

Instructions for Running the FVS-WRENS Water Yield Post-processor

Overview

The FVS-WRENS post processor uses the stand attributes and vegetative data from the Forest Vegetation Simulator (Dixon, 2002) projections, and State Climate Normals precipitation data (or custom user-input data) to calculate stand water yield using the methodology described in Chapter III of the Water Resources Evaluation of Non-point Silvicultural Sources (WRENS) Handbook (Troendle and Leaf, 1980). The purpose of the FVS-WRENS post-processor is to predict water yield changes caused by silvicultural actions or stand disturbance. The water balance predictions should be used to compare alternative scenarios, they are not considered accurate as stand-alone predictions.

Automated WRENS computations were first programmed by Bernier (1986) for the snow-dominated areas of Southern Canada. Huff and others (1999) expanded Bernier's Fortran program to both rain- and snow-dominated procedures in the Central Sierra region of the US, and applied the program to a GIS analysis of water yield changes. The FVS-WRENS post processor was developed from the program written by Huff and others (1999) and expanded to cover the rain- and snow-dominated regions of the United States, and to incorporate the current snow redistribution theory in Hydrologic Province 4 referred to as the Modified Rocky Mountain method.

In Province 4, the snow redistribution hydrology and ET calculations may be optionally modeled using the Modified Rocky Mountain procedure (Troendle and others, 2010). In this method, stand basal area is not converted to cover density using the WRENS Handbook curves. ET modifier coefficients are a function of the relative basal area of either conifer or deciduous cover types. There are 4 linear relationships that describe ET Modifier Coefficients (values 0 to 1) and stand basal area. There are three curves for conifers, for the 3 aspects N, S and E&W, and a single curve for aspen which is used for all deciduous stands. When using the WRENS Handbook snow redistribution method, the Handbook Cover Density ET methods are used. There are 10 unique Cover Density versus basal area curves in the WRENS Handbook (figures III.41 – III.45). These curves are used to describe the maximum cover density as a function of the stand basal area. ET modifier coefficients (figures III-46 – III.56) are based on season and stand aspect and are used to adjust the maximum cover density to actual stand conditions for ET calculations.

Table 1. The relationship between the WRENS Handbook Forest Types and the FIA Cover Type Codes used in FVS.

FOREST TYPE	FIA CODE	HYDROLOGIC PROVINCE
1) CONIFEROUS	<= 400	1
2) DECIDUOUS	> 400	1,4,5,6,7

3) SPRUCE-FIR	260,270, 120-129	4, 6
4) LODGEPOLE(Default)	281	4
5) PONDEROSA	220,221	4
6) HEM-SPRUCE	270,301,304,305	5
7) DOUG.FIR	201,202,222,223, 224,241,341	5
8) LODGEPOLE	281	7
9) WEST.LARCH	321-329	6
10) LODGEPOLE	281	6

Input Data Preparation

When used as an FVS post-processor, the FVS-WRENSS Input file (WRENSSIN.DAT) is generated by a program (readFVSfiles.exe) that parses the FVS main output file (the .out file). This file is copied to a file with the .dat extension and has the same name as the FVS .out file. The .dat file may be manually edited to adjust the input data for simulation. The other input file required to run FVS-WRENSS is the State Climate Normals (STATENAME.TXT) file. The FVS main output file should be located in the project directory. The default project directory is c:\FVSdata, but any directory may be used.

FVS Simulations

Prepare the FVS input data with the management actions desired. The compute statement, below, MUST be included in the .key file for each stand. These compute statements may be added through Suppose by selecting - Select Outputs > Event Monitor (EM) Compute Variables > Compute WRENSS Variables. The maximum basal area calculated by FVS is used to calculate the relative cover density used in the estimation of the ET modifier coefficients. FVS-WRENSS may be run through Suppose, as described above, or one may manually browse to an FVS output file using the WRENSS GUI. Create a desktop shortcut to c:\FVSbin\FVS-WRENSS.exe to access WRENSS outside of FVS.

