



Macroinvertebrate Communities and Habitat Characteristics in the Northern and Southern Colorado Plateau Networks

Pilot Protocol Implementation

Natural Resource Technical Report NPS/NCPN/NRTR—2010/320



ON THE COVER

Clockwise from bottom left: Coyote Gulch, Glen Canyon National Recreation Area (USGS/Anne Brasher); Intermittent stream (USGS/Anne Brasher); Coyote Gulch, Glen Canyon National Recreation Area (USGS/Anne Brasher); Caddisfly larvae of the genus *Neophylax* (USGS/Steve Fend); Adult damselflies (USGS/Terry Short).

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Acronyms

ANOSIM	Analysis of Similarity
AZ	Arizona
CO	Colorado
EMAP	Environmental Monitoring and Assessment Program (U.S. Environmental Protection Agency)
GRTS	Generalized Random Tessellation Stratified
I&M	inventory and monitoring
IDAS	Invertebrate Data Analysis System
NAWQA	National Water-Quality Assessment program (USGS)
NCPN	Northern Colorado Plateau Network
NM	New Mexico
NMDS	non-metric multidimensional scaling
NPS	National Park Service
QA/QC	quality assurance/quality control
SCPN	Southern Colorado Plateau Network
SIMPER	Similarity Percentage analysis
USGS	U.S. Geological Survey
UT	Utah

NCPN parks

ARCH	Arches National Park
CANY	Canyonlands National Park
CARE	Capitol Reef National Park
ZION	Zion National Park

SCPN parks

BAND	Bandelier National Monument
GLCA	Glen Canyon National Recreation Area
MEVE	Mesa Verde National Park

Abstract

Aquatic macroinvertebrates have been identified by the National Park Service Inventory and Monitoring (I&M) program as a vital sign that can indicate the status of aquatic ecosystems in national parks of the Colorado Plateau. Monitoring macroinvertebrate assemblages can complement physical and chemical water-quality assessment methods, and provide a more complete evaluation of watershed condition. Because macroinvertebrates integrate, temporally and spatially, the effects of land and water use in a watershed, they are excellent indicators of both long-term changes and short-term events. Monitoring physical habitat in conjunction with macroinvertebrates provides an important link between macroinvertebrate community composition and anthropogenic activities that can affect watershed quality.

A pilot implementation study was conducted at nine sites in eight streams in seven national parks across the Colorado Plateau. Streams for this pilot study were selected to represent a range of habitat characteristics (stream types) and maximize variance across sites. Two types of macroinvertebrate samples were collected in each reach: one from a measured (quantitative) area within a targeted habitat (riffles), and the other a qualitative sample collected from multiple habitat types. Quantitative samples provide estimates of species densities and allow statistical comparisons among sites and over time, while qualitative samples provide a representative species list and information on biodiversity at a site. Physical habitat characteristics, including water depth, velocity, substrate size, and riparian canopy closure, were measured at three spatial scales: reach, transect, and points along each transect. Physical habitat characteristics were also measured at each quantitative macroinvertebrate sample location.

Overall, we collected 241 different taxa in 23 orders and 74 families. Considerable differences were observed in macroinvertebrate community structure among sites. The association between variation in macroinvertebrate community structure and habitat characteristics among the eight streams was examined using the multivariate statistical technique of non-metric multidimensional scaling (NMDS). Sampling sites ranged from small, shallow, intermittent streams to a deeper, wider stream with fast-flowing water. Percent canopy closure, an indication of shading, also varied widely among streams from sites with little canopy closure to sites almost completely shaded. Most of the sites were dominated by extremely small substrate (sand). Statistical analyses indicated that variables driven by stream size and discharge were largely responsible for controlling the community composition of macroinvertebrates at the sampling sites. The ability to detect differences in macroinvertebrate fauna among streams suggests that this monitoring protocol will also be able to detect differences (changes) in macroinvertebrate communities over time—especially changes associated with alterations to habitat characteristics.

