



STREAM NOTES

To Aid In Securing Favorable Conditions of Water Flows

Rocky Mountain Research Station

April 2005

WinXSPRO, A Channel Cross Section Analyzer, Version 3.0

The Stream Systems Technology Center is pleased to announce the release of *WinXSPRO, A Channel Cross Section Analyzer, User's Manual, Version 3.0* as Rocky Mountain Research Station General Technical Report RMRS-GTR-147. Programming and document revision was supervised by **Dr. Thomas Hardy**, Utah State University, Institute for Natural Systems Engineering, and programming changes were made by **Mrs. Palavi Panja** and **Mr. Dean Mathias**.

WinXSPRO is a Windows™ based software package designed for analyzing channel cross section data in an interactive, user-friendly environment. WinXSPRO version 3.0 contains numerous enhancements and improvements from WinXSPRO version 2.0 based on user input and feedback. While the look and appearance of version 3 is largely unchanged from version 2, the new version is more stable, efficient, and user-friendly. Basic input and output files remain unchanged; however, cross section data files are now identified with a *.sec extension instead of a *.dat extension. Other refinements include an improved input data editor, more intuitive data entry screens and

displays, more error trapping routines, increased plotting capabilities, and better labeled output tables.

WinXSPRO was specifically developed for high-gradient streams (slopes > 0.01), but it can be used on streams of any gradient. WinXSPRO uses a resistance-equation approach at a single cross section to analyze the geometry, hydraulics, and sediment transport potential of that particular cross section. Channel boundary roughness or Manning's roughness coefficient (n) can be determined by three methods:

- 1) direct solution of Manning's equation for n ,
- 2) comparison of computed n values for other channels using tables or photographs (e.g., Chow 1959, Barnes 1967), and
- 3) empirical formulas relating n to other hydraulic parameters (Jarrett 1984, Thorne and Zevenbergen 1985, Nelson *et al.* 1991).

The program allows the user to subdivide the channel cross section so that overbank areas, mid-channel islands, and high-water overflow channels may be analyzed separately. Although WinXSPRO is primarily a

STREAM NOTES is produced quarterly by the Stream Systems Technology Center located at Rocky Mountain Research Station, Fort Collins, Colorado.

STREAM is a unit of the Watershed, Fish, Wildlife, Air, and Rare Plants Staff in Washington D.C.
John Potyondy, Program Manager

The **PRIMARY AIM** is to exchange technical ideas and transfer technology among scientists working with wildland stream systems.

CONTRIBUTIONS are voluntary and will be accepted at any time. They should be typewritten, single-spaced, and limited to two pages. Graphics and tables are encouraged.

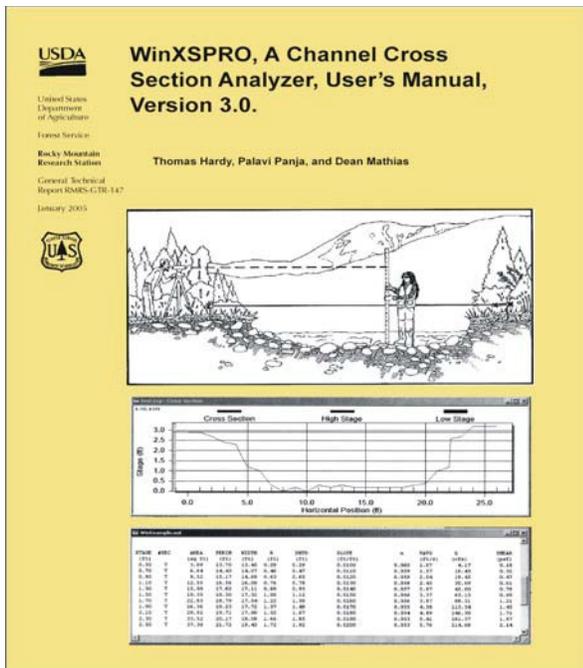
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CORRESPONDENCE:
E-Mail: rmrs_stream@fs.fed.us
Phone: (970) 295-5983
FAX: (970) 295-5988

Web Site:
<http://www.stream.fs.fed.us>

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channel hydraulics program, it can also be used to perform sediment transport calculations using a bed load equation appropriate for gravel-bed streams (Parker 1990) and a bed-material load transport function appropriate for sand-bed streams (Ackers and White 1973).

