Calibrating Parameters in the Bronx River Watershed

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This report details the calibration of hydrological parameters in the Bronx River Watershed (25,000 acres, Figure 1) using the i-Tree Hydro model (Wang et al., 2008). Model calibration adjusts soil and hydrology parameters to best match simulated flow to observed flow on an hourly basis. This analysis is part of a larger report on the ecosystem services of New York City's tree canopy (Nowak et al. 2018).

Data and Model Calibration

The hourly weather data were derived from a local weather station at the LaGuardia Airport weather station (USAF-WBAN: 725030-14732). Tree and impervious cover parameters were derived for the watershed from photo-interpretation of Google Earth imagery (image date circa 2015) using 400 randomly located points (Table 1).

Table 1. Cover estimates for Bronx River Watershed, 2016

	Cover				
Area	**Impervious**	**Tree/shrub**[b]	**Grass/herbaceous**	**Bare Soil**	**Water**
acres			*percent*		
24,576	40.75[a]	45.8	20.0	0.5	1.25

[a] Total is greater than 100% because 8.3% of ground cover beneath tree canopies was modeled as impervious.
[b] Tree/shrub is hereafter referred to as tree cover.

Tree canopy leaf area index (LAI) was set to 5 based on various field studies (Asner et al, 2003; Nowak, 2016). The amount of impervious area directly connected to the stream is a key model input. Under the current condition case of 40.75 percent impervious, 34 percent of the impervious cover was assumed directly connected to the stream. The percent of impervious cover connected to the stream varied with percent impervious so that as percent impervious cover increased, the percent connected also increased, based on the Sutherland Effective Imperious Area (EIA) Equations (Sutherland, 2000).

The model's hydrological parameters were calibrated using hourly stream flow data collected at the "Bronx River at NY Botanical Garden at Bronx NY" gauging station (USGS 01302020) from 01/01/2012-12/30/2012. The natural contributing area of this stream gauge includes an area which is now diverted for municipal water supplies. To perform model calibration, it was necessary to reduce the difference between model inputs affecting predicted streamflow and actual conditions affecting observed streamflow. For this purpose, the contributing area of this stream gauge was reduced from its natural area (of 51.1 square miles) to only the un-diverted area (of 38.4 square miles; Figure 2) based on maps of watersheds provided by the NYC Urban Field Station (Auyeung & Larson, 2016).

Model results were calibrated against measured stream flow to yield the best fit between model and measured stream flow results (Appendix 1). Calibration coefficients (-1 to +1 with +1.0 = perfect fit) were calculated for peak flow, base flow, and balance flow (peak and base) (Table 2). A coefficient of +1 indicates a perfect fit, 0 indicates the models predicts the same as using the mean value, and negative values indicate using the mean is a better predictor than the model (Moriasi et al., 2007). Differences between measured and estimated flow can be substantially different, particularly for peak flows, due to mismatching of stream flow and weather data as the weather stations are often outside of the watershed area. For example, it may be raining at the weather station and not in the watershed or vice versa.

Table 2. Calibration coefficients for model estimates and gauging station data.

	Calibration Coefficients		
Watershed	Peak Flow	Base Flow	Balanced Flow
Bronx River	0.32	-0.01	0.96

Model calibration procedures adjust several model parameters (mostly related to soils) to find the best fit between the observed flow and the model flow on an hourly basis. However, there are often mismatches between the precipitation data, which often collected outside of the watershed, and the actual precipitation that occurs in the watershed. Even if the precipitation measurements are within the watershed, local variations in precipitation intensity can lead to differing amounts of precipitation than observed at the measurement station. These differences in precipitation can lead to poorer fits between the observed and predicted estimates of flow as the precipitation is a main driver of the stream flow. As can often be observed in Figure 1, the observed and simulated results will diverge, which is often an artifact of the precipitation data. For example, observed flow will rise sharply, but predicted flow does not, which is an indication of rain in the watershed but not at the precipitation measurement station. Conversely, the simulated flow may rise but the observed flow does not, which is an indication of rain at the precipitation station, but not in the watershed.

Since the model simulations are comparisons between the base simulation flows and another simulated flow where surface cover is changed (e.g., increase or decrease in tree cover), both model runs are using the same simulation parameters. This means that the effects of changes in cover types are comparable, but may not exactly match the flow of the stream. Stated in another way, the estimates of the changes in flow are reasonable (e.g., the relative amount of increase or decrease in flow is sound as both are using the same model parameters and precipitation data), but the absolute estimate of flow may be incorrect. Thus the model results can be used to assess the relative differences in flow due to changes in cover parameters, but should not be used to predict the actual effects on stream flow due to precipitation and calibration imperfections. The model can be used to compare the changes in flow (e.g., increased tree cover leads to an X% change in stream flow), but will likely not exactly match the flow observed in the stream. The model is more diagnostic of cover change effects than predictive of actual stream flow due to imperfections of models and data used in the model.

