Surface (SEDR)	Mass (MEDR)	GcF
102	30.0	.05	3	.14	5	.012	.076	.80
109A	5985.0	9.35	40	374.06	35	.061	.125	.90
109B	439.0	.69	35	24.01	40	.050	.110	.90
120B	1306.0	2.04	35	71.42	55	.081	.127	1.10
120B1	2501.0	3.91	50	195.39	45	.080	.134	1.20
120C	423.0	.66	80	52.86	55	.113	.127	1.10
120D	309.0	.48	95	45.87	70	.239	.371	1.10
122	281.0	.44	135	59.27	75	.358	.576	1.10
5091	68.0	.11	90	9.56	60	.293	.156	1.00
5201	46.0	.07	30	2.16	50	.212	.103	1.00
Totals	11388.0	17.79		834.76				

~47 tons/mi²/year

TOTALS FOR WATERSHED

Total watershed area = 17.79 square miles
Channel Sediment Routing Coefficient = .596

Total natural sediment yield = 835 tons/year
Total natural sediment yield to critical reach = 497.2 tons/year

Average natural sediment yield = 46.91 tons/square mi/year
Natural sediment yield to the critical reach = 27.9 tons/sq mi/yr

DEPOSITION THRESHOLD CALCULATIONS:

Percent increase over natural before sediment deposition begins = 134 percent
Sediment increase at critical reach = 665.9 tons/yr
~~Total sediment threshold for watershed at the critical reach =~~ 1163.1 tons/yr

How is "Channel Sediment Routing Coefficient" derived?

Decade 1

ROAD NUMBER	--CONSTRUCTION-- YEAR	TYPE/USE	LANDTYPE	ROAD AREA	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
493	1956	Existing/Cl	S091	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
493	1963	Recon-Lt/Cl	S091	.3	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
493	1956	Existing/Cl	S201	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
493	1963	Recon-Lt/Cl	S201	.3	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
493G	1956	Existing/Cl	1208	3.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
493G	1965	Recon-Lt/Cl	1208	3.7	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
493G1	1956	Existing/Cl	1208	2.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
493G1	1963	Recon-Lt/Cl	1209	2.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
495	1956	Existing/Lt	12081	.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
495	1956	Existing/Lt	S091	1.4	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
495	1956	Existing/Lt	S201	.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
495A	1963	Existing/Cl	1094	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495A	1956	Existing/Cl	12081	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495A	1963	Recon-Lt/Cl	12081	1.0	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
495A1	1963	Existing/Cl	12081	1.1	.8	.8	.5	.5	.5	.4	.4	.4	.4	.4
495A2	1956	Existing/Cl	12081	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495A2	1963	Recon-Lt/Cl	12081	.6	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495AX	1963	Existing/Cl	12081	1.1	.8	.8	.5	.5	.5	.4	.4	.4	.4	.4
495B	1957	Existing/Cl	1208	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B	1963	Recon-Lt/Cl	1208	.8	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3
495B	1957	Existing/Cl	12081	2.4	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
495B1	1957	Existing/Cl	1208	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B1	1963	Recon-Lt/Cl	1208	.4	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495B1	1957	Existing/Cl	12081	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B1	1963	Recon-Lt/Cl	12081	.2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
495B2	1957	Existing/Cl	1208	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B2	1963	Recon-Lt/Cl	1208	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B2	1957	Existing/Cl	12081	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B2	1963	Recon-Lt/Cl	12081	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B3	1957	Existing/Cl	12081	1.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B3	1963	Recon-Lt/Cl	12081	1.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
495B4	1957	Existing/Cl	1208	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B4	1963	Recon-Lt/Cl	1208	.2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
495B4	1963	Existing/Cl	12081	.5	.4	.4	.2	.2	.2	.2	.2	.2	.2	.2
495B5	1963	Existing/Cl	1094	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B5	1963	Existing/Cl	12081	1.2	.9	.9	.6	.6	.6	.5	.5	.5	.5	.5
495B6	1963	Existing/Cl	12081	.5	.4	.4	.2	.2	.2	.2	.2	.2	.2	.2
495B62	1963	Existing/Cl	12081	.4	.3	.3	.2	.2	.2	.2	.2	.2	.2	.2
495C	1957	Existing/Cl	1094	2.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495C	1963	Recon-Lt/Cl	1094	2.0	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495CX	1963	Existing/Cl	1094	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495CY	1957	Existing/Cl	12081	1.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495CY	1963	Recon-Lt/Cl	12081	1.9	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7
495E	1957	Existing/Cl	102	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1963	Recon-Lt/Cl	102	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1957	Existing/Cl	1094	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1963	Recon-Lt/Cl	1094	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1957	Existing/Cl	1208	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1963	Recon-Lt/Cl	1208	.2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
495E	1957	Existing/Cl	12081	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1963	Recon-Lt/Cl	12081	.6	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495E1	1957	Existing/Cl	102	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E1	1963	Recon-Lt/Cl	102	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E1	1957	Existing/Cl	1094	.6	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
TOTAL FOR ALL ROADS				28.50	23.9	23.9	22.7	22.7	22.7	22.1	22.1	22.1	22.1	22.1

