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

## *2012 Summary Report*

Natural Resource Data Series NPS/SCPN/NRDS—2014/684

**ON THE COVER**
The Mancos River in 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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Stacy E. Stumpf
Stephen A. Monroe

National Park Service
Southern Colorado Plateau Network
Northern Arizona University
P.O. Box 5765
Flagstaff, Arizona 86011-5765

August 2014

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 H1200090005 (Task NAU-404). 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-59).

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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 2012 crew consisted of Melissa Dyer and Tim Sullivan. SCPN staff provided support for the project.

Please cite this publication as:

Stumpf, S. E., and S. A. Monroe. 2014. Aquatic macroinvertebrate and physical habitat monitoring for the Mancos River in Mesa Verde National Park: 2012 summary report. Natural Resource Data Series NPS/SCPN/NRDS—2014/684. National Park Service, Fort Collins, Colorado.

NPS 307/125809, August 2014

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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 scientific foundation for making decisions and working with other agencies and the public to protect park ecosystems. Water-related 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) fluvial geomorphology, 6) riparian vegetation, composition, and structure, and 7) spring 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 U.S. Geological Survey (USGS) streamflow gaging station, #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 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 (see Appendix A for list of locations, codes, and common names of monitoring sites) on the Mancos River in MEVE (Stumpf and Monroe 2009):

> *Mancos River at Gage* (MEVEMAN01), identified in this report as MAN01, was first sampled in 2005 and 2006 by the USGS as part of a pilot study designed to support development of the *Aquatic 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 Figure 1). An SCPN water quality monitoring site was later established at the same site.
>
> *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 (Figure 1).

Three main vegetation communities exist along the Mancos River: the Coyote Willow/Mesic Forb Shrubland, located directly along the banks of the Mancos River; the Narrowleaf Cottonwood-Rocky Mountain Juniper Woodland, occurring on the floodplains adjacent to the active river channel; and the Lanceleaf Cottonwood Riparian Woodland, located adjacent to the river in low lying areas. For a detailed description of these vegetation communities, please refer to Thomas et al. (2009).

The purpose of this report is to (a) document SCPN aquatic macroinvertebrate monitoring activities that occurred at the Mancos River in MEVE in 2012, (b) summarize the data collected, and (c) where appropriate, place the data in the context of current environmental conditions.

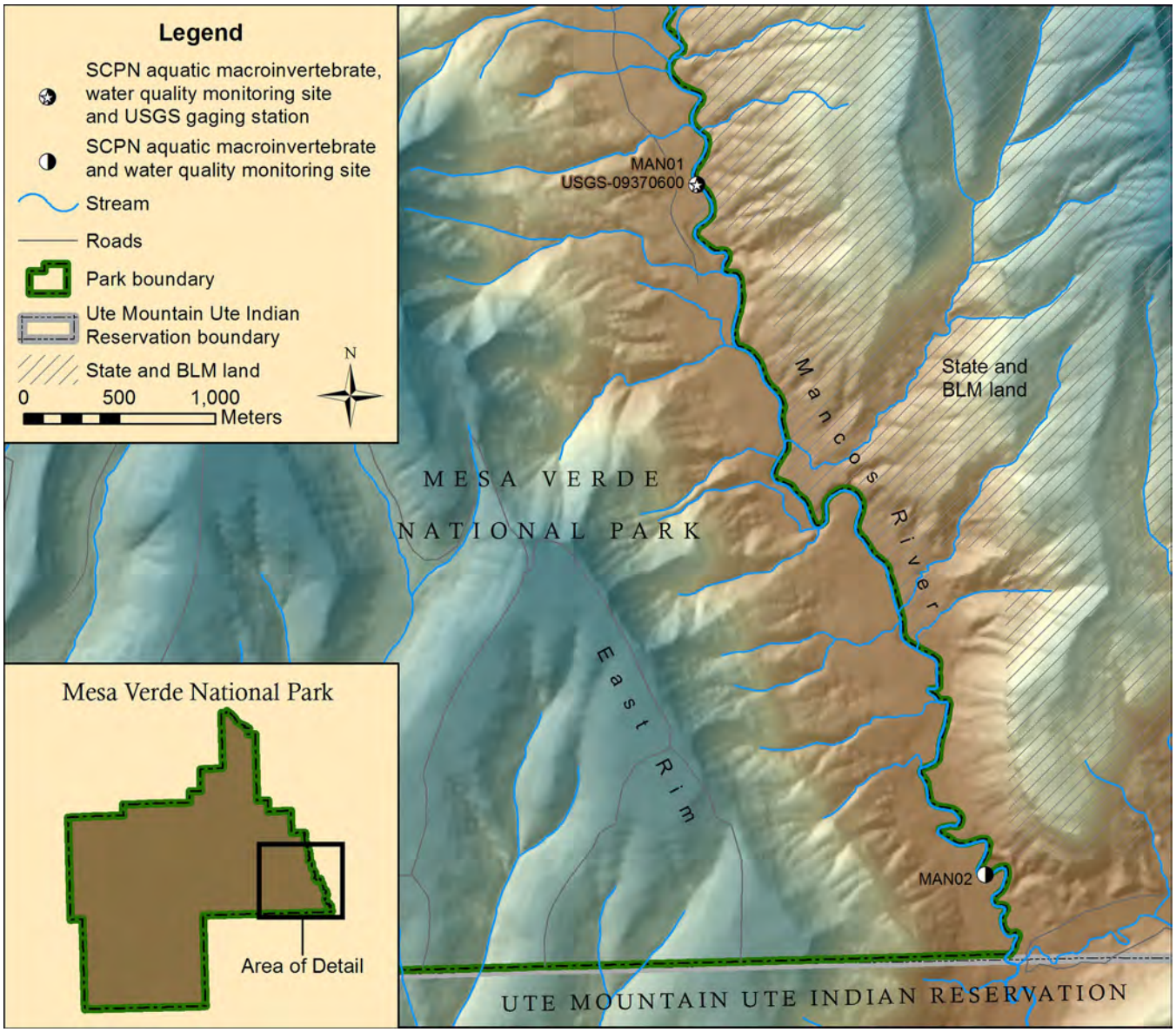



**Figure 1. Map of Mancos River through Mesa Verde National Park, Colorado, showing the location of the 2 monitoring sites, MAN01 and MAN02, in 2012.**

# 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 in elevation are faunistically similar to mountain streams (Paul et al. 2005), and therefore should be sampled during the late summer/early fall.

On 04–05 October 2012, 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 Figure 2 for reach layout diagram). A detailed description of sampling methods can be found in Brasher et al. (2011).

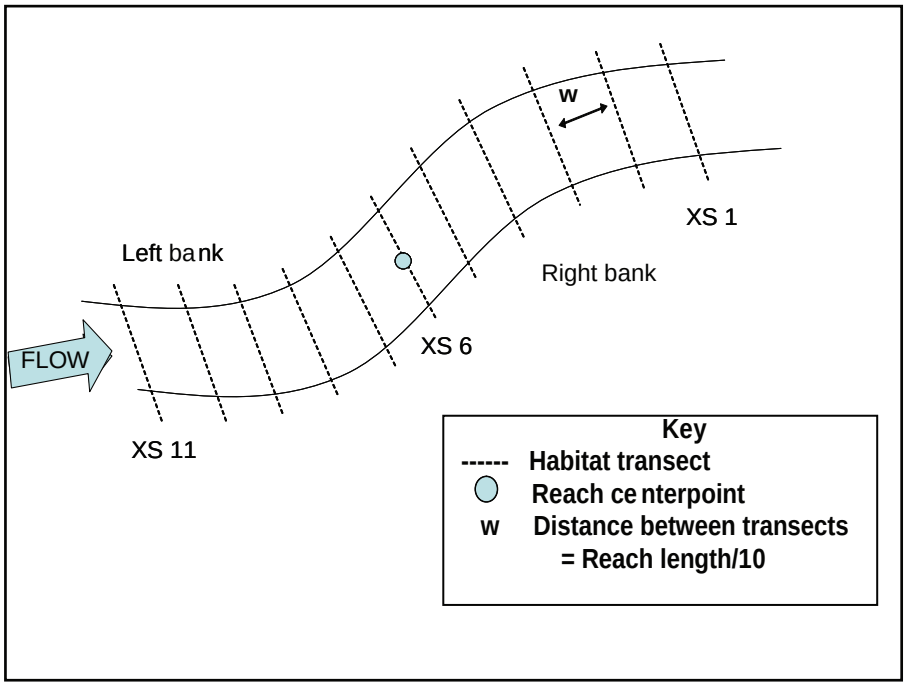



**Figure 2. General aquatic macroinvertebrate sampling reach layout.**

We collected 2 types of aquatic macroinvertebrate samples at MAN01 and MAN02 in 2012:

- 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.

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

- For each of the targeted riffle micro habitats where quantitative samples are collected 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,
  - estimated canopy closure at both ends and at the center of each transect
  - measured water depth and velocity 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
  - identified and recorded geomorphic channel units (GCU) at 5 equally spaced points along each transect
- For the entire reach, we
  - identified and measured the length of GCUs (the proportion of the reach representing each 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 Hydrologic data collection

In addition to our own SCPN air and water temperature measurements, hydrologic data presented in this report were collected at the USGS streamflow gaging station on the Mancos River, *Mancos River at Anitas Flat* (09370600), for the period 27 January through 22 December 2012 (USGS 2012).

## 2.3 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 subsampling large samples. Ten percent of the sorted samples were re-sorted for quality assurance.

A taxonomist certified by the North American Benthological Society identified all aquatic macroinvertebrates to the family or genus level. 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).

## 2.4 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.

For quantitative aquatic macroinvertebrate data, we calculate means and standard deviations from the 5 replicate samples collected. For those parameters measured along transects (such as habitat characterization), we calculate means and standard deviations from the 7 to 11 transect values.

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

We present key metrics calculated from sampling aquatic macroinvertebrate communities from 2007 to 2012 at MAN01 and MAN02. Figures in this section refer to quantitative data unless otherwise noted, and error bars represent one standard deviation from the mean. All corresponding data values are available in table format in Appendix C (Tables C1–C3). Appendix D lists all aquatic macroinvertebrate species detected at the sites, from both quantitative and qualitative methods.

