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

2011 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2012/419

ON THE COVER
Mesa Verde National Park
Photograph courtesy of SCPN

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

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Natural Resource Data Series NPS/SCPN/NRDS—2012/419

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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. The 2011 crew consisted of Melissa Dyer and Tim Sullivan. SCPN staff provided support for the project.

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Contents

Figures

Figures (continued)

Tables

Appendices

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 scientific foundation for making decisions and working with other agencies and the public to protect park ecosystems. Hydrologic vital signs are the fundamental components defining overall riparian and aquatic ecosystem integrity. The Southern Colorado Plateau Network (SCPN) has identified 7 vital signs pertaining to riparian and spring ecosystems, the first 2 of which we focus on in this report: 1) aquatic macroinvertebrates, 2) stream water quality, 3) stream flow and depth to groundwater, 4) spring water quality, 5) channel morphology, 6) riparian vegetation, composition, and structure, and 7) spring, seep and tinaja ecosystems. These vital signs are closely related and are all included in the *Vital Signs Monitoring Plan for the Southern Colorado Plateau Network* (Thomas et al. 2006). The context and ecological significance of these vital signs are further explained in Scott et al. (2005).

The Mancos River in Colorado makes up approximately 6 km of Mesa Verde National Park's (MEVE) eastern boundary, and is located adjacent to a checkerboard of federal, state, and private lands. Water is diverted upstream from the park for irrigation and flow in the river has been partially regulated by Jackson Gulch Reservoir since 1949. Several streamflow gaging stations are located on the Mancos River in and near MEVE. The streamflow gaging station, USGS 09370600 *Mancos River at Anitas Flat below Mancos, CO*, is 1.69 km south of the park boundary and is operated cooperatively by the National Park Service (NPS) and the U.S. Geological Survey (USGS). Streamflow gaging station, USGS 09371000 Mancos River near Towaoc, CO, is 45 km downstream of the park boundary on the Ute Indian Reservation. The state of Colorado has a streamflow gaging station, MANMANCO, 15 km upstream of the park, near the town of Mancos.

Little information is available describing the condition of Mancos River aquatic ecosystems in MEVE. 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 monitoring of aquatic macroinvertebrates and physical habitat at 2 sites on the Mancos River in MEVE (Stumpf and Monroe 2009):

Mancos River at Gage (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 USGS, as part of the process of developing the A*quatic Macroinvertebrate Monitoring Protocol for the Southern Colorado Plateau Network* (Brasher et al. 2011). The site was established as an index site, valuable for its co-location with a USGS streamflow gaging station (USGS 09370600 in fig. 1). An SCPN water quality monitoring site was later established at the same site. The dominant riparian vegetation at MAN01 is cottonwood (*Populus fremontii, P. deltoides*), 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. This site was also established as an index site with the goal of achieving spatial variability along the river as well as meeting accessibility considerations. It is located on a large meander bend near the downstream park boundary (fig. 1). The vegetation community is composed primarily of coyote willow, juniper (*Juniperus monosperma*), rabbitbrush (*Chrysothamnus* spp.) and narrowleaf cottonwood (*Populus angustifolia*).

The purpose of this report is to (a) document SCPN aquatic macroinvertebrate monitoring activities that occurred at the Mancos River in MEVE in 2011, (b) summarize the data collected, and (c) where appropriate, place the data in the context of current environmental conditions.

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

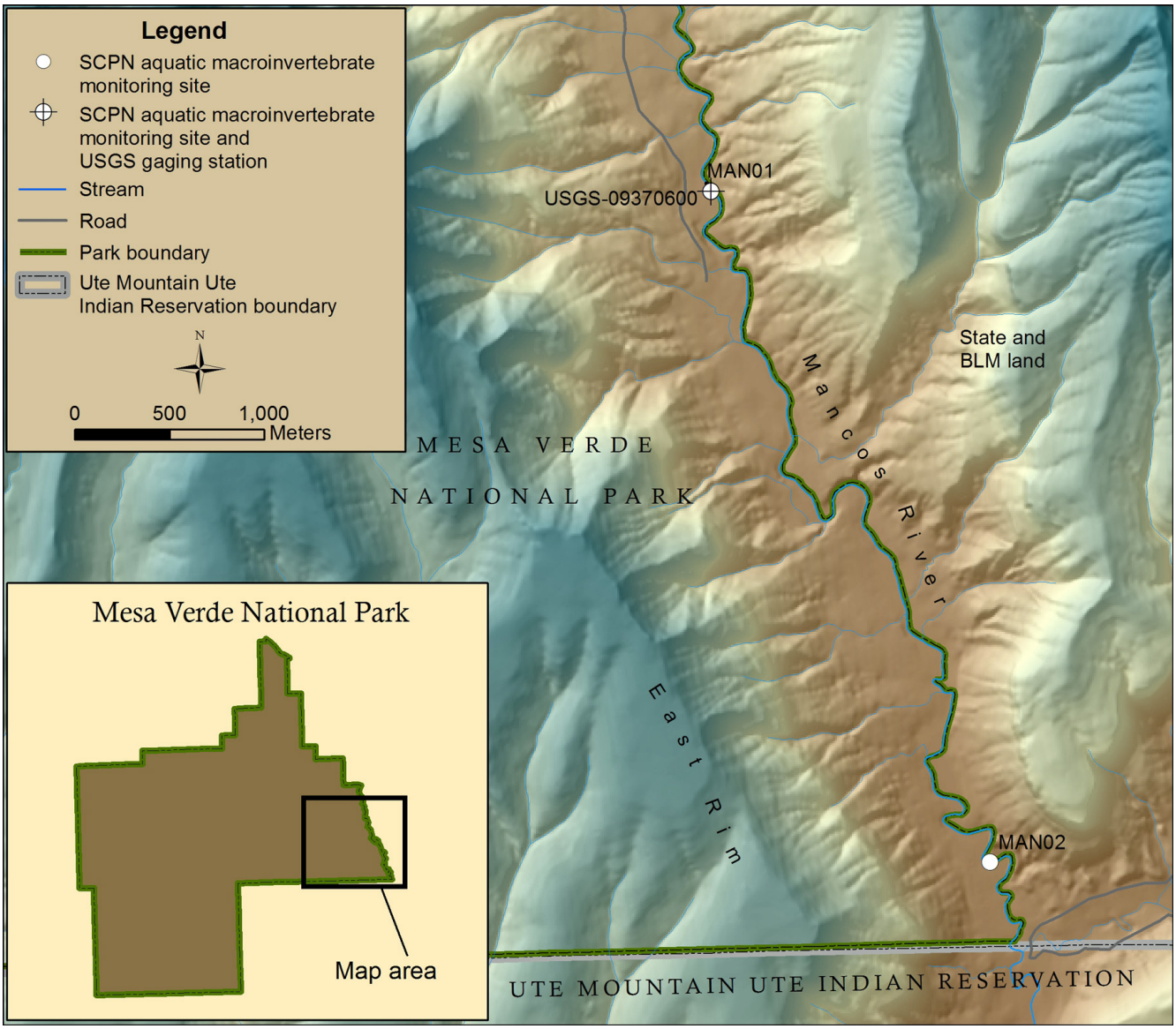


Figure 1. Map of Mancos River through Mesa Verde National Park, Colorado, showing the location of the 2 monitoring sites, MAN01 and MAN02, in 2011

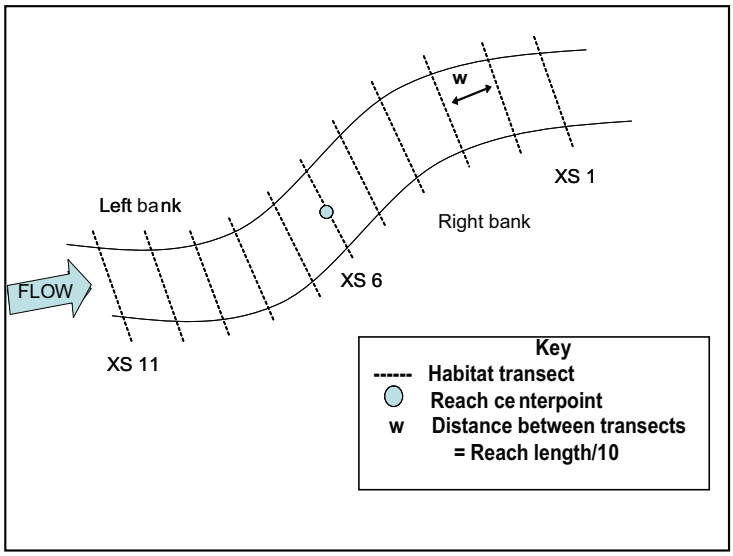


Figure 2. General aquatic macroinvertebrate sampling reach layout

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 09–10 September 2011, the SCPN water resources field crew collected aquatic macroinvertebrate samples and physical habitat data at 2 monitoring sites, MAN01 and MAN02, on the Mancos River in MEVE. These sites consist of a 150 m reach, divided into 11 transects, spaced 15 meters apart (see fig. 2 for reach layout diagram). A detailed description of sampling methods can be found in Brasher et al. (2011).

We collected 2 types of aquatic macroinvertebrate samples at MAN01 and MAN02 in 2011:

- Replicate quantitative samples were collected from 5 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 was collected to develop a comprehensive list of species present at the site. We used a Slack sampler to collect samples from all habitat types within the monitoring site, which we then compiled into one composite sample. A list of existing habitat types from which qualitative samples were collected can be found in section 3.2 of this report.

