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Use of Multiple Linear Regression to Estimate Flow Regimes for All Rivers Across Illinois, Michigan, and Wisconsin

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Abstract.–We estimated flow regimes for all river reaches in Illinois, Michigan, and Wisconsin, as a step in developing consistent ecological river mapping and assessment frameworks across this diverse climatic and physiographic region. Our objectives were to: 1) build and evaluate, for each state, multiple linear regression models that predict attributes of stream flow regimes, using catchment summaries of climate and landscape attributes as independent variables; 2) compare the performance of the state models with alternative 'full region' and 'ecoregion' models; and 3) predict stream flow regimes for all ungaged stream reaches. Recent stream discharge regimes were characterized using data from a set of 206 U.S. Geological Survey stream gages scattered across the three states. As independent variables we used data summarizing climate and landscape attributes for catchments of selected gage sites and also for every stream reach within the three states. We successfully built multiple linear regression models for a range of exceedance discharges representing several seasons, using gage data stratified by either state, ecoregion, or entire three-state region Significant independent variables consistently included catchment area, precipitation, slope, surficial geology variables that index hydrologic conductivity, and amount of land in urban and agricultural uses. Models explained a very high degree of observed variation in exceedance discharges; however model predictions often showed fair deviation from observed values in the initial data and even larger deviation from observed values using independent data. Performance of single-state models was similar to that of ecoregional models and both sets performed better than the three-state model. We used the single-state models to populate all river reaches across the three states, providing a data system containing exceedance discharges and flow duration curves for any reach of interest, and that can also be used to display the regional hydrologic landscape (or riverscape) in terms of any selected exceedance discharge. Despite the relative ease of model development, the excellent statistical fit of

the models, and the appeal of generating comprehensive stream flow metrics for all ungaged reaches; the regression modeling approach has some important limitations that translate into substantial prediction error in some instances. Targeted flow sampling strategies and use of hybrid statistical—spatial accounting modeling approaches should reduce prediction error rates in future iterations. The statewide hydrologic attributes described herein are currently used in combination with other sets of ecological attributes as a powerful riverscape framework for a number of statewide river management applications in Illinois, Michigan, and Wisconsin.