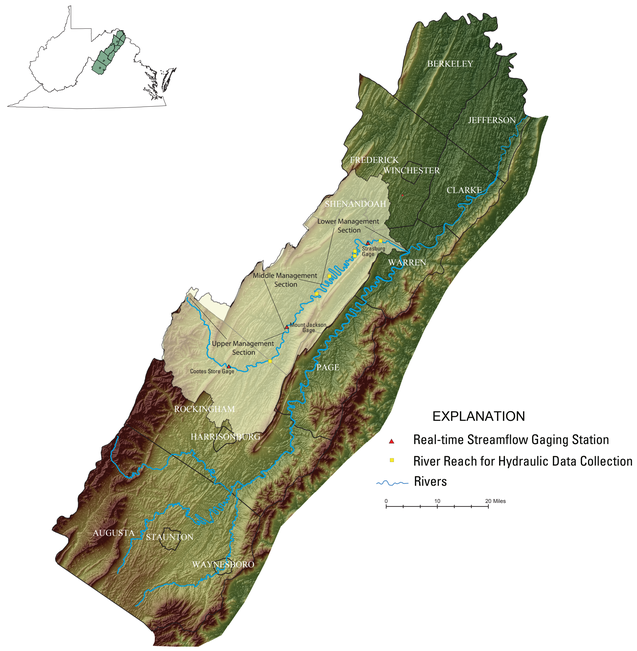
Habitat Availability During Low-Flow Periods on the North Fork Shenandoah River, Virginia

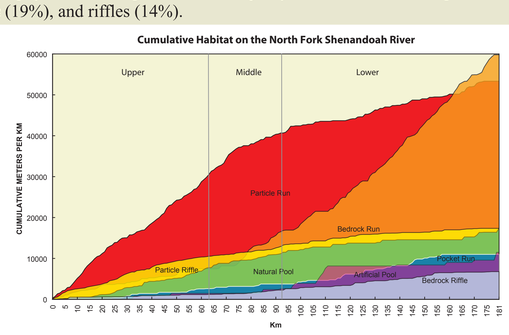
by Jennifer L. Krstolic, Donald C. Hayes

The objectives of this research were to enhance understanding of low-flow conditions, to relate water availability to physical habitat needs of fish, and to develop a relation for the availability of suitable habitat and instream flows. In an unregulated, rural basin with a growing population (30% growth 1980-2000), the question at hand is how to manage water-resources in a way that maintains the health of the aquatic ecosystem. The North Fork Shenandoah River basin (1033 mi²) was divided into three river management sections, the upper, middle, and lower, with stream gages near the downstream end of each section: at Cootes Store, at Mount Jackson, or near Strasburg.

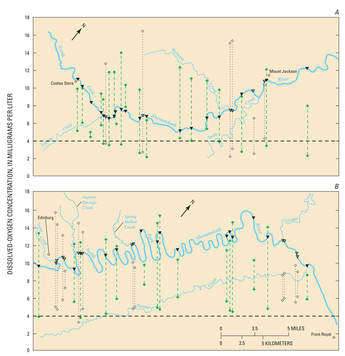


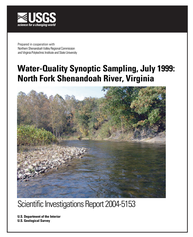
Study Components: Six river reaches were selected for study. River reaches contain two or more mesohabitats and vary in length from 150 ft to 2000 ft, and in width from 100 ft to 200 ft. Reach-specific hydraulic measurements, physical habitat-mapping, fish habitat-suitability curve development, low-flow water-quality monitoring, and physical habitat simulation models (RHABSIM) were the main components study.

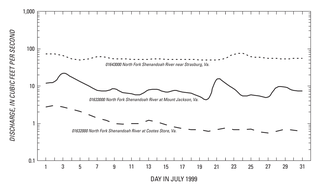
Mesohabitat Mapping: Detailed mapping of physical habitat (100 mi) provided an accurate representation of river conditions for habitat-flow modeling. The river was classified by the relative amount of physical habitat present. The majority of the river is made up of runs (67%), followed by pools (19%), and riffles (14%).



