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Aquatic Condition Response to Buffer Establishment on Northern Virginia Streams

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Aquatic Condition Response to Buffer Establishment on Northern Virginia Streams

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Aquatic Condition Response To Buffer Establishment on Northern Virginia Streams

Introduction

The critical role of riparian vegetation in providing stream habitats that support healthy biological assemblages and the value of streamside buffers in reducing nonpoint source pollution are now well documented (Karr and Schlosser 1978; Sweeney 1992; Castelle et al. 1994, Lowrance et al. 1997). Because of deforestation, fewer than half of the historically forested riparian areas in the Continental United States remain today, and most of those are adversely impacted by human activities (Fredrickson and Reid 1986). In response to the loss of ecological function in these areas, the reestablishment of riparian buffers is now widely advocated through a variety of Federal and State conservation programs. In May 1997, for example, USDA officially launched the National Conservation Buffer Initiative that pledged to assist farmers and ranchers install 2 million miles of buffers nationwide. Accordingly, financial and technical assistance for buffer establishment were made available through several USDA programs (e.g., continuous Conservation Reserve Program (CRP), Environmental Quality Incentives Program, Wildlife Habitat Incentives Program, Wetlands Reserve Program, Stewardship Incentives Program, and Emergency Watershed Protection Program). Additionally, the CRP has been combined with state programs, through the Conservation Reserve Enhancement Program (CREP), to provide additional incentives to establish buffers in environmentally sensitive watersheds, such as the Chesapeake Bay drainage. From 1997 through 2003, nearly 1.4 million miles of buffers were established nationwide under the National Conservation Buffer Initiative, and over 15,000 acres of forested riparian buffers were established from 2000 to 2003 through Virginia's CREP.

Over the past two decades, researchers have shown that preserving naturally vegetated corridors along streams can buffer the degrading effects of nonpoint source pollution (Wenger and Fowler, 2000). Although newly planted buffers are expected to sustain water quality functions similar to natural ecosystems, few studies have documented specific changes in the condition of aquatic resources before and after buffer establishment (Virginia Riparian Forest Buffer Panel 1998). An important initial component of any evaluation of riparian recovery should be an assessment of the ecological status of existing riparian and aquatic systems. Ideally, this assessment should be conducted at the watershed scale, while still being sufficiently detailed to evaluate local stream reaches where particular restoration activities might occur (Kauffman et al. 1997). Because the factors that influence riparian ecosystems are complex and many, effective assessments of riparian recovery generally require integrators of those influences to provide ecologically sound endpoints against which progress can be measured (Hughes et al. 1990; Karr and Chu 1997). One widely used technique to assess the condition of aquatic resources is the index of biotic integrity (IBI) (Karr et al. 1986), which relies on metrics depicting characteristics of faunal assemblages, such as fish. The IBI has not only been used to assess conditions of streams and their watersheds (Fausch et al. 1990; Roth et al. 1996; Wang et al. 1997), but also to assess the ecological impacts of specific human disturbances (Berkman et al. 1986; Leonard and Orth 1986; Hughes and Gammon 1987; Steedman 1988). Various versions of the IBI are currently used in nearly all of North America (Davis et al. 1996; Simon 1999).

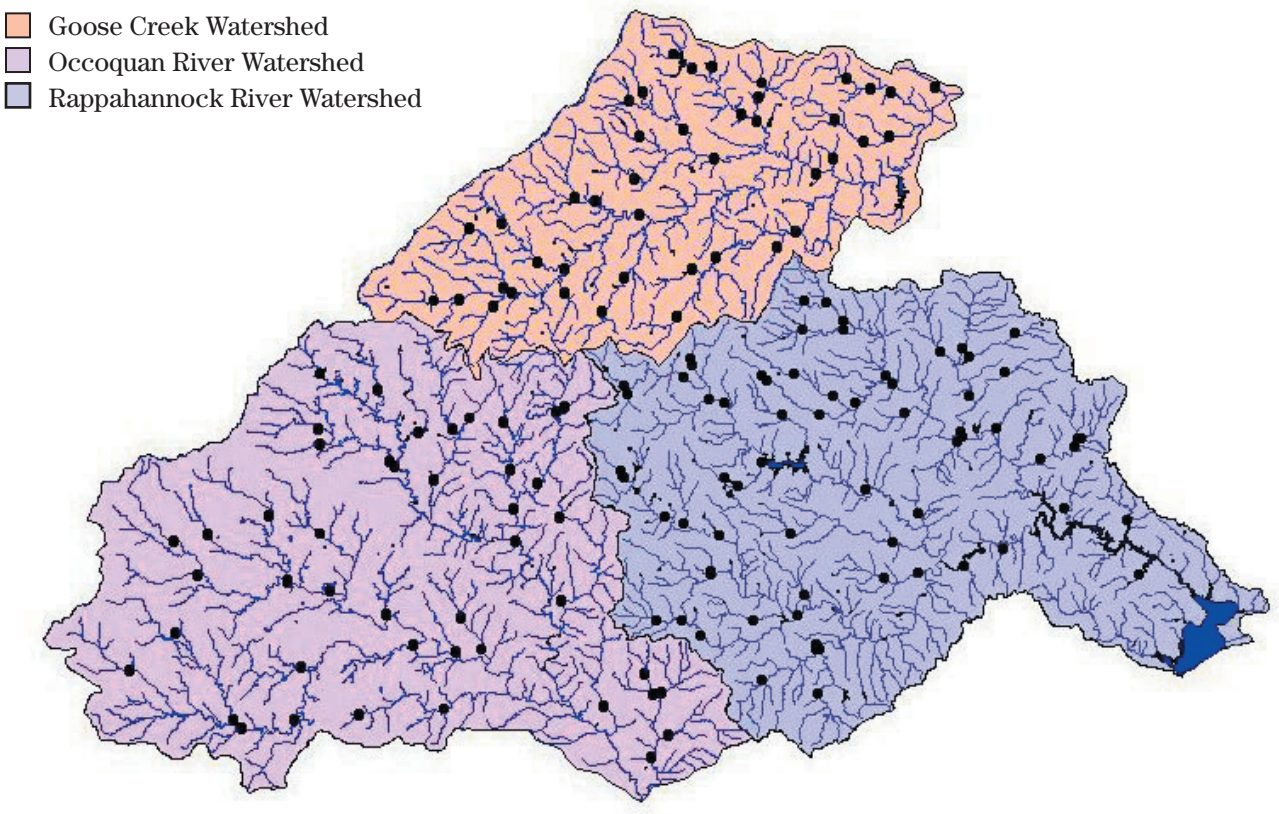
In a previous study in the Piedmont of northern Virginia, Teels and Danielson (2001) developed a regional IBI based on fish surveys conducted on 157 individual stream segments in the Occoquan River, Goose Creek, and upper Rappahannock River Watersheds (fig. 1). By testing and validating the component metrics, a regional IBI was produced that demonstrated high sensitivity in detecting degrees of human disturbance across the 157-site reference. In that study a separate measure, the NRCS Stream Visual Assessment Protocol (SVAP) (USDA, NRCS 1998), was used to assess the physical condition of stream reaches. Together, the SVAP and IBI provided an integrated assessment for both watershed and local influences that combine to determine the aquatic condition of a site. Using those two techniques as measures, this study evaluated the effects of riparian restoration by examining aquatic condition before and after buffer establishment for 36 northern Virginia projects over a 4-year period. Watershed land use patterns, local site disturbances, and project design features were analyzed at each site to determine their influence on riparian recovery.

Study area

The study area is defined by the boundaries of the previous study (Teels and Danielson 2001) (fig. 1). This study also relies on the IBI and SVAP of that study, which were developed to be regionally sensitive to the prevailing human influences and faunal assemblages of the northern Virginia Piedmont. The study area is composed of the Occoquan River (1,528 km^2, 589 mi^2), upper Rappahannock River (1,744 km^2, 673 mi^2), and Goose Creek (997 km^2, 385 mi^2) Watersheds. Collectively, the three watersheds compose an area of 4,259 km^2 (1,644 mi^2).

The western limits of the study area begin at the summit of the Blue Ridge, approximately 90 to 140 kilometers (55.9 to 87 mi) west of Washington, D.C. The Rappahannock River originates near Front Royal, Virginia. From there it flows southeasterly before emptying into the Chesapeake Bay below Fredericksburg. The study area includes that portion of the Rappahannock drainage above and including Marsh Run. The source of Goose Creek is also near Front Royal. It flows northeasterly before entering the upper Potomac River below Leesburg. All of Goose Creek and its tributaries are within the study area's boundary. The Occoquan River arises to the east of the previously described drainages. Its three principal tributaries—Cedar Run,

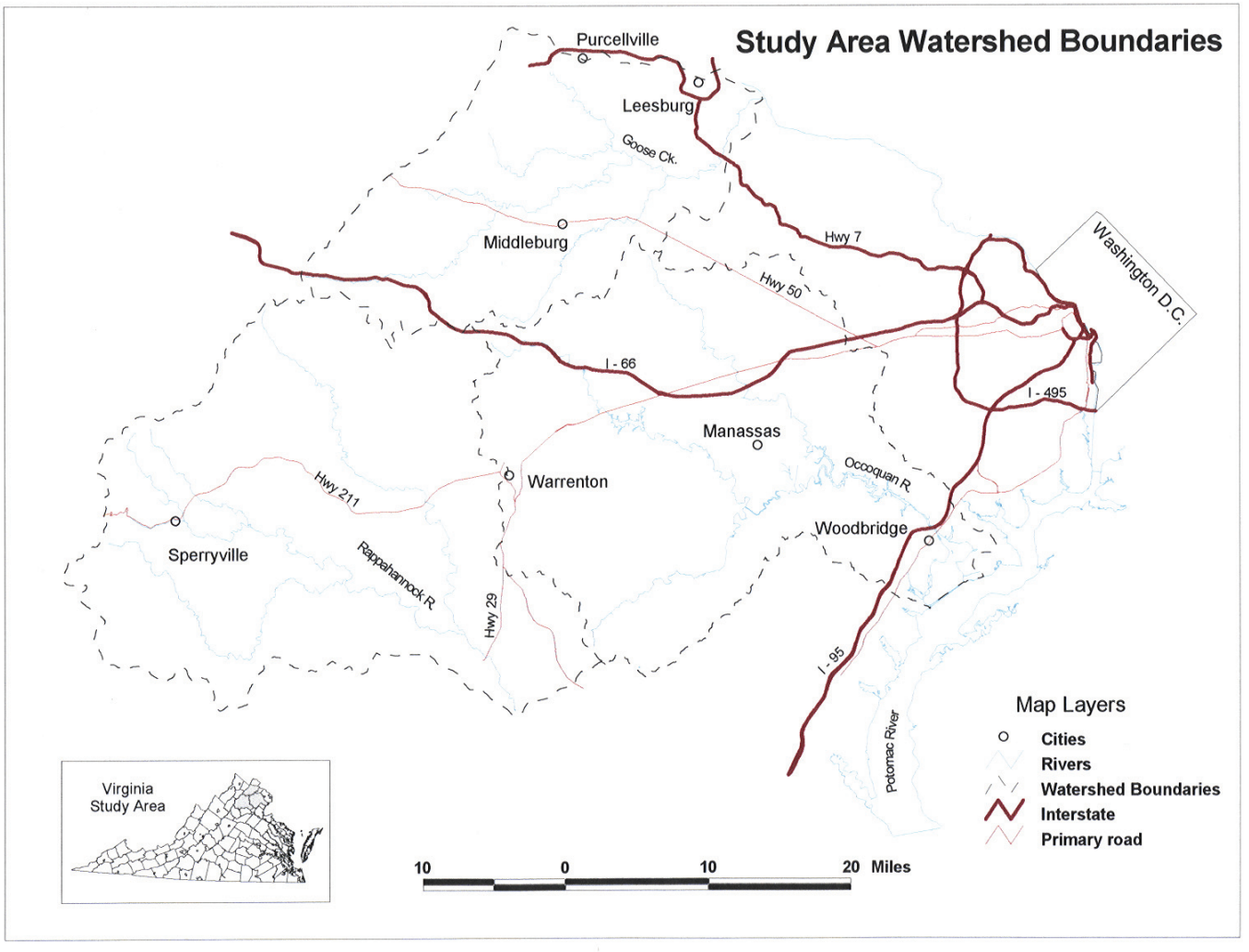
Figure 1 Study area and geographic distribution of sites composing the 157-site regional reference for the IBI and SVAP (from Teels and Danielson 2001)



Broad Run, and Bull Run—begin in the Piedmont foothills near Marshall, Warrenton, and The Plains, respectively, and flow easterly before uniting to form the Occoquan River near Manassas. Below Manassas the river is impounded by Occoquan Reservoir, with its dam located just a few miles above the river's confluence with the Potomac River near Woodbridge. The entire Occoquan drainage is also within the boundary of the study area (fig. 2).

The western portion of all three watersheds is rural, with a mixture of agriculture, woodland, and small towns. Most upper Rappahannock tributaries originate in the forested Shenandoah National Park, resulting in relatively high quality headwater streams. Upper Goose Creek tributaries also originate in predominantly forested mountain landscapes and most exhibit relatively high water quality. Much of the Occoquan watershed is rapidly developing, which has significantly impacted its streams and aquatic life (Teels and Danielson 2001). Although landscapes in the western portion of the Occoquan drainage are predominantly rural, rapid development has occurred in the watershed's eastern end and is now spreading throughout the entire watershed. Thus, the Occoquan Watershed possesses proportionately more degraded streams than either the upper Rappahannock or Goose Creek Watershed.

Figure 2 Study area watershed boundaries



Methods

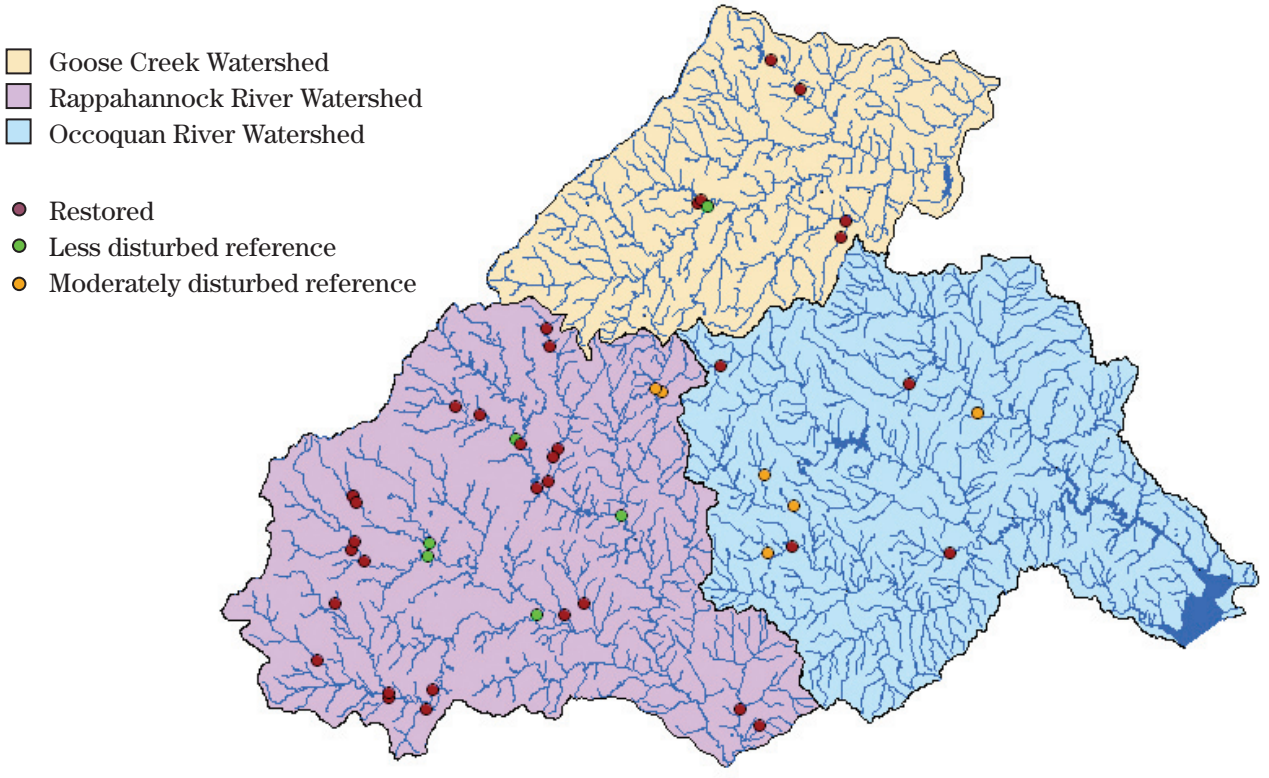
Buffer sites

Beginning in 2000, we consulted the Natural Resources Conservation Service (NRCS) field offices in Fauquier, Culpeper, Loudoun, and Prince William Counties to identify prospective sites for the study based on landowner-expressed interest in participating in riparian conservation buffer programs. Sites were added to the study if lands were associated with streams large enough to support fish assemblages capable of producing a meaningful IBI (> 5 km^2, 1.9 mi^2) drainage area). Because program enrollment is a continuous process, sites were added with each year of the study. Cumulatively, 36 sites that have been enrolled in buffer programs were monitored over the course of the study. With the exception of one site (Catoc @287) located in the adjacent Catoctin Watershed, all sites monitored were within the boundaries of the previous study area (fig. 3).

Baseline sampling began in 2000 on those sites that qualified for program participation. Sampling began on subsequent sites during the year they qualified for the program. Over the course of the study, 20 sites were sampled in 2000, 29 in 2001, 33 in 2002, and 36 in 2003. In addition, 12 reference sites, located on streams near the established buffers, were sampled annually from 2000 to 2003. Using information on stream condition from the previous study (Teels and Danielson 2001), six of the reference sites were established on streams with lesser levels of disturbance and six on streams with moderate levels of disturbance.

Streamside vegetated buffers were established on most sites the year after they were enrolled in the program. At least 1 year of baseline information was obtained for all restored sites before buffers were established. Established buffers varied between 10.5 and 90 meters (34.4 to 295 ft) in width, depending on the size of the flood plain and the landowner's objectives. Buffer area varied from 2.2 to 42.2 hectares (mean = 11.9) (5.5 to 105.5 ac; mean = 29.8) and buffer length varied from 603.5 to 7,461.5 meters (mean = 2,718.3) (1991.6 – 24,623.1 ft; mean =8,970.4 ft.). Of the 36 sites, 32 were restored by fencing stream corridors to exclude livestock and planting hardwood trees at the rate of 72 trees per hectare (180 trees per acre). The remaining four sites were fenced, but not planted, relying on natural processes to revegetate the buffer.

Figure 3 Location of restored and reference sites



In this study, stream reaches are identified by the stream name and the number of an adjacent or crossing road (e.g., Hughes @644). If there were no adjacent or crossing roads, reaches were identified by the stream name and the name of the property or landowner (e.g., Marsh @Ott).

The Index of Biotic Integrity (IBI)

The need to test and validate biological responses (metrics) across a gradient of human disturbance is a core assumption of the IBI (Karr and Chu 1997). Although the IBI is widely used, it is not a widely standardized method. Essentially, a unique IBI must be developed for each regional faunal assemblage based on observable biological responses in the area and reference conditions derived from the region's least impaired streams (fig. 4). In the previous study, Teels and Danielson (2001) developed a Human Disturbance Index (HDI) to test and validate the performance of metrics that were incorporated into the regional IBI. The HDI was based on land-use variables and onsite assessment of stream characteristics using the SVAP.

Evaluation of IBI metric performance and the sequence of activities used for developing the regional IBI are outlined in figure 4 and described in detail in Teels and Danielson (2001). Biological groupings (guilds and attributes) follow Teels and Danielson (2001) and are summarized in table 1. Metrics for the IBI are summarized below.

Number of native species—The total number of species per sample less the species considered to be non-native or probably non-native by Jenkins and Burkhead (1993) for the receiving drainages (Potomac and Rappahannock) of the project area.

Number of darter species—The number of species per sample of the genera Percina or Etheostoma.

Number of minnow species—The number of species of the family Cyprinidae per sample.

Percent of the dominant species—The proportion (percent) of individuals per sample comprised of the single most abundant species.

Number of intolerant species—The number of species per sample considered to be intolerant to the combined effects of human disturbance in the northern Virginia Piedmont.

Percent tolerant individuals—The proportion (percent) of individuals per sample of species considered to be tolerant to the combined effects of human disturbance in the northern Virginia Piedmont.

Percent omnivorous individuals—The proportion (percent) of individuals per sample of species that as adults feed across the three food groups of algae, plants, and invertebrates (AHI; table 1).

Percent benthic invertebrates—The proportion (percent) of individuals per sample that are considered benthic (Ben; table 1) and as adults feed predominantly on invertebrates (Inv; table 1).

Percent specialist carnivores minus tolerant species—The proportion (percent) of individuals per sample comprised of species designated as piscivores (Pisc; table 1) or invertivore/piscivores, excluding individuals from tolerant species.

Percent simple lithophilic spawners minus tolerant species—The proportion (percent) of individuals per sample comprised of species that scatter their eggs over rock, rubble, or gravel substrates (Lith; table 1) without nest preparation or parental care of the eggs, excluding individuals from tolerant species (table 1).

Number of late-maturing species—The number of species per sample that normally do not breed before their third year (table 1).

Percent anomalies—The proportion (percent) of individuals per sample with externally visible abnormalities, such as disease, tumors, fin damage, and lesions.

Non-native: Species considered by Jenkins and Burkhead

Figure 4 Sequence of activities in developing the IBI (from Teels and Danielson 2001)

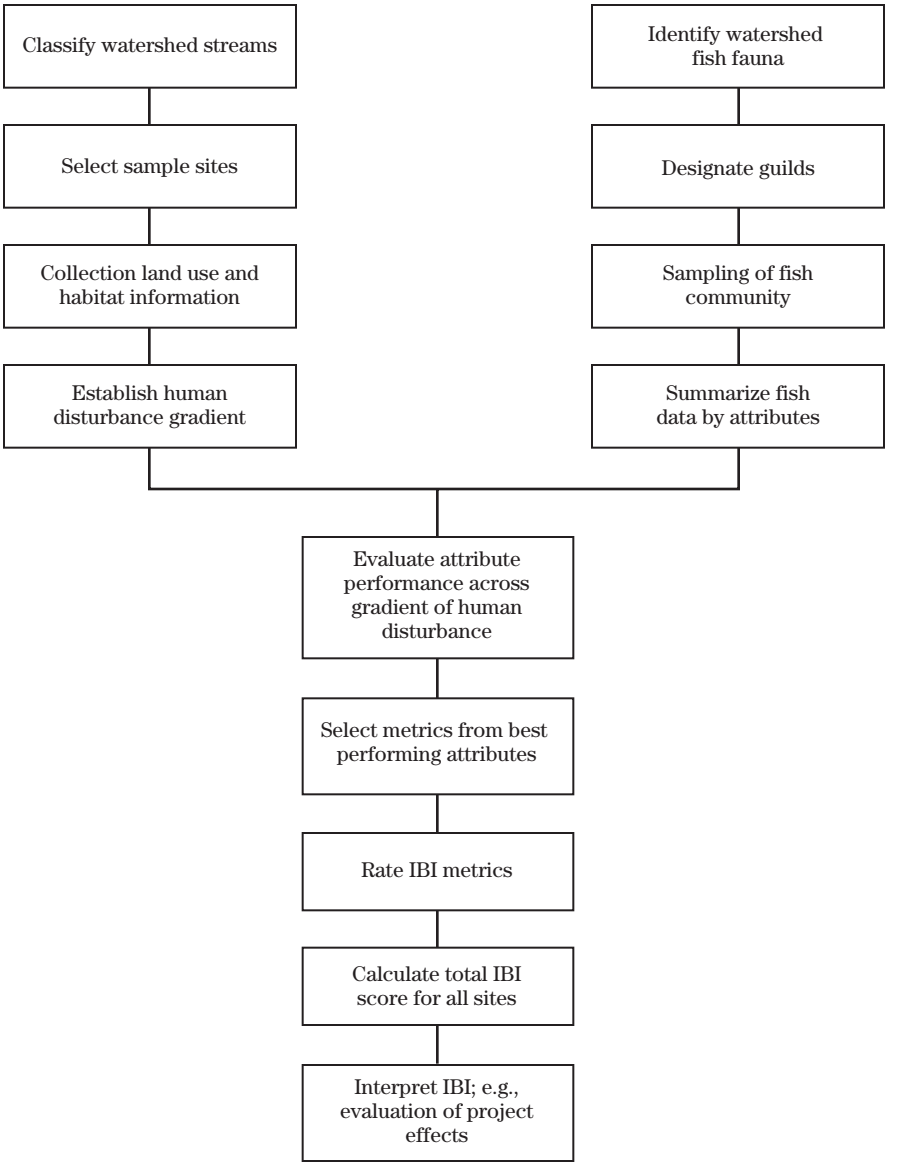


Table 1 Biological groupings for fish species collected across the three watersheds (from Teels and Danielson 2001)

Common name	Non-native	Tol.	No. food groups	Trophic	Ben.	Lith.	Pio.	Late maturing	Var. spawner
American brook lamprey		I	2	DAH	x			x	
Gizzard shad			2	AHI					x
American eel			2	IP				x	
Redfin pickerel		I	1	PIS					
Eastern mudminnow			1	INV					x
Common carp	x		4	AHI			x	x	x
Golden shiner			2	AHI			x		
Mountain redbelly dace	x		3	DAH		x			
Roseyside dace			1	INV		x			
Fallfish			4	IP					
Creek chub		T	4	IP			x		
River chub			3	INV				x	
Bluehead chub			3	AHI				x	
Cutlips minnow			1	INV					
Blacknose dace		T	3	INV		x			
Longnose dace			2	INV	x	x			
Central stoneroller			2	DAH		x			
Eastern silvery minnow			2	AHI					
Common shiner			4	INV		x			
Satinfin shiner			2	INV					
Spotfin shiner			3	INV					
Bluntnose minnow	x	T	3	AHI			x		x
Fathead minnow	x		3	AHI			x		x
Comely shiner			1	INV		x			
Spottail shiner			2	INV					
Swallowtail shiner			2	INV		x			
Roseyface shiner		I	1	INV		x			
Silverjaw minnow		T	3	AHI		x			
White sucker		T	3	AHI	x	x			
Creek chubsucker			3	INV	x		x		

(1994) to be non-native to the above drainages.
Tol: Species designated as tolerant (T) or intolerant (I) (each limited to 15% of the total fauna).
No. food groups: Number of food groups upon which a species normally relies.
Trophic groups: PIS = piscivore, INV = invertivore, AHI = algivore/herbivore/invertivore, IP = invertivore/piscivore, DAH = detritivore/algivore/herbivore (Smogor 1996).
Ben: Species considered benthic (bottom dwelling).
Lith: Species considered simple lithophils (scatter their eggs in gravel and provide no care for their young).
Late maturing: Species that normally do not breed until their third year or after.
Var. spawner: Species that can manipulate various substrates in order to spawn.

Table 1 Biological groupings for fish species collected across the three watersheds (from Teels and Danielson 2001) (cont.)

Common name	Non- native	Tol.	No. food groups	Trophic	Ben.	Lith.	Pio.	Late maturing	Var. spawner
Northern hogsucker			2	INV	x	x		x	
Torrent sucker	x		2	INV	x	x		x	
Golden redhorse	x		3	INV	x	x		x	
Shorthead redhorse			3	INV	x	x		x	
Channel catfish	x		3	IP				x	x
Yellow bullhead			3	IP			x		x
Brown bullhead			3	IP				x	x
Margined madtom		I	2	INV	x			x	
Banded killifish			1	INV					
Eastern mosquitofish		T	1	INV			x		
Mottled sculpin		I	1	INV	x				x
Potomac sculpin		I	1	INV	x				x
Redbreast sunfish			2	IP					
Green sunfish	x	T	2	IP			x		x
Pumpkinseed			2	INV			x		x
Bluegill	x	T	1	INV			x		x
Redear sunfish	x		1	INV					x
Rock bass	x		2	IP					
Black crappie	x		2	IP			x		x
Smallmouth bass	x		2	PIS					x
Yellow perch			2	IP					
Largemouth bass	x		1	PIS					x
Shield darter		I	1	INV	x				
Stripeback darter			1	INV	x	x			
Tesselated darter			1	INV	x				x
Glassy darter		I	1	INV	x				
Fantail darter			1	INV	x				
Greenside darter	x		1	INV	x				

The metrics selected for the IBI were scored by assigning values of 5, 3, or 1 depending on whether the data they represent were comparable to, deviated somewhat from, or deviated greatly from, respectively, values exhibited by the region's least-impaired streams (Karr et al. 1986). Since certain metrics tend to increase or decrease in value with increasing stream size (Smogor and Angermeier 1999), scoring for all metrics was based on the trisection technique described by Lyons (1992) that considers size of the contributing drainage in the scoring process. Metric scores were then summed to generate an IBI for each site with possible scores ranging from 12 to 60. Actual scores for sites within the 157-site reference base ranged from 16 to 54 and were categorized using the biological integrity classification scheme of Karr et al. (1986) (table 2).

Fish

Since seines have been shown to be an effective technique for sampling fish in small, relatively simple streams (Karr et al. 1986), we used hand-held seines to sample fish. Seining was conducted using a 2.4-meter (7.9-ft) width by 1.8-meter (5.9-ft) depth minnow seine. All sampling was performed by a three- to four-person crew with the primary investigator present to assist with species identification and to ensure uniform application of the technique. All sampling was conducted within a standard 2-hour timeframe, which included the time required to move from one point to the next and to sort the samples. Although no standard distance was covered, the length of stream sampled was always well in excess of 300 meters (984 ft), thus reducing error because of inadequate sample size (Angermeier and Karr 1986). All habitat types, such as pools, runs, and riffles, that could be covered within the standard timeframe were sampled in proportion to their occurrence. Microhabitats, such as spaces beneath logs and boulders, undercut banks, and aquatic vegetation, were sampled by disturbing the area and then quickly seining through. To reduce identification error and temporal bias to young-of-the-year fish, only specimens greater than 25 millimeters in length (.9 in) were enumerated and included in the data (Angermeier and Karr 1986). These were identified to species, counted, recorded and then released back into the stream. Specimens that could not be identified were preserved in 10 percent formalin and taken to the laboratory for identification. All sampling was conducted during daylight hours between late May and mid-September during periods of low flow.

Table 2 Biological integrity classification system for study area sites (from Teels and Danielson 2001)

Total IBI score (sum of the 12 metric ratings)	Integrity class	Attributes
49–54	Excellent	Comparable to the best situations across the three watersheds with minimal disturbance; contains all species expected for the watershed for the habitat and stream size, including the most intolerant forms; exhibits balanced trophic structure and reproductive success.
41–48	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundances; trophic structure and reproduction shows some sign of stress.
33–40	Fair	Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure (e.g., increasing frequency of omnivores or tolerant species); older age classes of top predators may be rare.
25–32	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; reproductive and condition factors commonly depressed; diseased fish often present.
16–24	Very Poor	Dominated by highly tolerant forms (e.g., green sunfish, creek chubs); disease, lesions, parasites, fin damage, and other anomalies may be regular.

Stream Visual Assessment Protocol (SVAP)

The physical condition of stream reaches was assessed using the SVAP (NRCS 1998). Crew members applied the procedure following completion of the fish sampling at each site. The technique provides a quality assessment score based primarily on visual inspection of physical features of a stream reach and its associated riparian area. It is performed in view of land management practices applied within the reach that may adversely impact the aquatic resource. The SVAP is conducted by assigning a score to individual assessment elements based on how field observations best fit the element condition descriptions contained in the protocol. Scores corresponding to the element descriptions (ranging from 1 to 10) are assigned for each element. Scores are then averaged to yield a total SVAP score from 1 to 10 (fig. 5).

Figure 5 Stream Visual Assessment Protocol elements and condition classification scheme.

Assessment Elements

Channel condition	☐	Pools	☐
Hydrologic alteration	☐	Invertebrate habitat	☐
Riparian zone	☐	Canopy cover	☐
Bank stability	☐	Manure presence	☐
Water appearance	☐	Salinity	☐
Nutrient enrichment	☐	Riffle embeddedness	☐
Barriers to fish movement	☐	Macroinvertebrates	☐
Instream fish cover	☐	observed	☐

Summary rating: (Summed ratings of the assessment elements divided by the number of elements scored)

<6.0	Poor
6.0-7.4	Fair
7.5-9.0	Good
>9.0	Excellent

Landscape assessment

Agricultural land-use information was obtained from the Virginia Geographic Information System (VirGIS) (fig. 6). The Virginia Gap Analysis was used to delineate urban/disturbed lands for rural landscapes. The Occoquan Watershed Land Use Survey (Northern Virginia Regional District Commission 2000) was used to identify urban/disturbed land in the developing Occoquan Watershed. ArcView was used to delineate drainage areas above each sample site and calculate land use percentages.

Results

Baseline conditions

Land use/cover

Land use/cover varied greatly among the drainages above sites containing established riparian buffers. The extent of agricultural land (cropland and pasture) within the 36 drainages ranged from 2.0 percent (Hughes @707) to 71.7 percent (N Goose @611). Cropland varied from 0 percent (Keyser @614 and Racer @614) to 42.7 percent (Harper @Ott). Pasture ranged from 1.6 percent (Hughes @707) to 40.9 percent (Thum @Basup). Of the various land use/cover variables, percent cropland corresponded most closely with baseline scores of the IBI (Pearson's correlation coefficient, $r = -0.38$) (fig. 7). Percent of rural nonagricultural land (principally forest) and percent pasture were correlated with the IBI, but to lesser degrees ($r = 0.31$ and $r = -0.16$, respectively) (fig. 7). From mid-1990 Virginia GAP data, urban/developed land in the drainages of the rural western portion of the study area ranged from 0 percent (W Thum @688 and W Thum @729) to 2.4 percent (Marsh @Ott). The amount of urban/developed land among drainages within the developing Occoquan Watershed ranged from 3.2 percent (Broad @746) to 13.2 percent (Cathar @704).

SVAP

Pre-restoration SVAP baseline scores for the restored sites ranged from 3.4 (poor) to 8.8 (good) with an average of 6.8 (fair); however, the majority (66.7%) of sites fell within the lower condition classes of fair and poor. Baseline condition for less disturbed reference sites ranged from 8.1 (good) to 9.3 (excellent) with an average of 8.7 (good). Baseline condition for moderately disturbed reference sites ranged from 4.9 (poor) to 8.4 (good), averaging 6.9 (fair). Baseline SVAP and IBI

Figure 6 VirGIS land-use data for the study area and region

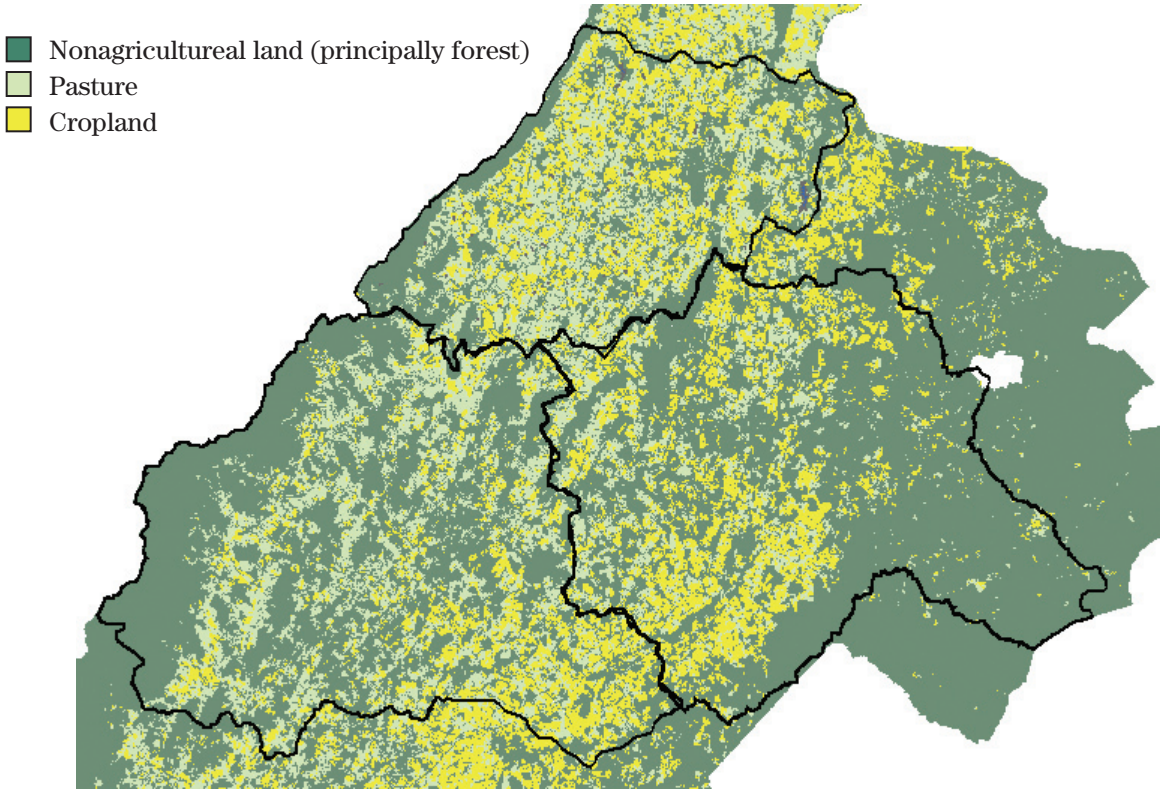
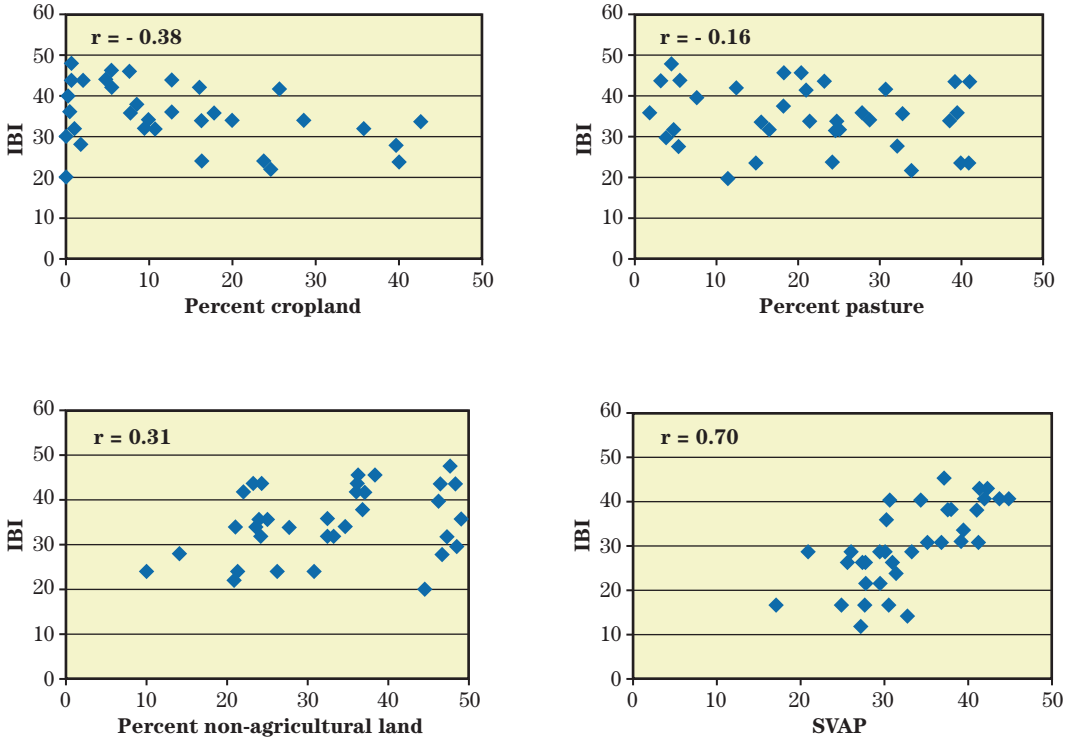


Figure 7 Relationships between baseline IBI scores and three categories of land use for the drainages above each site, and between IBI and SVAP scores



scores for restored sites corresponded highly ($r = 0.70$), much better than the relationship observed between the IBI and any of the land use/cover variables (fig. 7).

