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Aquatic Macroinvertebrate and Physical Habitat Monitoring for the Mancos River in Mesa Verde National Park

2009 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2011/288

ON THE COVER
Mesa Verde National Park
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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.

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The corresponding author and project manager for this project is Stephen Monroe (stephen_monroe@nps.gov). Stacy Stumpf is the Water Resources Lead Technician for the project. Water Resources field crew for 2009 consisted of Kelly Lawrence and Clayton Bliss. SCPN staff provided support for the project.

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1 Introduction and background

The National Park Service Inventory and Monitoring Program was designed to determine the current status and monitor long-term trends in the condition of park natural resources, providing park managers with a strong scientific foundation for making decisions and working with other agencies and the public to protect park ecosystems. The Southern Colorado Plateau Network (SCPN) is monitoring aquatic macroinvertebrates as an overall indicator of aquatic ecosystem integrity (Thomas et al. 2006).

Little information is available describing the condition of Mancos River aquatic ecosystems in Mesa Verde National Park (MEVE), Colorado. T-Walk sampling in the early 2000s (Colyer 2005) and a functional assessment of the Mancos River (Stacey 2007) both suggested the river was in poor condition. In 2007 the SCPN implemented annual aquatic macroinvertebrate monitoring at two sites on the Mancos River in MEVE (Stumpf and Monroe 2009):

- *Mancos River at Gauge* (MEVEMAN01), identified in this report as MAN01, (see appendix A for list of locations, codes, and common names of monitoring sites), was first sampled in 2005 and 2006 by the U.S. Geological Survey (USGS) for a pilot study to develop and test aquatic macroinvertebrate monitoring protocols (Brasher et al. 2010). The site was co-located with a SCPN water quality monitoring site and a USGS streamflow gauging station (USGS 09370600 in fig. 1). The dominant riparian vegetation at MAN01 is cottonwood (*Populus* spp.), coyote willow (*Salix exigua*), and silver buffaloberry (*Shepherdia argentea*).
- *Mancos River above Downstream Park Boundary* (MEVEMAN02), identified in this report as MAN02, was sampled for the first time in 2007. The site was selected using Generalized Random-Tessellation Stratified design and is located on a large meander bend near the downstream park boundary. The vegetation community is composed primarily of coyote willow, juniper (*Juniperus monosperma*), rabbitbrush (*Chrysothamnus* spp.) and narrowleaf cottonwood (*Populus angustifolia*).

The primary purpose of this report is to (a) document the monitoring activities that occurred at MAN01 in 2009, (b) summarize data that were collected, and (c) where appropriate, place these data in the context of aquatic habitat, biological condition, and management actions within the park through time.

2 Methods

2.1 Field methods

The state of Colorado recommends collecting aquatic macroinvertebrate samples during baseflow conditions, which typically occur in late summer to fall for mountain streams, but does not provide a recommendation for xeric streams (Colorado Department of Public Health and Environment 2003). Xeric streams in Colorado that are above 1,500 m elevation are faunistically similar to mountain streams (Paul et al., 2005), and therefore should be sampled during the late summer/early fall.

On October 20, 2009, the SCPN water resources field crew collected aquatic macroinvertebrate samples and physical habitat data at one site—MAN01—on the Mancos River in MEVE. This site consists of a 150 m reach, divided into 11 transects spaced 15 meters apart (see fig. 2 for reach layout diagram). Due to inclement weather, we were only able to sample 6 of the 11 planned transects at MAN01 (see figure 2 for reach layout diagram) and were unable to collect any samples or data at

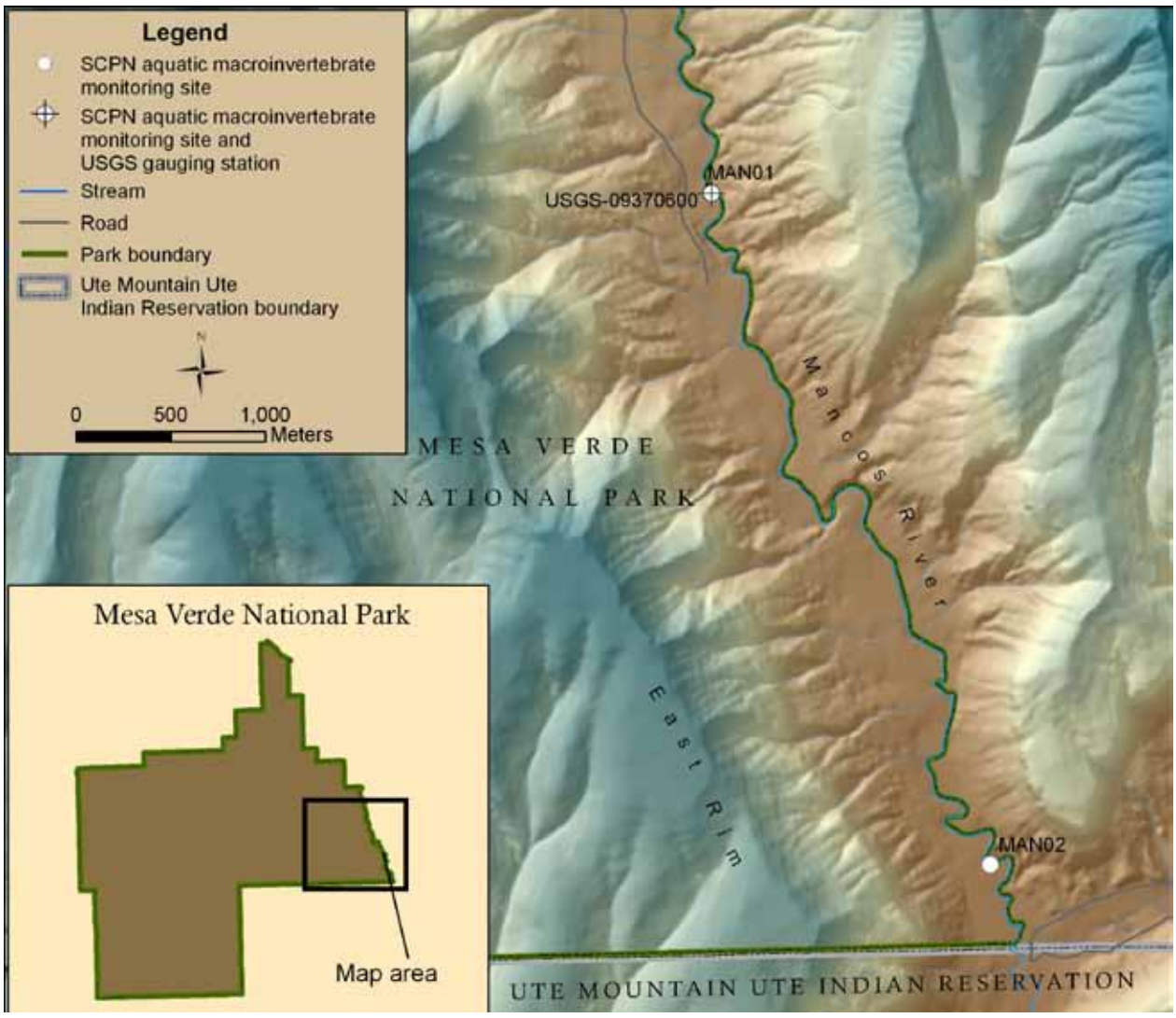


Figure 1. Map of Mancos River, Mesa Verde National Park, Colorado, with the location of two monitoring sites, MAN01 and MAN02 in 2009

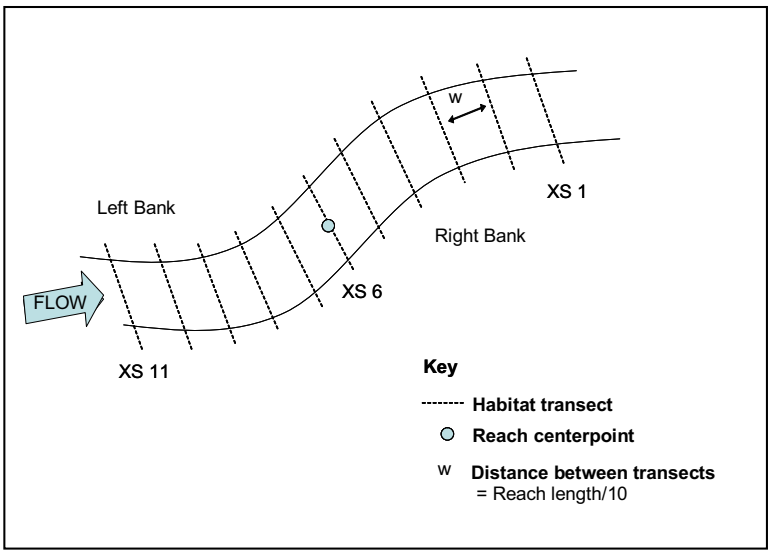


Figure 2. General aquatic macroinvertebrate sampling reach layout

MAN02. Transects where data was collected include T1, T3, T5, T7, T9, and T11. A detailed description of sampling methods can be found in Brasher et al. (in press).