We collected physical habitat data at 3 spatial scales—microhabitat, transect, and reach:

- For each of the quantitative targeted riffle microhabitats, we
  - measured depth
  - measured velocity
  - measured substrate particle size
  - measured substrate particle embeddedness
- For each of the 11 transects, we
  - measured wetted and active channel widths
  - measured water depth, velocity, and canopy closure at 5 equally spaced points along each transect
  - observed and recorded the presence or absence, and types of aquatic macroinvertebrate habitats, represented by point data (5 points/transect) across the entire site
  - measured geomorphic channel units (GCU) at 5 equally spaced points along each transect
- For the entire reach, we
  - identified and measured the length of GCUs (reach characterization data represents the proportion of the reach representing that particular GCU)
  - identified the dominant vegetation and land cover
  - recorded descriptions of flow conditions
  - 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, turbidity, and stream discharge
  - 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 site (this reach-based pebble count method differs from transect-based methods conducted in 2007–2008)

2.2 Laboratory methods

Aquatic macroinvertebrate samples were sent to the National Aquatic Monitoring Center's Bug Lab, a Bureau of Land Management laboratory at Utah State University in Logan, Utah. Samples were sorted under a dissecting scope at 10X magnification, and a 500-organism, fixed-count method was used for sub-sampling 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. To ensure data quality, 10 percent of the identified samples were re-identified by a second certified taxonomist.

Quantitative and qualitative aquatic macroinvertebrate samples will be maintained by the contract aquatic laboratory for at least 5 years to allow for repeat subsampling should any data questions arise. For a more detailed description of laboratory methods see Brasher et al. (2011).

2.3 Data analysis

In this report we summarize 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). Also, they 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

Key metrics are presented in Table 1 (qualitative) and in Tables 2 and 3 (quantitative), describing aquatic macroinvertebrate communities from samples collected at MAN01 and MAN02 from 2007 to 2011. For all tables and figures listed in this section, results are presented in left to right order corresponding to upstream to downstream position along the stream. Figures in this section refer to quantitative data unless otherwise noted, and error bars represent one standard deviation from the mean. Appendix C lists all aquatic macroinvertebrate species detected at the site, from both quantitative and qualitative methods.

Abundance. Abundance values for targeted riffle habitat samples averaged 469.40 individuals at MAN01 (fig. 3). Sample abundances at MAN01 ranged from 72 (low) to 797 (high). Abundance at MAN02 averaged 202.40 individuals. Sample abundances ranged from a low of 41 to a high of 434.

Taxa richness. Richness for quantitative samples collected at MAN01 ranged from 10 to 14 taxa and averaged 12.20 (fig. 4a). At MAN02, richness for quantitative samples ranged from 7 to 14 taxa and averaged 12.00. Richness of qualitative samples was 23 taxa at MAN01 and 27 taxa at MAN02 (fig. 4b).

Diversity. We measured taxonomic and functional diversity using the Simpson's Diversity Index. Taxonomic diversity averaged 0.46 at MAN01 and 0.70 at MAN02 (fig. 5a). Functional diversity averaged 0.33 at MAN01 and 0.53 at MAN02 (fig. 5b).

Stress tolerance. Taxa which are intolerant to disturbance dominated both the relative abundance and taxa richness values at MAN01 (figs. 6a, 6b). Relative abundance of intolerant taxa at MAN01 averaged 78.28%. Richness of intolerant taxa averaged 50.89% at MAN01. Moderately tolerant individuals and taxa were the second most abundant at MAN01. Relative abundance and richness of moderately intolerant individuals and taxa averaged 21.72% and 49.11%, respectively, at MAN01. No tolerant individuals were found at MAN01.

Moderately tolerant individuals dominated samples from MAN02. Relative abundance for moderately tolerant individuals averaged 52.63%. Richness of moderately tolerant taxa averaged 60.02%. Intolerant taxa were the next most abundant and taxa rich at MAN02, averaging 47.29% of the individuals and 38.16% of taxa per sample. Few tolerant taxa were found at MAN02 in 2011; relative abundance averaged 0.09%, while richness averaged 1.82%.

EPT taxa. Relative abundance of Trichoptera (caddisflies) from the sensitive EPT taxa (Ephemeroptera [mayflies], Plecoptera [stoneflies], Trichoptera) dominated both monitoring sites (fig. 7). Trichoptera averaged 72.42% of the individuals collected from MAN01 and 40.24% of the individuals from MAN02. Ephemeroptera were the second most abundant at both sites, averaging 11.38% at MAN01 and 28.97% at MAN02. Few plecopterans were collected at either site: 1.20% from MAN01 and 1.61% from MAN02.

Aquatic macroinvertebrate orders. Trichoptera and Ephemeroptera were the most abundant orders collected from quantitative samples at MAN01 in 2011 (fig. 8). Non-chironomid dipterans (flies) were the next most abundant at 7.06%. Chironomids and noninsect taxa accounted for 3.58% and 3.57% of the sample from MAN01. Coleopterans (beetles) were the least abundant order collected from MAN01, at 0.79%. No odonates (dragonflies/damselflies) were collected at MAN01.

Similarly to MAN01, Trichoptera and Ephemeroptera were the most abundant orders collected at MAN02 in 2011. Non-chironomid dipterans were next most abundant at 12.08%, followed by noninsect taxa at 9.85%, chironomids at 6.67%, and coleopterans at 0.58%. No odonates were collected at MAN02.

continued on page 14...

Table 1. Qualitative metrics for aquatic macroinvertebrate samples collected from MAN01 and MAN02 at the Mancos River in Mesa Verde National Park, Colorado, 2007–2011. 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**	**2010**	**2011**	**2007**	**2008**	**2009**	**2010**	**2011**
Taxa richness	19	22	27	25	23	10	20	—	19	27
Tolerance group										
Richness of tolerant taxa (%)	16.67	15.00	16.00	0.00	5.26	11.11	11.11	—	11.11	4.17
Richness of moderately tolerant taxa (%)	44.44	50.00	52.00	63.64	57.89	55.56	44.44	—	55.56	54.17
Richness of intolerant taxa (%)	38.89	35.00	32.00	36.36	36.84	33.33	44.44	—	33.33	41.67
Functional group										
Richness of collector-filterers (%)	16.67	19.05	14.81	12.50	14.29	20.00	15.79	—	11.11	11.54
Richness of collector-gatherers (%)	50.00	38.10	37.04	33.33	28.57	50.00	36.84	—	33.33	30.77
Richness of scrapers (%)	0.00	9.52	7.41	8.33	4.76	0.00	5.26	—	11.11	7.69
Richness of shredders (%)	0.00	9.52	7.41	12.50	4.76	0.00	5.26	—	11.11	7.69
Richness of predators (%)	33.33	23.81	33.33	33.33	47.62	30.00	36.84	—	33.33	42.31
Taxonomic group										
Number of EPT taxa	7	7	9	9	9	4	6	—	5	8
Richness of EPT taxa (%)	36.84	31.82	33.33	36.00	39.13	40.00	30.00	—	26.32	29.63
Richness of Ephemeroptera (%)	21.05	18.18	11.11	20.00	13.04	30.00	15.00	—	15.79	18.52
Richness of Plecoptera (%)	0.00	4.55	11.11	4.00	8.70	0.00	5.00	—	5.26	3.70
Richness of Trichoptera (%)	15.79	9.09	11.11	12.00	17.39	10.00	10.00	—	5.26	7.41
Richness of noninsect taxa (%)	26.32[a]	31.82[a]	22.20	16.00	21.74	30.00[a]	15.00	—	15.79	18.52
Richness of Chironomid Diptera (%)	10.53	13.64	11.11	8.00	13.04	10.00	15.00	—	15.79	11.11
Richness of non-Chironomid Diptera (%)	21.05	13.64	25.93	20.00	17.39	20.00	15.00	—	31.58	25.93
Richness of Coleoptera (%)	0.00	9.10	3.70	12.00	8.70	0.00	15.00	—	10.53	11.11
Richness of Odonata (%)	5.26	0.00	3.70	8.00	0.00	0.00	10.00	—	0.00	3.70

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

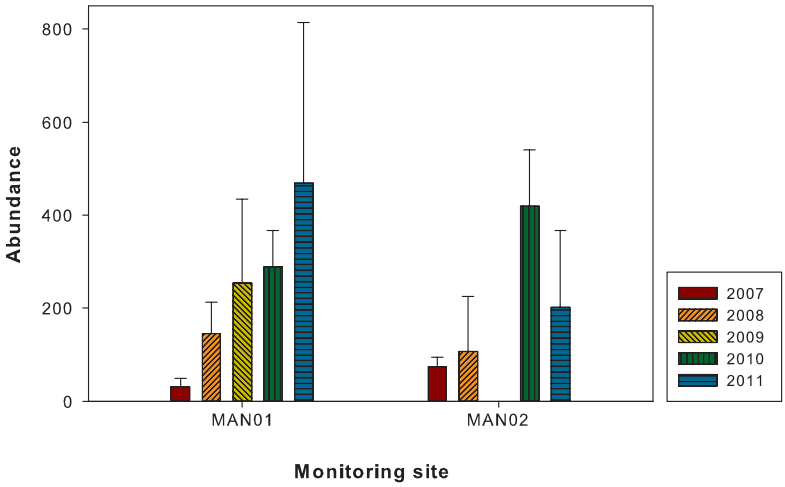


Figure 3. Total abundance expressed as the mean number of individuals per quantitative targeted riffle sample collected from MAN01 and MAN02, at the Mancos River, in MEVE, 2007–2011. No data were collected at MAN02 in 2009.

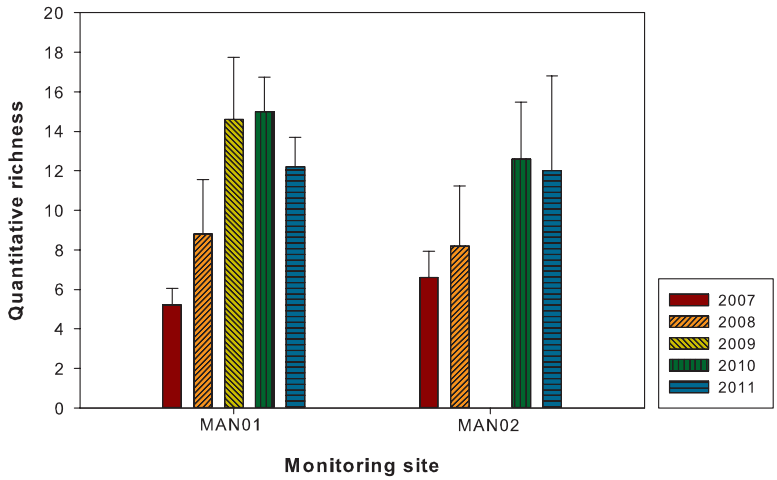


Figure 4a. Mean taxa richness of quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2011. No data were collected at MAN02 in 2009.