IBI

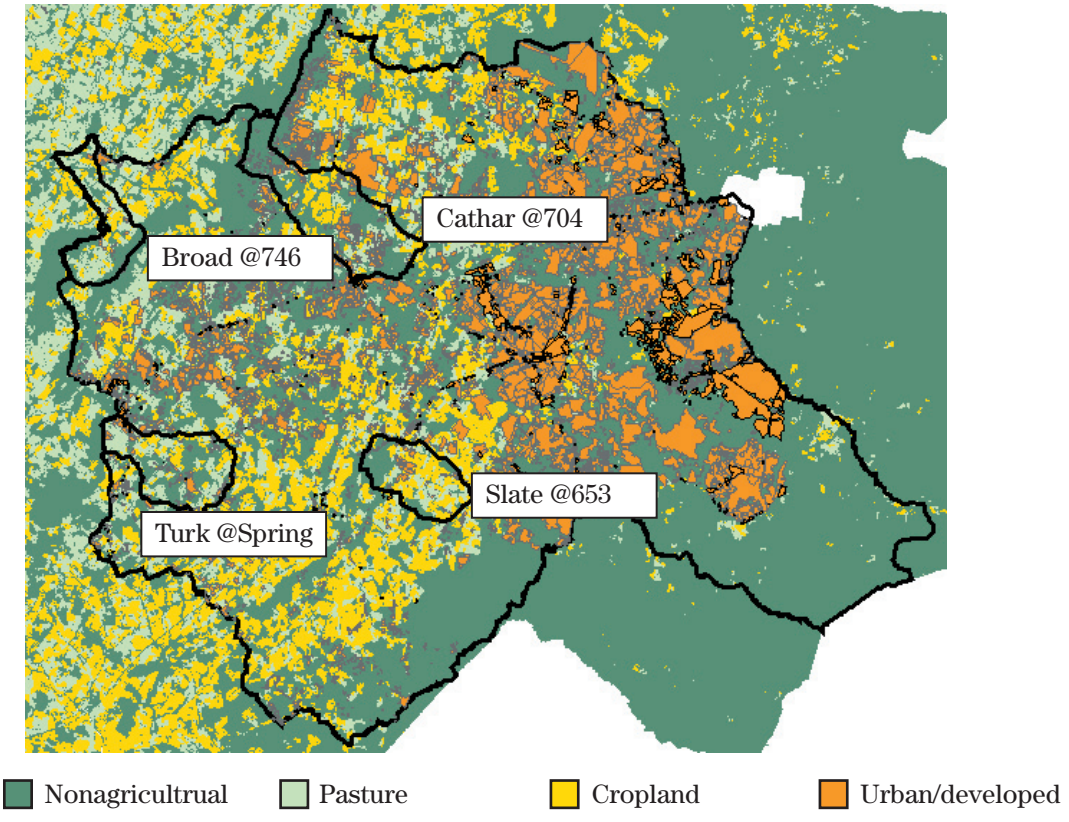
Baseline scores for the IBI ranged from 20 (very poor) to 48 (good) with an average of 34.8 (fair) for the restored sites; however, the majority of sites (69.4%) fell within the condition classes of fair, poor, and very poor. Baseline condition for less disturbed reference sites ranged from 42 (good) to 48 (good) with a mean of 46.3 (good). Baseline condition for moderately disturbed reference sites ranged from 18 (very poor) to 46 (good), averaging 37.3 (fair). Regressions of land use/cover variables and the SVAP against the IBI revealed that the SVAP accounted for the greatest degree of variation in the IBI ($r^2 = 0.50$, s.e. = 5.58). The addition of land use/cover variables improved the regression only slightly ($r^2 = 0.53$, s.e. = 5.52).

Changes in baseline conditions

Land use/cover

Little measurable change in land use/cover occurred over the course of the study in the western rural portion of the study area. However, rapid development is occurring above sample locations in the developing Occoquan Watershed (fig. 8). For example, mid-1990's GAP data for Cathar @704 indicated 0.9 percent urban/developed land compared to 13.2 percent urban/developed land indicated by the 2000 Occoquan Land Use Survey (NVPDC 2000).

Figure 8 Urban sprawl in the Occoquan Watershed (NVPDC 2000). The spread of urban/suburban development is reaching the western end of the Occoquan Watershed where buffers have been established in predominantly rural landscapes. Such development is confounding the aquatic response to buffers. Impacts of development at sites such as Cathar @704 are evident after storm events (see appendix A28).



SVAP

The mean SVAP score for restored sites increased from a baseline of 6.82 to 7.20 (n = 20) the first year, 7.21 (n = 29) the second year, and 7.63 (n = 33) the third year after restoration (fig. 9). Of the 33 (66.7%) sites with more than 1 year of data, 22 had improved SVAP scores the year following restoration; however, only 17 (51.5%) maintained scores higher than the base condition for subsequent years (table 3). Baseline condition was classified as good (3), fair (7) and poor (7) for those sites with positive trends (table 3). The mean SVAP score for moderately disturbed reference sites remained relatively constant over the course of the study—6.86 (2000), 6.96 (2001), 6.65 (2002), and 6.65 (2003) (fig. 10). The mean SVAP score was also

Figure 9 Trend in mean SVAP and IBI scores for restored sites

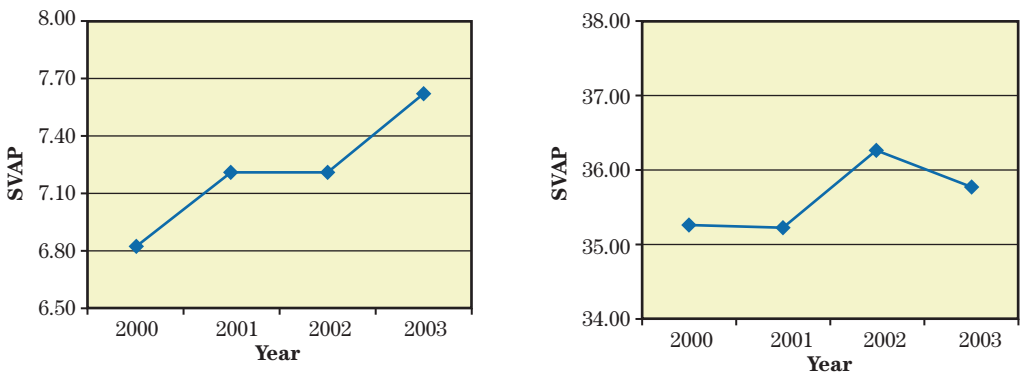


Figure 10 Trend in mean SVAP and IBI scores for less disturbed reference (n = 6), restored (n = 33), and moderately disturbed reference (n = 6) sites

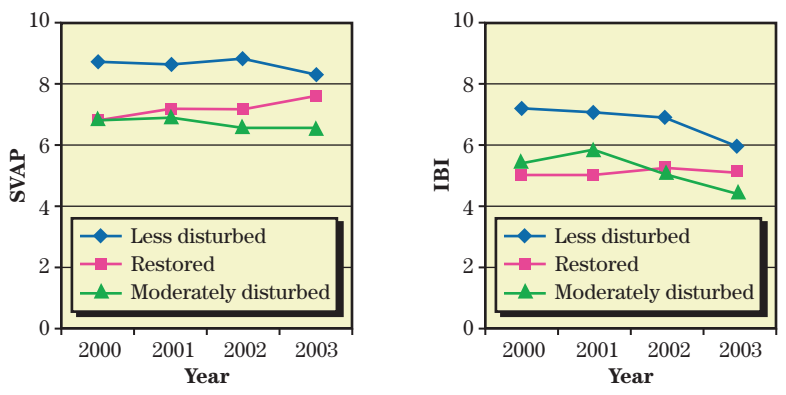


Table 3 IBI and SVAP scores for restored and reference sites over all years.

Site Name	IBI					SVAP			
Restored sites	**2000**	**2001**	**2002**	**2003**		**2000**	**2001**	**2002**	**2003**
Hughes @644[ab]	38	38	42	40		7.9	8.3	8.8	8.8
Hazel @644[b]	44	44	44	40		6.9	7.2	7.6	7.5
Hughes @707[b]	36	36	34	34		7.8	8.1	8.3	8.1
Thorn @620[b]	44	42	46	42		8.4	8.7	8.4	8.7
Thorn @522[b]	48	44	44	46		7.4	8.2	8.0	8.2
N Thorn @211	44	42	42	42		8.8	8.8	8.7	8.5
Racer @614[ab]	20	34	36	28		5.4	7.1	7.2	7.6
Keyser @614[ab]	30	38	42	34		6.3	7.6	7.1	8.0
Coving @622[b]	40	38	38	36		6.1	7.7	7.5	7.9
Hittles @522[ab]	28	28	34	34		5.9	6.3	7.7	7.5
Rapp @647	42	46	44	42		8.2	8.3	8.1	8.1
Thum @Basdn[ab]	36	38	42	40		7.0	6.9	7.1	7.5
Thum @736	44	44	42	40		9.0	8.7	8.5	8.2
Thum @Basup	44	40	42	36		6.1	7.1	7.3	5.7
Hungry @632	36	34	26	18		6.8	7.5	7.2	5.8
Little @632	22	26	26	22		6.5	6.5	6.9	6.4
Plum @50[ab]	24	28	38	34		6.1	6.6	7.2	7.0
Panth @Slater[b]	42	40	38	38		7.6	7.9	8.1	7.8
N Goose @782	32	30	38	32		7.3	7.3	7.7	7.1
Catoc @287[ab]	30	30	32	40		7.7	8.6	7.7	8.4
Devils @522[a]		36	40	38			5.2	5.0	6.5
Hazel @522		42	42	32			8.3	8.4	7.7
Marsh @Ott		24	22	20			5.9	5.8	5.9
Harper @Ott		34	36	32			6.9	6.8	6.4
W Thum @688		32	32	32			5.1	4.9	5.3

a = increasing IBI trends
b = increasing SVAP trends

Table 3 IBI and SVAP scores for restored and reference sites over all years (cont.)

Site Name	IBI					SVAP			
Restored sites	**2000**	**2001**	**2002**	**2003**		**2000**	**2001**	**2002**	**2003**
W Thum @729		34	32	32			6.0	5.7	5.2
Slate @653[b]		24	20	30			3.4	4.0	4.1
Cathar @704		42	36	36			7.5	7.6	6.7
N Goose @611[ab]		28	30	32			5.6	7.0	6.2
Hazel @231[ab]			32	38				5.5	6.9
Jordan @Farms			46	40				8.5	8.1
Turk @Spring			40	28				7.4	6.9
Indian @229[b]			32	32				6.2	7.0
Water @611				28					5.5
Rapp @Baer				36					8.3
Broad @746				24					5.0
Reference Sites									
Less disturbed									
Coving @626	42	44	46	38		9.3	8.9	9.4	8.9
Thorn @626	44	44	44	40		9.0	8.6	8.7	8.4
Jordan @637	48	48	46	44		8.3	8.8	8.4	8.9
Rapp @W'loo	48	50	48	44		8.6	8.8	8.7	8.1
Thorn @628	48	42	42	34		8.1	8.4	8.8	7.6
Goose @50	48	46	44	40		8.9	8.7	8.9	8.3
Moderately disturbed									
Cedar @602	38	42	44	38		7.0	7.3	7.5	7.9
Turkey@ 602	40	40	40	40		7.5	7.5	7.4	7.3
Mill @605	46	36	38	34		6.6	6.9	6.2	6.9
Bull @R Park	46	46	30	26		8.4	8.4	8.1	7.0
Horner @691	18	32	24	24		4.9	4.6	4.2	4.1
Carter @691	36	40	36	32		6.8	7.1	6.5	6.7

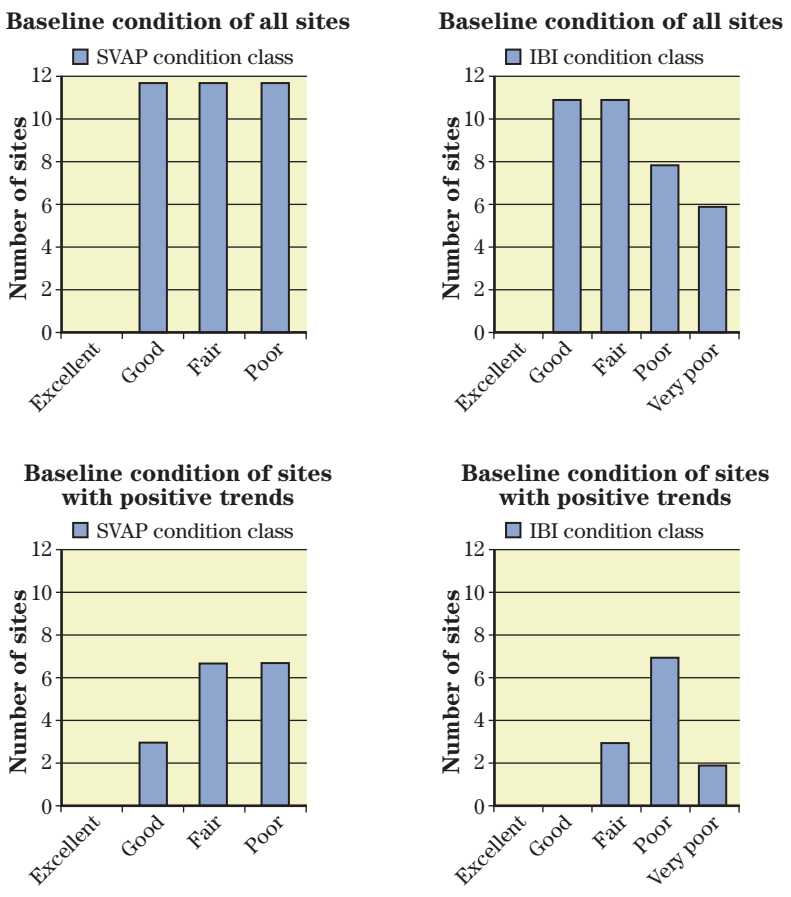
a = increasing IBI trends
b = increasing SVAP trends

relatively constant for less disturbed reference sites except for 2003 when a slightly downward trend was observed—8.7 (2000), 8.7 (2001), 8.82 (2002), and 8.37 (2003) (fig. 10). Of the 17 sites with positive SVAP trends, 13 (76.5%) had smaller than average drainages (< 53.8 km^2, 2.28 mi^2). Size and length of the riparian buffer had no effect on response of the SVAP.

IBI

The mean IBI score for restored sites increased from a baseline of 35.27 to 35.33 (n = 20) the first year after restoration, increased to 36.28 (n = 29) the second year after restoration, and decreased to 35.8 (n = 33) the third year after restoration (fig. 9). Of the sites with more than 1 year of data, 14 (42.4%) had improved IBI scores the year after restoration; however, only 10 (30.3%) maintained scores higher than the baseline condition for subsequent years (table 3). Of the 10 sites with positive IBI trends, 8 (80%) had smaller than average drainages (< 53.8 km^2, 32.28 mi^2). Baseline condition for those sites with positive IBI trends was classified as fair (3), poor (5), and very poor (2) (fig. 11). Regressions in SVAP and IBI post-restoration scores showed a positive relationship for all years, with r^2 = 0.33, 0.40, and 0.08 for the years 2000 to 2003, 2001 to 2003, and 2002 to 2003, respectively. The mean IBI score for moderately disturbed reference sites displayed a slightly downward trend over the course of the study—37.33 (2000), 39.33 (2001), 35.33 (2002), and 32.33 (2003) (fig. 10). The trend for the mean IBI score was also slightly downward for less disturbed reference sites—46.33 (2000), 43.67 (2001), 45.0 (2002), and 40.0 (2003) (fig. 10). Log normal regression comparisons of the IBI between restored sites with at least 3 years data and nearby paired, less-disturbed reference sites revealed that 20 out of 28 restored sites had slopes that were more positive than their paired refer-

Figure 11 Distribution of baseline condition classes for all restored sites vs. baseline condition classes for those restored sites with positive post-restoration trends



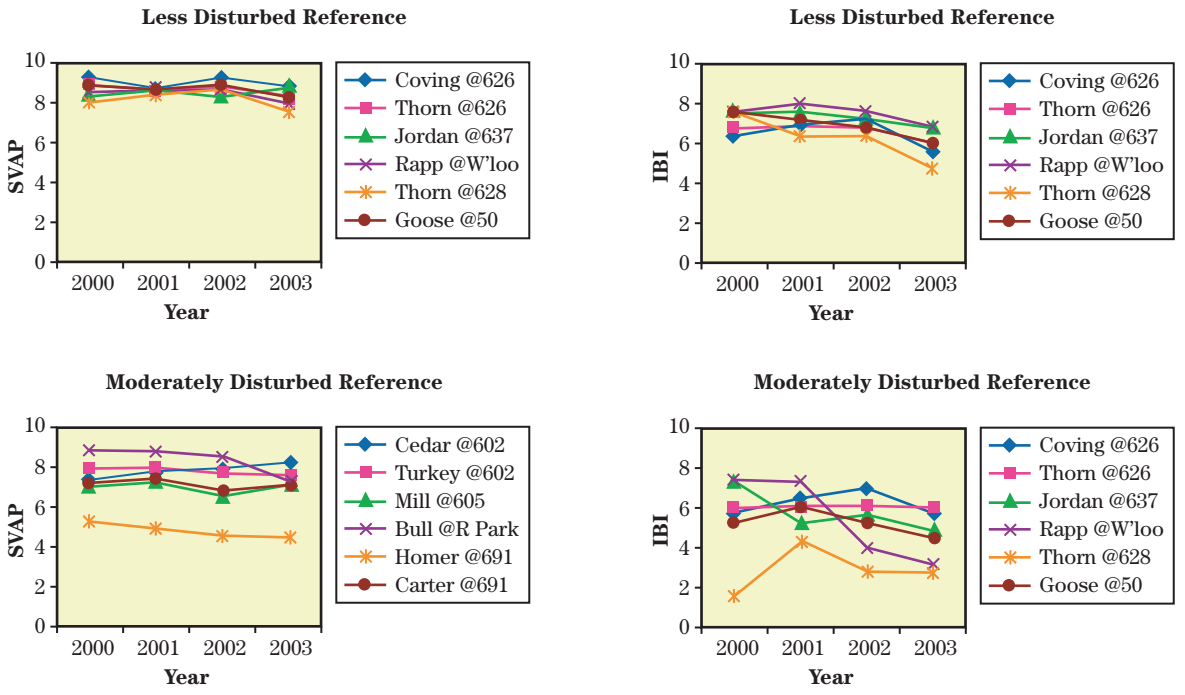
ence sites. This indicates that buffer sites showed a more positive trend in the IBI score than nearby reference sites ($p < 0.05$). Positive IBI response tended to come from highly disturbed sites with small, relatively undisturbed drainages.

Discussion

Ecological functions of riparian vegetation

An intact naturally vegetated riparian zone is widely held to be critical for proper functioning stream ecosystems (Kauffman et al. 1997; Sweeny 1992). Streamside buffers provide shade, ameliorating the effects of summer heating, thus reducing stress to organisms sensitive to high temperatures and low oxygen concentrations. Woody material from trees and fallen logs provides cover for aquatic organisms and influences the development of channel morphology. Leaf litter and organic debris supply a source of energy to the aquatic food web. Riparian vegetation regulates the transport of sediment and moderates inputs of nutrients and other pollutants from urban and agricultural sources. Riparian vegetation slows down the flow of water and absorbs precipitation, reducing downcutting of streambeds and streambank erosion; thus, reducing the delivery of sediment that obliterates the clean gravel surface needed for spawning habitat by many species.

Figure 12 Relative variation in SVAP and IBI trends from less disturbed and moderately disturbed reference sites



Comparison in trends between restored and reference streams

According to Karr and Chu (1997), aquatic assessments must have a standard, or reference condition, against which the conditions at one or more sites can be evaluated. Traditionally, reference conditions have been set by sampling the biological and physical characteristics of least-disturbed streams. Such reference is important in defining the attainable conditions for impaired streams; however, defining the condition of highly disturbed sites may be equally important, especially for assessments that focus on the effects of practices designed to restore the aquatic condition of impaired streams. Without such reference there would be no way of determining if observations at restored sites were the result of the designed practices, chance, or other influences.

Restored and moderately impaired reference sites had nearly identical SVAP baseline means; however, the SVAP trend remained relatively constant at moderately disturbed reference sites while increasing at restored sites (fig. 10). Likewise restored and moderately impaired reference sites had similar IBI baseline means; however, the trend for restored sites remained relatively constant while it decreased somewhat at both less-disturbed and moderately disturbed sites. Log normal regression comparisons of the IBI between restored sites with at least 3 years data and their nearest (paired) less-disturbed reference site revealed that 20 out of 28 restored sites had slopes that were more positive than their comparisons (see appendix for chart comparisons of each restored site with its paired reference). These comparison data suggest that buffer establishment is having a positive effect on fish community structure.

As expected, mean SVAP and IBI baseline scores from less-disturbed reference sites were higher than those from restored and moderately disturbed reference sites (fig. 10). In addition, SVAP and IBI trends at less-disturbed reference sites were much less variable than at moderately disturbed sites (fig. 12). The stability in IBI trends for the less-disturbed reference sites is consistent with several studies that have observed that as the IBI increases, its variance decreases (Karr et al. 1987; Steedman 1988; Rankin and Yoder 1990; Yoder 1991). Karr and Chu (1997) observed that highly variable trends in the IBI may be an early warning sign of excessive human disturbance. The less-disturbed reference sites selected for this study appear to be good candidates for establishing reference conditions that the restored sites can be expected to attain. Given adequate response time, SVAP and IBI scores for restored sites should approach those of their nearby less-disturbed reference sites. If they do not, then individual SVAP assessment elements and IBI metrics should be examined to identify those lacking positive trends, which may help to determine why certain projects are not achieving otherwise seemingly attainable goals.

Factors affecting aquatic response

Watershed-wide vs. local variables

Consistent with the findings of many other studies (Schlosser 1982; Matthews 1987; Roth et al. 1996), this study found that the biological integrity of the fish assemblage, as measured by the IBI, was directly correlated to the physical attributes of stream reaches ($r = 0.70$) (fig. 7). Regressions of baseline variables for land use/cover and the SVAP against IBI baseline scores demonstrated that the SVAP accounted for practically all of the IBI variation at restored sites ($r^2 = 0.50$, s.e. = 5.58). This finding is consistent with a Wisconsin study (Wang et al. 1997) that found grazing riparian areas had removed bank grasses and woody vegetation, resulting in higher stream temperature and loss of overhanging cover for fish. For those sites, they concluded that local impairments influenced the IBI more than broader, watershed-wide impacts. However, our findings contrast with those of Roth et al. (1996) and others (Karr and Schlosser 1978; Steedman 1988) who found stream biotic integrity to be more strongly influenced by broad land-use patterns, such as the proportion of a watershed in agriculture. Because the restored sites in this study tended to be degraded (before buffer establishment, lands had to be grazed or cropped to be eligible for enrollment in the programs), local condition probably had a greater influence on most sites than broader landscape features.

Effects of degradation

Positive response to restoration measures was most evident at the most degraded sites (e.g., those with low baseline scores) (fig. 11). Of the 17 sites with positive SVAP trends (sites with scores for all post-restoration years equal to or higher than the baseline condition), 14 (82.4%) had baseline scores classified no better than fair. Similarly, for the IBI, all 10 sites with positive post-restoration trends had baseline scores classified no better than fair (table 3; fig. 11). These results suggest that a positive response in aquatic condition can be most expected at sites that are the most impaired prior to buffer establishment.

Alignment between SVAP and IBI response

There appears to be a close relationship in the response of both the IBI and SVAP to buffer establishment, although their responses are not identical. Regressions in the changes between SVAP and IBI for sites with more than 1 year of data after restoration demonstrated a positive relationship (r^2 = 0.33, 0.40, and 0.08 for the years 2000 to 2003, 2001 to 2003, and 2002 to 2003, respectively). When just the sites with positively trending IBI scores were examined (sites with scores for all post-restoration years equal to or higher than the baseline condition), an even closer relationship is observed. At the 10 sites with positive IBI trends, a similar trend was observed in the SVAP in all but one site. This finding indicates that, at least for certain sites, aquatic condition (as measured by the IBI) is improving concurrently with the physical recovery of the stream (as measured by the SVAP).

Whereas the SVAP and IBI response were closely aligned at some sites, for others they were not. At those sites, additional time may be needed before physical or biological responses to buffer establishment can be measured by the SVAP or IBI. For example, even though trees have been successfully planted, seedlings are currently small and contribute little to the restoration's effects. According to Sweeney (2002), achieving full canopy closure from tree planting in the mid-Atlantic region can take as long as 15 years. Physical restoration responses, such as improved fish cover and invertebrate habitat, may require even longer periods. Additional time may be necessary for the biological processes that influence the structure and composition of fish assemblages to recover enough to effect measurable change in stream fauna. Several reproductive cycles may be necessary before changes are evident in metrics, such as number of late-maturing species and percent specialist carnivores. Because of the lag in response, it is understandable that the biological metrics of the IBI would not show signs of recovery as quickly as the physical measures of SVAP. Therefore, the lack of alignment between the SVAP and IBI observed at certain sites in this study is not altogether surprising. In view of the study's timeframe, it may be more surprising that corresponding trends were observed at any of the sites.

Effects of scale

According to Roth et al. (1996), the functional benefits of riparian vegetation within a watershed are likely to be scale-dependent. At the local scale, riparian vegetation can influence instream habitat by providing shade and inputs of organic matter and wood, and can aid in maintaining local bank and channel stability. However, the extent of riparian cover over some much larger spatial scale must be of greater importance to overall stream nutrient and sediment inputs, water temperature, energy sources, and flow regime. Because the SVAP is designed to account for physical changes at the local scale, continued improvements in the SVAP are expected for sites where local stressors (e.g., livestock) have been removed and riparian vegetation is allowed to recover. However, because the IBI integrates upstream influences, IBI scores may not respond to the effects of local restoration at sites with degraded watersheds unless the upstream problems are addressed. Observations of land use patterns and other watershed-wide influences associated with sites where IBIs do not respond to local restoration actions may provide useful insight for targeting buffer projects from areas that are less likely to improve stream biological conditions. Likewise, examining the land use patterns above successful projects may help target projects to locations that are most likely to be successful.

Urban impacts

Although watershed land use patterns did not influence the IBI as much as local conditions over all the restored sites, there was some correlation (fig. 7). Baseline IBI scores corresponded negatively to percent cropland and percent pasture (r = - 0.38 and - 0.16, respectively) and positively to percent non-agricultural land (r = 0.31). The IBI also responded negatively to land use development patterns. Most of the restored sites are located to the west and to a large degree outside of the influence of the Washington, D.C. suburbs. However, in the rapidly developing Occoquan Watershed, dramatic declines in the SVAP and IBI were observed in at least one restored site (Cathar @704) (fig. 13). Sediment-laden water was frequently observed at the site, resulting primarily from land-use disturbances associated with upstream housing developments. Similar declines in the SVAP and IBI were noted at the nearest moderately disturbed reference site (Bull @R Park). In 1997, the Bull @R Park site was found to exhibit very high scores for both the SVAP (8.3—good) and IBI (50—excellent) (Teels and Danielson 2001). However, by 2003 the site's SVAP score had declined to 7.0 (fair), and the IBI score had dropped to 26 (poor). Similarly, in the 3 years of this study, the SVAP score for Cathar @704 declined from 7.5 (good)

to 6.7 (fair), and the IBI score dropped from 42 (good) to 36 (fair), despite the restoration that occurred in the spring of 2002 (see appendix A28).

Influence of stream size

The importance of small streams in sustaining the physical, chemical, and biotic integrity of our Nation's water is becoming increasingly clear (Sweeney 1992; Gomi et al. 2002; Meyer et al. 2003). Leopold (1964) concluded that streams in need of riparian restoration generally are small (first through third order). The size of streams restored in this study varied greatly (stream drainage area = 7.3—216.1 km^2, 134.3 mi^2; mean = 53.8 km^2, 33.4 mi^2). However, we observed that the greatest restoration response tended to come from streams smaller than the mean (< 53.8 km^2, 33.4 mi^2). Of the 17 restored sites that showed positive trends in SVAP scores (sites with scores for all post-restoration years equal to or higher than the baseline condition), 13 (76.5%) were on first or second order streams with smaller than average drainage areas. Similarly, 8 (80%) of the 10 sites with positive IBI trends were on smaller than average streams (table 4). The combination of high site disturbance with low upstream influence (that does not overwhelm the effect of the restoration) seems to be important in generating a positive restoration response.

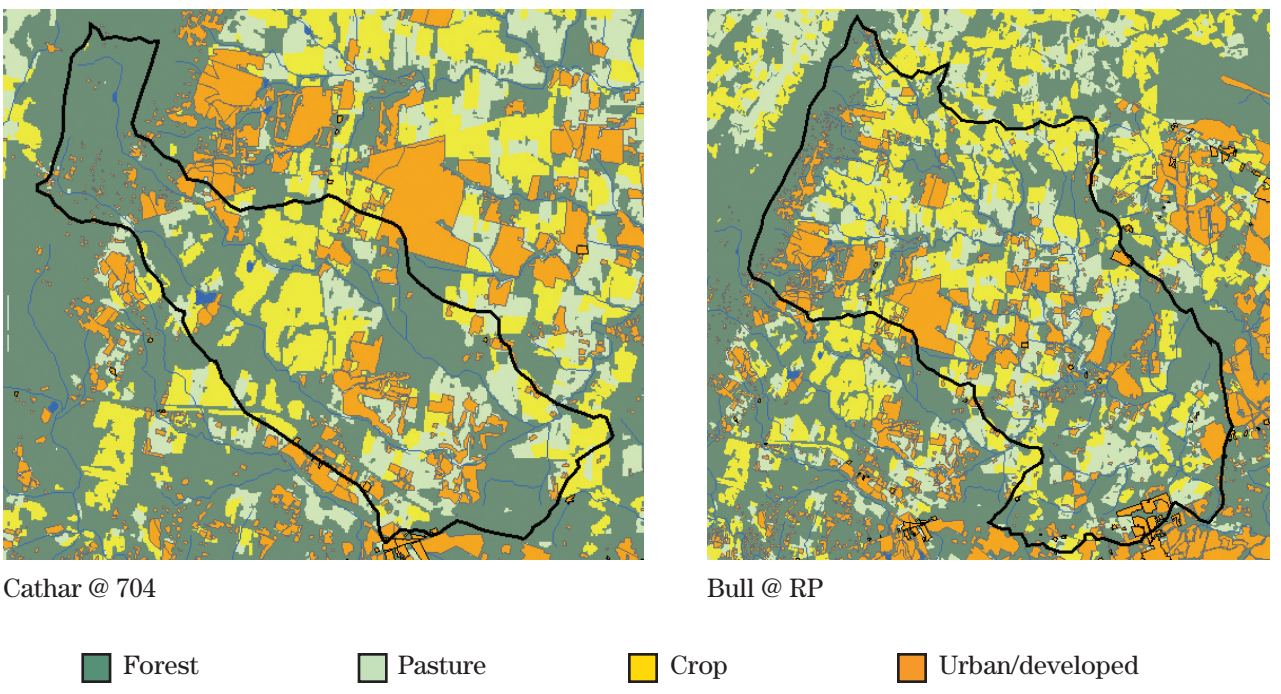
Impacts of livestock grazing

Of the 36 sites that qualified for buffer programs, 32 (88.9%) did so based upon the impacts of grazing. Livestock grazing has been the most prevalent cause of ecological degradation for many riparian ecosystems across the nation (Kaufmann and Krueger 1984; Kauffman 1988; Fleischner 1994). After extensive field reviews of fish habitat improvement projects in eastern Oregon, Beschta et al. (1991) concluded that the cessation of livestock grazing in riparian zones was the single most ecologically effective approach to restoring aquatic habitats. In central Oregon, Busse (1989) found a lack of willow and cottonwood reproduction in grazed riparian zones. After constructing corridor fencing, she recorded a widespread and rapid rate of willow and cottonwood establishment. Likewise,

Table 4 Distribution of restored sites with positive SVAP or IBI trends in relation to watershed size

	Positive trend	
	SVAP	**IBI**
Number < Average watershed size	13	8
Number > Average watershed size	4	2
Total	17	10

Figure 13 Extent of urban/developed land at Cathar @704 and Bull @R Park (NVRDC 2000)



in this study exclusion of livestock stimulated rapid growth in natural riparian vegetation on most sites within 1 year of fencing (see cover illustration). This observation was supported by an increase in SVAP scores for 22 of the 36 sites within the first year of restoration, and, as previously noted, 17 of those sites maintained scores higher than their baseline condition throughout the course of the study. Although many of the SVAP assessment elements responded positively, those most responsible for increasing SVAP trends were manure reduction and streambank stability. Those two elements contributed to increasing SVAP trends in 14 of the 17 cases. Other assessment elements that frequently contributed to increasing SVAP trends were canopy cover and water appearance, which increased in 9 of the 17 cases.

Prior to restoration, the adverse impacts of manure were evident at all grazed sites. In most instances, animal droppings were observed in the stream, on the streambank, and on the adjacent flood plain. Foul smell, off color, and algal blooms were commonly recorded on grazed streams. In the course of fish sampling, it was not uncommon to seine up dung before livestock were excluded.

The most apparent cause of unstable streambanks was livestock grazing. Livestock paths leading to and from the streams were responsible for streambank erosion, sloughing of channel banks, and sedimentation of streambeds. However, upstream disturbances are at least partly responsible for those observations and may be exacerbating the impacts of grazing.

The response of canopy cover to restoration measures was highly variable. As previously described, most of the effects of tree planting have yet to occur. However, nine sites responded to livestock exclusion with rapid growth of woody and herbaceous vegetation that had been formerly suppressed by grazing. At some sites streambank vegetation responded rapidly to provide shade, bank stability, and cover for fish and wildlife within a year of fencing (see cover illustration).

Metric response to physical changes

A number of studies have used fish IBIs to reveal the effects of a broad array of human activities on water quality. In Illinois, for example, Karr et al. (1986) found that IBIs were lowest at sites where cultivation reached the streamside and stream channels had been dredged and straightened, and IBIs were higher at sites with vegetated riparian zones and where the natural stream channel was intact. In the Pacific Northwest, logging and urbanization have been shown to produce lower IBI scores (Kleindl 1995, Fore et al. 1996). However, an important use of the IBI is not only to portray water quality problems and causes of impairment, but to serve as a measure of the effectiveness of practices designed to improve water quality. For example, on the Scioto River in Ohio, construction and operation of an advanced wastewater treatment facility resulted in dramatic improvements in dissolved oxygen, ammonia-N, and common heavy metals that were followed by a positive response in the IBI that confirmed the effectiveness of the wastewater treatment improvements (Yoder and Smith 1999).

In this study, riparian buffer establishment increased streambank cover, improved water appearance, and decreased sedimentation, manure, and nutrients. These changes were illustrated by SVAP at the 17 sites with positive SVAP trends (sites with scores for all post-restoration years equal to or higher than the baseline condition detected at 17 restoration sites). In response, the IBI displayed positive trends at 9 of those 17 sites. Although several metrics contributed to the positive IBI trends, percent tolerant individuals was the metric most frequently responsible, responding positively in seven of the nine cases. Other metrics that frequently contributed were percent lithophilic spawners minus tolerant species and percent of the dominant species, which both increased in six of the nine cases. Although the precise mechanisms for the positive IBI response is not fully understood (whether the diverse foods of trophic specialists have been restored, whether spaces between gravel substrates have been cleared enabling lithophilic spawning, whether oxygen related stress has been reduced for intolerant species, or the combination of these and other factors), the empirical pattern is clear—that specific metrics are responding in a predictable fashion to improvements in the local environment that are brought about by the restoration.

Ecosystem resiliency and the need to factor in time

In evaluating the success of buffer establishment, it is important to understand the response of riparian ecosystems to human perturbations, as well as the capacity of sites to recover after removal of the problem-causing activities (Kauffman et al. 1997). For example, severe disturbances (e.g., channelization, clearcutting, dams) may sufficiently alter some riparian ecosystems such that recovery is unattainable or may take as long as 50 years (Detenbeck et al. 1992). On the other hand, because some disturbances are less damaging and some ecosystems more resilient, cessation of the disturbances may be all that is necessary for some sites to respond. As described, most of the initial improvements observed in this study are due to the restriction

of grazing and not the effects of tree planting. This illustrates the inherent resilience of these riparian areas and their ability to respond to passive restoration measures, such as stream fencing.

Although many sites in this study show no measurable signs of recovery, it is quite possible that they will eventually. The 4 years entailed by this study can only address the beginning stages of restoration and point out some factors that may be causing initial responses. The physical conditions of restored sites and corresponding SVAP scores are expected to improve with time, as are the IBI scores for most sites. Although the timeframe of this study is longer than most, it points out the temporal nature of most attempts to measure ecological response and the need to observe restoration over longer periods.

Conclusion

According to the National Research Council (1992), complex ecosystems and associated habitat features cannot be created via simple and artificial construction of selected components. Effective ecological restoration must take a holistic approach that embraces natural ecological processes rather than focusing on isolated manipulations of individual elements. The establishment and maintenance of riparian buffers as a management technique ensures that several functions of the stream ecosystem will be provided. However, the integrity of most streams is influenced by complex human activities that alter the hydrology, morphology, and biology of stream, riparian, and upland ecosystems. Simple solutions, such as buffer establishment, cannot alone be expected to protect the stream from adverse human impacts that occur at a broader scale (Leavitt 1998). Therefore, riparian restoration should be planned and carried out in concert with other conservation practices at a watershed scale to provide a more comprehensive solution to water quality problems and maximize the many other benefits that buffers provide.

Riparian zones are rich ecosystems in terms of biological diversity, biogeochemical processes, and productivity. The maintenance of intact riparian ecosystems and the restoration of degraded ones are important to local, regional, and global societies as well as to future generations (Kauffman et al. 1997). In this study, the attributes of healthy riparian and aquatic ecosystems were defined prior to the study, and the success of restoration projects were assessed in the context of those attributes. The following summarizes the more significant observations and recommendations.

- For effective riparian buffer establishment, the attributes of healthy riparian zones and aquatic condition should be defined using integrative assessment techniques (e.g., the SVAP and IBI) to establish baseline condition for comparing sites or evaluating restoration success.
- For certain sites in this study, aquatic condition (as measured by the IBI) is improving concurrently with the physical recovery of the stream (as measured by the SVAP). This observation is an important indication that some buffer projects are achieving their intended objectives. Examining land use patterns in successful projects may help target buffer projects to locations that are most likely to benefit the environment.
- The lack of response in the IBI to local physical improvements at some sites may indicate that aquatic condition may be controlled more by landscape factors than by local riparian restoration actions. Observations of watershed land use patterns from such sites may provide information useful in targeting buffer projects away from sites that are less likely to benefit the environment.
- For certain sites, an adequate response time may be needed before restoration improvements can be detected. Therefore, judgment on the success of riparian restoration projects should not be hurried.
- Dramatic declines in SVAP and IBI scores were observed at both restored and reference sites located in urbanizing areas. This illustrates the need to consider upstream influences in the site selection process.
- The greatest restoration response tended to come from smaller streams. The combination of high site disturbance with lesser degrees of upstream influence (that do not overwhelm restoration response) seems to be important in producing positive restoration response.
- Consistent with many other studies, exclusion of livestock stimulated rapid growth in natural

riparian vegetation at most restored sites within a year of fencing. Although many of the SVAP assessment elements responded positively to livestock exclusion, those most responsible for increasing SVAP score trends were manure reduction and streambank stability.

- Positive trends in aquatic condition occurred at some sites due to fencing alone. Partial recovery at such sites point to the resilience of riparian vegetation and the importance of livestock exclusion.
- The physical conditions, and corresponding SVAP scores, of restored sites are expected to continue improving with time as will the IBI scores for some sites. Although the timeframe of this study is longer than most, it points out the temporal nature of most attempts to measure ecological response and the need to observe restoration over longer periods.
- Simple solutions, such as maintenance of a riparian buffer, cannot alone be expected to protect the stream from adverse human impacts that occur at a broader scale. Therefore, riparian restoration should be planned and carried out in concert with other conservation practices at a watershed scale to provide a more comprehensive solution to water quality problems and maximize the many other benefits that riparian buffers provide.

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Appendix A

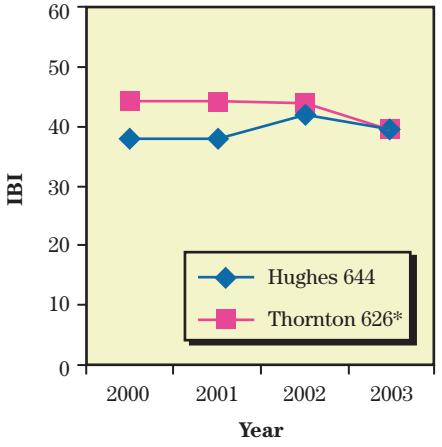
Site Descriptions and Data

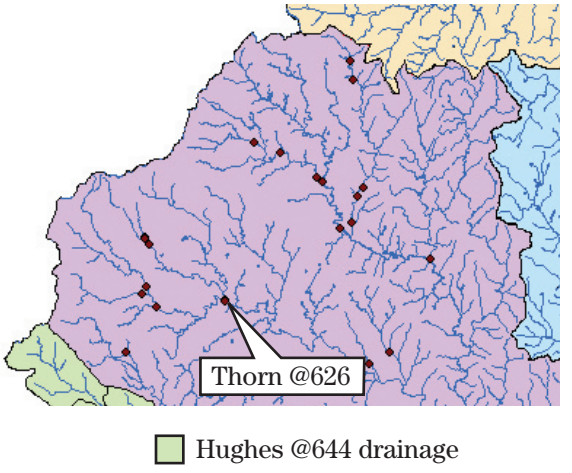
Appendix A1—Hughes River @644, Rappahannock Co., VA

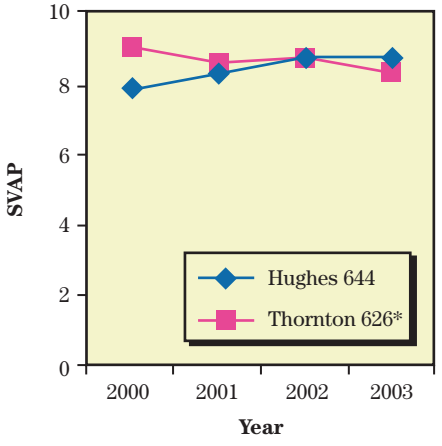
Basis qualified: Grazing
Restored: Spring 2001
Size: 119.7 km^2
Baseline SVAP: 7.9 (Good)
Baseline IBI: 38 (Fair)
Upstream land use
- Cropland %: 8.5
- Pasture %: 18.1
- Non-ag %: 73.5
- Urban/disturbed %: 0.79

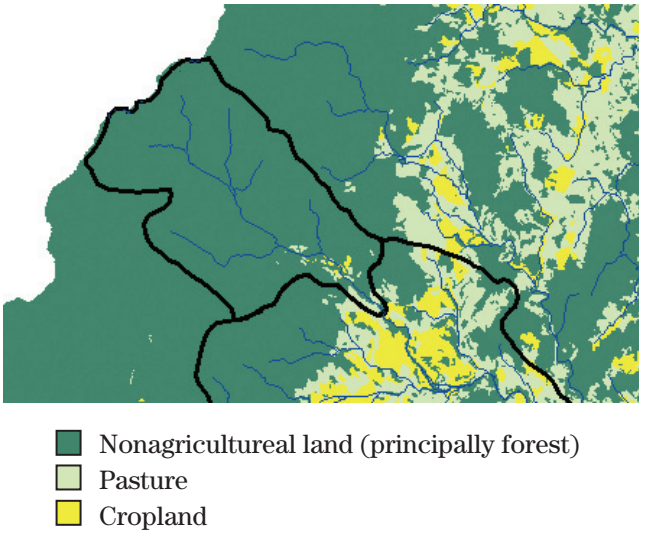
Buffer area (ha): 10.1
Buffer length (m): 1,277.7

IBI and SVAP trends for Hughes @644 and its paired less-disturbed reference, Thorton @626.