While it is possible to use the program without reading the user's manual, first time users are encouraged to carefully read the manual to make sure that they understand the theoretical foundations of channel hydraulic modeling and sediment transport computations. The manual contains four examples that can be used to easily learn the most common applications for the program. The manual also describes all of the program's unique features such as modeling the hydraulics of undercut banks and overlaying cross section plots to compute changes to cross sectional area measured over several time periods.

In an attempt to help users learn to use the program easily, the software is distributed with a set of sample files. These sample files, located in a SAMPLES directory, contain input files that are known to work for the major features of the program such as a file for a simple cross-section (EXAMPLE.SEC), a data file for an undercut bank (UNDERCUT.SEC), data files to compare cross sections (BEFORE.SEC & AFTER.SEC), and bedload computations

(EXAMPLE.SEC, EXAMPLE.DAT, and DISCHARGE.DIS). Users should be able to execute these sample files without error and then substitute their own data sets as they learn to use the program.

How to Obtain the Software and Manual

Copies of Rocky Mountain Research Station General Technical Report RMRS-GTR-147, *WinXSPRO, A Channel Cross Section Analyzer, User's Manual, Version 3.0* are available in hard-copy format and on the Web. The hard-copy manual contains a CD-ROM with a WinXSPRO installation disk. Hard copies of RMRS-GTR-147 are available by telephone: (970) 498-1392, facsimile: (970) 498-1396, or e-mail: rschneider@fs.fed.us. The WinXSPRO Version 3.0 software and user's guide can also be downloaded from the STREAM Web page: <http://www.stream.fs.fed.us/publications/software.html>. Users are encouraged to periodically check the web site for the latest updates.

WinXSPRO technical support is available from USDA Forest Service, Washington Office Watershed, Fish, Wildlife, Air, & Rare Plants Staff, Streams Systems Technology Center, Fort Collins, CO. To obtain technical support, send an e-mail to rmrs_stream@fs.fed.us requesting "WinXSPRO Support" in the subject line.

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Water Resources Monitoring (WARM): A Database Tool to Share and Query Watershed Resources Monitoring Information

by Sherry Hazelhurst and Ken Heffner

At an Intermountain Regional meeting of Forest Watershed Program managers, several Forest staff recognized they were duplicating monitoring across Forest boundaries and had no good way of knowing what each other was learning from their projects and monitoring activities. Some Forest specialists who were new to their Forests had no records of what the person before them prescribed for watershed restoration, whether past restoration efforts were successful, or what worked well for others facing similar problems. The inability to effectively utilize past monitoring results has led to repeated NEPA challenges, inefficient and sometimes ineffective BMP application, and poor feedback for the adaptive management process.

In response to this need, the Intermountain Regional Office staff collaborated with the Stream Team, Pacific Northwest Region and Station personnel, and the NRIS Water and Tools team to develop a tool to share monitoring information. The objective was to create an Intranet-based system that allows users to easily store and retrieve various types of watershed resources monitoring information relevant to resource specialists, districts, forests, or regions. The Watershed Resources Monitoring (WARM) database is the result of this effort.

The database was built as a module to the Wildlife, Fish, & Rare Plants (WFRP) Intranet reporting system. Utilizing the front end development and structure of the WFRP system leveraged funding to offer users customized features such as look-up tables, partnership documentation, a photo database, and querying capabilities. Perhaps the biggest advantage of building on the WFRP system is that the platform made the module available to all Forest System units rather than only those in the Intermountain Region.