WATERSHED: DOLLZ MIT PROJECT: PROJECTED ALTERNATIVE: ADJ ROAD WIDTHS DATA VALIDITY DATE: 10/15/90

TONS DELIVERED EACH YEAR FROM ROADING

Decade 2

ROAD NUMBER	--CONSTRUCTION-- YEAR	TYPE/USE	LANDTYPE	ROAD AREA	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
493	1956	Existing/Cl	S091	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
493	1963	Recon-Lt/Cl	S091	.3	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
493	1956	Existing/Cl	S201	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
493	1963	Recon-Lt/Cl	S201	.3	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
493G	1956	Existing/Cl	1208	3.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
493G	1963	Recon-Lt/Cl	1208	3.7	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
493G1	1956	Existing/Cl	1208	2.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
493G1	1963	Recon-Lt/Cl	1208	2.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
495	1956	Existing/Lt	12081	.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
495	1956	Existing/Lt	S091	1.4	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
495	1956	Existing/Lt	S201	.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
495A	1963	Existing/Cl	109A	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495A	1956	Existing/Cl	12091	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495A	1963	Recon-Lt/Cl	12081	1.0	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
495A1	1963	Existing/Cl	12061	1.1	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
495A2	1956	Existing/Cl	12081	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495A2	1963	Recon-Lt/Cl	12C81	.6	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495AX	1963	Existing/Cl	12061	1.1	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
495B	1957	Existing/Cl	1208	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B	1963	Recon-Lt/Cl	1208	.8	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3
495B	1957	Existing/Cl	12C81	2.4	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
495B1	1957	Existing/Cl	1208	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B1	1963	Recon-Lt/Cl	1208	.4	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495B1	1957	Existing/Cl	12081	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B1	1963	Recon-Lt/Cl	12081	.2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
495B2	1957	Existing/Cl	1208	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B2	1963	Recon-Lt/Cl	1208	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B2	1957	Existing/Cl	12081	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B2	1963	Recon-Lt/Cl	12081	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B3	1957	Existing/Cl	12081	1.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B3	1963	Recon-Lt/Cl	12081	1.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
495B4	1957	Existing/Cl	1208	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B4	1963	Recon-Lt/Cl	1208	.2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
495B4	1963	Existing/Cl	12081	.5	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495B5	1963	Existing/Cl	109A	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B5	1963	Existing/Cl	12081	1.2	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
495B6	1963	Existing/Cl	12081	.5	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495BB2	1963	Existing/Cl	12081	.4	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495C	1957	Existing/Cl	109A	2.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495C	1963	Recon-Lt/Cl	109A	2.0	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495CX	1963	Existing/Cl	109A	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495CY	1957	Existing/Cl	12081	1.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495CY	1963	Recon-Lt/Cl	12081	1.9	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7
495E	1957	Existing/Cl	102	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1963	Recon-Lt/Cl	102	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1957	Existing/Cl	109A	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1963	Recon-Lt/Cl	109A	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1957	Existing/Cl	1208	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1963	Recon-Lt/Cl	1208	.2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
495E	1957	Existing/Cl	12081	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1963	Recon-Lt/Cl	12081	.6	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495E1	1957	Existing/Cl	102	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E1	1963	Recon-Lt/Cl	102	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E1	1957	Existing/Cl	109A	.6	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
TOTAL FOR ALL ROADS				23.50	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1