Appendix A1—Hughes River @644, Rappahannock Co., VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				1
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				3
Roseyside dace				
Fallfish	36	21	20	5
Creek chub	1	25	12	22
River chub	3	31	11	23
Bluehead chub		6	26	20
Cutlips minnow				2
Blacknose dace		6		6
Longnose dace	21	10	8	19
Central stoneroller				
Eastern silvery minnow				
Common shiner	12	12	54	17
Satinfin shiner	171	256	115	219
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner	2	2		2
Spottail shiner				
Swallowtail shiner		8	30	19
Roseyface shiner	12	48	87	42
Silverjaw minnow		2		
White sucker	3	1		2
Creek chubsucker				
Northern hogsucker	1	2	3	
Torrent sucker	1	1		
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead		1		
Margined madtom	1	1	1	
Banded killifish				
Eastern mosquitofish				
Mottled sculpin	13	6	4	15
Potomac sculpin				
Redbreast sunfish	7	7	7	38
Green sunfish	7	6	14	14
Pumpkinseed				1
Bluegill		1	2	2
Redear sunfish				
Rock bass	16	17	13	10
Black crappie				
Smallmouth bass	6	1	6	
Largemouth bass				
Shield darter	1			
Stripeback darter				
Tesselated darter	12	12	12	58
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total	**326**	**483**	**425**	**540**
Anomalies	1			1

American brook lamprey, a rarely encountered, late-maturing, intolerant species, collected at Hughes @644.

Satinfin shiner, the dominant species in all years of sampling at Hughes @644.

Appendix A1—Hughes River @644, Rappahannock Co., VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	15	1	19	3	14	1	18	3
# darter species	2	3	1	1	1	1	1	1
# minnow species	8	1	12	3	9	3	13	3
% dominant species	0.525	1	0.530	1	0.271	3	0.406	1
# intolerant species	4	5	3	5	3	5	3	5
% tolerant individuals	0.034	5	0.085	5	0.066	5	0.085	5
% omnivores	0.012	5	0.021	5	0.061	5	0.041	5
% benthic invertivores	0.150	3	0.064	1	0.066	1	0.170	3
% specialist carnivores	0.199	3	0.097	3	0.108	3	0.098	3
% simple lithophils	0.153	1	0.172	1	0.428	5	0.183	1
# late maturing species	5	5	7	5	4	5	4	5
% anomalies	0.003	5	0.000	5	0.000	5	0.002	5
IBI		**38**		**38**		**42**		**40**

SVAP element ratings

SVAP elements	**2000**	**2001**	**2002**	**2003**
Channel condition	8.7	8.7	9.0	8.3
Hydrologic alteration	9.0	8.3	8.7	8.3
Riparian width	4.0	4.7	6.0	7.3
Bank stability	4.3	7.3	7.7	8.3
Canopy cover	8.3	5.3	10.0	9.0
Water appearance	8.3	9.0	8.0	7.7
Nutrient enrichment	8.3	7.7	8.7	7.3
Manure presence				
Fish barriers	9.3	9.7	10.0	10.0
Fish cover	9.0	9.0	9.3	9.0
Pools	8.3	7.3	7.3	9.3
Riffle quality	8.7	8.3	7.7	7.0
Invertebrate habitat	8.7	9.3	9.0	9.0
Invertebrates observed	7.7	13.0	13.3	13.7
SVAP	**7.9**	**8.3**	**8.8**	**8.8**

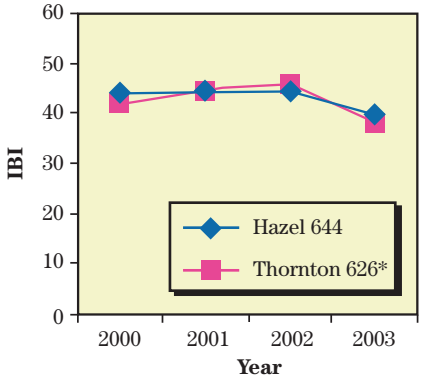
Site notes:

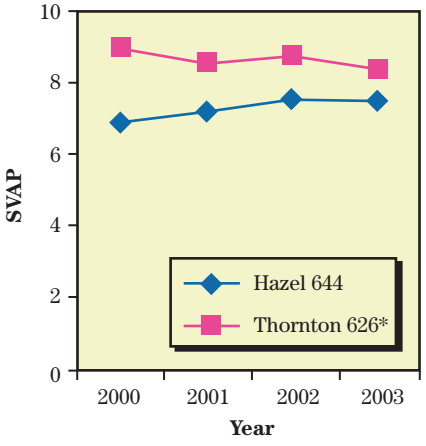
Hughes @644 has a large, relatively undisturbed drainage, beginning at the Blue Ridge summit. The site's overall appearance was good prior to restoration; however, both SVAP and IBI scores have improved somewhat since buffer establishment. Prior to restoration, the site was lightly grazed with some livestock-induced streambank erosion; however, no manure was observed in or near the stream. The site possesses a narrow band of relatively mature trees (about 3 m wide) along most of its course, providing canopy cover and other riparian functions. Hughes @644 and Hazel @644 are parts of a single project located at the Hazel/Hughes confluence, owned by a single landowner.

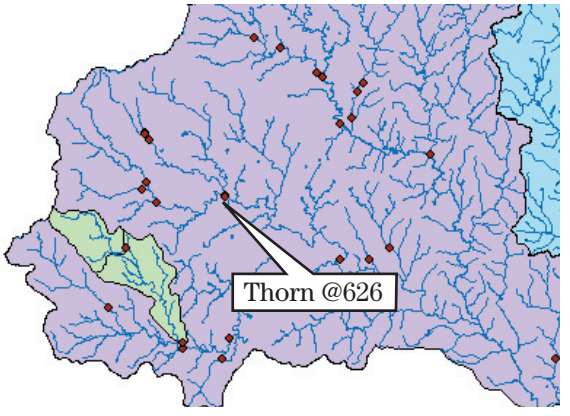
Appendix A2—Hazel River @644, Rappahannock Co., VA

Basis qualified: Grazing
Restored: Spring 2001
Size: 61.5 km^2
Baseline SVAP: 6.9 (Fair)
Baseline IBI: 44 (Good)
Upstream land use
  Cropland %: 5.0
  Pasture %: 23.0
  Non-ag %: 72.0
  Urban/disturbed %: 0.44
Buffer area (ha): 10.4
Buffer length (m): 695.6

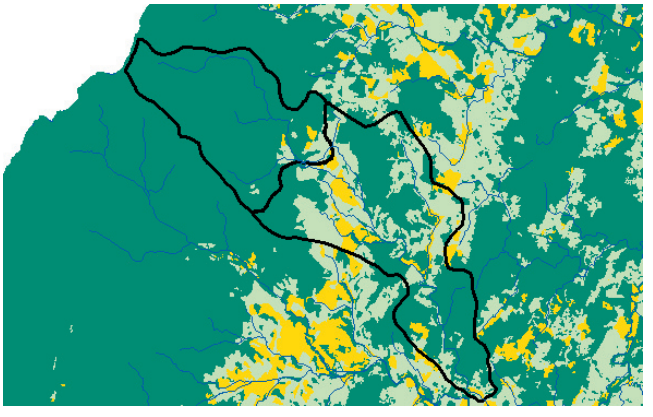
IBI and SVAP trends for Hazel @644 and its paired less-disturbed reference, Thorton @626.







Hazel @644 drainage



Nonagricultureal land (principally forest)
Pasture
Cropland

Appendix A2—Hazel River @644, Rappahannock Co., VA

Raw fish data

Common Name	2000	2001	2002	2003
American brook lamprey				1
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				1
Roseyside dace				
Fallfish	27	16	20	8
Creek chub		2	5	11
River chub	11	11	23	15
Bluehead chub	2	2	26	20
Cutlips minnow		2	1	
Blacknose dace		1		2
Longnose dace	15	10	18	28
Central stoneroller				
Eastern silvery minnow				
Common shiner	36	45	26	16
Satinfin shiner	159	149	122	197
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner	5	17	12	3
Spottail shiner				
Swallowtail shiner	9	16	20	19
Roseyface shiner	35	18	44	30
Silverjaw minnow		10		1
White sucker	2			2
Creek chubsucker				
Northern hogsucker	1	5	3	2
Torrent sucker		1	2	1
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom		1	1	2
Banded killifish				
Eastern mosquitofish				
Mottled sculpin	1	1		
Potomac sculpin				
Redbreast sunfish	19	7	9	5
Green sunfish	2	1	1	1
Pumpkinseed				
Bluegill	2	2		
Redear sunfish				
Rock bass	12	5	4	1
Black crappie				
Smallmouth bass	6	2	1	
Largemouth bass				
Shield darter	1	1	2	
Stripeback darter				
Tesselated darter	14	36	11	26
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total	**359**	**361**	**351**	**392**
Anomalies	5	1		

Northern hogsucker, a late-maturing, benthic invertivore collected each year at Hazel @644.

Shield darter, an intolerant, lithophilic, benthic invertivore, collected in 3 of 4 years at Hazel @644.

Appendix A2—Hazel River @644, Rappahannock Co., VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	15	3	16	3	16	3	18	3
# darter species	2	3	2	3	2	3	1	1
# minnow species	9	3	11	3	11	3	13	3
% dominant species	0.443	1	0.348	1	0.348	1	0.406	1
# intolerant species	3	5	3	5	3	5	3	5
% tolerant individuals	0.017	5	0.017	5	0.017	5	0.085	5
% omnivores	0.011	5	0.080	5	0.080	5	0.041	5
% benthic invertivores	0.089	3	0.100	3	0.100	3	0.170	3
% specialist carnivores	0.178	3	0.097	3	0.097	3	0.098	3
% simple lithophils	0.284	3	0.362	3	0.362	3	0.183	1
# late maturing species	4	5	5	5	5	5	4	5
% anomalies	0.014	5	0.000	5	0.000	5	0.002	5
IBI		**44**		**44**		**44**		**40**

SVAP element ratings

SVAP elements	**2000**	**2001**	**2002**	**2003**
Channel condition	7.0	6.3	8.0	5.7
Hydrologic alteration	6.7	6.7	5.7	5.7
Riparian width	5.3	3.7	5.0	5.3
Bank stability	2.0	3.0	2.7	4.0
Canopy cover	5.7	4.0	6.3	8.0
Water appearance	7.0	7.7	7.7	6.7
Nutrient enrichment	7.3	6.7	8.3	7.0
Manure presence				
Fish barriers	9.0	9.3	10.0	10.0
Fish cover	8.3	9.0	8.7	8.7
Pools	7.7	7.3	7.7	8.3
Riffle quality	7.0	7.7	7.7	7.0
Invertebrate habitat	8.7	9.3	8.3	8.7
Invertebrates observed	8.0	13.0	12.3	12.7
SVAP	**6.9**	**7.2**	**7.6**	**7.5**

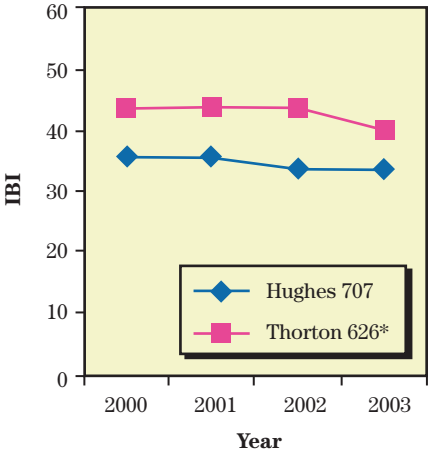
Site notes:

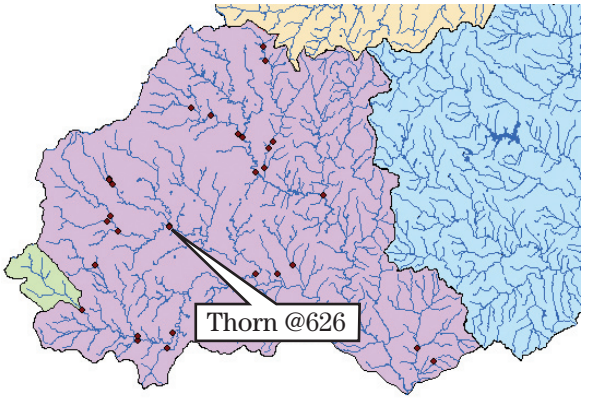
Hazel @644 is a stream with good water quality and instream structure; however, much of the reach has extreme streambank erosion, threatening the adjacent field and nearby County Road 707. Some sediment from the erosion has been deposited in the bed of the channel; however, most of it is being carried downstream. Grazing was light and did not appear to be a major influence prior to restoration. Fish and invertebrate habitat were good, and the site has maintained high IBI scores over all years of sampling. The upstream watershed is large, mostly wooded and in good condition. SVAP scores should continue to improve dramatically with development of the buffer and the protection of streambanks.

Appendix A3—Hughes River @707, Rappahannock Co., VA

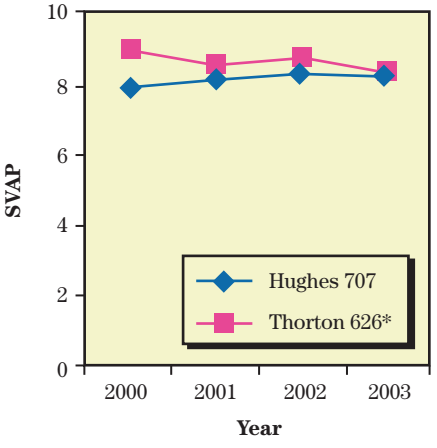
Basis qualified: Cropping
Restored: Spring 2001
Size: 44.25 km^2
Baseline SVAP: 7.8 (Good)
Baseline IBI: 36 (Fair)
Upstream land use
  Cropland %: 0
  Pasture %: 1.6
  Non-ag %: 98.0
  Urban/disturbed %: 0.05
Buffer area (ha): 19.2
Buffer length (m): 3,013.3

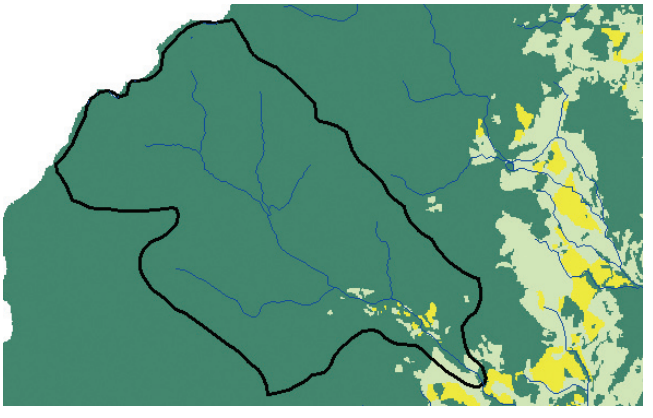
IBI and SVAP trends for Hughes @707 and its paired less-disturbed reference, Thorton @626.





Hughes @707 drainage





Nonagricultureal land (principally forest)
Pasture
Cropland

Appendix A3—Hughes River @707, Rappahannock Co., VA

Raw fish data

Common Name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace	11	3		1
Roseyside dace		17	7	8
Fallfish	3	1	5	1
Creek chub	4	14	1	3
River chub	21	31	17	16
Bluehead chub		5	4	
Cutlips minnow	1	3		3
Blacknose dace	4	141	108	140
Longnose dace	54	7	7	13
Central stoneroller				
Eastern silvery minnow				
Common shiner	41	46	98	178
Satinfin shiner		2	2	6
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow				
White sucker	3	2		
Creek chubsucker				
Northern hogsucker	1		1	
Torrent sucker	1	3	13	3
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom	1			
Banded killifish				
Eastern mosquitofish				
Mottled sculpin	11	12	12	25
Potomac sculpin				
Redbreast sunfish		1		
Green sunfish				
Pumpkinseed				
Bluegill				
Redear sunfish				
Rock bass	9	2	4	4
Black crappie				
Smallmouth bass	1	4	4	3
Largemouth bass			1	
Shield darter				
Stripeback darter				
Tesselated darter	9	21	2	26
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total	**175**	**315**	**286**	**430**
Anomalies	0			1

Torrent sucker, a recently introduced, benthic invertivore, appears to be quickly spreading to the upper most reaches of the Rappahannock Watershed (e.g., Hughes @707).

Giant stonefly larvae, an example of a Group I taxa, or intolerant species that are indicative of good water quality.

Appendix A3—Hughes River @707, Rappahannock Co., VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	12	1	14	3	12	1	11	1
# darter species	1	1	1	1	1	1	1	1
# minnow species	8	3	11	3	9	3	10	3
% dominant species	0.309	3	0.448	1	0.378	1	0.414	1
# intolerant species	2	3	1	3	1	3	1	3
% tolerant individuals	0.349	3	0.498	3	0.381	3	0.333	3
% omnivores	0.023	5	0.032	5	0.059	5	0.007	5
% benthic invertivores	0.149	3	0.127	3	0.077	1	0.149	3
% specialist carnivores	0.074	1	0.025	1	0.049	1	0.019	1
% simple lithophils	0.269	3	0.232	3	0.441	5	0.470	5
# late maturing species	5	5	4	5	4	5	2	3
% anomalies	0.000	5	0.000	5	0.000	5	0.002	5
IBI		**36**		**36**		**34**		**34**

SVAP element ratings

SVAP elements	**2000**	**2001**	**2002**	**2003**
Channel condition	5.3	5.3	7.0	5.3
Hydrologic alteration	7.3	7.7	7.3	7.3
Riparian width	4.7	5.3	6.0	6.7
Bank stability	4.0	7.3	6.3	7.3
Canopy cover	6.0	9.7	8.7	7.0
Water appearance	8.3	8.3	8.7	8.7
Nutrient enrichment	9.3	8.7	7.7	8.7
Manure presence				
Fish barriers	9.7	9.3	10.0	10.0
Fish cover	10.0	7.7	9.0	7.3
Pools	6.3	6.7	7.3	7.7
Riffle quality	8.0	8.7	8.7	8.3
Invertebrate habitat	9.0	8.3	9.0	7.7
Invertebrates observed	14.0	12.3	12.3	13.7
SVAP	**7.8**	**8.1**	**8.3**	**8.1**

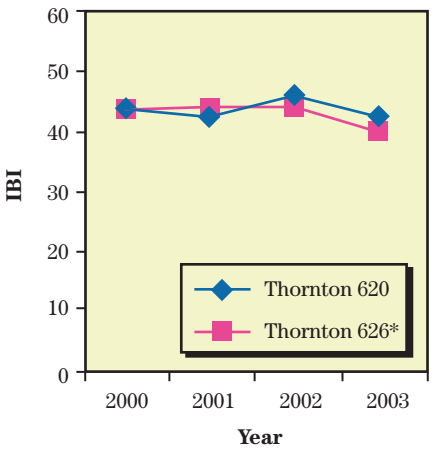
Site notes:

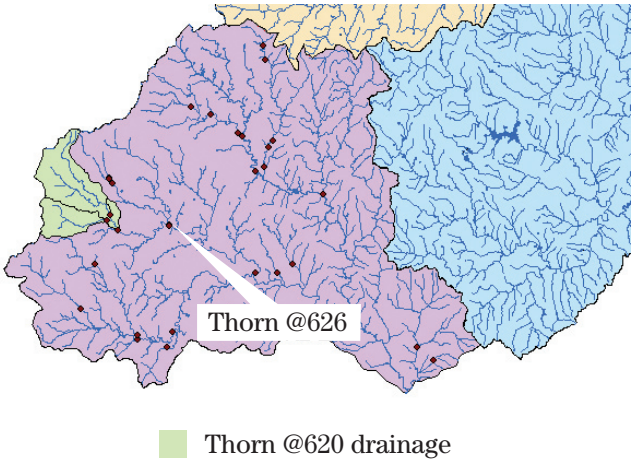
Hughes @707 is a medium-sized drainage with extremely good water quality. It is one of the few places where we commonly collected giant stoneflies, one of the region's most intolerant aquatic invertebrates. The project buffers the Hughes River and a small, unnamed tributary. The project is separated from the mainstem of the Hughes by a county road. The reach has a mix of protected and unprotected channel banks and is experiencing some streambank erosion, especially where the channel is near the road. SVAP scores are relatively high and improving despite the noted streambank erosion. However, IBI scores are only fair and have not improved over time. The streambank adjacent to the road may continue to be a problem if not treated, despite the establishment of the buffer.

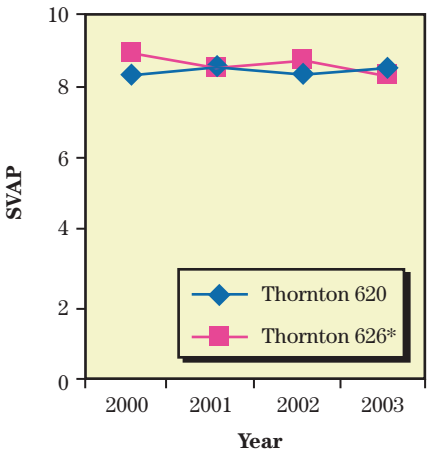
Appendix A4—Thornton River @620, Rappahannock Co., VA

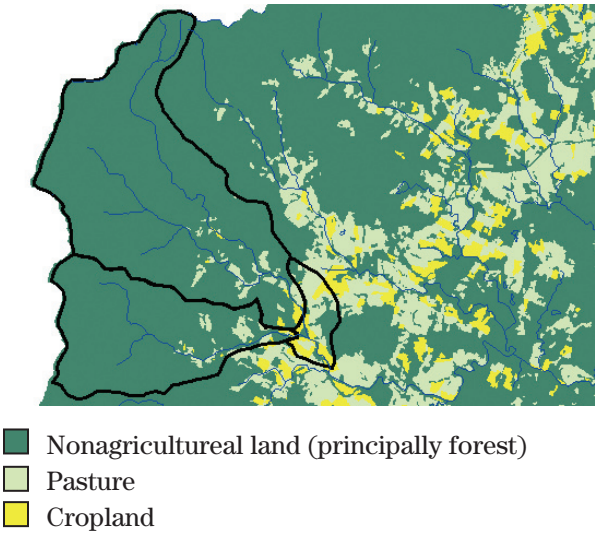
Basis qualified: Grazing
Restored: Spring 2001
Size: 82.2 km^2
Baseline SVAP: 8.4 (Good)
Baseline IBI: 44 (Good)
Upstream land use
  Cropland %: 2.0
  Pasture %: 5.3
  Non-ag %: 92.7
  Urban/disturbed %: 0.73
Buffer area (ha): 37.6
Buffer length (m): 5,999.1

IBI and SVAP trends for Thorn @620 and its paired less-disturbed reference, Thornton @626.









Appendix A4—Thornton River @620, Rappahannock Co., VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey	1			
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace			3	
Roseyside dace		4	6	2
Fallfish	19	5	38	10
Creek chub	2	7	4	2
River chub	2	17	5	8
Bluehead chub		1	17	5
Cutlips minnow	4	7	2	2
Blacknose dace		1	5	2
Longnose dace	20	24	28	12
Central stoneroller				
Eastern silvery minnow				
Common shiner	58	24	64	28
Satinfin shiner		2	5	
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner		2	3	
Spottail shiner				
Swallowtail shiner				
Roseyface shiner		31	17	32
Silverjaw minnow				
White sucker	2	1	3	1
Creek chubsucker				
Northern hogsucker			1	1
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom	1			
Banded killifish				
Eastern mosquitofish				
Mottled sculpin	12	19	13	23
Potomac sculpin				
Redbreast sunfish	3	4	3	3
Green sunfish		1	1	1
Pumpkinseed				
Bluegill				
Redear sunfish				
Rock bass	14	31	12	9
Black crappie				
Smallmouth bass	2	2	1	2
Largemouth bass	2	2	1	24
Shield darter				
Stripeback darter				
Tesselated darter	27	36	25	45
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total	**169**	**221**	**257**	**212**
Anomalies	2	1		

Tesselated darter, a common riffle species collected in each year of sampling at Thorn @620.

Rosyface shiner, an intolerant species collected in 3 out of the 4 years of sampling at Thorn @620.

Appendix A4—Thornton River @620, Rappahannock Co., VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	12	1	16	3	17	3	15	1
# darter species	1	1	1	1	1	1	1	1
# minnow species	6	1	12	3	13	3	10	3
% dominant species	0.343	1	0.163	3	0.249	3	0.212	3
# intolerant species	3	5	2	3	2	3	2	3
% tolerant individuals	0.024	5	0.045	5	0.051	5	0.028	5
% omnivores	0.012	5	0.009	5	0.078	5	0.028	5
% benthic invertivores	0.355	5	0.357	5	0.261	5	0.382	5
% specialist carnivores	0.237	5	0.199	3	0.214	3	0.226	3
% simple lithophils	0.462	5	0.385	3	0.463	5	0.354	3
# late maturing species	4	5	3	3	4	5	4	5
% anomalies	0.012	5	0.005	5	0.000	5	0.000	5
IBI		**44**		**42**		**46**		**42**

SVAP element ratings

SVAP elements	**2000**	**2001**	**2002**	**2003**
Channel condition	9.7	9.0	7.3	9.0
Hydrologic alteration	9.3	9.3	8.0	9.7
Riparian width	5.3	6.7	5.3	6.0
Bank stability	6.7	9.0	7.3	8.7
Canopy cover	7.3	9.3	9.0	6.7
Water appearance	8.0	8.3	9.0	8.3
Nutrient enrichment	9.0	7.7	8.3	8.3
Manure presence	4.3	3.7		
Fish barriers	10.0	9.3	10.0	10.0
Fish cover	9.3	9.3	9.3	9.0
Pools	8.3	8.3	7.3	8.0
Riffle quality	8.7	9.0	9.0	8.7
Invertebrate habitat	9.7	9.0	8.3	8.7
Invertebrates observed	12.3	13.7	11.3	12.7
SVAP	**8.4**	**8.7**	**8.4**	**8.7**

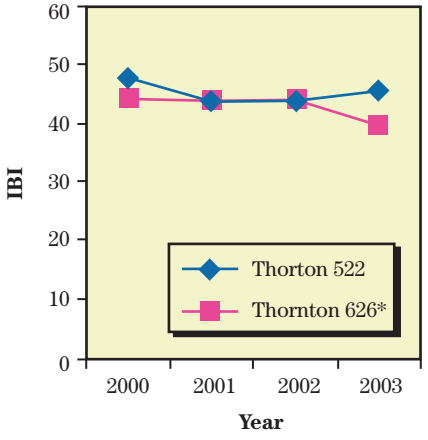
Site notes:

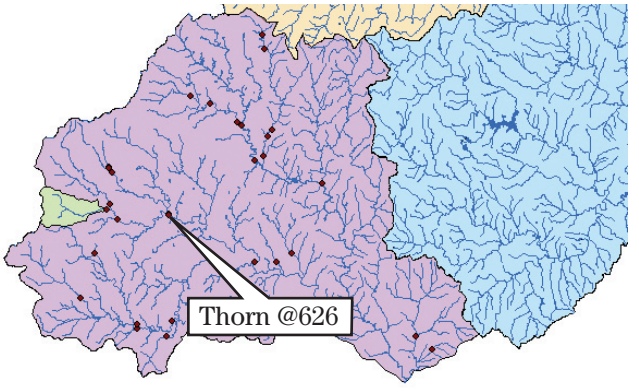
Thorn @620 is the downstream reach of a large project on the Thornton River that also includes Thorn @522 and N Thorn @211. The project extends from near Sperryville to just above the County Road 620 crossing of the Thornton at Fletcher's Mill. Thorn @620 has a relatively large drainage and receives the benefits of buffers located on the aforementioned upstream forks of the Thornton. The site has an existing narrow buffer that provides shade and other riparian functions. The site was grazed prior to restoration; however, the site's drainage is in good condition and most site disturbances are overwhelmed by the positive affects of its predominantly forested watershed. Both SVAP and IBI scores were high prior to restoration.

Appendix A5—Thornton River @522, Rappahannock Co., VA

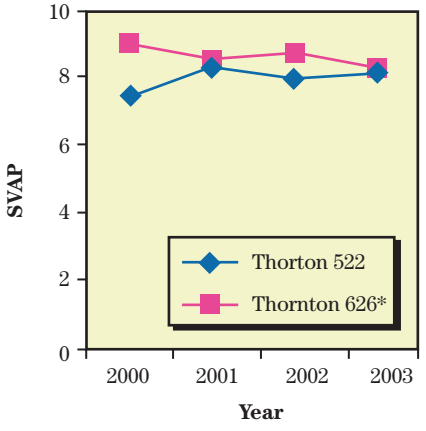
Basis qualified: Grazing
Restored: Spring 2001
Size: 26.0 km^2
Baseline SVAP: 7.4 (Fair)
Baseline IBI: 48 (Good)
Upstream land use
  Cropland %: 0.7
  Pasture %: 4.2
  Non-ag %: 95.2
  Urban/disturbed %: 1.28
Buffer area (ha): 22.9
Buffer length (m): 4,903.6

IBI and SVAP trends for Thorn @522 and its near paired less-disturbed reference, Thornton @626.





Thorn @522 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A5—Thornton River @522, Rappahannock Co., VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace	1	5	21	30
Fallfish	29	5	81	24
Creek chub			1	1
River chub	19	7	22	14
Bluehead chub		8	6	2
Cutlips minnow	1	1	1	
Blacknose dace	4	17	30	4
Longnose dace	33	31	8	4
Central stoneroller				
Eastern silvery minnow				
Common shiner	16	9	55	61
Satinfin shiner				
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner			1	
Spottail shiner				
Swallowtail shiner				
Roseyface shiner				1
Silverjaw minnow				
White sucker	1	3	2	3
Creek chubsucker				
Northern hogsucker	2	2	4	1
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom	1			
Banded killifish				
Eastern mosquitofish				
Mottled sculpin	31	24	6	10
Potomac sculpin				
Redbreast sunfish		2		
Green sunfish				
Pumpkinseed				
Bluegill			1	2
Redear sunfish				
Rock bass	27	8	6	
Black crappie				
Smallmouth bass	4	2	2	1
Largemouth bass	2			
Shield darter				
Stripeback darter				
Tesselated darter	6	16	2	15
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				1
Total	**177**	**140**	**249**	**174**
Anomalies	2		1	

Smallmouth bass, a specialist carnivore occupying the pools at Thorn @522.

Mottled sculpin, an intolerant, benthic invertivore found in relative abundance during each year of sampling at Thorn @522.

Appendix A5—Thornton River @522, Rappahannock Co., VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	12	1	13	3	14	3	13	3
# darter species	1	1	1	1	1	1	1	1
# minnow species	7	3	8	3	10	3	9	3
% dominant species	0.186	5	0.221	3	0.325	3	0.351	3
# intolerant species	2	5	1	3	1	3	2	5
% tolerant individuals	0.028	5	0.143	5	0.137	5	0.057	5
% omnivores	0.006	5	0.079	5	0.032	5	0.029	5
% benthic invertivores	0.412	5	0.521	5	0.080	3	0.172	3
% specialist carnivores	0.350	5	0.121	3	0.357	5	0.144	3
% simple lithophils	0.294	3	0.336	3	0.357	3	0.557	5
# late maturing species	4	5	4	5	4	5	4	5
% anomalies	0.011	5	0.000	5	0.004	5	0.000	5
IBI		**48**		**44**		**44**		**46**

SVAP element ratings

SVAP elements	**2000**	**2001**	**2002**	**2003**
Channel condition	6.3	7.3	8.3	8.3
Hydrologic alteration	6.0	6.0	7.3	9.3
Riparian width	5.3	4.3	6.3	7.0
Bank stability	6.7	7.7	6.7	8.0
Canopy cover	7.7	8.7	8.7	6.3
Water appearance	8.0	9.3	8.7	8.7
Nutrient enrichment	7.0	8.0	8.0	6.3
Manure presence				
Fish barriers	7.7	10.0	10.0	8.7
Fish cover	8.7	9.0	8.3	8.0
Pools	7.3	7.0	5.7	6.7
Riffle quality	7.3	8.7	7.0	8.0
Invertebrate habitat	8.3	8.0	8.7	8.3
Invertebrates observed	10.3	12.7	10.3	12.3
SVAP	**7.4**	**8.2**	**8.0**	**8.2**

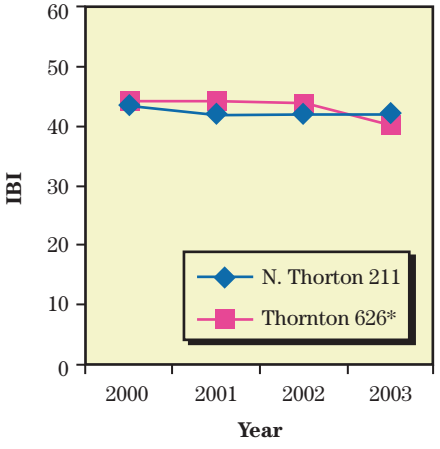
Site notes:

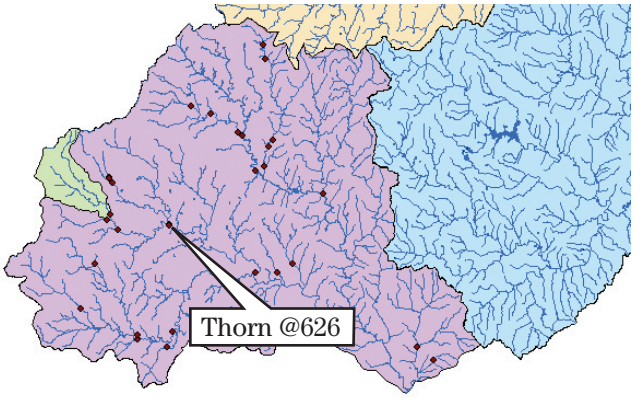
Thorn @522 is located on the mainstem Thornton River just above its confluence with the North Fork below the town of Sperryville. The site is a high gradient, boulder-strewn stream. Its drainage includes Highway 211 above Sperryville, which follows the river's path up the Blue Ridge to Thornton Gap. The small town of Sperryville is within the site's drainage, including its sewage treatment plant, which is adjacent to the reach. Grazing was not a significant problem prior to restoration. A county road borders most of the reach and is experiencing significant streambank erosion. Due to the proximity of Sperryville, substantial amounts of trash have been observed at the site. However, the vast majority of the watershed is in extremely good condition, having a positive overwhelming affect.

Appendix A6—N. Fork Thornton River @211, Rappahannock Co., VA

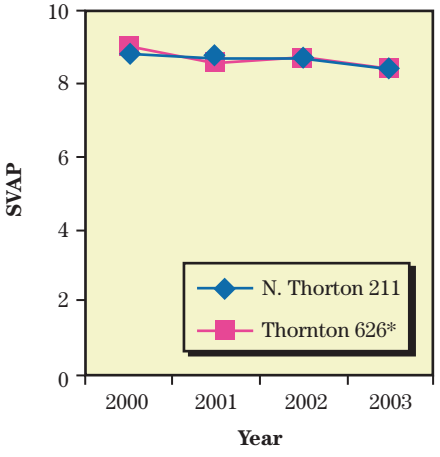
Basis qualified: Cropping
Restored: Spring 2001
Size: 51.9 km^2
Baseline SVAP: 8.8 (Fair)
Baseline IBI: 44 (Good)
Upstream land use
  Cropland %: 0.7
  Pasture %: 3.0
  Non-ag %: 96.3
  Urban/disturbed %: 0.01
Buffer area (ha): 8.3
Buffer length (m): 794.6

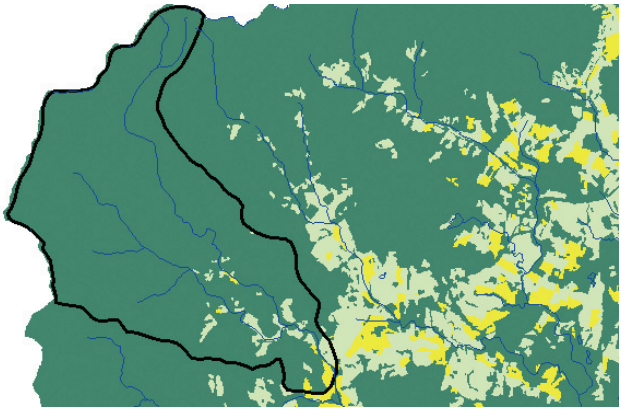
IBI and SVAP trends for N Thorn @211 and its paired less-disturbed reference, Thornton @626.





N Thorn @211 drainage





Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A6—N. Fork Thornton River @211, Rappahannock Co., VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace		17	7	8
Roseyside dace	1	40	6	28
Fallfish	14	24	55	20
Creek chub	1	1	3	
River chub	13	14	17	15
Bluehead chub		50	2	1
Cutlips minnow	6	9	1	3
Blacknose dace	22	34	24	9
Longnose dace	29	20	6	7
Central stoneroller				
Eastern silvery minnow				
Common shiner	11	26	28	28
Satinfin shiner				
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow				
White sucker	1	1		
Creek chubsucker				
Northern hogsucker	2	1	4	1
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead			1	
Brown bullhead				
Margined madtom	2	1		
Banded killifish				
Eastern mosquitofish				
Mottled sculpin	16	20	24	16
Potomac sculpin				
Redbreast sunfish				
Green sunfish				
Pumpkinseed				
Bluegill	5	6	3	2
Redear sunfish				
Rock bass	38	31	6	3
Black crappie				
Smallmouth bass	1	2	4	2
Largemouth bass	3		1	
Shield darter				
Stripeback darter				
Tesselated darter	28	34	17	22
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids			1	
Total	**193**	**331**	**210**	**165**
Anomalies	2	1		

Margined madtom, an intolerant, benthic invertivore, collected in 2 out of 4 years of sampling at N Thor @211.

Rock bass, a specialist carnivore, was a common inhabitant of pools and undercut banks at N Thorn @211.

Appendix A6—N. Fork Thornton River @211, Rappahannock Co., VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	13	1	14	3	12	1	11	1
# darter species	1	1	1	1	1	1	1	1
# minnow species	8	3	10	3	10	3	9	3
% dominant species	0.197	3	0.151	5	0.262	3	0.170	5
# intolerant species	2	3	2	3	1	3	1	3
% tolerant individuals	0.150	5	0.127	5	0.143	5	0.067	5
% omnivores	0.005	5	0.154	3	0.010	5	0.006	5
% benthic invertivores	0.399	5	0.230	3	0.243	5	0.279	5
% specialist carnivores	0.290	5	0.172	3	0.319	5	0.152	3
% simple lithophils	0.223	3	0.263	3	0.210	1	0.388	3
# late maturing species	4	5	5	5	4	5	3	3
% anomalies	0.010	5	0.003	5	0.000	5	0.000	5
IBI		**44**		**42**		**42**		**42**

SVAP element ratings

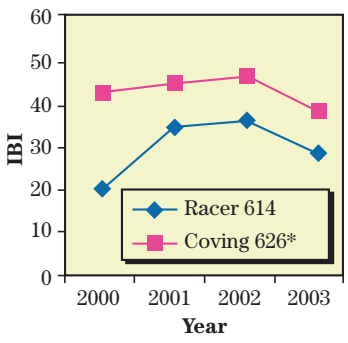
SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition	7.0	8.7	7.3	9.0
Hydrologic alteration	9.7	8.0	7.7	9.0
Riparian width	6.7	7.7	7.3	7.0
Bank stability	7.3	8.3	7.7	8.0
Canopy cover	8.3	9.3	9.7	7.3
Water appearance	9.0	9.0	8.0	8.7
Nutrient enrichment	9.0	7.7	7.7	8.3
Manure presence				
Fish barriers	10.0	10.0	10.0	10.0
Fish cover	9.0	9.0	9.7	8.3
Pools	7.3	8.3	7.7	7.3
Riffle quality	8.7	8.0	7.7	9.3
Invertebrate habitat	8.0	9.3	9.7	7.7
Invertebrates observed	14.0	11.7	13.3	10.3
SVAP	**8.8**	**8.8**	**8.7**	**8.5**

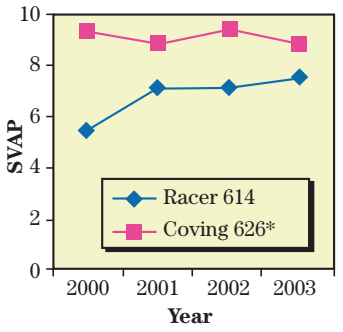
Site notes:

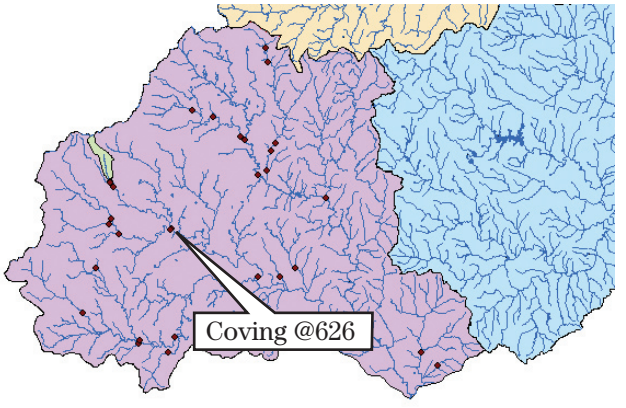
N Thorn @211 includes that portion of the aforementioned project on the North Fork of the Thornton River above State Highway 211. Although the field adjacent to the stream was cropped prior to buffer establishment, the watershed is predominantly forested and has had a positive, overwhelming influence on the site. The stream is high gradient with boulder and cobble substrate. Water quality is good. County Road 612 borders much of the reach on the opposite side of the buffer and is experiencing some streambank erosion. Trash has been dumped from the road onto the streambanks in a number of places. Despite a few site problems, baseline SVAP and IBI scores were good prior to restoration.

