National Park Service
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Natural Resource Stewardship and Science

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

## *2010 Summary Report*

Natural Resource Data Series NPS/SCPN/NRDS—2012/239

ON THE COVER
Mesa Verde National Park
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# Aquatic Macroinvertebrate and Physical Habitat Monitoring for the Mancos River in Mesa Verde National Park

*2010 Summary Report*

Natural Resource Data Series NPS/SCPN/NRDS—2012/239

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February 2012

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Funding for the SCPN water resources field crew was provided to Northern Arizona University by the National Park Service through Colorado Plateau CESU Agreement H1200040002 (Task NAU-331). Funding for aquatic macroinvertebrate identification and enumeration was provided by the National Park Service to Utah State University through Colorado Plateau CESU Agreement H1200090005 (Task USUCP-51).

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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 crew leader for the project. The 2010 crew consisted of Kelly Lawrence, and Melissa Dyer. SCPN staff provided support for the project.

Please cite this publication as:

Stumpf, S. E., and S. A. Monroe. 2012. Aquatic macroinvertebrate and physical habitat monitoring for the Mancos River in Mesa Verde National Park: 2010 summary report. Natural Resource Data Series NPS/SCPN/NRDS—2012/239. National Park Service, Fort Collins, Colorado.

NPS 307/112713, February 2012

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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), as part of the process of developing the *Aquatic Macroinvertebrate Monitoring Protocol for the Southern Colorado Plateau Network* (Brasher et al. 2011). 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 (fig. 1). 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 monitoring activities that occurred in 2010, (b) summarize data that were collected, and (c) where appropriate, place these data in the context of the 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 September 10–11, 2010, the SCPN water resources field crew collected aquatic macroinvertebrate samples and physical habitat data at two 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).

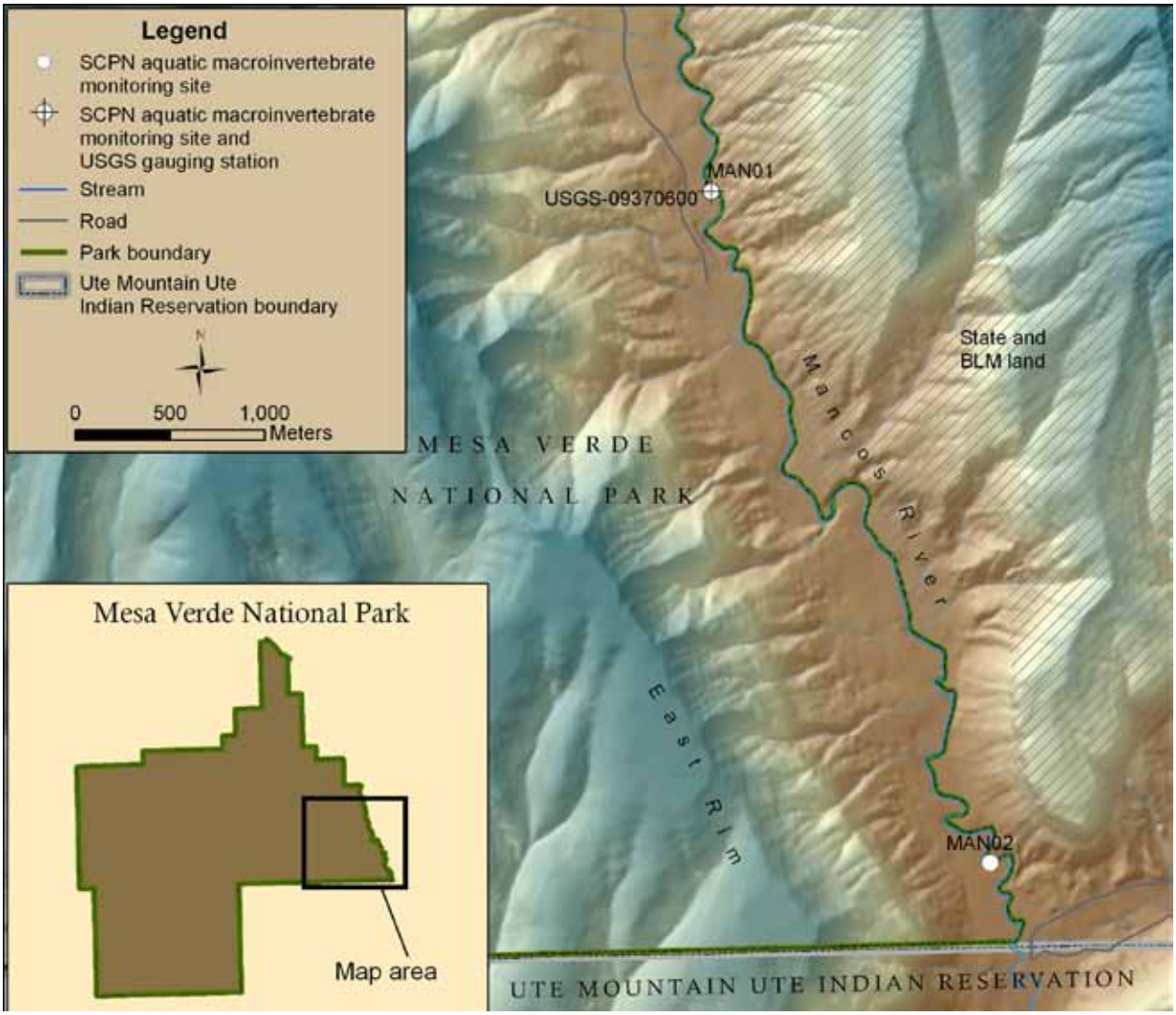



**Figure 1.** Map of Mancos River, Mesa Verde National Park, Colorado, with the location of two monitoring sites, MAN01 and MAN02, in 2010

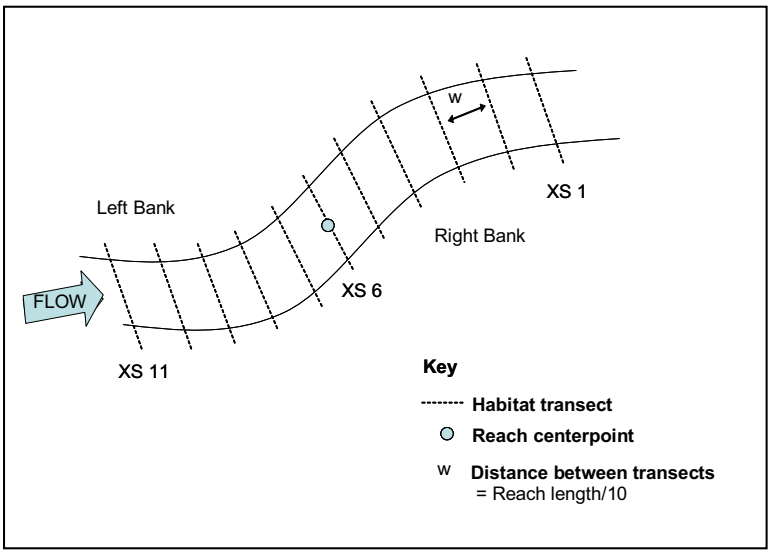



**Figure 2.** General aquatic macroinvertebrate sampling reach layout

We collected two types of aquatic macroinvertebrate samples at MAN01 and MAN02 in 2010. These were:

- Replicate quantitative samples were collected 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 was collected 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, which were 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 three 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 five 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 reach
  - measured geomorphic channel units (GCU) at five 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 characterized by 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 across the length of the entire reach (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 five 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 2010. 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 288.20 individuals at MAN01 (fig. 3). Sample abundances at MAN01 ranged from 200 (low) to 397 (high). Abundance at MAN02 averaged 419.20 individuals. Sample abundances ranged from a low of 246 to a high of 572.

**Taxa richness**. Quantitative targeted riffle richness was 15.00 taxa at MAN01 (fig. 4). Samples ranged from a low of 14 taxa to a high of 18. Richness at MAN02 averaged 12.60 taxa. Richness values from MAN02 ranged from a low of 9 taxa to a high of 16 taxa. Richness from qualitative multihabitat samples was 25 taxa at MAN01 and 19 taxa at MAN02.

**Diversity**. We measured taxonomic and functional diversity using the Simpson's Diversity Index. Taxonomic diversity averaged 0.71 at MAN01 and 0.54 at MAN02 (fig. 5a). Functional diversity averaged 0.58 at MAN01 and 0.47 at MAN02 (fig. 5b).

