United States Environmental Protection Agency | Office of Research and Development

National Exposure Research Laboratory
Research Abstract

Government Performance Results Act (GPRA) Goal #4.5.2
Annual Performance Measure # 251

Significant Research Findings:

Comparisons of Hydrologic Responses at Different Watershed Scales

Scientific Problem and Policy Issues

Land surface hydrology controls runoff production and transport of sediments and nutrients from upland and hillslope areas to streams and other water bodies. In general, landscape characteristics such as soil, geology, land use and land cover, and topography of a watershed influence hydrologic responses. Knowing the relationships between landscape characteristics and hydrologic responses would enable decision makers to select watershed management practices that target specific landscape characteristics. The basis of the underlying scientific problem that this study attempts to answer is what controls the hydrologic response of a watershed and why watersheds respond differently to climatic inputs. Other equally important hydrologic response related questions include what constitutes a hydrologic response of a watershed and how best can it be represented.

Research Approach

The objectives of this study are: (1) to identify the dominant landscape descriptors that control the hydrologic responses of the Mid-Atlantic watersheds; (2) to develop relationships between landscape-climate descriptors and hydrologic response descriptors; and (3) to compare the hydrologic responses of the Mid-Atlantic watersheds. To achieve these objectives, a number of approaches were used.

- Selection of representative watersheds from the Mid-Atlantic Region
- Collection of landscape (e.g., soil, geology, land use and land cover, and topography), climate, and hydrologic response descriptor data from watersheds located in the Appalachian Plateau, Ridge and Valley, Blue Ridge, and Piedmont Physiographic Provinces.
- Development of landscape-climate and hydrologic response relationships using multiple regression analysis.
- Comparisons of hydrologic responses of the Mid-Atlantic watersheds at different spatial and temporal scales using a water balance approach and a flow duration curve statistical approach.

Results and Impact

The findings of this research can be summarized as follow:

- The hydrologic responses of the Mid-Atlantic watersheds were strongly influenced by elevation and latitudinal position of a watershed within the region. As a result, mountainous watersheds in the Appalachian Plateau and the ridge-dominated Ridge and Valley Provinces had higher seasonal variability in hydrologic responses than watersheds located in the Piedmont and the valley-dominated Ridge and Valley Provinces. Snowmelt runoff which is dependent on elevation and latitudinal position was the main source of seasonal variability in streamflow.

- The Appalachian Plateau and the Ridge and Valley watersheds had the lowest sustained low flows and thus the highest vulnerability to droughts. By contrast, the Piedmont watersheds had the highest sustained low flows and therefore had the lowest vulnerability to droughts.
- At the regional spatial scale and multi-year temporal scale, dryness index, a climate descriptor, was the best hydrologic response predictor for high flow conditions (Q1 to Q50). For low flow conditions (Q70 to Q95), however, baseflow index which is a surrogate geology descriptor was the best hydrologic response predictor.
- At the physiographic province spatial scale and annual time scale, mean monthly rainfall, dryness index, and baseflow index were the best hydrologic response predictors for the Ridge and Valley Physiographic Province. For the Appalachian Plateau watersheds, the mean monthly December precipitation was the best hydrologic response predictor whereas April, June, July, and August mean monthly precipitation and soil moisture storage capacity were the best hydrologic response predictors.
- Soil descriptors such as soil texture classes, bulk density, soil depth, and saturated hydraulic conductivity of the top two soil layers were the second best hydrologic response predictors across different flow conditions. Other important hydrologic response predictors included drainage density, relief ratio, channel slope, and median watershed slope.

Future Research

The method developed herein has a potential for identification of hydrologic model parameters, testing existing hydrologic models, and the development of new hydrologic models that have strong physical basis and less parameters than those currently available. Additional research that extends the landscape-climate and hydrologic response relationships presented herein to relationships between hydrologic responses and pollutant loads are needed.

Contacts for Additional Information

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