Appendix A7—Racer Run @614, Rappahanncok County, VA

IBI and SVAP trends for Racer @614 and its paired less-disturbed reference, Covington @626.

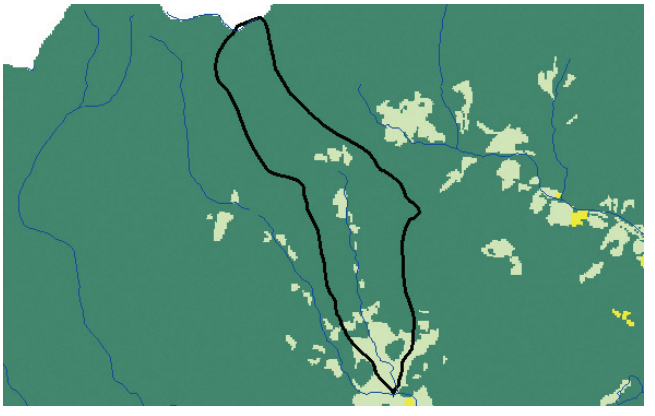






Racer @614 drainage

Basis qualified: Grazing
Restored: Spring 2001
Size: 6.9 km^2
Baseline SVAP: 5.4 (Poor)
Baseline IBI: 20 (Very poor)
Upstream land use
  Cropland %: 0
  Pasture %: 11.3
  Non-ag %: 88.7
  Urban/disturbed %: 0
Buffer area (ha): 11.0
Buffer length (m): 4,130.0



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A7—Racer Run @614, Rappahanncok County, VA

Raw fish data

Common Name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace	12	7	6	18
Fallfish			2	
Creek chub	6	5	43	18
River chub			2	
Bluehead chub	6	5	16	38
Cutlips minnow	7	16	8	22
Blacknose dace	390	332	91	63
Longnose dace	34	17	1	2
Central stoneroller				
Eastern silvery minnow				
Common shiner		51	45	52
Satinfin shiner	81			
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				1
Comely shiner				
Spottail shiner				
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow				
White sucker		1	1	
Creek chubsucker				
Northern hogsucker		1		
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom		1	1	
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish			7	2
Green sunfish	4	2	2	4
Pumpkinseed				
Bluegill			1	3
Redear sunfish				
Rock bass			7	
Black crappie				
Smallmouth bass		1		
Largemouth bass				1
Shield darter				
Stripeback darter				
Tesselated darter	13	89	43	24
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids			1	
Total	**553**	**528**	**277**	**248**
Anomalies	41		3	1

Tolerant blacknose dace heavily dominated the fish assemblage at Racer @614 prior to restoration; however, its relative abundance has since declined.

The proportion of common shiner is increasing in the fish assemblage at Racer @614.

Appendix A7—Racer Run @614, Rappahanncok County, VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	8	1	11	3	13	3	9	1
# darter species	1	1	1	1	1	1	1	1
# minnow species	7	3	7	3	9	3	8	3
% dominant species	0.705	1	0.629	1	0.329	3	0.254	3
# intolerant species	0	1	1	3	1	3	0	1
% tolerant individuals	0.723	1	0.644	1	0.498	3	0.355	3
% omnivores	0.011	5	0.011	5	0.061	5	0.157	3
% benthic invertivores	0.085	3	0.205	5	0.162	3	0.105	3
% specialist carnivores	0.000	1	0.002	1	0.058	1	0.012	1
% simple lithophils	0.083	1	0.144	1	0.188	1	0.290	3
# late maturing species	1	1	4	5	4	5	1	1
% anomalies	0.074	1	0.004	5	0.011	5	0.004	5
IBI		**20**		**34**		**36**		**28**

SVAP element ratings

SVAP elements	**2000**	**2001**	**2002**	**2003**
Channel condition	6	8.0	7.7	7.7
Hydrologic alteration	6	7.7	7.0	8.0
Riparian width	2	6.0	7.0	5.3
Bank stability	4	8.0	7.3	7.0
Canopy cover	1	1.3	4.0	6.0
Water appearance	6	7.7	8.3	8.3
Nutrient enrichment	6	7.7	6.7	8.7
Manure presence	3			
Fish barriers	10	10.0	10.0	10.0
Fish cover	4	7.3	6.0	5.3
Pools	4	3.3	3.7	4.7
Riffle quality	9	9.0	7.3	8.3
Invertebrate habitat	5	6.3	8.3	7.0
Invertebrates observed	10	10.0	9.7	12.0
SVAP	**5.4**	**7.1**	**7.2**	**7.6**

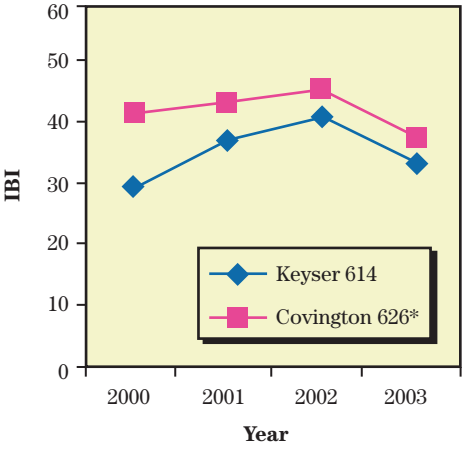
Site notes:

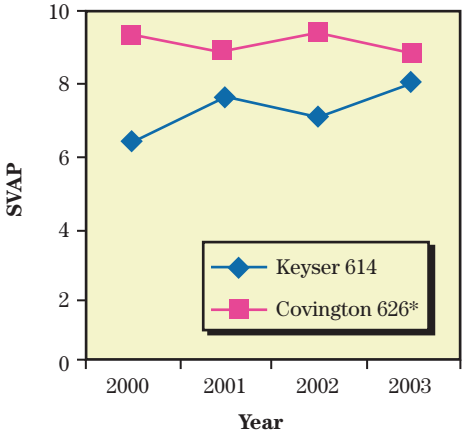
Racer @614 has experienced the most obvious improvement of any site in the study. The site had no appreciable riparian zone prior to restoration and was heavily grazed. The site's watershed is small and predominantly forested; thus, providing a positive, but small influence. Rapid growth was observed in woody streambank vegetation (e.g., black willow, hazel alder, sycamore) in response to fencing. Herbaceous streambank cover (e.g., sweet flag, reed canary grass) also increased significantly. Both SVAP and IBI scores have improved dramatically. Tolerant blacknose dace is still the dominant species at the site, but its relative abundance has diminished and other less tolerant species are increasing. The combination of high levels of site disturbance with small, but positive upstream influences are likely responsible for the pronounced response.

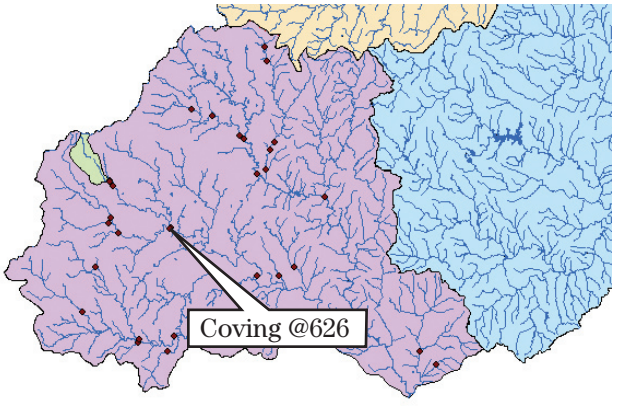
Appendix A8—Keyser Run @614, Rappahannock County, VA

Basis qualified: Grazing
Restored: Spring 2001
Size: 15.2 km^2
Baseline SVAP: 6.3 (Fair)
Baseline IBI: 30 (Poor)
Upstream land use
  Cropland %: 0
  Pasture %: 3.5
  Non-ag %: 96.5
  Urban/disturbed %:
Buffer area (ha): 8.7
Buffer length (m): 1,827.6

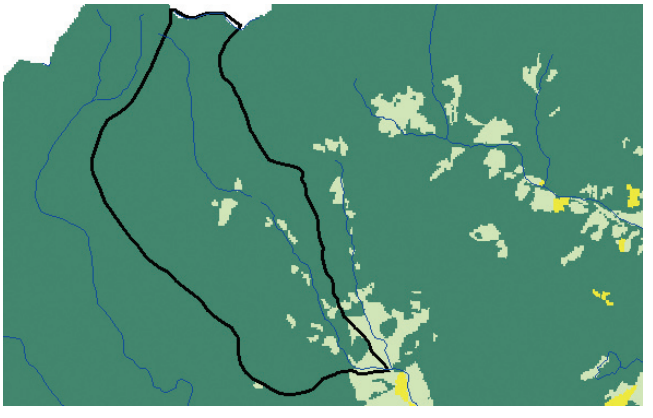
IBI and SVAP trends for Keyser @614 and its paired less-disturbed reference, Covington @626.







Keyser @614 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A8—Keyser Run @614, Rappahannock County, VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace	29	21	12	13
Fallfish	13	2	7	
Creek chub	12	4	6	9
River chub		1	3	
Bluehead chub	31	6	7	13
Cutlips minnow	9	26	14	7
Blacknose dace	311	198	82	37
Longnose dace	51	54	2	3
Central stoneroller				
Eastern silvery minnow				
Common shiner	31	61	62	13
Satinfin shiner				
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow				
White sucker	2	2	2	
Creek chubsucker				
Northern hogsucker	4	8	2	1
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom			1	
Banded killifish				
Eastern mosquitofish				
Mottled sculpin	8	4	22	6
Potomac sculpin				
Redbreast sunfish			1	
Green sunfish	1		10	5
Pumpkinseed				
Bluegill		2	5	7
Redear sunfish				
Rock bass		2	9	2
Black crappie				
Smallmouth bass	1	10	5	1
Largemouth bass			1	
Shield darter				
Stripeback darter				
Tesselated darter	28	37	21	14
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				1
Total	**531**	**438**	**274**	**132**
Anomalies	23		4	2

Bluehead chub, a non-native, late-maturing omnivore collected in each year at Keyser @614.

Longnose dace, a riffle-dwelling, benthic invertivore, collected in each year at Keyser @614.

Appendix A8—Keyser Run @614, Rappahannock County, VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	12	3	13	3	15	3	10	1
# darter species	1	1	1	1	1	1	1	1
# minnow species	8	3	9	3	9	3	7	3
% dominant species	0.586	1	0.452	1	0.299	3	0.280	3
# intolerant species	1	3	1	3	2	5	1	3
% tolerant individuals	0.614	1	0.470	3	0.383	3	0.439	3
% omnivores	0.062	5	0.018	5	0.033	5	0.098	5
% benthic invertivores	0.171	3	0.235	5	0.175	3	0.182	3
% specialist carnivores	0.026	1	0.032	1	0.084	3	0.023	1
% simple lithophils	0.158	1	0.329	3	0.285	3	0.227	3
# late maturing species	3	5	4	5	5	5	2	3
% anomalies	0.043	3	0.002	5	0.015	5	0.015	5
IBI		**30**		**38**		**42**		**34**

SVAP element ratings

SVAP elements	**2000**	**2001**	**2002**	**2003**
Channel condition	5	8.0	6.7	8.0
Hydrologic alteration	6	8.3	6.3	8.3
Riparian width	6	5.0	6.3	5.7
Bank stability	6	7.7	7.0	8.3
Canopy cover	1	3.0	6.0	6.7
Water appearance	8	8.7	8.7	8.3
Nutrient enrichment	6	6.7	7.0	8.7
Manure presence	3			
Fish barriers	10	10.0	10.0	10.0
Fish cover	7	8.3	6.7	5.7
Pools	5	4.7	3.3	5.0
Riffle quality	9	9.0	7.3	8.3
Invertebrate habitat	7	8.0	7.0	7.3
Invertebrates observed	9	11.0	9.3	14.0
SVAP	**6.3**	**7.6**	**7.1**	**8.0**

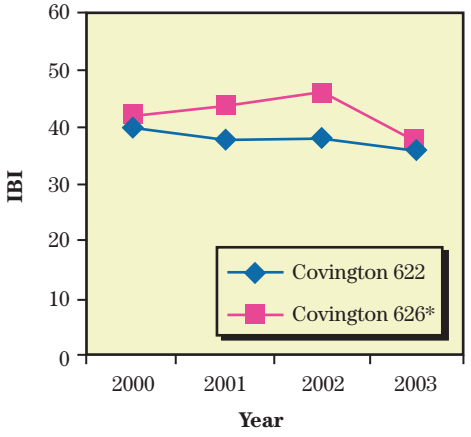
Site notes:

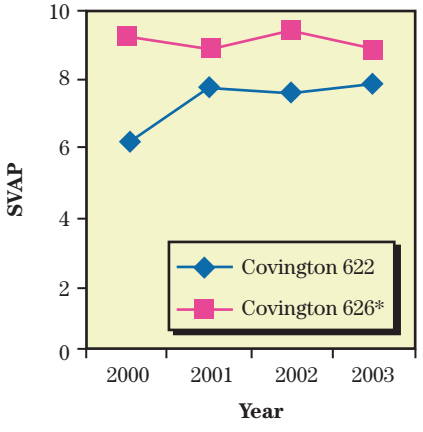
Keyser Run and Racer Run combine within the project area to form the Covington River. Keyser @614 is a small upstream tributary with many of the same features of Racer @614. The site was also heavily grazed prior to restoration and had practically no riparian zone. Fencing has had many of the same effects noted at Racer @614. Increased growth of woody and herbaceous streambank vegetation, shifts in dominance of the fish assemblage, and improved SVAP and IBI scores have all occurred. However, the improving trends observed at Keyser @614 are not as pronounced as those at Racer @614.

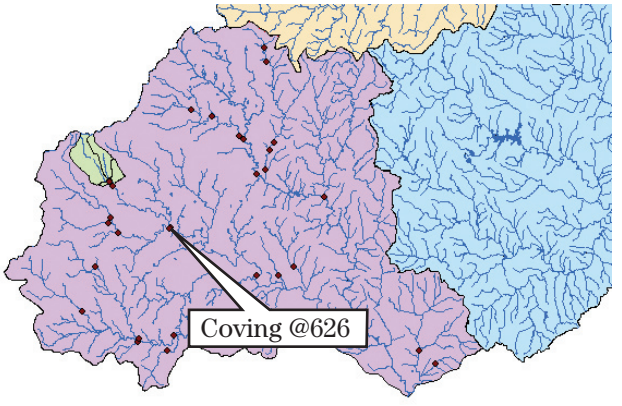
Appendix A9—Covington River @622, Rappahannock County, VA

Basis qualified: Grazing
Restored: Spring 2001
Size: 26.0 km^2
Baseline SVAP: 6.1 (Fair)
Baseline IBI: 40 (Fair)
Upstream land use
  Cropland %: 0.3
  Pasture %: 7.4
  Non-ag %: 92.3
  Urban/disturbed %: 0.03
Buffer area (ha): 27.6
Buffer length (m): 6,373.4

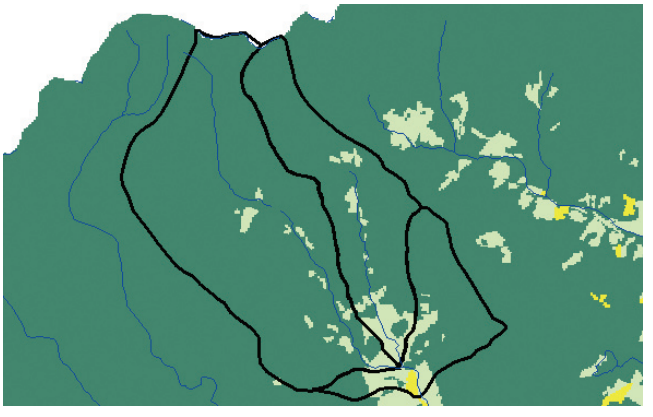
IBI and SVAP trends for Coving @622 and its paired less-disturbed reference, Covington @626.







Coving @622 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A9—Covington River @622, Rappahannock County, VA

Raw fish data

Common Name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace	3	9	37	13
Fallfish	1	1	12	1
Creek chub	3	6	10	11
River chub	9		11	
Bluehead chub		18	4	24
Cutlips minnow	6	56	20	31
Blacknose dace	71	291	122	49
Longnose dace	39	18	4	2
Central stoneroller				
Eastern silvery minnow				
Common shiner	83	119	154	122
Satinfin shiner				
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow				
White sucker	19	37	7	1
Creek chubsucker				
Northern hogsucker	1	10	22	4
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom	2	1	3	
Banded killifish				
Eastern mosquitofish				
Mottled sculpin	12	4	12	8
Potomac sculpin				
Redbreast sunfish	14	3	2	26
Green sunfish		8		1
Pumpkinseed				
Bluegill			4	12
Redear sunfish				
Rock bass	1	3	2	1
Black crappie				
Smallmouth bass	1	8	4	
Largemouth bass			3	
Shield darter				
Stripeback darter				
Tesselated darter	36	73	15	55
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total	**301**	**665**	**448**	**361**
Anomalies	6	3	27	17

Redbreast sunfish, a native specialist carnivore inhabiting pools at Coving @622.

Rosyside dace, a lithophilic, insectivorous minnow collected each year at Coving @622.

Appendix A9—Covington River @622, Rappahannock County, VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	14	3	14	3	15	3	13	3
# darter species	1	1	1	1	1	1	1	1
# minnow species	8	3	8	3	9	3	8	3
% dominant species	0.426	1	0.438	1	0.344	3	0.338	3
# intolerant species	2	5	2	5	2	5	1	3
% tolerant individuals	0.481	3	0.514	3	0.319	3	0.205	3
% omnivores	0.047	5	0.083	5	0.025	5	0.069	5
% benthic invertivores	0.224	5	0.159	3	0.125	3	0.191	3
% specialist carnivores	0.042	1	0.023	1	0.051	1	0.078	3
% simple lithophils	0.314	3	0.235	3	0.518	5	0.391	3
# late maturing species	4	5	4	5	5	5	3	3
% anomalies	0.015	5	0.005	5	0.060	1	0.047	3
IBI		**40**		**38**		**38**		**36**

SVAP element ratings

SVAP elements	**2000**	**2001**	**2002**	**2003**
Channel condition	7.7	8.0	8.0	8.0
Hydrologic alteration	7.3	8.3	7.7	8.3
Riparian width	2.3	2.3	6.0	7.3
Bank stability	5.3	7.0	8.0	7.7
Canopy cover	5.3	2.0	5.3	4.3
Water appearance	7.0	7.3	8.7	7.3
Nutrient enrichment	4.7	8.3	7.0	7.7
Manure presence	4.0			
Fish barriers	9.3	10.0	10.0	10.0
Fish cover	7.7	8.7	8.0	7.0
Pools	6.3	8.0	4.7	7.0
Riffle quality	6.0	8.7	7.7	8.0
Invertebrate habitat	6.3	8.0	8.0	8.0
Invertebrates observed	5.7	13.3	9.0	11.7
SVAP	**6.1**	**7.7**	**7.5**	**7.9**

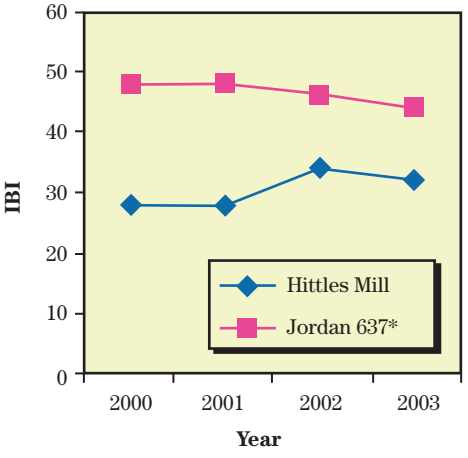
Site notes:

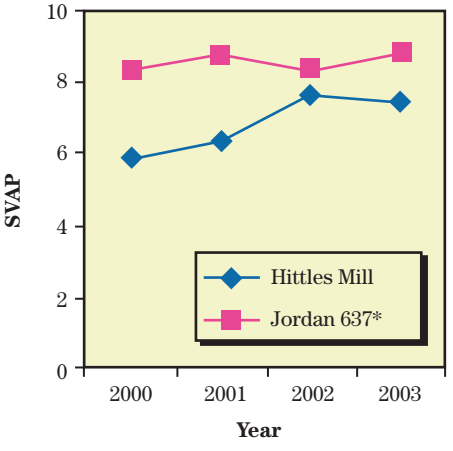
Coving @622 is the downstream reach of Covington River project located below the County Road 622 crossing of the Covington. Since it is in the same setting as Racer @614 and Keyser @614, it has many of the same physical and biological characteristics; however, it has not demonstrated similar trends in improvement. Although response in streambank vegetation is occurring, it has been more gradual. Because the stream is wider than its headwater tributaries, its new woody growth is providing much less canopy cover. Also, streambanks have not healed over in certain sections of the reach and are still exposed to the eroding forces of the stream. Although SVAP scores are improving, the IBI has declined over the sampling period for no apparent reason.

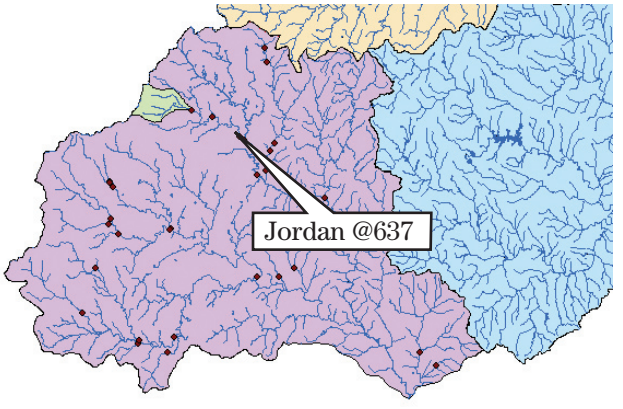
Appendix A10—Hittles Mill Run @522, Rappahannock Co. VA

Basis qualified: Grazing
Restored: Spring 2002
Size: 20.3 km^2
Baseline SVAP: 5.9 (Poor)
Baseline IBI: 28 (Poor)
Upstream land use
  Cropland %: 1.8
  Pasture %: 5.1
  Non-ag %: 93.1
  Urban/disturbed %: 0.13
Buffer area (ha): 7.4
Buffer length (m): 1,539.2

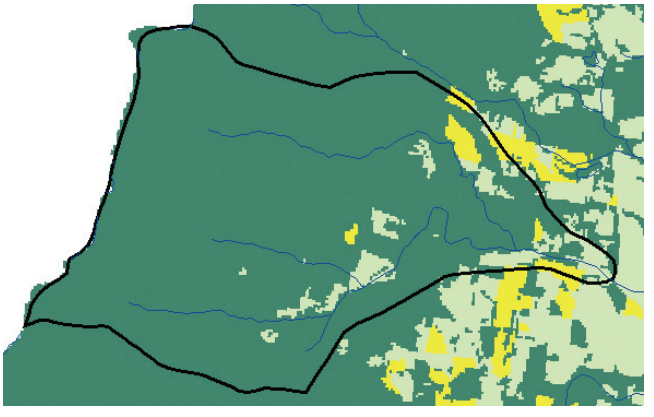
IBI and SVAP trends for Hittles @522 and its paired less-disturbed reference, Jordan @637.







Hittles @522 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A10—Hittles Mill Run @522, Rappahannock Co. VA

Raw fish data

Common Name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace	1	6	23	6
Fallfish			1	
Creek chub	20	1	6	6
River chub	2	2	16	4
Bluehead chub	1	20	28	3
Cutlips minnow	1	2	3	2
Blacknose dace	156	64	93	25
Longnose dace			1	3
Central stoneroller				
Eastern silvery minnow				
Common shiner	9	6	24	22
Satinfin shiner		1		
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow				
White sucker	5	9	13	23
Creek chubsucker				
Northern hogsucker			3	
Torrent sucker	14	2	29	33
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin	3	7		6
Potomac sculpin				
Redbreast sunfish	1			1
Green sunfish	68	31	3	3
Pumpkinseed				
Bluegill	22	28	23	47
Redear sunfish				
Rock bass	2	1		1
Black crappie				
Smallmouth bass	1			
Largemouth bass	5	7	13	3
Shield darter				
Stripeback darter				
Tesselated darter	10	4	28	17
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total	**321**	**191**	**307**	**205**
Anomalies	2	2		

Green sunfish, a tolerant pool species that decreased in abundance after the buffer was established at Hittles @522.

Cutlips minnow, an insectivorous minnow known for plucking the eyes out of small fishes, collected at Hittles @522 during each year of sampling.

Appendix A10—Hittles Mill Run @522, Rappahannock Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	11	1	11	1	12	3	12	3
# darter species	1	1	1	1	1	1	1	1
# minnow species	7	3	8	3	9	3	8	3
% dominant species	0.486	1	0.335	3	0.303	3	0.229	3
# intolerant species	1	3	1	3	0	1	1	3
% tolerant individuals	0.844	1	0.696	1	0.450	3	0.507	3
% omnivores	0.062	5	0.162	3	0.228	3	0.288	1
% benthic invertivores	0.040	1	0.058	1	0.104	3	0.127	3
% specialist carnivores	0.028	1	0.042	1	0.046	1	0.024	1
% simple lithophils	0.075	1	0.073	1	0.261	3	0.312	3
# late maturing species	4	5	4	5	5	5	4	5
% anomalies	0.006	5	0.010	5	0.000	5	0.000	5
IBI		**28**		**28**		**34**		**34**

SVAP element ratings

SVAP elements	**2000**	**2001**	**2002**	**2003**
Channel condition	6.3	5.3	8.0	7.3
Hydrologic alteration	6.3	7.3	6.7	7.0
Riparian width	3.0	3.0	3.7	5.7
Bank stability	4.3	3.3	7.3	8.0
Canopy cover	6.7	7.3	8.3	8.0
Water appearance	6.7	9.0	8.7	8.3
Nutrient enrichment	5.7	5.7	8.3	8.0
Manure presence	1.7	1.3		
Fish barriers	8.7	9.7	10.0	10.0
Fish cover	6.7	7.7	8.0	6.7
Pools	6.0	4.7	3.7	4.7
Riffle quality	5.7	8.3	7.3	7.3
Invertebrate habitat	6.0	7.3	8.3	7.0
Invertebrates observed	8.7	8.3	11.7	9.0
SVAP	**5.9**	**6.3**	**7.7**	**7.5**

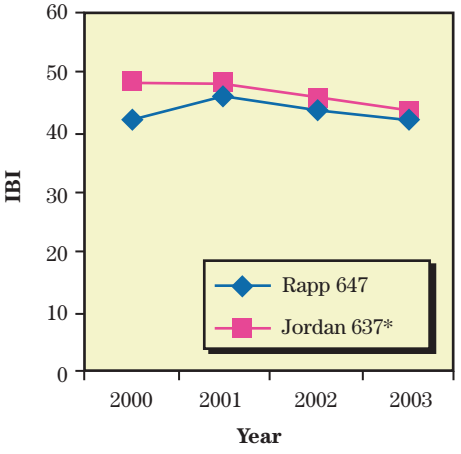
Site notes:

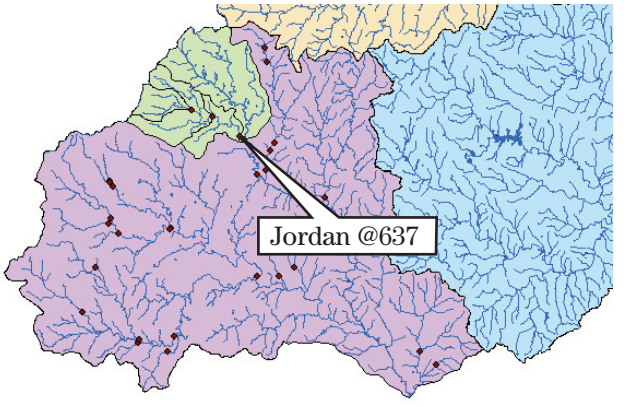
Hittles @522 is a small, high gradient, boulder/cobble stream. The site was heavily impacted by grazing prior to buffer establishment. Cattle trails were frequent to and from the stream. Manure was abundant in the stream, on streambanks, and on the flood plain. Streambanks were eroding and cutting into the pasture and County Road 630 that parallels the stream. A narrow band of alder lined much of the stream prior to buffer establishment providing some protection; however, cattle had concentrated at several intervals along the stream creating significant reaches of denuded, eroding streambank. Response to buffer establishment has been mainly the growth of herbaceous vegetation on the flood plain and channel banks. Both SVAP and IBI scores have improved since restoration.

Appendix A11—Rappahannock River @647, Fauquier Co. VA

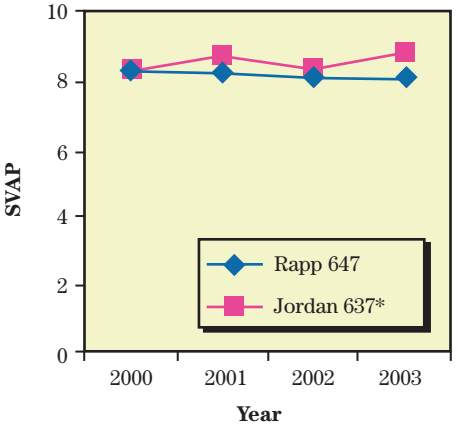
Basis qualified: Grazing
Restored: Spring 2002
Size: 114.7 km^2
Baseline SVAP: 8.2 (Good)
Baseline IBI: 42 (Good)
Upstream land use
  Cropland %: 5.5
  Pasture %: 20.8
  Non-ag %: 73.6
  Urban/disturbed %: 1.39
Buffer area (ha): 6.7
Buffer length (m): 3,218.7

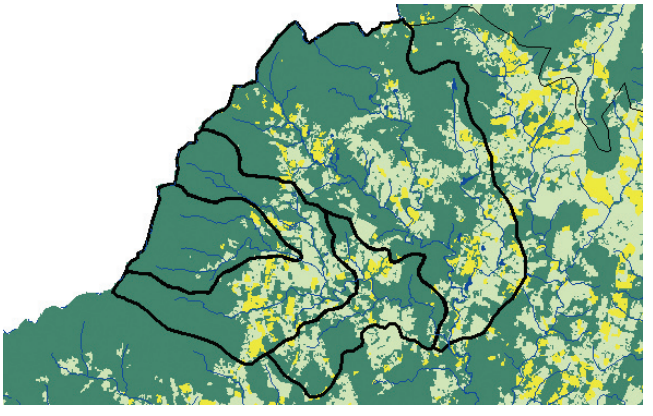
IBI and SVAP trends for Rapp @647 and its paired less-disturbed reference, Jordan @637.





Rapp @647 drainage



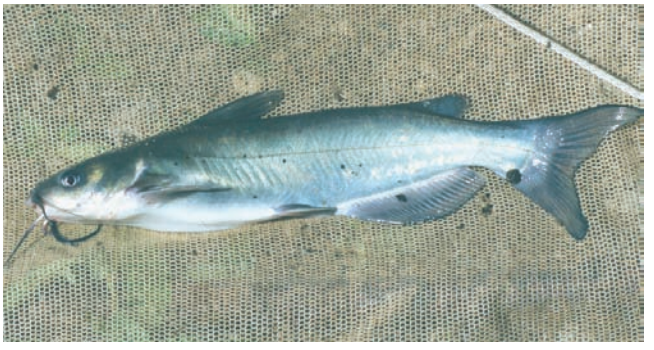


Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A11—Rappahannock River @647, Fauquier Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace				
Fallfish	104	149	34	26
Creek chub		1		2
River chub	11	14	57	10
Bluehead chub	49	12	2	2
Cutlips minnow	4		10	1
Blacknose dace	3	3	10	
Longnose dace	10	41	70	2
Central stoneroller				
Eastern silvery minnow				
Common shiner	63	29	50	77
Satinfin shiner	131	124	104	162
Spotfin shiner				
Bluntnose minnow	4	2		11
Fathead minnow				
Comely shiner	18	15	3	14
Spottail shiner	14	3	5	7
Swallowtail shiner	92	40	159	120
Roseyface shiner	52	92	23	5
Silverjaw minnow	8	3	5	12
White sucker	18	3	13	12
Creek chubsucker			5	
Northern hogsucker	10	11	4	
Torrent sucker	1	5		
Golden redhorse				
Shorthead redhorse				
Channel catfish	1			
Yellow bullhead			3	
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish	8	11	13	33
Green sunfish	20	5	1	12
Pumpkinseed	1			
Bluegill	16	1	2	3
Redear sunfish				
Rock bass	3	4	6	3
Black crappie				
Smallmouth bass			1	
Largemouth bass	5	1	1	6
Shield darter	1	7	3	1
Stripeback darter				
Tesselated darter	107	64	50	93
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids	1		2	1
Total	**755**	**640**	**636**	**615**
Anomalies	7		1	1



The single channel catfish collected in this study was collected at Rapp @647 in 2000.

Fallfish, a native, specialist carnivore, is common at Rapp @647 and most of the larger Rappahannock River drainage sites.

Appendix A11—Rappahannock River @647, Fauquier Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	19	3	18	3	20	3	17	3
# darter species	2	3	2	3	2	3	2	3
# minnow species	14	3	14	3	13	3	14	3
% dominant species	0.174	3	0.233	3	0.250	3	0.263	3
# intolerant species	2	3	2	3	2	3	2	3
% tolerant individuals	0.091	5	0.028	5	0.049	5	0.085	5
% omnivores	0.106	3	0.039	5	0.031	5	0.060	5
% benthic invertivores	0.170	3	0.192	3	0.208	3	0.156	3
% specialist carnivores	0.160	3	0.258	5	0.091	3	0.111	3
% simple lithophils	0.327	3	0.375	3	0.491	5	0.356	3
# late maturing species	6	5	5	5	4	3	3	3
% anomalies	0.009	5	0.000	5	0.002	5	0.002	5
IBI		**42**		**46**		**44**		**42**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition	8.3	8.3	9.0	8.0
Hydrologic alteration	8.0	9.3	7.7	8.3
Riparian width	8.0	6.0	7.3	7.3
Bank stability	6.7	5.0	6.7	6.3
Canopy cover	6.0	4.7	8.7	6.7
Water appearance	8.0	8.7	7.3	7.7
Nutrient enrichment	7.7	9.3	6.7	7.3
Manure presence				
Fish barriers	10.0	10.0	10.0	10.0
Fish cover	9.3	8.0	9.0	9.3
Pools	8.0	9.7	7.3	8.7
Riffle quality	7.3	7.3	7.7	8.0
Invertebrate habitat	9.3	9.0	8.7	8.3
Invertebrates observed	10.3	12.0	8.7	9.0
SVAP	**8.2**	**8.3**	**8.1**	**8.1**

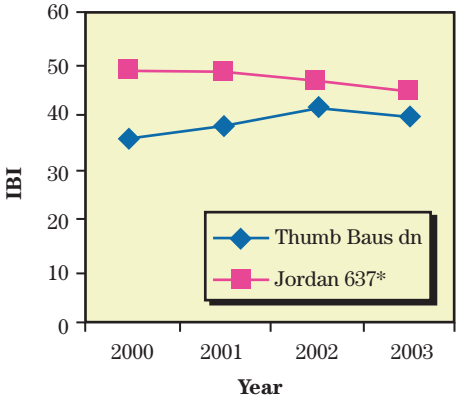
Site notes:

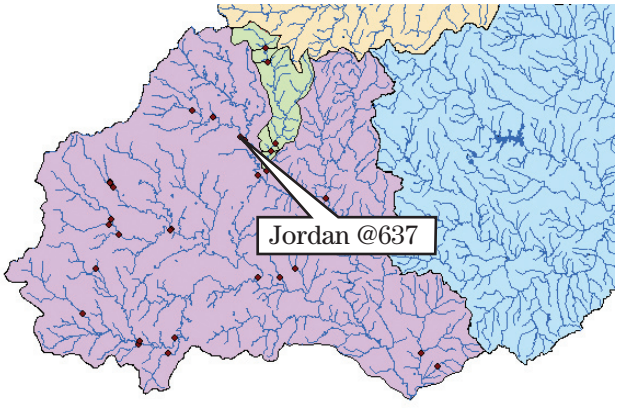
Rapp @647 has a large drainage that is in relatively good condition. A well-developed riparian area exists on the side of the stream opposite the buffer, and a narrow one exists adjacent to the buffer. The stream has good physical structure and reasonably good water quality, although streambank stability and sedimentation are somewhat of a problem. Both SVAP and IBI baseline scores were high and no improvement has been observed in either of those measures.

Appendix A12—Thumb Run @Bauserman (downstream), Fauquier Co. VA

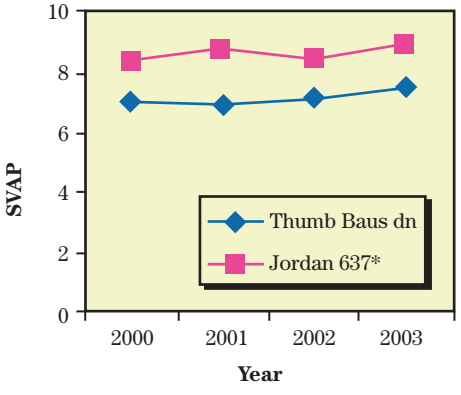
Basis qualified: Grazing
Restored: Spring 2002
Size: 79.7 km^2
Baseline SVAP: 7.0 (Fair)
Baseline IBI: 36 (Fair)
Upstream land use
  Cropland %: 12.7
  Pasture %: 39.4
  Non-ag %: 48.0
  Urban/disturbed %: 0
Buffer area (ha): 5.4
Buffer length (m): 2,487.2

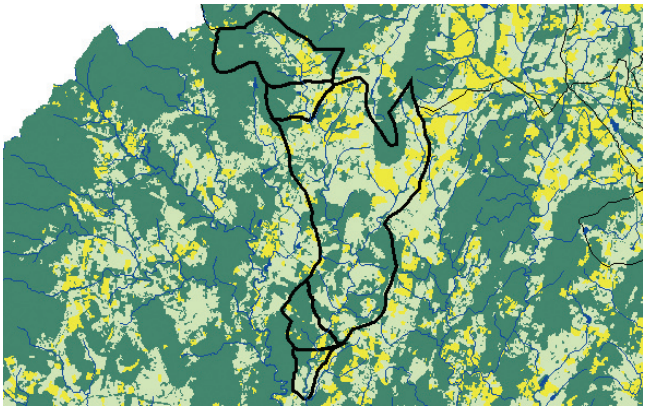
IBI and SVAP trends for Thum @Basdn and its paired less-disturbed reference, Jordan @637.





Thum @Basdn drainage





Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A12—Thumb Run @Bauserman (downstream), Fauquier Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace	2	1	11	3
Fallfish	44	83	27	19
Creek chub	8	3	2	1
River chub	19	11	31	16
Bluehead chub	38	25	3	2
Cutlips minnow				
Blacknose dace	11	12	21	10
Longnose dace	3	12	21	9
Central stoneroller				
Eastern silvery minnow				
Common shiner	115	54	30	98
Satinfin shiner	120	68	67	50
Spotfin shiner				
Bluntnose minnow		1		
Fathead minnow				
Comely shiner	1	1		12
Spottail shiner				
Swallowtail shiner	102	84	33	47
Roseyface shiner	67	23	52	39
Silverjaw minnow	45	152	49	14
White sucker	12	53	16	5
Creek chubsucker				
Northern hogsucker	9	5	4	6
Torrent sucker			4	
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish	13	6	5	19
Green sunfish	10	1	1	2
Pumpkinseed	2	1	2	
Bluegill	21	3	13	9
Redear sunfish				
Rock bass	3			1
Black crappie				
Smallmouth bass	3			
Largemouth bass		2	1	4
Shield darter		3	5	
Stripeback darter				
Tesselated darter	27	32	14	24
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total	**675**	**636**	**412**	**390**
Anomalies	1	1	2	1

Silverjaw minnow, a tolerant omnivore favoring sandy runs, has diminished in relative abundance at Thum @Basdn since buffer establishment.

Swallowtail shiner, an insectivorous, lithophilic minnow was abundant at Thum @Basdn in all years of sampling.