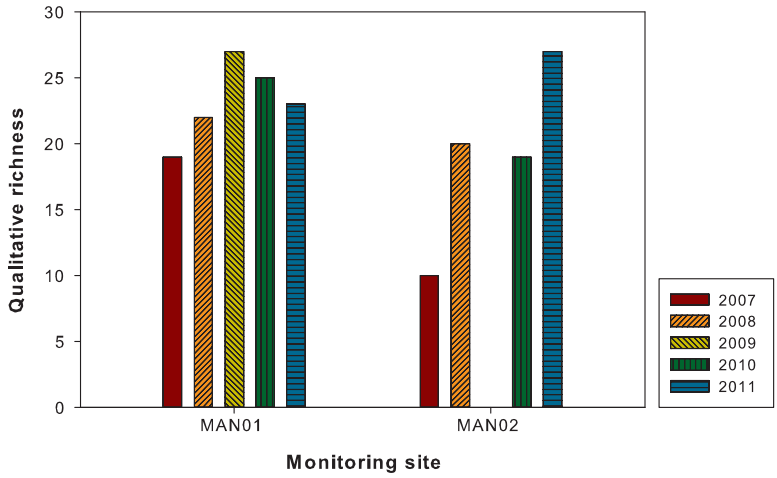


Figure 4b. Taxa richness of qualitative multihabitat samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2011. No data were collected at MAN02 in 2009.

Table 2. (left page, 2007–2009) Quantitative metrics for aquatic macroinvertebrate samples collected from MAN01 at the Mancos River in Mesa Verde National Park, Colorado, 2007–2011. 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.

	2007		2008		2009	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Total abundance	31.20	18.66	145.00	68.52	254.60	179.83
Total richness	5.20	0.84	8.80	2.77	14.60	3.13
Simpson's Diversity—taxonomic	0.66	0.06	0.51	0.16	0.64	0.12
Simpson's Diversity—functional group	0.38	0.07	0.36	0.11	0.53	0.08
Dominant taxa	55.83	4.41	67.89	12.07	53.65	13.56
Tolerance group						
Relative abundance of tolerant taxa (%)	0.00	0.00	0.27	0.60	0.00	0.00
Relative abundance of moderately tolerant taxa (%)	75.79	9.88	26.47	9.81	35.34	9.51
Relative abundance of intolerant taxa (%)	24.21	9.88	73.26	9.95	64.66	9.51
Richness of tolerant taxa (%)	0.00	0.00	3.33	7.45	0.00	0.00
Richness of moderately tolerant taxa (%)	55.33	19.27	58.73	9.83	58.09	7.21
Richness of intolerant taxa (%)	44.67	19.27	37.94	8.92	41.91	7.21
Functional group						
Relative abundance of collector-filterers (%)	27.61	25.19	76.88	8.45	56.35	12.99
Relative abundance of collector-gatherers (%)	68.47	22.86	19.03	7.82	35.93	12.78
Relative abundance of scrapers (%)	0.00	0.00	0.24	0.36	0.04	0.08
Relative abundance of shredders (%)	0.00	0.00	0.18	0.41	0.85	0.59
Relative abundance of predators (%)	3.93	4.27	3.65	0.93	6.83	1.31
Richness of collector-filterers (%)	31.33	12.38	33.35	7.49	16.66	3.72
Richness of collector-gatherers (%)	57.33	7.23	36.41	9.92	30.71	8.10
Richness of scrapers (%)	0.00	0.00	3.54	4.91	1.00	2.24
Richness of shredders (%)	0.00	0.00	2.50	5.59	5.63	3.39
Richness of predators (%)	11.33	10.43	24.20	5.86	45.99	8.37
Taxonomic group						
Number of EPT taxa	3.00	0.71	4.40	0.89	5.60	0.55
Relative abundance of EPT taxa (%)	73.51	16.87	89.52	3.86	62.88	13.64
Relative abundance of Ephemeroptera (%)	59.43	18.82	12.76	6.57	5.72	2.60
Relative abundance of Plecoptera (%)	0.00	0.00	1.99	2.10	3.04	0.62
Relative abundance of Trichoptera (%)	14.08	4.69	74.77	8.82	54.12	14.17
Relative abundance of noninsect taxa (%)	3.93	4.27	1.23	0.95	11.21	10.13
Relative abundance of Chironomid Diptera (%)	9.04	7.44	6.53	2.99	19.41	5.20
Relative abundance of non-Chironomid Diptera (%)	13.53	22.31	2.37	1.46	6.39	2.27
Relative abundance of Coleoptera (%)	0.00	0.00	0.27	0.41	0.11	0.25
Relative abundance of Odonata (%)	0.00	0.00	0.09	0.20	0.00	0.00

Table 2. (right page, 2010–2011) Quantitative metrics for aquatic macroinvertebrate samples collected from MAN01 at the Mancos River in Mesa Verde National Park, Colorado, 2007–2011. 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.

	2010		2011	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**
Total abundance	288.20	78.72	469.40	345.12
Total richness	15.00	1.73	12.20	1.48
Simpson's Diversity—taxonomic	0.71	0.06	0.46	0.21
Simpson's Diversity—functional group	0.58	0.05	0.33	0.15
Dominant taxa	43.96	7.47	70.83	16.28
Tolerance group				
Relative abundance of tolerant taxa (%)	0.67	0.74	0.00	0.00
Relative abundance of moderately tolerant taxa (%)	55.99	8.81	21.72	13.27
Relative abundance of intolerant taxa (%)	43.33	8.99	78.28	13.27
Richness of tolerant taxa (%)	7.13	5.12	0.00	0.00
Richness of moderately tolerant taxa (%)	56.78	8.07	49.11	14.28
Richness of intolerant taxa (%)	36.09	5.51	50.89	14.28
Functional group				
Relative abundance of collector-filterers (%)	42.11	9.23	79.46	11.29
Relative abundance of collector-gatherers (%)	47.39	8.53	14.85	8.21
Relative abundance of scrapers (%)	1.04	0.50	1.57	2.53
Relative abundance of shredders (%)	0.06	0.13	0.37	0.41
Relative abundance of predators (%)	9.40	5.65	3.76	2.11
Richness of collector-filterers (%)	13.78	1.13	26.37	5.92
Richness of collector-gatherers (%)	39.66	3.67	33.49	7.65
Richness of scrapers (%)	6.89	0.56	9.22	6.54
Richness of shredders (%)	1.18	2.63	5.36	4.96
Richness of predators (%)	38.49	3.99	25.56	9.41
Taxonomic group				
Number of EPT taxa	4.40	1.52	5.20	1.10
Relative abundance of EPT taxa (%)	72.39	10.56	85.01	9.90
Relative abundance of Ephemeroptera (%)	33.38	14.58	11.38	5.95
Relative abundance of Plecoptera (%)	0.46	0.48	1.20	1.28
Relative abundance of Trichoptera (%)	38.56	8.99	72.42	15.40
Relative abundance of noninsect taxa (%)	2.40	1.65	3.57	3.88
Relative abundance of Chironomid Diptera (%)	13.45	6.95	3.58	4.48
Relative abundance of non-Chironomid Diptera (%)	10.70	3.38	7.06	7.33
Relative abundance of Coleoptera (%)	0.99	0.81	0.79	15.40
Relative abundance of Odonata (%)	0.06	0.13	0.00	0.00

Table 3. (left page, 2007–2009) Quantitative metrics for aquatic macroinvertebrate samples collected from MAN02 at the Mancos River in Mesa Verde National Park, Colorado, 2007–2011. 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.

	2007		2008		2009	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Total abundance	74.00	20.48	106.40	118.73	—	—
Total richness	6.60	1.34	8.20	3.03	—	—
Simpson's Diversity—taxonomic	0.60	0.10	0.63	0.12	—	—
Simpson's Diversity—functional group	0.50	0.40	0.48	0.13	—	—
Dominant taxa	56.79	6.00	56.03	13.19	—	—
Tolerance group						
Relative abundance of tolerant taxa (%)	0.25	0.56	0.00	0.00	—	—
Relative abundance of moderately tolerant taxa (%)	82.43	9.77	50.00	20.42	—	—
Relative abundance of intolerant taxa (%)	17.32	9.87	50.00	20.42	—	—
Richness of tolerant taxa (%)	2.86	6.39	0.00	0.00	—	—
Richness of moderately tolerant taxa (%)	53.00	13.98	50.59	5.02	—	—
Richness of intolerant taxa (%)	44.14	12.80	49.41	5.02	—	—
Functional group						
Relative abundance of collector-filterers (%)	32.95	7.82	49.46	28.85	—	—
Relative abundance of collector-gatherers (%)	61.92	6.65	40.82	26.81	—	—
Relative abundance of scrapers (%)	0.45	1.02	0.80	1.40	—	—
Relative abundance of shredders (%)	0.00	0.00	0.93	1.46	—	—
Relative abundance of predators (%)	4.68	1.86	7.98	3.07	—	—
Richness of collector-filterers (%)	31.33	6.39	31.36	13.41	—	—
Richness of collector-gatherers (%)	39.67	6.25	33.24	8.28	—	—
Richness of scrapers (%)	2.50	5.59	4.86	6.82	—	—
Richness of shredders (%)	0.00	0.00	4.17	5.89	—	—
Richness of predators (%)	26.50	8.79	26.38	4.94	—	—
Taxonomic group						
Number of EPT taxa	3.40	0.89	4.80	1.64	—	—
Relative abundance of EPT taxa (%)	73.37	12.52	88.81	3.28	—	—
Relative abundance of Ephemeroptera (%)	59.04	8.10	38.99	26.53	—	—
Relative abundance of Plecoptera (%)	3.00	2.17	5.23	4.58	—	—
Relative abundance of Trichoptera (%)	11.33	7.95	44.60	28.79	—	—
Relative abundance of noninsect taxa (%)	1.43	0.90	1.40	2.32	—	—
Relative abundance of Chironomid Diptera (%)	3.13	2.57	1.98	1.82	—	—
Relative abundance of non-Chironomid Diptera (%)	21.62	12.31	6.16	4.80	—	—
Relative abundance of Coleoptera (%)	0.45	1.02	1.58	1.65	—	—
Relative abundance of Odonata (%)	0.00	0.00	0.07	0.15	—	—

Table 3. (right page, 2010–2011) Quantitative metrics for aquatic macroinvertebrate samples collected from MAN02 at the Mancos River in Mesa Verde National Park, Colorado, 2007–2011. 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.

