USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Defining Perennial, Intermittent and Ephemeral Channels in Eastern Kentucky; Application to Forestry Best Management Practices

Focus Categories: NPP, WQN, G&G

Keywords: Best Management Practices, Geomorphology, Stream Classification

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Federal Funds Requested: $6,000

Non-Federal Funds Pledged: $12,621

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Congressional Districts: 4th and 5th

Statement of Critical Regional Water Problem

Addressing nonpoint source pollution during silvicultural and timber harvesting operations requires that all parties be able to properly determine the types of streams and channels that are being impacted. The type of Best Management Practice (BMP) applied is dependent on whether a channel is classified as ephemeral, intermittent or perennial. For Forestry BMPs, the presence and width of a streamside management zone (SMZ), the level of disturbance allowed within the SMZ, and the distance to major soil disturbances (e.g. roads) are dependent on the stream classification. Incorrect evaluation of stream channel class leads to either enhanced nonpoint source pollution in the form of sediment and nutrients when actual flow duration is longer than that assessed, or to costly, unneeded BMP implementation when flow duration is shorter than that assessed. US Geological Survey (USGS) Quadrangle topographic maps are generally used to define the periodicity of flow. Solid blue lines are considered perennial, dotted lines are considered intermittent and channels not defined on the map are considered ephemeral. Although the USGS monitors thousands of perennial streams, they seldom monitor

intermittent or ephemeral streams. The map delineation between perennial-intermittent and intermittent-ephemeral is based on conceptual landscape relationships with very little supportive data, and the accuracy is certainly questionable, especially at the site level. Because of the potential pollutant and economic impact, we propose the development of a field based approach relating stream morphology to flow duration.

Statement of Results and Benefits

Stream physical properties such as channel depth, width, slope, and bottom materials will be measured at 15 sites across eastern Kentucky, ranging from known perennial to known ephemeral. Watershed parameters such as drainage area, hillslope percent, dominant vegetation, soil types present, and occurrences of disturbed area will also be measured. Other appropriate sites that are currently monitored by the USGS and the Department of Forestry (Robinson Forest) will be used in the analysis. Comparisons will be made between flow duration and the physical parameters measured onsite and in the watershed. Ordination and regression analysis will be used to classify streams and develop relationships between physical variables and flow regime. No studies that we are aware have determined these relationships in Kentucky, Appalachia, or the Eastern U.S. The results will be used to provide natural resource agency, operators, industry and extension personnel with information to determine channel class on a regional and local basis. Furthermore, the results will be used to develop field guides designed for operators and landowners, ultimately leading to more sound and cost-effective implementation of BMPs.

Nature, Scope and Objectives of Research

The most common question asked by loggers, landowners and foresters at Kentucky Forestry Best Management Practice (BMP) training courses is "How does one determine whether a stream is perennial vs. intermittent vs. ephemeral?" Currently, Kentucky Forestry BMPs define stream classes as follows (Stringer et al., 1998).

Perennial -- streams that hold water throughout the year

Intermittent -- stream that holds water during wet portions of the year

Ephemeral -- channel that holds water only during and immediately after rain events

The definitions above poorly define a continuum of flow regimes that occur in nature. Are streams that flow an average of 11 months a year intermittent or perennial? Conversely, are streams that flow 1 month a year intermittent or ephemeral? Incorrect evaluation of stream channel type leads to either enhanced nonpoint source pollution when actual flow duration is longer than that assessed, or to costly, unneeded SMZ implementation when flow duration is shorter than that assessed.

Hedman and Osterkamp (1982) defined perennial streams as those having measurable discharge 80% of the time, intermittent 10-80% of the time, and ephemeral <10% of the

time while Hewlett (1982) defined perennial streams as having water present >90% of the time. As shown by the literature, there are even discrepancies in the stream class definitions.

The only method currently available to ascertain stream class is to use USGS Quadrangle topographic maps where solid blue lines are considered perennial, dotted lines are considered intermittent and channels not defined on the map are considered ephemeral. The reliability of these maps is questionable, especially at the site scale. The USGS focuses their monitoring efforts on perennial streams so that they can produce flood and water supply information, seldom do they monitor intermittent or ephemeral streams. The map delineation between perennial-intermittent and intermittent-ephemeral streams is based on regional models and a landscape-level understanding of hydrologic systems, generally with very little supportive data. For regional or statewide applications this scale is adequate but for site-specific assessment the reliability is certainly questionable.

We propose a site-specific morphological approach to streamflow periodicity classification.

The specific objectives of this research are:

1. To quantify relationships between streamflow duration in eastern Kentucky and stream and watershed physical/morphological properties.

2. To develop easily measurable parameters that forest operators can use to define stream types in eastern Kentucky, where over one-half of the state's timber reserves lie and over 80% of the land is forested.

3. To help clarify the application of BMP guidelines addressing timber harvesting near streams, assuring that SMZs are properly implemented.