WATERSHED: DELLE MIT PROJECT: PROJECTED ALTERNATIVE: ADJ ROAD WIDTHS DATA VALIDITY DATE: 10/15/9[illegible]

TONS DELIVERED EACH YEAR FROM ROADING

Decade 3

ROAD NUMBER	--CONSTRUCTION-- YEAR	TYPE/USE	LANDTYPE	ROAD AREA	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
493	1956	Existing/C1	5091	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
493	1963	Recon-Lt/C1	5091	.3	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
493	1956	Existing/C1	5201	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
493	1963	Recon-Lt/C1	5201	.3	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
493G	1956	Existing/C1	1208	3.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
493G	1965	Recon-Lt/C1	1208	3.7	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
493G1	1956	Existing/C1	1208	2.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
493G1	1963	Recon-Lt/C1	1208	2.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
495	1956	Existing/Lt	12081	.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
495	1956	Existing/Lt	5091	1.4	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
495	1956	Existing/Lt	5201	.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
495A	1963	Existing/C1	109A	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495A	1956	Existing/C1	12081	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495A	1963	Recon-Lt/C1	12081	1.0	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
495A1	1963	Existing/C1	12081	1.1	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
495A2	1956	Existing/C1	12081	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495A2	1963	Recon-Lt/C1	12081	.6	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495AX	1963	Existing/C1	12081	1.1	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4
495B	1957	Existing/C1	1208	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B	1963	Recon-Lt/C1	1208	.8	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3
495B	1957	Existing/C1	12081	2.4	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9
495B1	1957	Existing/C1	1208	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B1	1963	Recon-Lt/C1	1208	.4	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495B1	1957	Existing/C1	12081	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B1	1963	Recon-Lt/C1	12081	.2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
495B2	1957	Existing/C1	1208	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B2	1963	Recon-Lt/C1	1208	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B2	1957	Existing/C1	12081	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B2	1963	Recon-Lt/C1	12081	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B3	1957	Existing/C1	12081	1.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B3	1963	Recon-Lt/C1	12081	1.6	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
495B4	1957	Existing/C1	1208	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B4	1963	Recon-Lt/C1	1208	.2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
495B4	1963	Existing/C1	12081	.5	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495B5	1963	Existing/C1	109A	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495B5	1963	Existing/C1	12081	1.2	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
495B6	1963	Existing/C1	12081	.5	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495BB2	1963	Existing/C1	12081	.4	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495C	1957	Existing/C1	109A	2.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495C	1963	Recon-Lt/C1	109A	2.0	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495CX	1963	Existing/C1	109A	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495CY	1957	Existing/C1	12081	1.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495CY	1963	Recon-Lt/C1	12081	1.9	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7
495E	1957	Existing/C1	102	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1963	Recon-Lt/C1	102	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1957	Existing/C1	109A	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1963	Recon-Lt/C1	109A	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1957	Existing/C1	1208	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1963	Recon-Lt/C1	1208	.2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
495E	1957	Existing/C1	12081	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E	1963	Recon-Lt/C1	12081	.6	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
495E1	1957	Existing/C1	102	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E1	1963	Recon-Lt/C1	102	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
495E1	1957	Existing/C1	109A	.6	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
TOTAL FOR ALL ROADS				28.50	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1