**Anthropogenic stress tolerance**. Relative abundance and taxa richness values for tolerance classes at MAN01 were dominated by moderately tolerant taxa (figs. 6a, 6b). Relative abundance of moderately tolerant taxa at MAN01 averaged 55.99%. Richness of moderately tolerant taxa averaged

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

[a]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 at the Mancos River in Mesa Verde National Park, Colorado, 2007–2010. 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 | | 2010 | |
|---|---|---|---|---|---|---|---|---|
| **Quantitative metric** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| Total abundance | 31.20 | 18.66 | 145.00 | 68.52 | 254.60 | 179.83 | 288.20 | 78.72 |
| Total richness | 5.20 | 0.84 | 8.80 | 2.77 | 14.60 | 3.13 | 15.00 | 1.73 |
| Simpson's Diversity—taxonomic | 0.66 | 0.06 | 0.51 | 0.16 | 0.64 | 0.12 | 0.71 | 0.06 |
| Simpson's Diversity—functional group | 0.38 | 0.07 | 0.36 | 0.11 | 0.53 | 0.08 | 0.58 | 0.05 |
| Dominant taxa | 55.83 | 4.41 | 67.89 | 12.07 | 53.65 | 13.56 | 43.96 | 7.47 |
| **Tolerance group** | | | | | | | | |
| Relative abundance of tolerant taxa (%) | 0.00 | 0.00 | 0.27 | 0.60 | 0.00 | 0.00 | 0.67 | 0.74 |
| Relative abundance of moderately tolerant taxa (%) | 75.79 | 9.88 | 26.47 | 9.81 | 35.34 | 9.51 | 55.99 | 8.81 |
| Relative abundance of intolerant taxa (%) | 24.21 | 9.88 | 73.26 | 9.95 | 64.66 | 9.51 | 43.33 | 8.99 |
| Richness of tolerant taxa (%) | 0.00 | 0.00 | 3.33 | 7.45 | 0.00 | 0.00 | 7.13 | 5.12 |
| Richness of moderately tolerant taxa (%) | 55.33 | 19.27 | 58.73 | 9.83 | 58.09 | 7.21 | 56.78 | 8.07 |
| Richness of intolerant taxa (%) | 44.67 | 19.27 | 37.94 | 8.92 | 41.91 | 7.21 | 36.09 | 5.51 |
| **Functional group** | | | | | | | | |
| Relative abundance of collector-filterers (%) | 27.61 | 25.19 | 76.88 | 8.45 | 56.35 | 12.99 | 42.11 | 9.23 |
| Relative abundance of collector-gatherers (%) | 68.47 | 22.86 | 19.03 | 7.82 | 35.93 | 12.78 | 47.39 | 8.53 |
| Relative abundance of scrapers (%) | 0.00 | 0.00 | 0.24 | 0.36 | 0.04 | 0.08 | 1.04 | 0.50 |
| Relative abundance of shredders (%) | 0.00 | 0.00 | 0.18 | 0.41 | 0.85 | 0.59 | 0.06 | 0.13 |
| Relative abundance of predators (%) | 3.93 | 4.27 | 3.65 | 0.93 | 6.83 | 1.31 | 9.40 | 5.65 |
| Richness of collector-filterers (%) | 31.33 | 12.38 | 33.35 | 7.49 | 16.66 | 3.72 | 13.78 | 1.13 |
| Richness of collector-gatherers (%) | 57.33 | 7.23 | 36.41 | 9.92 | 30.71 | 8.10 | 39.66 | 3.67 |
| Richness of scrapers (%) | 0.00 | 0.00 | 3.54 | 4.91 | 1.00 | 2.24 | 6.89 | 0.56 |
| Richness of shredders (%) | 0.00 | 0.00 | 2.50 | 5.59 | 5.63 | 3.39 | 1.18 | 2.63 |
| Richness of predators (%) | 11.33 | 10.43 | 24.20 | 5.86 | 45.99 | 8.37 | 38.49 | 3.99 |
| **Taxonomic group** | | | | | | | | |
| Number of EPT taxa | 3.00 | 0.71 | 4.40 | 0.89 | 5.60 | 0.55 | 4.40 | 1.52 |
| Relative abundance of EPT taxa (%) | 73.51 | 16.87 | 89.52 | 3.86 | 62.88 | 13.64 | 72.39 | 10.56 |
| Relative abundance of Ephemeroptera (%) | 59.43 | 18.82 | 12.76 | 6.57 | 5.72 | 2.60 | 33.38 | 14.58 |
| Relative abundance of Plecoptera (%) | 0.00 | 0.00 | 1.99 | 2.10 | 3.04 | 0.62 | 0.46 | 0.48 |
| Relative abundance of Trichoptera (%) | 14.08 | 4.69 | 74.77 | 8.82 | 54.12 | 14.17 | 38.56 | 8.99 |
| Relative abundance of noninsect taxa (%) | 3.93 | 4.27 | 1.23 | 0.95 | 11.21 | 10.13 | 2.40 | 1.65 |
| Relative abundance of Chironomid Diptera (%) | 9.04 | 7.44 | 6.53 | 2.99 | 19.41 | 5.20 | 13.45 | 6.95 |
| Relative abundance of non-Chironomid Diptera (%) | 13.53 | 22.31 | 2.37 | 1.46 | 6.39 | 2.27 | 10.70 | 3.38 |
| Relative abundance of Coleoptera (%) | 0.00 | 0.00 | 0.27 | 0.41 | 0.11 | 0.25 | 0.99 | 0.81 |
| Relative abundance of Odonata (%) | 0.00 | 0.00 | 0.09 | 0.20 | 0.00 | 0.00 | 0.06 | 0.13 |

**Table 3**. Quantitative metrics for aquatic macroinvertebrate samples collected from MAN02 at the Mancos River in Mesa Verde National Park, Colorado, 2007–2010. 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 | | 2010 | |
|---|---|---|---|---|---|---|---|---|
| **Quantitative metric** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| Total abundance | 74.00 | 20.48 | 106.40 | 118.73 | — | — | 419.20 | 121.49 |
| Total richness | 6.60 | 1.34 | 8.20 | 3.03 | — | — | 12.60 | 2.88 |
| Simpson's Diversity—taxonomic | 0.60 | 0.10 | 0.63 | 0.12 | — | — | 0.54 | 0.09 |
| Simpson's Diversity—functional group | 0.50 | 0.40 | 0.48 | 0.13 | — | — | 0.47 | 0.11 |
| Dominant taxa | 56.79 | 6.00 | 56.03 | 13.19 | — | — | 63.16 | 9.58 |
| **Tolerance group** | | | | | | | | |
| Relative abundance of tolerant taxa (%) | 0.25 | 0.56 | 0.00 | 0.00 | — | — | 0.05 | 0.11 |
| Relative abundance of moderately tolerant taxa (%) | 82.43 | 9.77 | 50.00 | 20.42 | — | — | 28.27 | 6.24 |
| Relative abundance of intolerant taxa (%) | 17.32 | 9.87 | 50.00 | 20.42 | — | — | 71.69 | 6.31 |
| Richness of tolerant taxa (%) | 2.86 | 6.39 | 0.00 | 0.00 | — | — | 1.43 | 3.19 |
| Richness of moderately tolerant taxa (%) | 53.00 | 13.98 | 50.59 | 5.02 | — | — | 53.24 | 9.85 |
| Richness of intolerant taxa (%) | 44.14 | 12.80 | 49.41 | 5.02 | — | — | 45.34 | 11.01 |
| **Functional group** | | | | | | | | |
| Relative abundance of collector-filterers (%) | 32.95 | 7.82 | 49.46 | 28.85 | — | — | 67.48 | 11.19 |
| Relative abundance of collector-gatherers (%) | 61.92 | 6.65 | 40.82 | 26.81 | — | — | 23.02 | 6.06 |
| Relative abundance of scrapers (%) | 0.45 | 1.02 | 0.80 | 1.40 | — | — | 0.08 | 0.11 |
| Relative abundance of shredders (%) | 0.00 | 0.00 | 0.93 | 1.46 | — | — | 0.00 | 0.00 |
| Relative abundance of predators (%) | 4.68 | 1.86 | 7.98 | 3.07 | — | — | 9.43 | 6.16 |
| Richness of collector-filterers (%) | 31.33 | 6.39 | 31.36 | 13.41 | — | — | 21.39 | 6.79 |
| Richness of collector-gatherers (%) | 39.67 | 6.25 | 33.24 | 8.28 | — | — | 28.23 | 4.99 |
| Richness of scrapers (%) | 2.50 | 5.59 | 4.86 | 6.82 | — | — | 2.92 | 4.06 |
| Richness of shredders (%) | 0.00 | 0.00 | 4.17 | 5.89 | — | — | 0.00 | 0.00 |
| Richness of predators (%) | 26.50 | 8.79 | 26.38 | 4.94 | — | — | 47.46 | 5.00 |
| **Taxonomic group** | | | | | | | | |
| Number of EPT taxa | 3.40 | 0.89 | 4.80 | 1.64 | — | — | 4.80 | 1.30 |
| Relative abundance of EPT taxa (%) | 73.37 | 12.52 | 88.81 | 3.28 | — | — | 88.04 | 5.34 |
| Relative abundance of Ephemeroptera (%) | 59.04 | 8.10 | 38.99 | 26.53 | — | — | 20.12 | 5.45 |
| Relative abundance of Plecoptera (%) | 3.00 | 2.17 | 5.23 | 4.58 | — | — | 3.61 | 1.07 |
| Relative abundance of Trichoptera (%) | 11.33 | 7.95 | 44.60 | 28.79 | — | — | 64.31 | 9.50 |
| Relative abundance of noninsect taxa (%) | 1.43 | 0.90 | 1.40 | 2.32 | — | — | 5.01 | 5.96 |
| Relative abundance of Chironomid Diptera (%) | 3.13 | 2.57 | 1.98 | 1.82 | — | — | 1.70 | 1.39 |
| Relative abundance of non-Chironomid Diptera (%) | 21.62 | 12.31 | 6.16 | 4.80 | — | — | 5.20 | 4.78 |
| Relative abundance of Coleoptera (%) | 0.45 | 1.02 | 1.58 | 1.65 | — | — | 0.05 | 0.10 |
| Relative abundance of Odonata (%) | 0.00 | 0.00 | 0.07 | 0.15 | — | — | 0.00 | 0.00 |