The WARM database stores reports, often referred to as “gray literature,” produced by forest specialists that typically do not appear in standard publications such as journals, books, or conference proceedings. This Intranet-based tool allows users to locate actual monitoring information collected and documented within specific watersheds, across individual forests, or about specific management or conservation practices.

Reports can be retrieved through two forms of querying. A simple query option allows users to quickly find a specific individual report. A detailed query option uses a Google like search engine to find sets of reports that meet the searcher’s criteria. This detailed query tool allows the user to search based on location (district, forest, region, state), author, topic or keyword, hydrologic unit code, and primary/secondary lithology (figure 1). The query tool then returns a list of reports that can be copied and pasted into the text of an email and forwarded to others for viewing.

The WARM tool allows users to enter and edit monitoring reports and query the system for information collected within specific watersheds, across individual districts or forests, or about specific management or conservation practices. Users have the option of directly entering new reports or capturing a synopsis of existing reports. New reports can be generated on the spot by filling in the fields. This option is valuable for single event monitoring and short monitoring reports. Existing reports can be summarized by cutting and pasting in the mandatory and summary fields. The user also has the option to create a link back to the original full report through



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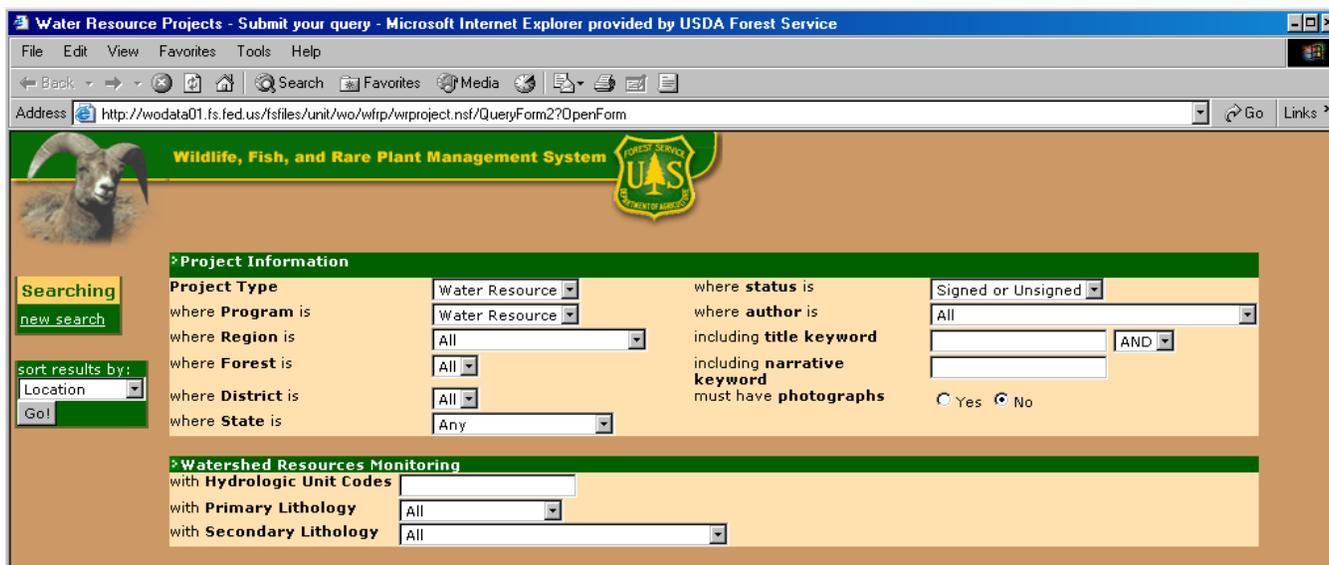


Figure 1. WARM detailed query screen.

the fsweb. This option is best for large or detailed reports and older ones that have good information, but may take too long to enter. The linking capability reduces data entry redundancy and allows authors to reference other relevant documents, photos, or websites. By linking photos directly into the system, it is captured as a corporate photo and is accessible by other users through a browser tool.

