THE COMPLETE WRENSS HYDROLOGIC MODEL

Robert H. Swanson[1]

ABSTRACT

In 1980, the USEPA published a set of graphical procedures to estimate the hydrologic effects of various forest silvicultural practices on water yield and quality. The results from the hydrologic procedures (which I abbreviate as Wrns to distinguish the hydrologic procedure from the entire WRENSS handbook) were the basis for most of the subsequent analyses. Most of the parameters needed to operate Wrns were available from sets of regionalized curves for all forested regions in the United States. Although Wrns incorporated state of the art routines for spatial distribution of snow and required only precipitation as a climatic variable, these graphical procedures received limited use because of the time-consuming nature of them.

Forestry Canada produced an MSDOS version, WRNSHYD, for the hydrologic procedures, with the regionalized curves extended into Canada based on climate and forest similarities, WRNSHYD has received wide use in both Canada and the United States. The main drawbacks in using WRNSHYD are that both precipitation and silvicultural data must be entered via the screen; the results are not available for analysis in a user-friendly format; it is limited to batch calculations; and it cannot be used to generate time series of changes in water yield with regrowth and/or subsequent harvests.

A new program developed jointly with the US Forest Service, WinWrnsHyd, that overcomes most of these drawbacks is now available. It incorporates the latest research on snow accumulation from the USDA Rocky Mountain Research Station. It is programmed in Microsoft Access and uses database tables as input so that harvesting scenarios can be created with a GIS or other forest planning tool. Silvicultural input data can consist of a series of "snapshots" of forested land units at various times and the subsequent impact on water yield simulated as a batch calculation. If regrowth functions or equations are available then these can be incorporated in WinWrnsHyd to simulate a time series of the effects of regeneration, growth and even subsequent harvests on water yield. All results are available in database or spreadsheet formats for convenient analysis and presentation. Constant precipitation data, or an included routine to generate random time series of precipitation, remains the primary climatic driving variable. WinWrnsHyd can also estimate probable peak flow changes resulting from forest harvest. The magnitude of these changes can be flagged by user-selectable criteria for further field investigations to determine if the estimated changes would be detrimental to in-stream or downstream water users.

EPA GRAPHICAL PROCEDURE

The United States Environmental Protection Agency (1980) published a set of graphical procedures, An approach to Water Resources Evaluation of Non-Point Silvicultural Sources (WRENSS), to estimate the hydrologic effects of various forest silvicultural practices on water yield and quality. Chapter III, "Hydrology" contained procedures to estimate the change in water yield associated with various forest harvesting practices. These hydrologic results formed the basic input data for most of the subsequent analyses within WRENSS. All of the parameters needed to operate WRENSS were available from sets of regionalized curves for all forested regions in the United States.

WRENSS provides an estimate of seasonal evapotranspiration under various forest conditions. In the snow dominated procedure precipitation is modified by the configuration of the forest and in turn modifies the amount of evapotranspiration. In the rain dominated procedure precipitation is irrelevant as the change in evapotranspiration that takes place when a forest is harvested is the amount of water yield change that can be expected. Although the WRENSS hydrologic procedures incorporated state of the art routines for spatial distribution of snow and required only precipitation as a climatic variable, they received limited use because of the time-consuming nature of the graphical method.

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[1] Forest Hydrology Consultant, #28, 216 Three Sisters Drive, Canmore, AB T1W 2M2 rhswan@telusplanet.net

FORESTRY CANADA'S WRNSHYD

Forestry Canada produced an MSDOS version, WRNSHYD[2], to computerize the hydrologic procedures of WRENSS, with the regionalized curves extended into Canada based on climate and forest similarities, WRNSHYD has received wide use in both Canada and the United States. The main drawbacks in using WRNSHYD were that both precipitation and silvicultural data had to be entered manually via the screen; the results were not available for analysis in a user-friendly format; it was limited to calculations on data contained in a non-standard database structure; and it could not be used, except with cumbersome manual entry of regrowth data, to generate time series of changes in water yield with regrowth and/or subsequent harvests.

USFS WINWRNSHYD

A new program developed for the U.S. Forest Service, WinWrnsHyd, overcomes most of the drawbacks of WRNSHYD and adds an appreciable amount of new capability. All of the input data required for WinWrnsHyd resides in tables in standard database formats, e.g., Microsoft Access[3], Excel or xBase. These data tables can be created with a GIS or other forest-planning tool. Access tables are preferred because they are fully functional within WinWrnsHyd, which is programmed in Microsoft Visual Basic For Application (VBA).