**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, 2007–2010. No data were collected at MAN02 in 2009.

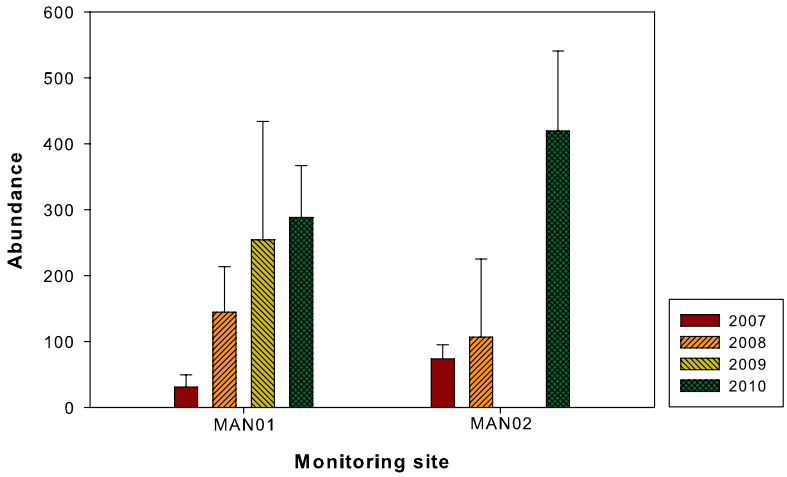



**Figure 4**. Mean taxa richness of quantitative targeted riffle samples and total taxa richness of qualitative multihabitat samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2010. No data were collected at MAN02 in 2009.

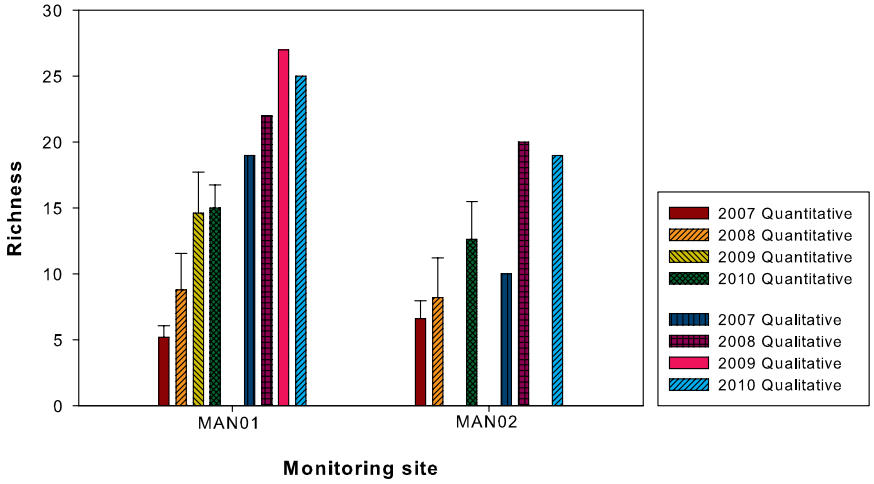
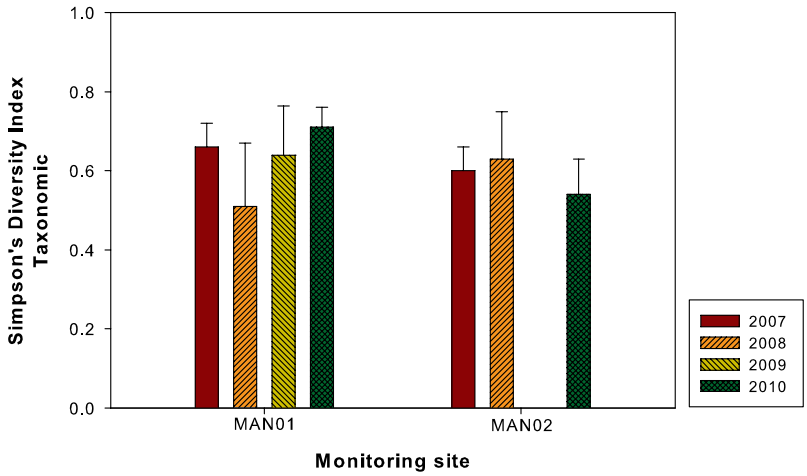



**Figure 5a**. Simpson's Diversity Index for taxonomic diversity in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2010. Values are means of all quantitative samples collected from each site. No data were collected at MAN02 in 2009.



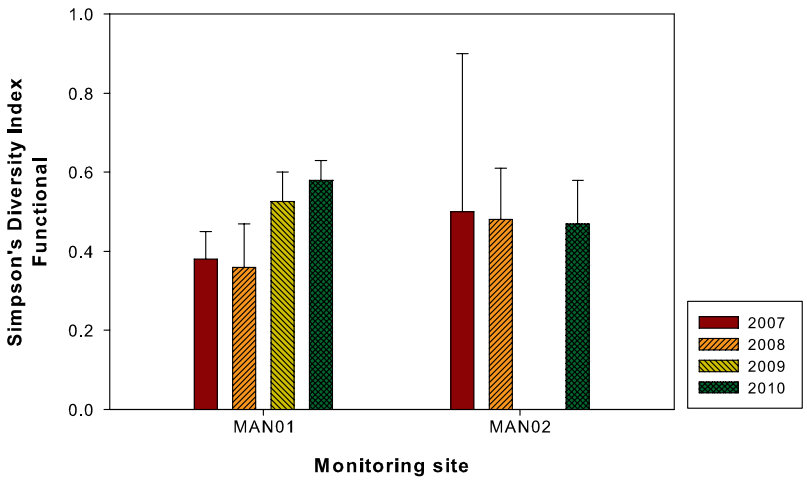



**Figure 5b**. Simpson's Diversity Index for functional diversity in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2010. Values are means of all quantitative samples collected from each site. No data were collected at MAN02 in 2009.

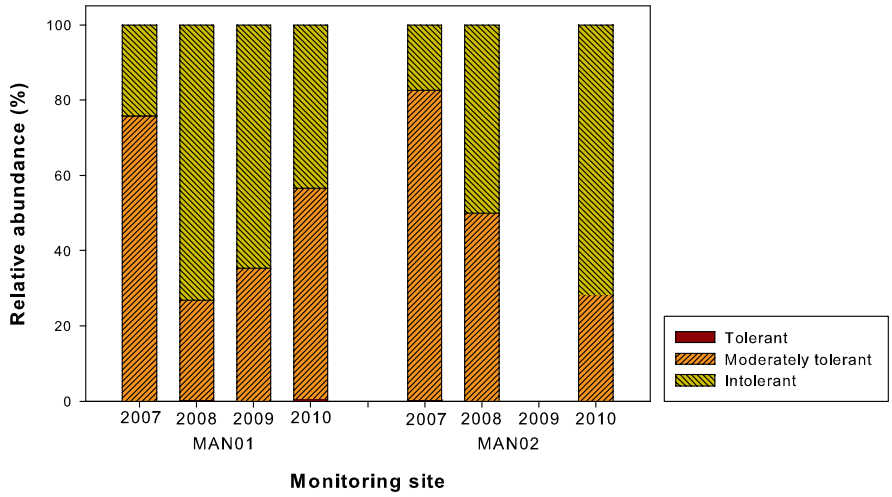



**Figure 6a**. Mean relative abundance of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2010, based on their tolerance to perturbation. No data were collected at MAN02 in 2009.

