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Natural Resource Stewardship and Science

Fish Community Monitoring at George Washington Carver National Monument

2006–2016 Status Report

Natural Resource Data Series NPS/HTLN/NRDS—2018/1151

ON THE COVER
Carver Branch at George Washington Carver National Monument.
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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

This report is available from Heartland Inventory and Monitoring Network website, and the Natural Resource Publications Management website.

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Abstract

George Washington Carver National Monument (NM), located in southwest Missouri, is comprised of tallgrass prairie, woodlands, and three small streams: Carver, Harkins, and Williams branches. These park streams may offer important habitat and protection for fish species that have been adversely impacted by land use changes throughout the Midwest. Between 2006 and 2016, the Heartland I&M Network sampled fish communities, water quality, and physical habitat at all three streams within the park. Goals of this long-term monitoring are to determine status and detect trends in fish community composition and to compare these community data to water quality and habitat conditions. Numerous native fish species were found in these streams. Several darter, sculpin, and madtom species that are sensitive to poor water quality and habitat conditions were present, suggesting high water quality in the park. Additionally, low occurrence of fish anomalies or diseases and high biotic integrity scores suggest that the fish populations are diverse and healthy and that streams within the park are in fair to good condition. Harkins Branch had lower biotic integrity scores for most years sampled due to higher number of species tolerant to poor water quality and habitat conditions.

Acknowledgments

We would like to thank staff at George Washington Carver NM, David Bowles, Tyler Cribbs and Jan Hinsey from Heartland I&M Network and the several interns for their assistance with field work. Also, thanks to Jen Haack (Heartland I&M Network) for GPS/GIS assistance.

Introduction

George Washington Carver National Monument (NM), located in the Ozark Highlands of southwest Missouri, was established at the birthplace and childhood home of Carver to interpret the historic and cultural resources related to his life and achievements. An important part of interpreting this historic site is the role that natural history played in the events of Carver's early life. Maintaining the natural resources that Carver enjoyed as a child is a priority for the park. The park is approximately 0.85 km^2 in area with 0.59 km^2 of restored prairie and approximately 1.8 km of streams.

Land upstream of the park is predominately used for agriculture and rural residences. Many native fish populations have been adversely impacted throughout their ranges by a number of factors associated with land use changes, including habitat loss and fragmentation, sedimentation, and reduced water quality. As a result of degraded stream conditions in the Midwest, the Arkansas darter (*Etheostoma cragini*), a native stream fish found in the park, is a species of conservation concern in Missouri (MDC 2017). Although anthropogenic disturbances at the watershed scale can dramatically alter a lotic system, protecting portions of Ozark streams on publicly owned lands may offer protection for native species.

Changes or shifts in stream habitat complexity and water quality often determine the composition of biotic communities (Lazorchak et al. 1998). Monitoring trends in fish community composition along with associated habitat conditions serves as a strong indicator of stream integrity. Many fish species are considered intolerant of habitat alterations and monitoring their assemblages can serve as a useful tool to assess changes in water and habitat quality (Karr 1981; Robison and Buchanan 1988; Pflieger 1997; Barbour et al. 1999; Dauwalter et al. 2003; Peitz 2005). Accordingly, trends in the composition and abundance of fish populations have long been used to assess the biological integrity of streams (Karr 1981; Barbour et al. 1999; Moulton et al. 2002; Dauwalter et al. 2003). Moreover, the intrinsic value of fish to the public as environmental indicators and as recreational opportunities makes the status of fish diversity a valuable interpretive topic for park visitors and an informative tool for protecting and conserving the aquatic resources at George Washington Carver NM.

Objectives of fish community monitoring at George Washington Carver NM are

1. to determine the status and long-term trends in fish richness (number of fish species collected), diversity, abundance (total number of fish collected per sampling effort), and community composition (percent abundance of each species), and
2. to correlate the long-term community data to overall water quality and habitat condition.

Methods

Details on methods of site selection, fish sampling, and habitat and water quality data collection not listed in this report can be found in the Protocol for Monitoring Fish Communities in Small Streams in the Heartland Inventory and Monitoring Network (Dodd et al. 2008).

Study Area and Site Selection

Portions of three wadeable streams run through the park: Carver Branch (~ 1.0 km), Williams Branch (~0.25 km), and Harkins Branch (~ 0.51km). For each stream, a reach was selected as far downstream as possible before their confluences with one another (Figure 1). Reach length was defined as 20 times the mean wetted stream width (MWSW) with a minimum of 150 m, allowing inclusion of representative channel units (riffle, run, and pool habitats) located within the stream (Moulton et al. 2002; Dodd et al. 2008). Because the streams in the park were small and narrow, the minimum reach length of 150 m was sampled for each stream.

Fish Collection

Fish communities were sampled in May/June of 2006-2007, 2010, 2013, and 2016. Fish were collected during a single pass with a pulsed DC backpack electrofishing unit throughout each sampling reach. During sampling, fish were collected with nets and placed in buckets fitted with aerators. All fish were identified to species on site, if possible, and counted. A subsample of 30 individuals per species were measured and weighed, and any anomalies (deformities, eroded fins, lesions, tumors, and blackspot parasite) were recorded. Fish that were too small or too difficult to identify in the field were preserved for identification at a later time in the laboratory. All other fish were released back into the sample reach. Details on fish collection and sample processing techniques can be found in Dodd et al. (2008).

Habitat and Water Quality

Physical habitat and water quality data were collected in conjunction with fish sampling. An 11-transect method was used to collect data on general channel morphology, fish cover, and bank conditions within the entire reach. In-stream habitat (depth, velocity, substrate, etc.) and fish cover (presence of small and large woody debris, tree roots, boulders, hydrophytes, etc.) were assessed at three points per transect (see Dodd et al. 2008 for a list of all habitat parameters collected). Fish cover along the banks (undercut banks, overhanging terrestrial vegetation, etc.) and bank/riparian stability were assessed on the left and right banks at each transect. Hourly water quality data (temperature, dissolved oxygen, pH, specific conductance, and turbidity) were collected using calibrated loggers deployed downstream of the reach for at least 24 hours. Detailed methods on habitat and water quality collection are located in Dodd et al. (2008).