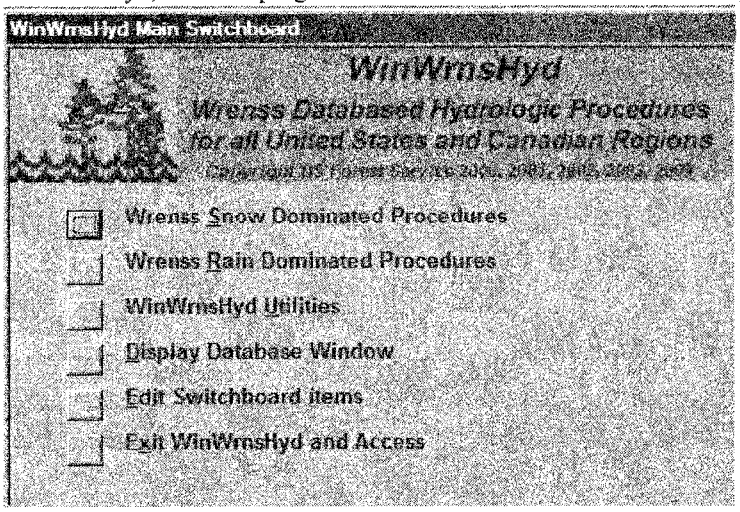

Figure 1. Main WinWrnsHyd switchboard. This information on this form can be customized to suit the users preferences.

Both rain dominated (Rdp) and snow dominated (Sdp) procedures are available in WinWrnsHyd, Figure 1. The snow dominated procedure allows optional incorporation of the latest research on snow accumulation from the USDA Rocky Mountain Research Station (Troendle, 1987, Troendle et al., 2003).

Several screen shots of WinWrnsHyd forms are included here to illustrate the type of data required and results that one can expect to produce. The snow dominated procedure will be used for illustrative purposes. The rain dominated procedure uses similar data and produces results

Two types of simulation are available; snap shots, or time series. Snap shots (Figure 2) represent the silvicultural state of forested land units at discrete times. The results of the simulation of several of these snap shots can be displayed against time or a number of other variables. Time series (Figure 3) start from some initial condition, usually an uncut forest stand, and simulate the effects of harvest and subsequent regeneration, growth of basal area, tree height (Sdp) or leaf area index and rooting depth (Rdp) on water yield change. Precipitation, which may be constant or variable with time, is the primary climatic driving variable for both snap shot and time series simulations, although winter wind speed is used to drive snow loss, transport and redeposition in the snow dominated procedures.

The results of both snap shot and time series simulations are available in database or spreadsheet formats for subsequent analysis and presentation, as shown in Figures 4 and 5. The time series results can be used to estimate probable peak flow changes resulting from forest harvest, Figure 6. The magnitude of these changes can be flagged in yellow or red by user-selectable

[2] WRNSHYD is available free from the author by email download only.

[3] Microsoft Access and Excel are trademarks of Microsoft Corporation. The xBase format refers to data in sets based on the dBase configuration, (dBase is a trademark of dBASE Inc. 2548 Vestal Parkway E Vestal, NY 13850.) Macintosh is a trademark of Apple.