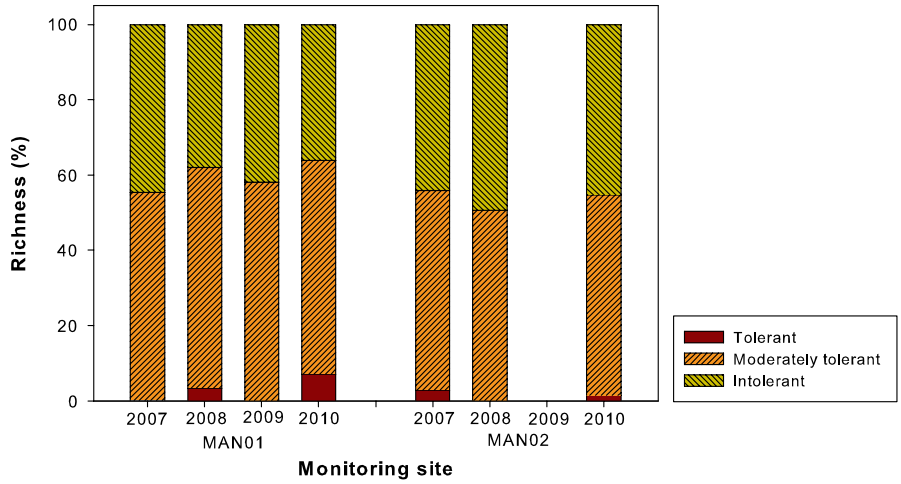



**Figure 6b**. Mean richness of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE 2007–2010, based on their tolerance to perturbation. No data were collected at MAN02 in 2009.

56.78% at MAN01. Intolerant individuals and taxa were the second most abundant at MAN01. Relative abundance and richness of intolerant individuals and taxa averaged 43.33% and 36.09% respectively at MAN01. Very few tolerant individuals, 0.67%, or taxa, 7.13%, were found at MAN01. Intolerant individuals dominated samples from MAN02. Relative abundance for intolerant individuals averaged 71.69%. Relative abundance of moderately tolerant taxa averaged 28.27%. Very few tolerant individuals (0.05%) were found at MAN02. Moderately tolerant taxa were the most taxa rich at MAN02, averaging 53.24% of the taxa per sample. Intolerant taxa averaged 45.34% and tolerant taxa averaged 1.43% at MAN02.

**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 38.56% of the individuals collected from MAN01 and 64.31% of the individuals from MAN02. Ephemeroptera were the second most abundant at both sites, averaging 33.38% at MAN01 and 20.12% at MAN02. Few plecopterans were collected at either site: 0.46% from MAN01 and 3.61% from MAN02.

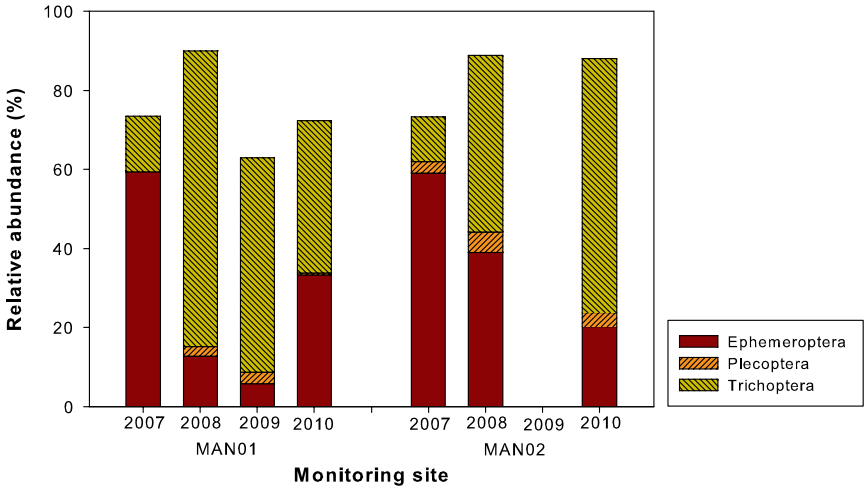



**Figure 7**. Relative abundance of sensitive EPT orders in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2010. No data were collected at MAN02 in 2009.

**Aquatic macroinvertebrate orders**. Trichoptera and Ephemeroptera were the most abundant orders collected from quantitative samples from MAN01 (fig. 8). Chironomids (midges) were the third most abundant order sampled at MAN01, averaging 13.45%. Non-chironomid dipterans (flies) averaged 10.70% and noninsect taxa (worms, water mites, and springtails) averaged 2.40%. Very few coleopterans (beetles), only .99%, or odonates (damselflies/dragonflies), 0.06%, were found at MAN01 in 2010. Similarly to MAN01, Trichoptera and Ephemeroptera were the most abundant orders collected at MAN02 in 2010. Non-chironomid dipterans were the next most abundant group sampled at MAN02, averaging 5.20%. Noninsect orders (water mites) averaged 5.01%, chironomids averaged 1.70%, and coleopterans averaged 0.05%. No odonates were collected at MAN02.

**Functional feeding groups**. Collector-gatherers were the most abundant group at MAN01 at 47.39% (fig. 9). Collector-filterers were the second most abundant functional group at MAN01, averaging 42.11%. Predators averaged 9.40% followed by scrapers at 1.04% and shredders at 0.06%. Collector-filterers were the most abundant functional group collected at MAN02, averaging 67.48%. Collector-gatherers were the second most abundant, averaging 23.02%, followed by predators at 9.43%, and scrapers at 0.08%. No shredders were collected at MAN02.

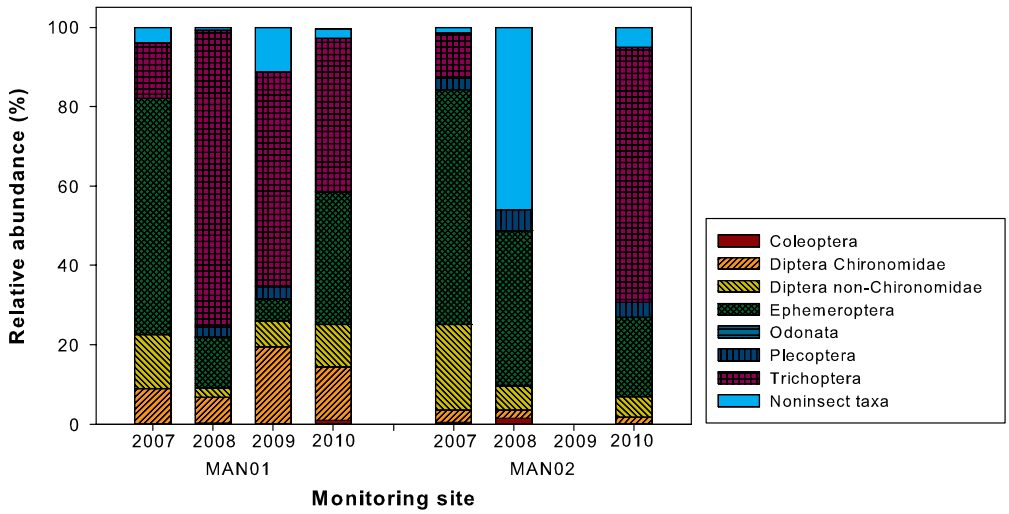



**Figure 8**. Relative abundance of orders in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River, in MEVE, 2007–2010. No data were collected at MAN02 in 2009.

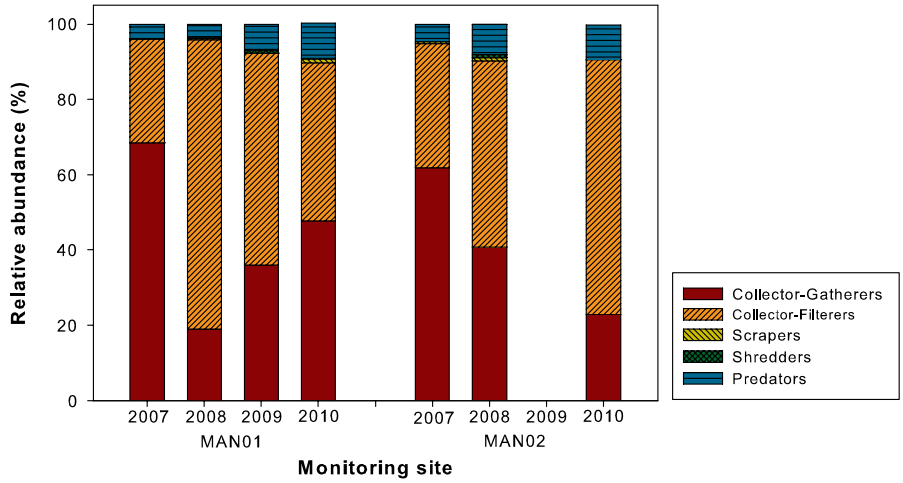



**Figure 9.** Relative abundance of functional feeding groups in quantitative targeted riffle samples collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2010. No data were collected at MAN02 in 2009.