Data Analysis

Biological metrics were calculated for each reach and each year sampled. These metrics reflect fish community diversity (species richness and Simpson's Index [SI]), abundance (catch per unit effort), composition (number and percent composition of specific taxa), and overall stream integrity (Index of Biotic Integrity [IBI]). Community diversity was assessed using Simpson's Index (Attrill 2002), which gives the probability that two individuals picked at random from the site are the same species. Therefore, Simpson's Index decreases with increasing diversity. Because of this inverse relationship with diversity, we used 1-SI in the analyses. A 1-SI value of 1 indicates a completely diverse community and a value of 0 indicates no diversity. For composition, the number and percent composition of sucker (Catastomidae), percent of sunfish (Centrarchidae), and percent of combined darter/sculpin/madtom species (*Etheostoma* and *Percina*/*Cottus*/*Noturus*) were calculated because these metrics are typically used in several IBI calculations (Karr 1981; Dauwalter et al. 2003; Smogor 2005) and these species demonstrate sensitivity to human disturbance.

The IBI developed by Dauwalter et al. (2003) was used to assess overall stream health and includes seven metrics: (1) percent of individuals as algivorous/herbivorous, invertivorous, and piscivorous; (2) percent with an anomaly (disease, eroded fins, lesions, or tumors) or blackspot parasite; (3) percent as green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), yellow bullhead (*Ameiurus natalis*), or channel catfish (*Ictalurus punctatus*); (4) percent invertivores; (5) percent top carnivores; (6) number

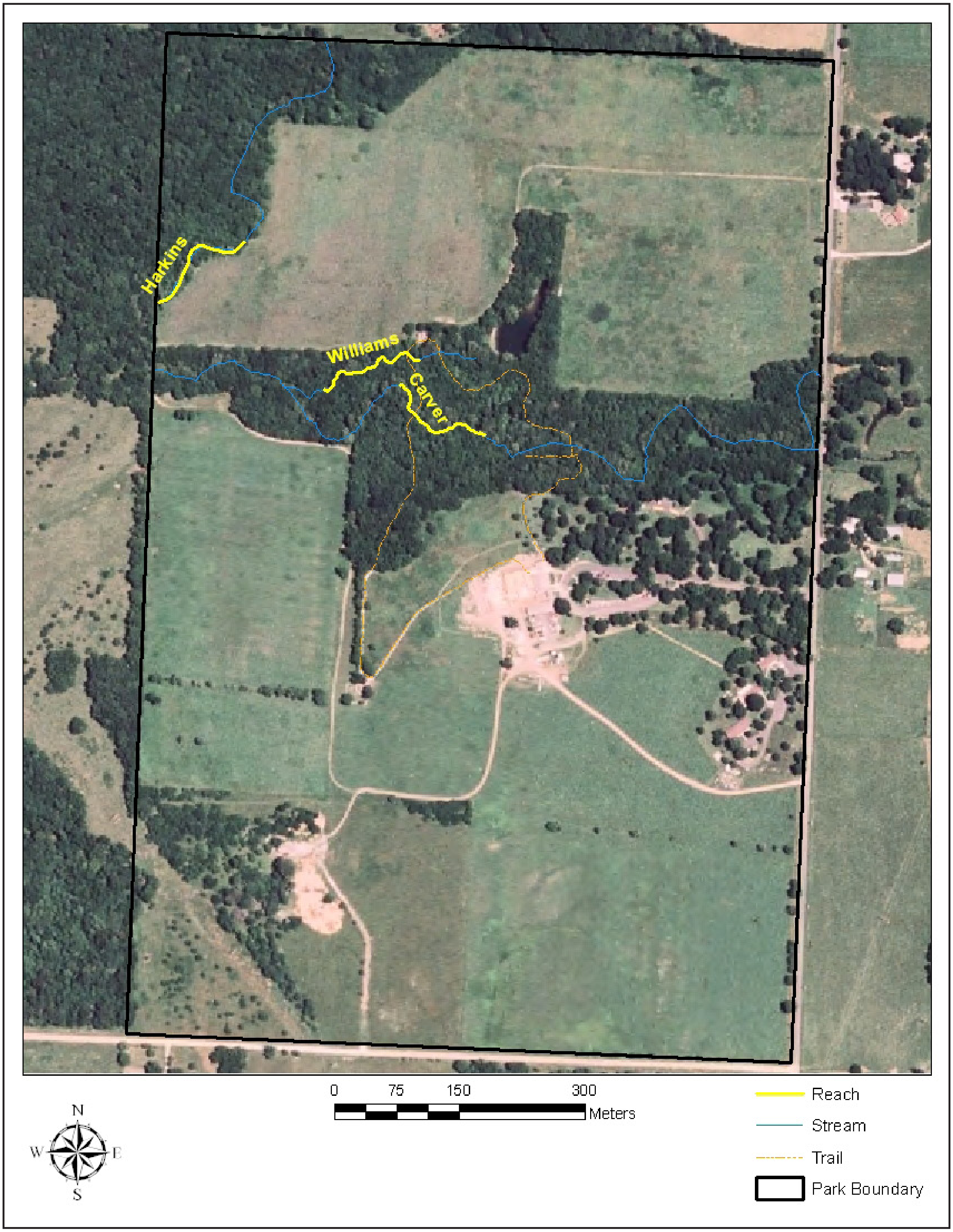

Figure 1. Stream reach locations for long-term fish monitoring at George Washington Carver NM.

of darter/sculpin/madtom species; and (7) number of lithophilic (sand/gravel) spawning species. Each of the seven raw metric values was scored from 0 to 10 based on upper and lower thresholds developed for the Ozarks region. The metric scores were added to calculate an IBI score that ranges from 0 to 100. Based on this IBI score, the overall integrity of the stream is classified from very poor to excellent: very poor = 0-20; poor = 20-40; fair = 40-60; good = 60-80; excellent (reference condition) = 80-100. More detailed methods on calculating the IBI used in this report can be found in Dauwalter et al. (2003).