**Abundance**. Abundance values for targeted riffle habitat samples averaged 160.40 individuals at MAN01 in 2012 (Figure 3). Sample abundances at MAN01 ranged from 62 (low) to 363 (high). Abundance at MAN02 averaged 245.40 individuals. Sample abundances ranged from a low of 90 to a high of 449.

**Taxa richness**. Richness for quantitative samples collected at MAN01 ranged from 10 to 15 taxa and averaged 12.60 in 2012 (Figure 4a). At MAN02, richness for quantitative samples ranged from 10 to 16 taxa and averaged 13.80. Richness of qualitative samples was 18 taxa at MAN01 and 20 taxa at MAN02 (Figure 4b).

**Figure 3. Aquatic macroinvertebrate abundance in samples from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2012. No data were collected at MAN02 in 2009.**

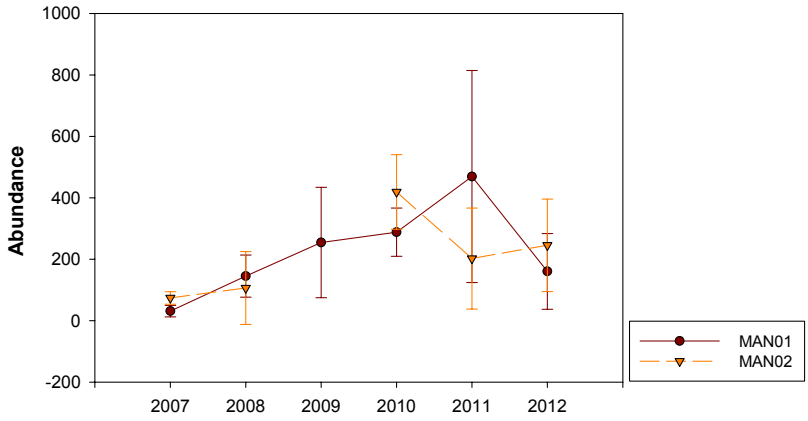
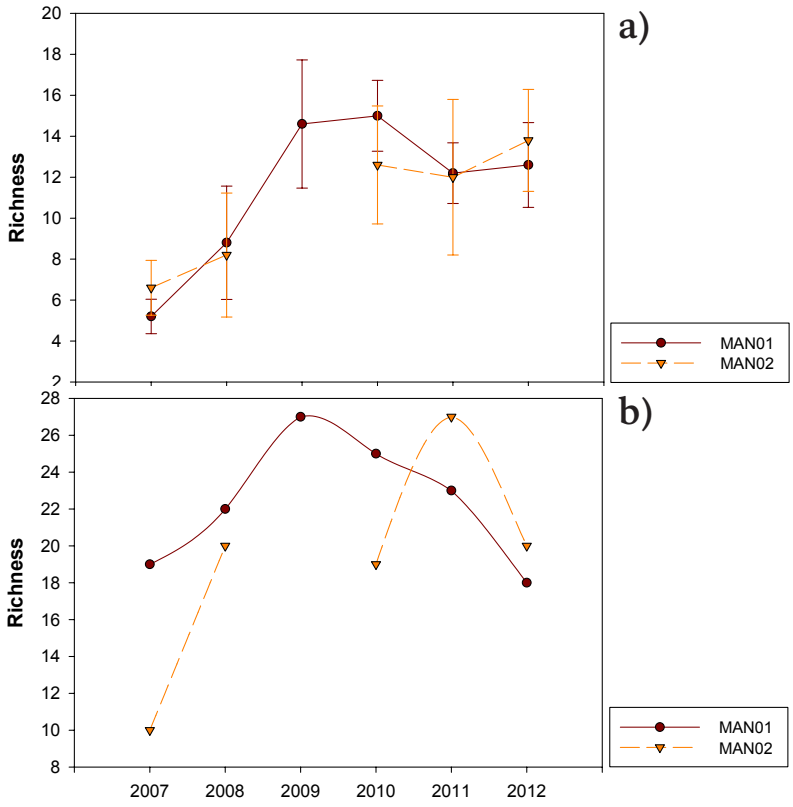



**Figure 4. Taxa richness in a) quantitative and (b) qualitative samples from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2012. No data were collected at MAN02 in 2009.**



**Diversity**. We measured taxonomic and functional diversity using the Simpson's Diversity Index. Taxonomic diversity averaged 0.72 at MAN01 and 0.66 at MAN02 in 2012 (Figure 5a). Functional diversity averaged 0.48 at MAN01 and 0.48 at MAN02 (Figure 5b).

**Stress tolerance**. Taxa which are moderately tolerant to disturbance dominated the samples collected from MAN01 in 2012, with an average relative abundance of 57.32% (Figure 6). Intolerant individuals were the second most abundant at MAN01, with an average relative abundance of 42.68%. No tolerant individuals were found at MAN01 in 2012.

At MAN02, intolerant individuals were the most abundant, averaging 60.05% for the relative abundance of individuals collected in 2012 (Figure 6). Moderately tolerant taxa were the next most abundant at MAN02, averaging 39.95% of the individuals per sample. No tolerant taxa were found at MAN02 in 2012.

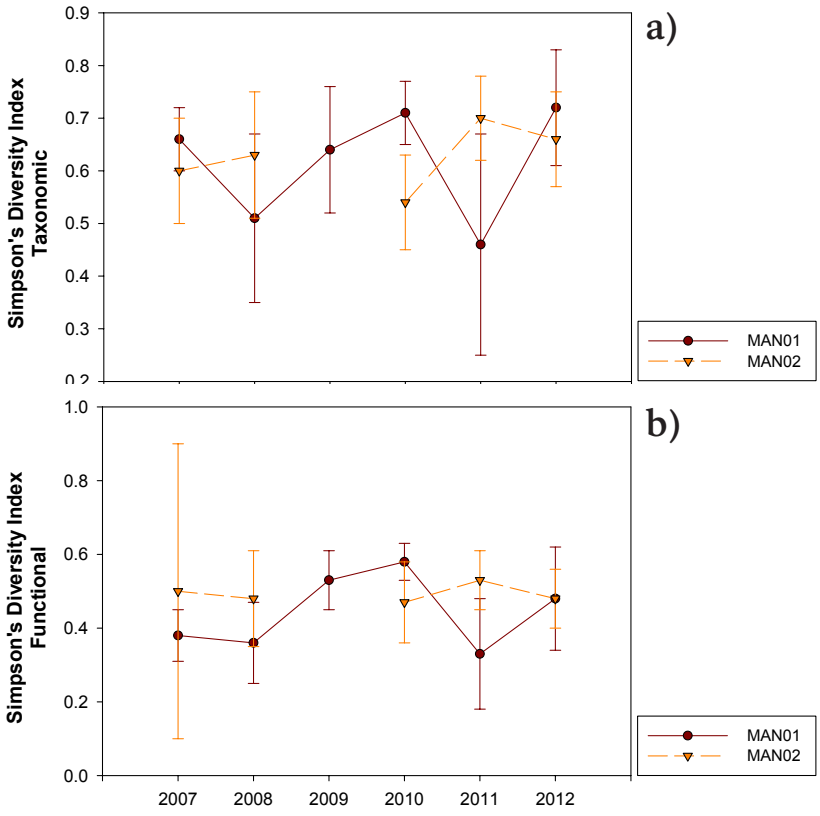



**Figure 5. Taxonomic (a) and functional (b) diversity in samples from MAN01 and MAN02 at the Mancos River, in MEVE, 2007–2012. No data were collected at MAN02 in 2009.**

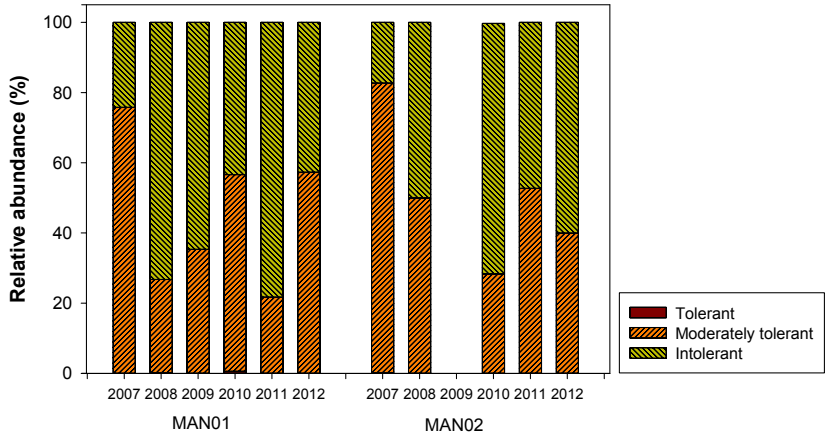



**Figure 6. Mean relative abundance by tolerance group of aquatic macroinvertebrate samples from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2012. No data were collected at MAN02 in 2009. In all 5 years, tolerant taxa never comprised more than 1% of the samples.**

**EPT taxa**. At MAN01, Trichoptera (caddisflies) had the highest relative abundance of sensitive EPT taxa (Ephemeroptera [mayflies], Plecoptera [stoneflies], Trichoptera) in 2012 (Figure 7), averaging 33.9% of the individuals collected from the site. Ephemeroptera were the second most abundant, averaging 4.81%. Few Plecoptera were collected from MAN01, at 1.50%.

At MAN02, Trichoptera were the most abundant EPT taxa collected in 2012, averaging 45.97% of the individuals collected from quantitative targeted riffle samples (Figure 7). Relative abundance of Ephemeroptera and Plecoptera at MAN02 averaged 4.44% and 0.86%, respectively.

**Aquatic macroinvertebrate orders**. Non-Chironomidae Diptera (flies) was the order with the most abundant individuals collected from quantitative samples at MAN01 in 2012, at 47.33% (Figure 8 ). Trichoptera was the next most abundant, at 33.90%, followed by Chironomidae (midges) at 5.91%, and noninsect taxa at 5.24%. Coleoptera (beetles) was the least abundant order collected from MAN01, at 1.32%. No individuals in the order Odonata (dragonflies/damselflies) were collected at MAN01.

Trichoptera was the most abundant order collected at MAN02 in 2012, at 45.97% of the sample (Figure 8). Non-Chironomidae Diptera was the next most abundant, at 30.97%, followed by Coleoptera at 7.89%, Ephemeroptera at 4.44%, Chironomidae at 3.29%, and Plecoptera at 0.86%. No individuals from Odonata were collected at MAN02.