We collected two types of aquatic macroinvertebrate samples at MAN01 in 2009. These were:

- Replicate quantitative samples from five targeted riffle habitats to provide estimates of abundances of organisms. We used a Slack sampler to collect a timed sample from a 0.25 m^2 area at each targeted riffle.
- A qualitative sample to develop a comprehensive list of species present at the site. A Slack Sampler was used to collect samples from all habitat types within the sampling reach. These samples were compiled into one composite sample. A list of the habitat types from which qualitative samples were collected can be found in section 3.2 of this report.

In addition to the quantitative and qualitative macroinvertebrate samples, we collected physical habitat data at three spatial scales: microhabitat, transect, and reach.

- For each of the targeted riffle microhabitats, we
  - measured depth
  - measured velocity
  - measured particle size
  - measured particle embeddedness
- For each of the 6 transects we
  - measured wetted and active channel widths
  - measured water depth, velocity, and canopy closure at multiple points along each transect
  - measured geomorphic channel units (GCU) at multiple points along each transect
  - observed and recorded the presence or absence, and types of macroinvertebrate habitats, represented by point data (5 points/transect) across the entire reach
- For the entire reach, we
  - identified and measured the length of GCUs (reach characterization data represents the proportion of the reach characterized by that particular GCU)
  - conducted a zig-zag pebble count measuring the size of a minimum of 400 randomly-selected particles using a modified Wolman pebble count across the length of the entire reach
  - identified the dominant vegetation and land cover
  - recorded descriptions of flow conditions
  - measured stream discharge
  - recorded weather conditions
  - observed and recorded evidence of anthropogenic or natural disturbances
  - measured NPS core water quality parameters of temperature, specific conductivity, pH, dissolved oxygen, and turbidity

2.2 Laboratory methods

Macroinvertebrate samples were sent to be sorted and identified at the Utah State University National Aquatic Monitoring Center's Bug Lab, a Bureau of Land Management laboratory based in Logan, Utah. There, samples were sorted under a dissecting scope at 10× magnification, and a 500-organism,

fixed-count method was used for subsampling large samples. Ten percent of the sorted samples were re-sorted for quality assurance.

A taxonomist, certified by the North American Benthological Society, identified all aquatic macroinvertebrates to the family or genus level. Ten percent of the identified samples were re-identified by a second certified taxonomist to ensure data quality.

Quantitative and qualitative macroinvertebrate samples will be maintained by the contract aquatic laboratory for at least five years to allow for repeat subsampling should any data questions arise. For a more detailed description of laboratory methods see Brasher et al. (in press).

2.3 Data analysis

For this report, we summarized aquatic macroinvertebrate data in terms of community structure and function. Genera were classified into functional feeding guilds using the classifications presented in Barbour et al. (1999). If functional class information was not available for a particular genus, we applied a more generalized, family-level classification.

We selected aquatic macroinvertebrate metrics that are generally considered to be sensitive, reliable indicators of water quality and/or stream health (see appendix B for a table of metrics and their definitions). Most of these metrics have been used to detect changes in water quality and habitat conditions in other streams in the Southern Rocky Mountains ecoregion (Griffith et al. 2005). They also enable a comprehensive assessment of multiple aspects of community structure because they represent a range of ecological characteristics. SCPN will periodically evaluate the interpretive value of the listed metrics and may drop or add additional metrics based upon these evaluations.

3 Results

3.1 Aquatic macroinvertebrate community data

Tables 1 and 2 present qualitative and quantitative data describing aquatic macroinvertebrate communities from samples collected at MAN01 during 2007, 2008, and 2009 (we were unable to collect data or samples from MAN02 due to inclement weather) . For all tables and figures included in this section, monitoring site results are presented in left to right order corresponding to upstream to downstream positioning along the stream. Figures presented in this section refer to data collected from quantitative samples, unless otherwise noted. Appendix C lists all aquatic macroinvertebrate species detected at the site, from both quantitative and qualitative methods.

Abundance. Overall mean abundance for quantitative targeted riffle samples taken from MAN01 averaged 254.6 individuals. Riffle abundances ranged from a low of 67 individuals to a high of 538 (fig. 3).

Taxa richness. Taxa richness for quantitative targeted riffle samples averaged 14.6 taxa. Richness values ranged from a low of 12 taxa to a low of 20 taxa. Taxa richness for the qualitative multi-habitat sample was much higher, at 27 taxa (fig. 4).

Diversity. We calculated taxonomic and functional diversity using the Simpson's Diversity Index. Taxonomic diversity measured 0.64 and functional diversity measured 0.53 (figs. 5a, 5b).

Tolerant taxa. Relative abundance of aquatic macroinvertebrate tolerance classes was greatest for intolerant individuals, which comprised 64.7% of the individuals collected. Moderately tolerant individuals made up 35.3%, but no tolerant individuals were collected (fig. 6a). Taxa richness of

Table 1. Qualitative metrics for aquatic macroinvertebrate samples collected from MAN01 and MAN02 at the Mancos River in Mesa Verde National Park, 2007–2009. Richness-based metrics are expressed as the percentage of taxa in a given order, tolerance or functional feeding group.

	MAN01			MAN02		
Qualitative metric	**2007**	**2008**	**2009**	**2007**	**2008**	**2009**[a]
Taxa richness	19.00	22.00	27.00	10.00	20.00	n.d.
Tolerance group						
Richness of tolerant taxa (%)	16.67	15.00	16.00	11.11	11.11	n.d.
Richness of moderately tolerant taxa (%)	44.44	50.00	52.00	55.56	44.44	n.d.
Richness of intolerant taxa (%)	38.89	35.00	32.00	33.33	44.44	n.d.
Functional group						
Richness of collector-filterers (%)	16.67	19.05	14.81	20.00	15.79	n.d.
Richness of collector-gatherers (%)	50.00	38.10	37.04	50.00	36.84	n.d.
Richness of scrapers (%)	0.00	9.52	7.41	0.00	5.26	n.d.
Richness of shredders (%)	0.00	9.52	7.41	0.00	5.26	n.d.
Richness of predators (%)	33.33	23.81	33.33	30.00	36.84	n.d.
Taxonomic group						
Number of EPT taxa	7.00	7.00	9.00	4.00	6.00	n.d.
Richness of EPT taxa (%)	36.84	31.82	33.33	40.00	30.00	n.d.
Richness of Ephemeroptera (%)	21.05	18.18	11.11	30.00	15.00	n.d.
Richness of Plecoptera (%)	0.00	4.55	11.11	0.00	5.00	n.d.
Richness of Trichoptera (%)	15.79	9.09	11.11	10.00	10.00	n.d.
Richness of noninsect taxa (%)	26.32[b]	31.82[b]	22.22	30.00[b]	15.00	n.d.
Richness of Chironomid Diptera (%)	10.53	13.64	11.11	10.00	15.00	n.d.
Richness of non-Chironomid Diptera (%)	21.05	13.64	25.93	20.00	15.00	n.d.
Richness of Coleoptera (%)	0.00	9.10	3.70	0.00	15.00	n.d.
Richness of Odonata (%)	5.26	0.00	3.70	0.00	10.00	n.d.

[a]No data was collected in MAN02 during 2009.

[b]Pre-2009 reports labeled the "noninsect" category as "Other". The "Other" category was less inclusive of species, resulting in a different richness count.

Table 2. Quantitative metrics for aquatic macroinvertebrate samples collected from MAN01 and MAN02 at the Mancos River in Mesa Verde National Park, 2007–2009. For a given order, tolerance or functional feeding group, abundance-based metrics are expressed as the percentage of individuals in the group, while richness-based metrics are expressed as the percentage of taxa in the group.