The modular design of the data entry features allows users to create new reports at any level of detail desired, from a single site evaluation to annual forest monitoring report. There is a small set of mandatory fields that establish a basic record, while all other fields are optional. The structured fields each include a description accessible by clicking on the term. Each report is formatted in a standard way to maintain a consistent look and feel.

Several benefits of using the WARM database as identified by Program Managers include improving documentation, corporate memory, and information sharing. First, by querying for information relevant to a local project, NEPA documentation is expected to improve as specialists use applicable monitoring to document rational thought processes and support best professional judgment. Second, as watershed specialists move in and out of different positions, information stored within the WARM database will serve as the corporate memory for monitoring results and will facilitate efficient adaptive management processes. Third, monitoring information will be easily

shared since any employee using a Forest Service computer will have access to all completed monitoring reports. Access to such information is expected to improve understanding of management activity effects and allow specialist to better integrate monitoring activities across forest boundaries.

Detailed instructions on how to access and use WARM are available on the Intermountain Region fsweb at (<http://fsweb.r4.fs.fed.us/unit/bpr/watershed/fsweb/databases/databases.htm>). Information at this site includes instructions for how to obtain an Internet password, a list of Regional Administrators who can grant user access, a PowerPoint slide show illustrating the features of the database, and the full documentation about the data fields and look-up tables. The vision for the WARM database is that it will serve as corporate memory for monitoring information. Successful application of the WARM tool should lead to reduced monitoring costs, improved project design, more defensible NEPA documentation, and shortened learning curves for soil and water resource specialists new to the agency or area.

Sherry Hazelhurst was the Assistant Hydrologist, R4 Intermountain Region. She is currently an Emergency Management Specialist, USFS International Programs, Disaster Assistance Support Program, (202) 273-4739, shazelhurst@fs.fed.us.

Ken Heffner is the Regional Water Quality and Watershed Improvement Program Manager, R4 Intermountain Region, (801) 625-5368, kheffner01@fs.fed.us.



An Approach for Modeling the Influence of River Flow Regime on Riparian Cottonwood Populations

David A. Lytle and David M. Merritt

Riparian cottonwood (*Populus deltoides*) forests represent the most extensive and ecologically important deciduous forest ecosystems in arid parts of the western United States. Cottonwood trees are key components of river bottomland ecosystems, influencing floodplain processes such as rates of alluviation and river meandering, aquatic and terrestrial nutrient cycling, light and water availability, as well as providing insect and animal food, shelter, and habitat. Cottonwood forest development is closely coupled with hydrologic and fluvial processes, which are responsible for creating new sites for cottonwood seedling establishment, providing hydrologic conditions necessary for seedling survival, and stream meandering and floodplain dynamics that accompany cottonwood stand development.

Many investigations have documented cottonwood forest decline along rivers in western North America (e.g., Rood and Mahoney 1990). This decline has coincided with the widespread water development of rivers of the western U.S. and Canada through the construction of dams, flow diversions, and groundwater pumping which have directly or indirectly caused changes in the hydrologic and fluvial processes necessary for riparian forest establishment and persistence.

We utilized existing information about the relationships between cottonwood establishment, cottonwood survival, and streamflow hydrology to model cottonwood population dynamics through time and develop an approach for modeling the age-class structure of cottonwood stands in response to modifications in flow. By relating essential birth and death rates of cottonwood to stream hydrology we are able to observe how more complex population dynamics arise from these fundamental quantities. The model was parameterized using data from a free-flowing river in the Colorado Plateau to estimate how riparian forest dynamics may change in response to human or climate-driven alterations to the flow regime. Sensitivity analysis enabled us to draw some conclusions regarding controlled management of flows. The model can be applied to other riparian plant

species if the relationships between hydrograph components (magnitude, duration, timing, rate of change, etc.) and plant survival at different life stages are understood.