Appendix A12—Thumb Run @Bauserman (downstream), Fauquier Co. VA

IBI metric values and scores

IBI Metrics	2000 value	rating	2001 value	rating	2002 value	rating	2003 value	rating
# native species	18	3	19	3	18	3	17	3
# darter species	1	1	2	3	2	3	1	1
# minnow species	13	3	14	5	12	3	13	3
% dominant species	0.178	3	0.239	3	0.163	5	0.251	3
# intolerant species	1	1	2	3	2	3	1	1
% tolerant individuals	0.159	3	0.354	3	0.197	3	0.105	5
% omnivores	0.141	3	0.363	1	0.175	3	0.054	5
% benthic invertivores	0.058	1	0.082	1	0.107	3	0.100	3
% specialist carnivores	0.093	3	0.143	3	0.080	1	0.110	3
% simple lithophils	0.443	5	0.288	3	0.439	5	0.297	3
# late maturing species	4	5	4	5	5	5	4	5
% anomalies	0.001	5	0.002	5	0.005	5	0.003	5
IBI		**36**		**38**		**42**		**40**

SVAP element ratings

SVAP Elements	2000	2001	2002	2003
Channel condition	8.3	8.3	8.0	7.0
Hydrologic alteration	5.0	8.3	7.7	6.7
Riparian width	7.0	4.3	6.3	7.3
Bank stability	4.3	4.0	5.3	7.3
Canopy cover	8.7	10.0	8.3	8.3
Water appearance	6.7	7.0	6.7	6.3
Nutrient enrichment	6.3	6.7	8.3	7.3
Manure presence	3.7	1.3	3.7	
Fish barriers	10.0	10.0	10.0	10.0
Fish cover	8.0	8.0	8.3	7.0
Pools	6.7	6.3	6.3	7.3
Riffle quality	5.3	7.3	4.0	6.0
Invertebrate habitat	7.0	7.7	7.7	6.0
Invertebrates observed	11.7	7.3	9.0	11.0
SVAP	**7.0**	**6.9**	**7.1**	**7.5**

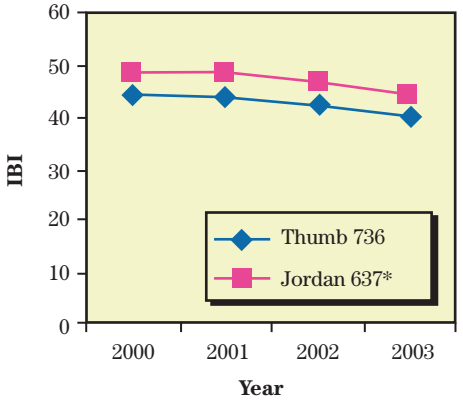
Site notes:

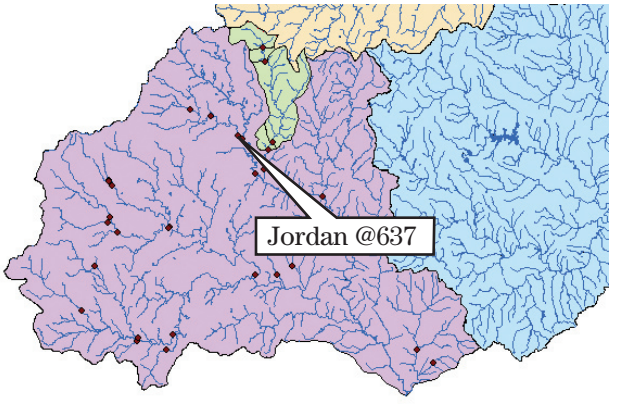
Thum @Basdn is the most downstream in a series of projects on Thumb Run, a stream listed as impaired by the Virginia Department of Environmental Quality 2002 303(d) report. One important aspect of this study is to examine the cumulative impacts of buffers, and Thumb Run is perhaps the best stream where that can be done. Thum @Basdn is located less than 1 mile above Thumb Run's confluence with the Rappahannock River. In addition to the five projects that we evaluated on Thumb Run, buffers have been established on smaller tributaries within the drainage that do not fit the criteria for this study; however, they collectively contribute to the benefit of the stream. Prior to restoration, Thum @Basdn was heavily grazed with bank stability and sedimentation problems. Livestock exclusion stimulated a response from herbaceous vegetation, although response from woody vegetation has been small. Both SVAP and IBI scores have climbed steadily since restoration. Because it is the most downstream site on Thumb Run, its IBI scores may be incorporating the cumulative effects of the upstream projects.

Appendix A13—Thumb Run @736, Fauquier Co. VA

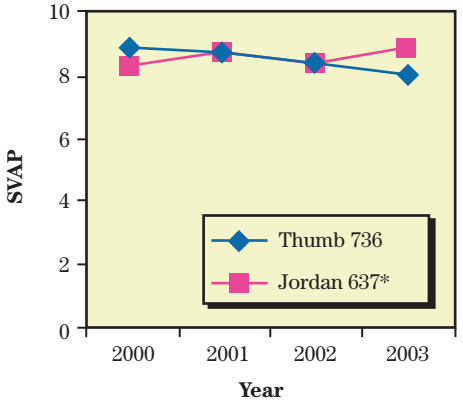
Basis qualified: Cropping
Restored: Spring 2002
Size: 76.8 km^2
Baseline SVAP: 9.0 (Good)
Baseline IBI: 44 (Good)
Upstream land use
  Cropland %: 12.6
  Pasture %: 39.2
  Non-ag %: 48.2
  Urban/disturbed %: 0
Buffer area (ha): 9.4
Buffer length (m): 2,816.4

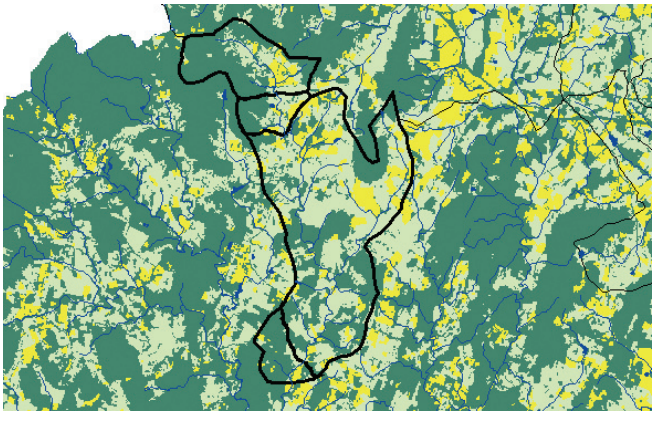
IBI and SVAP trends for Thum @736 and its paired less-disturbed reference, Jordan @637.





Thum @736 drainage





Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A13—Thumb Run @736, Fauquier Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey	1			
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace	3	5	15	3
Fallfish	83	222	110	19
Creek chub			4	14
River chub	4	6	8	2
Bluehead chub		19	10	13
Cutlips minnow		2		
Blacknose dace	1	6	12	6
Longnose dace	30	35	52	3
Central stoneroller				
Eastern silvery minnow				
Common shiner	100	29	98	70
Satinfin shiner	79	96	61	53
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner	1	2	3	1
Spottail shiner				
Swallowtail shiner	3	38	31	26
Roseyface shiner	54	2	6	1
Silverjaw minnow		21	37	51
White sucker	4	13	26	4
Creek chubsucker				
Northern hogsucker	2	14	10	3
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead		1		
Brown bullhead				
Margined madtom			1	1
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish	3	28	17	6
Green sunfish		2	10	6
Pumpkinseed				
Bluegill	5	6	4	21
Redear sunfish				
Rock bass			2	
Black crappie				
Smallmouth bass	2			
Largemouth bass	2	3	1	
Shield darter		3	4	2
Stripeback darter				
Tesselated darter	22	31	49	22
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids		1	2	
Total	**399**	**585**	**573**	**327**
Anomalies				

White sucker, a tolerant species, was collected each year at Thum @736.

Comely shiner, an insectivorous, lithophilic minnow was collected in small numbers in each year of sampling at Thum @736.

Appendix A13—Thumb Run @736, Fauquier Co. VA

IBI metric values and scores

IBI metrics	2000 value	2000 rating	2001 value	2001 rating	2002 value	2002 rating	2003 value	2003 rating
# native species	15	3	19	3	19	3	19	3
# darter species	1	1	2	3	2	3	2	3
# minnow species	10	3	13	3	13	3	13	3
% dominant species	0.251	3	0.379	1	0.192	3	0.214	3
# intolerant species	2	3	2	3	3	5	3	5
% tolerant individuals	0.025	5	0.082	5	0.162	3	0.312	3
% omnivores	0.010	5	0.091	5	0.127	3	0.208	3
% benthic invertivores	0.135	3	0.142	3	0.202	3	0.095	3
% specialist carnivores	0.226	3	0.434	5	0.227	3	0.076	1
% simple lithophils	0.484	5	0.219	3	0.382	3	0.333	3
# late maturing species	4	5	4	5	5	5	5	5
% anomalies	0.000	5	0.000	5	0.000	5	0.000	5
IBI		**44**		**44**		**42**		**40**

SVAP element ratings

SVAP Elements	2000	2001	2002	2003
Channel condition	9.7	8.3	8.6	8.3
Hydrologic alteration	9.3	8.7	8.3	8.0
Riparian width	7.7	7.3	7.4	7.3
Bank stability	8.0	7.0	7.1	8.3
Canopy cover	10.0	9.7	9.1	8.3
Water appearance	8.3	7.3	7.7	7.3
Nutrient enrichment	8.3	8.3	8.2	8.0
Manure presence				
Fish barriers	10.0	10.0	10.0	9.3
Fish cover	9.7	9.3	8.6	8.0
Pools	9.0	8.7	6.8	7.7
Riffle quality	8.3	8.3	8.3	6.7
Invertebrate habitat	9.3	9.0	8.4	8.0
Invertebrates observed	9.0	11.7	11.9	10.7
SVAP	**9.0**	**8.7**	**8.5**	**8.2**

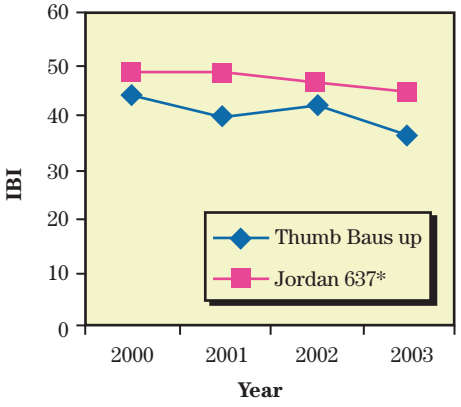
Site notes:

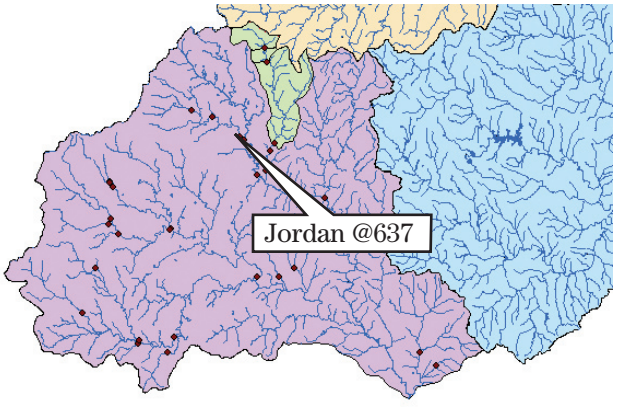
Three sites are located on lower Thumb Run in close proximity of each other (Thum @Basdn, Thum @736, and Thum @Basup). Of the three, Thum @736 was in the best condition prior to restoration as reflected by both its SVAP and IBI scores. The major impairment in the Thumb Run system appears to be sediment, although fecal coliform bacteria is also listed as an impairment according to the Virginia 303(d) report. Over half of the site's watershed is either cropland or pasture. Riffle quality and invertebrate habitat scores are generally low for the system due to sedimentation; however, SVAP and IBI baseline conditions were better at Thum @736 than at any of the other Thumb Run sites. The site had a narrow, but mature riparian zone prior to buffer establishment, and grazing was not a problem since the site qualified for the program based on cropping. Both IBI and SVAP scores have gradually declined over the course of the study, possibly due to increasing rates of sedimentation that is filling the channel, decreasing pool depth, and burying riffle habitat.

Appendix A14—Thumb Run @Bauserman (upstream), Fauquier Co. VA

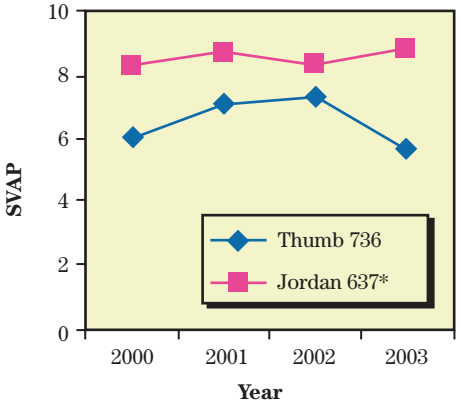
Basis qualified: Grazing
Restored: Spring 2002
Size: 72.3 km^2
Baseline SVAP: 6.1 (Fair)
Baseline IBI: 44 (Good)
Upstream land use
  Cropland %: 12.9
  Pasture %: 41.0
  Non-ag %: 46.2
  Urban/disturbed %: 0
Buffer area (ha): 3.0
Buffer length (m): 1,005.8

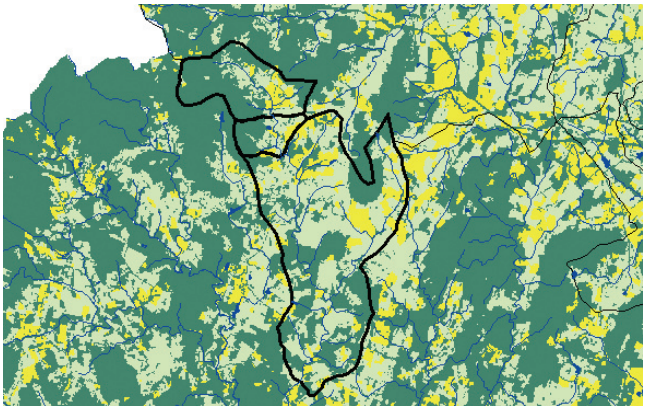
IBI and SVAP trends for Thum @Basup and its paired less-disturbed reference, Jordan @637.





Thum @Basup drainage





Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A14—Thumb Run @Bauserman (upstream), Fauquier Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace	21	6	39	3
Fallfish	90	286	154	34
Creek chub		2	11	8
River chub	17	1	11	11
Bluehead chub	7	20	9	9
Cutlips minnow	2			
Blacknose dace	2	7	2	
Longnose dace	3	9	16	4
Central stoneroller				
Eastern silvery minnow				
Common shiner	90	39	39	80
Satinfin shiner	217	57	41	48
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner	8			4
Spottail shiner	1			
Swallowtail shiner	60	33	45	33
Roseyface shiner		7	17	
Silverjaw minnow	93	39	38	16
White sucker	2	32	13	3
Creek chubsucker				
Northern hogsucker	14	17	20	1
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead		1		
Brown bullhead				
Margined madtom	2			
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish	22	20	7	7
Green sunfish			1	6
Pumpkinseed	1	5		
Bluegill	2	4	7	45
Redear sunfish			3	
Rock bass	1	1		
Black crappie				
Smallmouth bass	1		1	
Largemouth bass		3	3	7
Shield darter	2	2	6	
Stripeback darter				
Tesselated darter	60	68	10	12
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total	**718**	**659**	**493**	**331**
Anomalies	7		4	

Creek chub, a tolerant, trophic genearalist has increased in relative abundance despite buffer establishment at Thum @Basup.

Bluegill, a tolerant pool species has increased in abundance at Thum @Basup despite buffer establishment.

Appendix A14—Thumb Run @Bauserman (upstream), Fauquier Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	20	5	19	3	17	3	15	3
# darter species	2	3	2	3	2	3	1	1
# minnow species	13	3	12	3	12	3	11	3
% dominant species	0.302	3	0.434	1	0.312	1	0.242	3
# intolerant species	2	3	2	3	2	3	0	1
% tolerant individuals	0.138	5	0.127	5	0.146	5	0.236	3
% omnivores	0.142	3	0.138	3	0.122	3	0.085	5
% benthic invertivores	0.113	3	0.146	3	0.105	3	0.051	1
% specialist carnivores	0.159	3	0.472	5	0.335	5	0.145	3
% simple lithophils	0.276	3	0.171	1	0.369	3	0.378	3
# late maturing species	5	5	4	5	4	5	4	5
% anomalies	0.010	5	0.000	5	0.008	5	0.000	5
IBI		**44**		**40**		**42**		**36**

SVAP element ratings

SVAP Elements	2000	2001	2002	2003
Channel condition	6.0	7.0	7.7	4.0
Hydrologic alteration	7.7	6.7	6.0	5.0
Riparian width	4.7	4.7	5.3	5.7
Bank stability	3.0	5.3	5.3	2.0
Canopy cover	7.7	8.7	7.3	8.0
Water appearance	4.7	5.7	7.0	5.3
Nutrient enrichment	6.7	7.3	8.7	7.0
Manure presence	2.7			
Fish barriers	9.7	10.0	10.0	10.0
Fish cover	7.7	7.0	8.7	5.7
Pools	6.3	5.7	5.3	7.0
Riffle quality	5.7	6.3	6.0	3.7
Invertebrate habitat	7.3	7.7	7.3	4.3
Invertebrates observed	6.3	10.0	10.7	6.0
SVAP	**6.1**	**7.1**	**7.3**	**5.7**

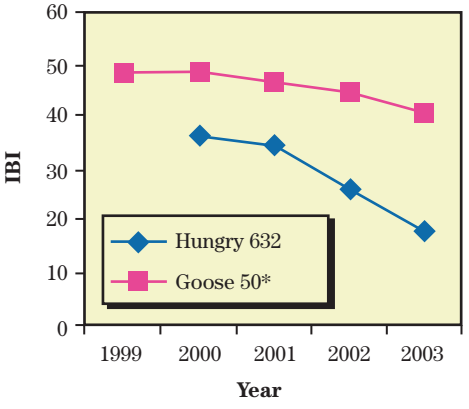
Site notes:

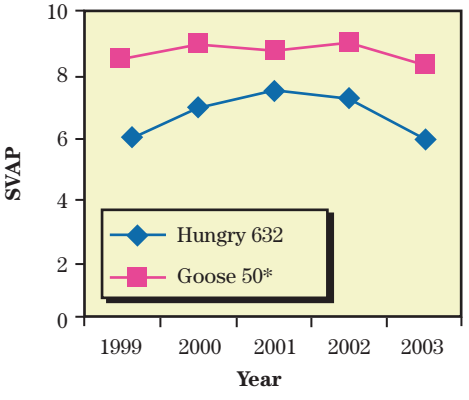
Thum @Basup is the upper most of the three projects located on lower Thumb Run. The site was moderately impacted by livestock prior to buffer establishment as indicated by the low SVAP scores for manure presence, bank stability, and water appearance. However, overall conditions at the site have deteriorated over the course of the study. Streambank erosion is still a significant problem. Large reaches of bank continue to slough into the stream, despite the improved cover conditions created by the fencing. Extensive sedimentation is filling the channel and covering fish and invertebrate habitat. These problems were particularly evident in 2003 when above average rainfall created conditions that made the problems more apparent. SVAP and IBI scores appear to be headed downward rather than up. Although there is no good explanation as to why the condition may be worsening, it is clearly due to factors that are beyond the influence of the restoration project.

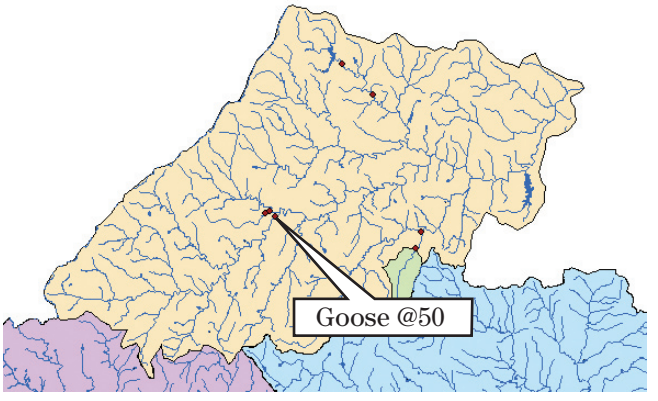
Appendix A15—Hungry Run @632, Loudoun Co. VA

Basis qualified: Grazing
Restored: Spring 2000
Size: 14.5 km^2
Baseline SVAP: 6.8 (Fair)
Baseline IBI: 36 (Fair)
Upstream land use
  Cropland %: 16.3
  Pasture %: 28.6
  Non-ag %: 55.1
  Urban/disturbed %: 0
Buffer area (ha): 12.4
Buffer length (m): 3,143.8

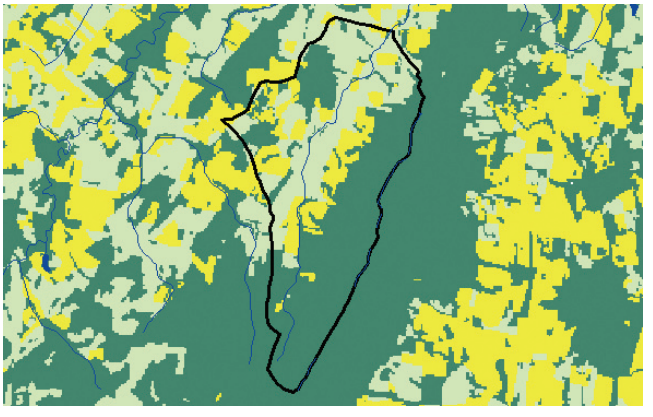
IBI and SVAP trends for Hungry @632 and its paired less-disturbed reference, Goose @50.







Hungry @632 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A15—Hungry Run @632, Loudoun Co. VA

Raw fish data

Common Name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner	1			
Mountain redbelly dace				
Roseyside dace	50	86	60	26
Fallfish				
Creek chub	9	9	6	9
River chub				
Bluehead chub				
Cutlips minnow				
Blacknose dace	147	96	201	20
Longnose dace	24	23	36	
Central stoneroller				
Eastern silvery minnow				
Common shiner	1		2	
Satinfin shiner				
Spotfin shiner				
Bluntnose minnow	60	69	198	107
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow			2	
White sucker	3	21	13	1
Creek chubsucker	2	2	2	4
Northern hogsucker				
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead			1	
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin	24	15	4	2
Redbreast sunfish	22	25	35	30
Green sunfish	32	3		9
Pumpkinseed				
Bluegill	2	13	22	43
Redear sunfish				
Rock bass				
Black crappie				
Smallmouth bass				
Largemouth bass		1		10
Shield darter				
Stripeback darter				
Tesselated darter	1	4	1	
Glassy darter				
Fantail darter	19	35	42	2
Greenside darter	20	31	11	
Hybrids	1			
Total	**418**	**433**	**636**	**263**
Anomalies	24	53	113	12

Bluntnose minnow, a tolerant, variable substrate manipulative spawner is one of the co-dominants at Hungry @632, along with blacknose dace.

A high incidence of anomalies, particularly blackspot disease, was observed each year at Hungry @632.

Appendix A15—Hungry Run @632, Loudoun Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	12	3	10	1	13	3	8	1
# darter species	3	5	3	5	3	5	1	1
# minnow species	7	3	5	1	7	3	4	1
% dominant species	0.189	5	0.212	5	0.316	3	0.407	1
# intolerant species	1	3	1	3	1	3	1	3
% tolerant individuals	0.481	3	0.466	3	0.695	1	0.719	1
% omnivores	0.201	3	0.199	3	0.335	1	0.411	1
% benthic invertivores	0.283	5	0.243	5	0.151	3	0.030	1
% specialist carnivores	0.069	1	0.102	3	0.057	1	0.152	3
% simple lithophils	0.236	3	0.241	3	0.154	1	0.099	1
# late maturing species	1	1	1	1	1	1	1	1
% anomalies	0.075	1	0.073	1	0.178	1	0.046	3
IBI		**36**		**34**		**26**		**18**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition	7.7	7.3	8.0	6.3
Hydrologic alteration	8.3	7.0	7.7	5.7
Riparian width	7.0	8.3	4.7	7.0
Bank stability	4.0	5.7	4.7	5.3
Canopy cover	7.0	6.0	8.7	6.7
Water appearance	6.0	7.0	7.0	4.0
Nutrient enrichment	7.3	6.7	8.3	3.7
Manure presence	5.0	5.0		
Fish barriers	9.7	10.0	10.0	7.7
Fish cover	7.7	9.0	8.0	6.0
Pools	5.3	7.7	6.0	5.0
Riffle quality	7.7	7.7	8.0	5.0
Invertebrate habitat	7.0	9.7	7.0	6.0
Invertebrates observed	6.0	8.0	6.0	7.3
SVAP	**6.8**	**7.5**	**7.2**	**5.8**

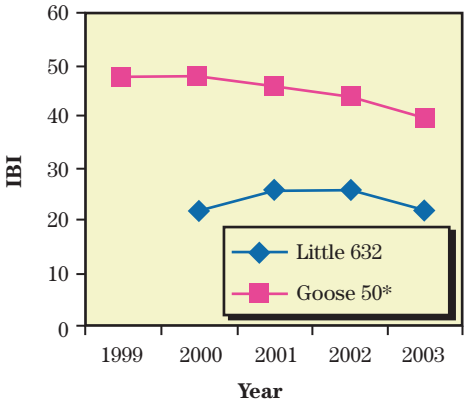
Site notes:

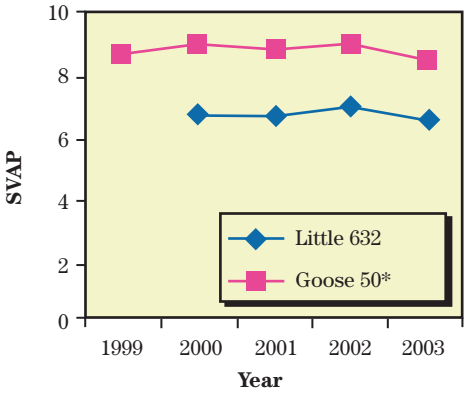
Hungry @632 has a small watershed that is moderately influenced by cropping and grazing. The site was heavily impacted by livestock prior to buffer establishment, as indicated by its low SVAP scores for manure presence, bank stability, water appearance, and pool quality. The baseline IBI condition was fair. Hungry @632 was one of the three projects that was fenced only and not planted to trees. Cattle still have access to the stream through a gravel walkway located at the project's upstream boundary. Although both herbaceous and woody vegetation have responded to the fencing, the site's scores for water appearance, riffle quality, and invertebrate habitat have diminished. The water still has a foul smell throughout the reach. IBI scores have declined as well. The site is heavily grazed outside of the fenced area, and those livestock have access to the stream through the walkway that was designed to provide water, but protect channel banks. That access, or other upstream influences may be influencing the response at the site.

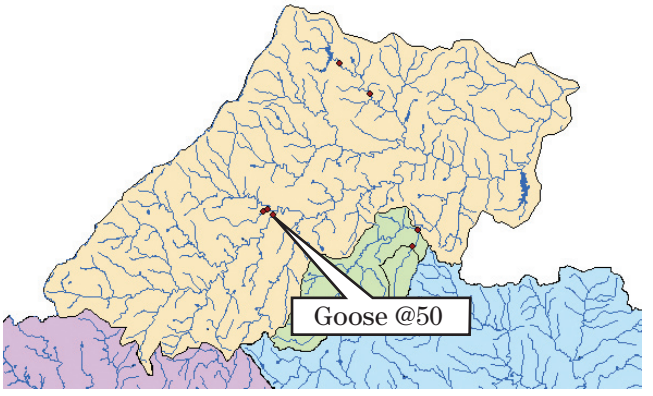
Appendix A16—Little River @632, Loudoun Co. VA

Basis qualified: Grazing
Restored: Spring 1999
Size: 89.2 km^2
Baseline SVAP: 6.5 (Fair)
Baseline IBI: 22 (Very poor)
Upstream land use
  Cropland %: 24.6
  Pasture %: 33.8
  Non-ag %: 41.6
  Urban/disturbed %: 0.22
Buffer area (ha): 7.7
Buffer length (m): 2,621.3

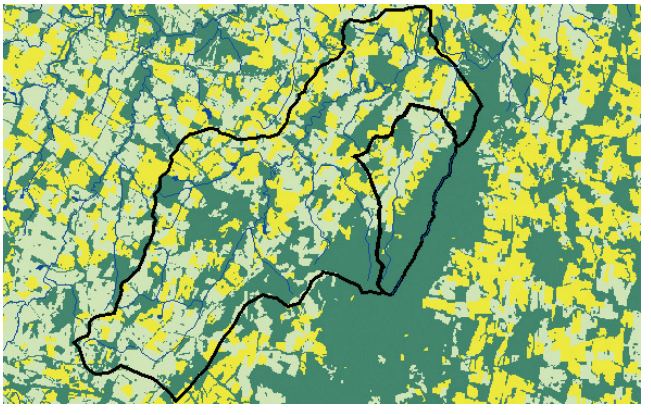
IBI and SVAP trends for Little @632 and its paired less-disturbed reference, Goose @50.







Little @632 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A16—Little River @632, Loudoun Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner	16	6	2	
Mountain redbelly dace				
Roseyside dace	16	34	28	2
Fallfish				
Creek chub		9	16	1
River chub				
Bluehead chub				
Cutlips minnow				
Blacknose dace	65	102	80	25
Longnose dace	11	70	26	1
Central stoneroller				
Eastern silvery minnow				
Common shiner	17	26	6	
Satinfin shiner				
Spotfin shiner	9	2	7	12
Bluntnose minnow	128	58	98	37
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow	20	3	13	48
White sucker	11	41	11	2
Creek chubsucker	2	7	3	
Northern hogsucker	3	1	4	
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead			6	
Brown bullhead				
Margined madtom			1	
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin	6	2		15
Redbreast sunfish	10	9	11	2
Green sunfish	30	7	1	1
Pumpkinseed				
Bluegill	23	22	15	48
Redear sunfish			2	
Rock bass				
Black crappie				
Smallmouth bass				
Largemouth bass			3	4
Shield darter				
Stripeback darter				
Tesselated darter	18	18	13	
Glassy darter				
Fantail darter	4	18	13	8
Greenside darter	52	11	35	1
Hybrids	2			
Total	**443**	**447**	**394**	**207**
Anomalies	26	57	79	

Goldern shiner, an herbivorous pool dweller was collected at Little @632 in 3 of the 4 years of sampling.

Spotfin shiner, although found sporadically in the Occoquan drainage, is common in the Goose Creek drainage and has been collected every year at Little @632.

Appendix A16—Little River @632, Loudoun Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	14	1	15	1	15	1	10	1
# darter species	3	5	3	5	3	5	2	3
# minnow species	8	3	9	3	9	3	7	1
% dominant species	0.289	3	0.228	3	0.249	3	0.232	3
# intolerant species	1	1	1	1	1	1	1	1
% tolerant individuals	0.625	1	0.541	1	0.594	1	0.783	1
% omnivores	0.395	1	0.242	1	0.315	1	0.420	1
% benthic invertivores	0.217	3	0.286	5	0.241	3	0.121	3
% specialist carnivores	0.023	1	0.020	1	0.051	1	0.029	1
% simple lithophils	0.106	1	0.295	3	0.162	1	0.014	1
# late maturing species	2	1	2	1	4	5	1	1
% anomalies	0.059	1	0.128	1	0.201	1	0.000	5
IBI		**22**		**26**		**26**		**22**

SVAP element ratings

SVAP elements	**2000**	**2001**	**2002**	**2003**
Channel condition	7.0	6.3	7.3	6.3
Hydrologic alteration	7.0	6.7	7.0	7.3
Riparian width	7.3	6.3	5.3	6.7
Bank stability	4.0	7.0	5.3	5.7
Canopy cover	7.3	6.0	8.0	7.0
Water appearance	6.0	4.7	5.3	4.7
Nutrient enrichment	6.7	6.3	8.0	5.3
Manure presence	5.0	4.7		
Fish barriers	3.0	4.3	3.0	3.0
Fish cover	8.0	9.0	8.7	8.7
Pools	8.3	8.7	9.0	9.0
Riffle quality	7.3	4.7	6.7	5.3
Invertebrate habitat	7.0	9.0	7.3	7.7
Invertebrates observed	7.7	7.7	8.7	7.0
SVAP	**6.5**	**6.5**	**6.9**	**6.4**

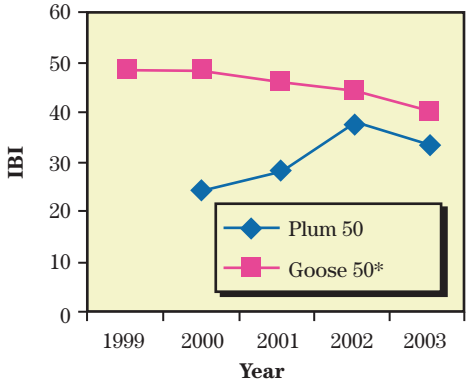
Site notes:

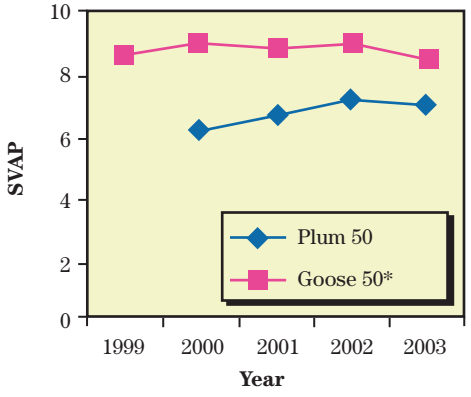
Little @632 and Hungry @632 are part of the same project, but Little @632 is located on the much larger Little River. The site has a large, predominantly agricultural watershed. It is also influenced by an old mill dam located less than a mile downstream, which retards the flow of water at the site and causes sediment deposition. Although the site was grazed prior to restoration, many other influences affect its condition. Both SVAP and IBI scores were low prior to restoration and have remained low since. Although herbaceous vegetation has responded, streambank erosion and sedimentation continue to occur at the site.

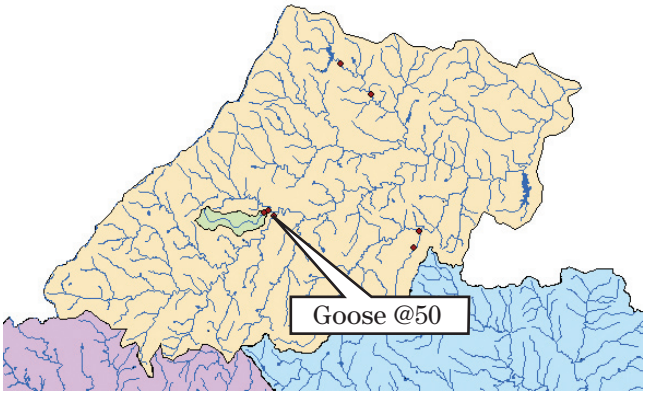
Appendix A17—Plum Run @50, Loudoun Co. VA

Basis qualified: Grazing
Restored: Spring 2000
Size: 10.6 km^2
Baseline SVAP: 6.1 (Fair)
Baseline IBI: 24 (Very poor)
Upstream land use
  Cropland %: 40.1
  Pasture %: 40.0
  Non-ag %: 19.9
  Urban/disturbed %: 0
Buffer area (ha): 12.5
Buffer length (m): 1,365.5

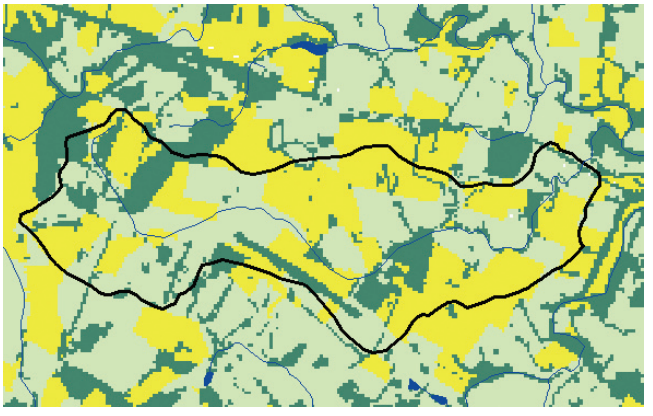
IBI and SVAP trends for Plum @50 and its paired less-disturbed reference, Goose @50.







Plum @50 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A17—Plum Run @50, Loudoun Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner		5	7	
Mountain redbelly dace				
Roseyside dace	2	2	15	1
Fallfish			4	
Creek chub		3	3	2
River chub			1	
Bluehead chub				
Cutlips minnow				
Blacknose dace	90	60		13
Longnose dace		1	55	6
Central stoneroller	1		1	5
Eastern silvery minnow				
Common shiner		11	24	83
Satinfin shiner			7	
Spotfin shiner			25	7
Bluntnose minnow	2	1	77	30
Fathead minnow				1
Comely shiner				
Spottail shiner			2	
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow			4	
White sucker	10	17	4	1
Creek chubsucker	4	6		2
Northern hogsucker				
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead	1			1
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish	8	8	7	9
Green sunfish	21	21	19	69
Pumpkinseed		2	7	10
Bluegill	20	39	20	112
Redear sunfish				
Rock bass				
Black crappie				
Smallmouth bass				
Largemouth bass	4		17	9
Shield darter				
Stripeback darter				
Tesselated darter		3		
Glassy darter				
Fantail darter	14		6	11
Greenside darter		3	4	21
Hybrids			1	3
Total	**177**	**182**	**310**	**396**
Anomalies	1	2	9	

Creek chubsucker, a benthic invertivore found in pool habitats of Plum @50 in 3 out of 4 years.

Central stoneroller, found only in the Goose Creek system among the three watersheds, was collected in 3 out of 4 years at Plum @50.

Appendix A17—Plum Run @50, Loudoun Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	8	1	11	3	16	3	13	3
# darter species	1	1	2	3	2	3	2	3
# minnow species	4	1	7	3	13	5	9	3
% dominant species	0.508	1	0.330	3	0.248	3	0.283	3
# intolerant species	0	1	0	1	0	1	0	1
% tolerant individuals	0.808	1	0.775	1	0.410	3	0.573	3
% omnivores	0.068	5	0.126	3	0.297	3	0.081	5
% benthic invertivores	0.102	3	0.071	3	0.210	5	0.101	3
% specialist carnivores	0.073	3	0.044	1	0.090	3	0.048	1
% simple lithophils	0.017	1	0.077	1	0.306	3	0.240	3
# late maturing species	1	1	1	1	2	3	1	1
% anomalies	0.006	5	0.011	5	0.029	3	0.000	5
IBI		**24**		**28**		**38**		**34**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition	7.3	8.0	6.7	7.7
Hydrologic alteration	7.0	7.7	8.3	7.7
Riparian width	7.0	6.3	7.3	8.0
Bank stability	5.7	5.3	7.3	7.3
Canopy cover	8.0	9.3	8.3	8.7
Water appearance	4.7	5.3	6.7	4.7
Nutrient enrichment	5.3	5.3	7.0	6.0
Manure presence	2.3	2.7		5.0
Fish barriers	6.3	10.0	10.0	10.0
Fish cover	7.0	6.3	7.0	5.7
Pools	6.3	5.0	6.7	7.3
Riffle quality	6.0	7.3	6.0	6.7
Invertebrate habitat	7.7	8.0	6.3	6.3
Invertebrates observed	5.0	6.0	6.0	6.3
SVAP	**6.1**	**6.6**	**7.2**	**7.0**

Site notes:

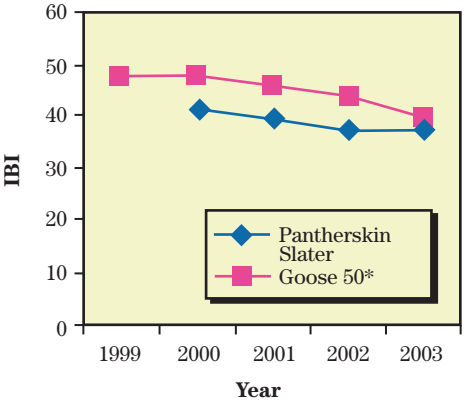
Plum @50 has a small watershed that is heavily influenced by agriculture. It also is one of the few sites that was fenced only and not planted to trees. The site had a well-developed riparian zone throughout much of the reach prior to fencing; however, it was heavily grazed and highly impacted by livestock. Baseline SVAP scores for manure presence, bank stability, and nutrient enrichment were low. The IBI prior to restoration indicated that the site was in poor condition as well. Except for occasions when cattle have accessed the stream because gates were left open, the stream's water quality and overall appearance have improved with the fencing. Increasing SVAP and IBI scores also indicate a trend of improvement.

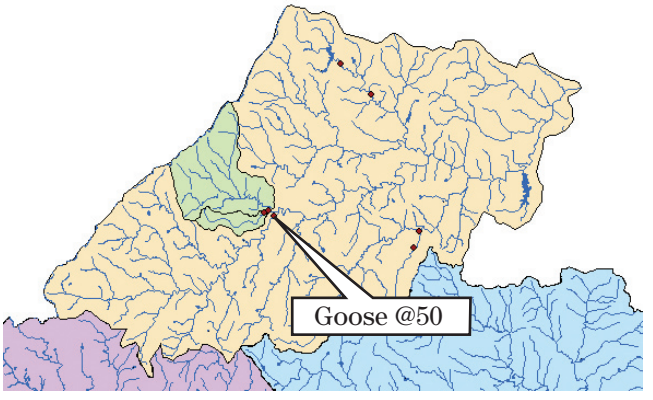
Appendix A18—Pantherskin Creek @Slater, Loudoun Co. VA

Basis qualified: Grazing
Restored: Spring 2002
Size: 62.3 km^2
Baseline SVAP: 7.6 (Good)
Baseline IBI: 42 (Good)
Upstream land use
- Cropland %: 25.7
- Pasture %: 30.6
- Non-ag %: 43.7
- Urban/disturbed %: 0.50

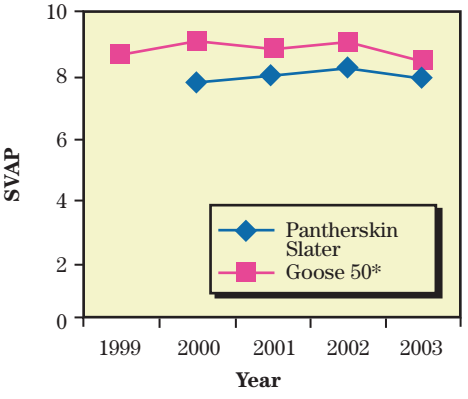
Buffer area (ha): 25.7
Buffer length (m): 5,657.1

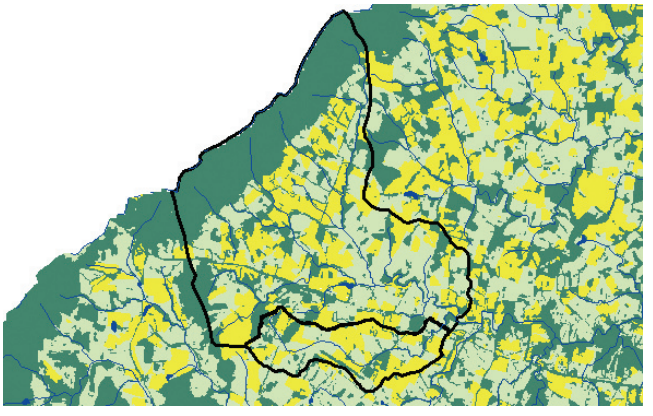
IBI and SVAP trends Panth @Slater and its paired less-disturbed reference, Goose @50.