### 3.2 Physical habitat characteristics

Physical habitat data collected at MAN01 and MAN02 from 2007 to 2010 are presented in Tables 4 and 5. Additional transect data can be found in Appendix D.

**Microhabitat**. Velocity at the targeted riffle sampling areas averaged 0.47 m/s at MAN01 and 0.77 m/s at MAN02. Depths were identical at the two sampling reaches, averaging 0.14 m. On average, 39.8% of each particle was embedded at MAN01, while 48.4% of each particle was embedded at MAN02 (figs. 10a, b).

**Transect**. Active channel widths averaged 8.4 m at MAN01 and 8.0 m at MAN02. Velocity averaged 0.51 m/s at MAN01 and 0.40 m/s at MAN02. Depths were identical for both sampling reaches, averaging 0.21 m. Riparian canopy cover was sparse, averaging 1.3% at MAN02 and 0.0% at MAN01 (tables 4, 5).

Rock was the dominant habitat type at MAN01, accounting for 68.0% of the habitat sampled (fig. 11). Vegetation was the second most abundant habitat type at 14.7%. Root wad and woody debris were also present at 5.3% and 4.0% respectively. At MAN02, rock was again the dominant habitat type, but less abundant than upstream, accounting for 49.3% of the habitat sampled. Root wads were

**Table 4.** Physical habitat and hydrologic data from MAN01 at Mancos River in Mesa Verde National Park, Colorado, 2007–2010. Particle embeddedness and canopy closure measurements are expressed as percentages.

| | 2007 | | 2008 | | 2009 | | 2010 | |
|---|---|---|---|---|---|---|---|---|
| **Physical habitat metric** | **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 |
| Depth (m) | 0.18 | 0.07 | 0.13 | 0.04 | 0.11 | 0.05 | 0.14 | 0.05 |
| Embeddedness (%) | 19.2 | 9.0 | 31.6 | 5.6 | 26.3 | 12.7 | 39.8 | 3.0 |
| **Transect level** | | | | | | | | |
| **Channel dimensions** | | | | | | | | |
| Velocity (m/s) | 0.68 | 0.23 | 0.50 | 0.23 | 0.41 | 0.10 | 0.51 | 0.17 |
| Depth (m) | 0.30 | 0.10 | 0.30 | 0.15 | 0.13 | 0.05 | 0.21 | 0.08 |
| Wetted channel width (m) | 5.7 | 2.1 | 5.6 | 1.8 | 6.3 | 1.2 | 4.9 | 1.9 |
| Active channel width (m) | 7.5 | 2.2 | 9.4 | 3.3 | 10.0 | 3.1 | 8.4 | 2.0 |
| **Riparian cover** | | | | | | | | |
| Canopy closure (%) | 9.0 | 12.9 | 19.3 | 25.8 | 4.8 | 6.9 | 0.0 | 0.0 |
| **Reach level** | | | | | | | | |
| **Water quality** | **Value** | | **Value** | | **Value** | | **Value** | |
| Temperature (°C) | 10.8 | | 17.5 | | 9.0 | | 14.2 | |
| Specific conductivity (µS/cm) | — | | 945 | | 1510 | | 1290 | |
| pH | — | | 8.5 | | 8.4 | | 8.4 | |
| Dissolved oxygen (% saturation) | — | | 106 | | 91.3 | | 104.2 | |
| Dissolved oxygen (mg/L) | — | | 10.1 | | 8.2 | | 8.3 | |
| Turbidity (NTU) | — | | 12.2 | | 16.7 | | 9.8 | |
| Discharge (cfs) | 46.0[a] | | 19.0[a] | | 10.0 | | 11.5 | |

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

**Table 5.** Physical habitat and hydrologic data from MAN02 at Mancos River in Mesa Verde National Park, Colorado, 2007–2010. Particle embeddedness and canopy closure measurements are expressed as percentages.

| | 2007 | | 2008 | | 2009 | | 2010 | |
|---|---|---|---|---|---|---|---|---|
| **Physical habitat metric** | **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 |
| Depth (m) | 0.15 | 0.05 | 0.06 | 0.01 | — | — | 0.14 | 0.07 |
| Embeddedness (%) | 28.0 | 12.9 | 27.6 | 8.5 | — | — | 48.4 | 12.9 |
| **Transect level** | | | | | | | | |
| **Channel dimensions** | | | | | | | | |
| Velocity (m/s) | 0.63 | 0.19 | 0.45 | 0.19 | — | — | 0.40 | 0.18 |
| Depth (m) | 0.31 | 0.10 | 0.25 | 0.07 | — | — | 0.21 | 0.07 |
| Wetted channel width (m) | 6.4 | 2.4 | 5.4 | 0.9 | — | — | 5.4 | 1.7 |
| Active channel width (m) | 10.3 | 4.2 | 10.0 | 2.6 | — | — | 8.0 | 2.8 |
| **Riparian cover** | | | | | | | | |
| Canopy closure (%) | 14.3 | 26.8 | 23.0 | 33.4 | — | — | 1.3 | 4.6 |
| **Reach level** | | | | | | | | |
| **Water quality** | **Value** | | **Value** | | **Value** | | **Value** | |
| Temperature (°C) | 11.2 | | 16.9 | | — | | 13.4 | |
| Specific conductivity (µS/cm) | — | | 993 | | — | | 1330 | |
| pH | — | | 8.5 | | — | | 8.3 | |
| Dissolved oxygen (% saturation) | — | | 104.9 | | — | | 106.1 | |
| Dissolved oxygen (mg/L) | — | | 10.2 | | — | | 8.6 | |
| Turbidity (NTU) | — | | 16 | | — | | 18 | |
| Discharge (cfs) | 41.0[a] | | 19.0[a] | | — | | 10.4 | |

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

**Figure 10a**. Mean particle embeddedness at each of five individual quantitative targeted riffle habitats collected from MAN01 and MAN02 at the Mancos River in MEVE, 2010

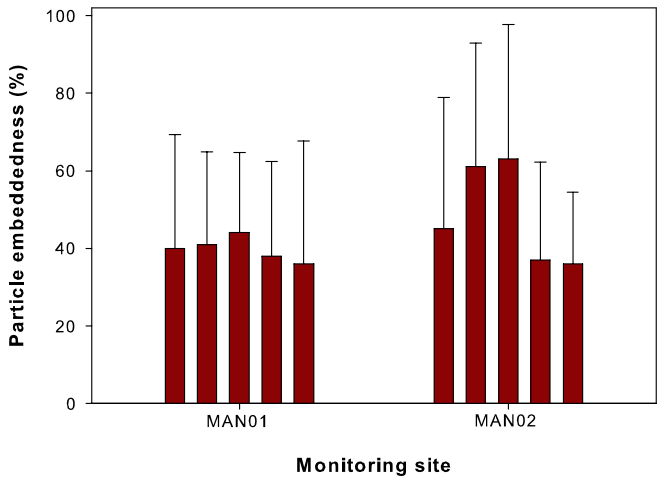



**Figure 10b**. Mean particle embeddedness at quantitative targeted riffle habitats collected from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2010. No data were collected at MAN02 in 2009.