Methods, Procedures and Facilities

We will select sites spanning the continuum from known ephemeral to known perennial in eastern Kentucky. The goal is to select at least three streams in each of the following subclasses: ephemeral, ephemeral-intermittent, intermittent, intermittent-perennial, and perennial. The Department of Forestry currently monitors three perennial and one intermittent-perennial stream for flow at Robinson Forest (Kentucky River Watershed). In another study, the principal investigator is currently instrumenting semi-continuous stage height recording wells in two ephemeral streams in southeastern Kentucky (Cumberland River Watershed). We will utilize the data from these six sites and augment the data with nine additional sites through this study. In this study we will select two additional intermittent-perennial streams, three intermittent streams, three ephemeral-intermittent streams, and one additional ephemeral stream. We will review USGS quad

maps and select upward of 100 ungauged sites and stratify into the above four categories and sites will be randomly selected from each group. Sites will be visited and morphological parameters will be measured. If for any reason a site is deemed unacceptable, a new site in the appropriate category will be randomly selected. Our selection of new sites will be constrained to the Daniel Boone National Forest. Jon Walker, Hydrologist at the Daniel Boone National Forest, has agreed to cooperate with study, providing support in site selection and possibly data collection. We will also possibly integrate sites that are currently monitored by the USGS. The USGS currently monitors approximately 38 stations in eastern Kentucky. Rock Creek has the smallest drainage area, approximately 1100 ha, others are much larger ranging from 15,000 ha (John's Creek) to 16 million ha (Ohio River @ Greenup Dam). Rock Creek will certainly be considered, as well as other smaller watersheds currently monitored by the USGS.

Semi-continuous stage height recording wells will be installed at the nine randomly selected ungauged sites. Wells will be placed upright in the deepest part of the channel and secured with rebar. Wells will be programmed to take stage readings four-times daily (i.e. every six hours) allowing us approximately four months between site visitations. Physical properties measured or collected at each site will include bankfull width, bankfull depth profiles, cross-sectional area, bottom material, flood-prone area, stream slope, and sinuosity (Rosgen, 1996). Watershed parameters collected will include drainage area, hillslope percent, dominant vegetation, soil types present, surface geology and occurrences of disturbed area.

Parameters will be analyzed through ordination analysis (detrended correspondence analysis) to determine how systems group or cluster depending on their periodicity of flow and physical properties. Stepwise multiple regression models will be developed to determine which physical parameters have the greatest capability in predicting flow periodicity. The Department of Forestry has all the necessary facilities to carry out the proposed research.

Because of annual climate variability, we understand that one year of data will not adequately characterize periodicity of flow. We will maintain the sites after the funding period until we feel that we have adequately assessed flow duration. We suspect that it may take 5-10 years until we arrive at statistically sound predictions that encompass the range in annual climate. Alternatively we will investigate flow relationships with nearby USGS stations and Robinson Forest stations to predict past flows in the ungauged streams. If valid relationships are developed, we can predict past flows in the ungauged streams and use those past flows to develop the statistical relationships described above.

Related Research

Others have successfully related stream geometry to flow characteristics (Mackey et al., 1998; Wharton, 1992; Osterkamp and Hedman, 1982; Mosely, 1979). Relationships developed are commonly applied for flood discharge prediction. Generally these equations take the form of power relationships with stream width or with a combination of width and depth or with a combination of width and bottom material composition

(Wharton, 1995; Osterkamp and Hedman, 1979). Few have investigated these relationships for intermittent and/or ephemeral streams and, as stated by Wharton (1995), no relevant research has been conducted in the eastern US. Previous studies on intermittent and ephemeral streams conducted in the western US have related discharge directly to stream width (Omang et al., 1983; Osterkamp and Hedman, 1979). The previous approaches have shown to be reasonably accurate in estimating perennial flows within ± 30-40%, however ephemeral flow errors are as high as 104% (Osterkamp and Hedman, 1979). Although ephemeral and intermittent flows appear to be more difficult to predict, it is likely that the lack of relevant data hinders these relationships.
In this study the primary objective is to characterize the presence and duration of flow not the magnitude. No studies in which we are aware have attempted to relate stream and watershed physical properties to streamflow periodicity. We expect the presence and duration of flow will be significantly related to these physical properties and will yield better relationships than those done previously for flow.

Literature Cited

Hedman, E.R., and W.R. Osterkamp. 1982. Streamflow Characteristics Related to Channel Geometry of Streams in Western United States. USGS Water-Supply Paper 2193. 17 p.

Hewlett,J.D. 1982. Principles of Forest Hydrology. University of Georgia Press. 183p.

Mackey, P.C., P.M. Barlow, and K.G. Ries. 1998. Relationships Between Discharge and Wetted Perimeter and Other Hydraulic-Geometry Characteristics at Selected Streamflow Gaging Stations in Massachusetts. USGS Water-Resources Investigations Report 98-4094.

Mosely, M.P. 1979. Prediction of hydrologic variables from channel morphology, South Island Rivers. Journal of Hydrology (NZ), 18(2): 109-120.

Omang, R.J., C. Parrett, and J.A. Hull. 1983. Mean Annual Runoff and Peakflow Estimates Based on Channel Geometry of Streams in Southeastern Montana. USGS Water Resources Investigations, 82-4092.

Osterkarnp, W.R., and E.R. Hedman. 1982. Perennial Streamflow Characteristics Related to Channel Geometry in the Missouri River Basin. USGS Professional Paper 1242.

Osterkamp, W.R., and E.R. Hedman. 1979. Discharge estimates in surface-mine areas using channel-geometry techniques. In: Proceedings of the Symposium on Surface Mining Hydrology, Sedimentology and Reclamation, U. of Kentucky, Lexington, KY. pp. 43-49.

Rosgen, D.L. 1996. Applied river morphology. Wildland Hydrology, Colorado.

Stringer, J., L. Lowe, M. Smidt, and C. Perkins 1998. Field guide to best management practices for timber harvesting in Kentucky. Univ. of KY., Coop. Ext. Serv., Dept. of For. FOR-69.

Wharton, G. 1995. The channel geometry method: guidelines and applications. Earth Surface Processes and Landforms, 20: 649-660.

Wharton, G. 1992. Flood estimation from channel size: guidelines for using the channel geometry method. Applied Geography, 12: 339-359.