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Collecting a qualitative macroinvertebrate sample at Courthouse Wash, Arches National Park.



Using a densiometer to estimate riparian canopy cover at Coyote Gulch, Glen Canyon National Recreation Area.

1 Introduction

Macroinvertebrates are sensitive to changes in the physical and chemical environment (Oberlin et al. 1999). Therefore, their responses can be monitored to provide an assessment of watershed and stream quality. Indeed, macroinvertebrate community structure has been monitored since the early 1900s to assess the status and trends of aquatic life in rivers (Cairns and Pratt 1993; Rosenberg and Resh 1993). Over time, various multimetric methods, such as the Index of Biological Integrity (IBI; Karr 1981) have been developed and used to integrate and synthesize assemblage data. Monitoring the status of macroinvertebrate assemblages can complement physical and chemical water-quality assessment methods and provide a more complete evaluation of watershed condition (Karr 1991; Allan 1995; Karr and Chu 1999).

Because macroinvertebrates integrate (temporally and spatially) the effects of land and water use in a watershed, they are excellent indicators of both long-term changes (such as siltation) and short-term events (such as point-source pollutants) (Maret et al. 2001; Blinn and Ruiter 2006). Moreover, macroinvertebrates play a vital role in aquatic and riparian systems by providing a link in the food chain between the primary producers (algae and plants) and larger vertebrates, such as fish and birds, and by acting as a key component for the processing of organic material and in nutrient cycling (Scott et al. 2005).

It is for these reasons that macroinvertebrates have been identified as a vital sign that can indicate the status of aquatic ecosystems in national parks of the Colorado Plateau. Because aquatic macroinvertebrate assemblages were selected as a core/high-priority vital sign for the Northern and Southern Colorado Plateau networks (NCPN and SCPN, respectively) of the National Park Service (NPS) Inventory and Monitoring (I&M) program (O'Dell et al. 2005; Thomas et al. 2006), a protocol and set of standard operating procedures were developed to guide monitoring activities (Brasher et al. in press).

Monitoring physical habitat provides an important link between macroinvertebrate community composition and anthropogenic activities that can affect watershed quality. Habitat assessments are conducted concurrently with macroinvertebrate



Photo 1-1. Macroinvertebrates include crustaceans, mollusks, worms, and insects. Some invertebrates spend their larval stage in the water, and their adult stage as flying insects.

collections to provide supporting information and multiple lines of evidence regarding stream and watershed quality. Changes in either habitat features or macroinvertebrate communities can serve as a warning to managers that the system is changing. Assessing macroinvertebrate response to habitat characteristics will provide information to help inform management decisions.

Monitoring the status of macroinvertebrate assemblages will provide information on natural variation and allow for the detection of change over time (trends). By monitoring both habitat characteristics and macroinvertebrate assemblages, a scientific link to management activities will be established and can be used to help determine management strategies. Management action may be needed if long-term environmental change is detected in the macroinvertebrate communities monitored (Noon 2003). Data collected by the NCPN and SCPN following the monitoring protocol will allow managers to identify (1) environmental stressors affecting macroinvertebrate communities and habitat (Scott et al. 2005) and (2) long-term status and trends of aquatic resources relative to natural processes and anthropogenic stressors.



Photo 1-2. Sampling site at Courthouse Wash, Arches National Park.

Although the networks chose to develop the monitoring protocol jointly, allowing shared data and better establishment of baseline information, each network operates independently, and the two networks have different monitoring objectives. The objectives of aquatic macroinvertebrate monitoring for the SCPN are to (1) determine status and trends in the composition and abundance of aquatic macroinvertebrate assemblages in selected reaches, (2) determine status and trends in the distribution and quality of available habitats in selected stream reaches, (3) correlate physical habitat measures with changes in the composition and abundance of aquatic macroinvertebrate assemblages, and (4) correlate water quality measures with changes in the composition and abundance of aquatic macroinvertebrate assemblages (Thomas et al. 2006).