Physical habitat and water quality data were summarized using averages with standard errors (SE) or percentages, where appropriate. Physical habitat data were analyzed as in-stream habitat, fish cover, and bank stability. Analysis of in-stream substrate data used the Wentworth code for particle sizes (Wentworth 1922). For assessment of stream banks, categories of bank angle, percent vegetation, height, and substrate were used to assess overall bank stability. Water quality data were analyzed using averages and standard errors.

Results

Fish Community

Species richness (i.e., number of species) ranged from 9 to 12 at Carver Branch, 5 to 12 at Williams Branch, and 12 to 15 at Harkins Branch (Figure 2). In each year, Harkins Branch had the highest number of species. Species richness at Williams Branch was most variable among years. All streams had moderate (0.5 – 0.75) to high (>0.75) community diversity in all years. Harkins Branch had the highest diversity in all years, except 2006 and 2016, and the lowest variability across all years sampled (Figure 3). Carver Branch showed the greatest variability in diversity across years. Fish abundance ranged from 7 to 18 fish/min at Carver Branch, 2 to 4 fish/min at Williams Branch, and 3 to 25 fish/min at Harkins Branch (Figure 4). Harkins Branch had the highest variability in abundance due to high numbers of Stoneroller species (*Campostoma* spp.) in 2006, while Williams Branch had the lowest variability among years. At all sites, abundance was lowest in 2007.

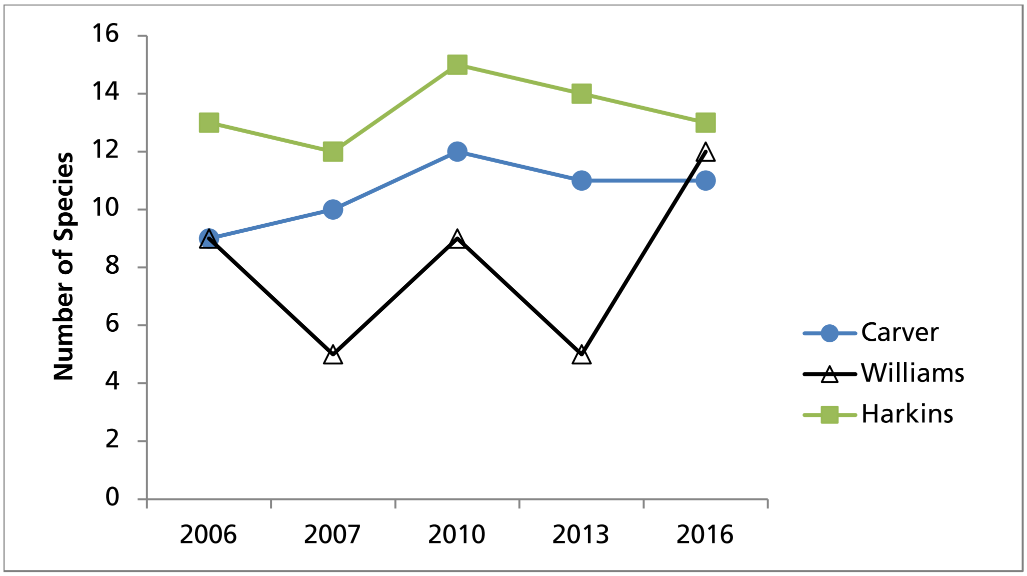

Figure 2. Species richness for reaches sampled at George Washington Carver NM.

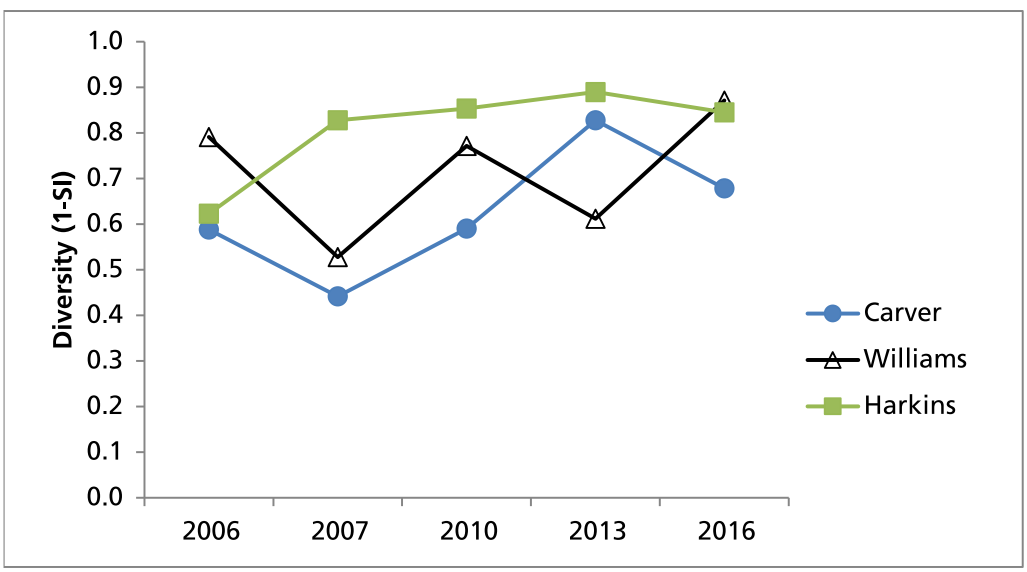

Figure 3. Community diversity (1 - Simpson's Index) for reaches sampled at George Washington Carver NM.