Cottonwood Life Cycle

Cottonwood seeds are dispersed over a 2-3 week period in spring-early summer and seedlings become established upon moist, freshly-deposited sediment (Moss 1938, Fenner *et al.* 1984). Water is the primary resource limiting seedling survival. In arid regions of the western U.S. where summer precipitation and/or soil water are insufficient, the rate of groundwater decline must not exceed the root growth rate of cottonwood seedlings (~2 cm/day) (Segelquist *et al.* 1993, Mahoney and Rood 1998, Amlin and Rood 2002). Saplings, young adults, and mature cottonwood are increasingly resilient to drought and scour on subsequent years as they grow and mature. Later life stages benefit from flooding but remain vulnerable to xylem cavitation, canopy dieback, and mortality during prolonged or severe drought or human-influenced water depletion.

Model Structure

We developed a structured population model to:

- 1) consolidate information concerning cottonwood population dynamics in a conceptual and analytical framework,
- 2) determine whether basic cottonwood vital rates and river hydrology can predict complex forest stand dynamics, and
- 3) aid in planning prescribed floods by projecting how altered flow regimes may affect populations.

The model describes how annual variation in the hydrograph affects cottonwood mortality (via floods and droughts) and recruitment (via scouring of new habitat, groundwater decline, and seedling



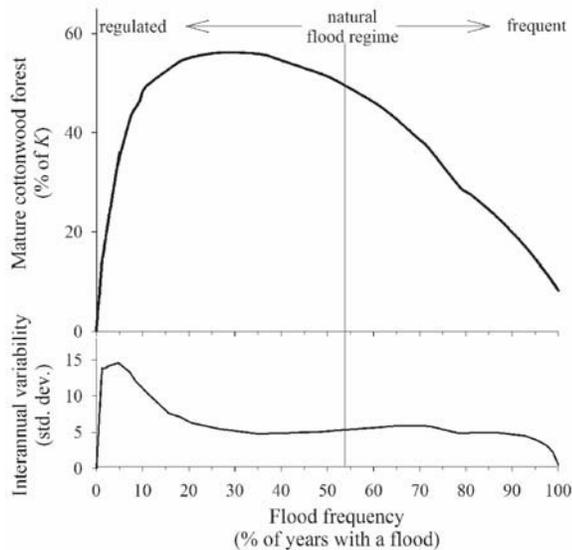


Figure 1. Effect of altered flood regime on mature cottonwood populations. Flood frequency varies from frequent (a scouring flood every year) to highly regulated (no floods). Top panel: mature cottonwood forest is most abundant when floods are slightly less frequent than the natural flood regime. Bottom panel: interannual variability in coverage is lowest at intermediate and high flood frequencies, while low flood frequencies result in variable populations that sometimes disappear locally from reaches.

establishment). Since cottonwood stands of different ages experience different growth and mortality rates, we used a matrix model with separate stages for seedlings, 2-year old saplings, 3-year old saplings, 4-year old saplings, non-reproductive juveniles between 5- and 10-years old, and reproductive adults.

The model was calibrated using cottonwood life history data from the literature and data specific to one focal study site, the Yampa River at Deerlodge Park in Dinosaur National Monument, Colorado. Flood and drought mortality rates were derived from the literature (e.g., Amlin and Rood 2002). The probability of cottonwood transitioning from one stage to the next was determined by the combination of hydrologic factors on any given year and age-specific responses to those factors. Although these vital rates are relatively consistent for cottonwood, threshold values for what constitutes a mortality-causing flood or drought as well as a suitable timed peak and drawdown relative to seed release must be varied in the model to reflect a particular geographic area.