	2010		2011	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**
Total abundance	419.20	121.49	202.40	164.62
Total richness	12.60	2.88	12.00	3.08
Simpson's Diversity—taxonomic	0.54	0.09	0.70	0.08
Simpson's Diversity—functional group	0.47	0.11	0.54	0.08
Dominant taxa	63.16	9.58	49.73	7.16
Tolerance group				
Relative abundance of tolerant taxa (%)	0.05	0.11	0.09	0.19
Relative abundance of moderately tolerant taxa (%)	28.27	6.24	52.63	21.67
Relative abundance of intolerant taxa (%)	71.69	6.31	47.29	21.59
Richness of tolerant taxa (%)	1.43	3.19	1.82	4.07
Richness of moderately tolerant taxa (%)	53.24	9.85	60.02	16.44
Richness of intolerant taxa (%)	45.34	11.01	38.16	14.85
Functional group				
Relative abundance of collector-filterers (%)	67.48	11.19	47.96	21.46
Relative abundance of collector-gatherers (%)	23.02	6.06	39.15	22.32
Relative abundance of scrapers (%)	0.08	0.11	2.21	2.37
Relative abundance of shredders (%)	0.00	0.00	0.26	0.41
Relative abundance of predators (%)	9.43	6.16	10.41	4.38
Richness of collector-filterers (%)	21.39	6.79	22.14	5.85
Richness of collector-gatherers (%)	28.23	4.99	40.24	11.10
Richness of scrapers (%)	2.92	4.06	6.43	3.82
Richness of shredders (%)	0.00	0.00	2.76	3.79
Richness of predators (%)	47.46	5.00	28.43	7.36
Taxonomic group				
Number of EPT taxa	4.80	1.30	4.80	1.30
Relative abundance of EPT taxa (%)	88.04	5.34	70.82	26.08
Relative abundance of Ephemeroptera (%)	20.12	5.45	28.97	18.39
Relative abundance of Plecoptera (%)	3.61	1.07	1.61	1.89
Relative abundance of Trichoptera (%)	64.31	9.50	40.24	20.54
Relative abundance of noninsect taxa (%)	5.01	5.96	9.85	19.07
Relative abundance of Chironomid Diptera (%)	1.70	1.39	6.67	8.43
Relative abundance of non-Chironomid Diptera (%)	5.20	4.78	12.08	4.89
Relative abundance of Coleoptera (%)	0.05	0.10	0.58	0.86
Relative abundance of Odonata (%)	0.00	0.00	0.00	0.00

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, 2007–2011. Values are means of all quantitative samples collected from each site. No data were collected at MAN02 in 2009.

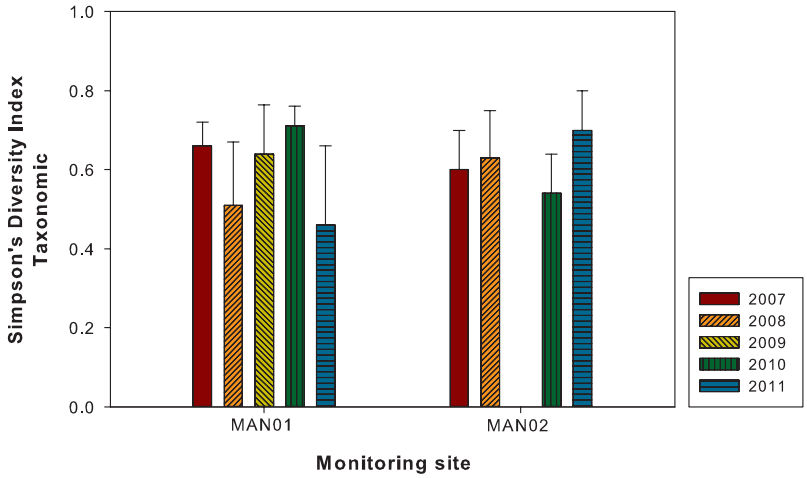


Figure 5b. Simpson's Diversity Index for functional diversity in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2011. Values are means of all quantitative samples collected from each site. No data were collected at MAN02 in 2009.

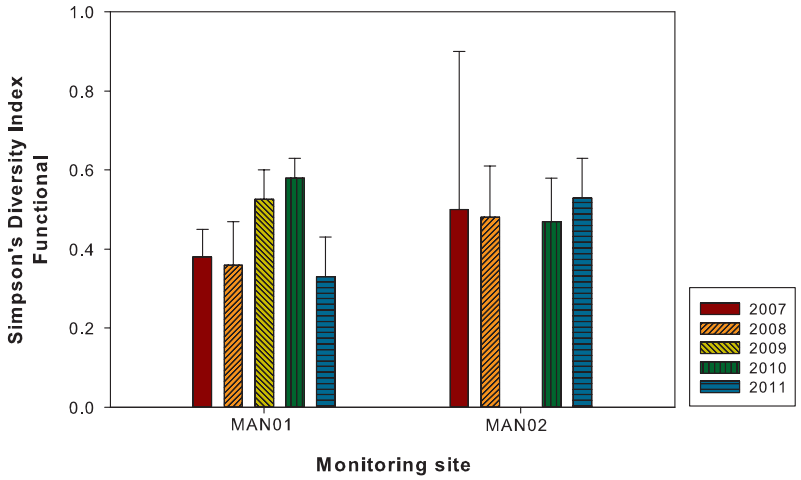
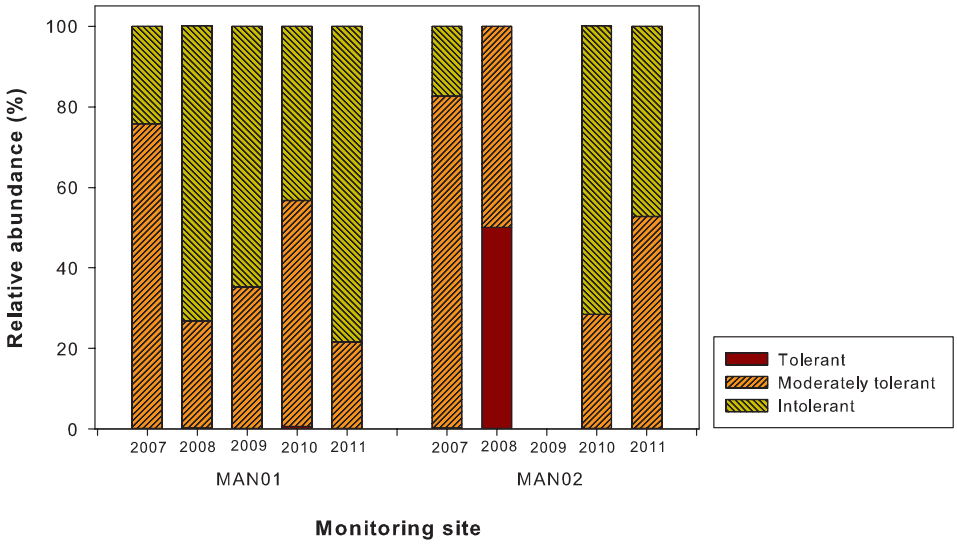


Figure 6a. Mean relative abundance of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2011, based on their tolerance to perturbation. No data were collected at MAN02 in 2009.



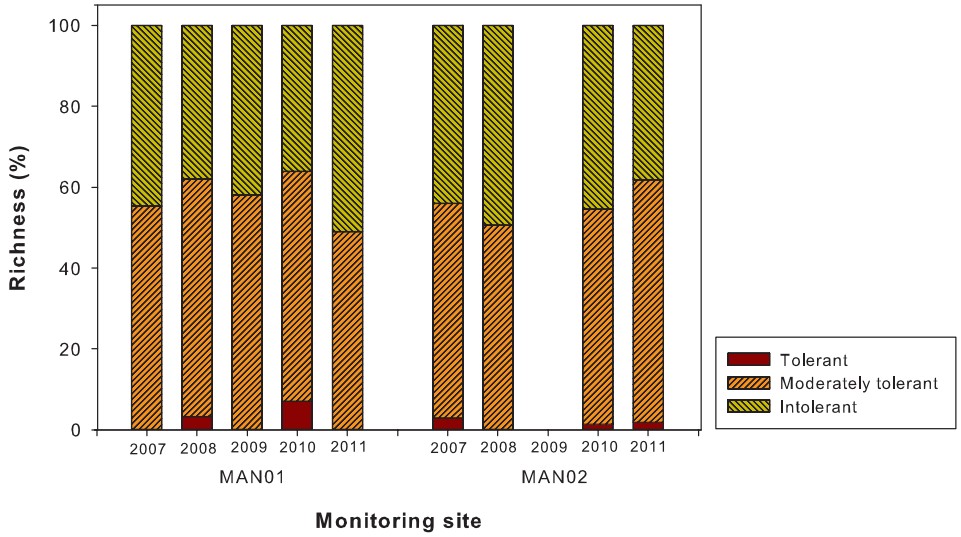


Figure 6b. Mean richness of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE 2007–2011, based on their tolerance to perturbation. No data were collected at MAN02 in 2009.

