A Hybrid Regional Approach to Model Discharge at Multiple Sub-Basins within the Calapooia Watershed, Oregon, USA

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Modeling is a useful tool for quantifying ecosystem services and understanding their temporal dynamics. Here we describe a hybrid regional modeling approach for sub-basins of the Calapooia watershed that incorporates both a precipitation-runoff model and an indexed regression model. The Calapooia River is a perennial tributary to the Willamette River in western Oregon with a mean discharge of 25 $m^3 s^{-1}$. The Calapooia has a watershed area of 963 km^2, with elevation ranging from 56 to 1,576 m. The upper portion of the Calapooia is situated on the western flanks of the Cascade Mountains and is primarily forestland with low permeability bedrock, while the lower Calapooia is primarily flat agricultural land with high permeability aquifers. Precipitation occurs mostly from October to May due to Oregon's Mediterranean climate. Analyses of long-term USGS gauge data indicate that discharge at the mouth of the Calapooia is dominated by lowland precipitation during the wet winter months, but flow is maintained by mountain sources during the dry summer months. Given this seasonal pattern, we hypothesized that discharge at sub-basins within the Calapooia could be modeled as a function of regional factors, using a combination of lowland and mountain runoff. We used a physically-based, rainfall-runoff model to estimate lowland runoff, using precipitation and temperature data from a local climate station as drivers. A Monte Carlo method was used to parameterize this model with data collected from one of the Calapooia sub-basins. We used a regression approach to estimate mountain runoff based on runoff from two index mountain streams occurring outside the Calapooia basin. These two model components were combined and weighted to estimate discharge in 20 Calapooia sub-basins, including mainstem locations and tributaries. Percent of lowland and mountain area in each sub-basin were used as weighting factors. A comparison of observed and estimated discharge for each sub-basin using point discharge measurements over a 2-3 year period found log transformed Nash-Sutcliffe efficiencies (NSE) ranging from 0.23 to 0.97 and averaging 0.73. NSE values were greater than 0.6 for all but two of the sub-basins. The ability of the combined lowland and mountain models to estimate discharge in the different sub-basins supports our hypothesis that sub-basin hydrology in the Calapooia is dominated by broad, regional factors (lowland vs. mountain terrain) rather than local (sub-basin) characteristics. Future work will combine this hybrid model with an approach for estimating intermittent and ephemeral flows to assess the ecosystem services of different stream types. The model will also be combined with nitrogen and fish models to further investigate ecosystem services in the Calapooia basin.