	MAN01						MAN02					
	2007		2008		2009		2007		2008		2009[a]	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Total abundance	31.20	18.66	145.00	68.52	254.60	179.83	74.00	20.48	106.40	118.73	n.d.	
Total richness	5.20	0.84	8.80	2.77	14.60	3.13	6.60	1.34	8.20	3.03	n.d.	
Simpson's Diversity—taxonomic	0.66	0.06	0.51	0.16	0.64	0.12	0.60	0.06	0.63	0.12	n.d.	
Simpson's Diversity—functional group	0.38	0.07	0.36	0.11	0.53	0.08	0.50	0.40	0.48	0.13	n.d.	
Dominant taxa	55.83	4.41	67.89	12.07	53.65	13.56	56.79	6.00	56.03	13.19	n.d.	
Tolerance group												
Relative abundance of tolerant taxa (%)	0.00	0.00	0.27	0.60	0.00	0.00	0.25	0.56	0.00	0.00	n.d.	
Relative abundance of moderately tolerant taxa (%)	75.79	9.88	26.47	9.81	35.34	9.51	82.43	9.77	50.00	20.42	n.d.	
Relative abundance of intolerant taxa (%)	24.21	9.88	73.26	9.95	64.66	9.51	17.32	9.87	50.00	20.42	n.d.	
Richness of tolerant taxa (%)	0.00	0.00	3.33	7.45	0.00	0.00	2.86	6.39	0.00	0.00	n.d.	
Richness of moderately tolerant taxa (%)	55.33	19.27	58.73	9.83	58.09	7.21	53.00	13.98	50.59	5.02	n.d.	
Richness of intolerant taxa (%)	44.67	19.27	37.94	8.92	41.91	7.21	44.14	12.80	49.41	5.02	n.d.	
Functional group												
Relative abundance of collector-filterers (%)	27.61	25.19	76.88	8.45	56.35	12.99	32.95	7.82	49.46	28.85	n.d.	
Relative abundance of collector-gatherers (%)	68.47	22.86	19.03	7.82	35.93	12.78	61.92	6.65	40.82	26.81	n.d.	
Relative abundance of scrapers (%)	0.00	0.00	0.24	0.36	0.04	0.08	0.45	1.02	0.80	1.40	n.d.	
Relative abundance of shredders (%)	0.00	0.00	0.18	0.41	0.85	0.59	0.00	0.00	0.93	1.46	n.d.	
Relative abundance of predators (%)	3.93	4.27	3.65	0.93	6.83	1.31	4.68	1.86	7.98	3.07	n.d.	
Richness of collector-filterers (%)	31.33	12.38	33.35	7.49	16.66	3.72	31.33	6.39	31.36	13.41	n.d.	
Richness of collector-gatherers (%)	57.33	7.23	36.41	9.92	30.71	8.10	39.67	6.25	33.24	8.28	n.d.	
Richness of scrapers (%)	0.00	0.00	3.54	4.91	1.00	2.24	2.50	5.59	4.86	6.82	n.d.	
Richness of shredders (%)	0.00	0.00	2.50	5.59	5.63	3.39	0.00	0.00	4.17	5.89	n.d.	
Richness of predators (%)	11.33	10.43	24.20	5.86	45.99	8.37	26.50	8.79	26.38	4.94	n.d.	
Taxonomic group												
Number of EPT taxa	3.00	0.71	4.40	0.89	5.60	0.55	3.40	0.89	4.80	1.64	n.d.	

Table 2 *(cont'd.)*

	MAN01						MAN02					
	2007		2008		2009		2007		2008		2009[a]	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Taxonomic group (*cont'd.*)												
Relative abundance of EPT taxa (%)	73.51	16.87	89.52	3.86	62.88	13.64	73.37	12.52	88.81	3.28	n.d.	
Relative abundance of Ephemeroptera (%)	59.43	18.82	12.76	6.57	5.72	2.60	59.04	8.10	38.99	26.53	n.d.	
Relative abundance of Plecoptera (%)	0.00	0.00	2.48	2.10	3.04	0.62	3.00	1.58	5.23	4.58	n.d.	
Relative abundance of Trichoptera (%)	14.08	4.69	74.77	8.82	54.12	14.17	11.33	7.95	44.60	28.79	n.d.	
Relative abundance of noninsect taxa (%)	3.93	4.27	1.23	0.95	11.21	10.13	1.43	0.90	1.40	2.32	n.d.	
Relative abundance of Chironomid Diptera (%)	9.04	7.44	6.53	2.99	19.41	5.20	3.13	2.57	1.98	1.82	n.d.	
Relative abundance of non-Chironomid Diptera (%)	13.53	22.31	2.37	1.46	6.39	2.27	21.62	12.31	6.16	4.80	n.d.	
Relative abundance of Coleoptera (%)	0.00	0.00	0.27	0.41	0.11	0.25	0.45	1.02	1.58	1.65	n.d.	
Relative abundance of Odonata (%)	0.00	0.00	0.09	0.20	0.00	0.00	0.00	0.00	0.07	0.15	n.d.	

[a]No data was collected in MAN02 during 2009.

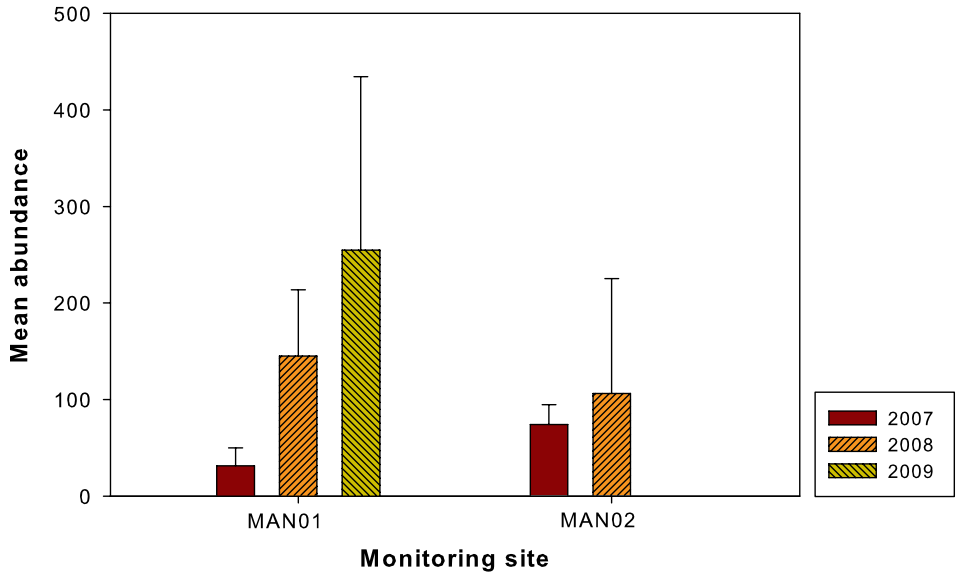


Figure 3. Total abundance expressed as the mean number of individuals per sample collected from MAN01 and MAN02 at the Mancos River in MEVE , 2007–2009

Figure 4. Mean taxa richness in qualitative multihabitat and quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2009

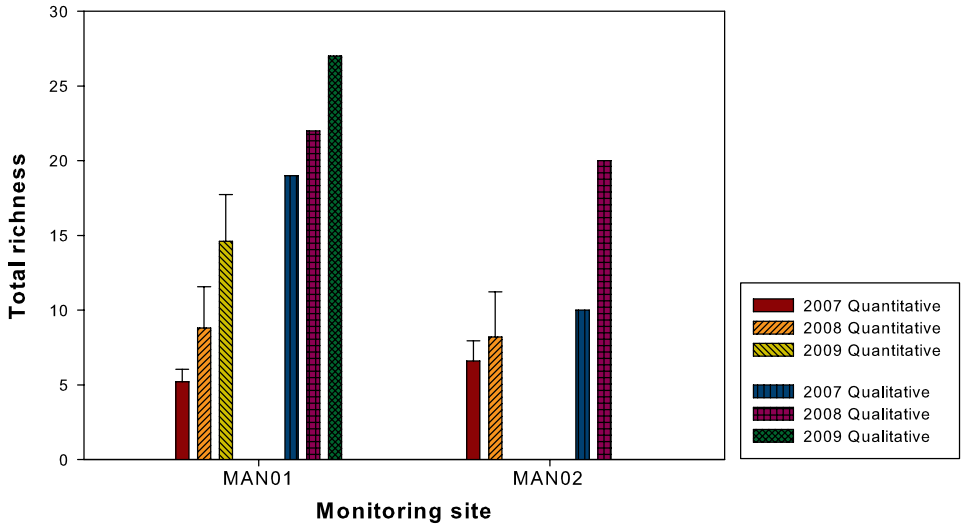


Figure 5a. Simpson's Diversity Index for taxonomic diversity in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2009. Values expressed are means of all samples collected from each monitoring site.