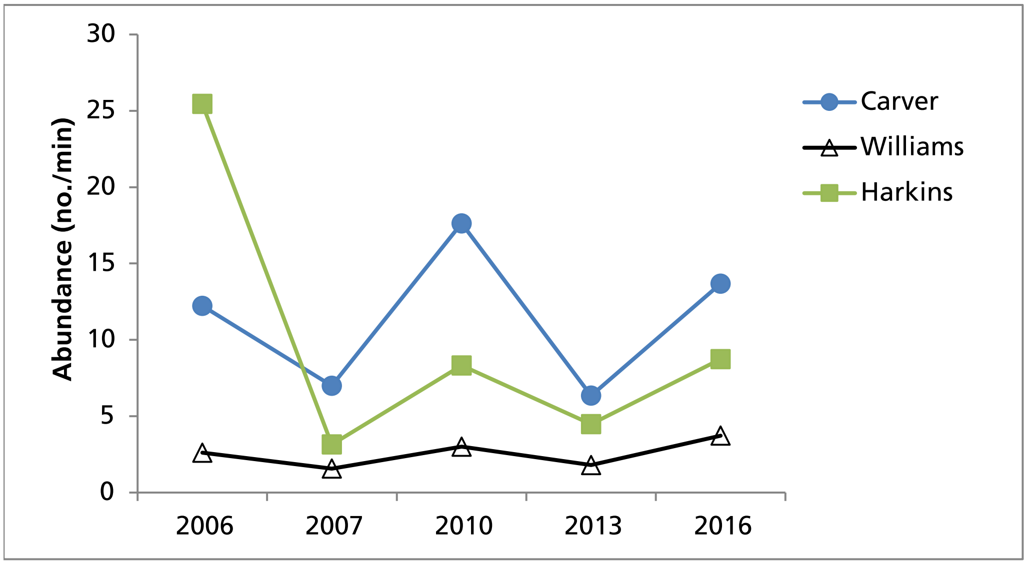

Figure 4. Abundance for reaches sampled at George Washington Carver NM.

Table 1. Number of species and percent composition of sucker, sunfish, and darter/sculpin/madtom species for reaches sampled at George Washington Carver NM.

Year	Sample Reach	No. Species Suckers	% Comp Suckers	No. Species Sunfish	% Comp Sunfish	No. Species Darters, Sculpins, Madtoms	% Comp Darters, Sculpins, Madtoms
2006	Carver	1	0.4	0	0.0	4	13.6
	Williams	0	0.0	0	0.0	5	61.9
	Harkins	0	0.0	1	0.5	6	10.5
2007	Carver	1	0.6	1	3.3	5	13.2
	Williams	0	0.0	1	4.3	2	87.0
	Harkins	0	0.0	2	7.5	6	26.1
2010	Carver	1	0.5	1	0.8	5	19.8
	Williams	0	0.0	0	0.0	6	80.7
	Harkins	1	0.3	2	10.7	7	33.1
2013	Carver	0	0.0	2	3.1	5	39.6
	Williams	0	0.0	0	0.0	4	97.0
	Harkins	0	0.0	3	34.1	6	29.3
2016	Carver	0	0.0	1	6.1	6	27.9
	Williams	1	0.8	2	3.9	6	57.8
	Harkins	0	0.0	3	21.5	6	29.2

All streams had low numbers and percent composition of sucker and sunfish species with Harkins Branch having the highest composition of sunfish compared to the other streams (Table 1). Composition of darter/sculpin/madtom species (species sensitive to siltation and poor water quality) in the overall community was highest at Williams Branch. In 2007, the number of darter/sculpin/madtom species was low (two species), indicating much of the community was made up of two sensitive species. Arkansas darter, a species of conservation concern, was found in all three streams, but in low numbers (31 specimens across all streams and years).

IBI scores ranged from 55 to 68 (fair to good) at Carver Branch, 59 to 81 (fair to excellent) at Williams Branch, and 35 to 73 (poor to good) at Harkins Branch (Figure 5). All reaches rated as good in 2006 and 2007. Carver dropped to a rating of fair in all other years and Harkins Branch rated as fair in 2010 and 2016 and as poor in 2013. Higher occurrences of anomalies in both Carver Branch and Harkins Branch, in those years, and a higher percentage of tolerant Green sunfish and Bluegill in Harkins Branch explains the lower biotic integrity ratings. Williams Branch rated as excellent in 2010, fair in 2013, and good in 2016.

Habitat and Water Quality

All streams were typically narrow (< 5m) and shallow (<30 cm) on average (Figures 6 and 7). All streams had the highest velocities in 2007 compared to other years sampled (Figure 8). Carver Branch was the widest stream in all years sampled, with the exception