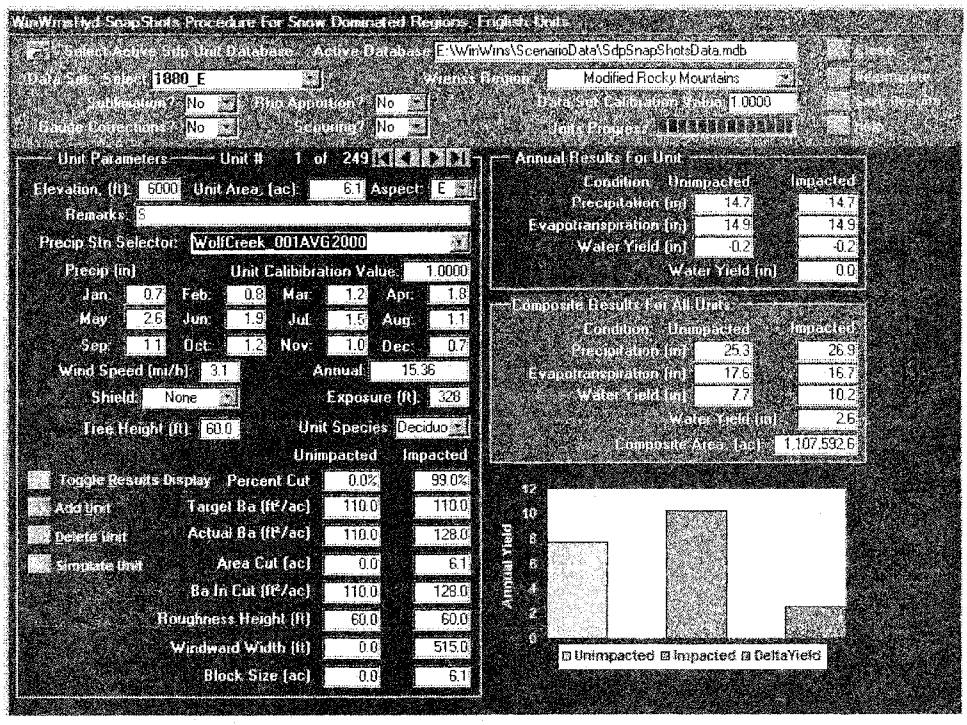

Figure 2. Snap shot form. Data and results from the North Platte River in Colorado for 1880 used as an example.

criteria for further field investigations to determine if the estimated changes would be detrimental to in-stream or downstream water users.

It is anticipated that the WinWrnsHyd program will be available for distribution by the U.S. Forest Service by the end of 2004. WinWrnsHyd requires a fully functional copy of Microsoft Access 2000 or later version in order to operate. Microsoft Access is not available for Apple Macintosh computers.