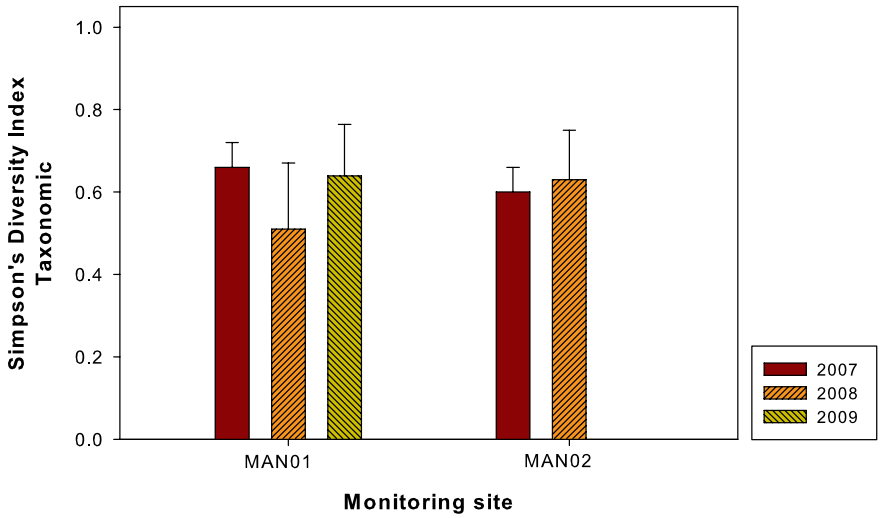
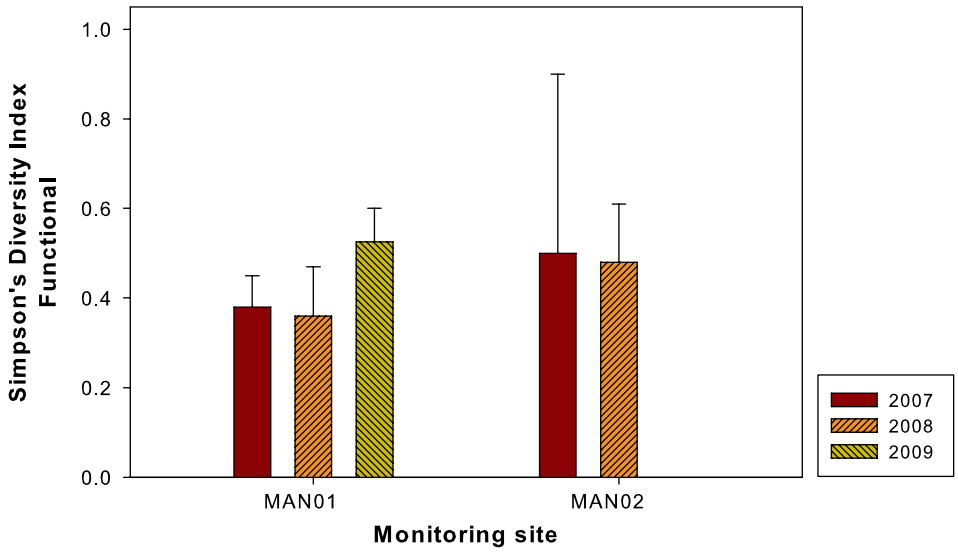


Figure 5b. Simpson's Diversity Index for functional diversity in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2009. Values expressed are means of all samples collected from each site.



tolerance classes was greatest for the moderately tolerant taxa, which represented 58.1% of the taxa collected. Intolerant taxa included 41.9% of the taxa collected (fig. 6b).

EPT taxa. Relative abundance of EPT (orders Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) individuals was greatest for order Trichoptera, which comprised 54.1% of the individuals collected from our samples. Ephemeroptera made up 5.7% of the individuals collected and Plecoptera made up 3.0% of the individuals collected from our samples (fig. 7).

Aquatic macroinvertebrate orders. Trichoptera was the most abundant of all orders collected. Dipterans belonging to the family Chironomidae were the second most abundant order at 19.4%. Taxa belonging to the category "noninsect" (worms, water mites, scuds, crayfish, and peaclams) made up 11.2% of the individuals collected. Coleoptera (beetles) made up <1% of the individuals collected, and no Odonates (dragonflies/damselflies) were collected (fig. 8).

Functional feeding groups. Collector-filterers was the most abundant functional group in the samples, with individuals of that group making up 56.4%. Collector-gatherers made up 35.9% of the

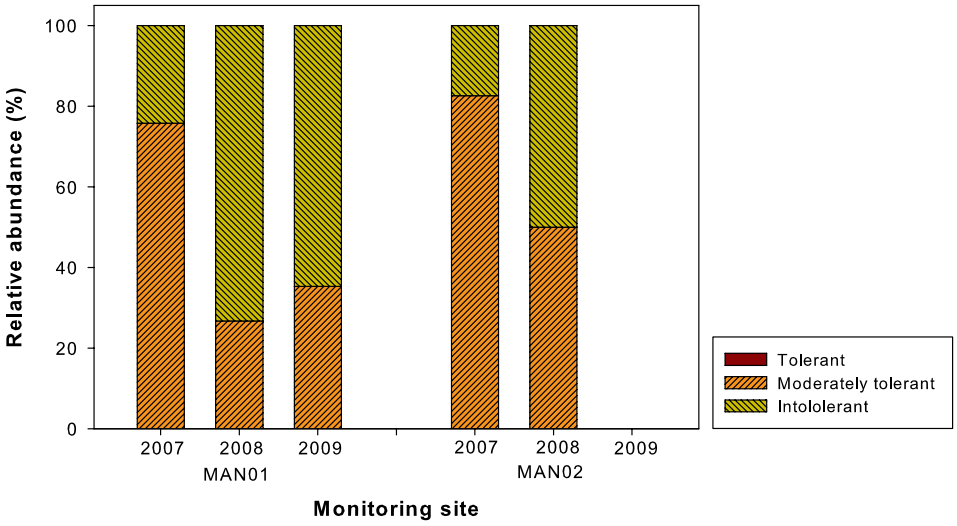


Figure 6a. Mean relative abundance of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2009, based on their tolerance to perturbation

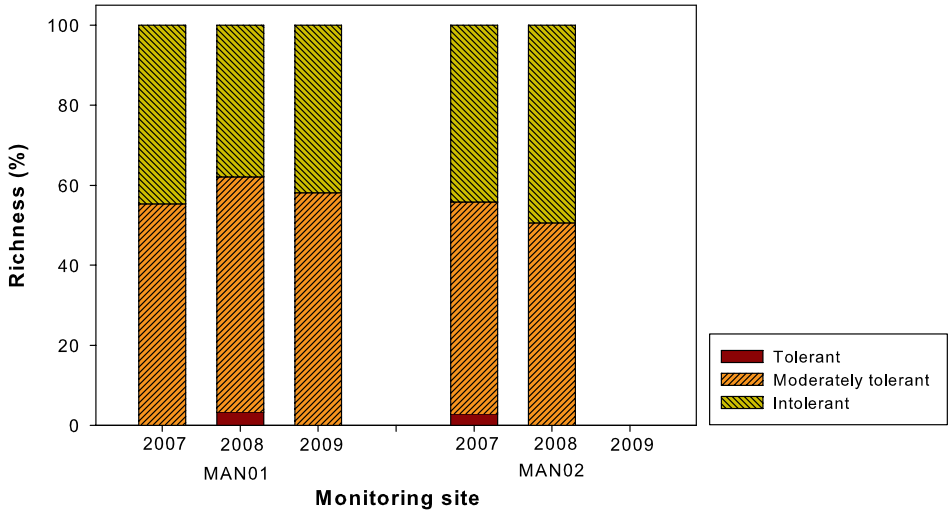


Figure 6b. Mean richness of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2009, based on their tolerance to perturbation