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COMPUTE      0
BAMAXWY=BSDIMAX*.5454154*.85
BAMAXEND=ASDIMAX*.5454154*.85
END

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Meteorological File

Obtain a State Normals Climate file or use one of the files from the National Climate Data Center provided in the FVS setup package. Select a meteorological station that best represents the precipitation statistics of the site. The WRENSS program uses the station number to find the elevation and monthly precipitation data in the State Normals file. The station elevation is read in the first group of data and the monthly precipitation statistics are read in the third group of data. New station numbers may be added with site specific data as long as the number is unique, and the format is consistent with the State Climate Normals data file format.

Precipitation Time Series: FVS simulations may have a time horizon long enough where climate change could be expected to impact precipitation trends. To represent the effects of climate change, the input precipitation pattern may be varied for each cycle of the FVS simulation by adding custom precipitation records to the State Normals data file. Each custom precipitation record represents data for a single cycle. Station numbers must be greater than 1000 and appear consecutively (e.g. 1001, 1002, 1003, ...). Add these records to the end of the PRECIPITATION NORMALS section of the State Normals file. Add a record having the first station number of the series to the end of the first section, the STATE INVENTORY section. See the COLORADO.TXT State Normals file for an example of how to use time series precipitation in FVS-WRENSS simulations.

Running FVS-WRENSS

Run the FVS-WRENSS Post-Processor Through Suppose

To run the FVS-WRENSS post-processor through Suppose, press the Select Post Processors button, and then select WRENSS Water Yield from the list of available post-processors. Press the Select Outputs button and select Event Monitor (EM) Compute Variables from the list of outputs, then select Compute WRENSS variables. If the FVS Output File Processed window appears at the end of the FVS simulation, press OK and the FVS-WRENSS GUI will start.

Select Meteorological Station from State Climate Normals Data

Use the Browse button to select the State Climate Normals meteorological file (e.g. ARIZONA.TXT). Select the record with the meteorological station to be used for input precipitation and station elevation data and click OK. The station number box is automatically populated.

FVS-WRENSS Parameters

The seven text boxes contain input parameters for the water yield simulations, and default values are shown.

- *Meteorological Station Number.* Browse to the State Normals data file and select a meteorological station or enter the meteorological station number in the text box.
- *WRENSS Hydrologic Province.* Press Map to display the hydrologic provinces used in the FVS-WRENSS model. FVS-WRENSS uses different hydrologic evaluation methods in rain-dominated regions compared with snow-dominated regions. Some hydrologic provinces use both procedures (e.g. provinces 5, 6 and 7) with snow dominating in high elevations (greater than 610 meters), and rainfall dominating in lower elevations (less than 610 meters) (Huff and others 1999). In province 7 the snow-dominated region above 610 meters is separated into high and low snow regions at an elevation of 1220 meters. Select the appropriate Province for the study site using the drop down list.

- *Rainfall Lapse Rate* (in/1000 ft elevation change). If the study site is at a significantly different elevation than the meteorological station, a rainfall lapse rate may be used to adjust the measured precipitation statistics to better represent the precipitation at the study site. Enter zero if no rainfall lapse rate is to be used in the analysis. An example lapse rate for the Canadian Rocky Mountain foothills is 0.342 in/1000 ft. (Smith 2009).
- *Average Daily Snowfall Rate* (mm/day). The daily snowfall rate is used in Province 4 snow hydrology simulation. It is used to estimate the number of snowfall days in the winter season by dividing the total winter season precipitation by the average daily precipitation (snowfall) rate. If the winter season length is shorter than the number of precipitation days, calculated in this manner, snowpack ablation will be insignificant. The default value is 2.0 mm/day.
- *Average Root Depth* (feet). The average tree root depth is used in rainfall dominated provinces 2 and 3, and low elevation areas (below 610 m) in provinces 5, 6, and 7. The default value is 4.0 feet.
- *Snow Method Province 4*. The snow redistribution method may be specified in Province 4. The WRENSS handbook considers snow redistribution to be insignificant in the other provinces except for the very western part of Province 1, and FVS-WRENSS does not simulate snow redistribution in Province 1. Use the drop down box to select either the Handbook snow redistribution method or the Modified Rocky Mountain Method.
- *Wind Speed* (km/hr). The U10 wind speed is used in Province 4 snow hydrology simulation. It is important in snow pack ablation, when the number of snowfall-free days is significant (i.e. when the average daily snowfall rate is relatively high compared to the total winter precipitation). The default value is 10.0 km/hour.
- *Number of Cut Blocks*. The number of cut blocks in the harvest is used with the percent of stand harvested to estimate the opening size for snow redistribution calculations in Province 4. The default is 0.
- *Percent of Stand Harvested* (percent). The percent of the stand harvested is used in Province 4 snow redistribution calculations. The default is 80 percent.