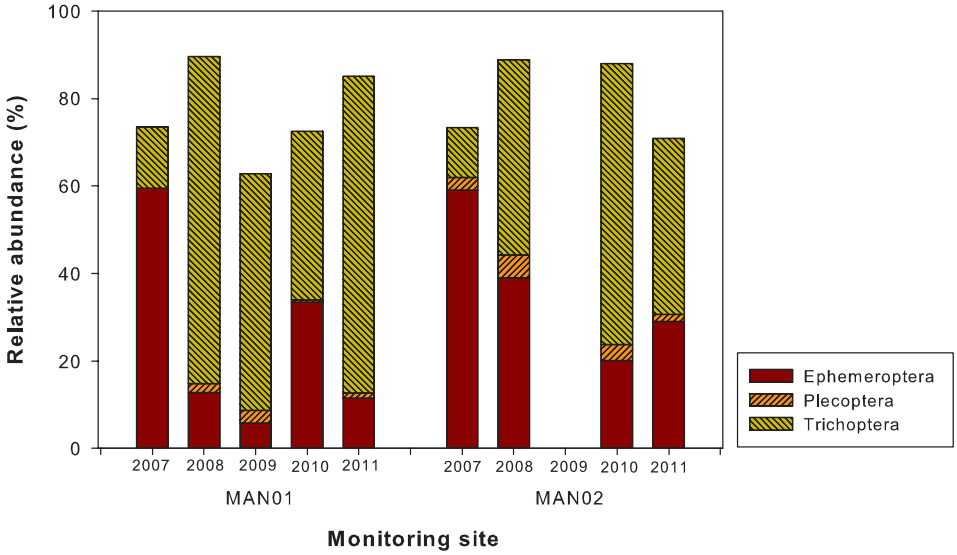


Figure 7. Relative abundance of sensitive EPT orders in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2011. No data were collected at MAN02 in 2009.

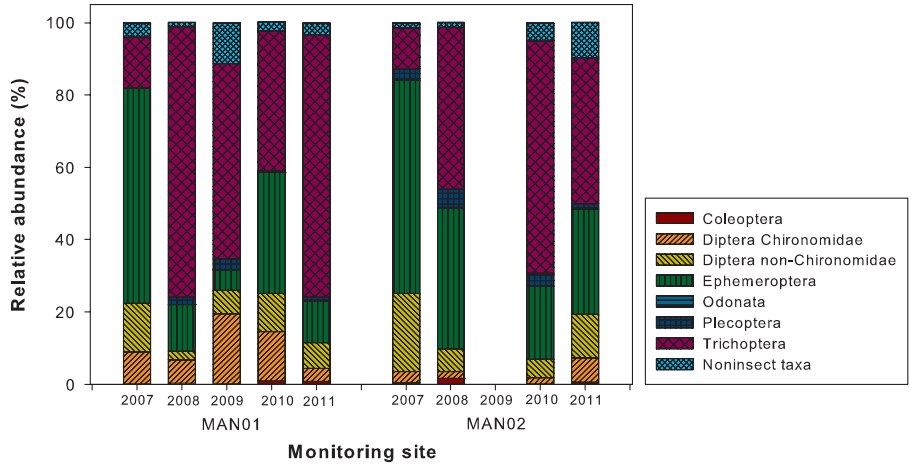


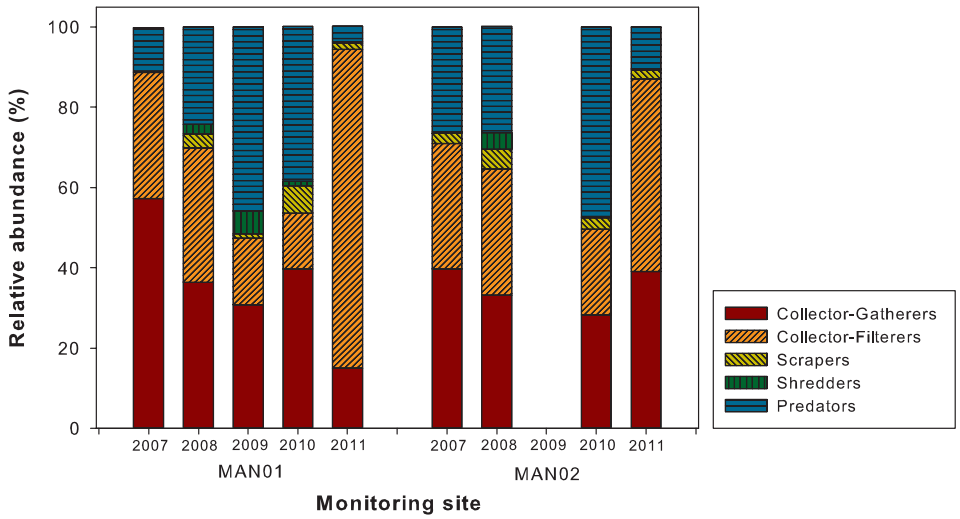
Figure 8. Relative abundance of orders in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River, in MEVE, 2007–2011. No data were collected at MAN02 in 2009.

...continued from page 5

Functional feeding groups. Collector-filterers were the most abundant group at MAN01, at 79.46% (fig. 9). Collector-gatherers were the second most abundant functional group at MAN01, averaging 14.85%. Predators averaged 3.76%, followed by scrapers at 1.57%, and shredders at 0.37%.

Collector-filterers were the most abundant functional group collected at MAN02, averaging 47.96%. Collector-gatherers were the second most abundant, averaging 39.15%, followed by predators at 10.41%, and scrapers at 2.21%. Shredders were the least abundant order collected at MAN02, averaging 0.26%.

Figure 9. Relative abundance of functional feeding groups in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2011. No data were collected at MAN02 in 2009.



3.2 Physical habitat characteristics

Physical habitat data collected at MAN01 and MAN02 from 2007 to 2011 are presented in Tables 4 and 5. Additional transect data can be found in Appendix D.

Microhabitat. In 2011, velocity at the targeted riffle sampling areas averaged 0.68 m/s at MAN01 and 0.47 m/s at MAN02. Depths averaged 0.18 m at MAN01 and 0.11 m at MAN02. Particle embeddedness at MAN01 ranged from a low of 10.3% to a high of 33.0% (fig. 10a). At MAN02, particle embeddedness ranged from a low of 23.0% to a high of 66.0%. On average for 2011, 23.2% of each particle was embedded at MAN01, while 41.0% of each particle was embedded at MAN02 (fig. 10b).

Transect. Active channel widths averaged 15.7 m at MAN01 and 44.4 m at MAN02. Velocity averaged 0.41 m/s at MAN01 and 0.39 m/s at MAN02. The average depth along transects was 0.18 m at MAN01 and 0.21 m at MAN02. Riparian canopy closure averaged 16.6% at MAN01 and 20.2% at MAN02

Rock was the dominant habitat type at MAN01, accounting for 71.6% of the habitat sampled (fig. 11). Root wads, found along 6.8% of MAN01, were the second most frequent habitat type. Woody debris and vegetation were each found along 1.4% of MAN01. The category "Absence", meaning it lacked habitat that we define as appropriate for aquatic macroinvertebrates, occurred along 18.9% of MAN01.

Rock was the dominant habitat type at MAN02, accounting for 33.8% of the habitat sampled (fig. 11). Root wad accounted for 7.8%. Woody debris and vegetation each accounted for 2.6% of the habitat sampled at MAN02, and "Absence" accounted for 53.2% of MAN02.

Reach. Channel structure dynamics are represented by particle size distributions in Figures 12a and 12b. At MAN01 (fig. 12a), cobbles (65–250 mm) were the dominant particle type, accounting for 36.5% of the particles sampled in 2011. Silt (<0.06, gritty) and gravel (3–64 mm) accounted for 26.5% and 25.0%, respectively, of the

Table 4. Physical habitat and hydrologic data from MAN01 at Mancos River in Mesa Verde National Park, Colorado, 2007–2011. Particle embeddedness and canopy closure measurements are expressed as percentages.

	2007		2008		2009		2010		2011	
Physical habitat metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Microhabitat level										
Riffles										
Velocity (m/s)	0.69	0.27	0.63	0.13	0.55	0.36	0.47	0.17	0.68	0.37
Depth (m)	0.18	0.07	0.13	0.04	0.11	0.05	0.14	0.05	0.18	0.04
Embeddedness (%)	19.2	9.0	31.6	5.6	26.3	12.7	39.8	3.0	23.2	10.6
Transect level										
Channel dimensions										
Velocity (m/s)	0.68	0.23	0.50	0.23	0.41	0.10	0.51	0.17	0.41	0.15
Depth (m)	0.30	0.10	0.30	0.15	0.13	0.05	0.21	0.08	0.18	0.07
Wetted channel width (m)	5.7	2.1	5.6	1.8	6.3	1.2	4.9	1.9	4.7	1.5
Active channel width (m)	7.5	2.2	9.4	3.3	10.0	3.1	8.4	2.0	15.7	5.9
Riparian cover										
Canopy closure (%)	9.0	12.9	19.3	25.8	4.8	6.9	0.0	0.0	16.6	25.2
Reach level										
Water quality	**Value**		**Value**		**Value**		**Value**		**Value**	
Temperature (°C)	10.8		17.5		9.0		14.2		14.0	
Specific conductivity (µS/cm)	—		945		1510		1290		1315	
pH	—		8.5		8.4		8.4		8.3	
Dissolved oxygen (% saturation)	—		106		91.3		104.2		103.1	
Dissolved oxygen (mg/L)	—		10.1		8.2		8.3		8.5	
Turbidity (NTU)	—		12.2		16.7		9.8		8.7	
Discharge (cfs)	46.0		19.0		10.0		11.5		9.7	

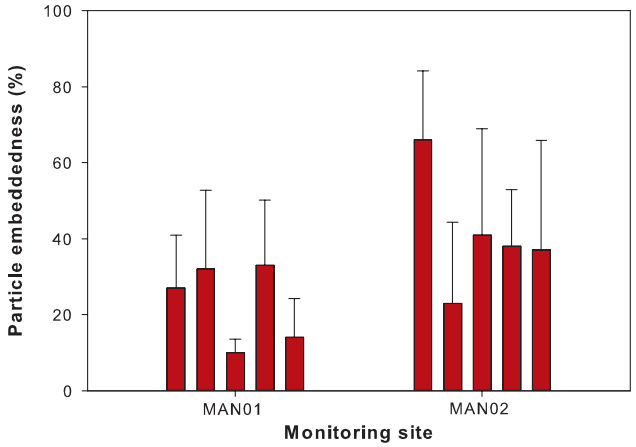


Figure 10a. Mean particle embeddedness at each of 5 individual quantitative targeted riffle habitats collected from MAN01 and MAN02 at the Mancos River in MEVE, 2011

Table 5. Physical habitat and hydrologic data from MAN02 at Mancos River in Mesa Verde National Park, Colorado, 2007–2011. Particle embeddedness and canopy closure measurements are expressed as percentages.