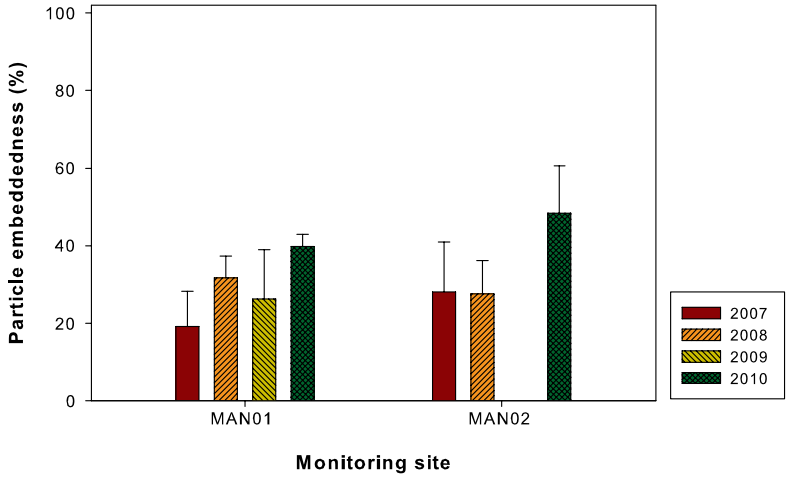
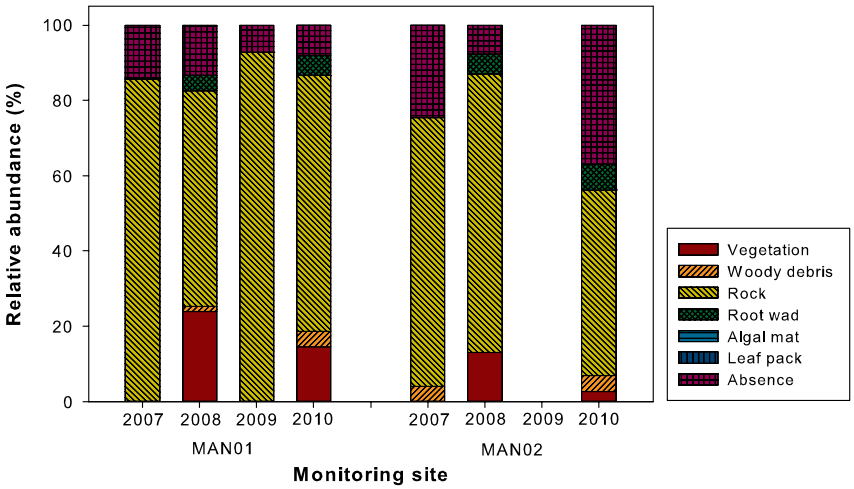



**Figure 11**. Aquatic macroinvertebrate habitat characterization based upon line point intercept data collected along habitat transects from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2010. No data were collected at MAN02 in 2009. Some habitat structure types were not observed.



the second most abundant habitat type at 6.9%. Woody debris and vegetation were also present at 4.1% and 2.7% respectively. At MAN02, 37.0% of the habitat was categorized as "Absence", meaning it did not fit into a category that SCPN has identified as appropriate for aquatic macroinvertebrates.

**Reach**. Channel structure dynamics are represented by particle size distributions in Figures 12a and b, and are based on modified Wolman pebble counts. Fines (<2 mm) were the most abundant size class at both sampling reaches in 2010. Fines were detected along 26.2% of MAN01 and 32.3% of MAN02. Cobbles (64–128 mm) and coarse gravels (32–64 mm) were the next most abundant at MAN01, making up 24.9% and 22.2% of the reach respectively. At MAN02, coarse gravels and cobbles were next most abundant, at 19.0% and 16.7%, respectively.

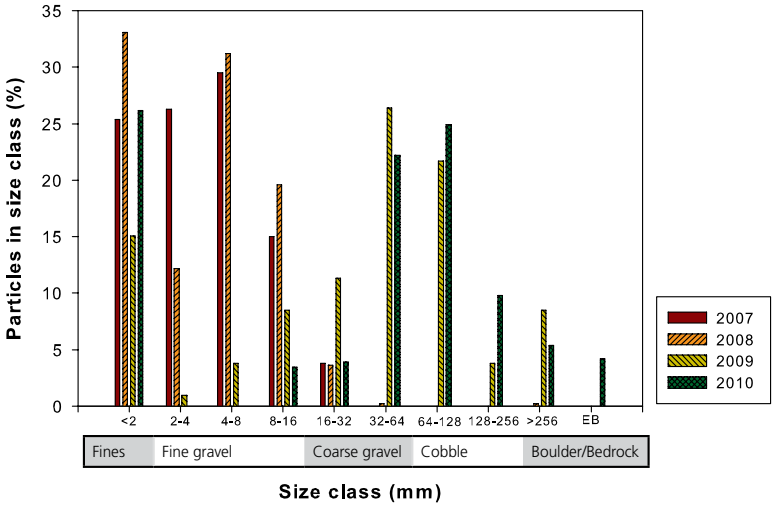



**Figure 12a**. Particle size distribution, based on modified Wolman pebble counts (minimum 400 particles), for aquatic macroinvertebrate sampling from MAN01 at the Mancos River in MEVE, 2007–2010. EB represents particles that are completely embedded into the stream channel, which precludes size measurements.

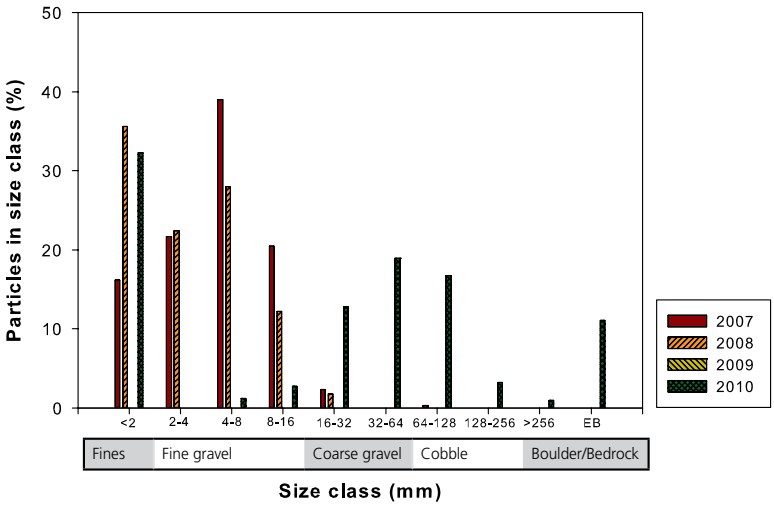
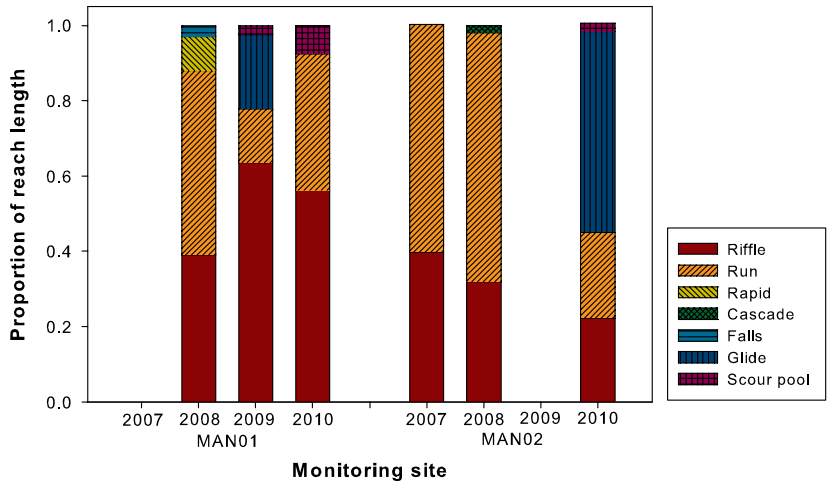



**Figure 12b**. Particle size distribution, based on modified Wolman pebble counts (minimum 400 particles), for aquatic macroinvertebrate sampling from MAN02 at the Mancos River in MEVE, 2007–2010. No data were collected at MAN02 in 2009. EB represents particles that are completely embedded into the stream channel, which precludes size measurements.

Riffles were the most abundant GCU at MAN01, found along 56.2% of the sampling reach (fig. 13). Runs were found along 36.3% of MAN01 and scour pools found along 7.5%. Glides were the dominant GCU downstream at MAN02 and were found along 53.3% of the sampling reach. Riffles and runs were equally abundant, occurring along 22.3% and 22.1% of the reach respectively. Scour pools were found along 2.3% of MAN02.

**Figure 13**. Geomorphic channel unit characterization from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2010. No data were collected at MAN01 in 2007, or MAN02 in 2009.