The objectives for the NCPN are to (1) establish baseline information (status) on the condition of macroinvertebrates in selected stream reaches, (2) assess status and trends in habitat quality, and (3) detect long-term trends in the distribution, abundance, and species composition of macroinvertebrates at selected sites in selected streams (D. Perkins, personal communication).

The purpose of this pilot implementation study was to evaluate the effectiveness of the protocols developed for the NCPN and SCPN (Brasher et al. in press) and assess the information generated by the pilot sampling efforts.

During this pilot study, we measured key habitat characteristics, including water depth, velocity, substrate size, and riparian canopy closure. Because habitat assessments can be relatively time-consuming, we evaluated the amount of data that needed to be collected to adequately characterize habitat conditions in the stream.

Because the sampling methods for both macroinvertebrates and habitat characterization are well-established throughout the country (Cuffney et al. 1993; Fitzpatrick et al. 1998; Moulton et al. 2002; Peck et al. 2006), we focused on implementation of these protocols in remote, arid southwest parks where there is a general lack of scientific data on macroinvertebrate communities. Protocols were field-tested using different crews over the two years of the pilot study, and streams were sampled over a range of geomorphology across the Colorado Plateau.

In order to meet the stated objectives of both networks, preliminary analyses were done to determine the amount of habitat data (e.g., number of transects and number of pebbles counted) required to characterize a site, and to identify some appropriate macroinvertebrate metrics to assess a site. Additionally, this report compares quantitative and qualitative macroinvertebrate samples spatially and temporally by comparing macroinvertebrate communities (1) during three sampling events at one site over the sampling season (i.e., across the index period), (2) during sampling events across two different years, at two different sites located along one reach, and (3) in different streams across the Colorado Plateau. Finally, a multivariate statistical approach was used to quantify the relationships between habitat characteristics and macroinvertebrate community structure.

2 Methods

2.1 Sampling locations and timing

The pilot implementation study was conducted at nine sites on eight streams in seven national parks (Table 2-1, Figure 2-1, Appendix A). Five NCPN streams were sampled: Courthouse Wash, in Arches National Park (ARCH), Utah; Halls Creek, in Capitol Reef National Park (CARE), Utah; La Verkin Creek and North Creek, in Zion National Park (ZION), Utah; and Salt Creek, in Canyonlands National Park (CANY), Utah.

Three SCPN streams were sampled: Capulin Creek, in Bandelier National Monument (BAND), New Mexico; Coyote Gulch, in Glen Canyon National Recreation Area (GLCA), Utah; and the Mancos River, in Mesa Verde National Park (MEVE), Colorado.†

Sampling streams for this pilot study were selected to represent a range of habitat characteristics

(stream types) along the Colorado Plateau and maximize variance across sites. Specific sampling sites were selected to correspond with ongoing water-quality monitoring efforts (S. Monroe, C. Schelz, D. Thoma, personal communications).

Samples were collected once in the five NCPN streams, in spring/summer 2006. With the exception of Capulin Creek Site 2, where one sample was collected in the fall of 2006, multiple samples were collected in the three SCPN streams between fall 2005 and fall 2006. Sample dates for each stream are shown in Table 2-2.

2.2 Reach layout for habitat assessment

Reach locations were selected according to several criteria, including the presence of riffle habitats, the feasibility of effectively using sampling equipment throughout the reach (i.e., appropriate depth), the absence of artificial structures, and lack of spring or tributary inflows.

†Two sites were sampled at Capulin Creek in fall 2006. The second site was chosen to overlap with a riparian sampling site that had been randomly selected using the Generalized Random Tessellation Stratified (GRTS) selection method.

Table 2-1. Pilot study sites in Northern and Southern and Colorado Plateau network parks.