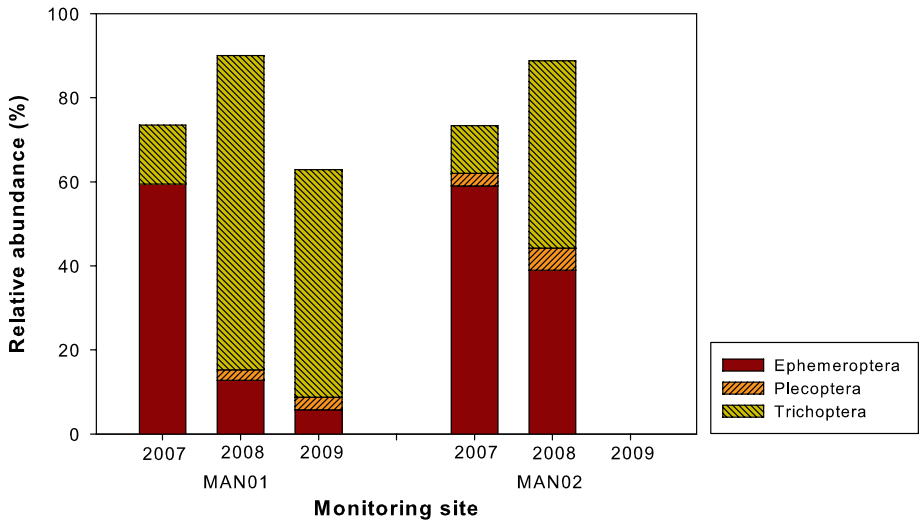


Figure 7. Relative abundance of sensitive EPT orders in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2009

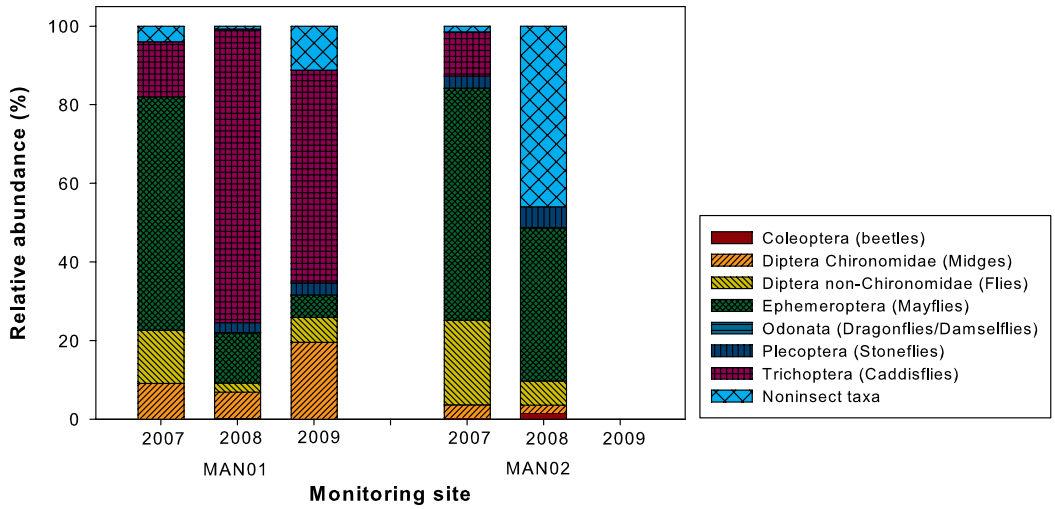


Figure 8. Relative abundance of individuals by taxonomic order in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2009

total number of individuals collected and predators were 6.8%. Scrapers and shredders both made up <1% of the individuals collected (fig. 9).

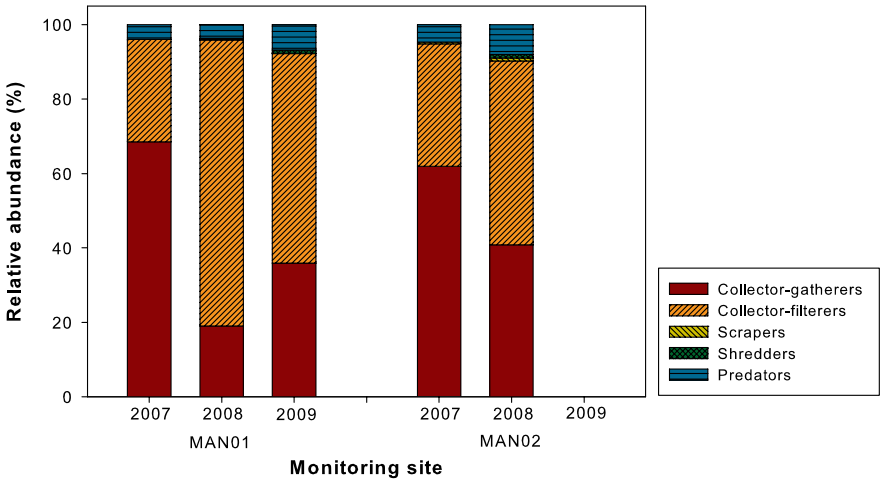


Figure 9. Relative abundance of functional feeding groups in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2009

3.2 Physical habitat characteristics

Physical habitat data collected at MAN01 from 2007–2009, and MAN02 in 2007 and 2008 are presented in Table 3, and additional transect and microhabitat data can be found in Appendix D. Macroinvertebrate habitat was described from point data collected along all transects (5 points/transect). Geomorphic channel units (GCU) are described as the proportion of the reach characterized by a particular GCU. Particle size distribution data are presented as the proportion of particles counted across the entire reach.

Microhabitat. Velocity at our quantitative targeted riffle sample locations averaged 0.55 m/s. The average depth at each riffle was 0.11 m. Of the particles measured at riffle habitat, 96.0% belonged to the fine gravel size class (2–16 mm). The remaining 4% belonged to the coarse gravel size class (16–64 mm). The average embeddedness for all those particles was 28.3% (table 3).

Transect. Velocity along our habitat transects was slightly lower than at our riffles, averaging 0.41 m/s. Average depth across our transects was slightly greater than in the targeted riffle areas—averaging 0.13 m. Wetted and active channel widths averaged 6.3 and 10.0 meters, respectively. Riparian canopy closure averaged 4.8% at our monitoring site (table 3).

Aquatic macroinvertebrate habitat was dominated by rocky substrate, which made up 92.9% of the site sampled. The remaining 7.1% of the site lacked aquatic macroinvertebrate habitat that fit into one of the specific habitat types (fig. 10).

Reach. Riffles were the dominant geomorphic channel units at MAN01, making up 63.4% of the reach. Glides were the next most abundant, making up 19.9% of the reach (fig. 11).

Coarse gravels (16–64 mm) and cobble (64–256 mm) were dominant in the MAN01 sampling reach, making up 63.2%. Fines (<2 mm) made up 15.1% of the reach and large boulders and bedrock (>256 mm) made up 8.5% (fig. 12).

NPS water quality core parameters are reported as values recorded at or near midday of the sampling event. Temperature was 8.9°C. Specific conductivity measured 1514 µS/cm. The pH was 8.4. Dissolved oxygen measured 91.3% saturation and 8.2 mg/L. The average turbidity for the site was 16.7 NTU (table 3).

Table 3. Physical habitat characteristics from MAN01 and MAN02 at the Mancos River in Mesa Verde National Park, Colorado, 2007–2009. Particle embeddedness and canopy closure measurements are expressed as percentages.

	MAN01						MAN02					
	2007		2008		2009		2007		2008		2009[a]	
Physical habitat metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Microhabitat												
Riffles												
Velocity (m/s)	0.69	0.27	0.63	0.13	0.55	0.36	0.91	0.20	0.39	0.12	n.d.	
Depth (m)	0.18	0.07	0.13	0.04	0.11	0.05	0.15	0.05	0.06	0.01	n.d.	
Embeddedness (%)	19.20	9.04	31.60	5.64	26.28	12.74	28.00	12.88	27.60	8.50	n.d.	
Transect												
Channel dimensions												
Velocity (m/s)	0.68	0.23	0.50	0.23	0.41	0.10	0.63	0.19	0.45	0.19	n.d.	
Depth (m)	0.30	0.10	0.30	0.15	0.13	0.05	0.31	0.10	0.25	0.07	n.d.	
Wetted channel width (m)	5.71	2.11	5.56	1.82	6.25	1.15	6.37	2.35	5.41	0.93	n.d.	
Active channel width (m)	7.49	2.16	9.36	3.32	9.98	3.05	10.28	4.19	9.98	2.57	n.d.	
Riparian cover												
Canopy closure (%)	9.05[b]	12.88[b]	19.33[b]	25.81[b]	4.83	6.87	10.05[b]	18.68[b]	22.98[b]	33.42[b]	n.d.	
Reach												
Water quality[c]	**Value**		**Value**		**Value**		**Value**		**Value**		**Value**	
Temperature (°C)	10.8		17.5		8.9		11.2		16.9		n.d.	
Specific conductivity (µS/cm)	n.d.[a]		945		1514		n.d.[a]		993		n.d.	
pH	n.d.[a]		8.5		8.4		n.d.[a]		8.5		n.d.	
Dissolved oxygen (% saturation)	n.d.[a]		106.0		91.3		n.d.[a]		104.9		n.d.	
Dissolved oxygen (mg/L)	n.d.[a]		10.1		8.2		n.d.[a]		10.2		n.d.	
Turbidity (NTU)	n.d.[a]		12.24		16.70		n.d.[a]		16.34		n.d.	
Discharge (cfs)	46.0		19.0		10.0[d]		41.0		19.0		n.d.	