ROAD DATA TABLE

Road ID Number	CONSTRUCTION Year	CONSTRUCTION Type	CONSTRUCTION Use	Total Years Projected	LANDTYPE	SEF	DELIVERY RATIOS Surface	DELIVERY RATIOS Mass	ROAD Grad	ROAD Miles	DISTURBED Width	DISTURBED Area	Mitigation Coefficients Used
493	1956	Existing	Closed	7	S091	1.00	.293	.156	2	.30	39.9	1.5	2
493	1963	Recon-Lt	Closed	To Term	S091	1.00	.293	.156	2	.30	39.9	1.5	2
493	1956	Existing	Closed	7	S201	1.00	.212	.103	2	.30	33.6	1.2	2
493	1963	Recon-Lt	Closed	To Term	S201	1.00	.212	.103	2	.30	33.6	1.2	2
493G	1956	Existing	Closed	0	1208	1.10	.081	.127	2	3.70	36.9	16.5	2
493G	1963	Recon-Lt	Closed	To Term	1206	1.10	.081	.127	2	3.70	36.9	16.5	2
493G1	1956	Existing	Closed	7	1206	1.10	.081	.127	2	2.40	36.9	10.7	2
493G1	1963	Recon-Lt	Closed	To Term	1208	1.10	.081	.127	2	2.40	36.9	10.7	2
495	1956	Existing	Light	To Term	12081	1.20	.080	.134	2	.60	29.7	2.2	2
495	1956	Existing	Light	To Term	S091	1.00	.293	.156	2	1.40	39.9	6.8	2
495	1956	Existing	Light	To Term	S201	1.00	.212	.103	2	.70	33.6	2.9	2
495A	1963	Existing	Closed	To Term	109A	.90	.061	.125	2	.40	23.0	1.1	2
495A	1956	Existing	Closed	7	12081	1.20	.080	.134	2	1.00	29.7	3.6	2
495A	1963	Recon-Lt	Closed	To Term	12081	1.20	.080	.134	2	1.00	29.7	3.6	2
495A1	1963	Existing	Closed	To Term	12081	1.20	.080	.134	2	1.10	29.7	4.0	2
495A2	1956	Existing	Closed	7	12081	1.20	.080	.134	2	.60	29.7	2.2	2
495A2	1963	Recon-Lt	Closed	To Term	12081	1.20	.080	.134	2	.60	29.7	2.2	2
495AX	1963	Existing	Closed	To Term	12081	1.20	.080	.134	2	1.10	29.7	4.0	2
495B	1957	Existing	Closed	6	1208	1.10	.081	.127	2	.80	36.9	3.6	2
495B	1963	Recon-Lt	Closed	To Term	1206	1.10	.081	.127	2	.80	36.9	3.6	2
495B	1957	Existing	Closed	To Term	12081	1.20	.080	.134	2	2.40	29.7	8.6	2
495B1	1957	Existing	Closed	6	1206	1.10	.081	.127	2	.40	36.9	1.8	2
495B1	1963	Recon-Lt	Closed	To Term	1208	1.10	.081	.127	2	.40	36.9	1.8	2
495B1	1957	Existing	Closed	6	12081	1.20	.080	.134	2	.20	29.7	.7	2
495B1	1963	Recon-Lt	Closed	To Term	12081	1.20	.080	.134	2	.20	29.7	.7	2