Panth @Slater drainage





Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A18—Pantherskin Creek @Slater, Loudoun Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner			1	
Mountain redbelly dace				
Roseyside dace				2
Fallfish	1	2	3	
Creek chub			1	
River chub	2	5	5	
Bluehead chub				
Cutlips minnow	1	3	3	
Blacknose dace	42	59	45	8
Longnose dace	14	11	8	6
Central stoneroller	9	4	1	1
Eastern silvery minnow				
Common shiner	26	44	55	39
Satinfin shiner	3	15	30	22
Spotfin shiner	25	32	49	42
Bluntnose minnow	11	9	24	11
Fathead minnow		1		1
Comely shiner	16	16		
Spottail shiner	54	23	17	3
Swallowtail shiner	2		2	28
Roseyface shiner		15	9	2
Silverjaw minnow	36	10	8	10
White sucker	3		3	
Creek chubsucker		2		
Northern hogsucker	5	3	1	
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead	1			
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin	1	1	1	2
Redbreast sunfish	1	1	1	10
Green sunfish	11	1	4	3
Pumpkinseed	3		1	
Bluegill	10	3		9
Redear sunfish				
Rock bass		1		1
Black crappie				
Smallmouth bass		1	1	
Largemouth bass	1			1
Shield darter				
Stripeback darter				
Tesselated darter	19	14	2	2
Glassy darter				
Fantail darter	15	24	21	19
Greenside darter	33	16	4	14
Hybrids	2		1	
Total	**347**	**316**	**301**	**236**
Anomalies	8	4	28	1

Potomac sculpin, an intolerant, benthic invertivore was collected each year at Panth @Slater.

Spottail shiner was a relatively abundant minnow species at Panth @Slater in most years of sampling.

Appendix A18—Pantherskin Creek @Slater, Loudoun Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	21	5	19	3	22	5	15	3
# darter species	3	5	3	5	3	5	3	5
# minnow species	14	5	15	5	16	5	13	3
% dominant species	0.156	5	0.187	3	0.183	3	0.178	3
# intolerant species	1	1	2	3	2	3	2	3
% tolerant individuals	0.326	3	0.259	3	0.282	3	0.174	3
% omnivores	0.144	3	0.063	5	0.120	3	0.093	5
% benthic invertivores	0.251	5	0.225	3	0.123	3	0.182	3
% specialist carnivores	0.012	1	0.016	1	0.017	1	0.051	1
% simple lithophils	0.207	1	0.294	3	0.252	3	0.331	3
# late maturing species	3	3	2	1	3	3	0	1
% anomalies	0.023	5	0.013	5	0.093	1	0.004	5
IBI		**42**		**40**		**38**		**38**

SVAP element ratings

SVAP elements	**2000**	**2001**	**2002**	**2003**
Channel condition	8.0	9.0	8.7	7.7
Hydrologic alteration	9.0	8.0	8.0	7.7
Riparian width	9.0	8.0	8.7	8.3
Bank stability	7.3	7.0	7.7	8.7
Canopy cover	8.7	9.7	9.0	8.7
Water appearance	7.3	8.0	7.7	5.7
Nutrient enrichment	7.3	6.3	6.7	6.7
Manure presence	2.7	4.3		
Fish barriers	9.3	10.0	10.0	10.0
Fish cover	5.7	8.3	7.7	7.3
Pools	6.3	7.0	5.7	6.7
Riffle quality	7.7	8.7	7.3	7.0
Invertebrate habitat	9.0	8.3	7.7	7.0
Invertebrates observed	9.0	8.0	11.0	10.3
SVAP	**7.6**	**7.9**	**8.1**	**7.8**

Site notes:

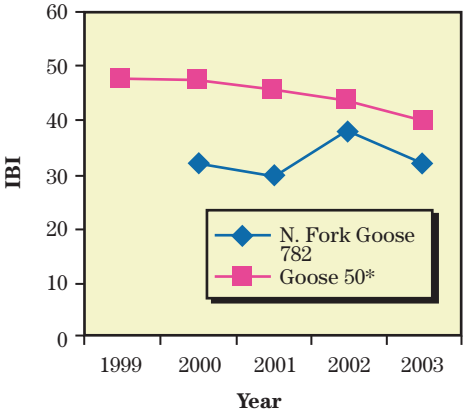
Panth @Slater and Plum @50 are part of the same project, but Panth @Slater is on the much larger Pantherskin Creek. Land use in the site's watershed is predominantly agriculture. However, the site is located adjacent to a large forested bluff, and the stream's structure and physical appearance rank with the best in the study. Boulder and cobble substrates provide an abundance of riffle habitat and fish cover. A mature riparian zone was present along both sides of the stream prior to fencing. However, it was also heavily grazed, and exclusion of livestock has prompted a positive response in herbaceous vegetation. Improvement at the site has been measured by the SVAP, but not the IBI.

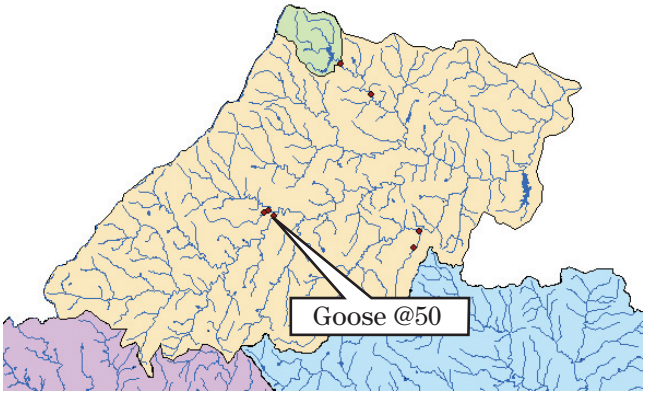
Appendix A19—N. Fork Goose Creek @782, Loudoun Co. VA

Basis qualified: Grazing
Restored: Spring 1999
Size: 28.7 km^2
Baseline SVAP: 7.3 (Fair)
Baseline IBI: 32 (Poor)
Upstream land use
- Cropland %: 28.5
- Pasture %: 24.5
- Non-ag %: 46.9
- Urban/disturbed %: 0.78

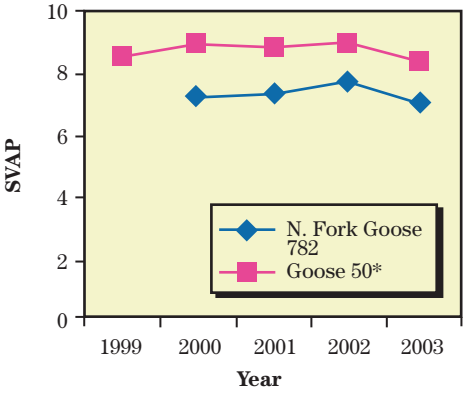
Buffer area (ha): 4.4
Buffer length (m): 1,280.2

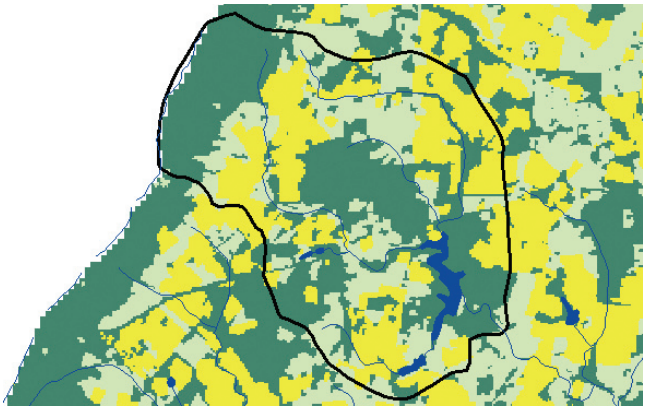
IBI and SVAP trends for N Goose @782 and its paired less-disturbed reference, Goose @50.





N Goose @782 drainage





Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A19—N. Fork Goose Creek @782, Loudoun Co. VA

Raw fish data

Common Name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner		1		
Mountain redbelly dace				
Roseyside dace	5	2		
Fallfish			2	1
Creek chub	1	1	7	
River chub				
Bluehead chub				
Cutlips minnow				
Blacknose dace	29	45	27	3
Longnose dace	2	6	9	6
Central stoneroller			1	1
Eastern silvery minnow				
Common shiner	4	6	1	22
Satinfin shiner	2	11	40	4
Spotfin shiner	22	2	41	59
Bluntnose minnow	106	107	26	17
Fathead minnow		1		
Comely shiner				
Spottail shiner	5	38	2	4
Swallowtail shiner	190	128	59	67
Roseyface shiner				
Silverjaw minnow				4
White sucker	6	3	2	1
Creek chubsucker	5	1		
Northern hogsucker	1	1	1	1
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead	10	4	4	2
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish	24	17	32	39
Green sunfish		1		5
Pumpkinseed	1	2	1	4
Bluegill	160	66	48	231
Redear sunfish				
Rock bass				
Black crappie		1	10	9
Smallmouth bass				
Largemouth bass	5	12	35	20
Shield darter				
Stripeback darter				
Tesselated darter			1	
Glassy darter				
Fantail darter	4		14	5
Greenside darter	3		1	3
Hybrids				7
Total	**585**	**456**	**364**	**515**
Anomalies	4	14	2	1

Black crappie was collected in 3 of 4 years at N Goose @782, probably due to escapes from upstream Sleeter Lake.

Fantail darter, a riffle dwelling benthic invertivore was collected in 3 out of 4 years of sampling at N Goose @782.

Appendix A19—N. Fork Goose Creek @782, Loudoun Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	16	3	16	3	17	3	16	3
# darter species	2	3	0	1	3	5	2	3
# minnow species	10	3	12	3	11	3	11	3
% dominant species	0.325	3	0.281	3	0.162	5	0.449	1
# intolerant species	0	1	0	1	0	1	0	1
% tolerant individuals	0.516	3	0.489	3	0.302	3	0.507	3
% omnivores	0.191	3	0.246	3	0.077	5	0.043	5
% benthic invertivores	0.026	1	0.018	1	0.071	1	0.029	1
% specialist carnivores	0.067	1	0.075	3	0.228	3	0.138	3
% simple lithophils	0.345	3	0.314	3	0.195	1	0.188	1
# late maturing species	2	3	2	3	2	3	2	3
% anomalies	0.007	5	0.031	3	0.005	5	0.002	5
IBI		**32**		**30**		**38**		**32**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition	8.3	7.3	8.3	7.7
Hydrologic alteration	8.3	8.0	7.3	7.0
Riparian width	10.0	9.3	9.0	8.7
Bank stability	7.3	8.0	7.7	5.7
Canopy cover	2.0	5.7	6.7	7.0
Water appearance	8.7	9.0	8.3	8.0
Nutrient enrichment	8.7	8.0	7.7	7.7
Manure presence				
Fish barriers	3.0	3.0	3.7	3.0
Fish cover	8.0	9.0	8.7	7.3
Pools	7.0	4.7	7.0	7.3
Riffle quality	7.0	8.0	7.7	7.7
Invertebrate habitat	8.7	9.3	9.3	6.7
Invertebrates observed	7.3	6.0	9.0	9.0
SVAP	**7.3**	**7.3**	**7.7**	**7.1**

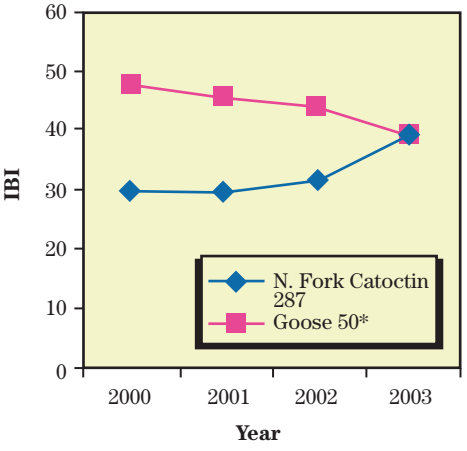
Site notes:

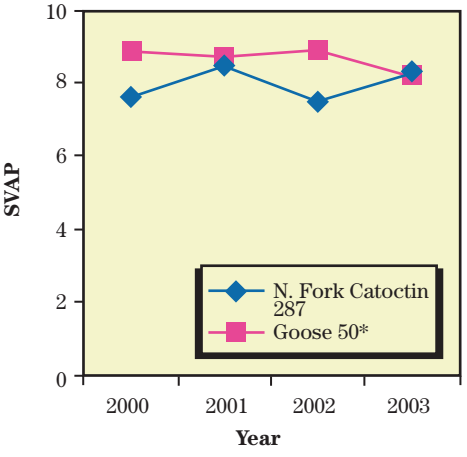
N Goose @782 has a small watershed that is influenced by recent upstream development near Round Hill and Purcelville. Sleeter Lake, located on the North Fork of Goose Creek less than a mile upstream from the site, also influences the site. Restoration at the site has caused a pronounced response in both the woody and herbaceous vegetation. Planted trees are 2 meters tall, and will soon be contributing stream shade and other riparian functions. Although there seems to be a significant improvement in overall appearance and condition at the site, those observations are not necessarily reflected by SVAP or IBI scores. Although some SVAP elements are trending upwards, others are trending down. The IBI has been up and down as well. For example, in some years benthic invertivores are present in good numbers and the next they are hard to find. The ups and downs of the site are hard to explain; however, it is clear that influences besides the established buffer are operating.

Appendix A20—N. Fork Cotoctin Creek @287, Loudoun Co. VA

Basis qualified: Grazing
Restored: Spring 2000
Size: 68.4 km^2
Baseline SVAP: 7.7 (Good)
Baseline IBI: 30 (Poor)
Upstream land use
  Cropland %: 22.7
  Pasture %: 35.6
  Non-ag %: 41.7
  Urban/disturbed %: 1.7
Buffer area (ha): 11.9
Buffer length (m): 2865.1

IBI and SVAP trends for Catoc @287 and its paired less-disturbed reference, Goose @50.

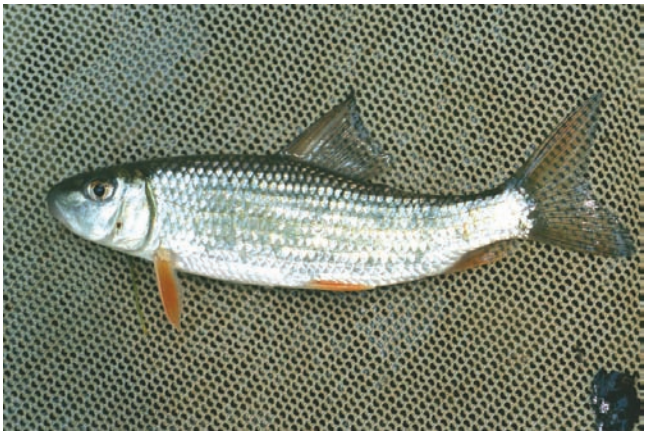




Appendix A20—N. Fork Cotoctin Creek @287, Loudoun Co. VA

Raw fish data

Common Name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner	4	6	3	
Mountain redbelly dace				
Roseyside dace				
Fallfish				
Creek chub	5	14	4	
River chub				
Bluehead chub				
Cutlips minnow		6	6	
Blacknose dace	38	52	45	58
Longnose dace	19	16	4	26
Central stoneroller	4	42	37	18
Eastern silvery minnow				
Common shiner	12	10	12	
Satinfin shiner		1		2
Spotfin shiner	3	17	43	27
Bluntnose minnow	33	140	63	61
Fathead minnow			1	
Comely shiner			1	
Spottail shiner	14	35	42	2
Swallowtail shiner	4	13		2
Roseyface shiner				
Silverjaw minnow	106	56	40	32
White sucker	21	25	14	4
Creek chubsucker	5	7	5	1
Northern hogsucker	1	8	3	8
Torrent sucker				
Golden redhorse	24	8		17
Shorthead redhorse				
Channel catfish				
Yellow bullhead		2	2	4
Brown bullhead				
Margined madtom				3
Banded killifish				1
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin			2	3
Redbreast sunfish	18	14	21	10
Green sunfish		2	4	13
Pumpkinseed	2	12	2	2
Bluegill	25	66	33	76
Redear sunfish				
Rock bass				
Black crappie				
Smallmouth bass				
Largemouth bass	4	12	3	4
Shield darter				
Stripeback darter				
Tesselated darter	36	62	41	28
Glassy darter				
Fantail darter	20	18	8	63
Greenside darter	9	26	8	9
Hybrids	2			1
Total	**409**	**670**	**447**	**475**
Anomalies	12	27	16	



Golden redhorse, rare in the Goose Creek, Occoquan, and Rappahannock drainages is relatively common at Catoc @287.

Banded killifish occurs sporadically in the Goose Creek drainage and has been collected on one occasion at Catoc @287.

Appendix A20—N. Fork Cotoctin Creek @287, Loudoun Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species	17	3	20	5	20	5	19	3
# darter species	3	5	3	5	3	5	3	5
# minnow species	11	3	13	3	13	3	9	3
% dominant species	0.259	3	0.209	3	0.141	5	0.160	5
# intolerant species	0	1	0	1	1	1	2	3
% tolerant individuals	0.557	1	0.530	1	0.454	3	0.514	1
% omnivores	0.401	1	0.339	1	0.271	1	0.204	3
% benthic invertivores	0.279	5	0.216	3	0.159	3	0.333	5
% specialist carnivores	0.054	1	0.042	1	0.058	1	0.038	1
% simple lithophils	0.156	1	0.145	1	0.128	1	0.149	1
# late maturing species	3	3	3	3	2	1	4	5
% anomalies	0.029	3	0.040	3	0.036	3	0.000	5
IBI		**30**		**30**		**32**		**40**

SVAP element ratings

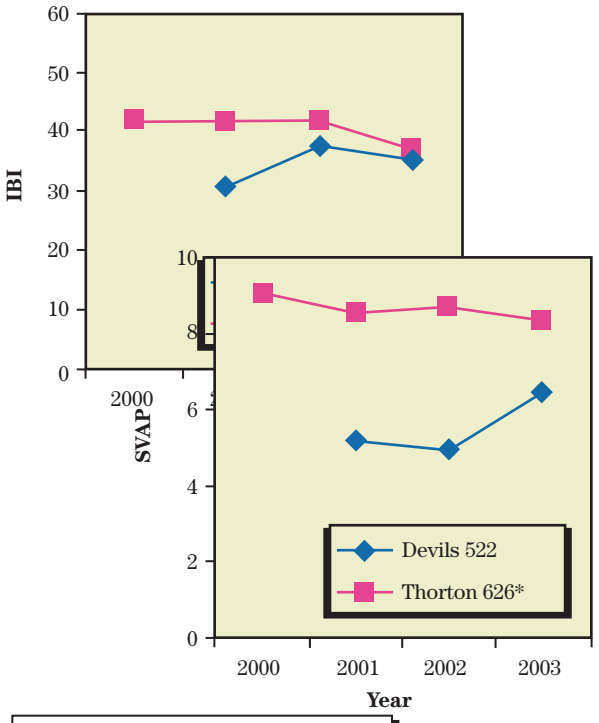
SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition	8.7	8.4	8.7	9.0
Hydrologic alteration	7.7	8.3	8.7	8.3
Riparian width	8.0	8.7	8.0	8.0
Bank stability	7.7	8.2	8.0	8.0
Canopy cover	9.7	8.2	9.0	8.7
Water appearance	6.3	8.4	4.7	7.7
Nutrient enrichment	7.0	7.8	6.3	7.7
Manure presence				
Fish barriers	9.3	10.0	10.0	10.0
Fish cover	7.7	8.7	8.7	8.0
Pools	7.0	8.3	7.0	6.7
Riffle quality	5.3	7.8	5.7	7.7
Invertebrate habitat	8.0	7.7	7.7	8.3
Invertebrates observed	7.7	10.8	7.7	11.7
SVAP	**7.7**	**8.6**	**7.7**	**8.4**

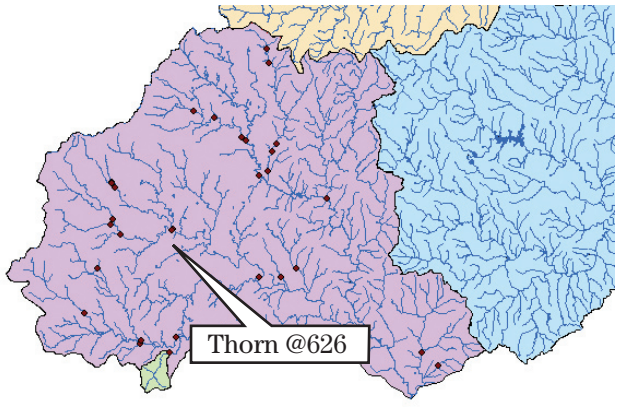
Site notes:

Catoc @287 has medium size watershed and predominantly agricultural drainage although some development is occurring near Hillsboro and along the State Highway 9 corridor. Although the site is located just outside the study area, it is close enough that prevailing stream disturbances and the local fauna are not materially different, and was therefore included in the study. The site was lightly grazed prior to restoration; however, grazing was well managed, and few livestock problems were observed. Restoration has caused a positive response in both herbaceous and woody cover. Upstream bridge construction impacted SVAP and IBI scores in 2002; however, the site has been trending upward since buffer establishment in 2000.

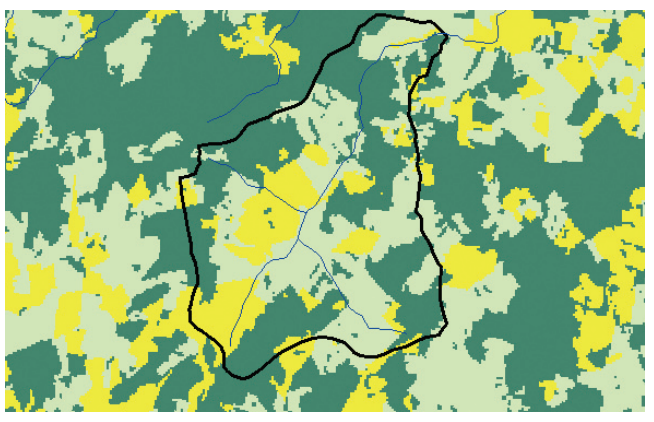
Appendix A21—Devils Run @522, Culpeper Co., VA

IBI and SVAP trends for Devils @522 and its paired less-disturbed reference, Thornton @626.





Devils @522 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Basis qualified: Grazing
Restored: Spring 2002
Size: 13.9 km^2
Baseline SVAP: 5.2 (Poor)
Baseline IBI: 36 (Fair)
Upstream land use
  Cropland %: 19.9
  Pasture %: 38.3
  Non-ag %: 41.9
  Urban/disturbed %: 0
Buffer area (ha): 42.2
Buffer length (m): 7461.5

Appendix A21—Devils Run @522, Culpeper Co., VA

Raw fish data

Common Name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner		3	2	1
Mountain redbelly dace		21	19	7
Roseyside dace		2		1
Fallfish		18	16	2
Creek chub		21	58	12
River chub		6	3	
Bluehead chub		33	52	28
Cutlips minnow				
Blacknose dace		12	8	5
Longnose dace		15	14	18
Central stoneroller				
Eastern silvery minnow				
Common shiner		84	65	78
Satinfin shiner		62	47	31
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner		34	48	54
Roseyface shiner				
Silverjaw minnow		81	36	92
White sucker		2	4	2
Creek chubsucker				
Northern hogsucker			2	1
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead			1	
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish		24	36	24
Green sunfish			2	6
Pumpkinseed				1
Bluegill			2	
Redear sunfish				
Rock bass		6	8	6
Black crappie				
Smallmouth bass		1		
Largemouth bass				
Shield darter				
Stripeback darter				
Tesselated darter		32	56	47
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total		**457**	**479**	**416**
Anomalies		4		3

Mountain redbelly dace, a recent introduction into the Rappahannock Watershed, is a common component of the fish assemblage at Devils @522.

Brown bullhead is collected very sporadically across the study area, but was found one year at Devils @522.

Appendix A21—Devils Run @522, Culpeper Co., VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	value	rating	value	rating	value	rating	value	rating
# native species			15	3	16	3	16	3
# darter species			1	1	1	1	1	1
# minnow species			13	5	12	5	12	5
% dominant species			0.325	3	0.136	5	0.221	5
# intolerant species			0	1	0	1	0	1
% tolerant individuals			0.388	3	0.230	3	0.281	3
% omnivores			0.393	1	0.196	3	0.296	1
% benthic invertivores			0.084	3	0.150	3	0.159	3
% specialist carnivores			0.088	3	0.127	3	0.077	3
% simple lithophils			0.242	3	0.269	3	0.365	3
# late maturing species			3	5	5	5	3	5
% anomalies			0.007	5	0.000	5	0.007	5
IBI				**36**		**40**		**38**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition		7.3	5.7	6.0
Hydrologic alteration		6.0	6.0	6.7
Riparian width		2.0	2.3	5.0
Bank stability		3.0	4.3	4.7
Canopy cover		1.7	2.3	6.7
Water appearance		5.0	3.7	6.7
Nutrient enrichment		5.0	5.7	5.7
Manure presence		1.7	3.3	
Fish barriers		8.7	10.0	10.0
Fish cover		5.0	6.0	7.0
Pools		6.3	4.0	7.3
Riffle quality		6.3	4.0	6.7
Invertebrate habitat		7.7	6.7	5.3
Invertebrates observed		7.7	6.0	7.0
SVAP		**5.2**	**5.0**	**6.5**

Site notes:

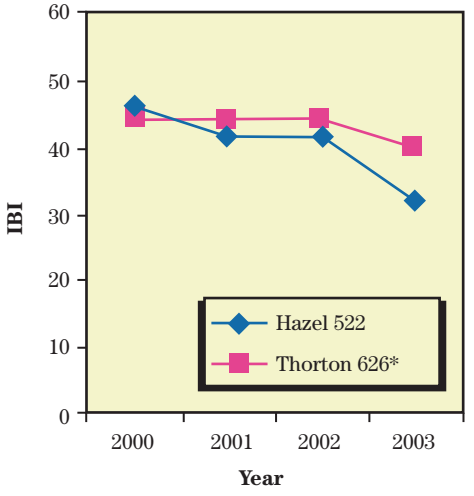
Devils @522 has a small, predominantly agricultural watershed. The site had practically no riparian zone prior to buffer establishment and was heavily grazed. SVAP baseline scores were low for most assessment elements. The IBI for the site was fair. Although only 2 years of data have been collected since restoration, there was a marked increase in the SVAP score after the second year of buffer establishment, and the overall appearance of the site has improved. The IBI score has been up since restoration. Although there may be some adverse upstream influences, because the watershed is small, they may not overwhelm the positive effects of the buffer.

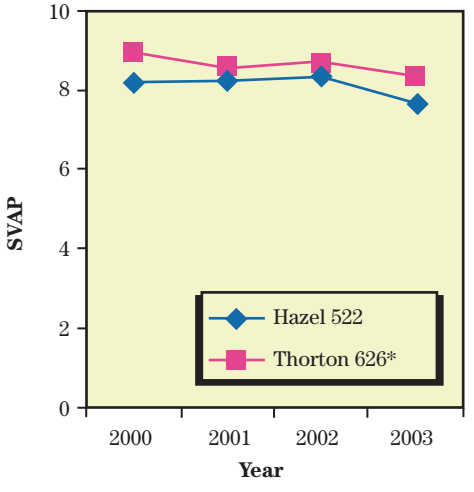
Appendix A22—Hazel River @522, Culpeper Co., VA

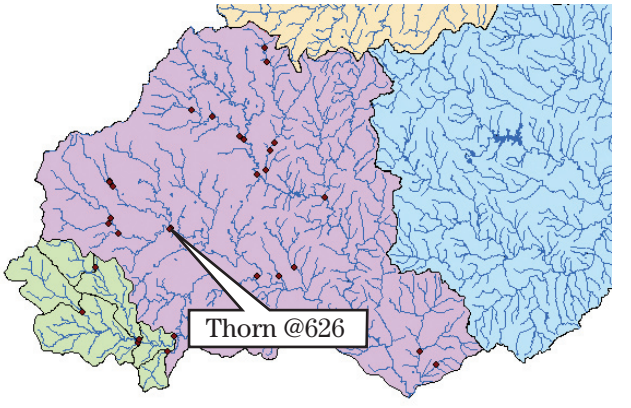
Basis qualified: Grazing
Restored: Spring 2002
Size: 198.3 km^2
Baseline SVAP: 8.3 (Good)
Baseline IBI: 42 (Good)
Upstream land use
- Cropland %: 7.7
- Pasture %: 20.2
- Non-ag %: 41.9
- Urban/disturbed %: 0.58

Buffer area (ha): 11.3
Buffer length (m): 2254.3

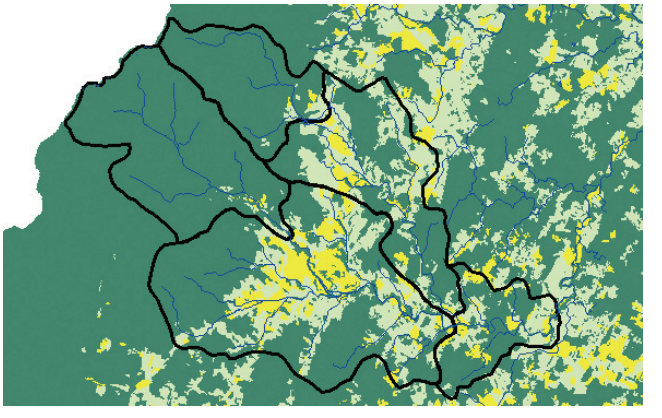
IBI and SVAP trends for Hazel @522 and its paired less-disturbed reference, Thornton @626.







Hazel @522 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A22—Hazel River @522, Culpeper Co., VA

Raw fish data

Common Name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner		4	6	7
Mountain redbelly dace				
Roseyside dace				
Fallfish		21	11	127
Creek chub		11	7	12
River chub		9	9	2
Bluehead chub		12	13	13
Cutlips minnow		1		
Blacknose dace				1
Longnose dace		56	20	19
Central stoneroller				
Eastern silvery minnow				
Common shiner		138	35	14
Satinfin shiner		187	112	347
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner		11	19	7
Spottail shiner				
Swallowtail shiner		14	66	62
Roseyface shiner		81	64	28
Silverjaw minnow		14	1	
White sucker		1	9	
Creek chubsucker				
Northern hogsucker		1		4
Torrent sucker		1	4	1
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				1
Brown bullhead				
Margined madtom			1	
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish		2	6	30
Green sunfish			2	18
Pumpkinseed				
Bluegill		1		26
Redear sunfish				
Rock bass		10	4	8
Black crappie				
Smallmouth bass		1	1	
Largemouth bass		1		
Shield darter		1	1	
Stripeback darter				
Tesselated darter		33	18	15
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total		**611**	**409**	**742**
Anomalies		2	1	1

Bluehead and river chub build mounded nests that other species use for spawning. Both chub species were common at Hazel @522.

Larger streams such as Hazel @522 may not be comprehensively sampled with a seine. Although a single largemouth bass was collected in 2001, adults can usually detect the seine and avoid capture.

Appendix A22—Hazel River @522, Culpeper Co., VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species			18	3	17	1	16	1
# darter species			2	3	2	3	1	1
# minnow species			13	3	12	3	12	3
% dominant species			0.306	1	0.274	1	0.468	1
# intolerant species			2	3	3	5	1	1
% tolerant individuals			0.044	5	0.046	5	0.042	5
% omnivores			0.052	5	0.081	5	0.028	5
% benthic invertivores			0.149	3	0.098	3	0.051	1
% specialist carnivores			0.057	1	0.054	1	0.224	5
% simple lithophils			0.496	5	0.511	5	0.182	1
# late maturing species			5	5	5	5	4	3
% anomalies			0.003	5	0.002	5	0.001	5
IBI				**42**		**42**		**32**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition		7.7	8.0	8.0
Hydrologic alteration		7.3	8.0	8.0
Riparian width		5.0	7.0	7.0
Bank stability		6.3	6.7	7.7
Canopy cover		6.7	5.7	6.3
Water appearance		9.3	8.7	7.7
Nutrient enrichment		8.7	8.3	6.7
Manure presence				
Fish barriers		10.0	10.0	10.0
Fish cover		9.3	9.7	7.7
Pools		9.0	8.7	8.0
Riffle quality		8.3	8.0	7.0
Invertebrate habitat		9.0	8.7	7.3
Invertebrates observed		11.3	11.7	9.3
SVAP		**8.3**	**8.4**	**7.7**

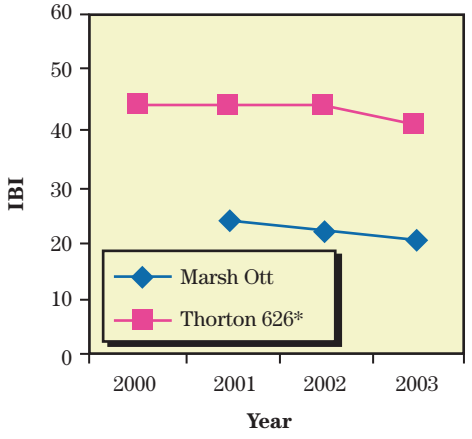
Site notes:

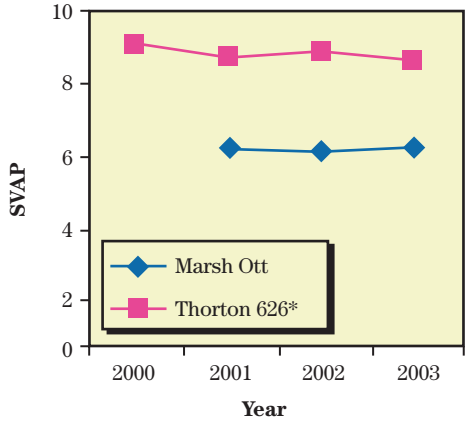
Hazel @522 has a large, predominantly forested watershed. The Hazel River is so large at the site that it was not effectively sampled in years with high water levels, such as 2003. Therefore, during those years, IBI scores may be affected more by sampling other factors than by human influences. Both the IBI and SVAP have varied at the site, indicating no significant trend. Due to the site's large drainage, the lack of maturity of the buffer, and our inability to effectively sample it each year, little can be said conclusively about the site.

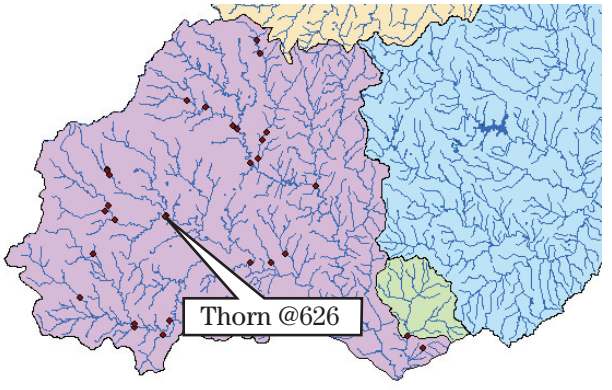
Appendix A23—Marsh Run @Ott, Fauquier Co. VA

Basis qualified: Grazing
Restored: Spring 2002
Size: 87.0 km^2
Baseline SVAP: 5.9 (Poor)
Baseline IBI: 24 (Very poor)
Upstream land use
  Cropland %: 42.7
  Pasture %: 15.3
  Non-ag %: 42.0
  Urban/disturbed %: 2.4
Buffer area (ha): 2.2
Buffer length (m): 603.5

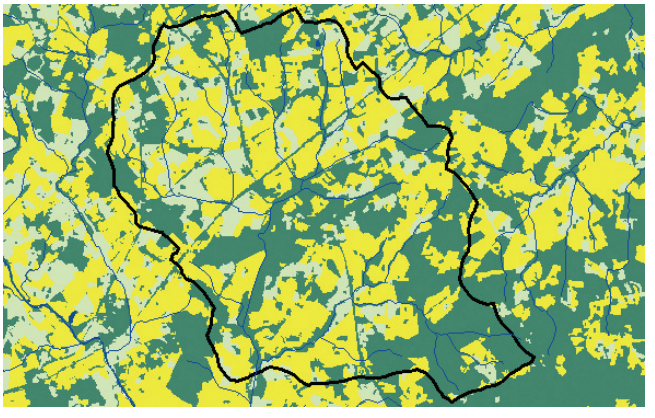
IBI and SVAP trends for Marsh @Ott and its paired less-disturbed reference, Thorn @626.







Marsh @522 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A23—Marsh Run @Ott, Fauquier Co. VA

Raw fish data

Common Name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner		12	3	1
Mountain redbelly dace				
Roseyside dace				
Fallfish				
Creek chub				
River chub			2	5
Bluehead chub		2		
Cutlips minnow				
Blacknose dace				
Longnose dace				
Central stoneroller				
Eastern silvery minnow		146	21	10
Common shiner		1	6	5
Satinfin shiner			6	3
Spotfin shiner				
Bluntnose minnow		56	19	20
Fathead minnow				
Comely shiner				
Spottail shiner		16	20	
Swallowtail shiner				3
Roseyface shiner				
Silverjaw minnow				
White sucker		3	1	1
Creek chubsucker				
Northern hogsucker				
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead		21	13	1
Brown bullhead			1	
Margined madtom				
Banded killifish				
Eastern mosquitofish		104	59	1
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish				2
Green sunfish		45	10	11
Pumpkinseed			2	2
Bluegill		41	55	16
Redear sunfish		3		
Rock bass				
Black crappie			2	
Smallmouth bass				
Largemouth bass		4	10	4
Shield darter				
Stripeback darter		1		
Tesselated darter		131	3	10
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				2
Total		586	233	97
Anomalies		**12**	**7**	**1**

Redear sunfish are not common in area streams; however, they are stocked in farm ponds and were infrequently collected. Three individuals were collected at Marsh @Ott in 2001.

Eastern silvery minnow is a detritivore/herbivore that inhabits lower gradient streams in the eastern portion of the study area, such as Marsh @Ott.

Appendix A23—Marsh Run @Ott, Fauquier Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species			10	1	12	1	12	1
# darter species			2	3	1	1	1	1
# minnow species			6	1	7	1	7	1
% dominant species			0.249	3	0.253	3	0.206	3
# intolerant species			0	1	0	1	0	1
% tolerant individuals			0.425	1	0.618	1	0.505	1
% omnivores			0.125	3	0.099	3	0.227	1
% benthic invertivores			0.225	3	0.013	1	0.103	3
% specialist carnivores			0.043	1	0.112	3	0.072	1
% simple lithophils			0.003	1	0.026	1	0.082	1
# late maturing species			2	1	3	3	2	1
% anomalies			0.020	5	0.030	3	0.010	5
IBI				**24**		**22**		**20**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition		6.7	6.7	6.0
Hydrologic alteration		6.3	6.0	5.7
Riparian width		4.7	4.7	4.7
Bank stability		6.3	5.7	6.3
Canopy cover		2.7	3.0	5.7
Water appearance		4.3	4.3	4.0
Nutrient enrichment		5.0	5.7	5.7
Manure presence		5.0		
Fish barriers		10.0	10.0	10.0
Fish cover		7.3	7.0	6.3
Pools		7.0	6.3	8.3
Riffle quality		5.0	4.7	4.7
Invertebrate habitat		6.7	7.3	4.0
Invertebrates observed		5.0	3.7	5.7
SVAP		**5.9**	**5.8**	**5.9**

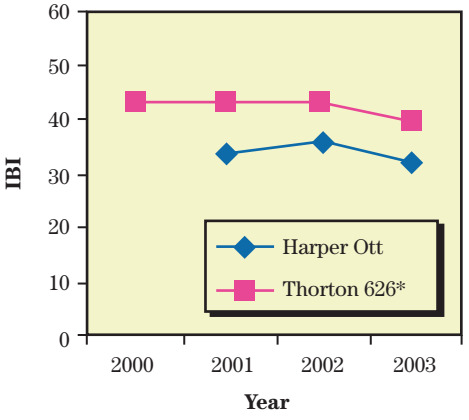
Site notes:

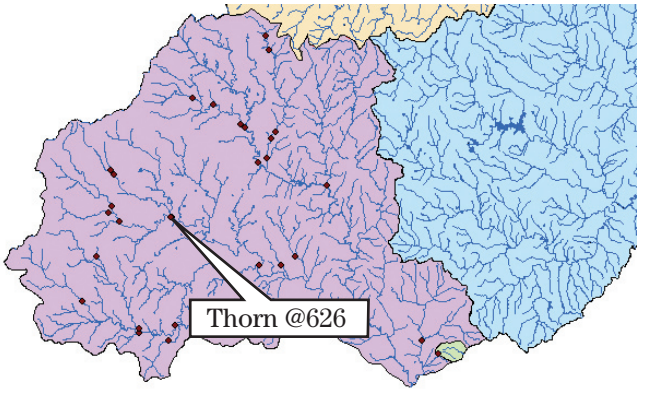
Marsh @Ott has a relatively large, highly disturbed watershed, including several large dairy operations and intensively managed cropland (42.7%). The entire watershed lies within the Culpeper basin, which has gentle relief and has experienced over 2 centuries of farming. The small town of Bealton is also within its watershed. Teels and Danielson (2001) found Marsh Run and its tributaries to be the most impaired system within the region. Baseline scores for Marsh @Ott were low for both SVAP and IBI. Although some initial signs of improvement appear to be occurring with the fencing, it has yet to be reflected in either SVAP or IBI scores.