**Figure 7. Mean relative abundance of aquatic macroinvertebrates belonging to sensitive EPT orders in samples from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2012. No data were collected from MAN02 in 2009.**

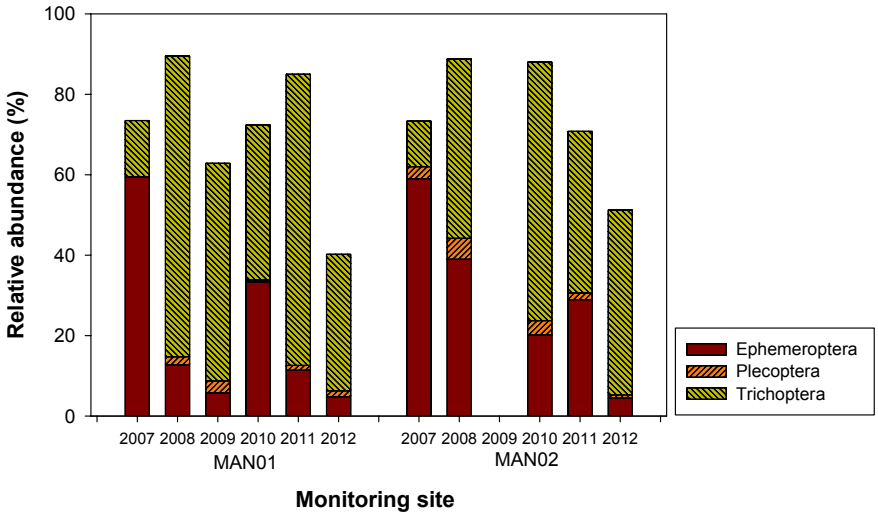
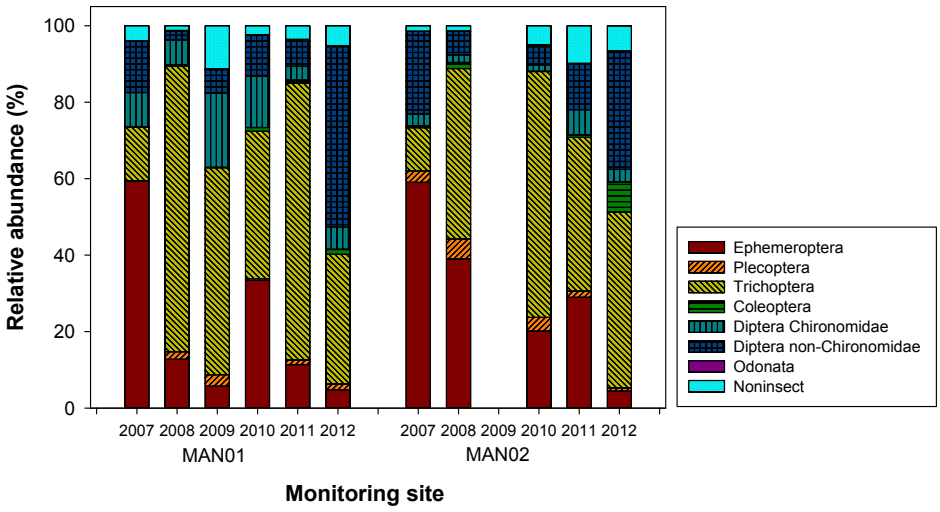



**Figure 8. Mean relative abundance by taxonomic order in samples from MAN01and MAN02 at the Mancos River, in MEVE, 2007–2012. No data were collected from MAN02 in 2009. In all 5 years, odonates never comprised more than 1% of the samples.**



**Functional feeding groups**. Collector-filterers were the most abundant functional group at MAN01 in 2012, at 64.34% (Figure 9). Predators were the second most abundant functional group at MAN01, averaging 20.83%. Collector-gatherers averaged 14.83%. No scrapers or shredders were found at MAN01 in 2012.

Collector-filterers were also the most abundant functional group collected at MAN02 in 2012, averaging 59.99% (Figure 9). Predators were the second most abundant, averaging 23.08%, followed by collector-gatherers at 15.95%, and scrapers at 0.97%. No shredders were collected at MAN02 in 2012.

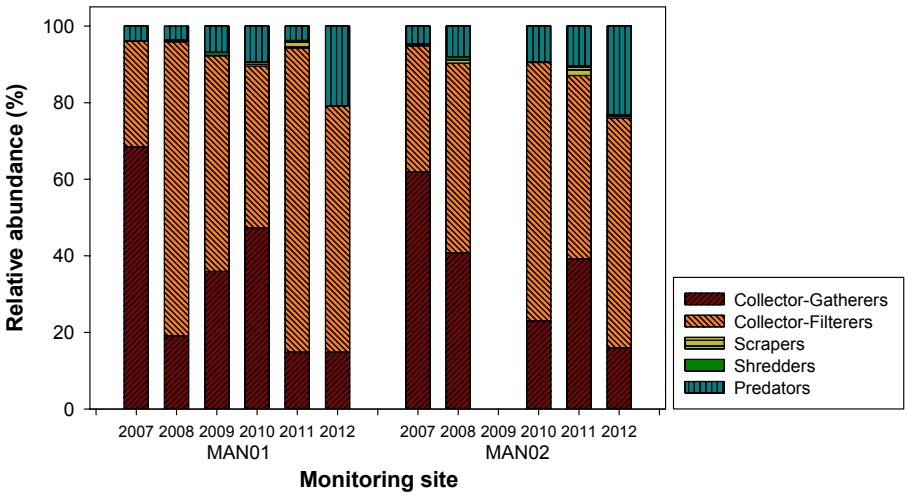



**Figure 9. Mean relative abundance by functional feeding group in aquatic macroinvertebrate samples from MAN01 and MAN02 at the Mancos River in MEVE, 2007–2012. No data were collected from MAN02 in 2009. In all 5 years, shredders never comprised more than 1% of the samples.**

## 3.2 Physical habitat characteristics

This section presents data describing physical habitat characteristics collected from 2007 to 2012 at MAN01 and MAN02. These data are summarized in table format in Appendix C (Tables C4, C5); additional transect data can be found in Appendix E.

**Microhabitat level**. In 2012, velocity at the targeted riffle sampling areas averaged 0.33 m/s at MAN01 and 0.11 m/s at MAN02. Depths averaged 0.06 m at MAN01 and 0.10 m at MAN02. Figure 10 shows the mean particle embeddedness for each riffle sample during 2012, where on average, 28.0% of each particle was embedded at MAN01, while 32.4% of each particle was embedded at MAN02. Figure 11 shows the embeddedness of riffle habitat at MAN01 and MAN02 across all years of sampling.

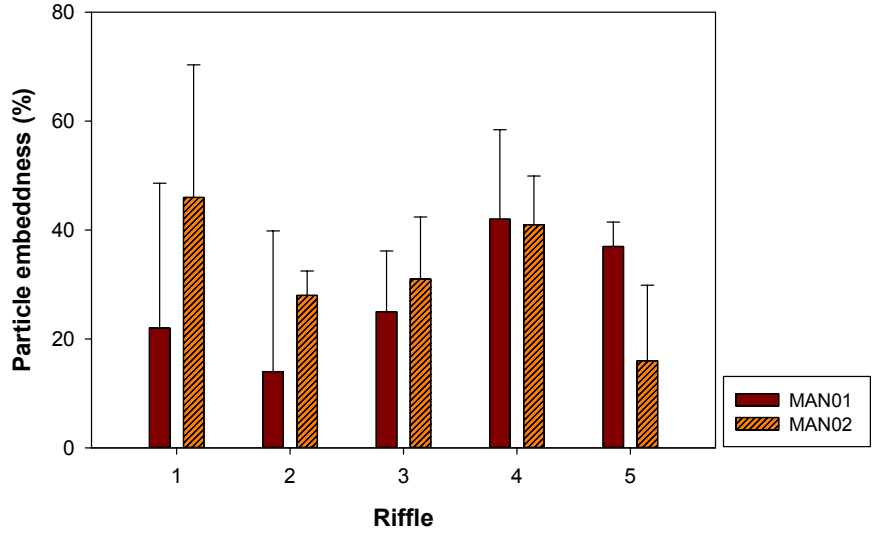
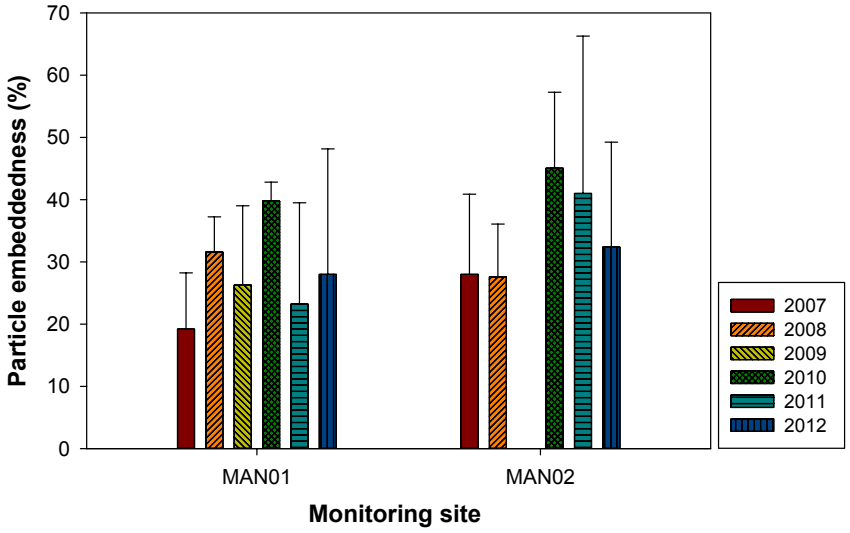



**Figure 10. Mean particle embeddedness in samples from MAN01 and MAN02 on the Mancos River in MEVE, 2012.**

**Figure 11. Mean particle embeddedness in samples from MAN01 and MAN02 on the Mancos River in MEVE, 2007–2012. No data were collected at MAN02 in 2009.**




**Transect level**. Wetted channel widths averaged 3.5 m at MAN01 and 3.2 m at MAN02 in 2012. Velocity averaged 0.09 m/s at MAN01 and 0.10 m/s at MAN02. The average depth along transects was 0.07 m at MAN01 and 0.11 m at MAN02. Riparian canopy closure averaged 18.5% at MAN01 and 16.9% at MAN02.