Substrate and habitat-unit size are differentiating variables that describe the form and function of habitat between the three river sections. In the upper section, the mesohabitat units are short, with many repeating riffle, run, riffle sequences. Particle-substrate riffles and runs are most common. The average length of an individual mesohabitat unit in the middle section is greater than the average length in the upper section, marking the transition between short, alternating sequences of riffles and runs, to longer stretches of riffles, runs, and pools. The lower section of North Fork Shenandoah River has seven artificial pools, which make up the longest individual mesohabitat units in the river (average 4149 ft). Extensive runs commonly lead up to artificial pools, making the lower section slow to react to decreases in flow.







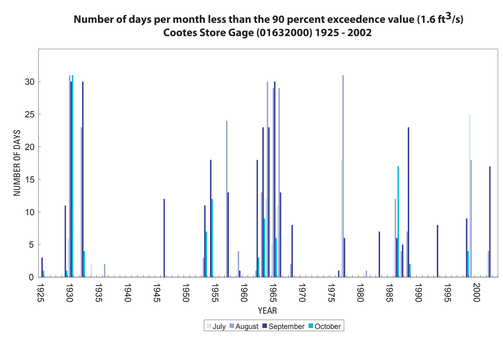
Streamflow in July 1999 for 3 streamflow-gaging stations on the North Fork Shenandoah River, Virginia.

Exceedance flows for low-flow months on the North Fork Shenandoah River, Virginia

Month	Exceedance percent	Cootes Store[1] (ft³/s)	Mount Jackson[2] (ft³/s)	Strasburg[1] (ft³/s)
July	Q 90 =	4	39	100
	Q 75 =	8.5	61	136
	Q 50 =	18	94	193
	Q 25 =	41	158	292
August	Q 90 =	1.4	26	84
	Q 75 =	3.5	44	115
	Q 50 =	13	74	169
	Q 25 =	46	169	300
September	Q 90 =	1.3	28	83
	Q 75 =	2.7	41	108
	Q 50 =	9.8	64	149
	Q 25 =	32	139	254
October	Q 90 =	2.3	32	88
	Q 75 =	4.5	45	113
	Q 50 =	12	74	156
	Q 25 =	50	153	267
Annual	Q 90 =	4.6	43	110
	Q 75 =	15	76	160
	Q 50 =	61	182	310
	Q 25 =	178	418	630
Aug Sept Oct	Q 90 =	1.6	29	85
	Q 75 =	3.6	43	112
	Q 50 =	11	71	160
	Q 25 =	42	153	272

[1]Historical data range 1925-2002; [2] Historical data range 1943- 2002]

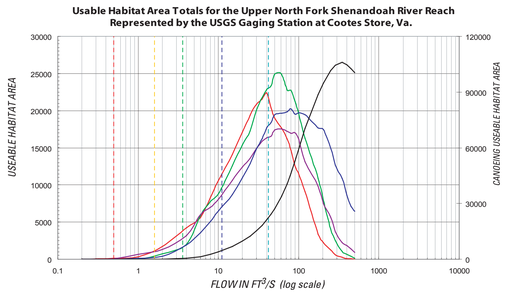
Water-Quality Synoptic Survey: Diurnal fluctuations of dissolved-oxygen (DO) concentrations were monitored during low-flow conditions in July, 1999. Daily values of flow were below the 90 percent exceedance flow for July during data collection. DO fluctuated daily 5–10 mg/L above the daily minimum. DO concentrations were equal to or less than the State water-quality minimum of 4.0 mg/l in the upstream portion of the river. pH values greater than the State water-quality maximum of 9.0 were found in the downstream portion of the river. Water-quality monitoring during normal flows, and investigation into the location of fractures, springs, and groundwater discharges to the river may help put these values into perspective. USGS Scientific Investigations Report-5153 available on-line **http://water.usgs.gov/pubs/sir/2004/5153.**



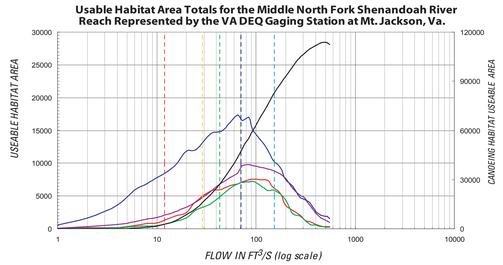
Year	June	July	Aug	Sept	Oct
		Cootes Store			
1930	0	6	31	30	31
1964	0	12	30	23	0
1965	0	5	29	30	6
1966	0	11	29	13	0
1999	0	25	18	0	0
2002	0	0	4	17	--
		Mount Jackson			
1930	--	--	--	--	--
1964	0	3	27	22	0
1965	0	1	15	10	13
1966	0	18	23	13	0
1999	15	31	19	3	0
2002	0	4	27	21	--
		Strasburg			
1930	2	15	26	23	31
1964	0	4	25	17	0
1965	0	3	1	1	8
1966	0	21	23	13	0
1999	20	31	22	0	0
2002	0	4	8	18	--

Number of days less than the 90 percent exceedance flow during past drought periods.