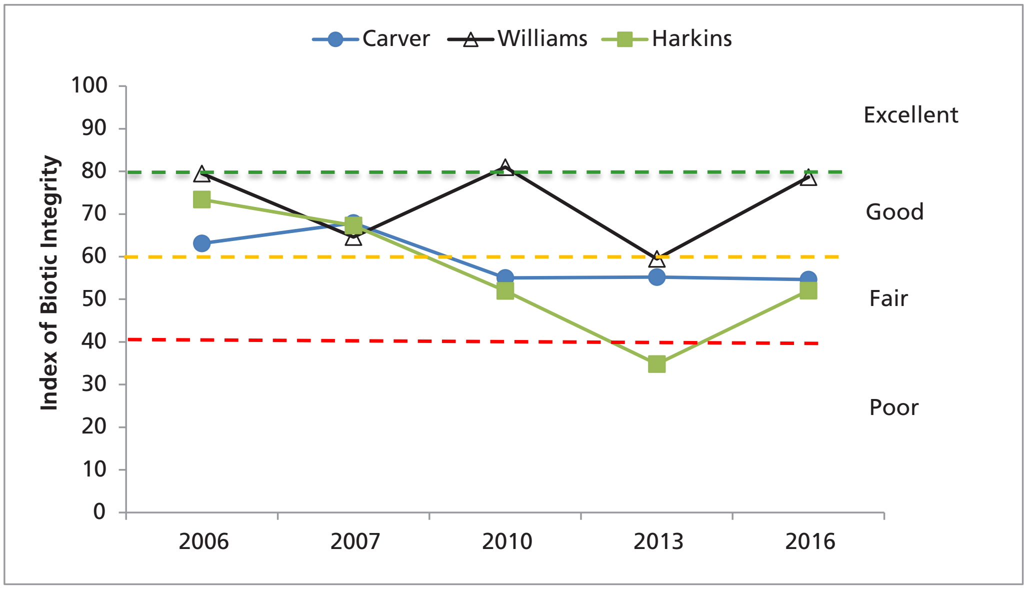

Figure 5. Index of Biotic Integrity scores and ratings for stream reaches sampled at George Washington Carver NM.

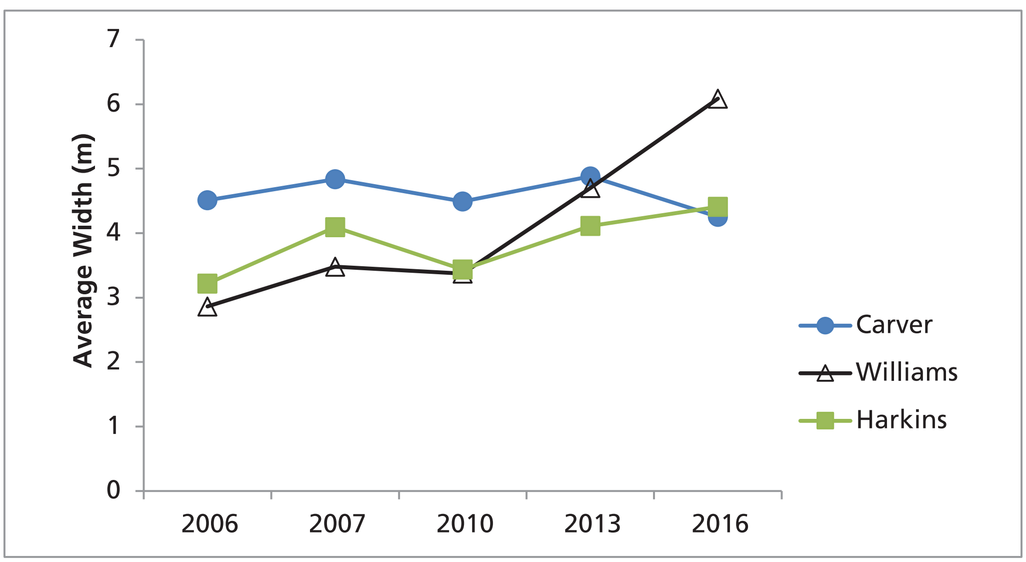

Figure 6. Average stream width for stream reaches sampled at George Washington Carver NM.

Figure 7. Average stream depth for stream reaches sampled at George Washington Carver NM.

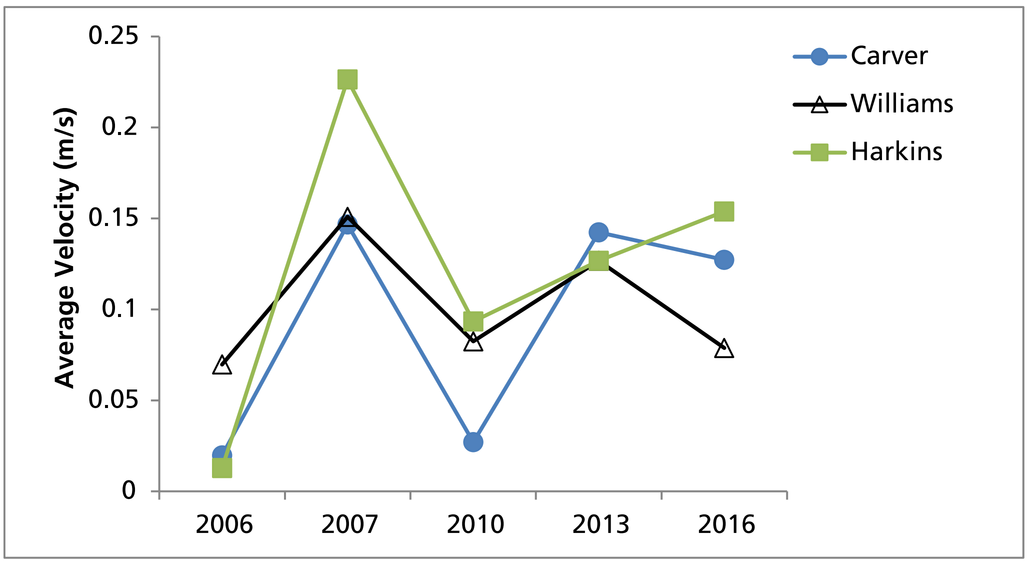

Figure 8. Average stream velocity for stream reaches sampled at George Washington Carver NM.

of 2016, when Williams Branch was wider and deeper due to an obstruction pool created by a beaver dam within the sample reach (Figures 9 and 10). Harkins Branch had the largest substrate sizes, consisting of large pebble and small cobble substrate. Substrates were small pebble at Carver Branch and fine to small gravel on average at Williams Branch.

Fish cover was primarily small woody debris, with each reach having more than 50% of its area covered by this cover type in all years sampled at Carver Branch (52-67%) and Williams Branch (66-70%) and for all years except 2016 at Harkins Branch (42-64%).