Stream name	Park name	Park abbreviation	State	Stream type	Location (UTMs)	Altitude (m)	Level III ecoregion ¹
NCPN sites							
Courthouse Wash	Arches National Park	ARCH	UT	Intermittent	12S 0617224 4282685	1,298	Colorado Plateau
Halls Creek	Capitol Reef National Park	CARE	UT	Perennial	12S 0511254 4163192	1,195	Colorado Plateau
La Verkin Creek	Zion National Park	ZION	UT	Perennial	12S 0307079 4142091	1,529	Colorado Plateau
North Creek	Zion National Park	ZION	UT	Perennial	12S 0313816 4126159	1,248	Colorado Plateau
Salt Creek	Canyonlands National Park	CANY	UT	Intermittent	12S 0608511 4218404	1,542	Colorado Plateau
SCPN sites							
Capulin Creek (Site 1)	Bandelier National Monument	BAND	NM	Perennial	13S 0379713 3958026	1,907	Southern Rocky Mtns
Capulin Creek (Site 2)	Bandelier National Monument	BAND	NM	Perennial	13S 0380162 3957416	1,869	Southern Rocky Mtns
Coyote Gulch	Glen Canyon National Recreation Area	GLCA	UT/AZ	Perennial	12S 0500945 4142249	1,147	Colorado Plateau
Mancos River	Mesa Verde National Park	MEVE	CO	Perennial (Degraded)	12S 0734440 4126037	1,929	Colorado Plateau

¹Based on Omernik (1987)

Northern and Southern Colorado Plateau Networks Arizona, Colorado, New Mexico, Utah, Wyoming

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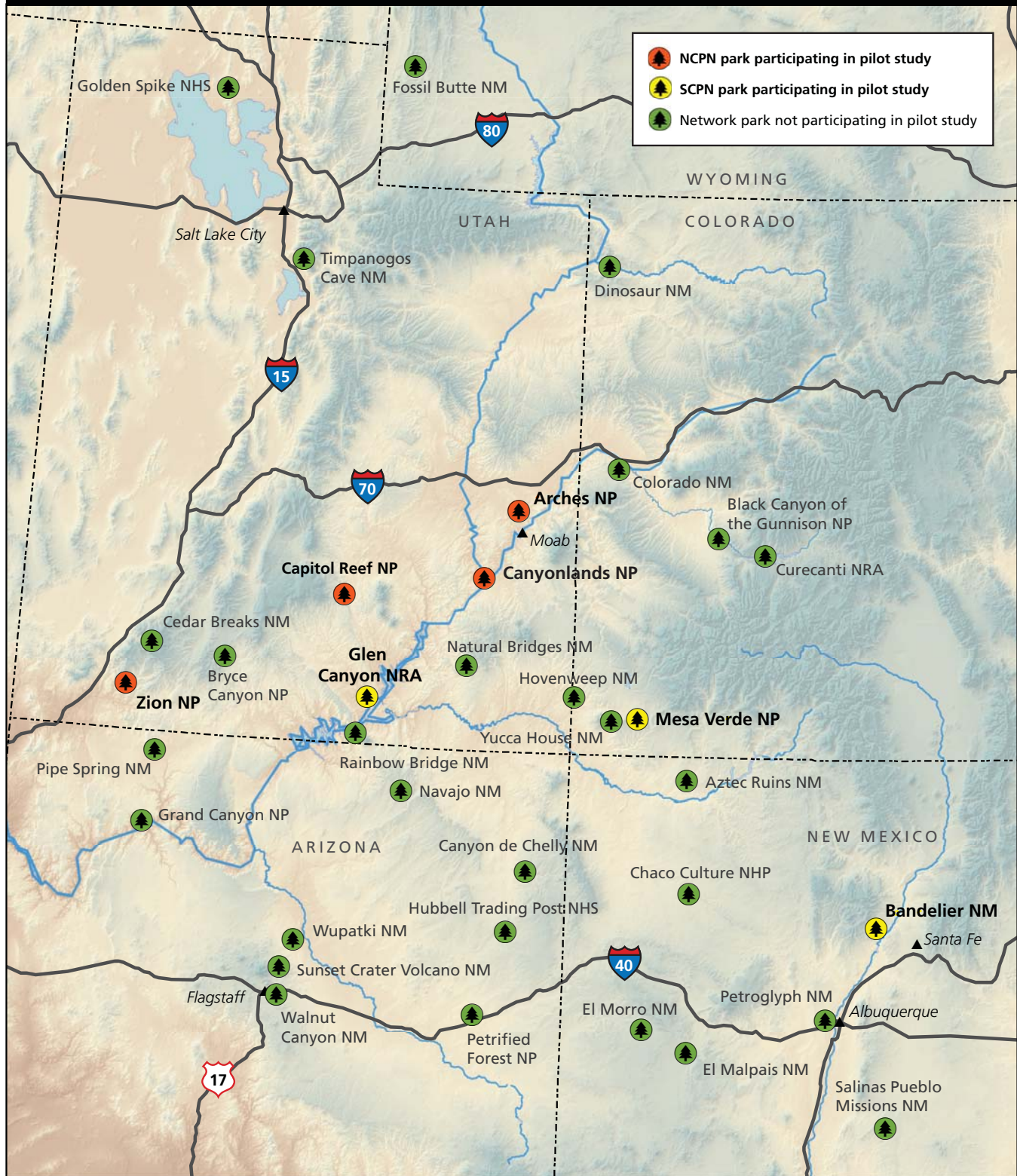