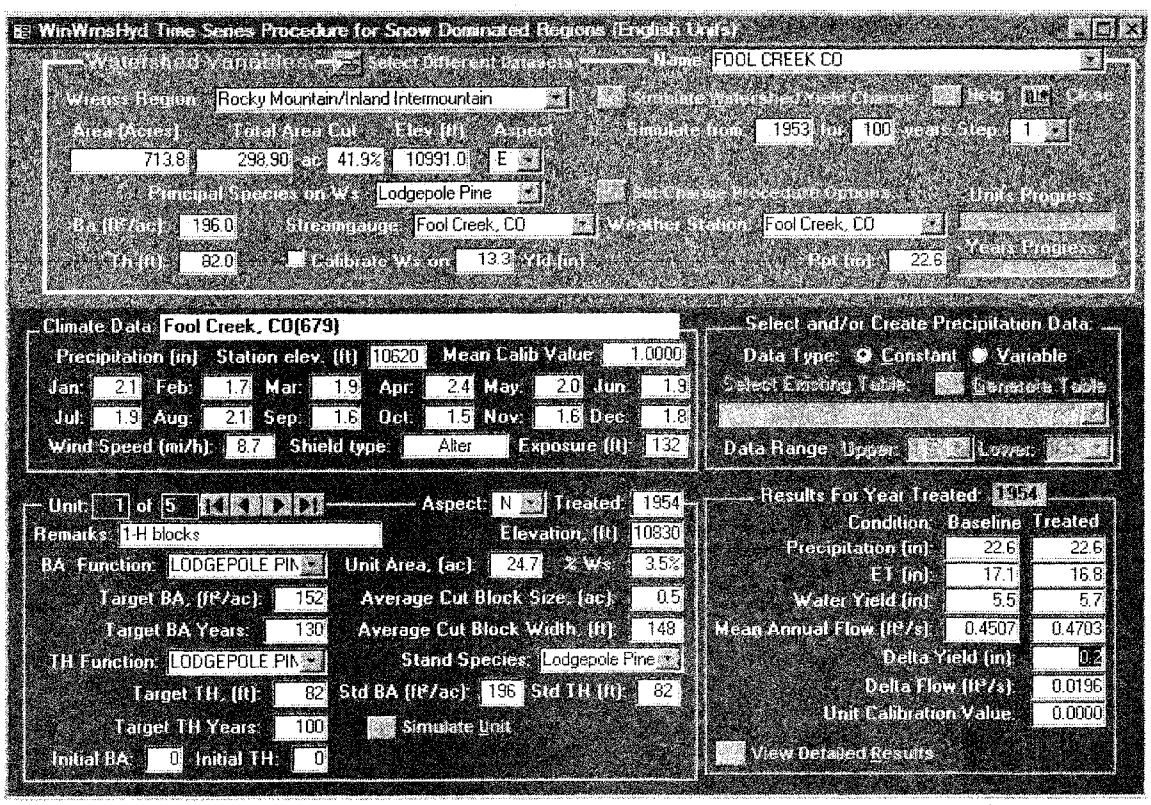

Figure 3. Data from Fool Creek, CO used as a time series example.

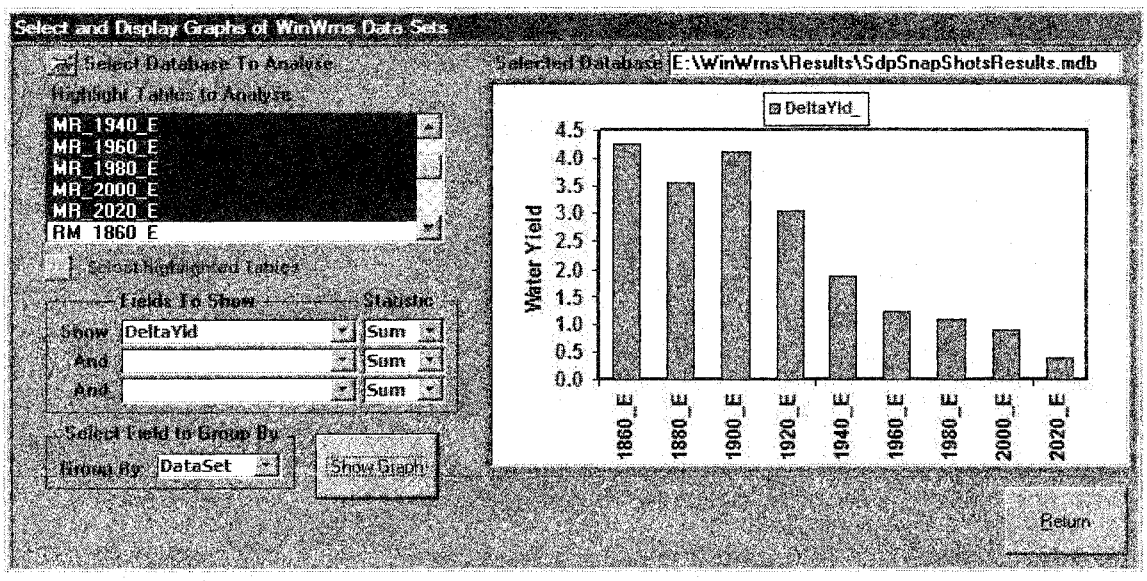

Figure 4. Pseudo time series obtained by plotting the discrete time snap shots, North Platte River in Colorado used as an example.