495B2	1957	Existing	Closed	6	1208	1.10	.081	.127	2	.10	36.9	.4	2
495B2	1963	Recon-Lt	Closed	To Term	1208	1.10	.081	.127	2	.10	36.9	.4	2
495B2	1957	Existing	Closed	6	12081	1.20	.080	.134	2	.10	29.7	.4	2
495B2	1963	Recon-Lt	Closed	To Term	12081	1.20	.080	.134	2	.10	29.7	.4	2
495B3	1957	Existing	Closed	6	12081	1.20	.080	.134	2	1.60	29.7	5.6	2
495B3	1963	Recon-Lt	Closed	To Term	12081	1.20	.080	.134	2	1.60	29.7	5.3	2
495B4	1957	Existing	Closed	6	1208	1.10	.081	.127	2	.20	36.9	.9	2
495B4	1963	Recon-Lt	Closed	To Term	1206	1.10	.081	.127	2	.20	36.9	.9	2
495B4	1963	Existing	Closed	To Term	12081	1.20	.080	.134	2	.50	29.7	1.8	2
495B5	1963	Existing	Closed	To Term	109A	.90	.061	.125	2	.20	23.0	.6	2
495B5	1963	Existing	Closed	To Term	12081	1.20	.080	.134	2	1.20	29.7	4.3	2
495B6	1963	Existing	Closed	To Term	12081	1.20	.080	.134	2	.50	29.7	1.8	2
495BB2	1963	Existing	Closed	To Term	12081	1.20	.080	.134	2	.40	29.7	1.4	2
495C	1957	Existing	Closed	6	109A	.90	.061	.125	2	2.00	23.0	5.6	2
495C	1963	Recon-Lt	Closed	To Term	109A	.90	.061	.125	2	2.00	23.0	5.6	2
495CX	1963	Existing	Closed	To Term	109A	.90	.061	.125	2	.40	23.0	1.1	2
495CY	1957	Existing	Closed	6	12081	1.20	.080	.134	2	1.90	29.7	6.8	2
495CY	1963	Recon-Lt	Closed	To Term	12081	1.20	.080	.134	2	1.90	29.7	6.8	2
495E	1957	Existing	Closed	6	102	.80	.012	.026	2	.20	14.8	.4	2
495E	1963	Recon-Lt	Closed	To Term	102	.80	.012	.026	2	.20	14.8	.4	2
495E	1957	Existing	Closed	6	109A	.90	.061	.125	2	.30	23.0	.8	2
495E	1963	Recon-Lt	Closed	To Term	109A	.90	.061	.125	2	.30	23.0	.8	2
495E	1957	Existing	Closed	6	1208	1.10	.081	.127	2	.20	36.9	.9	2
495E	1963	Recon-Lt	Closed	To Term	1206	1.10	.081	.127	2	.20	36.9	.9	2
495E	1957	Existing	Closed	6	12081	1.20	.080	.134	2	.60	29.7	2.2	2
495E	1963	Recon-Lt	Closed	To Term	12081	1.20	.080	.134	2	.60	29.7	2.2	2
495E1	1957	Existing	Closed	6	102	.80	.012	.026	2	.10	14.8	.2	2
495E1	1963	Recon-Lt	Closed	To Term	102	.80	.012	.026	2	.10	14.8	.2	2
495E1	1957	Existing	Closed	To Term	109A	.90	.061	.125	2	.60	23.0	1.7	2
										28.5		106.2	