Figure 2-1. National parks of the Northern and Southern Colorado Plateau networks. Streams were sampled during this pilot implementation study at NCPN parks indicated in red on the map and SCPN parks indicated in yellow. NM = National Monument, NP = National Park, NRA = National Recreation Area.

Table 2-2. Summary of NCPN and SCPN macroinvertebrate sampling.

Stream	Park	Sample date	Sample type		
			Quantitative		Qualitative
			Sampling device used (area sampled, m ²)	Number of replicates	
NCPN sites					
Courthouse Wash	ARCH	7/4/2006	D-frame net (0.72)	8 composited	1
Halls Creek	CARE	5/17/2006	D-frame net (0.72)	8 composited	1
La Verkin Creek	ZION	8/22/2006	D-frame net (0.72)	8 composited	1
North Creek	ZION	8/23/2006	D-frame net (0.72)	8 composited	1
Salt Creek	CANY	6/22/2006	D-frame net (0.72)	8 composited	1
SCPN sites					
Capulin Creek (Site 1)	BAND	9/24/2005	Surber Sampler (1.25)	5	3
		9/6/2006	D-frame net (0.45)	5	1
		10/1/2006	D-frame net (0.45)	5	1
		10/27/2006	D-frame net (0.45)	5	1
Capulin Creek (Site 2)	BAND	10/28/2006	D-frame net (0.45)	5	1
Coyote Gulch	GLCA	9/20/2005	Surber Sampler (1.25)	5	3
		10/31/2005	Surber Sampler (1.25)	5	3
		9/22/2006	D-frame net (0.45)	5	1
		10/12/2006	D-frame net (0.45)	5	1
		11/3/2006	D-frame net (0.45)	5	1
Mancos River	MEVE	9/12/2005	Surber Sampler (1.25)	5	3
		9/1/2006	D-frame net (0.45)	5	1
		9/29/2006	D-frame net (0.45)	5	1
		10/25/2006	D-frame net (0.45)	5	1

Each reach length was calculated as 20 times the wetted channel width (Fitzpatrick et al. 1998), with a minimum length of 150 meters. Minimum reach lengths were also constrained by geomorphic channel units (e.g., pools, riffles, runs) present in the stream. At Salt Creek and Courthouse Wash, there was only enough water for a reach length of 100 m. Once the reach location and length were determined, 11 equally spaced transects were established (Figure 2-2).