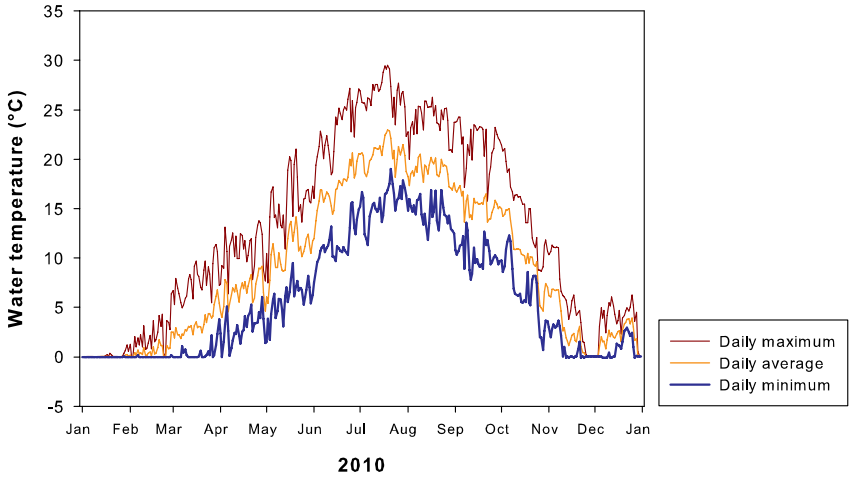

## 3.3 Hydrologic conditions

### *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). The midday temperature at MAN01 was 14.2°C. Specific conductivity was 1290 µS/cm, pH 8.4, and dissolved oxygen 8.3 mg/L. Turbidity was 9.8 NTU and stream discharge was 11.5 cfs. The midday temperature at MAN02 was 13.4°C. Specific conductivity and pH were 1330 µS/cm and 8.3 respectively. Dissolved oxygen was 8.6 mg/L. Turbidity was 18 NTU. Stream discharge measured 10.4 cfs.

Daily water and air temperatures were collected from MAN01 at the Mancos River every 15 minutes during 2010 (figs. 14a, 14b). The average water temperature for 2010 was 9.1°C. A low water temperature of -0.1°C was recorded at 0315 hrs on 12 November. A high water temperature of 29.5°C was recorded at 1500 hrs on 17 July. The average air temperature at MAN01 was 7.7°C. A low air temperature of -25.4°C was recorded at 2345 hrs on 31 December. A high air temperature of 39.4°C was recorded at 1745 hrs on 16 July.

**Figure 14a**. Water temperature recorded at 15 minute intervals in 2010 from MAN01 at the Mancos River in MEVE



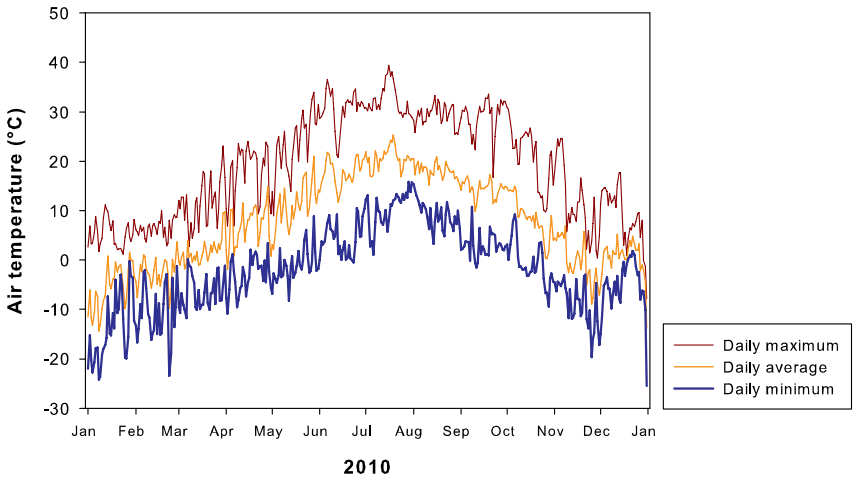



**Figure 14b**. Air temperature recorded at 15 minute intervals in 2010 from MAN01 at the Mancos River in MEVE

### *3.3.2 USGS/NOAA station data*

The USGS collects streamflow data at the gauging station, *Mancos River at Anitas Flat*, Mesa Verde National Park, CO (09370600) (USGS 2010). Figure 15 shows the hydrograph from February 2 through December 31 of 2010. The hydrograph shows large spikes that coincide with the typical snow melt period from March to June. Several smaller spikes occur during the monsoon months of July to September.

Precipitation was tracked by the National Oceanic and Atmospheric Administration's National Climatic Data Center (NOAA/NCDC) weather station 055327. Precipitation events appear to be well spread out throughout 2010 with the exception of the early summer months (fig. 16). The majority of precipitation events were small, measuring a daily total of <1.0 cm.

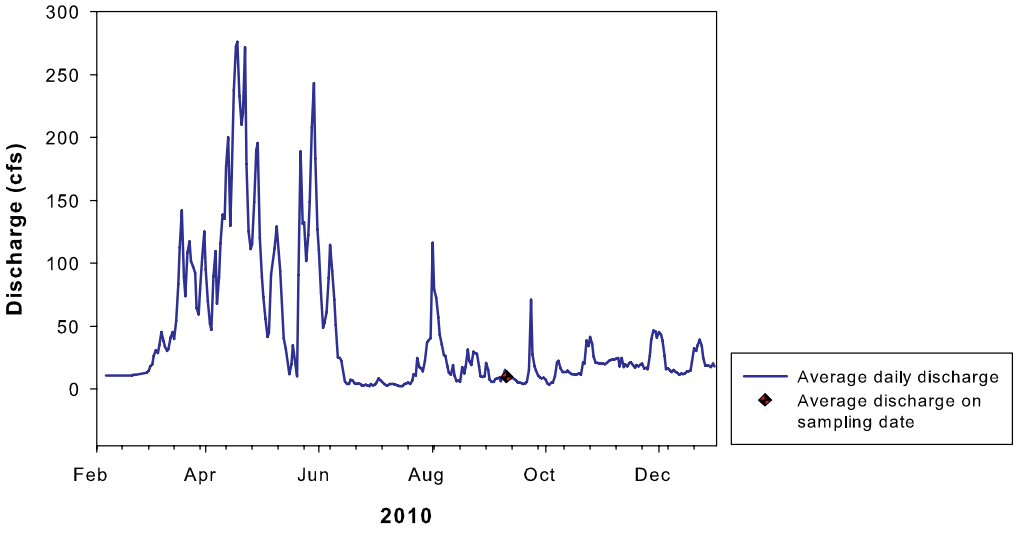
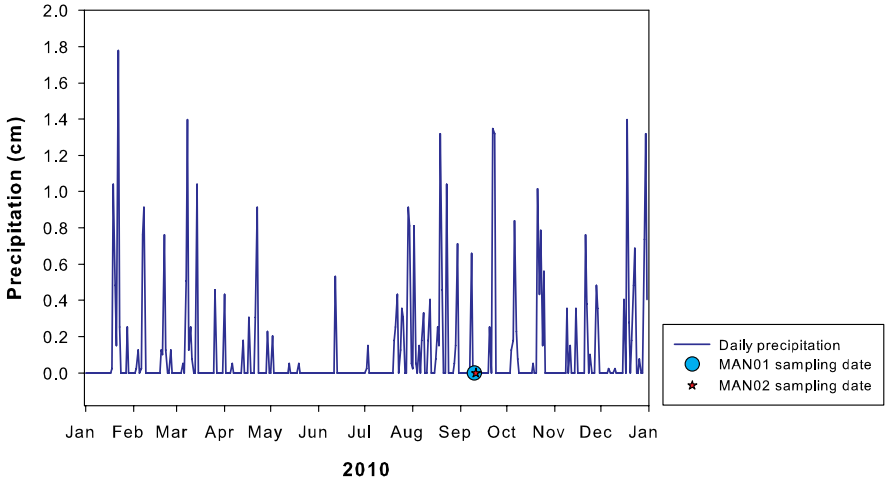



**Figure 15**. Hydrograph from the USGS streamflow gauging station (09370600) near MAN01 at the Mancos River in MEVE, 2010

**Figure 16**. Total daily precipitation from the NOAA/NCDC weather station (055327) at Mancos, Colorado, 2010




# 4 Discussion

This report presents data from SCPN's fourth 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 four 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

Relative abundance and richness numbers differed between our two monitoring sites at MEVE in 2010. Quantitative samples collected from MAN02 averaged 130 more individuals than samples collected from MAN01. However, samples from MAN01 averaged 2.4 more taxa per quantitative sample and qualitative samples had 6 more taxa than MAN02. As a result, taxonomic and functional diversity were higher at MAN01, even though fewer individuals were collected from that site.

Aquatic macroinvertebrate taxa can be separated based on their tolerance to perturbation or disturbance. Separating taxa into anthropogenic stress 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. Relative abundances of moderately tolerant and intolerant individuals were fairly evenly divided at MAN01. At MAN02 intolerant individuals were by far the most abundant, accounting for nearly two-thirds of the individuals collected from that site. 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 2010.

Further evidence of favorable stream conditions exists in the EPT data collected from both monitoring sites. EPT taxa are known to be susceptible to degraded water quality. EPT taxa represented 72.39% of the individuals collected at MAN01 and 88.04% 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

Very few differences in physical habitat or water quality existed between our two monitoring sites. The only large difference found between the two sites existed in aquatic macroinvertebrate habitat. Vegetation comprised 12% more of the habitat found along transects at MAN01 than at MAN02. These data could be one contributing factor to the greater diversity we see at MAN01. The greater presence of aquatic vegetation, which can serve as cover and nutrition for some taxa, may result in the accumulation of taxa not seen where vegetation is sparse.