Results and Discussion

Using only vital birth and death rates and actual hydrologic regimes, modeled reach-scale abundance of cottonwood was similar to actual measured abundance. Under flow scenarios with natural patterns of floods and droughts, population dynamics were characterized by extreme variation in seedling abundance and establishment, but fluctuations were more regular in the older stage classes. Abundances of seedlings and younger trees followed a boom-bust cycle driven by high flood mortalities while mature tree abundance followed a less erratic 5- to 15-year periodicity driven by multi-year sequences of flows favorable to stand recruitment. The abundance and mortality patterns are similar to the dynamics observed in natural cottonwood stands (Scott *et al.* 1997, Stromberg 1998). The model supports field observations that sequences of years exhibiting specific hydrologic characteristics such as floods and droughts are more important than single year events (Scott *et al.* 1997, Auble and Scott 1998). These emergent model properties suggest that many of the complexities of cottonwood population dynamics can be captured by a simple population model based on plant life history and flood hydrology.

By simulating flow alterations on the free-flowing Yampa ranging from many floods and droughts (natural flow regime) to few floods and droughts (damming), the model suggested that mature cottonwood forest should be most abundant near the observed natural flow regime (figure 1). Model analysis also suggested that flow regimes with frequently occurring floods resulted in smaller population sizes, but were more stable because of less interannual variability in abundance. In contrast, flow regimes lacking floods for long periods resulted in highly variable population sizes prone to local extinction because of high interannual variability in abundance. Chance occurrences of multiple drought years eliminated up to 50% of the available cottonwood habitat, providing opportunities for open areas to be colonized by other species (willow, tamarisk, etc.).

An unexpected outcome predicted by the model is that highly regulated flow regimes with few floods result in variable populations prone to local extinction, whereas regimes with frequent floods result in small, but stable populations (figure 1). This results from the fundamental



tradeoff between floods as being mortality-causing or recruitment-enabling events. When floods are common, recruitment occurs almost every year, however, population sizes are suppressed by high flood mortality, resulting in small, but stable populations. When floods are rare, adult stands senesce over the course of decades; recruitment occurs only after a scouring flood. This results in high year-to-year population variability and occasional extinction when return intervals between floods are long. This result underscores the importance of floods and flood-generated processes for the maintenance of viable cottonwood habitat (Scott *et al.* 1996).

The model is instructive in that it reveals that management strategies aimed at increasing the extent of mature forest should focus on increasing survivorship of seedlings and adults, rather than intermediate age classes. Adult population size is about twice as sensitive to changes in flood mortality vs. drought mortality, emphasizing the importance of threshold flood recurrence intervals of 10-15 years for cottonwood population dynamics. Increased mortality from other non-hydrologic factors such as fires, soil salinity issues, disease outbreaks, or beaver should also be evaluated as they may influence the successful transition from a young to mature forest. For example, mixed cottonwood-tamarisk stands destroyed by fire or disease might be succeeded by pure stands of tamarisk as this exotic species readily resprouts after fire.

This model is intended to provide a framework for understanding cottonwood populations that can be tailored to specific cottonwood forests or conservation objectives. Our hope is that such a modeling approach will stimulate more research into the relationships between vital rates and hydrologic regimes for other riparian species. Such models may provide a useful simulation tool to guide efficient management of river flow regimes to meet specific objectives for the structure of riparian vegetation.

For additional information and references, please refer to the following publication: Lytle, DA and Merritt, DM. 2004. Hydrologic regimes and riparian forests: a structured population model for cottonwood. *Ecology*, **85**, 2493-2503. Copies are available online from the STREAM website: <http://www.stream.fs.fed.us/publications/index.html>.

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David A. Lytle is an Aquatic Ecologist, Oregon State University, Dept. of Zoology, Corvallis, Oregon 97331, (541) 737-1068, david.lytle@science.oregonstate.edu.

David M. Merritt is a Riparian Ecologist, USDA Forest Service, Stream Systems Technology Center, Fort Collins, Colorado 80526, (970) 295-5987, dmmerritt@fs.fed.us.



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STREAM SYSTEMS TECHNOLOGY CENTER
USDA Forest Service
Rocky Mountain Research Station
2150 Centre Ave., Bldg A, Suite 368
Fort Collins, CO 80526-1891

April 2005

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