Run WRENSS Model

Press the Run button to run WRENSS. A window showing WRENSS Completed is displayed. Press OK. The output files are stored in the project directory. The Details, and Summary output files may be displayed by pressing buttons at the bottom of the form.

Output Files

The WRENSS output file names are prepended with the FVS main output file name (e.g. fvsoutname), and have the extension .wrn. The FVS-WRENSS output tables show annual or seasonal stand water balance calculations at FVS cycle boundaries. All units are in inches, except

for fields in acre-feet in the area-weighted calculations. To sum the volume over time, multiply these annual water balance results by the FVS cycle length in years.

The fvsoutname_details.wrn file provides the detailed, seasonal, stand water balance results. The Forest column represents the pre-treatment water balance components. The Cut column represents the after-treatment water balance components. The Change column shows the difference between the pre-and after-treatment conditions for the treatment cycle. The Effective Precipitation column (EFF. PRECIP.) represents the total precipitation minus interception (Forest) or snowpack scour and evaporation (Cut) losses. The table at the bottom of the file shows the area-weighted water balance values for the entire group of stands in the simulation. The values represent the after-treatment water balance components for the year shown.

The fvsoutname_summary.wrn file provides a summary of the stand annual water balance components, basal area, and WRENS cover type (see Table 1) for each cycle. The values are calculated using after-treatment stand conditions. The water yield Change column in the Details and Summary tables indicates the difference between the pre- and post-treatment states for the treatment cycle. The effects of treatment on water yield may persist in subsequent cycles as the stand recovers.

The fvsoutname_chartout.wrn file shows the stand sequential number, year, water yield flow and water yield change for all stands in the run.

The fvsoutname_output.wrn, and fvsoutname_input.wrn files show model debug output. They are overwritten each time the model is run.

For more information or questions contact Robert Havis, 970/295-5768, rhavis@fs.fed.us

References

Bernier, P. Y. 1986. A programmed procedure for evaluating the effect of forest management on water yield. Forestry Management Note No. 37. Northern Forestry Center, Canadian Forestry Service, Edmonton, Alberta, 12p.

Dixon, Gary, D. 2002. Essential FVS: A user guide to the Forest Vegetation Simulator. US Department of Agriculture, Forest Service, Forest Management Service Center, Fort Collins, Colorado.

Huff, D. D.; W. W. Hargrove; R. L. Graham. 1999. Adaptation of WRENS-Fortran-77 for a GIS application for water-yield changes. ORNL/TM-13747, ESD publication number 4860. Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 50p.

Smith, Craig D. 2009. Proceedings of the 77th Annual Western Snow Conference April 20-23 2009, Canmore, Alberta, Canada. (1) Climate Research Division, Environment, Canada, 11 Innovation Blvd. Saskatoon, SK, S7N 3H5.

Troendle, Charles, A. Lee H. MacDonald, Charles H. Luce, and I.J. Larsen. 2010. Fuel Management and Water Yield, in Cumulative Watershed Effects of Fuel Management in the Western United States, Rocky Mountain Research Station, RMRS-GTR-231, Chapter 7, pp.126-148

Troendle, C.A.; Leaf, Charles F. 1980. Hydrology. Chapter III. In: An approach to water resources evaluation of non-point silvicultural sources. U.S. Environmental Protection Agency. August 1980. EPA-600/8-80-012 Athens GA. III.1-III.173