2.3 Habitat characterization

2.3.1 Measurements

Physical habitat characteristics were measured at three spatial scales: reach, transect, and points along the transect. Physical habitat characteristics were also measured at each quantitative macroinvertebrate sample location (microhabitat measurements). See Brasher et al. (in press) for a detailed description of habitat assessments.

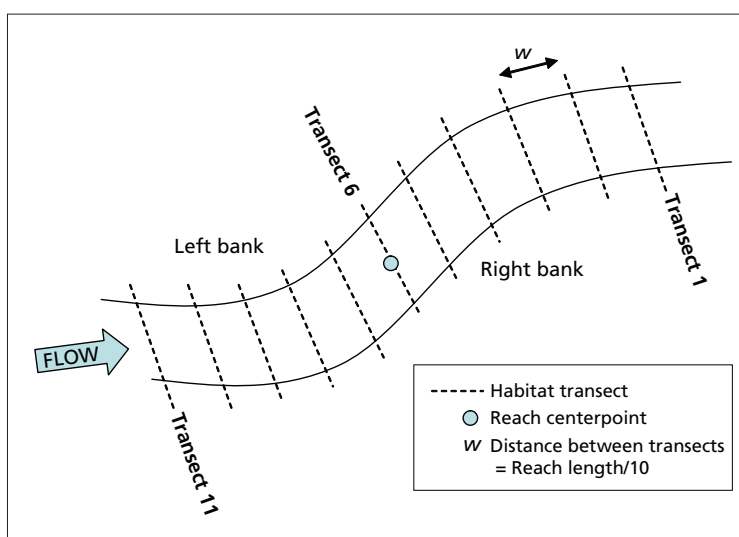


Figure 2-2. Reach layout showing 11 habitat characterization transects.

Reach-scale measurements included geomorphic channel-unit type (e.g., riffle, run, pool, following Hawkins et al. 1993) and length. Geomorphic channel units were also recorded at the transect and point scales (five points across each transect).

Transect measurements included solar radiation, measured with a Solar Pathfinder™ at the center of even-numbered transects (one measurement per transect), wetted channel width, and riparian canopy closure. Solar Pathfinder™ data were transcribed as percent solar radiation per month. The mean (and standard deviation) percent solar radiation of five transects was plotted. The mean, maximum, and minimum solar radiation values per year were calculated to compare Solar Pathfinder™ results among sites. No additional analysis/interpretation was completed due to the minimal number of measurements. Riparian canopy-closure measurements were collected using a concave spherical densiometer, facing each of four directions (upstream, downstream, left, and right) at both the left and right stream edges, for a total of 88 measurements per reach.

Five point measurements of depth, velocity, habitat cover, and geomorphic channel-unit type were collected at evenly spaced distances along each transect.

2.3.2 Transect analysis

During this pilot study, approximately half of the total sampling time at each reach was dedicated to habitat assessments (see Appendix B). The U.S. Geological Survey's National Water-Quality Assessment (NAWQA) program and the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) both collect habitat measurements at 11 transects along a reach (Appendix C). Because reducing the number of transects would expedite the habitat-survey process (and reduce associated temporal and monetary costs), an analysis of the number of transects needed to attain an accurate estimate of mean and variability in habitat conditions was conducted for velocity, depth, and canopy closure.

At each sampling site, one sampling event, for which habitat characteristics were recorded at all 11 transects in 2006, was selected for analysis (see Appendix D for summary statistics of habitat variables measured at the reach, transect, and micro-habitat scales for all sampling sites). The mean and

standard deviation for habitat measurements using 2–11 transects was calculated to determine whether habitat measurements, which are very time-consuming, could be collected at fewer than 11 transects while maintaining the value of the data.