Tree root cover was also commonly found at all three streams (27-39% at Carver Branch, 24-47% at Williams Branch, and 27-52% at Harkins Branch) and overhanging vegetation occurred frequently in Williams Branch (46-67%) and Carver Branch (30-61%).

Banks were relatively stable for Carver Branch and Williams Branch across years, while Harkins Branch showed greater bank angles, had less vegetation, and higher banks (Table 2). A large percentage of banks at Carver Branch and Williams Branch had angles less than 60 degrees, vegetation cover greater than

Figure 9. Beaver dam located within the sample reach of Williams Branch.

Figure 10. Pool habitat created upstream of the beaver dam located within the sample reach of Williams Branch.

Table 2. Bank angle, vegetation, height, and substrate characteristics (in percent of total bank) for each reach sampled at George Washington Carver NM.

		Carver					Williams					Harkins				
Characteristic	**Category**	**2006**	**2007**	**2010**	**2013**	**2016**	**2006**	**2007**	**2010**	**2013**	**2016**	**2006**	**2007**	**2010**	**2013**	**2016**
Angle	< 60o	50	86	82	86	73	82	96	100	100	100	41	68	64	73	41
	> 60o	50	14	18	14	27	18	5	0	0	0	50	32	36	27	59
Vegetation	>80%	36	82	100	95	96	64	100	100	91	100	0	41	59	73	82
	50-80%	64	18	0	5	5	36	0	0	9	0	82	59	41	27	9
	<50%	0	0	0	0	0	0	0	0	0	0	18	0	0	0	9
Height	<1m	73	55	73	77	77	100	100	100	100	100	50	41	41	32	18
	1-2m	27	41	27	23	23	0	0	0	0	0	36	27	32	59	55
	2-3m	0	5	0	0	0	0	0	0	0	0	14	9	27	9	27
	>3m	0	0	0	0	0	0	0	0	0	0	0	23	0	0	0
Substrate	Silt	82	55	64	36	64	100	100	100	100	100	36	14	0	0	5
	Sand/Gravel	18	41	36	64	32	0	0	0	0	0	64	55	91	96	32
	Cobble/ Boulder	0	5	0	0	5	0	0	0	0	0	0	32	9	5	64

80%, and bank heights less than 1 m. Banks at both Carver Branch and Williams Branch consisted of silt or sand/gravel substrate. Harkins Branch had a higher percentage of banks with angles greater than 60 degrees, vegetation cover less than 80%, and heights greater than 1 m. A small percentage of the banks at Harkins Branch did consist of cobble substrate, which is more stable than silt or sand/gravel.

Water quality showed more variability among years within a stream than among streams within a year (Figures 11-15). Average water temperatures were consistent across years for each stream except in 2006 when sampling took place in June rather than May, resulting in higher average water temperatures (Figure 11). In all years, all streams stayed below the state standard of less than 35°C for permanent flowing streams (MO DNR 2014).

At Carver and Williams branches, pH was more variable due to high values in 2007, while Harkin's Branch was consistent across years (Figure 12). Dissolved oxygen in Harkins Branch was more temporally variable than in the other two streams (Figure 13), although concentrations stayed above the state water quality standard of 5 mg/L (MO DNR 2014).

Turbidity was low (<10 NTU), on average, in all streams and in all years (Figure 14), but turbidity at Carver Branch and Harkins Branch was more variable than Williams Branch. The higher average turbidity in Carver Branch in 2007 was due to increased turbidity levels during the night hours, possibly due to terrestrial animal activity in the water or along the bank. Specific conductance (conductivity standardized at 25°C) was highest in 2006 at all three streams with higher temporal variability among years in Williams Branch and Harkins Branch compared to Carver Branch (Figure 15).

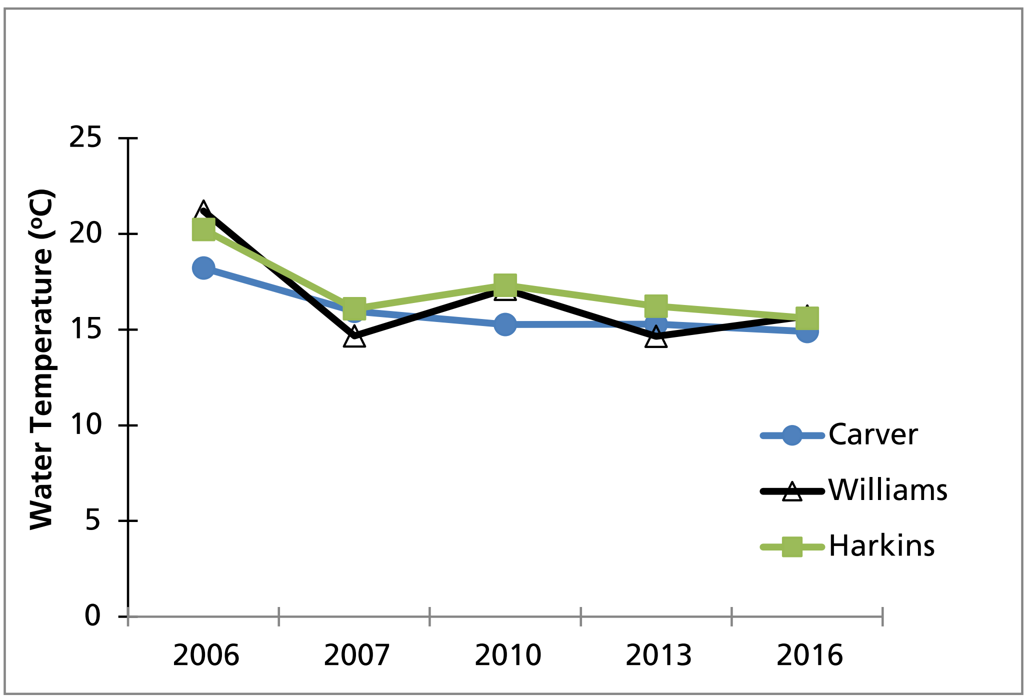

Figure 11. Average water temperature for streams sampled at George Washington Carver NM.