Appendix A24—Harper's Run @Ott, Fauquier Co. VA

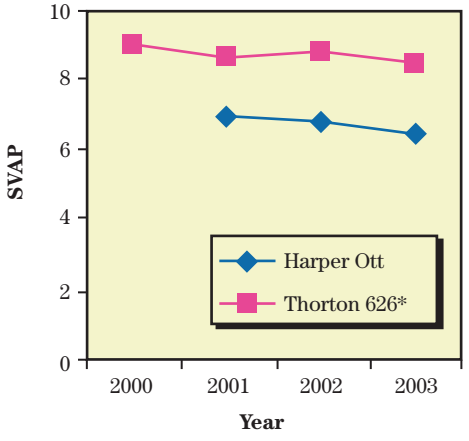
Basis qualified: Grazing
Restored: Spring 2002
Size: 7.3 km^2
Baseline SVAP: 6.9 (Fair)
Baseline IBI: 34 (Fair)
Upstream land use
  Cropland %: 35.8
  Pasture %: 16.1
  Non-ag %: 48.1
  Urban/disturbed %: 0
Buffer area (ha): 6.9
Buffer length (m): 2414.0

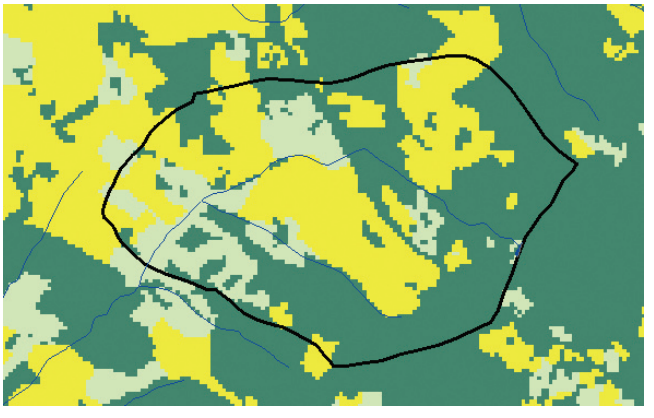
IBI and SVAP trends for Harper @Ott its paired less-disturbed reference, Thorn @626.





Harper @Ott drainage





Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A24—Harper's Run @Ott, Fauquier Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner		8	8	1
Mountain redbelly dace				
Roseyside dace		26	62	46
Fallfish		3	1	
Creek chub		23	30	10
River chub			5	1
Bluehead chub		27	17	2
Cutlips minnow				
Blacknose dace		15	24	36
Longnose dace				
Central stoneroller				
Eastern silvery minnow		4	7	
Common shiner		3	3	13
Satinfin shiner			1	
Spotfin shiner				
Bluntnose minnow		39	43	22
Fathead minnow				
Comely shiner				1
Spottail shiner			1	
Swallowtail shiner		6	16	1
Roseyface shiner				
Silverjaw minnow				
White sucker		12	16	52
Creek chubsucker			5	
Northern hogsucker				
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead		19	4	1
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish		3	11	
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish				
Green sunfish		19	79	13
Pumpkinseed			1	
Bluegill		20	7	110
Redear sunfish				
Rock bass				
Black crappie		1		
Smallmouth bass				
Largemouth bass		8	17	9
Shield darter				
Stripeback darter				
Tesselated darter		118	23	148
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids		11	3	2
Total		**365**	**384**	**468**
Anomalies		**2**	**5**	**1**

Eastern mosquitofish are top-dwelling, tolerant species found in the low gradient streams of the eastern portion of the study area, such as Harper @Ott.

Although hybrids were infrequently collected in the study area, Harper @Ott had hybrids in 3 of 4 years of sampling.

Appendix A24—Harper's Run @Ott, Fauquier Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species			13	3	18	5	12	3
# darter species			1	1	1	1	1	1
# minnow species			10	3	13	5	10	3
% dominant species			0.323	3	0.206	5	0.316	3
# intolerant species			0	1	0	1	0	1
% tolerant individuals			0.359	3	0.547	3	0.519	3
% omnivores			0.236	3	0.219	3	0.165	3
% benthic invertivores			0.323	5	0.073	1	0.316	5
% specialist carnivores			0.085	3	0.057	1	0.021	1
% simple lithophils			0.096	1	0.211	3	0.130	1
# late maturing species			2	3	3	3	3	3
% anomalies			0.005	5	0.013	5	0.002	5
IBI				**34**		**36**		**32**

SVAP element ratings

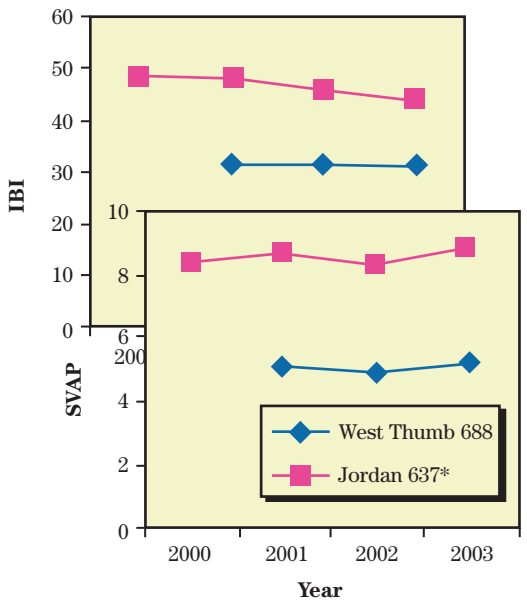
SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition		6.7	7.0	6.0
Hydrologic alteration		6.3	6.7	6.7
Riparian width		6.7	6.7	6.0
Bank stability		6.7	6.0	6.7
Canopy cover		7.3	8.7	7.0
Water appearance		5.7	6.0	5.7
Nutrient enrichment		6.3	5.7	6.3
Manure presence		5.0		
Fish barriers		10.0	9.7	10.0
Fish cover		7.7	8.0	7.0
Pools		6.7	6.3	7.7
Riffle quality		7.0	6.7	7.0
Invertebrate habitat		6.7	7.7	3.0
Invertebrates observed		7.3	3.0	4.7
SVAP		**6.9**	**6.8**	**6.4**

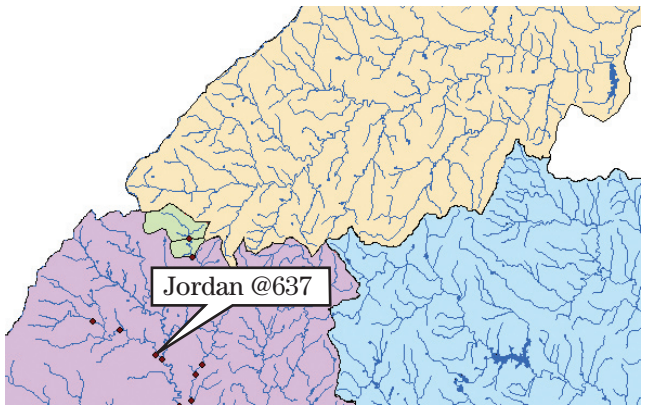
Site notes:

Harper @Ott has a small watershed, most of which is intensively used for agriculture. The site was lightly grazed prior to buffer establishment and in fair condition according to both the SVAP and IBI. Sparse tree cover occurred along the stream corridor. Fencing has caused a positive response from herbaceous cover, but woody cover has yet to respond measurably. Our observations over the 2-year period since restoration do not indicate significant trends; however, due to the small nature of the watershed and physical improvements that are likely to occur, the site should demonstrate improvements in both the SVAP and IBI.

Appendix A25—West Thumb Run @688, Fauquier Co. VA

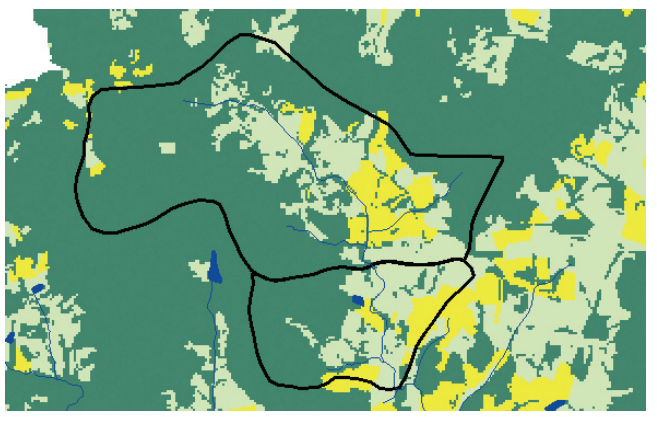
IBI and SVAP trends W Thum @688 and its paired less-disturbed reference, Jordan @637.





W Thum @688 drainage

Basis qualified: Grazing
Restored: Spring 2002
Size: 18.1 km^2
Baseline SVAP: 5.1 (Poor)
Baseline IBI: 32 (Poor)
Upstream land use
  Cropland %: 10.7
  Pasture %: 24.9
  Non-ag %: 64.4
  Urban/disturbed %: 0
Buffer area (ha): 5.7
Buffer length (m): 1408.2



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A25—West Thumb Run @688, Fauquier Co. VA

Raw fish data

Common Name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace		6	38	3
Fallfish		10	40	9
Creek chub		14	14	3
River chub		4	1	4
Bluehead chub		89	46	8
Cutlips minnow		3		
Blacknose dace		8		7
Longnose dace				
Central stoneroller				
Eastern silvery minnow				
Common shiner		17	14	3
Satinfin shiner		11	35	23
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner		58	56	24
Roseyface shiner				
Silverjaw minnow		7		19
White sucker		31		62
Creek chubsucker				
Northern hogsucker		2		
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead		1	3	2
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish		1	2	
Green sunfish		1	2	2
Pumpkinseed		162	11	3
Bluegill		40	92	31
Redear sunfish				
Rock bass				
Black crappie				
Smallmouth bass				
Largemouth bass		17	52	7
Shield darter				
Stripeback darter				
Tesselated darter		60	12	24
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total		542	418	234

Pumpkinseed heavily dominated the fish assemblage at W Thum @688 prior to restoration; however, they have diminished significantly after the buffer was installed.

Deformities, such as the skeletal malformation observed in this green sunfish collected at W Thum @688 are included in the anomalies metric.

Appendix A25—West Thumb Run @688, Fauquier Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species			17	3	12	3	14	3
# darter species			1	1	1	1	1	1
# minnow species			11	3	8	3	10	3
% dominant species			0.299	3	0.220	3	0.265	3
# intolerant species			0	1	0	1	0	1
% tolerant individuals			0.186	3	0.258	3	0.530	3
% omnivores			0.234	3	0.110	3	0.380	1
% benthic invertivores			0.114	3	0.029	1	0.103	3
% specialist carnivores			0.054	1	0.232	3	0.077	3
% simple lithophils			0.153	1	0.258	3	0.128	1
# late maturing species			4	5	2	3	3	5
% anomalies			0.000	5	0.000	5	0.004	5
IBI				**32**		**32**		**32**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition		5.3	7.7	4.7
Hydrologic alteration		8.7	7.0	6.7
Riparian width		2.0	2.0	4.0
Bank stability		3.0	3.7	3.3
Canopy cover		1.3	1.0	3.3
Water appearance		5.7	5.7	4.0
Nutrient enrichment		6.0	2.3	4.0
Manure presence		3.3		
Fish barriers		10.0	10.0	10.0
Fish cover		5.3	5.0	6.3
Pools		4.7	4.0	5.3
Riffle quality		4.3	4.0	5.3
Invertebrate habitat		5.3	3.3	6.3
Invertebrates observed		6.7	8.0	6.0
SVAP		**5.1**	**4.9**	**5.3**

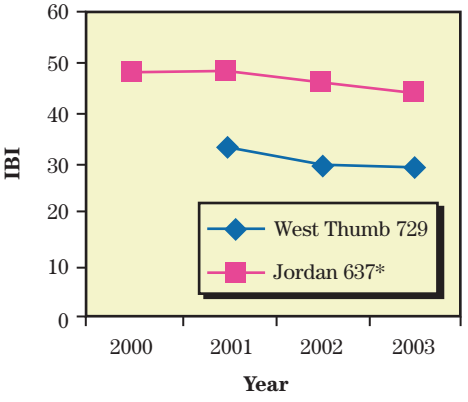
Site notes:

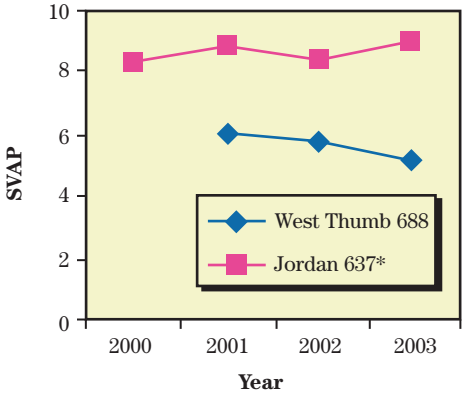
W Thum @688 is one of the five projects evaluated on Thumb Run. W Thum @688 is located on the West Branch of Thumb Run and has a predominately forested watershed with a highly impacted pre-restoration condition. Prior to buffer establishment, the site was intensively grazed, which is reflected by many low SVAP element scores. The IBI baseline condition for the site was poor. Restoration caused an immediate response in herbaceous vegetation; however, other factors measured by the SVAP have been slow to respond. The IBI has remained a constant 32 for all years of sampling. This site has all the elements to show dramatic improvements in aquatic condition; however, more time may be needed for measurable response to occur. Some other projects in this study have taken as long as 2 years before the SVAP and IBI began an upward trend.

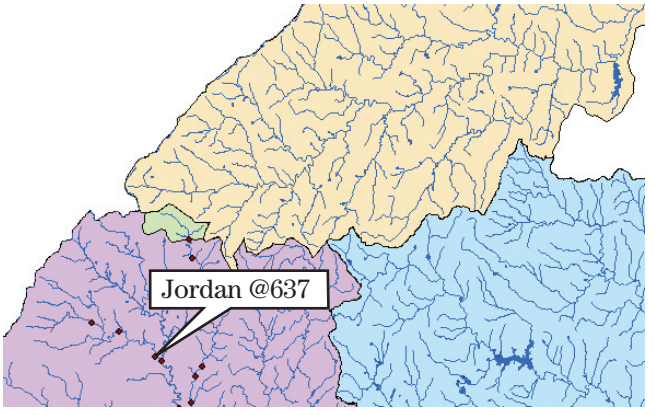
Appendix A26—West Thumb Run @729, Fauquier Co. VA

Basis qualified: Grazing
Restored: Spring 2001
Size: 13.5 km^2
Baseline SVAP: 6.0 (Poor)
Baseline IBI: 34 (Fair)
Upstream land use
  Cropland %: 9.9
  Pasture %: 21.2
  Non-ag %: 68.9
  Urban/disturbed %: 0
Buffer area (ha): 3.0
Buffer length (m): 804.7

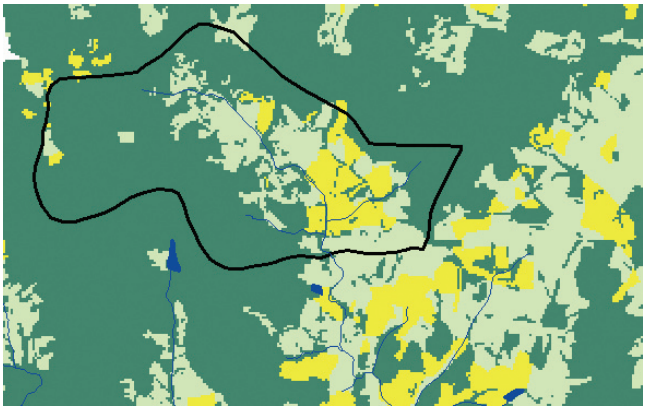
IBI and SVAP trends for W Thum @729 and its paired less-disturbed reference, Jordan @637.







W Thum @729 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A26—West Thumb Run @729, Fauquier Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace		50	21	1
Fallfish		2		
Creek chub		16	8	3
River chub		4		
Bluehead chub		29	18	2
Cutlips minnow				
Blacknose dace		151	40	15
Longnose dace				
Central stoneroller				
Eastern silvery minnow				
Common shiner		11	11	6
Satinfin shiner		3	3	3
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner		2	1	
Roseyface shiner				
Silverjaw minnow		2		1
White sucker		16	8	51
Creek chubsucker				
Northern hogsucker				
Torrent sucker				1
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead		1		
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish				
Green sunfish		1	4	3
Pumpkinseed		21	2	10
Bluegill		13	19	9
Redear sunfish				
Rock bass				
Black crappie				
Smallmouth bass				
Largemouth bass		5	6	6
Shield darter				
Stripeback darter				
Tesselated darter		212	141	98
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total		**539**	**282**	**209**
Anomalies		4	2	

Tesselated darter was the dominant species in all 3 years of sampling at W Thum @729.

Lesions, such as the one on the dorsal fin of this creek chub collected at W Thum @729, are included in the anomalies metric. This specimen also has black spot disease.

Appendix A26—West Thumb Run @729, Fauquier Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species			14	3	10	1	10	1
# darter species			1	1	1	1	1	1
# minnow species			10	3	7	3	7	3
% dominant species			0.393	1	0.500	1	0.469	1
# intolerant species			0	1	0	1	0	1
% tolerant individuals			0.369	3	0.280	3	0.392	3
% omnivores			0.087	5	0.092	5	0.263	3
% benthic invertivores			0.393	5	0.500	5	0.469	5
% specialist carnivores			0.015	1	0.021	1	0.029	1
% simple lithophils			0.117	1	0.117	1	0.038	1
# late maturing species			3	5	2	3	3	5
% anomalies			0.007	5	0.007	5	0.000	5
IBI				**34**		**30**		**30**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition		6.0	7.3	5.0
Hydrologic alteration		7.7	7.0	7.0
Riparian width		5.7	3.3	3.7
Bank stability		6.3	3.7	3.3
Canopy cover		4.7	3.3	4.0
Water appearance		5.3	6.7	4.0
Nutrient enrichment		6.3	6.7	3.7
Manure presence		3.7		
Fish barriers		10.0	10.0	10.0
Fish cover		6.3	5.7	5.7
Pools		3.7	3.3	5.0
Riffle quality		5.7	5.7	3.7
Invertebrate habitat		7.0	3.3	6.0
Invertebrates observed		6.0	8.7	6.0
SVAP		**6.0**	**5.7**	**5.2**

Site notes:

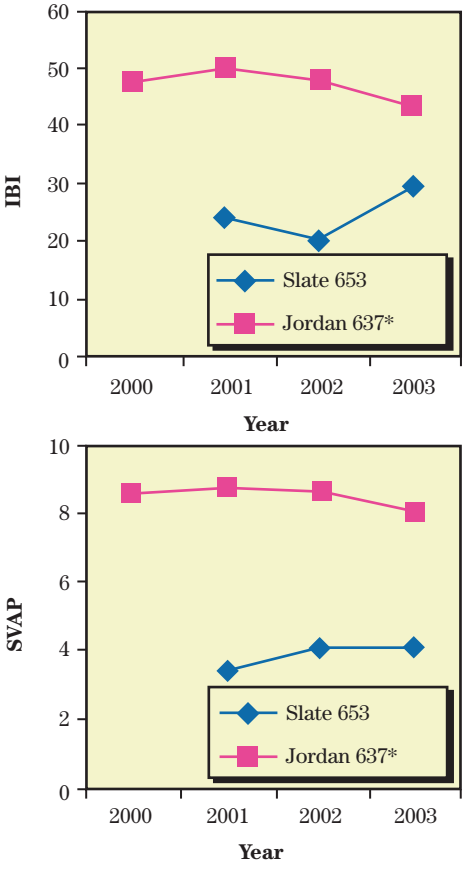
W Thum @729 is the most upstream of the Thum Run sites and has a small, mostly forested watershed. The site was heavily impacted by grazing prior to buffer establishment, as reflected by the low scores for many SVAP elements. The IBI indicated that the site was in fair condition. As with W Thum @688, the main early response at the site has been an increase in amount and condition of herbaceous vegetation. Some growth has also been observed in the existing willows and alders that occurred infrequently along the stream before the site was restored. However, there was no positive response in either the SVAP or the IBI, and like W Thum @688, more time may be needed for that to occur.

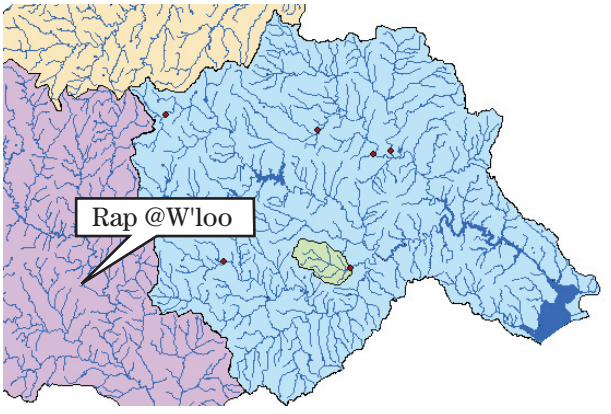
Appendix A27: Slate Run @653, Prince William Co. VA

Basis qualified: Grazing
Restored: Spring 2002
Size: 42.8 km^2
Baseline SVAP: 3.4 (Poor)
Baseline IBI: 24 (Very poor)
Upstream land use
- Cropland %: 34.7
- Pasture %: 24.9
- Non-ag %: 31.8
- Urban/disturbed %: 8.6

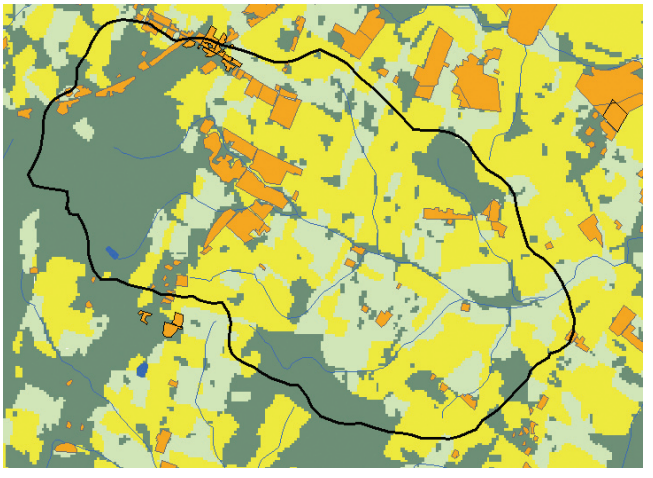
Buffer area (ha): 14.9
Buffer length (m): 2133.6

IBI and SVAP trends for Slate @653 and its paired less-disturbed reference, Rap @W'loo.





Slate @653 drainage



Nonagricultural land (principally forest)
Pasture
Cropland
Urban/developed

Appendix A27: Slate Run @653, Prince William Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad		1		
Common carp		1		18
Golden shiner		36	37	23
Mountain redbelly dace				
Roseyside dace				
Fallfish		8		2
Creek chub			2	
River chub				
Bluehead chub				
Cutlips minnow				
Blacknose dace				
Longnose dace				
Central stoneroller				
Eastern silvery minnow				44
Common shiner		1		1
Satinfin shiner				
Spotfin shiner				1
Bluntnose minnow		112	57	73
Fathead minnow				1
Comely shiner				
Spottail shiner		95	42	149
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow				
White sucker		4	5	48
Creek chubsucker		15	11	5
Northern hogsucker				
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead		36	95	80
Brown bullhead		3	1	1
Margined madtom				
Banded killifish		1	1	1
Eastern mosquitofish		11	83	29
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish		1	1	2
Green sunfish		68	162	33
Pumpkinseed		2	1	
Bluegill		19	45	57
Redear sunfish				
Rock bass				
Black crappie				
Smallmouth bass				
Largemouth bass		8	1	12
Shield darter				
Stripeback darter				
Tesselated darter		9		52
Glassy darter				
Fantail darter				1
Greenside darter				
Hybrids			1	2
Total		**431**	**545**	**635**
Anomalies		**45**	**29**	**41**

Gizzard shad, principally a pelagic algivore, was collected in this study only at Slate @653 in 2001, prior to buffer establishment.

Common carp was also collected only at Slate @653, one of the most disturbed sites in the study.

Appendix A27: Slate Run @653, Prince William Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species			14	3	11	1	15	3
# darter species			1	1	0	1	2	3
# minnow species			6	3	4	1	9	3
% dominant species			0.260	3	0.297	3	0.235	3
# intolerant species			0	1	0	1	0	1
% tolerant individuals			0.497	3	0.650	1	0.378	3
% omnivores			0.353	1	0.182	3	0.228	3
% benthic invertivores			0.056	1	0.020	1	0.091	3
% specialist carnivores			0.130	3	0.180	3	0.153	3
% simple lithophils			0.002	1	0.000	1	0.002	1
# late maturing species			3	3	2	3	3	3
% anomalies			0.104	1	0.053	1	0.065	1
IBI				**24**		**20**		**30**

SVAP element ratings

SVAP Elements	2000	2001	2002	2003
Channel condition		3.7	4.3	5.0
Hydrologic alteration		3.7	3.9	4.0
Riparian width		2.3	3.2	3.0
Bank stability		2.0	3.7	5.0
Canopy cover		1.0	3.6	1.7
Water appearance		2.0	2.3	1.7
Nutrient enrichment		3.3	2.9	1.7
Manure presence		1.3		
Fish barriers		8.7	9.9	10.0
Fish cover		5.0	4.7	4.7
Pools		5.0	5.1	5.7
Riffle quality		2.0	3.2	3.0
Invertebrate habitat		4.0	3.9	4.0
Invertebrates observed		3.7	1.3	4.0
SVAP		**3.4**	**4.0**	**4.1**

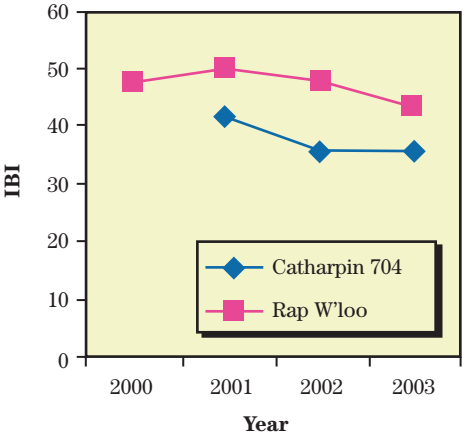
Site notes:

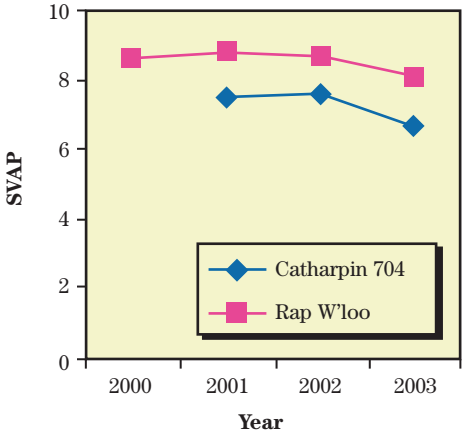
Slate @653 has a predominantly agricultural drainage that begins and ends within the Culpeper Basin, a land resource area that has been intensively farmed for over 2 centuries. Dairy operations and row crops dominate the landscape near the stream. The project is located near the lower end of Slate Run approximately a mile above its confluence with Cedar Run. The SVAP and IBI scores for the site prior to buffer establishment were the lowest of any observed in the study. However, there has been a very noticeable early response to buffer establishment; principally the growth and improved condition of streamside herbaceous vegetation (e.g., pickerelweed, rice cutgrass). Correspondingly, both SVAP and IBI scores appear to be improving.

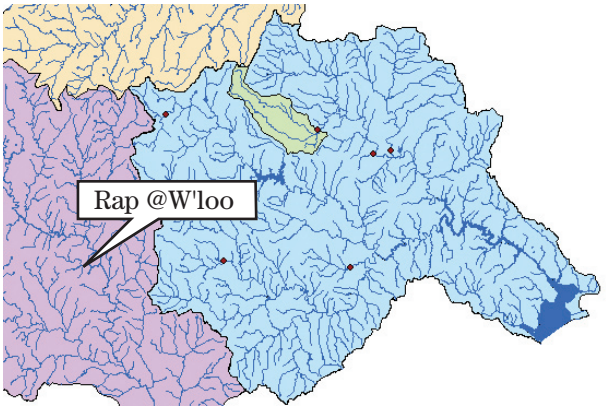
Appendix A28—Catharpin Run @704, Prince William Co. VA

Basis qualified: Grazing
Restored: Spring 2002
Size: 68.5 km^2
Baseline SVAP: 7.5 (Good)
Baseline IBI: 42 (Good)
Upstream land use
  Cropland %: 23.3
  Pasture %: 14.1
  Non-ag %: 49.4
  Urban/disturbed %: 13.2
Buffer area (ha): 6.4
Buffer length (m): 1645.9

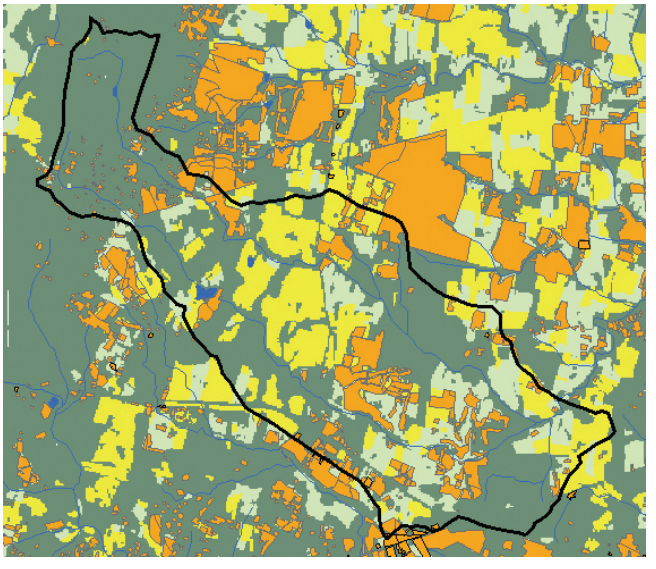
IBI and SVAP trends for Cathar @704 and its paired less-disturbed reference, Rap @W'loo.







Cathar @704 drainage



Nonagricultural land (principally forest)
Pasture
Cropland
Urban/developed

Appendix A28—Catharpin Run @704, Prince William Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner			14	1
Mountain redbelly dace				
Roseyside dace				
Fallfish		30	14	
Creek chub				
River chub		1		
Bluehead chub				
Cutlips minnow		1	2	3
Blacknose dace				
Longnose dace		14	11	5
Central stoneroller				
Eastern silvery minnow		20	4	
Common shiner		45	26	4
Satinfin shiner		19	22	30
Spotfin shiner				
Bluntnose minnow		45	11	96
Fathead minnow				
Comely shiner		67	43	50
Spottail shiner		36	7	3
Swallowtail shiner		46	10	70
Roseyface shiner		3		1
Silverjaw minnow				
White sucker		2		7
Creek chubsucker		1		
Northern hogsucker			2	
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead		1		
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish		1	4	
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish		32	14	38
Green sunfish		9	10	46
Pumpkinseed				1
Bluegill		9	98	72
Redear sunfish				
Rock bass				
Black crappie				
Smallmouth bass		1		
Largemouth bass		26	2	4
Shield darter				
Stripeback darter				
Tesselated darter		7	4	5
Glassy darter				
Fantail darter		32	45	36
Greenside darter				
Hybrids				
Total		448	343	472
Anomalies		4	2	

Redfin pickerel, an intolerant piscivore, was fairly abundant in Catharpin Creek just above Cathar @704 in 1998; however, it has not been collected at Cathar @704 or any other site during this study.

Open sores and lesions are not common in area streams, generally occurring in streams with most impaired conditions.

Appendix A28—Catharpin Run @704, Prince William Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species			18	3	15	3	14	3
# darter species			2	3	2	3	2	3
# minnow species			12	3	11	3	10	3
% dominant species			0.150	5	0.286	3	0.203	3
# intolerant species			1	3	0	1	1	3
% tolerant individuals			0.147	5	0.359	3	0.468	3
% omnivores			0.105	3	0.073	5	0.220	3
% benthic invertivores			0.121	3	0.181	3	0.097	3
% specialist carnivores			0.201	3	0.087	3	0.089	3
% simple lithophils			0.391	3	0.268	3	0.275	3
# late maturing species			2	3	1	1	1	1
% anomalies			0.009	5	0.006	5	0.000	5
IBI				**42**		**36**		**36**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition		8.0	9.0	7.7
Hydrologic alteration		8.0	8.3	7.3
Riparian width		8.7	5.3	6.3
Bank stability		6.3	7.0	6.3
Canopy cover		9.7	9.7	8.3
Water appearance		7.3	7.0	5.0
Nutrient enrichment		6.7	6.3	5.7
Manure presence				
Fish barriers		5.0	7.0	5.0
Fish cover		9.7	8.0	8.0
Pools		6.0	5.7	7.3
Riffle quality		6.0	7.7	3.7
Invertebrate habitat		9.7	7.0	7.0
Invertebrates observed		7.0	11.0	9.7
SVAP		**7.5**	**7.6**	**6.7**

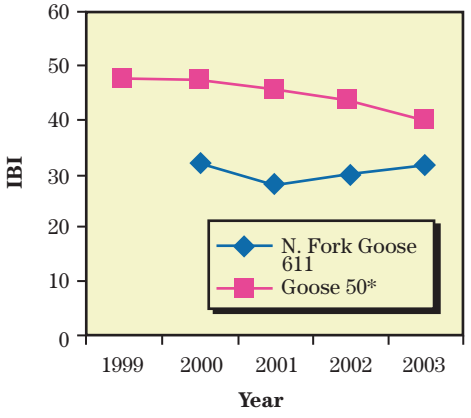
Site notes:

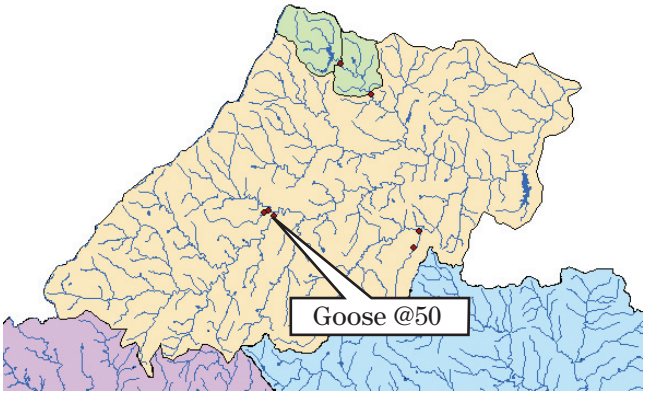
Cathar @704 has a relatively large drainage that is located in the rapidly developing portion of the Occoquan Watershed. In the previous study, Teels and Danielson (2001) found that a site on Catharpin Creek located immediately above the project area had a higher IBI score than any in the region. IBI scores for nearby reference sites were similarly high. However, recent suburban development has caused IBI scores to plummet at both Cathar @704 and nearby reference sites. Prior to buffer establishment, the site had a narrow band of riparian vegetation and displayed extremely good instream structure. However, SVAP and IBI scores have declined despite the restoration. This is probably due to sediment-laden storm flows that cover the surfaces of all channel features, fill pools, and bury riffle habitats.

Appendix A29—N. Fork Goose Creek @611, Loudoun Co. VA

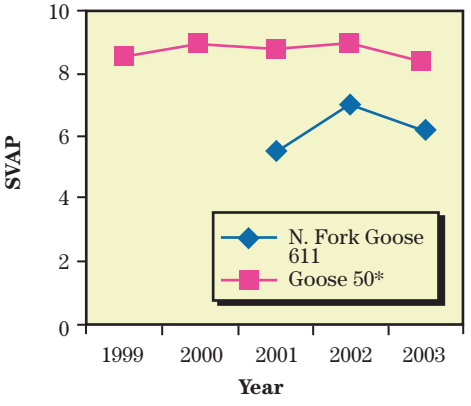
Basis qualified: Grazing
Restored: Spring 2002
Size: 50.1 km^2
Baseline SVAP: 5.6 (Poor)
Baseline IBI: 28 (Poor)
Upstream land use
  Cropland %: 39.7
  Pasture %: 32.0
  Non-ag %: 28.3
  Urban/disturbed %: 1.48
Buffer area (ha): 10.2
Buffer length (m): 3109.0

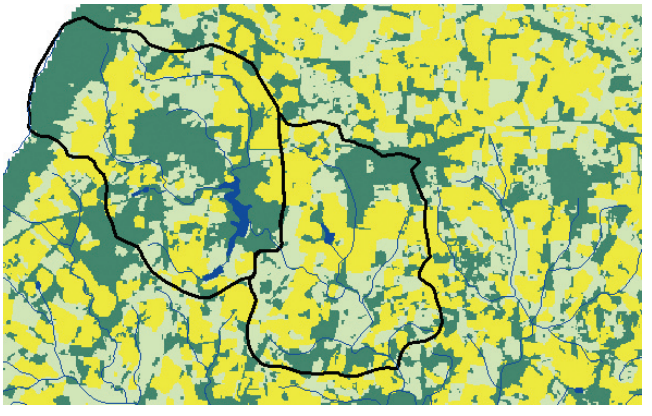
IBI and SVAP trends for N Goose @611 and its paired less-disturbed reference, Goose @50.





N Goose @611 drainage





Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A29—N. Fork Goose Creek @611, Loudoun Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner		1		
Mountain redbelly dace				
Roseyside dace		22	1	
Fallfish				
Creek chub		8	6	2
River chub				
Bluehead chub				
Cutlips minnow				
Blacknose dace		67	131	24
Longnose dace		61	103	34
Central stoneroller		1		
Eastern silvery minnow				
Common shiner		4	82	10
Satinfin shiner		3	8	33
Spotfin shiner		11	30	50
Bluntnose minnow		111	32	41
Fathead minnow		3		
Comely shiner				
Spottail shiner		73	99	4
Swallowtail shiner		24	32	95
Roseyface shiner				
Silverjaw minnow		26	32	104
White sucker		17	18	
Creek chubsucker		1	3	
Northern hogsucker		8	2	
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead		7	20	10
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish		13	8	25
Green sunfish		2	3	
Pumpkinseed			1	
Bluegill		11	10	38
Redear sunfish				
Rock bass				
Black crappie				2
Smallmouth bass				
Largemouth bass		1	16	2
Shield darter				
Stripeback darter				
Tesselated darter		6	19	1
Glassy darter				
Fantail darter		4	4	8
Greenside darter		11	9	3
Hybrids				2
Total		**496**	**669**	**488**
Anomalies		65	64	5

Greenside darter is a somewhat recent introduction to the Goose Creek system that is becoming common at many Goose Creek sites, such as N Goose @611.

Although not considered a tolerant species, yellow bullhead can tolerate a variety of water quality conditions and is particularly tolerant to sediment. It was relatively abundant in each year of sampling at N Goose @611.

Appendix A29—N. Fork Goose Creek @611, Loudoun Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species			19	3	18	3	13	1
# darter species			3	5	3	5	3	5
# minnow species			14	5	11	3	10	3
% dominant species			0.224	3	0.196	3	0.213	3
# intolerant species			0	1	0	1	0	1
% tolerant individuals			0.488	1	0.347	3	0.428	3
% omnivores			0.319	1	0.123	3	0.297	1
% benthic invertivores			0.183	3	0.209	3	0.094	3
% specialist carnivores			0.042	1	0.066	1	0.080	3
% simple lithophils			0.242	3	0.329	3	0.285	3
# late maturing species			2	1	2	1	0	1
% anomalies			0.131	1	0.096	1	0.010	5
IBI				**28**		**30**		**32**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition		8.0	8.0	5.3
Hydrologic alteration		6.7	8.3	5.3
Riparian width		2.7	4.7	5.3
Bank stability		4.3	7.0	4.0
Canopy cover		3.3	2.7	5.3
Water appearance		5.7	7.3	5.3
Nutrient enrichment		6.3	6.7	5.3
Manure presence		3.7		
Fish barriers		3.0	10.0	9.7
Fish cover		7.0	7.7	6.7
Pools		5.7	6.7	8.0
Riffle quality		8.0	7.0	6.0
Invertebrate habitat		8.0	6.7	7.3
Invertebrates observed		5.7	8.3	7.0
SVAP		**5.6**	**7.0**	**6.2**

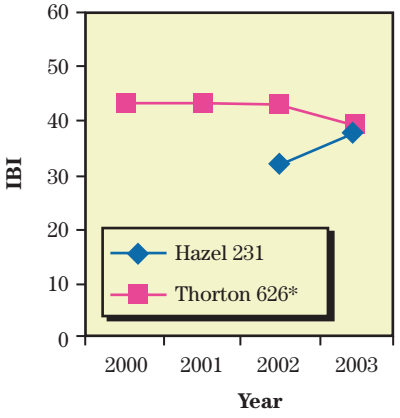
Site notes:

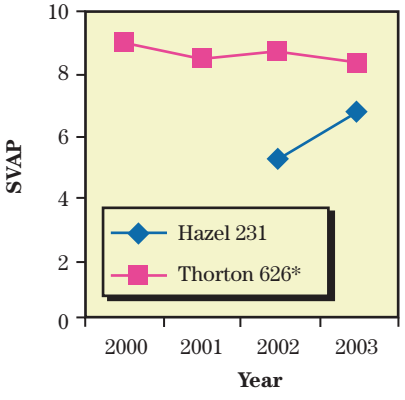
N Goose @611 has a medium size watershed that is impacted by both agriculture and suburban development around Purcelville and the Highway 7 corridor. Prior to restoration, the site was intensively grazed and had poor scores for most SVAP elements that are sensitive to livestock impacts. Baseline IBI indicated that the site was in poor condition. Although there was some herbaceous response during the first year of restoration, the site has since declined in overall appearance, which is supported by declining SVAP scores. Higher than average rainfall in 2003 created erosion problems that were not evident in previous drier years. Streambank erosion and sediment deposition were obvious in 2003. The erosion is also causing banks to slough, destroying some of the newly planted trees.