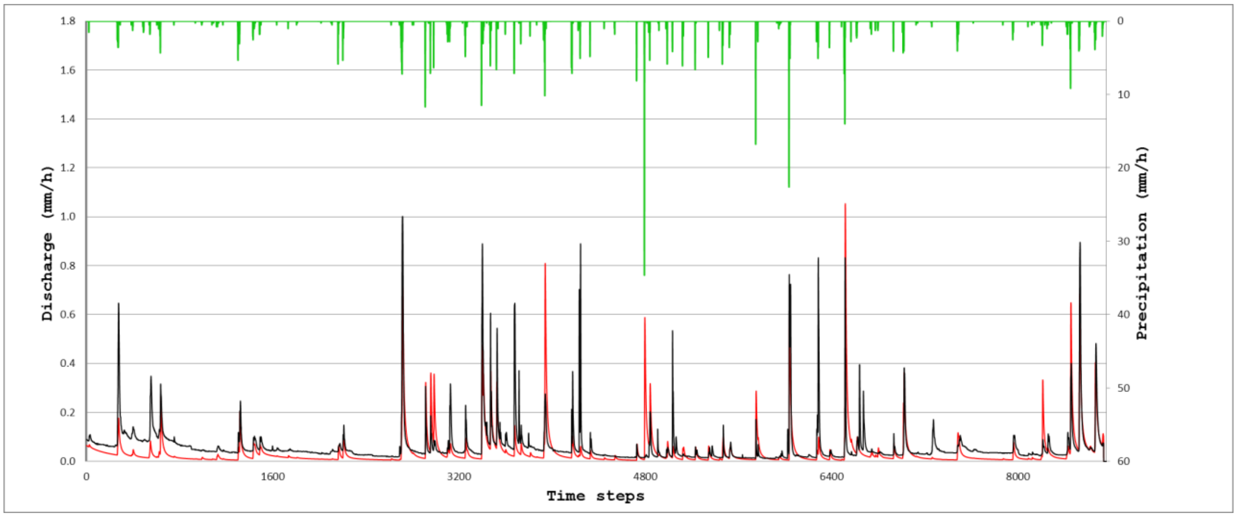

Figure 2. Comparison of simulated model flow vs. observed flow in Bronx River watershed. Red line = simulated results; black line = actual flow; green line = precipitation.

Overall the calibrated model tends to underestimate observed peak flows (Figure 2), particularly flows over about 600,000 cubic feet per hour in Bronx River, which did not occur too often during the simulation period.

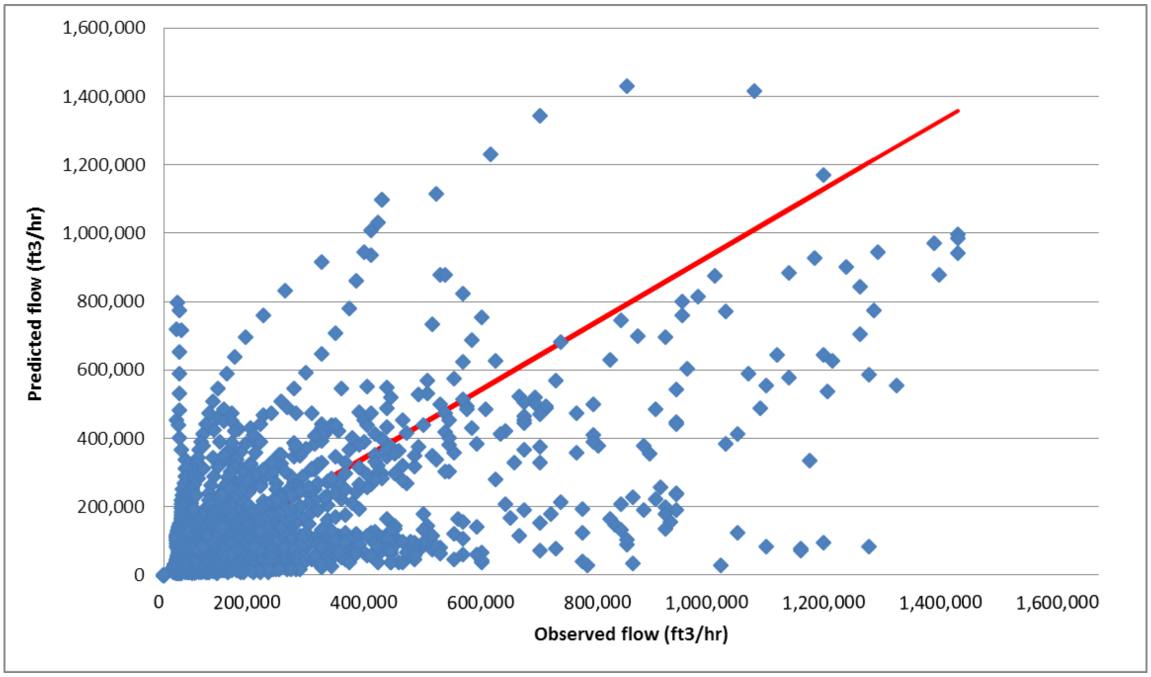

Figure 2. Comparison observed vs. simulated flow.

After calibration, the model was run under various conditions to determine stream flow response given varying tree and impervious cover values for the watershed area.

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