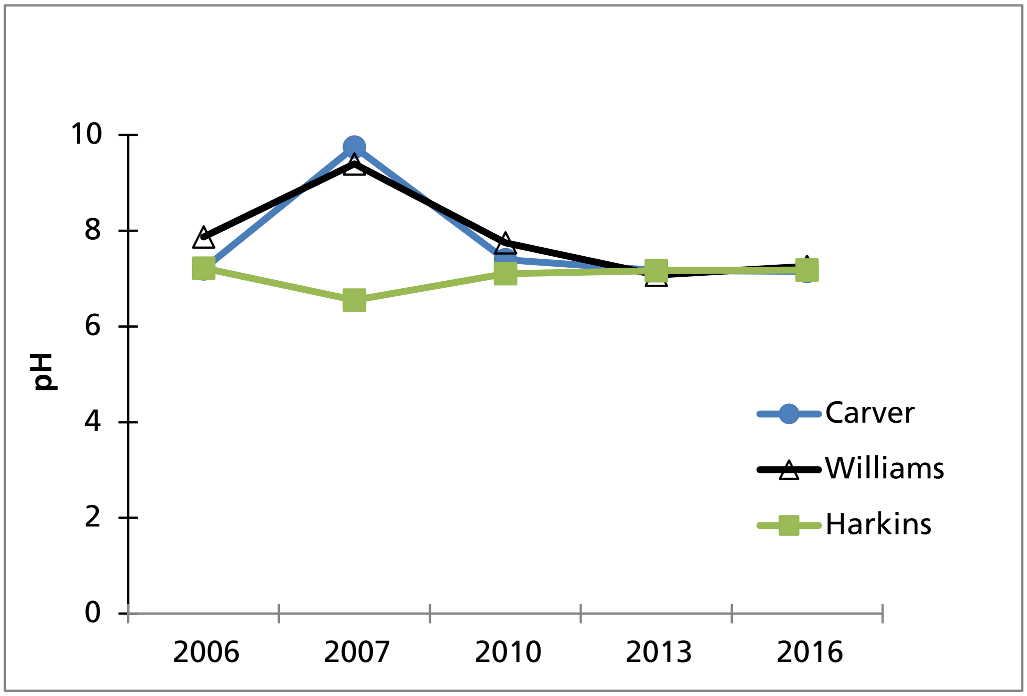

Figure 12. Average pH for streams sampled at George Washington Carver NM.

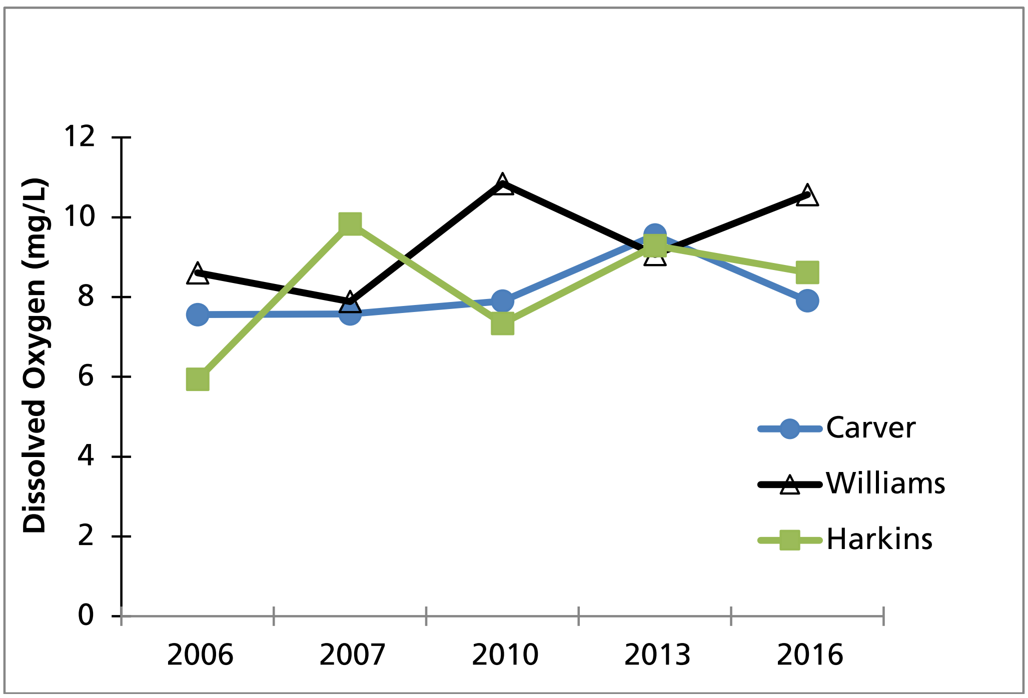

Figure 13. Average dissolved oxygen for streams sampled at George Washington Carver NM.