Rock was the dominant habitat type at MAN01, accounting for 63.5% of the habitat sampled in 2012 (Figure 12). Leaf packs, found along 1.4% of MAN01, was the second most frequent habitat type. The category "Absence", meaning it lacked habitat that we define as appropriate for aquatic macroinvertebrates, occurred along 35.1% of MAN01. No vegetation, woody debris, root wads, or algal mats were found at MAN01 in 2012.

Rock was the dominant habitat type at MAN02, accounting for 27.5% of the habitat sampled in 2012. Root wads accounted for 1.4%. "Absence" accounted for 71.0% of MAN02. No vegetation, woody debris, algal mats, or leaf packs were found at MAN02 in 2012.

**Reach level**. Channel structure dynamics are represented by particle size distributions in Figure 13 for 2012. At MAN01, cobbles (65–250 mm) were the dominant particle type, accounting for 32.8% of the particles sampled. Gravel (3–64 mm) and clay & silt (<0.06, gritty) accounted for 21.5% and 18.0%, respectively, of the particles sampled. Sand (0.06–2 mm) was found along 9.0% of MAN01. Boulders (251–4000 mm) were found along 0.75% of the monitoring site at MAN01,and bedrock was found along 0.05%. Along the reach, 17.5% of the particles were too cemented to measure.

At MAN02, clay & silt were the dominant particle types in 2012 accounting for 34.3% of the particles measured (Figure 13). Cobble and gravel were abundant at MAN02, accounting for 22.0% and 21.7% of the particles sampled. Of the particles sampled, 12.8% were too cemented to measure. Sand was found along 9.3% of MAN02.

Figure 14 shows the proportion of each reach length characterized by different geomorphic channel units. At MAN01, runs (38.9%) were the most abundant GCU in 2012. Glides were found along 34.0% of MAN01, followed by riffles at 9.6%. Scour pools were found along 9.0% of MAN01. Downstream at MAN02, riffles were the dominant GCU, found along 36.6% of the monitoring site. Glides (29.9%) were the next most frequent GCU, followed by runs (22.7%), and scour pools (10.7%) in 2012.

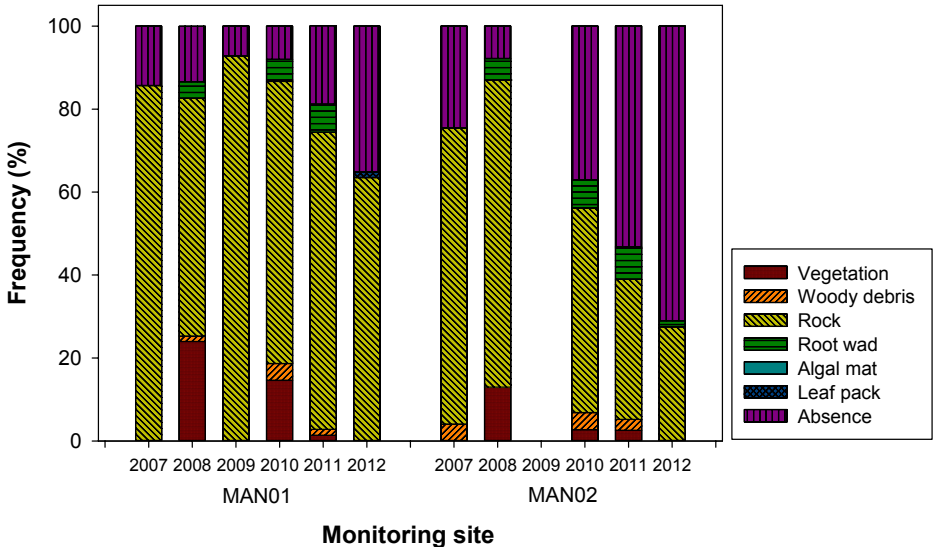



**Figure 12. Habitat characterization expressed as frequency of occurrence along transects at MAN01and MAN02 on the Mancos River in MEVE, 2007–2012. Some habitat structure types were not observed.**

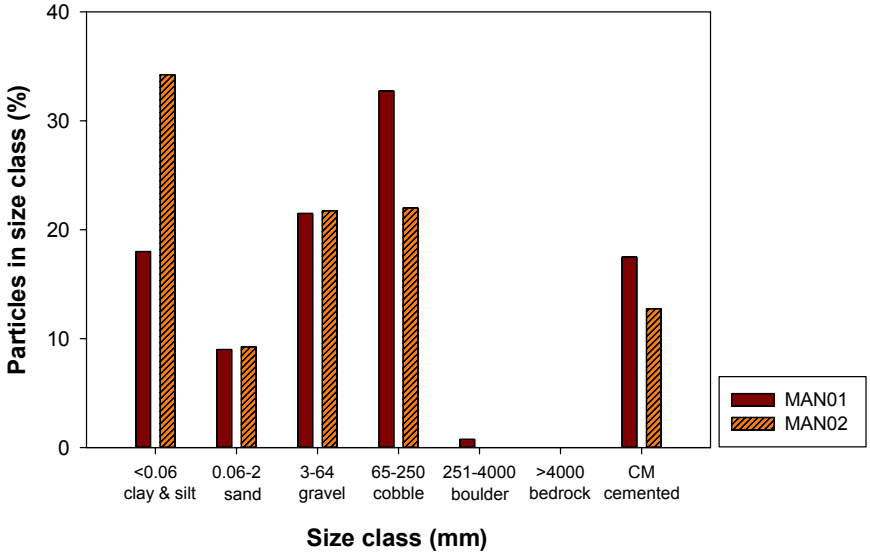



**Figure 13. Particle size distribution along the reaches at MAN01 and MAN02 on the Mancos River in MEVE, 2012. CM represents particles that are completely cemented into the stream channel, which precludes size measurements.**

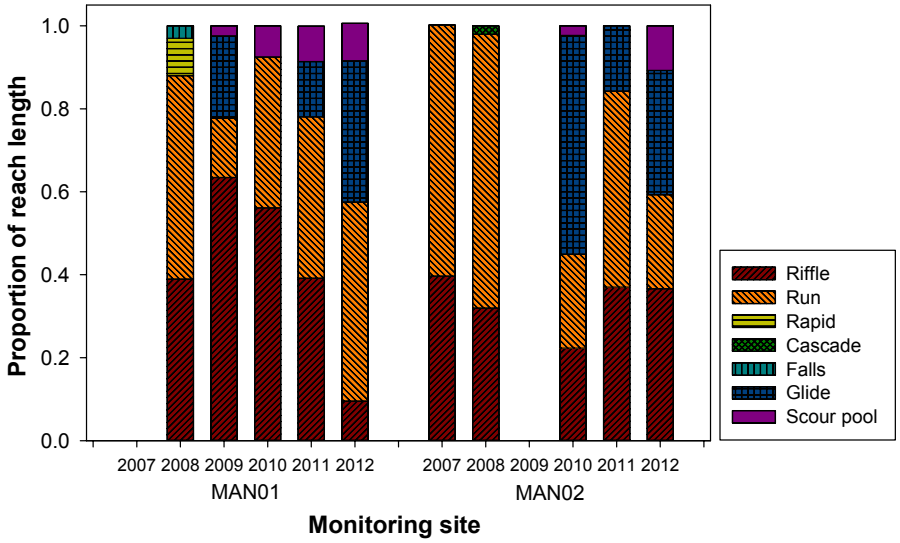



**Figure 14. Geomorphic channel unit characterization of MAN01 and MAN02 at the Mancos River in MEVE, 2007–2012. No data were collected at MAN01 in 2007 or MAN02 in 2009.**

## 3.3 Hydrologic conditions

### *3.3.1 SCPN water quality core parameter data*

NPS water quality core parameters are reported as measurements recorded at or nearest to midday on the day of the sampling event (Appendix C, Tables C4, C5). At MAN01 in 2012, the midday water temperature was 8.5°C. Specific conductivity was 2180 µS/cm, and pH was 8.2. Dissolved oxygen was 104.6% saturation and 9.7 mg/L. Turbidity was 0.6 NTU and stream discharge was 1.7 cfs. At MAN02, the midday water temperature was 8.9°C. Specific conductivity and pH were 1980 µS/cm and 8.4, respectively. Dissolved oxygen was 102.1% saturation and 9.4 mg/L. Turbidity was 3.1 NTU. Stream discharge measured 0.8 cfs.

Water and air temperatures were collected from MAN01 at the Mancos River every 15 minutes during 2012 (Figure 15). The average water temperature for 2012 was 10.0°C. A low water temperature of -0.1°C was recorded on several days during the year, typically when surface freeze had occurred. A high water temperature of 31.1°C was recorded on 01 July. The average air temperature at MAN01 was 8.8°C. A low air temperature of -26.2°C was recorded on 20 December. A high air temperature of 38.5°C was recorded on 01 July.