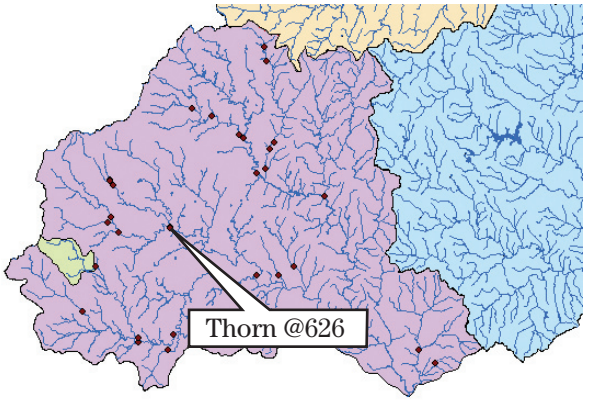
Appendix A30—Hazel River @231, Rappahannock Co., VA

Basis qualified: Grazing
Restored: Spring 2002
Size: 50.1 km^2
Baseline SVAP: 5.6 (Poor)
Baseline IBI: 32 (Poor)
Upstream land use
  Cropland %: 39.7
  Pasture %: 32.0
  Non-ag %: 28.3
  Urban/disturbed %: 1.48
Buffer area (ha): 10.2
Buffer length (m): 3109.0

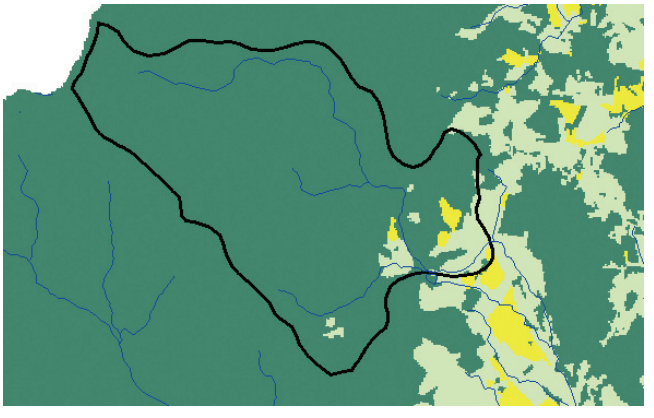
IBI and SVAP trends for Hazel @231 and its paired less-disturbed reference, Thornton @626.







Hazel @231 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A30—Hazel River @231, Rappahannock Co., VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace			9	40
Roseyside dace			93	87
Fallfish			6	2
Creek chub			5	
River chub			18	31
Bluehead chub			2	12
Cutlips minnow			2	17
Blacknose dace			238	188
Longnose dace			48	72
Central stoneroller				
Eastern silvery minnow				
Common shiner			56	99
Satinfin shiner				
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow				
White sucker				
Creek chubsucker				
Northern hogsucker				5
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin			51	60
Potomac sculpin				
Redbreast sunfish				
Green sunfish				
Pumpkinseed				
Bluegill			3	
Redear sunfish				
Rock bass				
Black crappie				
Smallmouth bass				
Largemouth bass				
Shield darter				
Stripeback darter				
Tesselated darter			2	11
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total			**533**	**624**
Anomalies				

Rosyside dace, mountain redbelly dace, rosyface shiner, and common shiner hover above a chub nest at Hazel @231.

Dragonfly larvae are examples of group two taxa that can be found in good or fair quality water.

Appendix A30—Hazel River @231, Rappahannock Co., VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species					11	1	11	1
# darter species					1	1	1	1
# minnow species					10	3	9	3
% dominant species					0.447	1	0.301	3
# intolerant species					1	3	1	3
% tolerant individuals					0.462	3	0.301	3
% omnivores					0.004	5	0.019	5
% benthic invertivores					0.189	3	0.237	5
% specialist carnivores					0.011	1	0.003	1
% simple lithophils					0.370	3	0.421	5
# late maturing species					2	3	3	3
% anomalies					0.000	5	0.000	5
IBI						**32**		**38**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition			5.0	6.0
Hydrologic alteration			5.0	6.3
Riparian width			1.7	5.7
Bank stability			4.7	6.0
Canopy cover			2.0	6.3
Water appearance			7.0	7.7
Nutrient enrichment			5.3	7.0
Manure presence			2.3	
Fish barriers			10.0	10.0
Fish cover			5.3	6.0
Pools			3.0	4.3
Riffle quality			7.7	8.0
Invertebrate habitat			7.0	6.7
Invertebrates observed			10.7	10.0
SVAP			**5.5**	**6.9**

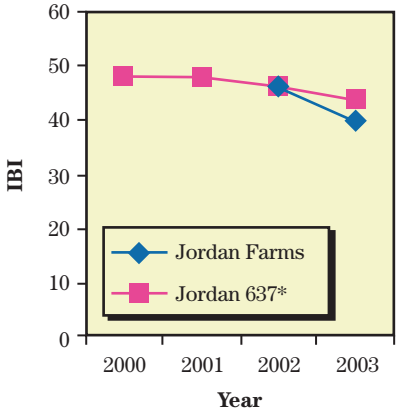
Site notes:

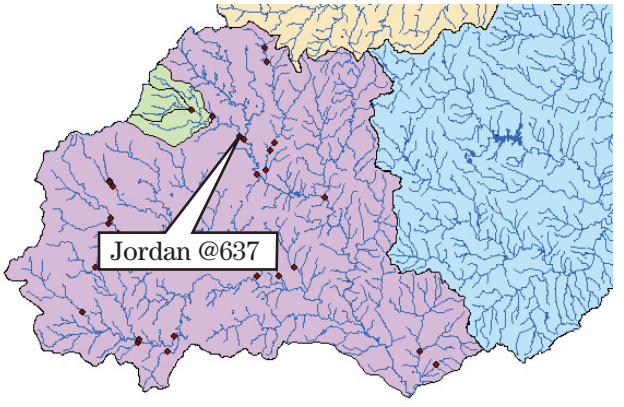
Hazel @231 has a small, predominantly forested watershed that poses few upstream problems. However, the site itself was extremely impaired prior to restoration due to high livestock concentrations. As previously discussed, this combination appears to be the prescription for quick restoration response. Although there is only 1 year of post-restoration data to support conclusions, Hazel @231 appears to have followed in the footsteps of Racer @614 with an immediate response to buffer establishment. Both the SVAP and IBI indicated that the site was in poor condition prior to restoration. Due to respsonse in both herbaceous and woody cover, the SVAP has increased within the first year from 5.5 (poor) to 6.9 (fair). The IBI has followed, increasing from 32 (poor) to 38 (fair).

Appendix A31—Jordan River @Jordan R. Farms, Rappahannock Co. VA

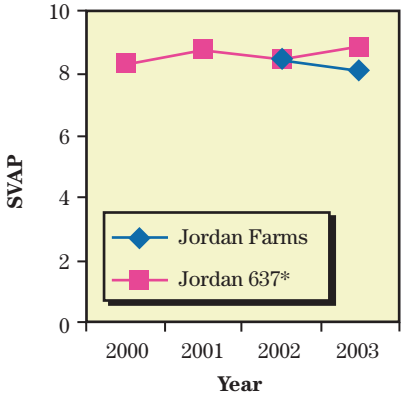
Basis qualified: Grazing
Restored: Spring 2002
Size: 64.03 km^2
Baseline SVAP: 8.5 (Good)
Baseline IBI: 46 (Good)
Upstream land use
  Cropland %: 5.5
  Pasture %: 18.1
  Non-ag %: 73.7
  Urban/disturbed %: 0.93
Buffer area (ha): 16.2
Buffer length (m): 4551.0

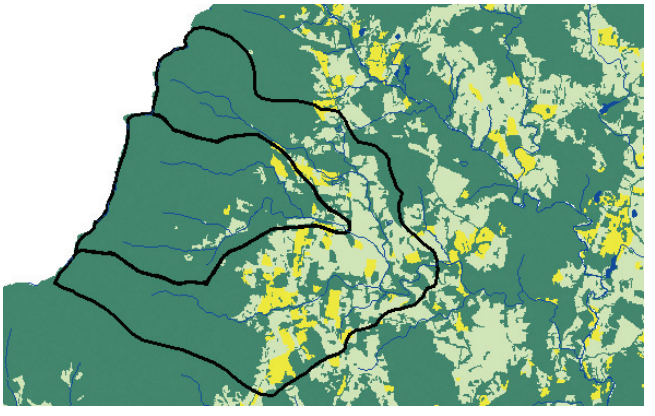
IBI and SVAP trends for Jordan @Farms and its paired less-disturbed reference, Jordan @637.





Jordan @Farms drainage





Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A31—Jordan River @Jordan R. Farms, Rappahannock Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace				
Fallfish			20	7
Creek chub			1	
River chub			9	9
Bluehead chub			18	9
Cutlips minnow			2	2
Blacknose dace			70	7
Longnose dace			17	2
Central stoneroller				
Eastern silvery minnow				
Common shiner			126	37
Satinfin shiner			134	166
Spotfin shiner				
Bluntnose minnow				
Fathead minnow				
Comely shiner			21	29
Spottail shiner				2
Swallowtail shiner			47	25
Roseyface shiner			67	23
Silverjaw minnow				1
White sucker			1	
Creek chubsucker				
Northern hogsucker			2	
Torrent sucker			5	1
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom			1	
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish			5	33
Green sunfish			1	4
Pumpkinseed				
Bluegill			2	5
Redear sunfish				
Rock bass			10	1
Black crappie				
Smallmouth bass				
Largemouth bass				1
Shield darter			1	2
Stripeback darter				
Tesselated darter			71	34
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids			1	
Total			**632**	**400**
Anomalies			2	

Eroded gills and gill covers are not common in area streams; however, they are infrequently observed and recorded as anomalies.

Appendix A31—Jordan River @Jordan R. Farms, Rappahannock Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species					18	3	16	3
# darter species					2	3	2	3
# minnow species					12	3	13	3
% dominant species					0.212	3	0.415	1
# intolerant species					3	5	2	3
% tolerant individuals					0.119	5	0.043	5
% omnivores					0.038	5	0.028	5
% benthic invertivores					0.146	3	0.095	3
% specialist carnivores					0.055	1	0.105	3
% simple lithophils					0.453	5	0.298	3
# late maturing species					6	5	3	3
% anomalies					0.003	5	0.000	5
IBI						**46**		**40**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition			8.7	9.0
Hydrologic alteration			8.3	7.7
Riparian width			7.3	7.7
Bank stability			8.7	7.7
Canopy cover			8.0	8.7
Water appearance			8.0	7.7
Nutrient enrichment			8.3	7.7
Manure presence				
Fish barriers			10.0	10.0
Fish cover			8.3	8.7
Pools			9.0	7.3
Riffle quality			8.3	8.0
Invertebrate habitat			8.0	7.0
Invertebrates observed			9.3	8.7
SVAP			**8.5**	**8.1**

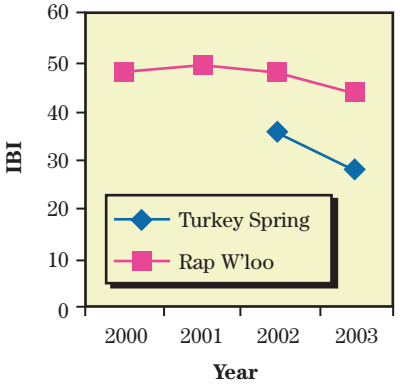
Site notes:

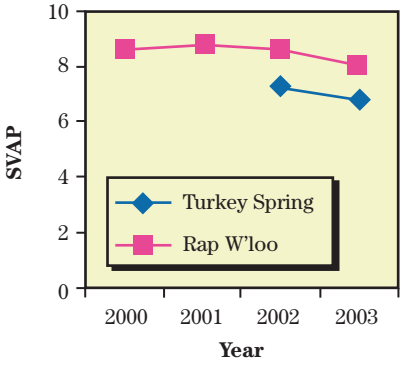
Jordan @Farms has a medium size watershed that is predominantly forested, exerting a positive influence on the site. Site conditions were extremely good prior to buffer establishment. Most of the restoration that took place with this project was installed on smaller tributaries and not the river itself. Both SVAP and IBI declined somewhat during the first year, probably due to circumstances beyond the control of the buffer.

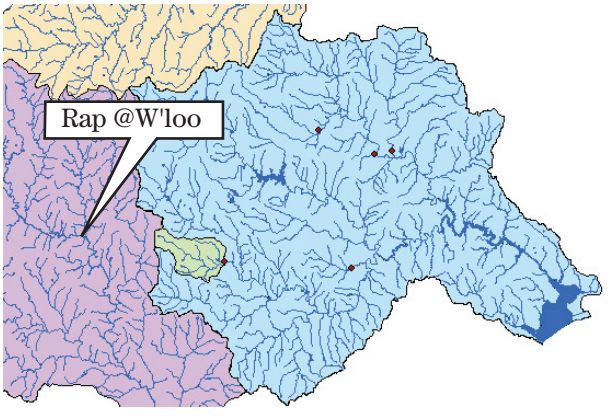
Appendix A32—Turkey Run @Spring Hill Farms, Fauquier Co. VA

Basis qualified: Grazing
Restored: Spring 2002
Size: 34.5 km^2
Baseline SVAP: 7.4 (Fair)
Baseline IBI: 36 (Fair)
Upstream land use
  Cropland %: 19.0
  Pasture %: 37.4
  Non-ag %: 34.4
  Urban/disturbed %: 9.2
Buffer area (ha): 8.2
Buffer length (m): 2,724.9

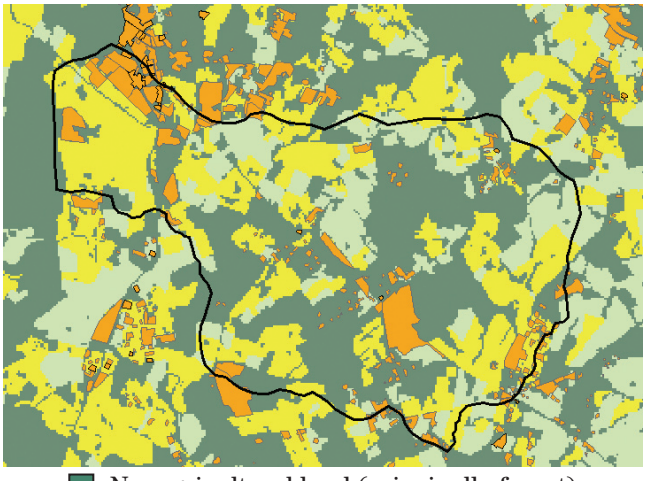
IBI and SVAP trends for Turk @Spring and its paired less-disturbed reference, Rap @W'loo.







Turk @Spring drainage



Nonagricultural land (principally forest)
Pasture
Cropland
Urban/developed

Appendix A32—Turkey Run @Spring Hill Farms, Fauquier Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner			3	
Mountain redbelly dace				
Roseyside dace			59	28
Fallfish			32	6
Creek chub				
River chub				
Bluehead chub				
Cutlips minnow			12	2
Blacknose dace			2	
Longnose dace				
Central stoneroller				
Eastern silvery minnow			58	26
Common shiner			5	2
Satinfin shiner			13	60
Spotfin shiner				
Bluntnose minnow			104	180
Fathead minnow				
Comely shiner			63	55
Spottail shiner			49	43
Swallowtail shiner			18	31
Roseyface shiner				
Silverjaw minnow				
White sucker			10	10
Creek chubsucker				1
Northern hogsucker			1	
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead			1	2
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish			2	
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish			49	37
Green sunfish			2	3
Pumpkinseed			1	
Bluegill			51	52
Redear sunfish				1
Rock bass				
Black crappie				
Smallmouth bass				
Largemouth bass			4	
Shield darter				
Stripeback darter				
Tesselated darter			13	9
Glassy darter				
Fantail darter			40	16
Greenside darter				
Hybrids				1
Total			**592**	**565**
Anomalies			3	

Fantail darter is a common riffle inhabitant at Turk @Spring.

Bluntnose minnow heavily dominated the species assemblage in both years of sampling at Turk @Spring.

Appendix A32—Turkey Run @Spring Hill Farms, Fauquier Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species					19	5	15	3
# darter species					2	3	2	3
# minnow species					12	3	10	3
% dominant species					0.176	5	0.319	3
# intolerant species					0	1	0	1
% tolerant individuals					0.289	3	0.434	3
% omnivores					0.198	3	0.336	1
% benthic invertivores					0.091	3	0.046	1
% specialist carnivores					0.145	3	0.080	3
% simple lithophils					0.247	3	0.205	1
# late maturing species					2	3	1	1
% anomalies					0.005	5	0.000	5
IBI						**40**		**28**

SVAP element ratings

SVAP Elements	2000	2001	2002	2003
Channel condition			7.7	8.0
Hydrologic alteration			9.0	7.3
Riparian width			4.3	5.3
Bank stability			6.3	6.3
Canopy cover			5.7	6.7
Water appearance			6.3	6.7
Nutrient enrichment			6.7	5.3
Manure presence			4.7	
Fish barriers			9.7	10.0
Fish cover			8.3	8.0
Pools			8.0	8.3
Riffle quality			8.0	5.3
Invertebrate habitat			9.0	7.0
Invertebrates observed			9.3	5.0
SVAP			**7.4**	**6.9**

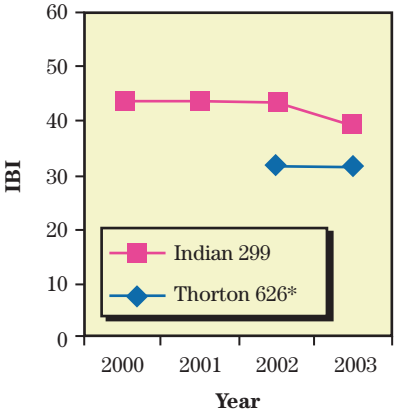
Site notes:

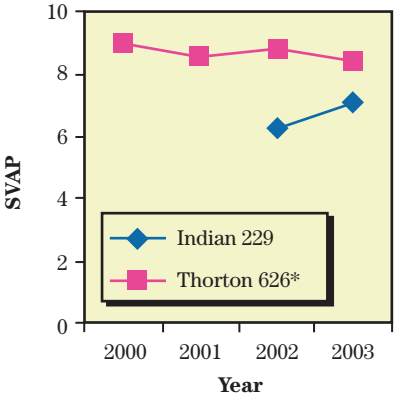
Turkey @Spring has a medium size watershed that is moderately impacted by agriculture and increasing suburban development. The site was lightly grazed prior to restoration and had reasonably good SVAP and IBI scores. The stream had good overall appearance and was unique among restoration sites in having extensive areas of water willow that provided both fish and invertebrate habitat. Growth in streambank vegetation and the water willow beds has been negligible after 1 year of restoration. SVAP scores actually diminished somewhat, and the IBI decreased dramatically. Not enough time has elapsed to draw conclusions about this site.

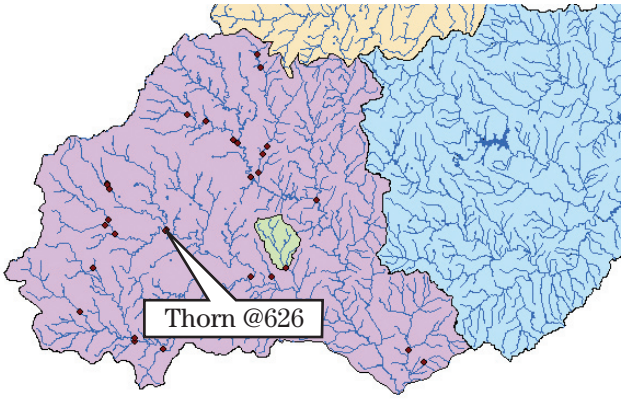
Appendix A33: Indian Run @229, Culpeper Co., VA

Basis qualified: Grazing
Restored: Spring 2002
Size: 13.5 km^2
Baseline SVAP: 6.2 (Fair)
Baseline IBI: 32 (Poor)
Upstream land use
  Cropland %: 25.5
  Pasture %: 9.6
  Non-ag %: 65.9
  Urban/disturbed %: 0.02
Buffer area (ha): 13.0
Buffer length (m): 2,984.9

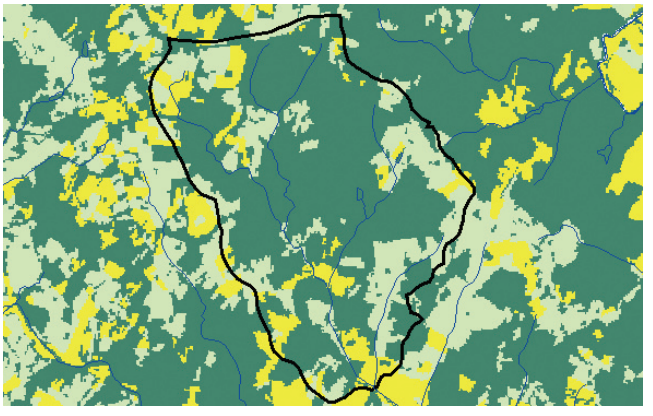
IBI and SVAP trends for Indian @229 and its paired less-disturbed reference, Thorn @626.







Indian @229 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A33: Indian Run @229, Culpeper Co., VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner			3	3
Mountain redbelly dace			14	10
Roseyside dace			160	2
Fallfish			22	
Creek chub			106	20
River chub				
Bluehead chub			105	6
Cutlips minnow			3	
Blacknose dace				2
Longnose dace			1	1
Central stoneroller				
Eastern silvery minnow			7	
Common shiner			96	91
Satinfin shiner			11	
Spotfin shiner				
Bluntnose minnow			38	55
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner			25	12
Roseyface shiner				
Silverjaw minnow			54	18
White sucker			4	4
Creek chubsucker				
Northern hogsucker			1	
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish			11	1
Green sunfish			2	1
Pumpkinseed			3	
Bluegill			46	3
Redear sunfish				
Rock bass				
Black crappie				
Smallmouth bass				
Largemouth bass			2	
Shield darter				
Stripeback darter			4	1
Tesselated darter			21	20
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids			2	
Total			**741**	**250**
Anomalies			8	

Stripeback darter, infrequently collected in the Rappahannock drainage, occurred at Indian @229.

Fish are typically sorted from a pocket formed in the seine that is allowed to extend just below the water's surface. This technique reduces mortality, particularly during lengthy sorts. Species are identified, enumerated, and returned immediately to the stream.

Appendix A33: Indian Run @229, Culpeper Co., VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species					18	3	13	3
# darter species					2	3	2	3
# minnow species					14	5	11	3
% dominant species					0.216	3	0.364	1
# intolerant species					0	1	0	1
% tolerant individuals					0.337	3	0.412	3
% omnivores					0.275	1	0.344	1
% benthic invertivores					0.036	1	0.088	3
% specialist carnivores					0.047	1	0.004	1
% simple lithophils					0.387	3	0.428	5
# late maturing species					3	3	2	3
% anomalies					0.011	5	0.000	5
IBI						**32**		**32**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition			6.0	6.7
Hydrologic alteration			4.7	6.3
Riparian width			5.7	6.7
Bank stability			4.3	5.7
Canopy cover			7.7	8.0
Water appearance			3.7	7.0
Nutrient enrichment			7.3	6.7
Manure presence				
Fish barriers			10.0	10.0
Fish cover			8.3	6.7
Pools			8.3	6.3
Riffle quality			5.0	6.7
Invertebrate habitat			6.7	7.3
Invertebrates observed			3.0	7.3
SVAP			**6.2**	**7.0**

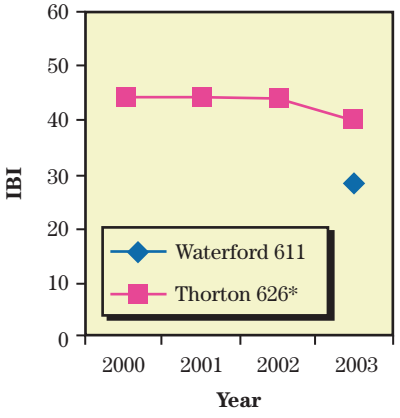
Site notes:

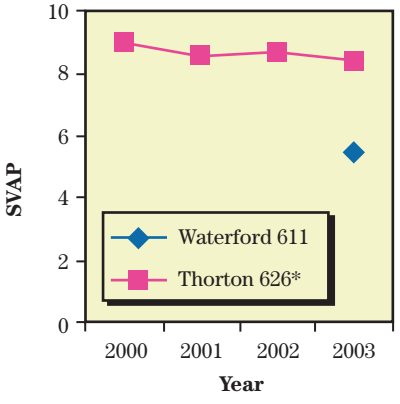
Indian @229 has a small, predominantly forested drainage. Indian Run is a rather low gradient stream with several beaver ponds within the sampled reach. The stream's channel is extremely straight, indicating past hydrologic alteration. The drainage has undergone some recent suburban development. The site qualified for the program based on cropping and was void of the many adverse livestock impacts described for other streams. Baseline SVAP and IBI conditions were fair and poor, resprctively. Hervaceous response was noted within a year of restoration and some woody vegetation is developing on the floodplain. SVAP scores have improved somewhat, but the IBI has remaind the same.

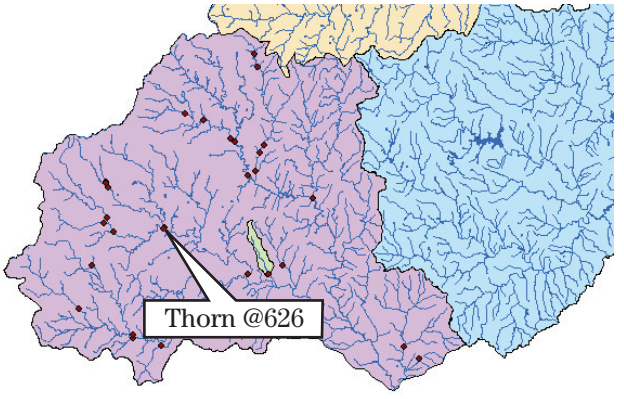
Appendix A34—Wacaterford Run @611, Culpeper Co. VA

Basis qualified: Grazing
Restored: Spring 2003
Size: 9.2 km^2
Baseline SVAP: 5.5 (Poor)
Baseline IBI: 28 (Poor)
Upstream land use
  Cropland %: 23.7
  Pasture %: 24.0
  Non-ag %: 52.2
  Urban/disturbed %: 0
Buffer area (ha): 17.7
Buffer length (m): 4,171.2

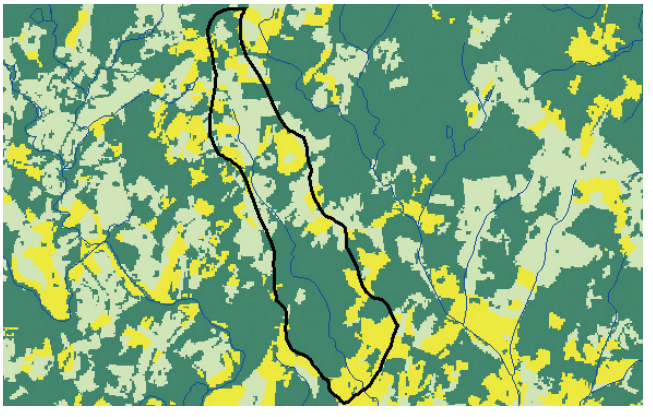
IBI and SVAP trends for Water @611 and its paired less-disturbed reference, Thorn @626.







Water @611 drainage



Nonagricultural land (principally forest)
Pasture
Cropland

Appendix A34—Wacaterford Run @611, Culpeper Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				130
Roseyside dace				69
Fallfish				
Creek chub				86
River chub				
Bluehead chub				31
Cutlips minnow				
Blacknose dace				58
Longnose dace				3
Central stoneroller				
Eastern silvery minnow				
Common shiner				34
Satinfin shiner				
Spotfin shiner				
Bluntnose minnow				103
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow				120
White sucker				7
Creek chubsucker				
Northern hogsucker				
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish				1
Green sunfish				4
Pumpkinseed				
Bluegill				
Redear sunfish				
Rock bass				
Black crappie				
Smallmouth bass				
Largemouth bass				
Shield darter				
Stripeback darter				
Tesselated darter				44
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				1
Total				**691**
Anomalies				1

Periodically, the seine is searched to determine the dominant invertebrate groups, which are a critical element of SVAP.

Appendix A34—Wacaterford Run @611, Culpeper Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species							10	3
# darter species							1	1
# minnow species							9	3
% dominant species							0.188	5
# intolerant species							0	1
% tolerant individuals							0.547	3
% omnivores							0.378	1
% benthic invertivores							0.068	1
% specialist carnivores							0.001	1
% simple lithophils							0.153	1
# late maturing species							2	3
% anomalies							0.001	5
IBI								**28**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition				5.7
Hydrologic alteration				5.0
Riparian width				4.3
Bank stability				4.0
Canopy cover				3.0
Water appearance				5.0
Nutrient enrichment				5.0
Manure presence				
Fish barriers				10.0
Fish cover				5.0
Pools				4.7
Riffle quality				6.3
Invertebrate habitat				6.3
Invertebrates observed				7.3
SVAP				**5.5**

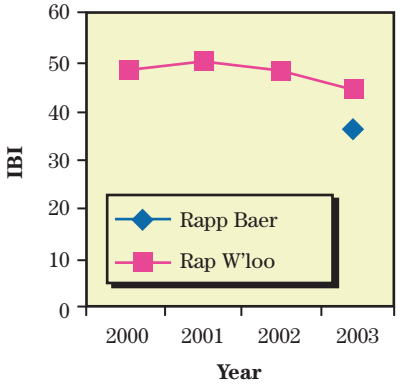
Site notes:

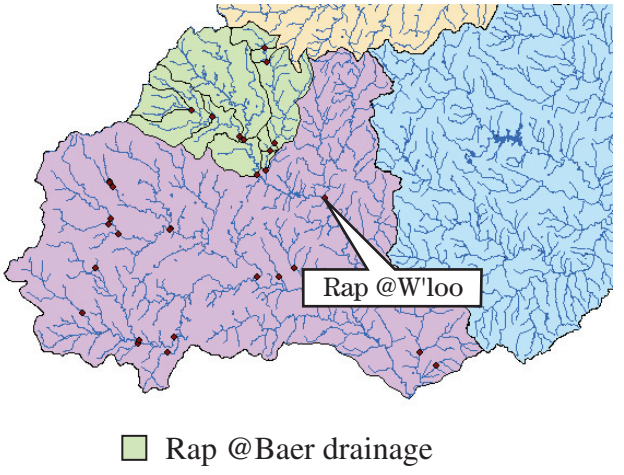
Water @611 has a small watershed that is about half forested, and the other half split equally between cropland and pasture. Waterford Run is a low gradient stream that has considerable sedimentation. Baseline SVAP and IBI scores indicated that the site was in poor condition. The site was first sampled in 2003, therefore, no trends have been observed.

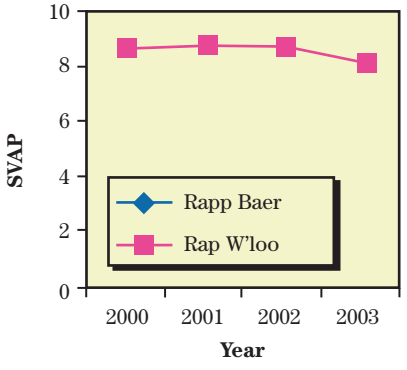
Appendix A35—Rappahannock River @Baer, Fauquier Co. VA

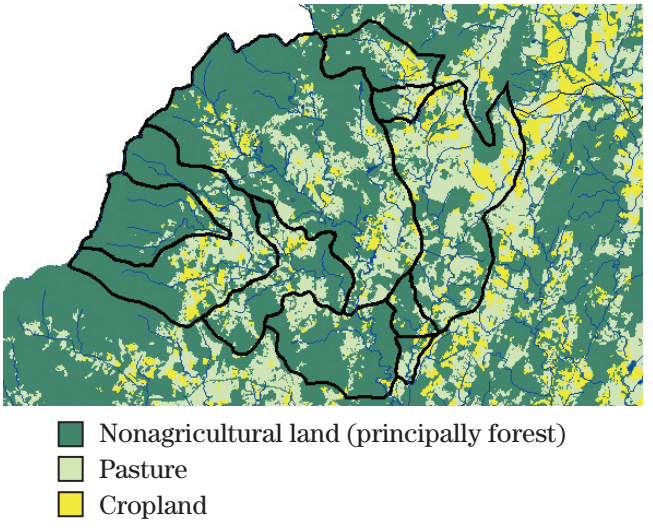
Basis qualified: Grazing
Restored: Restoration pending
Size: 216.08 km^2
Baseline SVAP: 8.3 (Good)
Baseline IBI: 36 (Fair)
Upstream land use
  Cropland %: 7.8
  Pasture %: 27.7
  Non-ag %: 64.5
  Urban/disturbed %: 0.07
Buffer area (ha): Not restored
Buffer length (m): Not restored

IBI and SVAP trends for Rapp @Baer and its paired less-disturbed reference, Rap @W'loo.









Appendix A35—Rappahannock River @Baer, Fauquier Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				
Mountain redbelly dace				
Roseyside dace				
Fallfish				1
Creek chub				2
River chub				5
Bluehead chub				8
Cutlips minnow				
Blacknose dace				5
Longnose dace				3
Central stoneroller				
Eastern silvery minnow				
Common shiner				56
Satinfin shiner				223
Spotfin shiner				
Bluntnose minnow				4
Fathead minnow				
Comely shiner				14
Spottail shiner				1
Swallowtail shiner				36
Roseyface shiner				16
Silverjaw minnow				13
White sucker				1
Creek chubsucker				
Northern hogsucker				
Torrent sucker				1
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				
Brown bullhead				
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish				10
Green sunfish				2
Pumpkinseed				
Bluegill				15
Redear sunfish				
Rock bass				1
Black crappie				
Smallmouth bass				
Largemouth bass				7
Shield darter				2
Stripeback darter				
Tesselated darter				55
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total				**481**
Anomalies				1

Glassy darter is an intolerant species that was collected at Rappahannock reference sites both above and below, but not at Rapp @Baer.

River chub, a common inhabitant of larger streams with gravel substrates, such as Rapp @Baer.

Appendix A35—Rappahannock River @Baer, Fauquier Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species							17	1
# darter species							2	3
# minnow species							14	3
% dominant species							0.464	1
# intolerant species							2	3
% tolerant individuals							0.087	5
% omnivores							0.056	5
% benthic invertivores							0.125	3
% specialist carnivores							0.040	1
% simple lithophils							0.266	3
# late maturing species							4	3
% anomalies							0.002	5
IBI								**36**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition				8.0
Hydrologic alteration				8.0
Riparian width				8.3
Bank stability				8.0
Canopy cover				8.7
Water appearance				7.0
Nutrient enrichment				8.3
Manure presence				
Fish barriers				10.0
Fish cover				8.0
Pools				9.3
Riffle quality				7.0
Invertebrate habitat				7.3
Invertebrates observed				9.3
SVAP				**8.3**

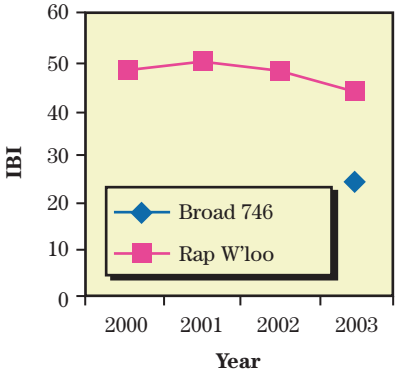
Site notes:

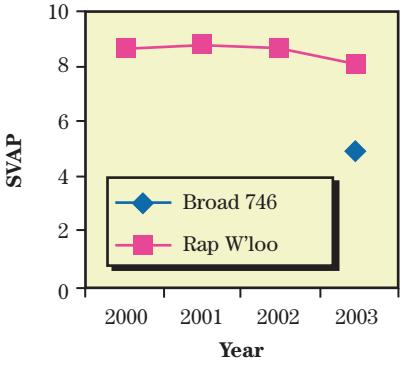
Rapp @Baer has a very large watershed that is predominantly forested and in good condition. Baseline SVAP scores indicated the site was in good condition; however, the IBI indicated only fair condition, possibly due to difficulty in sampling the site comprehensively due to high water conditions that prevailed in 2003. Restoration had not occurred in 2003, thus no response or trends were observed. Further sampling in more normal years may be needed to reinforce the IBI baseline condition.

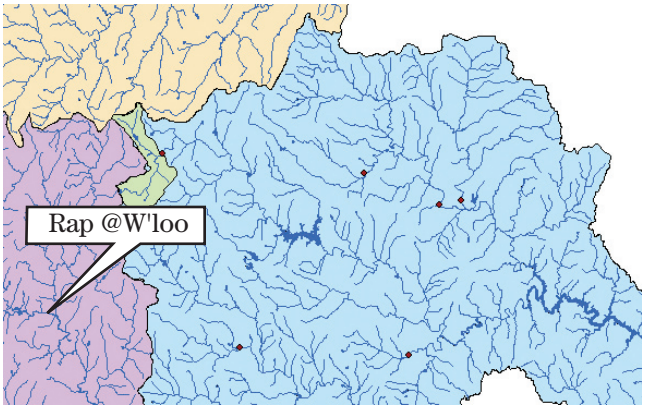
Appendix A36—Broad Run @746, Fauquier Co. VA

Basis qualified: Grazing
Restored: Spring 2002
Size: 24.8 km^2
Baseline SVAP: 5.0 (Poor)
Baseline IBI: 24 (Very poor)
Upstream land use
  Cropland %: 19.8
  Pasture %: 52.8
  Non-ag %: 23.2
  Urban/disturbed %: 3.2
Buffer area (ha): 3.8
Buffer length (m): 1,810.5

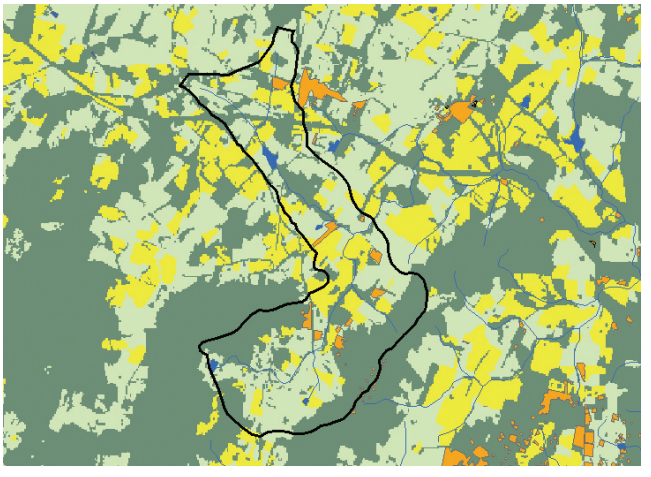
IBI and SVAP trends for Broad @746 and its paired less-disturbed reference, Rap @W'loo.







Broad @746 drainage



Nonagricultural land (principally forest)
Pasture
Cropland
Urban/developed

Appendix A36—Broad Run @746, Fauquier Co. VA

Raw fish data

Common name	2000	2001	2002	2003
American brook lamprey				
Gizzard shad				
Common carp				
Golden shiner				4
Mountain redbelly dace				
Roseyside dace				
Fallfish				1
Creek chub				
River chub				
Bluehead chub				
Cutlips minnow				
Blacknose dace				
Longnose dace				
Central stoneroller				
Eastern silvery minnow				
Common shiner				19
Satinfin shiner				4
Spotfin shiner				
Bluntnose minnow				16
Fathead minnow				
Comely shiner				
Spottail shiner				
Swallowtail shiner				
Roseyface shiner				
Silverjaw minnow				
White sucker				11
Creek chubsucker				
Northern hogsucker				
Torrent sucker				
Golden redhorse				
Shorthead redhorse				
Channel catfish				
Yellow bullhead				1
Brown bullhead				2
Margined madtom				
Banded killifish				
Eastern mosquitofish				
Mottled sculpin				
Potomac sculpin				
Redbreast sunfish				3
Green sunfish				8
Pumpkinseed				1
Bluegill				82
Redear sunfish				
Rock bass				
Black crappie				
Smallmouth bass				
Largemouth bass				12
Shield darter				
Stripeback darter				
Tesselated darter				
Glassy darter				
Fantail darter				
Greenside darter				
Hybrids				
Total				**164**
Anomalies				

SVAP data forms are completed at the end of each fish survey. Each survey member rates each SVAP element based on observations of stream, streambank, and riparian characteristics made during the survey.

Leeches are an example of Group III taxa, or pollution tolerant organisms that may be found in water of any quality.

Appendix A36—Broad Run @746, Fauquier Co. VA

IBI metric values and scores

	2000		2001		2002		2003	
IBI Metrics	**value**	**rating**	**value**	**rating**	**value**	**rating**	**value**	**rating**
# native species							9	1
# darter species							0	1
# minnow species							5	3
% dominant species							0.500	1
# intolerant species							0	1
% tolerant individuals							0.713	1
% omnivores							0.189	3
% benthic invertivores							0.000	1
% specialist carnivores							0.116	3
% simple lithophils							0.116	1
# late maturing species							2	3
% anomalies							0.000	5
IBI								**24**

SVAP element ratings

SVAP Elements	**2000**	**2001**	**2002**	**2003**
Channel condition				5.7
Hydrologic alteration				5.7
Riparian width				5.0
Bank stability				7.3
Canopy cover				1.7
Water appearance				4.3
Nutrient enrichment				4.0
Manure presence				
Fish barriers				5.3
Fish cover				5.7
Pools				7.7
Riffle quality				4.0
Invertebrate habitat				3.3
Invertebrates observed				5.0
SVAP				**5.0**

Site notes:

Broad @746 has a small, predominantly agricultural drainage. The site is heavily influenced by beavers and the culvert at County Road 746, which appears too small to pass water from many flood events; thus, retarding flows and adding to the inundation problems of the reach. Unusually large amounts of sediment were observed at the site, probably due to the retarding flows caused by the culvert and beaver ponds. Many of the mature trees at the site have been recently killed from the effects of the inundation. However, there appears to be rapid re-growth of woody vegetation that may be in part due to the fencing. SVAP and IBI scores at the site were poor and very poor, respectively. Only 1 year of data from the site does not permit trend analysis.