Subsets of the original data were taken to compare 2 transects (using transects 1 and 11), 3 transects (transects 1, 6, 11), 4 transects (1, 4, 8, 11), 5 transects (1, 3, 6, 9, 11), 6 transects (1, 3, 5, 7, 9, 11), 7 transects (1, 3, 5, 6, 7, 9, 11), 8 transects (1, 3, 4, 6, 8, 9, 10, 11), 9 transects (1, 2, 3, 4, 5, 7, 8, 10, 11), 10 transects (1, 2, 3, 4, 5, 7, 8, 9, 10, 11), and 11 transects (1 through 11) (Table 2-3).

To compare the number of transects required to characterize depth and velocity, the mean and standard deviation were calculated for each transect subset and graphed.

For canopy closure, each densiometer measurement was divided by 17 (total number of possible points) and multiplied by 100 to calculate percent canopy cover. The mean and standard deviation were calculated for each subset and graphed. To compare sites, the points at each transect were averaged (five for depth and velocity and eight for canopy closure). The mean and standard error of all 11 transects was then calculated and graphed.

2.3.3 Pebble count

Modified Wolman pebble counts of 25–50 pebbles (depending on stream width) were also done along each transect. Fifty pebbles were measured across each two-meter-wide (wetted width) transect and 40 pebbles were measured at narrower transects. In general, at least 400 pebbles were measured at each site. In Courthouse Wash and Salt Creek, where there was less than 2 meters wetted width, fewer than 400 pebbles were measured.

Pebble-count data were analyzed by taking random subsets of 100, 250, and 400 pebbles from the original 400 or 500 pebbles (depending on site). The mean pebble size (cm) and standard deviation were calculated and graphed for each site. The data were also “binned” by dividing raw data into size categories to illustrate pebble counts as substrate class, a common way to present such data. The number of pebbles in each size category was counted and divided by the total number of pebbles counted at that site and multiplied by 100 to get a percentage.

Table 2-3. Transects compared to determine the number needed to attain an accurate estimate of mean and variability in habitat conditions.

Transect	Number of transects compared										
	2	3	4	5	6	7	8	9	10	11	
1	X	X	X	X	X	X	X	X	X	X	
2								X	X	X	
3				X	X	X	X	X	X	X	
4			X				X	X	X	X	
5					X	X		X	X	X	
6		X		X		X	X			X	
7					X	X		X	X	X	
8			X				X	X	X	X	
9				X	X	X	X		X	X	
10							X	X	X	X	
11	X	X	X	X	X	X	X	X	X	X	

2.4 Sample collection

Two types of macroinvertebrate samples, one from a measured (quantitative), targeted habitat (riffles) and the other from multiple habitat types (qualitative), were taken from each reach during the pilot study (see Table 2-2). Complete sampling methods are described in detail in Brasher et al. (in press).

2.4.1 Quantitative samples

Quantitative samples were collected from a standard measured area within a riffle, which provided estimates of species densities and allowed comparisons among sites and over time. Individual samples were well-distributed spatially along each reach. Microhabitat measurements (including depth, velocity, substrate size, and substrate embeddedness) were made at each quantitative macroinvertebrate sampling location.

Quantitative samples were collected from heterogeneous (multiple types) riffles to test the protocol for a wide range of riffle characteristics. For continued monitoring purposes, homogeneous riffles should be selected to reduce among-sample variation. For the five streams in the NCPN, eight separate riffle locations were sampled, and the samples were composited into a single jar. For the three streams in the SCPN, five separate samples were collected along the reach (replicates). Replicate samples will be collected by the SCPN

during monitoring to allow statistical analyses that require replicates (standard deviation).

While the SCPN chose to replicate their samples in order to assess between-sample variability and potentially increase the types of statistical trend analyses that could be done, the NCPN chose to composite their samples to be consistent with protocols employed by NAWQA, EMAP, and the State of Utah (see Appendix E for sampling methodologies used by various state and federal agencies), and to reduce the cost of sample identification. For the pilot study, we used this information to assess variability along the reach. All samples along the reach were collected by the same crew. For this study, all samples were collected under the direct supervision of the lead author.