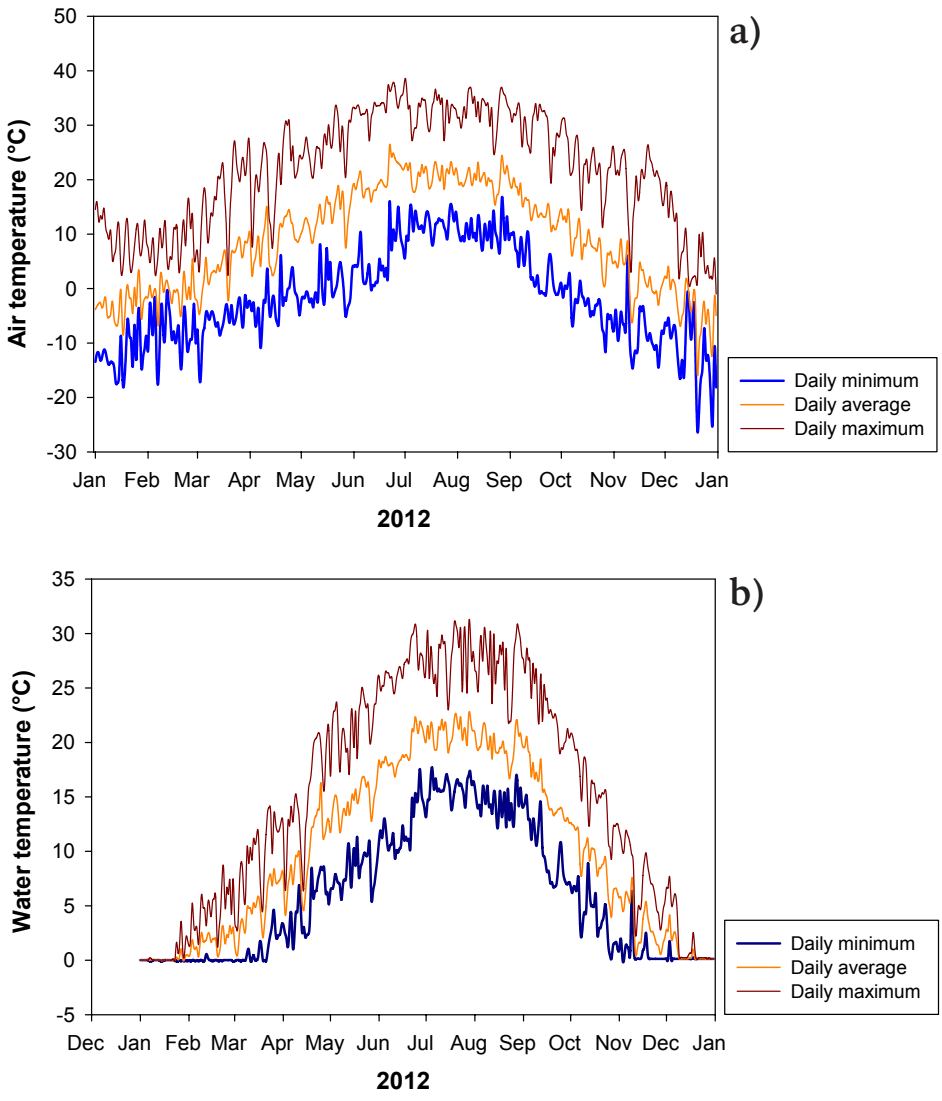



**Figure 15. Air (a) and water (b) temperature recorded at 15 minute intervals in 2012 from MAN01 at the Mancos River in MEVE.**

### *3.3.2 USGS streamflow data*

Figure 16 shows a hydrograph from the USGS streamflow gaging station *Mancos River at Anitas Flat* (09370600) for the period 27 January through 22 December 2012 (USGS 2012). Streamflow during winter is affected by ice and the USGS does not provide usable data for early January. The hydrograph for 2012 shows spikes occurring in March–May during the typical snowmelt period, and during the June–September monsoon season. A very large flow event occurred in late August. Maximum discharged reached 486.0 cfs and occurred on 23 August. Minimum discharge was 0.6 cfs on 06 October.

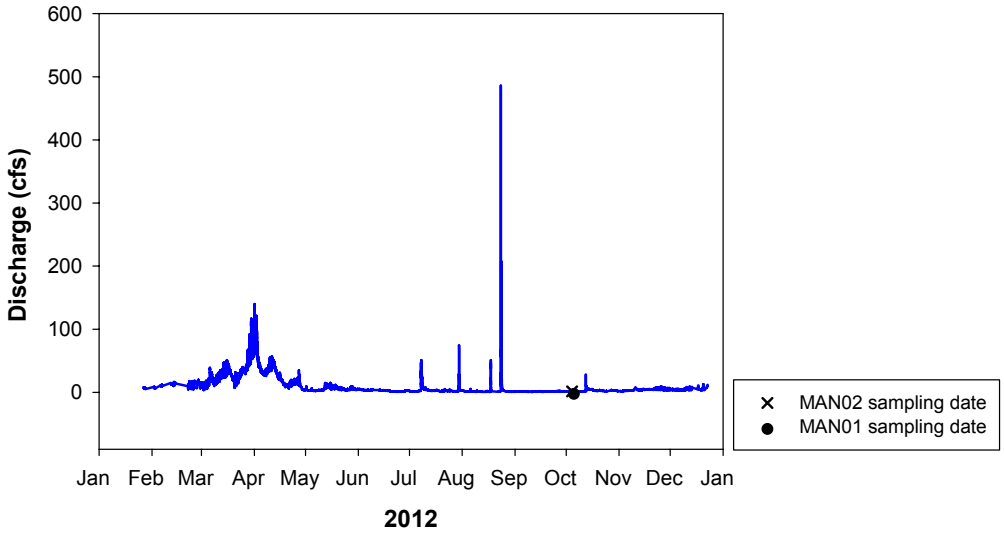



**Figure 16. Discharge for the Mancos River in 2012 from USGS streamflow gaging station #09370600, near MAN01.**

# 4 Discussion

This report presents data from SCPN's sixth 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.

Aquatic macroinvertebrate assemblages appear to be more robust downstream at MAN02 compared to MAN01. Total abundance of aquatic macroinvertebrates from our quantitative targeted riffle samples was greater downstream at MAN02, averaging 245.40 individuals, compared with 160.40 individuals at MAN01. Quantitative and qualitative richness was slightly higher downstream. Tolerance group data provide further evidence that conditions at MAN02 were better than at MAN01. Aquatic macroinvertebrate taxa can be separated based on their tolerance to perturbation or disturbance. Data collected in 2012 show that intolerant individuals—those taxa that are extremely susceptible to disturbance—dominated samples collected at MAN02 and were twice as abundant as moderately tolerant individuals at that site. In contrast, moderately tolerant individuals dominated samples collected from MAN01. Additionally, fewer intolerant individuals were found at MAN01 (42.68%) compared with the number found at MAN02 (60.05%).

The higher abundance of taxa and individuals susceptible to disturbance detected downstream at MAN02 is worth examining more closely. Physical habitat data collected, particularly particle size and macroinvertebrate habitat, suggest that MAN01 should be a more favorable location for aquatic macroinvertebrates. The discrepancy in community composition between the two sites could be the result of environmental differences. One possible explanation could be the conditions resulting from a large flood that occurred weeks before our sampling events. The difference in tolerance groups may be due to a difference in recovery between the two sites after the high flow event. An alternative hypothesis is that the difference in the aquatic macroinvertebrate community could be a result of differing water quality conditions that we were unable to capture in our monitoring. SCPN will continue to watch these assemblages in the coming years to see if this is a single year anomaly or if it is a continuing pattern.

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 Southern Colorado Plateau Network aquatic macroinvertebrate monitoring sites on the Mancos River in Mesa Verde National Park, Colorado, 2012

| Site Code | Common name | Report name | UTM Easting | UTM Northing | Elevation (m) |
|---|---|---|---|---|---|
| MEVEMAN01 | Mancos River at Gage | MAN01 | 734375 | 4126163 | 1933 |
| MEVEMAN02 | Mancos River above down-stream boundary | MAN02 | 735878 | 4122566 | 1882 |

*Note*: Horizontal coordinates are reported in Universal Transverse Mercator (UTM) Projection, Zone 12, North American Datum of 1983 (NAD 83). Vertical (elevation) coordinates are referenced to the North American Vertical Datum of 1988 (NAVD 88).

# 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 community and physical habitat data from aquatic macroinvertebrate monitoring sites on the Mancos River in Mesa Verde National Park, Colorado, 2007–2012

**Table C1. Quantitative aquatic macroinvertebrate community metrics from MAN01 on the Mancos River in Mesa Verde NP. For a given order, tolerance or functional feeding group, abundance-based metrics are the percentage of individuals in the group, while richness-based metrics for all years are the percentage of taxa in the group.**