	2007		2008		2009		2010		2011	
Physical habitat metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Microhabitat level										
Riffles										
Velocity (m/s)	0.91	0.20	0.39	0.12	—	—	0.77	0.32	0.47	0.37
Depth (m)	0.15	0.05	0.06	0.01	—	—	0.14	0.07	0.11	0.05
Embeddedness (%)	28.0	12.9	27.6	8.5	—	—	48.4	12.9	41.0	15.6
Transect level										
Channel dimensions										
Velocity (m/s)	0.63	0.19	0.45	0.19	—	—	0.40	0.18	0.39	0.18
Depth (m)	0.31	0.10	0.25	0.07	—	—	0.21	0.07	0.21	0.08
Wetted channel width (m)	6.4	2.4	5.4	0.9	—	—	5.4	1.7	5.2	1.0
Active channel width (m)	10.3	4.2	10.0	2.6	—	—	8.0	2.8	44.4	9.8
Riparian cover										
Canopy closure (%)	14.3	26.8	23.0	33.4	—	—	1.3	4.6	20.2	26.2
Reach level										
Water quality	**Value**		**Value**		**Value**		**Value**		**Value**	
Temperature (°C)	11.2		16.9		—		13.4		14.4	
Specific conductivity (µS/cm)	—		993		—		1330		1283	
pH	—		8.5		—		8.3		8.4	
Dissolved oxygen (% saturation)	—		104.9		—		106.1		103.3	
Dissolved oxygen (mg/L)	—		10.2		—		8.6		8.5	
Turbidity (NTU)	—		16		—		18		9.0	
Discharge (cfs)	41.0		19.0		—		10.4		10.8	

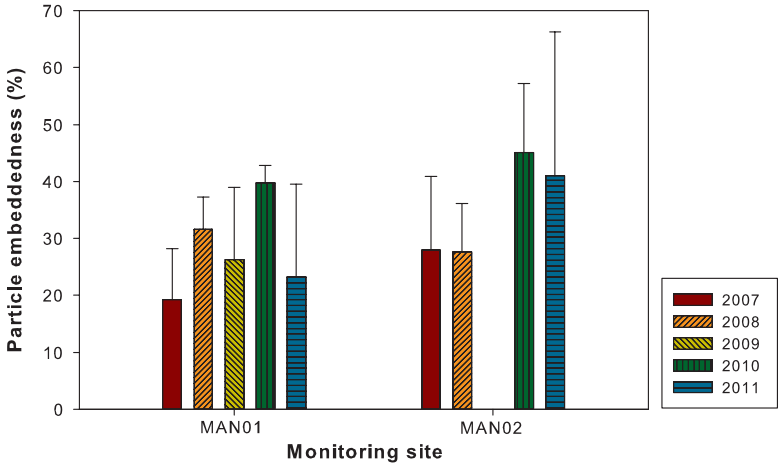


Figure 10b. Mean particle embeddedness at quantitative targeted riffle habitats collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2011. No data were collected at MAN02 in 2009.

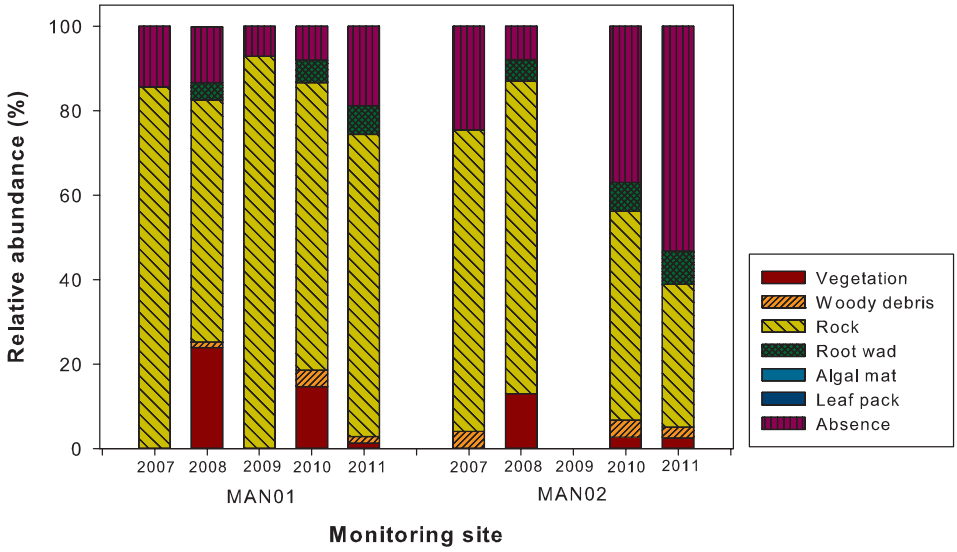


Figure 11. Aquatic macroinvertebrate habitat characterization based upon line point intercept data collected along habitat transects from MAN01 and MAN02 at the Mancos River in MEVE, 2007– 2011. No data were collected at MAN02 in 2009. Some habitat structure types were not observed.

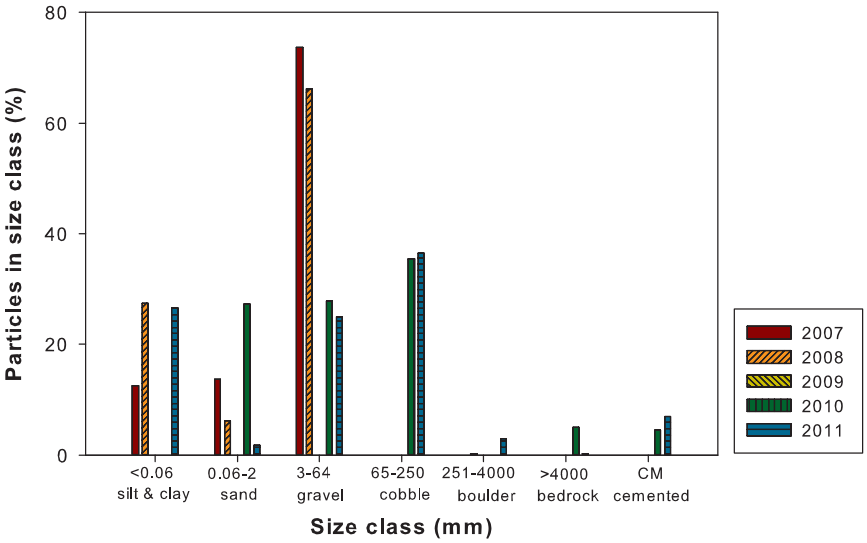


Figure 12a. Particle size distribution, based on modified Wolman pebble counts (minimum 400 particles) for aquatic macroinvertebrate sampling from MAN01 at the Mancos River in MEVE, 2007–2011. CM represents particles that are completely cemented into the stream channel, which precludes size measurements. Particle data in 2009 was collected as size class values using a different scale than other years, and is not reported here.

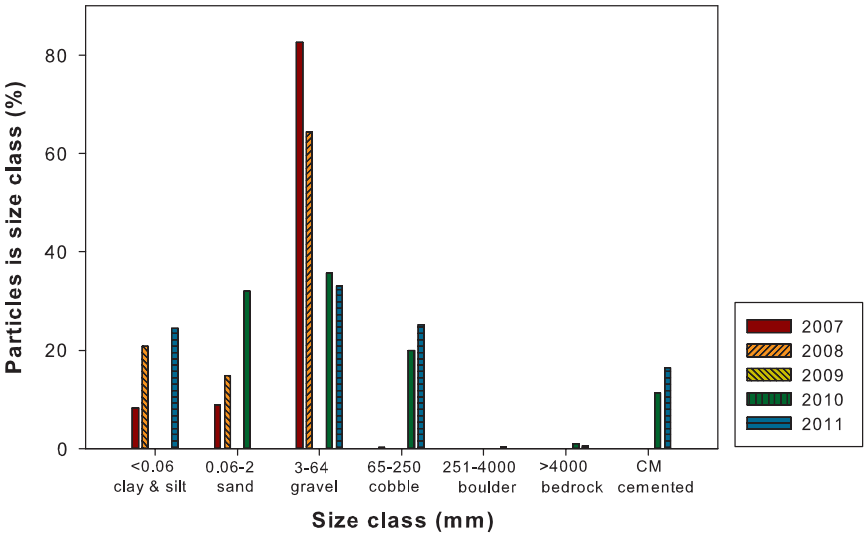


Figure 12b. Particle size distribution, based on modified Wolman pebble counts (minimum 400 particles) for aquatic macroinvertebrate sampling from MAN02 at the Mancos River in MEVE, 2007–2011. CM represents particles that are completely cemented into the stream channel, which precludes size measurements. Particle data in 2009 was collected as size class values using a different scale than other years, and is not reported here.

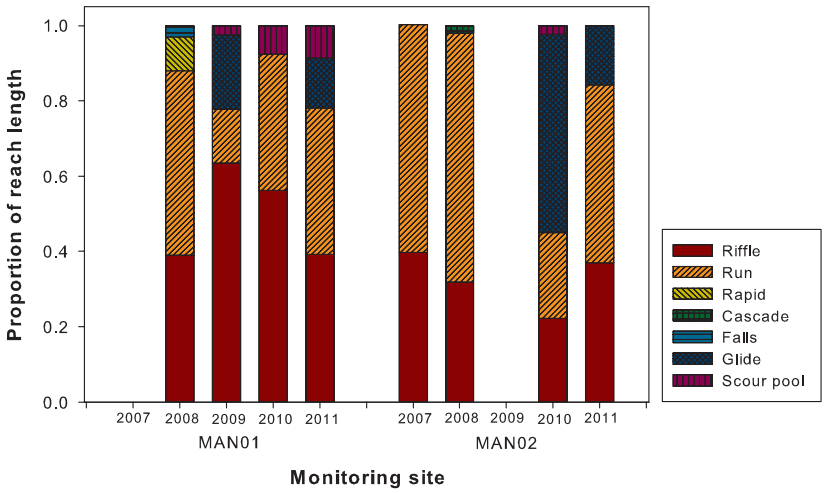
particles sampled. Boulders (251–4000 mm) were found along 3.0% of the monitoring site at MAN01. Sand (0.06–2 mm) was found along 1.8% of MAN01, and cemented particles accounted for 7.0%.