(Miles x 5280) = ft
x width (ft)
= road area in ft²
÷ 43,560
= Area (in acres)

150,980

Avg width = 31 ft
for this example

(N-17)

49561	1957	Existing	Closed	To Term	1094	.90	.061	.125	6	[illegible]	[illegible]	1.7	2
										28.50		106.2	

MITIGATION INFORMATION

Mit. Num. Num.	Mitigation Coefficents (by Year) 1	2	3	4	5	6	7	8	9	10+	Remarks
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	System Default Values
2	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	High Mitigation - Forest Plan

PON= Induced / Natural

SEDIMENT SUMMARY FOR TIMBER HARVEST AND ROADING

SDC -

91/04/05

Watershed: DCLLZ MIT

Project: PROJECTED   Alternative: ADJ ROAD WIDTHS

Natural Sediment at Critical Reach= 497.2 tons/yr   Threshold sediment to critical reach= 1163.1 tons/yr

Year	DELIVERED SEDIMENT				Total Sed @ Crt Rch		% over Natural		TONS		% Stream Energy Threshold Consumed
	Logging	Fires	Roading	Total	Induced	Ind+Nat	Annual	3 yr Mean	Deposit	Accumulated	
1956	.00	.00	293.0	292.98	174.5	671.7	35.1	11.7	.0	.0	57.8
1957	.00	.00	268.6	268.55	159.9	657.1	32.2	22.4	.0	.0	56.5
1958	14.92	.00	125.0	139.87	83.3	580.5	16.8	28.0	.0	.0	49.9
1959	7.90	.00	80.5	88.40	52.0	549.8	10.6	19.8	.0	.0	47.3
1960	6.14	.00	65.9	72.08	42.9	540.1	8.6	12.0	.0	.0	46.4
1961	3.95	.00	60.8	64.80	38.0	535.8	7.8	9.0	.0	.0	46.1
1962	1.75	.00	54.4	56.13	33.4	530.6	6.7	7.7	.0	.0	45.6
1963	.88	.00	156.8	157.63	93.9	591.1	18.9	11.1	.0	.0	50.8
1964	.00	.00	90.0	89.96	53.6	550.8	10.8	12.1	.0	.0	47.4
1965	10.33	.00	78.3	88.59	52.8	549.9	10.6	13.4	.0	.0	47.3
1966	5.47	.00	52.6	58.08	34.6	531.8	7.0	9.4	.0	.0	45.7
1967	4.25	.00	49.8	54.03	32.2	529.4	6.5	6.0	.0	.0	45.5
1968	2.73	.00	40.3	43.01	25.6	522.8	5.2	6.2	.0	.0	44.9
1969	1.22	.00	37.1	38.36	22.8	520.0	4.6	5.4	.0	.0	44.7
1970	.61	.00	36.3	36.89	22.0	519.2	4.4	4.7	.0	.0	44.6
1971	.00	.00	31.9	31.89	19.0	516.2	3.8	4.3	.0	.0	44.4
1972	.00	.00	28.5	28.46	16.9	514.1	3.4	3.9	.0	.0	44.2
1973	.00	.00	28.5	28.46	16.9	514.1	3.4	3.5	.0	.0	44.2
1974	.00	.00	26.0	25.95	15.5	512.6	3.1	3.3	.0	.0	44.1
1975	.00	.00	23.9	23.93	14.3	511.4	2.9	3.1	.0	.0	44.0
1976	.00	.00	23.9	23.93 *CRC*	14.3	511.4	2.9	2.9	.0	.0	44.0
1977	.00	.00	23.9	23.93	14.3	511.4	2.9	2.9	.0	.0	44.0
1978	.00	.00	22.7	22.66	13.5	510.7	2.7	2.8	.0	.0	43.9
1979	.00	.00	22.7	22.66	13.5	510.7	2.7	2.8	.0	.0	43.9
1980	.00	.00	22.7	22.66	13.5	510.7	2.7	2.7	.0	.0	43.9
1981	.00	.00	22.1	22.12	13.2	510.4	2.6	2.7	.0	.0	43.9
1982	.00	.00	22.1	22.12	13.2	510.4	2.6	2.7	.0	.0	43.9
1983	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
1984	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
1985	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
1986	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
1987	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
1988	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
1989	.00	106.58	22.1	128.70	76.7	573.8	15.4	6.9	.0	.0	49.3
1990	.00	23.25	22.1	45.37	27.0	524.2	5.4	7.8	.0	.0	45.1
1991	.00	4.84	22.1	26.97	16.1	513.2	3.2	6.0	.0	.0	44.1
1992	.00	.97	22.1	23.09	13.8	510.9	2.8	3.8	.0	.0	43.9
1993	.00	.00	22.1	22.12	13.2	510.4	2.6	2.9	.0	.0	43.9
1994	.00	.00	22.1	22.12	13.2	510.4	2.6	2.7	.0	.0	43.9
1995	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
1996	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
1997	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
1998	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
1999	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
2000	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
2001	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
2002	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
2003	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
2004	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9
2005	.00	.00	22.1	22.12	13.2	510.4	2.6	2.6	.0	.0	43.9

0.60