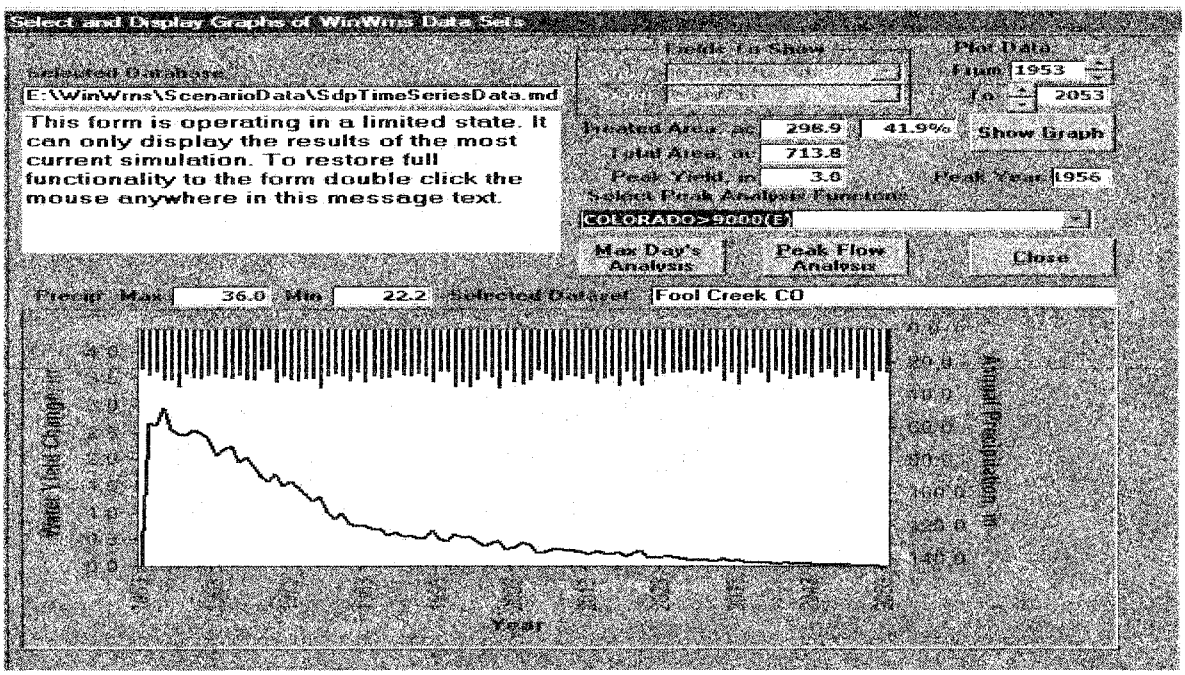

Figure 5. True time series, Fool Creek, CO data used as an example. Variable precipitation from random generator included in WinWrnsHyd.

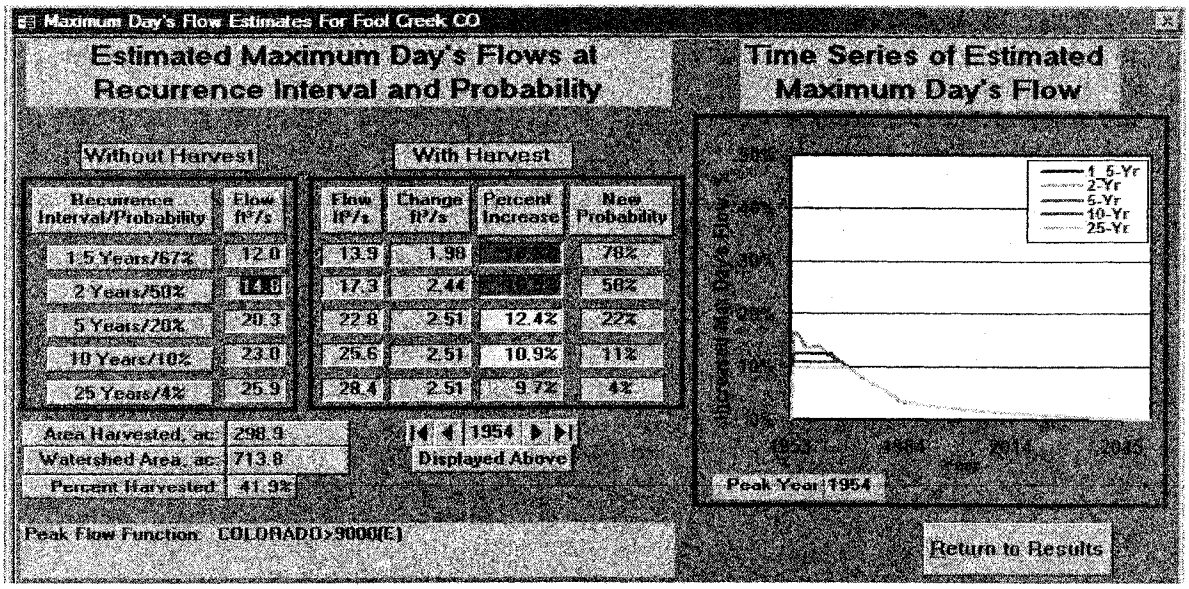

Figure 6. Peak flow estimates, Fool Creek, CO example. The levels where yellow warning or red critical colors are displayed are user defined.

LITERATURE CITED

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Troendle, C.A., J.M. Nankervis, and L.S. Porth. 2003. The impact of Forest Service Activities on the Stream Flow regime in the North Platte River. Final Report to the Rocky Mountain Region, U.S. Forest Service. Lakewood, CO. 50 p. plus Appendices.

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