Gravel was the dominant particle type at MAN02 in 2011 (fig. 12b). Cobble and silt were abundant at MAN02, accounting for 25.3% and 24.5% of the particle sampled. Cemented particles accounted for 16.5% of the MAN02 sample. Bedrock (>4000 mm) made up less than 1% of the particles sampled at either monitoring site.

Riffles (39.2%) and runs (38.9%) were the most abundant geomorphic channel units at MAN01(fig. 13). Glides were found along 13.3% of MAN01. Scour pools were found along 8.5% of MAN01.

Runs were the dominant GCU downstream at MAN02, and were found along 47.3% of the monitoring site (fig. 13). Riffles (37.0%) and glides (15.7%) were the only other GCUs found along MAN02.

Figure 13. Geomorphic channel unit characterization from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2011. No data were collected at MAN01 in 2007, or MAN02 in 2009.



3.3 Hydrologic conditions

3.3.1 SCPN field data

NPS water quality core parameters are reported as measurements recorded at or nearest to midday on the day of the sampling event (tables 4, 5). At MAN01, the midday water temperature was 14.0°C. Specific conductivity was 1315 µS/cm, and pH was 8.3. Dissolved oxygen was 103.1% saturation and 8.5 mg/L. Turbidity was 8.7 NTU and stream discharge was 9.7 cfs.

At MAN02, the midday water temperature was 14.4°C. Specific conductivity and pH were 1283 µS/cm and 8.4, respectively. Dissolved oxygen was 103.3% saturation and 8.5 mg/L. Turbidity was 9.0 NTU. Stream discharge measured 10.8 cfs.

Daily water and air temperatures were collected from MAN01 at the Mancos River every 15 minutes during 2011 (figs. 14a, 14b). The average water temperature for 2011 was 9.0°C. A low water temperature of -0.1°C was recorded on several days during the year. A high water temperature of 29.2°C was recorded on 07 July. The average air temperature at MAN01 was 7.7°C. A low air temperature of -31.0°C was recorded on 02 January. A high air temperature of 36.9°C was recorded on 02 July.

3.3.2 USGS/MesoWest station data

Figure 15 shows a hydrograph from the USGS streamflow gaging station *Mancos River at Anitas Flat* (09370600) for the period 17 February 2011 through 28 November 2011 (USGS 2011). Streamflow during winter is affected by ice and the USGS does not provide useable data for these months. The hydrograph for 2011 shows spikes occurred during the March–June snowmelt period and June–September monsoon season.

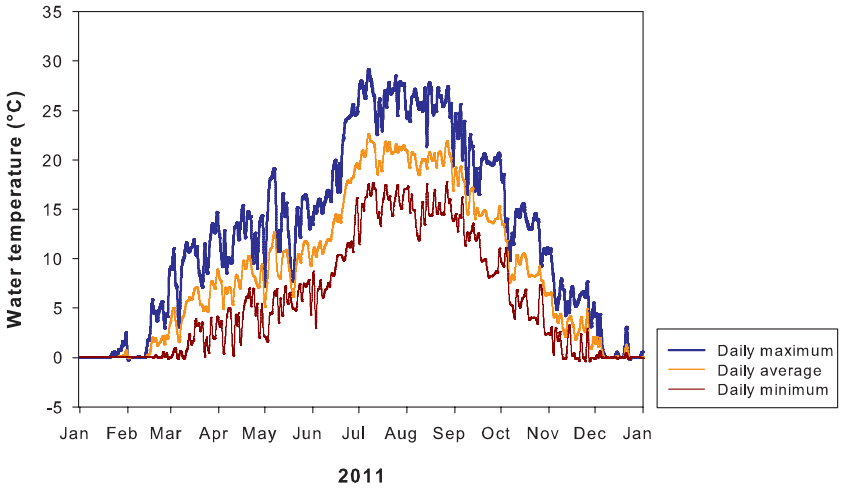


Figure 14a. Water temperature recorded at 15 minute intervals in 2011 from MAN01 at the Mancos River in MEVE

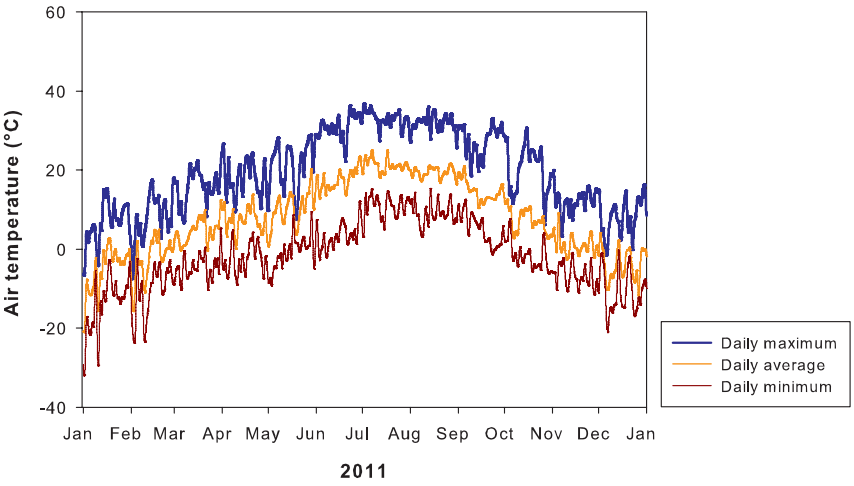


Figure 14b. Air temperature recorded at 15 minute intervals in 2011 from MAN01 at the Mancos River in MEVE

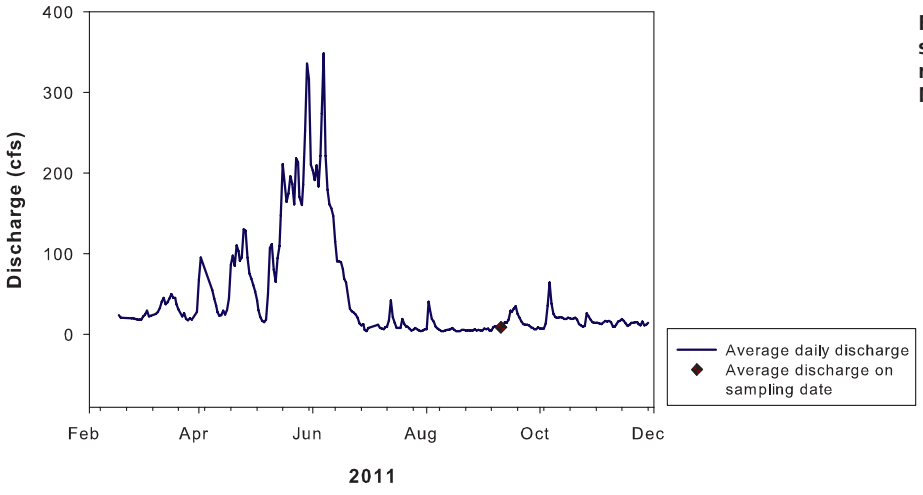
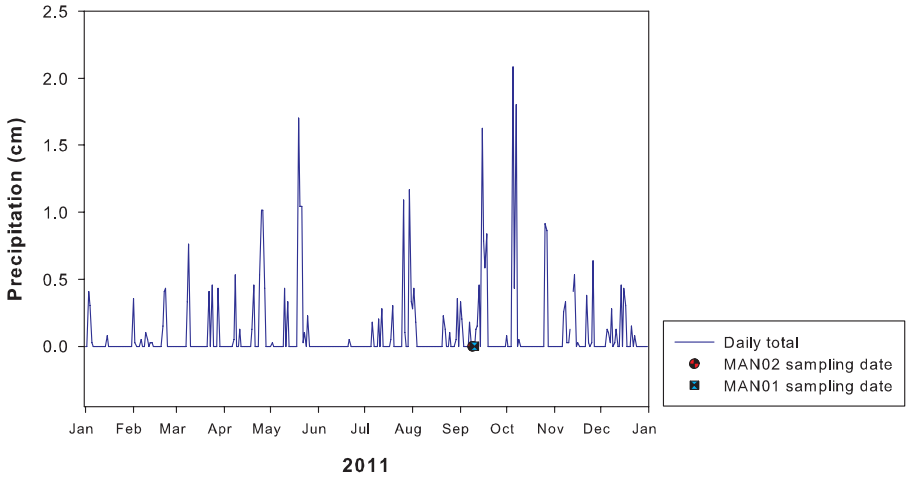


Figure 15. Hydrograph from the USGS streamflow gaging station (09370600) near MAN01 at the Mancos River in MEVE, 2011

Precipitation data collected at MesoWest weather station MRFC2 is presented in Figure 16. These data show that during 2011 the larger precipitation events occurred during late spring and fall, and the summer monsoon did not contribute a large amount of moisture this year.

Figure 16. Total daily precipitation from the MesoWest MOREFIELD weather station (MRFC2) near MAN01 in MEVE, 2011



4 Discussion

This report presents data from SCPN's fifth 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 by a few years of sampling data.

Differences can be attributed to multiple factors, including ecological variability and sampling error, or may be a result of observer bias. SCPN attempts to minimize such error by thoroughly training crew members in the proper field techniques prior to each sampling season.

4.1 Aquatic macroinvertebrate communities

Total abundance of aquatic macroinvertebrates from our quantitative targeted riffle samples was twice as high upstream at MAN01 compared to MAN02 in 2011. Quantitative samples from MAN01 averaged 267 more individuals than MAN02. Richness was similar at both sites. Taxonomic and functional diversity were higher downstream at MAN02.