Note: See Appendix B for detailed description of metrics in this table.

[a]Data was not collected.

[b]Riparian canopy closure was recalculated in 2009 for 2007 and 2008 data, resulting in different values in this 2009 report than shown in the reports for those earlier years.

[c]One water quality measurement only is reported for the site, based on the sampling event closest to 12:00 noon on the sampling day.

[d]Mean daily discharge based on gauging station results—note that this represents a different collection method than earlier years.

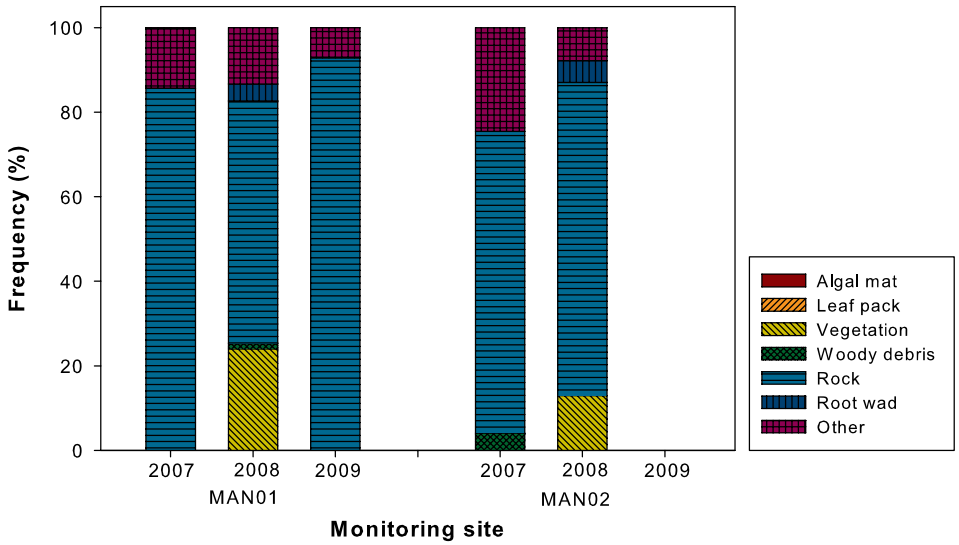


Figure 10. Macroinvertebrate habitat characterization based upon line point intercept data collected from habitat transects at MAN01 and MAN02 in the Mancos River, MEVE, 2007–2009. Some habitat structure types were not observed.

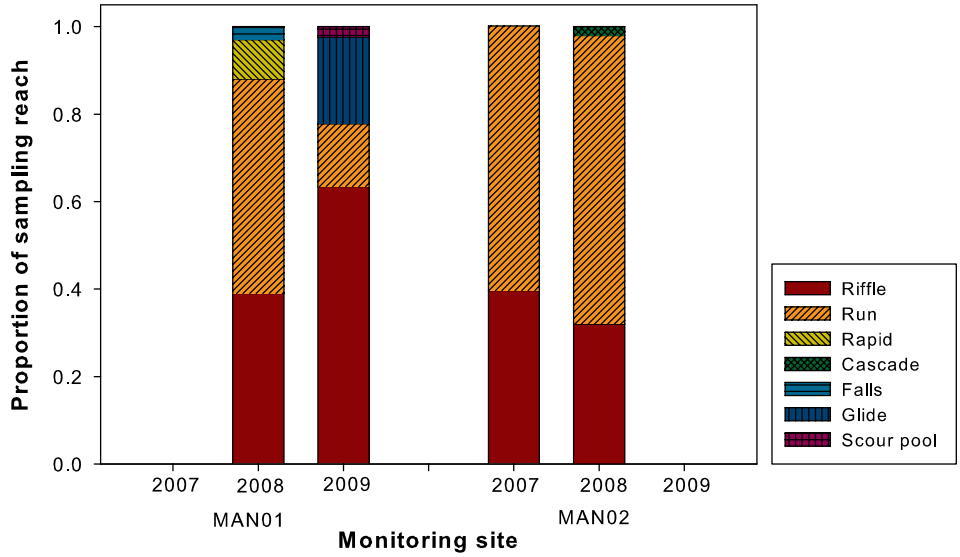


Figure 11. Geomorphic channel unit characterization of MAN01 and MAN02 at the Mancos River in MEVE, 2007–2009

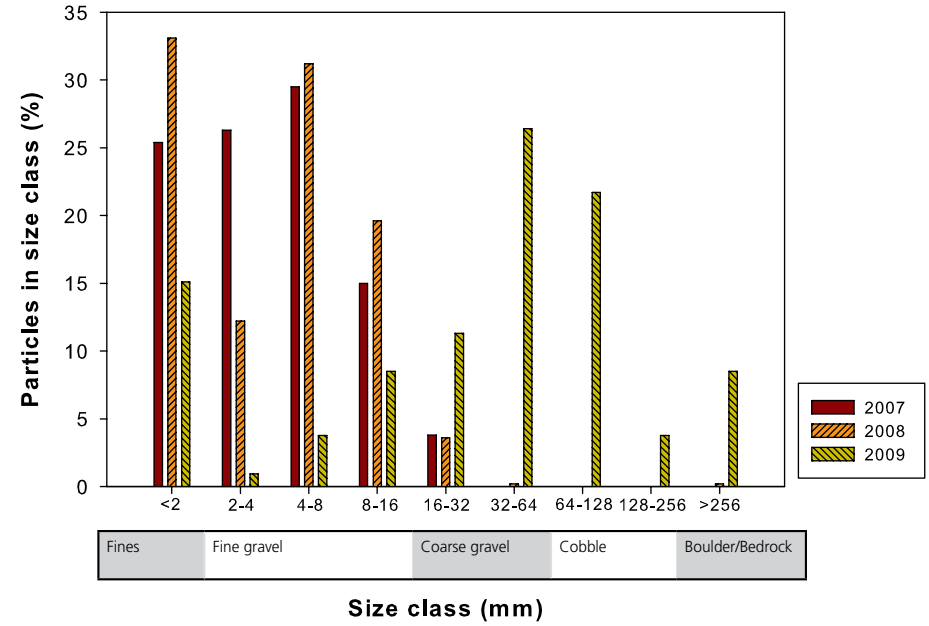


Figure 12. Particle size distribution, based on modified Wolman pebble counts from MAN01 at the Mancos River in MEVE, 2007–2009. Differences between 2009 data and other years may be attributed to a change in methodology in 2009.

3.3 Antecedent conditions

The USGS has collected streamflow data at the gauging station *Mancos River at Anitas Flat*, Mesa Verde National Park, CO (09370600) (USGS 2009). Daily discharge for the MAN01 monitoring site appears to be greatest at the time of spring snow melts from April through May. An additional spike of higher discharge occurs in late June. Discharge appears to be near baseflow for much of the typical monsoon season from July to September. Discharge for our sampling date was 10.0 cfs (fig. 13).

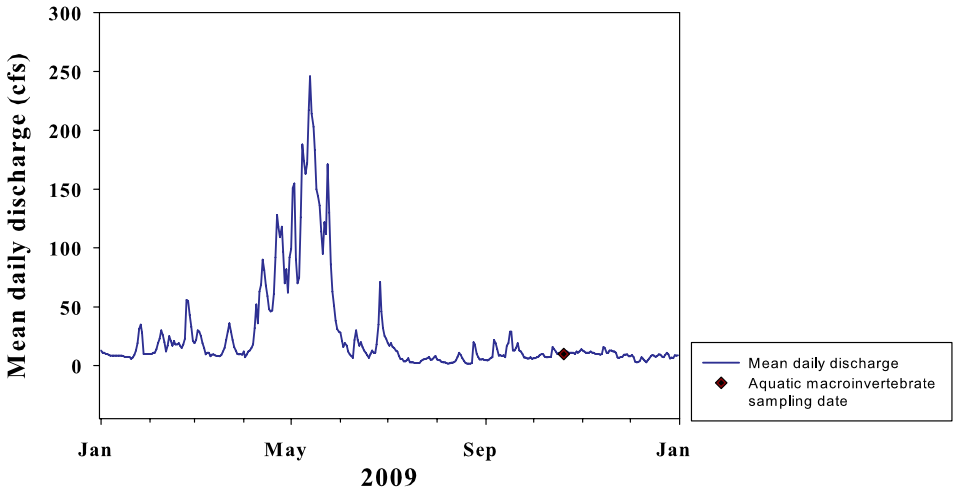


Figure 13. Hydrograph from the streamflow gauging station *Mancos River at Anitas Flat*, Mesa Verde National Park, CO (09370600) showing mean daily discharge for 2009

The Western Regional Climate Center has collected climate data both at the town of Mancos, Colorado, approximately 12.5 km upstream of the gauging station along the Mancos River, and at Mesa Verde National Park headquarters, approximately 14 km southeast of the gauging station on an escarpment above the river (Western Regional Climate Center 2009). The data presented below are from climate station 055327 located in the town of Mancos, CO. Period of record for climate data is 1898–2009. Average precipitation in 2009 was below average for all months except May, June, and December (fig. 14). Precipitation in June was 4 cm greater than the historic average for that month.

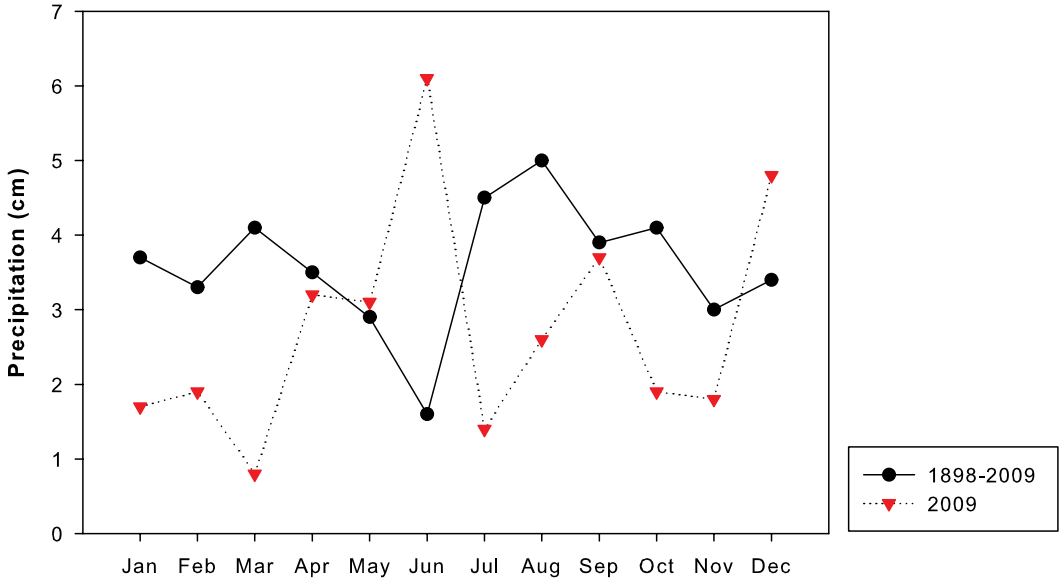


Figure 14. Mean monthly precipitation (cm) for Mancos, Colorado in 2009, and from 1898-2009 (WRCC 2009).

Air and water temperatures at our monitoring site were taken at 15 minute intervals for the entirety of our sampling window. These temperatures are shown in Figure 15. The average air temperature at our monitoring site was 9.5°C. Air temperatures ranged from a low of -12.4°C, recorded at 0615 hours on November 16, to a high of 36.8°C, recorded at 1615 on August 20. The average water temperature was 10.9°C. The minimum water temperature of 0.0°C was recorded at 0100 on November 16. The maximum was 26.5°C, recorded at 1430 on August 22.

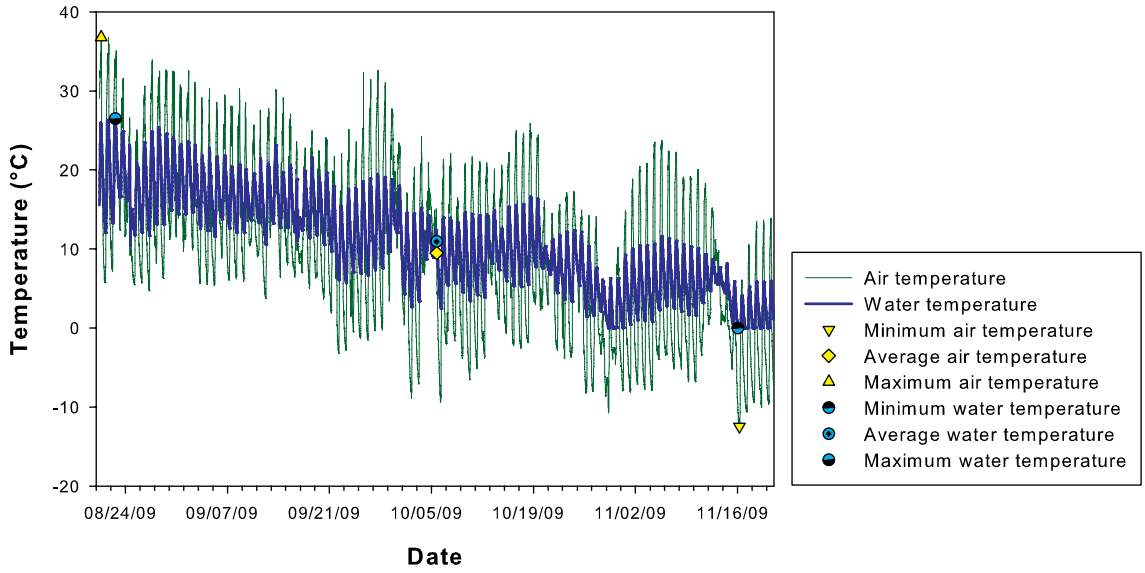


Figure 15. Air and water temperatures recorded at 15 minute intervals at the MAN01 monitoring site for the index period described by the state of Colorado

4 Discussion

This report presents data from SCPN's third year of monitoring aquatic macroinvertebrates and physical habitat at the Mancos River in Mesa Verde National Park, Colorado. We stress that any differences between sampling years and locations should not be interpreted as ecologically significant trends, as trends cannot be determined from three years of sampling data. Differences can be attributed to multiple factors, including ecological variability, sampling error, or observer bias. SCPN attempts to minimize sampling error and observer bias by thoroughly training crew members in the proper field techniques prior to each sampling season.

4.1 Aquatic macroinvertebrate communities

Mean total abundance of aquatic macroinvertebrates found in targeted riffle samples was greater than for any other year to date and increased by an average of 110 individuals over 2008 (fig. 3). Similarly, total richness values for quantitative and qualitative samples were higher than any previous sampling year (fig. 4).

4.2 Ecologically sensitive taxa

Ecological tolerance describes how well a taxon tolerates disturbance. For aquatic macroinvertebrate taxa, ecological tolerance relates to their ability to withstand pollution or environmental degradation in their environment. Taxa that are considered to be intolerant are expected to decline quickly as water quality degrades. Conversely, tolerant taxa would be expected to persist during times of degraded

water quality. In 2008 we found no tolerant taxa at MAN01, and relative abundances of moderately tolerant and intolerant taxa were evenly split among our samples. In 2009 we again found no tolerant taxa. Moderately tolerant taxa decreased by nearly 30%, and intolerant taxa increased by a nearly identical percentage (fig. 6a).

4.3 Physical habitat diversity

Riffle habitat was the only aquatic macroinvertebrate habitat type found in the MAN01 monitoring site in 2009. Vegetation, woody debris, and root wads, all of which were sampled previously, were not found this year.

4.4 Factors affecting our results

Our initial site visit occurred on October 12, 2009, and we had intended to sample the following day. On the night of the 12th, heavy to moderate downpours occurred for much of the night. The following day when we went to scope out the MAN02 site we noted that the stream was above base flow. Our sampling protocols prevent us from sampling under such conditions (Brasher et al., in press). Additionally we noted that the stream had undergone a change in stream color that we had not witnessed during previous sampling events at the Mancos River. During past sampling events, the stream color had been consistently gray. During our visit in 2009, the stream color ranged from dark yellow, and brown to black. We were unable to sample from the Mancos for another 7 days because of the rise in flow. We will look into the disturbance event and how it may have affected the 2009 data when we conduct a trend report in the coming years.