| | 2007 (*n* = 5) | 2008 (*n* = 5) | 2009 (*n* = 5) | 2010 (*n* = 5) | 2011 (*n* = 5) | 2012 (*n* = 5) |
|---|---|---|---|---|---|---|
| **Quantitative metric** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** |
| Total abundance | 31.20 (18.66) | 145.00 (68.52) | 254.60 (179.83) | 288.20 (78.72) | 469.40 (345.12) | 160.40 (123.27) |
| Total richness | 5.20 (0.84) | 8.80 (2.77) | 14.60 (3.13) | 15.00 (1.73) | 12.20 (1.48) | 12.60 (2.07) |
| Simpson's Diversity—taxonomic | 0.66 (0.06) | 0.51 (0.16) | 0.64 (0.12) | 0.71 (0.06) | 0.46 (0.21) | 0.72 (0.11) |
| Simpson's Diversity—functional group | 0.38 (0.07) | 0.36 (0.11) | 0.53 (0.08) | 0.58 (0.05) | 0.33 (0.15) | 0.48 (0.14) |
| Dominant taxa | 55.83 (4.41) | 67.89 (12.07) | 53.65 (13.56) | 43.96 (7.47) | 70.83 (16.28) | 44.70 (12.81) |
| **Tolerance group** | | | | | | |
| Relative abundance of tolerant taxa (%) | 0.00 (0.00) | 0.27 (0.60) | 0.00 (0.00) | 0.67 (0.74) | 0.00 (0.00) | 0.00 (0.00) |
| Relative abundance of moderately tolerant taxa (%) | 75.79 (9.88) | 26.47 (9.81) | 35.34 (9.51) | 55.99 (8.81) | 21.72 (13.27) | 57.32 (13.52) |
| Relative abundance of intolerant taxa (%) | 24.21 (9.88) | 73.26 (9.95) | 64.66 (9.51) | 43.33 (8.99) | 78.28 (13.27) | 42.68 (13.52) |
| Richness of tolerant taxa (%) | 0.00 (0.00) | 3.33 (7.45) | 0.00 (0.00) | 7.13 (5.12) | 0.00 (0.00) | 0.00 (0.00) |
| Richness of moderately tolerant taxa (%) | 55.33 (19.27) | 58.73 (9.83) | 58.09 (7.21) | 56.78 (8.07) | 49.11 (14.28) | 61.67 (7.45) |
| Richness of intolerant taxa (%) | 44.67 (19.27) | 37.94 (8.92) | 41.91 (7.21) | 36.09 (5.51) | 50.89 (14.28) | 38.33 (7.45) |
| **Functional group** | | | | | | |
| Relative abundance of collector-filterers (%) | 27.61 (25.19) | 76.88 (8.45) | 56.35 (12.99) | 42.11 (9.23) | 79.46 (11.29) | 64.34 (17.46) |
| Relative abundance of collector-gatherers (%) | 68.47 (22.86) | 19.03 (7.82) | 35.93 (12.78) | 47.39 (8.53) | 14.85 (8.21) | 14.83 (2.45) |
| Relative abundance of scrapers(%) | 0.00 (0.00) | 0.24 (0.36) | 0.04 (0.08) | 1.04 (0.50) | 1.57 (2.53) | 0.00 (0.00) |
| Relative abundance of shredders (%) | 0.00 (0.00) | 0.18 (0.41) | 0.85 (0.59) | 0.06 (0.13) | 0.37 (0.41) | 0.00 (0.00) |
| Relative abundance of predators (%) | 3.93 (4.27) | 3.65 (0.93) | 6.83 (1.31) | 9.40 (5.65) | 3.76 (2.11) | 20.83 (16.64) |
| Richness of collector-filterers (%) | 31.33 (12.38) | 33.35 (7.49) | 16.66 (3.72) | 13.78 (1.13) | 26.37 (5.92) | 18.19 (3.55) |
| Richness of collector-gatherers (%) | 57.33 (7.23) | 36.41 (9.92) | 30.71 (8.10) | 39.66 (3.67) | 33.49 (7.65) | 39.23 (5.95) |
| Richness of scrapers (%) | 0.00 (0.00) | 3.54 (4.91) | 1.00 (2.24) | 6.89 (0.56) | 9.22 (6.54) | 0.00 (0.00) |
| Richness of shredders (%) | 0.00 (0.00) | 2.50 (5.59) | 5.63 (3.39) | 1.18 (2.63) | 5.36 (4.96) | 0.00 (0.00) |
| Richness of predators (%) | 11.33 (10.43) | 24.20 (5.86) | 45.99 (8.37) | 38.49 (3.99) | 25.56 (9.41) | 42.59 (3.34) |
| **Taxonomic group** | | | | | | |
| Number of EPT taxa | 3.00 (0.71) | 4.40 (0.89) | 5.60 (0.55) | 4.40 (1.52) | 5.20 (1.10) | 4.00 (1.00) |
| Relative abundance of EPT taxa (%) | 73.51 (16.87) | 89.52 (3.86) | 62.88 (13.64) | 72.39 (10.56) | 85.01 (9.90) | 40.21 (12.55) |
| Relative abundance of Ephemeroptera (%) | 59.43 (18.82) | 12.76 (6.57) | 5.72 (2.60) | 33.38 (14.58) | 11.38 (5.95) | 4.81 (1.47) |
| Relative abundance of Plecoptera (%) | 0.00 (0.00) | 1.99 (2.10) | 3.04 (0.62) | 0.46 (0.48) | 1.20 (1.28) | 1.50 (2.35) |
| Relative abundanceof Trichoptera (%) | 14.08 (4.69) | 74.77 (8.82) | 54.12 (14.17) | 38.56 (8.99) | 72.42 (15.40) | 33.90 (12.94) |
| Relative abundance of noninsect taxa (%) | 3.93 (4.27) | 1.23 (0.95) | 11.21 (10.13) | 2.40 (1.65) | 3.57 (3.88) | 5.24 (2.67) |
| Relative abundance of Chironomidae Diptera (%) | 9.04 (7.44) | 6.53 (2.99) | 19.41 (5.20) | 13.45 (6.95) | 3.58 (4.48) | 5.91 (2.15) |
| Relative abundance of non-Chironomidae Diptera (%) | 13.53 (22.31) | 2.37 (1.46) | 6.39 (2.27) | 10.70 (3.38) | 7.06 (7.33) | 47.33 (11.69) |
| Relative abundance of Coleoptera (%) | 0.00 (0.00) | 0.27 (0.41) | 0.11 (0.25) | 0.99 (0.81) | 0.79 (15.40) | 1.32 (1.90) |
| Relative abundance of Odonata | 0.00 (0.00) | 0.09 (0.20) | 0.00 (0.00) | 0.06 (0.13) | 0.00 (0.00) | 0.00 (0.00) |

**Table C2. Quantitative aquatic macroinvertebrate community metrics from MAN02 on the Mancos River in Mesa Verde NP. For a given order, tolerance or functional feeding group, abundance-based metrics are expressed as the total number of individuals in the group, while richness-based metrics for all years are expressed as the percentage of taxa in the group.**

| | 2007 (*n* = 5) | 2008 (*n* = 5) | 2009 (*n* = 5) | 2010 (*n* = 5) | 2011 (*n* = 5) | 2012 (*n* = 5) |
|---|---|---|---|---|---|---|
| **Quantitative metric** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** |
| Total abundance | 74.00 (20.48) | 106.40 (118.73) | — | 419.20 (121.49) | 202.40 (164.62) | 245.40 (150.75) |
| Total richness | 6.60 (1.34) | 8.20 (3.03) | — | 12.60 (2.88) | 12.00 (3.08) | 13.80 (2.49) |
| Simpson's Diversity—taxonomic | 0.60 (0.10) | 0.63 (0.12) | — | 0.54 (0.09) | 0.70 (0.08) | 0.66 (0.09) |
| Simpson's Diversity—functional group | 0.50 (0.40) | 0.48 (0.13) | — | 0.47 (0.11) | 0.53 (0.08) | 0.48 (0.08) |
| Dominant taxa | 56.79 (6.00) | 56.03 (13.19) | — | 63.16 (9.58) | 49.73 (7.16) | 54.79 (9.06) |
| **Tolerance group** | | | | | | |
| Relative abundance of tolerant taxa (%) | 0.25 (0.56) | 0.00 (0.00) | — | 0.05 (0.11) | 0.09 (0.19) | 0.00 (0.00) |
| Relative abundance of moderately tolerant taxa (%) | 82.43 (9.77) | 50.00 (20.42) | — | 28.27 (6.24) | 52.63 (21.67) | 39.95 (22.01) |
| Relative abundance of intolerant taxa (%) | 17.32 (9.87) | 50.00 (20.42) | — | 71.69 (6.31) | 47.29 (21.59) | 60.05 (22.01) |
| Richness of tolerant taxa (%) | 2.86 (6.39) | 0.00 (0.00) | — | 1.43 (3.19) | 1.82 (4.07) | 0.00 (0.00) |
| Richness of moderately tolerant taxa (%) | 53.00 (13.98) | 50.59 (5.02) | — | 53.24 (9.85) | 60.02 (16.44) | 57.22 (12.04) |
| Richness of intolerant taxa (%) | 44.14 (12.80) | 49.41 (5.02) | — | 45.34 (11.01) | 38.16 (14.85) | 42.78 (12.04) |
| **Functional group** | | | | | | |
| Relative abundance of collector-filterers (%) | 32.95 (7.82) | 49.46 (28.85) | — | 67.48 (11.19) | 47.96 (21.46) | 59.99 (22.64) |
| Relative abundance of collector-gatherers (%) | 61.92 (6.65) | 40.82 (26.81) | — | 23.02 (6.06) | 39.15 (22.32) | 15.95 (5.43) |
| Relative abundance of scrapers (%) | 0.45 (1.02) | 0.80 (1.40) | — | 0.08 (0.11) | 2.21 (2.37) | 0.97 (0.86) |
| Relative abundance of shredders (%) | 0.00 (0.00) | 0.93 (1.46) | — | 0.00 (0.00) | 0.26 (0.41) | 0.00 (0.00) |
| Relative abundance of predators (%) | 4.68 (1.86) | 7.98 (3.07) | — | 9.43 (6.16) | 10.41 (4.38) | 23.08 (22.53) |
| Richness of collector-filterers (%) | 31.33 (6.39) | 31.36 (13.41) | — | 21.39 (6.79) | 22.14 (5.85) | 19.15 (4.05) |
| Richness of collector-gatherers (%) | 39.67 (6.25) | 33.24 (8.28) | — | 28.23 (4.99) | 40.24 (11.10) | 30.83 (6.12) |
| Richness of scrapers (%) | 2.50 (5.59) | 4.86 (6.82) | — | 2.92 (4.06) | 6.43 (3.82) | 7.97 (5.13) |
| Richness of shredders (%) | 0.00 (0.00) | 4.17 (5.89) | — | 0.00 (0.00) | 2.76 (3.79) | 0.00 (0.00) |
| Richness of predators (%) | 26.50 (8.79) | 26.38 (4.94) | — | 47.46 (5.00) | 28.43 (7.36) | 42.05 (3.36) |
| **Taxonomic group** | | | | | | |
| Number of EPT taxa | 3.40 (0.89) | 4.80 (1.64) | — | 4.80 (1.30) | 4.80 (1.30) | 4.20 (1.48) |
| Relative abundance of EPT taxa (%) | 73.37 (12.52) | 88.81 (3.28) | — | 88.04 (5.34) | 70.82 (26.08) | 51.28 (22.70) |
| Relative abundance of Ephemeroptera (%) | 59.04 (8.10) | 38.99 (26.53) | — | 20.12 (5.45) | 28.97 (18.39) | 4.44 (2.29) |
| Relative abundance of Plecoptera (%) | 3.00 (2.17) | 5.23 (4.58) | — | 3.61 (1.07) | 1.61 (1.89) | 0.86 (0.74) |
| Relative abundanceof Trichoptera (%) | 11.33 (7.95) | 44.60 (28.79) | — | 64.31 (9.50) | 40.24 (20.54) | 45.97 (20.96) |
| Relative abundance of noninsect taxa (%) | 1.43 (0.90) | 1.40 (2.32) | — | 5.01 (5.96) | 9.85 (19.07) | 6.57 (2.51) |
| Relative abundance of Chironomidae Diptera (%) | 3.13 (2.57) | 1.98 (1.82) | — | 1.70 (1.39) | 6.67 (8.43) | 3.29 (1.10) |
| Relative abundance of non-Chironomidae Diptera (%) | 21.62 (12.31) | 6.16 (4.80) | — | 5.20 (4.78) | 12.08 (4.89) | 30.97 (22.31) |
| Relative abundance of Coleoptera (%) | 0.45 (1.02) | 1.58 (1.65) | — | 0.05 (0.10) | 0.58 (0.86) | 7.89 (4.94) |
| Relative abundance of Odonata (%) | 0.00 (0.00) | 0.07 (0.15) | — | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |

**Table C3. Qualitative aquatic macroinvertebrate community metrics from MAN01 and MAN02 on the Mancos River in Mesa Verde NP. Richness-based metrics are expressed as the percentage of taxa in a given order, tolerance or functional feeding group. Site ordering from left to right in the table corresponds to upstream to downstream position.**

| | MAN01 | | | | | | MAN02 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Qualitative metric** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** |
| Taxa richness | 19 | 22 | 27 | 25 | 23 | 18 | 10 | 20 | —. | 19 | 27 | 20 |
| **Tolerance group** | | | | | | | | | | | | |
| Richness of tolerant taxa (%) | 16.67 | 15.00 | 16.00 | 0.00 | 5.26 | 18.75 | 11.11 | 11.11 | — | 11.11 | 4.17 | 16.67 |
| Richness of moderately tolerant taxa (%) | 44.44 | 50.00 | 52.00 | 63.64 | 57.89 | 56.25 | 55.56 | 44.44 | — | 55.56 | 54.17 | 55.56 |
| Richness of intolerant taxa (%) | 38.89 | 35.00 | 32.00 | 36.36 | 36.84 | 25.00 | 33.33 | 44.44 | — | 33.33 | 41.67 | 27.78 |
| **Functional group** | | | | | | | | | | | | |
| Richness of collector-filterers (%) | 16.67 | 19.05 | 14.81 | 12.50 | 14.29 | 17.65 | 20.00 | 15.79 | — | 11.11 | 11.54 | 10.00 |
| Richness of collector-gatherers (%) | 50.00 | 38.10 | 37.04 | 33.33 | 28.57 | 41.18 | 50.00 | 36.84 | — | 33.33 | 30.77 | 50.00 |
| Richness of scrapers (%) | 0.00 | 9.52 | 7.41 | 8.33 | 4.76 | 0.00 | 0.00 | 5.26 | — | 11.11 | 7.69 | 0.00 |
| Richness of shredders (%) | 0.00 | 9.52 | 7.41 | 12.50 | 4.76 | 0.00 | 0.00 | 5.26 | — | 11.11 | 7.69 | 0.00 |
| Richness of predators (%) | 33.33 | 23.81 | 33.33 | 33.33 | 47.62 | 41.18 | 30.00 | 36.84 | — | 33.33 | 42.31 | 40.00 |
| **Taxonomic group** | | | | | | | | | | | | |
| Number of EPT taxa | 7 | 7 | 9 | 9 | 9 | 3 | 4 | 6 | — | 5 | 8 | 6 |
| Richness of EPT taxa (%) | 36.84 | 31.82 | 33.33 | 36.00 | 39.13 | 16.67 | 40.00 | 30.00 | — | 26.32 | 29.63 | 30.00 |
| Richness of Ephemeroptera (%) | 21.05 | 18.18 | 11.11 | 20.00 | 13.04 | 5.56 | 30.00 | 15.00 | — | 15.79 | 18.52 | 20.00 |
| Richness of Plecoptera (%) | 0.00 | 4.55 | 11.11 | 4.00 | 8.70 | 0.00 | 0.00 | 5.00 | — | 5.26 | 3.70 | 5.00 |
| Richness of Trichoptera (%) | 15.79 | 9.09 | 11.11 | 12.00 | 17.39 | 11.11 | 10.00 | 10.00 | — | 5.26 | 7.41 | 5.00 |
| Richness of noninsect taxa (%) | 26.32[a] | 31.82[a] | 22.20 | 16.00 | 21.74 | 22.22 | 30.00[a] | 15.00 | — | 15.79 | 18.52 | 20.00 |
| Richness of Chironomidae Diptera (%) | 10.53 | 13.64 | 11.11 | 8.00 | 13.04 | 16.67 | 10.00 | 15.00 | — | 15.79 | 11.11 | 15.00 |
| Richness of non-Chironomidae Diptera (%) | 21.05 | 13.64 | 25.93 | 20.00 | 17.39 | 27.78 | 20.00 | 15.00 | — | 31.58 | 25.93 | 30.00 |
| Richness of Coleoptera (%) | 0.00 | 9.10 | 3.70 | 12.00 | 8.70 | 11.11 | 0.00 | 15.00 | — | 10.53 | 11.11 | 5.00 |
| Richness of Odonata (%) | 5.26 | 0.00 | 3.70 | 8.00 | 0.00 | 5.56 | 0.00 | 10.00 | — | 0.00 | 3.70 | 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 C4. Physical habitat and hydrologic data from MAN01 on the Mancos River in Mesa Verde NP. Particle embeddedness and canopy closure measurements are expressed as percentages.**

| | 2007 | | 2008 | | 2009 | | 2010 | | 2011 | | 2012 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Physical habitat metric** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| **Microhabitat level (*n* = 5)** | | | | | | | | | | | | |
| **Riffles** | | | | | | | | | | | | |
| Velocity (m/s) | 0.69 | 0.27 | 0.63 | 0.13 | 0.55 | 0.36 | 0.47 | 0.17 | 0.68 | 0.37 | 0.33 | 0.13 |
| Depth (m) | 0.18 | 0.07 | 0.13 | 0.04 | 0.11 | 0.05 | 0.14 | 0.05 | 0.18 | 0.04 | 0.06 | 0.02 |
| Embeddedness (%) | 19.2 | 9.0 | 31.6 | 5.6 | 26.3 | 12.7 | 39.8 | 3.0 | 23.2 | 10.6 | 28.0 | 11.4 |
| **Transect level (*n* = 11)** | | | | | | | | | | | | |
| **Channel dimensions** | | | | | | | | | | | | |
| Velocity (m/s) | 0.68 | 0.23 | 0.50 | 0.23 | 0.42 | 0.06 | 0.49 | 0.16 | 0.40 | 0.15 | 0.09 | 0.08 |
| Depth (m) | 0.30 | 0.10 | 0.30 | 0.15 | 0.12 | 0.05 | 0.21 | 0.08 | 0.18 | 0.07 | 0.07 | 0.06 |
| Wetted channel width (m) | 5.7 | 2.1 | 5.6 | 1.8 | 6.3 | 1.2 | 4.9 | 1.9 | 4.7 | 1.5 | 3.5 | 1.3 |
| Active channel width (m) | 7.5 | 2.2 | 9.4 | 3.3 | 10.0 | 3.1 | 8.4 | 2.0 | 15.7 | 5.9 | >50.0 | 0.0 |
| **Riparian cover** | | | | | | | | | | | | |
| Canopy closure (%) | 9.0 | 12.9 | 19.3 | 25.8 | 4.8 | 6.9 | 0.0 | 0.0 | 16.6 | 25.2 | 18.5 | 29.7 |
| **Reach level (*n* = 1)** | | | | | | | | | | | | |
| **Water quality** | **Value** | | **Value** | | **Value** | | **Value** | | **Value** | | **Value** | |
| Temperature (°C) | 10.8 | | 17.5 | | 9.0 | | 14.2 | | 14.0 | | 8.5 | |
| Specific conductivity (µS/cm) | — | | 945 | | 1510 | | 1290 | | 1320 | | 2180 | |
| pH | — | | 8.5 | | 8.4 | | 8.4 | | 8.3 | | 8.2 | |
| Dissolved oxygen (% saturation) | — | | 106.0 | | 91.3 | | 104.2 | | 103.1 | | 104.6 | |
| Dissolved oxygen (mg/L) | — | | 10.1 | | 8.2 | | 8.3 | | 8.5 | | 9.7 | |
| Turbidity (NTU) | — | | 12 | | 17 | | 9.8 | | 8.7 | | 1.7 | |
| Discharge (cfs) | 46.0[a] | | 19.0[a] | | 10.0 | | 11.5 | | 9.7 | | 0.6 | |

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

**Table C5. Physical habitat and hydrologic data from MAN02 on the Mancos River in Mesa Verde NP. Particle embeddedness and canopy closure measurements are expressed as percentages.**

| | 2007 | | 2008 | | 2009 | | 2010 | | 2011 | | 2012 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Physical habitat metric** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| **Microhabitat level (*n* = 5)** | | | | | | | | | | | | |
| **Riffles** | | | | | | | | | | | | |
| Velocity (m/s) | 0.91 | 0.20 | 0.39 | 0.12 | — | — | 0.77 | 0.32 | 0.47 | 0.37 | 0.11 | 0.03 |
| Depth (m) | 0.15 | 0.05 | 0.06 | 0.01 | — | — | 0.14 | 0.07 | 0.11 | 0.05 | 0.10 | 0.02 |
| Embeddedness (%) | 28.0 | 12.9 | 27.6 | 8.5 | — | — | 48.4 | 12.9 | 41.0 | 15.6 | 32.4 | 11.7 |
| **Transect level (*n* = 11)** | | | | | | | | | | | | |
| **Channel dimensions** | | | | | | | | | | | | |
| Velocity (m/s) | 0.63 | 0.19 | 0.45 | 0.19 | — | — | 0.39 | 0.19 | 0.39 | 0.18 | 0.10 | 0.06 |
| Depth (m) | 0.31 | 0.10 | 0.25 | 0.07 | — | — | 0.19 | 0.07 | 0.21 | 0.08 | 0.11 | 0.07 |
| Wetted channel width (m) | 6.4 | 2.4 | 5.4 | 0.9 | — | — | 5.4 | 1.7 | 5.2 | 1.0 | 3.2 | 1.0 |
| Active channel width (m) | 10.3 | 4.2 | 10.0 | 2.6 | — | — | 8.0 | 2.8 | 44.4 | 9.8 | >50.0 | 0 |
| **Riparian cover** | | | | | | | | | | | | |
| Canopy closure (%) | 14.3 | 26.8 | 23.0 | 33.4 | — | — | 1.3 | 4.6 | 20.2 | 26.2 | 16.9 | 33.0 |
| **Reach level (*n* = 1)** | | | | | | | | | | | | |
| **Water quality** | **Value** | | **Value** | | **Value** | | **Value** | | **Value** | | **Value** | |
| Temperature (°C) | 11.2 | | 16.9 | | — | | 13.4 | | 14.4 | | 8.9 | |
| Specific conductivity (µS/cm) | — | | 993 | | — | | 1330 | | 1280 | | 1980 | |
| pH | — | | 8.5 | | — | | 8.3 | | 8.4 | | 8.4 | |
| Dissolved oxygen (% saturation) | — | | 104.9 | | — | | 106.1 | | 103.3 | | 102.1 | |
| Dissolved oxygen (mg/L) | — | | 10.2 | | — | | 8.6 | | 8.5 | | 9.4 | |
| Turbidity (NTU) | — | | 16 | | — | | 18 | | 9.0 | | 3.1 | |
| Discharge (cfs) | 41.0[a] | | 19.0[a] | | | | 10.4 | | 10.8 | | 0.8 | |