Aquatic macroinvertebrate taxa can be separated based on their tolerance to perturbation or disturbance. Separating taxa into tolerance classes allows for inferences concerning the response of the aquatic macroinvertebrate community to stream conditions at the time of our sampling event. We found distinctions in the relative abundance and taxa richness of tolerance classes between our monitoring sites. Intolerant individuals had the highest relative abundance of samples at MAN01. At MAN02 moderately tolerant and intolerant individuals were nearly evenly split. Additionally, relative abundance of tolerant individuals at both sites combined equaled <1%. These data suggest that stream conditions were favorable for aquatic macroinvertebrates at the time of our visit in 2011.

Further evidence of favorable stream conditions exists in the EPT data collected from both monitoring sites. EPT taxa are known to be sensitive to degraded water quality. EPT taxa represented 85.01% of the individuals collected at MAN01 and 70.82% of the individuals collected at MAN02. Their large relative abundance values at both monitoring sites suggest that water quality at the time of our visit was advantageous for sensitive taxa.

4.2 Physical habitat and water quality

A few differences in physical habitat existed between our 2 monitoring sites. One of the biggest differences was in particle embeddedness. Particles in riffles along MAN02 continue to be more embedded than particles in riffles at MAN01. Additionally, over half of the habitat sampled at MAN02 did not fit into one of the categories we define as appropriate for aquatic macroinvertebrates. Conversely, rock made up the majority of the habitat found along MAN01. The large amount of habitat present and available (unembedded) at MAN01 compared with MAN02 may partially contribute to the large difference in abundances between the 2 monitoring sites.

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 in this report are provisional and are subject to change. When sufficient data are available, SCPN plans to produce an interpretive report including trend analysis of aquatic macroinvertebrate metrics and physical habitat data for the Mancos River.

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Appendix A Monitoring sites at Mesa Verde National Park, Colorado, 2011

Site Code	Common name	Report name	UTM X	UTM Y	Elevation (m)
MEVEMAN01	Mancos River At Gauge	MAN01	734375	4126163	1933
MEVEMAN02	Mancos River above down-stream boundary	MAN02	735878	4122566	1882

Appendix B Selected aquatic macroinvertebrate metrics

Metric type	Metric	Definition
Abundance/Richness/ Diversity	Total abundance	Total number of individuals.
	Taxa richness	Total number of taxa (measures the overall variety of aquatic macroinvertebrates in a sample).
	Simpson's diversity	A measure of the variety of taxa that takes into account the relative abundance of each taxon. $D = \sum(n_i(n_i -1)/N(N-1))$
Tolerance	Dominant taxa	Measures the dominance of the most abundant taxa. Typically calculated as dominant 2, 3, 4, or 5 taxa.
	Relative abundance tolerant taxa	Percent of individuals considered to be sensitive to perturbation.
	Percent richness of tolerant taxa	Percent of taxa considered to be sensitive 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 fine substrates).
	Percent richness burrowers	Percent of taxa that move between substrate particles (typically fine 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.
	Hydroptilidae+ Hydropsychidae/Trichoptera	Percent of trichopteran individuals in Hydroptilidae plus Hydropsychidae (ratio of tolerant caddisfly abundance to total caddisfly abundance).
	Relative abundance noninsect taxa	Percent of individuals that are not insects.
	Relative abundance Chironomidae	Percent of individuals that are midges.

Source: Data from Brasher et al. (2011)

Appendix C Aquatic macroinvertebrate species list from the MAN01 and MAN02 monitoring sites, Mesa Verde National Park, Colorado, 2011. "NEW" under the site column denotes a new record for this SCPN monitoring site.

Phylum	Class	Order	Family	SubFamily	Genus	Species	Common name	MAN01	MAN02
Annelida	Clitellata						segmented worms	x	x
Arthropoda	Arachnida	Trombidiformes	Sperchonidae		*Sperchon* sp.		water mites	x	x
Arthropoda	Arachnida	Trombidiformes					water mites	x	x
Arthropoda	Insecta	Coleoptera	Dryopidae		Postelichus sp.		long-toed water beetle	NEW	NEW
Arthropoda	Insecta	Coleoptera	Elmidae		*Microcylloepus*	*pusillus*	riffle beetles	x	x
Arthropoda	Insecta	Coleoptera	Elmidae		*Optioservus*	*quadrimaculatus*	riffle beetles		NEW
Arthropoda	Insecta	Coleoptera	Elmidae		*Optioservus* sp.		riffle beetles	x	
Arthropoda	Insecta	Coleoptera	Elmidae		*Zaitzevia*	*parvula* (Horn)	riffle beetles	x	NEW
Arthropoda	Insecta	Diptera	Athericidae		*Atherix*	*pachypus*	watersnipe flies		x
Arthropoda	Insecta	Diptera	Empididae	Hemerodromiinae	*Hemerodromia* sp.		dance flies	x	x
Arthropoda	Insecta	Diptera	Empididae				dance flies		x
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae	*Probezzia* sp.		biting midges		x
Arthropoda	Insecta	Diptera	Ceratopogonidae				biting midges	x	x
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae			midges	x	x
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae			midges	x	x
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae			midges	x	x
Arthropoda	Insecta	Diptera	Chironomidae				midges	x	x
Arthropoda	Insecta	Diptera	Psychodidae				moth and sand flies		x
Arthropoda	Insecta	Diptera	Simuliidae	Simuliinae	*Simulium* sp.		black flies	x	x
Arthropoda	Insecta	Diptera	Simuliidae				black flies	x	x
Arthropoda	Insecta	Diptera	Tipulidae		*Dicranota* sp.		pediciid crane flies	NEW	
Arthropoda	Insecta	Diptera	Tipulidae		*Hexatoma* sp.		limoniid crane flies	x	x
Arthropoda	Insecta	Diptera	Tipulidae	Tipulinae	*Tipula* sp.		large crane flies		x
Arthropoda	Insecta	Diptera					flies	x	
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae		*Tricorythodes* sp.		little stout crawler mayflies	x	x
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae		*Traverella*	*albertana*	pronggilled mayflies	NEW	
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae				pronggilled mayflies		x
Arthropoda	Insecta	Ephemeroptera	Baetidae		*Baetis* sp.		small minnow mayflies	x	x
Arthropoda	Insecta	Ephemeroptera	Baetidae		*Fallceon*	*quilleri*	small minnow mayflies	x	x

Appendix C *(continued)*

Phylum	Class	Order	Family	SubFamily	Genus	Species	Common name	MAN01	MAN02
Arthropoda	Insecta	Ephemeroptera	Heptageniidae		*Heptagenia* sp.		flatheaded mayflies		NEW
Arthropoda	Insecta	Ephemeroptera	Heptageniidae				flatheaded mayflies	x	x
Arthropoda	Insecta	Heteroptera	Veliidae		*Microvelia* sp.		smaller water striders		x
Arthropoda	Insecta	Hemiptera	Veliidae	Rhagoveliinae	*Rhagovelia* sp.		smaller water striders	x	x
Arthropoda	Insecta	Lepidoptera	Crambidae	Nymphulinae	*Petrophila* sp.		crambid snout moths	NEW	
Arthropoda	Insecta	Odonata	Gomphidae				clubtail dragonflies		x
Arthropoda	Insecta	Plecoptera	Perlidae		*Claassenia*	*sabulosa*	common stoneflies	NEW	
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlodinae	*Skwala*	*americana*	perlodid stoneflies	x	
Arthropoda	Insecta	Plecoptera	Perlodidae		*Isogenoides* sp.		perlodid stoneflies	NEW	
Arthropoda	Insecta	Plecoptera	Perlodidae				perlodid stoneflies	x	x
Arthropoda	Insecta	Plecoptera					stoneflies	x	
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	*Cheumatopsyche* sp.		netspinning caddisflies	x	x
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	*Hydropsyche* sp.		netspinning caddisflies	x	x
Arthropoda	Insecta	Trichoptera	Hydropsychidae				netspinning caddisflies	x	x
Arthropoda	Insecta	Trichoptera	Leptoceridae	Leptocerinae	*Oecetis* sp.		longhorned caddisflies	x	
Arthropoda	Insecta	Trichoptera	Rhyacophilidae		*Rhyacophila*	*vofixa*	Green sedge caddis-flies	NEW	
Arthropoda	Insecta	Trichoptera					caddisflies	NEW	
Arthropoda	Malacostraca	Decapoda	Cambaridae				crayfish	x	x
Nemata							nematodes	NEW	x

Appendix D Measured velocity and channel characteristics at the MAN01 and MAN02 monitoring sites, Mesa Verde National Park, Colorado, 2011

	Velocity (m/s)		Depth (m)		Wetted channel width (m)	Active channel width (m)
Transect	Mean	Std Dev	Mean	Std Dev	Value	Value
MAN01						
1	0.44	0.16	0.12	0.03	7.3	16.1
2	0.26	0.11	0.14	0.05	7.3	14.8
3	0.26	0.07	0.29	0.12	4.5	12.2
4	0.24	0.06	0.31	0.08	3.7	21.0
5	0.41	0.17	0.20	0.11	2.9	27.1
6	0.46	0.06	0.20	0.03	3.4	23.2
7	0.76	0.39	0.13	0.04	3.1	15.9
8	0.55	0.20	0.12	0.03	4.4	13.0
9	0.34	0.19	0.15	0.06	4.7	11.3
10	0.37	0.07	0.15	0.03	5.1	9.0
11	0.39	0.10	0.16	0.10	5.6	9.0
MAN02						
1	0.41	0.06	0.18	0.05	5.0	50.3
2	0.25	0.15	0.30	0.06	4.7	46.0
3	0.55	0.27	0.15	0.07	4.9	40.6
4	0.29	0.24	0.31	0.06	4.6	25.0
5	0.45	0.16	0.19	0.04	4.7	<50.0
6	0.83	0.54	0.12	0.03	4.6	<50.0
7	0.18	0.23	0.34	0.14	5.3	<50.0
8	0.29	0.10	0.19	0.08	5.4	<50.0
9	0.37	0.23	0.25	0.07	4.0	<50.0
10	0.35	0.25	0.12	0.04	7.0	<50.0
11	0.33	0.14	0.14	0.04	7.0	26.0