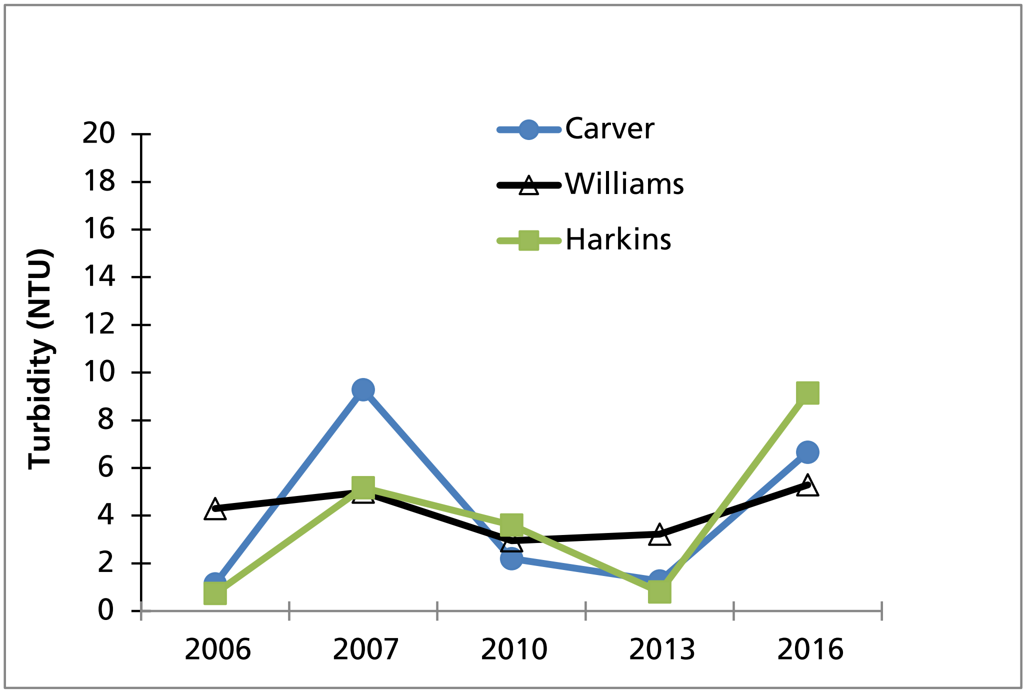

Figure 14. Average turbidity for streams sampled at George Washington Carver NM.

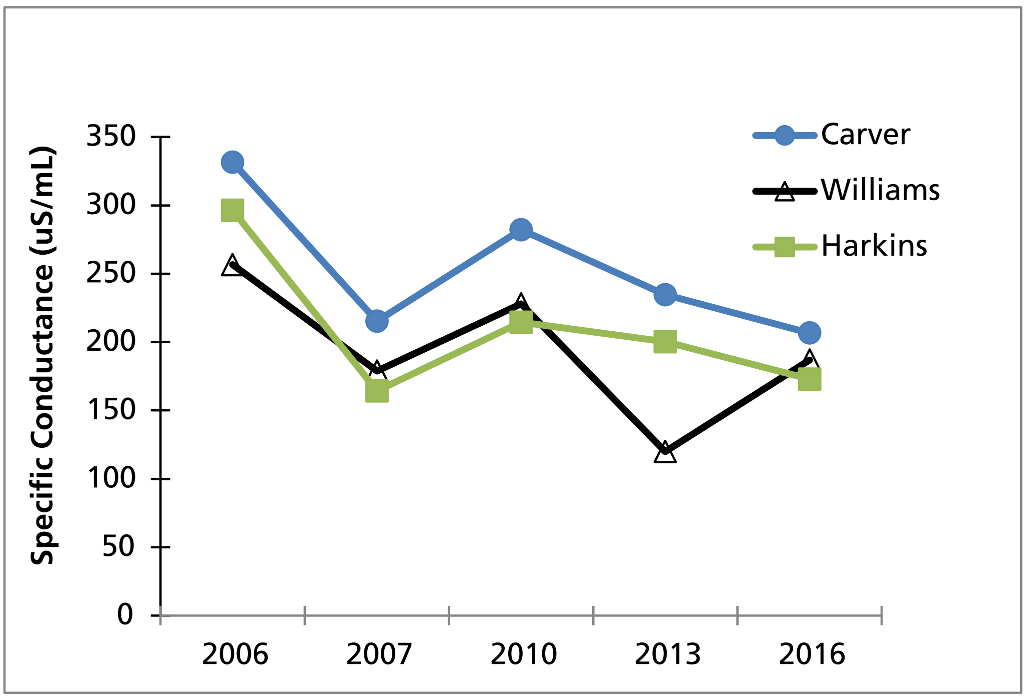

Figure 15. Average specific conductance for streams sampled at George Washington Carver NM.

Discussion

Fish communities within the small wadeable streams of George Washington Carver NM are moderately to highly diverse as evidenced by the numerous species present and the abundance of those species.

The temporal variability in species richness at Williams Branch was due to the collection of larger bodied species (White sucker [*Catostomus commersonii*], Green sunfish, and Bluegill) in 2016 that were not collected in previous years. In 2016, a beaver dam was present within our sample reach creating deeper and wider habitat, allowing for these larger fish to inhabit the stream. Although Williams Branch consisted of finer sediments and had lower species richness and fish abundance than the other streams, the high composition of sensitive darter, sculpin, and madtom species as well as good stream integrity ratings indicate this stream is in good condition. The low richness and abundance in Williams Branch and high composition of sensitive species is likely due to the small stream size, allowing mostly smaller bodied species such as darter, sculpins, and madtoms to inhabit this stream. Williams Branch begins at the outflow of Williams pond (a dammed spring) and lies completely inside the park boundary.

Although Harkins Branch typically had higher numbers of species and higher diversity than the other two streams, this stream typically had lower stream integrity (rated as poor or fair in three of the years sampled) due to the higher abundance of tolerant species and greater incidence of disease and anomalies. This stream showed greater bank instability and has very little of its length protected inside park boundaries (<500 m), which could lead to further bank erosion and sedimentation.

The number of species and stream integrity scores for Carver Branch fell between values of Williams Branch and Harkins Branch. Carver Branch, which was wider and deeper than the other streams, typically had higher fish abundance. The temporal variation in water quality parameters suggests that annual differences in environmental conditions (rain, air temperature, etc.) likely influence water quality in these streams. The lower temporal variability in temperature and dissolved oxygen at Carver Branch could be due to the influence of a spring upstream of the sample reach.

In general, streams at George Washington Carver NM provide good water quality and physical habitat to sustain a diverse native fish community, and provide some protection for the Arkansas darter, a species of conservation concern in Missouri.

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