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

# Appendix D Aquatic macroinvertebrate species list from aquatic macroinvertebrate monitoring sites on the Mancos River in Mesa Verde National Park, Colorado, 2012

| Phylum | Class | Order | Family | SubFamily | Genus | Species | Common name | Funct group[1] | Tol group[2] | MAN01 | MAN02 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Annelida | Clitellata | | | | | | segmented worms | coll-gath | n/a | x | |
| Annelida | | | | | | | segmented worms | coll-gath | n/a | | x |
| Arthropoda | Arachnida | Trombidiformes | Sperchonidae | | *Sperchon* sp. | | water mites | pred | n/a | x | x |
| Arthropoda | Arachnida | Trombidiformes | Sperchonidae | | | | water mites | pred | tol | x | |
| Arthropoda | Arachnida | Trombidiformes | | | | | water mites | n/a | n/a | x | x |
| Arthropoda | Insecta | Coleoptera | Gyrinidae | | *Gyrinus* sp. | | whirligig beetle | pred | mod tol | x | |
| Arthropoda | Insecta | Coleoptera | Elmidae | | *Microcylloepus* | *pusillus* | riffle beetles | coll-gath | intol | x | x |
| Arthropoda | Insecta | Coleoptera | Elmidae | | *Zaitzevia* | *parvulus* | riffle beetles | coll-gath | intol | x | |
| Arthropoda | Insecta | Diptera | Athericidae | | *Atherix* | *pachypus* | watersnipe flies | pred | intol | | x |
| Arthropoda | Insecta | Diptera | Empididae | Hemerodromiinae | *Chelifera* sp. | | dance flies | coll-gath | mod tol | | NEW |
| Arthropoda | Insecta | Diptera | Empididae | Hemerodromiinae | *Hemerodromia* sp. | | dance flies | coll-gath | mod tol | x | x |
| Arthropoda | Insecta | Diptera | Empididae | | *Neoplasta* sp. | | dance flies | pred | mod tol | x | NEW |
| Arthropoda | Insecta | Diptera | Empididae | | | | dance flies | pred | mod tol | x | x |
| Arthropoda | Insecta | Diptera | Ceratopogonidae | Ceratopogoninae | *Culicoides* sp. | | biting midges | pred | tol | | NEW |
| Arthropoda | Insecta | Diptera | Ceratopogonidae | Ceratopogoninae | *Probezzia* sp. | | biting midges | pred | mod tol | x | x |
| Arthropoda | Insecta | Diptera | Ceratopogonidae | | | | biting midges | pred | mod tol | x | x |
| Arthropoda | Insecta | Diptera | Chironomidae | Chironominae | | | midges | coll-gath | mod tol | x | x |
| Arthropoda | Insecta | Diptera | Chironomidae | Orthocladiinae | | | midges | coll-gath | mod tol | x | x |
| Arthropoda | Insecta | Diptera | Chironomidae | Tanypodinae | | | midges | pred | tol | x | x |
| Arthropoda | Insecta | Diptera | Chironomidae | | | | midges | coll-gath | mod tol | x | x |
| Arthropoda | Insecta | Diptera | Dixidae | | *Dixa* sp. | | meniscus midges | coll-gath | intol | NEW | |
| Arthropoda | Insecta | Diptera | Simuliidae | Simuliinae | *Simulium* sp. | | black flies | coll-filt | mod tol | x | x |
| Arthropoda | Insecta | Diptera | Simuliidae | | | | black flies | coll-filt | mod tol | x | x |
| Arthropoda | Insecta | Diptera | Tipulidae | | *Hexatoma* sp. | | crane flies | pred | intol | x | x |
| Arthropoda | Insecta | Diptera | Tipulidae | | | | crane flies | shredder | intol | x | NEW |
| Arthropoda | Insecta | Diptera | | | | | flies | n/a | mod tol | x | |
| Arthropoda | Insecta | Ephemeroptera | Leptohyphidae | | *Tricorythodes* sp. | | little snout crawler mayflies | coll-gath | mod tol | x | x |
| Arthropoda | Insecta | Ephemeroptera | Baetidae | | *Baetis* sp. | | small minnow mayflies | coll-gath | mod tol | x | x |
| Arthropoda | Insecta | Ephemeroptera | Baetidae | | *Fallceon* | *quilleri* | small minnow mayflies | coll-gath | n/a | x | x |
| Arthropoda | Insecta | Ephemeroptera | Baetidae | | | | small minnow mayflies | coll-gath | intol | | x |
| Arthropoda | Insecta | Ephemeroptera | Heptageniidae | | *Heptagenia* sp. | | flatheaded mayflies | scraper | intol | | x |

| Phylum | Class | Order | Family | SubFamily | Genus | Species | Common name | Funct group[1] | Tol group[2] | MAN01 | MAN02 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Arthropoda | Insecta | Ephemeroptera | Heptageniidae | | | | flatheaded mayflies | scraper | intol | | x |
| Arthropoda | Insecta | Hemiptera | Veliidae | Rhagoveliinae | *Rhagovelia* sp. | | small water striders | pred | mod tol | x | x |
| Arthropoda | Insecta | Lepidoptera | Crambidae | Nymphulinae | *Petrophila* sp. | | crambid snout moths | scraper | intol | | NEW |
| Arthropoda | Insecta | Odonata | Coenagrionidae | | | | narrow-winged damselflies | pred | mod tol | x | |
| Arthropoda | Insecta | Plecoptera | Perlodidae | | | | common stoneflies | pred | intol | x | x |
| Arthropoda | Insecta | Plecoptera | | | | | stoneflies | pred | n/a | x | x |
| Arthropoda | Insecta | Trichoptera | Hydropsychidae | Hydropsychinae | *Cheumatopsyche* sp. | | netspinning caddisflies | coll-filt | mod tol | x | x |
| Arthropoda | Insecta | Trichoptera | Hydropsychidae | Hydropsychinae | *Hydropsyche* sp. | | netspinning caddisflies | coll-filt | intol | x | x |
| Arthropoda | Insecta | Trichoptera | Hydropsychidae | | | | netspinning caddisflies | coll-filt | intol | x | x |
| Arthropoda | Insecta | Trichoptera | Hydroptilidae | | | | microcaddisflies | n/a | intol | x | |
| Arthropoda | Malacostraca | Amphipoda | Hyalellidae | | *Hyalella* sp. | | scuds | coll-gath | tol | x | |
| Arthropoda | Malacostraca | Decapoda | Cambaridae | | | | crayfish | coll-gath | mod tol | | x |
| Nemata | | | | | | | flatworms | n/a | n/a | x | |

*Note*: "NEW" under the site column denotes a new record for this SCPN monitoring site.
[1]Functional group abbreviations: coll-gath = collector-gatherer, coll-filt = coll-filterer, pred = predator.
[2]Tolerance group abbreviations: tol = tolerant, mod tol = moderately tolerant, intol = intolerant.

# Appendix E Stream velocity and channel characteristics at aquatic macroinvertebrate monitoring sites on the Mancos River in Mesa Verde National Park, Colorado, 2012

| | Velocity (m/s) (*n* = 5) | | Depth (m) (*n* = 5) | | Wetted channel width (m) | Active channel width (m) |
|---|---|---|---|---|---|---|
| **Transect** | **Mean** | **Std Dev** | **Mean** | **Std Dev** | **Value** | **Value** |
| **MAN01** | | | | | | |
| 1 | 0.06 | 0.09 | 0.03 | 0.03 | 5.8 | >50.0 |
| 2 | 0.07 | 0.06 | 0.04 | 0.02 | 4.9 | >50.0 |
| 3 | 0.03 | 0.01 | 0.12 | 0.03 | 4.3 | >50.0 |
| 4 | 0.02 | 0.02 | 0.24 | 0.08 | 3.2 | >50.0 |
| 5 | 0.09 | 0.07 | 0.08 | 0.05 | 1.9 | >50.0 |
| 6 | 0.13 | 0.09 | 0.08 | 0.04 | 2.8 | >50.0 |
| 7 | 0.29 | 0.20 | 0.05 | 0.04 | 1.6 | >50.0 |
| 8 | 0.13 | 0.20 | 0.02 | 0.01 | 2.6 | >50.0 |
| 9 | 0.04 | 0.03 | 0.10 | 0.02 | 3.8 | >50.0 |
| 10 | 0.07 | 0.06 | 0.04 | 0.03 | 4.2 | >50.0 |
| 11 | 0.10 | 0.14 | 0.03 | 0.03 | 3.3 | >50.0 |
| **MAN02** | | | | | | |
| 1 | 0.07 | 0.04 | 0.14 | 0.05 | 3.0 | >50.0 |
| 2 | 0.08 | 0.05 | 0.08 | 0.05 | 3.1 | >50.0 |
| 3 | 0.04 | 0.02 | 0.16 | 0.05 | 3.1 | >50.0 |
| 4 | 0.07 | 0.06 | 0.07 | 0.04 | 3.8 | >50.0 |
| 5 | 0.14 | 0.26 | 0.18 | 0.09 | 2.0 | >50.0 |
| 6 | 0.04 | 0.06 | 0.26 | 0.06 | 3.6 | >50.0 |
| 7 | 0.18 | 0.13 | 0.05 | 0.04 | 2.7 | >50.0 |
| 8 | 0.21 | 0.12 | 0.07 | 0.05 | 2.6 | >50.0 |
| 9 | 0.12 | 0.15 | 0.11 | 0.02 | 2.0 | >50.0 |
| 10 | 0.07 | 0.04 | 0.04 | 0.02 | 5.4 | >50.0 |
| 11 | 0.06 | 0.05 | 0.08 | 0.02 | 4.1 | >50.0 |

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NPS 307/125809, August 2014

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**Natural Resource Stewardship and Science**
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov