'Flow-Ecology' Relationships from Eight IFIM Studies for Use in Virginia State Water Resources Plan

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Motivation

Water demand in Virginia is projected to increase by 450 MGD (32%) by 2040, with 80% of this increase expected to come from surface water (VDEQ, 2014). The Virginia State Water Resources Plan (SWRP) is a comprehensive statewide water supply planning process developed by the Office of Water Supply at Virginia Department of Environmental Quality (VDEQ) to summarize existing and projected water use information, as well as potential impacts of future demands, to ensure the protection of human and ecosystem needs.
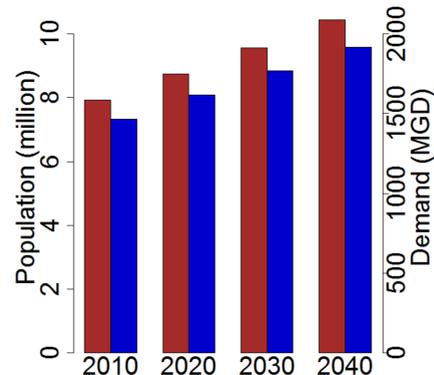
Figure 1. Population growth (red) and water demand (blue) in Virginia from 2010 to 2040.

In order to incorporate protection of environmental flows into the SWRP, a statewide assessment of existing data related to environmental flows was needed. This project pursues one type of available data: Instream Flow Incremental Methodology (IFIM) studies. The output data explored were flow time series, habitat time series, and the shape of the habitat rating curve.

Habitat Rating Curves

In order to compare curves across sites and across species, both axes of the typical WUA-discharge curve were standardized; the new axes are percent of maximum WUA and percentile flow. Parameters that describe the shape of the standardized curve were calculated for each curve:

- Flow at peak WUA
- Slope preceding peak
- Skewness
- Standard deviation
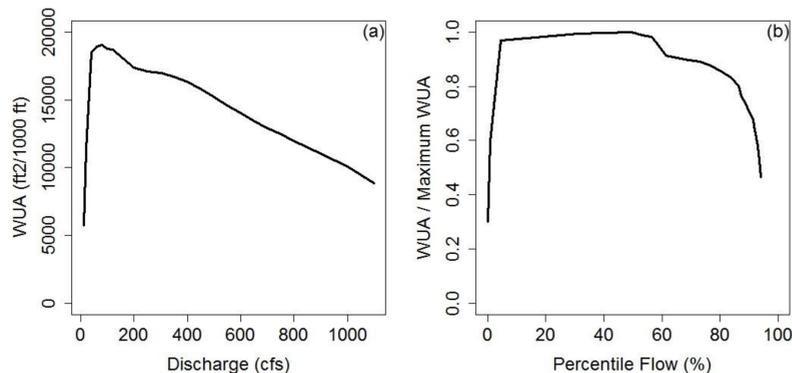
Figure 2. Original (a) and standardized (b) habitat rating curves for an individual species at one site.

Study Sites

Twenty-three river reaches within eleven rivers in Virginia have undergone extensive habitat mapping and modelling to determine the amount of aquatic habitat available at varying streamflow, following the Instream Flow Incremental Methodology (IFIM). By mapping flow and habitat statistics across the state, potential trends are being explored in ecologically relevant contexts, such as physiographic region. A total of 428 habitat rating curves for unique site-species combinations were compiled from the studies.
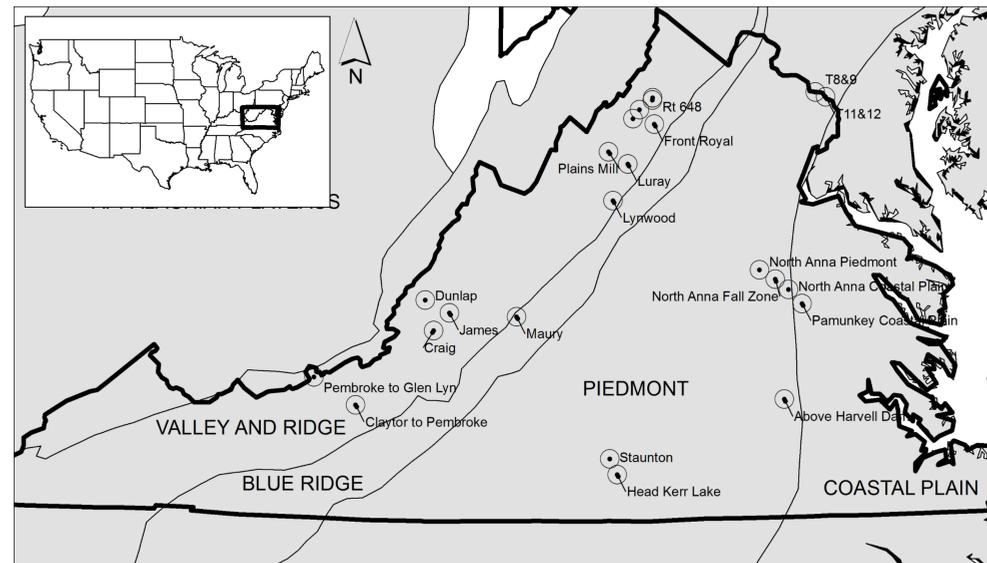
Figure 3. Location map of twenty three river reaches in Virginia where an Instream Flow Incremental Methodology (IFIM) study has occurred.

IFIM Study	Year Completed	Study Motivation	No. of Reaches
Appomattox River	2012	Brasfield Dam	1
New River at Claytor Dam	2008	Claytor Dam	2
North Anna/Pamunkey Rivers	2009	Lake Anna Dam	4
North Fork Shenandoah River	2004	Sustainable water allocation	5
Potomac River between Great Falls and Little Falls Dam	1981	Potomac River Low Flow Allocation Agreement	2
Roanoke River	2004	Clover Power Station	2
South Fork Shenandoah River	2012	Sustainable water allocation	3
Upper James River	1986	Transferability of instream flow rules	4

Project Goals

- Compile existing flow-habitat data from Instream Flow Incremental Methodology studies.
- Identify habitat metrics that describe species' response to low-flow alterations.
- Identify flow statistics that correlate to observed habitat at the statewide level.
- Select metrics for further examination.

Flow and Habitat Metrics

Flow metrics were calculated using daily flow time series from nearby USGS long-term streamflow gages and the help of the Indicators of Hydrologic Alteration (IHA) package in R. Habitat time series were calculated from flow time series and habitat rating curves. The primary habitat metrics that were explored were Index-B values: the average monthly habitat availability. Three recurring patterns of seasonal variability were observed:

a) Relative constancy in habitat availability throughout year
b) Peak in summer, lower in spring
c) Peak in spring, lower in summer
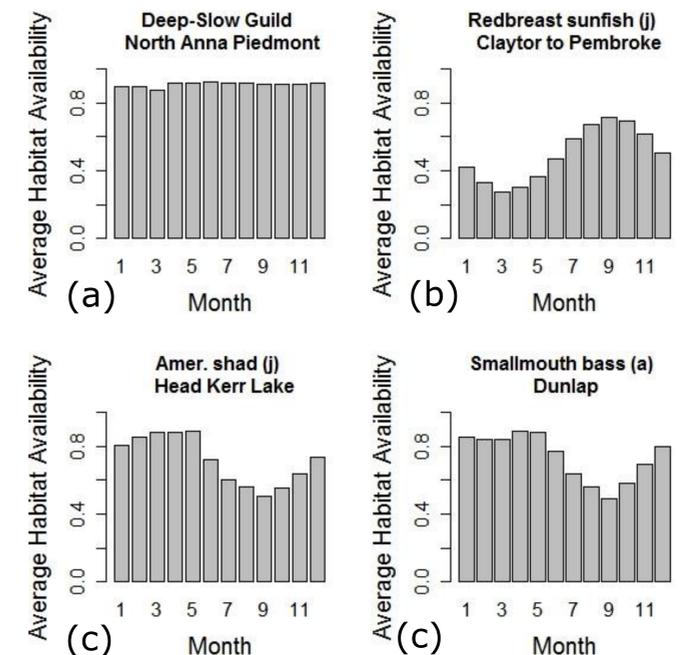
Figure 4. Representative patterns of seasonal variability in habitat availability.

VDEQ (Virginia Department of Environmental Quality). 2014. Status of Virginia's Water Resources: A Report on Virginia's Water Resources Management Activities. 2014. Richmond, VA: Office of Water Supply. http://www.deq.virginia.gov/Portals/0/DEQ/LawsAndRegulations/GeneralAssemblyReports/AWRP_090814FINAL.pdf