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, 2010

| 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, 2010. A bold **X** 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 | | | | | | | segmented worms | X | X |
| Arthropoda | Arachnida | Trombidiformes | Sperchonidae | | *Sperchon* sp. | | water mites | X | X |
| Arthropoda | Entognatha | Collembola | | | | | spring tails | X | X |
| Arthropoda | Insecta | Coleoptera | Curculionidae | | | | snout beetles | X | |
| Arthropoda | Insecta | Coleoptera | Dryopidae | | *Helichus* sp. | | long toed water beetles | X | X |
| Arthropoda | Insecta | Coleoptera | Elmidae | | *Microcylloepus* | *pusillus* | pusillanimous riffle beetle | **X** | |
| Arthropoda | Insecta | Coleoptera | Elmidae | | *Optioservus* sp. | | riffle beetles | X | X |
| Arthropoda | Insecta | Coleoptera | Elmidae | | *Optioservus* | *quadrimaculatus* (Horn) | riffle beetle | **X** | |
| Arthropoda | Insecta | Coleoptera | Elmidae | | *Zaitzevia* | *parvula* (Horn) | riffle beetle | **X** | |
| Arthropoda | Insecta | Diptera | | | | | flies | X | X |
| Arthropoda | Insecta | Diptera | Athericidae | | *Atherix* | *pachypus* | watersnipe flies | | **X** |
| Arthropoda | Insecta | Diptera | Ceratopogonidae | | | | biting midges | X | **X** |
| Arthropoda | Insecta | Diptera | Ceratopogonidae | Ceratopogoninae | *Probezzia* sp. | | biting midges | X | X |
| Arthropoda | Insecta | Diptera | Chironomidae | | | | 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 | Empididae | | | | dance flies | X | X |
| Arthropoda | Insecta | Diptera | Empididae | Hemerodromiinae | *Hemerodromia* sp. | | dance flies | X | X |
| Arthropoda | Insecta | Diptera | Empididae | | *Neoplasta* sp. | | dance flies | X | |
| Arthropoda | Insecta | Diptera | Simuliidae | | | | black flies | X | X |
| Arthropoda | Insecta | Diptera | Simuliidae | Simuliinae | *Simulium* sp. | | black flies | X | X |
| Arthropoda | Insecta | Diptera | Tipulidae | | | | crane flies | X | **X** |
| Arthropoda | Insecta | Diptera | Tipulidae | Tipulinae | *Tipula* sp. | | crane flies | X | **X** |
| Arthropoda | Insecta | Diptera | Tipulidae | | *Hexatoma* sp. | | black flies | X | X |
| Arthropoda | Insecta | Ephemeroptera | Baetidae | | | | small minnow mayflies | X | X |
| Arthropoda | Insecta | Ephemeroptera | Baetidae | | *Baetis* sp. | | small minnow mayflies | X | X |
| Arthropoda | Insecta | Ephemeroptera | Baetidae | | *Fallceon* | *quilleri* | small minnow mayflies | X | |

**Appendix C** (*continued*)

| Phylum | Class | Order | Family | SubFamily | Genus | Species | Common name | MAN01 | MAN02 |
|---|---|---|---|---|---|---|---|---|---|
| Arthropoda | Insecta | Ephemeroptera | Heptageniidae | | | | stream mayflies | X | X |
| Arthropoda | Insecta | Ephemeroptera | Leptohyphidae | | *Tricorythodes* sp. | | little stout crawler mayflies | X | X |
| Arthropoda | Insecta | Ephemeroptera | Leptophlebiidae | | | | pronggilled mayflies | X | |
| Arthropoda | Insecta | Hemiptera | Veliidae | Rhagoveliinae | *Rhagovelia* sp. | | small water striders | X | **X** |
| Arthropoda | Insecta | Odonata | Gomphidae | | | | clubtail dragonflies | X | |
| Arthropoda | Insecta | Odonata | Coenagrionidae | | *Argia* sp. | | dancers | **X** | |
| Arthropoda | Insecta | Odonata | Coenagrionidae | | | | winged damselflies | X | |
| Arthropoda | Insecta | Plecoptera | | | | | stoneflies | X | X |
| Arthropoda | Insecta | Plecoptera | Perlodidae | | | | perlodid stoneflies | X | X |
| Arthropoda | Insecta | Plecoptera | Perlodidae | Perlodinae | *Skwala* | *americana* | perlodid stoneflies | X | X |
| Arthropoda | Insecta | Plecoptera | Perlodidae | | *Isogenoides* sp. | | perlodid stoneflies | | **X** |
| Arthropoda | Insecta | Trichoptera | | | | | caddisflies | | X |
| Arthropoda | Insecta | Trichoptera | Hydropsychidae | | | | | X | X |
| Arthropoda | Insecta | Trichoptera | Hydropsychidae | Hydropsychinae | *Cheumatopsyche* sp. | | netspinning stoneflies | X | X |
| Arthropoda | Insecta | Trichoptera | Hydropsychidae | Hydropsychinae | *Hydropsyche* sp. | | netspinning stoneflies | X | X |
| Arthropoda | Insecta | Trichoptera | Hydroptilidae | | | | microcaddisflies | X | |
| Arthropoda | Insecta | Trichoptera | Leptoceridae | | | | longhorned caddisflies | X | |
| Arthropoda | Insecta | Trichoptera | Leptoceridae | Leptocerinae | *Oecetis* sp. | | longhorned caddisflies | **X** | **X** |
| Arthropoda | Insecta | Trichoptera | Philopotamidae | Chimarrinae | *Chimarra* sp. | | longhorned caddisflies | | **X** |
| Arthropoda | Malacos-traca | Decapoda | Cambaridae | | | | crayfish | X | X |

**Appendix D** Measured velocity and channel characteristics at the MAN01 and MAN02 monitoring sites, Mesa Verde National Park, Colorado, 2010

| | Velocity (m/s) | | Depth (m) | | Wetted channel width (m) | Active channel width (m) |
|---|---|---|---|---|---|---|
| **Transect** | **Mean** | **Std Dev** | **Mean** | **Std Dev** | **Value** | **Value** |
| **MAN01** | | | | | | |
| 1 | 0.41 | 0.23 | 0.10 | 0.06 | 8.4 | 9.1 |
| 2 | 0.34 | 0.10 | 0.18 | 0.05 | 6.5 | 8.6 |
| 3 | 0.42 | 0.11 | 0.11 | 0.04 | 7.4 | 8.8 |
| 4 | 0.36 | 0.06 | 0.33 | 0.12 | 4.5 | 9.4 |
| 5 | 0.39 | 0.09 | 0.32 | 0.04 | 3.8 | 5.4 |
| 6 | 0.68 | 0.36 | 0.21 | 0.09 | 2.9 | 6.2 |
| 7 | 0.58 | 0.13 | 0.28 | 0.02 | 2.6 | 5.6 |
| 8 | 0.82 | 0.73 | 0.18 | 0.13 | 3.0 | 11.9 |
| 9 | 0.75 | 0.22 | 0.18 | 0.07 | 4.3 | 10.5 |
| 10 | 0.38 | 0.19 | 0.18 | 0.09 | 5.2 | 9.3 |
| 11 | 0.47 | 0.45 | 0.23 | 0.02 | 5.2 | 7.8 |
| **MAN02** | | | | | | |
| 1 | 0.31 | 0.04 | 0.22 | 0.04 | 5.5 | 7.7 |
| 2 | 0.34 | 0.03 | 0.23 | 0.07 | 4.8 | 6.0 |
| 3 | 0.28 | 0.10 | 0.28 | 0.05 | 4.8 | 5.4 |
| 4 | 0.44 | 0.36 | 0.17 | 0.05 | 5.3 | 6.9 |
| 5 | 0.32 | 0.23 | 0.30 | 0.07 | 4.8 | 6.8 |
| 6 | 0.39 | 0.08 | 0.23 | 0.04 | 4.5 | 6.1 |
| 7 | 0.85 | 0.52 | 0.14 | 0.09 | 2.9 | 13.0 |
| 8 | 0.17 | 0.08 | 0.31 | 0.07 | 9.5 | 13.7 |
| 9 | 0.38 | 0.09 | 0.14 | 0.08 | 5.5 | 7.7 |
| 10 | 0.43 | 0.15 | 0.20 | 0.08 | 4.8 | 6.3 |
| 11 | 0.53 | 0.22 | 0.09 | 0.04 | 6.8 | 8.6 |