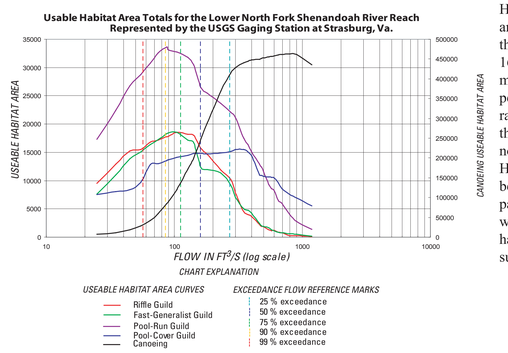
Historic Flow Context: Exceedance flows calculated from more than 75 years of streamflow data show that the months of August, September, and October represent the low-flow period. Exceedance values based on August, September, October (ASO) flows were used as representative low-flow statistics for this investigation. The chart above shows the number of days equal to or less than the (ASO) 90-percent exceedance flow. Extreme low-flow periods or droughts in the past 75 years are evident when majority days during low-flow months meet this criteria.



Habitat area was greatest with simulated flows higher than the 25 percent exceedance flow (42 ft3/s). The normal range of flows (25-75 % exceedance flows) brackets the left side of the useable habitat area curves, and only includes the peak of the riffle-guild useable habitat area curve. During low-flow months it is common for useable habitat area to be less than the maximum habitat area.



Habitat area was greatest within the normal range of flows for late summer. At flows less than the 75 % exceedance flow, habitat area decreases at a similar rate for all guilds.

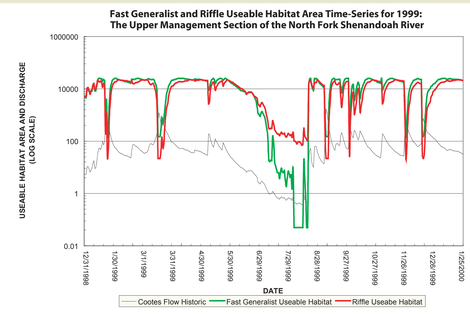


Habitat area for riffle, fast-generalist, and pool-run guilds is greatest between the 90 and 50 % exceedance flows (85-160 ft3/s). The pool-cover habitat is more limited, with a fairly undefined peak around 500 ft3/s. The normal range of flows brackets the right side of the useable habitat area curve, and does not does not include peaks of the curves. Habitat associated with low-flows may be comprised of mostly disconnected patches and edge areas, and the potential water-quality problems within shallow habitats make the overall habitat suitability questionable.

Physical Habitat Modeling: The study aimed to provide management information to assist in protecting habitat utilized by multiple species and life stages of fish. To accomplish this, fish species were grouped using the guild approach for development of habitat suitability criteria. Guilds included are: riffle, fast-generalist, pool-run, and pool-cover guilds.

RHABSIM was used to model habitat conditions for each guild. The upper and middle sections were each represented by one reach, while the lower section was a synthesis of four study reaches.

It is important to understand how the useable habitat curves relate to the hydrologic regime. Exceedance flows are plotted over each curve as a reference to normal and late summer conditions.



Time-series Analysis: The habitat-flow relation was overlayed on the entire historic streamflow record to illustrate how habitat abundance may have varied during low-flow periods. The 1999 time-series plot for the upper management section shows that useable habitat area for riffle and fast-generalist guilds were generally greater than 20,000 units; however, as streamflow decreased during June, useable habitat area declined sharply and remained less than 5000 units for 30 days.

USGS Cooperators:

NSVRC
NORTHERN SHENANDOAH VALLEY REGIONAL COMMISSION

Town of Strasburg

Research Partner:

Virginia Tech Department of Fisheries & Wildlife Sciences

Poster contains preliminary data, subject to revision