The data in this report should be viewed as a snapshot of conditions existing within the aquatic community at the time of our visit. Data and analyses within this report are provisional and subject to change. When sufficient data are available, SCPN plans to produce an interpretive report including trend analysis of macroinvertebrate metrics and physical habitat data for the Mancos River.

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Appendix A Monitoring sites at Mesa Verde National Park, Colorado, 2009

Site Code	Common name	Report name	UTM X	UTM Y	Elevation (m)
MEVEMAN01	Mancos River At Gauge	MAN01	734371.590279	4125939.018488	1933
MEVEMAN02	Mancos River above down-stream boundary	MAN02	735878.046499	4122566.754976	1882

Appendix B Selected aquatic macroinvertebrate metrics

Metric type	Metric	Definition
Abundance	Total abundance	Total number of individuals.
Richness	Taxa richness	Total number of taxa (measures the overall diversity of macroinvertebrates in a sample).
Diversity	Simpson's diversity	A measure of the variety of taxa that takes into account the relative abundance of each taxon. $DS = 1-[(\sum n(n-1))/(N(N-1))]$
Tolerance	Dominant taxa	Measures the dominance of the most abundant taxa. Typically calculated as dominant 2, 3, 4, or 5 taxa.
	Relative abundance for tolerant taxa	Percent of individuals considered to be tolerant to perturbation.
	Percent richness for tolerant taxa	Percent of taxa considered to be tolerant to perturbation.
Functional-feeding	Relative abundance collector-filterers	Percent of individuals that filter fine particulate organic matter from the water column.
	Percent richness collector-filterers	Percent of taxa that filter fine particulate matter from the water column.
	Relative abundance scrapers	Percent of individuals that scrape or graze upon periphyton.
Functional-habit	Relative abundance burrowers	Percent of individuals that move between substrate particles (typically finer substrates).
	Percent richness burrowers	Percent of taxa that move between substrate particles (typically finer substrates).
	Relative abundance clingers	Percent of individuals that have fixed retreats or adaptations for attachment to surfaces in flowing water.
	Percent richness clingers	Percent of taxa that have fixed retreats or adaptations for attachment to surfaces in flowing water.
Composition	Number of EPT taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies).
	Relative abundance EPT	Percent of individuals in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies).
	Relative abundance Ephemeroptera	Percent of individuals that are mayflies.
	Relative abundance Plecoptera	Percent of individuals that are stoneflies (for streams > 1,500 m in elevation).
	Relative abundance Trichoptera	Percent of individuals that are caddisflies.
	Relative abundance of Hydroptilidae or Hydropsychidae within Trichoptera	Percent of Trichopteran individuals belonging to Hydroptilidae or Hydropsychidae families (ratio of tolerant caddisfly abundance to total caddisfly abundance).
	Relative abundance non-insect taxa	Percent of individuals that are not insects.
	Relative abundance Chironomidae	Percent of individuals that are midges.

Source: Data from Brasher et al. (in press)

Appendix C Aquatic macroinvertebrate species list from the MAN01 monitoring site at Mesa Verde National Park, Colorado, 2009

Phylum	Class	Order	Family	SubFamily	Genus	Species	Common name
Annelida							segmented worms
Arthropoda	**Arachnida**	**Trombidi-formes**	**Sperchonidae**				water mites
Arthropoda	Arachnida	Trombidiformes	Sperchonidae		*Sperchon* sp.		water mites
Arthropoda	Arachnida						water mites
Arthropoda	Entognatha	Collembola					spring tails
Arthropoda	Insecta	Coleoptera	Elmidae		*Optioservus* sp.		riffle beetles
Arthropoda	**Insecta**	**Coleoptera**	**Elmidae**		***Zaitzevia* sp.**		riffle beetles
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae	*Probezzia* sp.		biting midges
Arthropoda	Insecta	Diptera	Ceratopogonidae				biting midges
Arthropoda	Insecta	Diptera	Chironomidae				non-biting midges
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae			non-biting midges
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae			non-biting midges
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae			non-biting midges
Arthropoda	Insecta	Diptera	Empididae				dance flies
Arthropoda	Insecta	Diptera	Empididae	Hemerodromiinae	*Chelifera* sp.		dance flies
Arthropoda	Insecta	Diptera	Empididae	Hemerodromiinae	*Hemerodromia* sp.		dance flies
Arthropoda	**Insecta**	**Diptera**	**Empididae**		***Neoplasta* sp.**		dance flies
Arthropoda	**Insecta**	**Diptera**	**Simuliidae**				black flies
Arthropoda	**Insecta**	**Diptera**	**Simuliidae**	**Simuliinae**	***Simulium* sp.**		black flies
Arthropoda	**Insecta**	**Diptera**	**Simuliidae**	**Simuliinae**	***Simulium***	***arcticum***	black flies
Arthropoda	**Insecta**	**Diptera**	**Stratiomyidae**		***Nemotelus* sp.**		soldier midges
Arthropoda	**Insecta**	**Diptera**	**Tipulidae**				crane flies
Arthropoda	**Insecta**	**Diptera**	**Tipulidae**		***Dicranota* sp.**		crane flies
Arthropoda	Insecta	Diptera	Tipulidae		*Hexatoma* sp.		crane flies
Arthropoda	Insecta	Diptera	Tipulidae	Limoniinae	*Limnophila* sp.		crane flies
Arthropoda	Insecta	Diptera	Tipulidae	Tipulinae	*Tipula* sp.		crane flies
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae		*Tricorythodes* sp.		mayflies
Arthropoda	Insecta	Ephemeroptera	Baetidae				small minnow mayflies
Arthropoda	Insecta	Ephemeroptera	Baetidae		*Baetis* sp.		small minnow mayflies

Appendix C (*cont'd.*)

Phylum	Class	Order	Family	SubFamily	Genus	Species	Common name
Arthropoda	Insecta	Ephemeroptera	Baetidae		*Fallceon*	*quilleri*	small minnow mayflies
Arthropoda	Insecta	Hemiptera	Veliidae				broad shouldered water striders
Arthropoda	Insecta	Odonata	Gomphidae				club tailed dragonflies
Arthropoda	Insecta	Plecoptera					stoneflies
Arthropoda	**Insecta**	**Plecoptera**	**Chloroperlidae**				green stoneflies
Arthropoda	**Insecta**	**Plecoptera**	**Perlodidae**				perlodid stoneflies
Arthropoda	**Insecta**	**Plecoptera**	**Perlodidae**	**Isoperlinae**	***Isoperla* sp.**		perlodid stoneflies
Arthropoda	**Insecta**	**Plecoptera**	**Perlodidae**	**Perlodinae**	***Skwala* sp.**		perlodid stoneflies
Arthropoda	**Insecta**	**Plecoptera**	**Taeniopterygidae**				winter stoneflies
Arthropoda	Insecta	Trichoptera	Hydropsychidae				netspinning caddisflies
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	*Cheumatopsyche* sp.		netspinning caddisflies
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	*Hydropsyche* sp.		netspinning caddisflies
Arthropoda	**Insecta**	**Trichoptera**	**Hydroptilidae**	**Hydroptilinae**	***Hydroptila* sp.**		microcaddisflies
Arthropoda	Malacostraca	Amphipoda	Hyalellidae		*Hyalella* sp.		scuds
Arthropoda	Malacostraca	Decapoda	Cambaridae				crayfish
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidiinae	*Pisidium* sp.		peaclams

Note: Bold denotes a new record for this SCPN monitoring site.

Appendix D Channel characteristics at the MAN01 monitoring site, Mesa Verde National Park, Colorado, 2009

Transect	Velocity (m/s)		Depth (m)		Wetted channel width (m)	Active channel width (m)
MAN01	Mean	Std Dev	Mean	Std Dev	Value	Value
1	0.46	0.38	0.14	0.07	5.19	15.64
3	0.55	0.21	0.10	0.01	7.45	7.15
5	0.38	0.28	0.09	0.09	6.40	7.6
7	0.29	0.30	0.09	0.08	7.34	9.8
9	0.45	0.13	0.13	0.02	6.52	9.27
11	0.33	0.09	0.21	0.12	4.60	10.39