It is important to note that because the data presented here were collected as part of a protocol-development process, quantitative sampling methods varied between 2005 and 2006. In 2005, a modified Surber sampler (500- μ m mesh net) was used to collect macroinvertebrate samples. Each sample location consisted of a 0.25-m² area immediately upstream of the net, and the total area sampled was 1.25 m² per reach. In 2006, a D-frame net (500- μ m mesh) was used to collect macroinvertebrate samples. Using this type of net, each sample location consisted of a 0.09-m² area. The total area sampled was 0.72 m² per reach for the NCPN sites (eight composited samples) and 0.45 m² per reach for the SCPN sites (five replicate samples). We switched to the D-frame net in 2006 due to the cumbersome nature of the modified Surber sampler, which was not ideal for backpacking long distances to field sites.

2.4.2 Qualitative samples

Qualitative multihabitat samples were collected from all types of habitat, in proportion to the habitat occurrence within the reach, and standardized over a set time period. Qualitative samples provided a representative species list but not abundance estimates. The number of each type of sample taken from NCPN and SCPN sites is shown in Table 2-2.

Qualitative samples were collected from all possible combinations of substrates (e.g., rocks, woody debris, algal mats, emergent vegetation) and flow (depth and velocity). Habitat types were categorized as fast, moderate, or slow velocity, and deep or shallow depths. Substrate types were



Photo 2-1. Measuring flow velocity in the Mancos River, Mesa Verde National Park.



Photo 2-2. Measuring pebbles at Capulin Creek, Bandelier National Monument.



Photo 2-3. Measuring solar radiation with a Solar Pathfinder™ at Coyote Gulch, Glen Canyon National Recreation Area.



Photo 2-4. Measuring habitat characteristics in the Fremont River, Capitol Reef National Park.

categorized as bedrock (>2 m), boulder (0.25–2 m), cobble (0.064–0.24 m), gravel (0.002–0.063 m), and sand/silt (<0.002 m). A range of habitats, including channel margins and backwater, were targeted during qualitative sampling. A timed (20–30 minutes, depending on the size of the stream) composite sample was collected by sampling each habitat for approximately 30–60 seconds via kicking, scrubbing, jabbing, dipping, or sweeping the substrate into the net. Some macroinvertebrates were also handpicked from substrate when appropriate. Although three replicate qualitative samples were collected at three SCPN sites in 2005, statistical comparison among the qualitative replicates was not conducted as part of this study.

Both quantitative and qualitative samples were sorted in the field to remove inorganic and organic debris (e.g., rocks and twigs), placed in a jar, and preserved with 70% ethanol. Samples were sent to EcoAnalysts, Inc., in Moscow, Idaho, for identification. The target count for all samples was 500 individuals. If the target count was not reached (i.e., 500 organisms were not present in the entire sample), all of the sample material was sorted, yielding the total abundance. Subsampling methods followed the U.S. Environmental Protection Agency's Rapid Bioassessment Protocol, but every sample was double-checked by a technician, instead of just one of ten. For taxonomy, the oligochaetes were identified to class and all other organisms identified to lowest practical level—typically, species or, sometimes, genus. Further information on QA/QC and taxonomic resolution can be found on the EcoAnalysts website, www.ecoanalysts.com. Macroinvertebrate data processing and ambiguous taxonomic resolution was accomplished using the Invertebrate Data Analysis System (IDAS) (Cuffney 2003). In addition, IDAS was used to generate macroinvertebrate metrics for use in analyses.

2.4.3 Comparison of quantitative and qualitative samples

To evaluate information generated by quantitative and qualitative macroinvertebrate samples, we compared taxa richness (i.e., number of different taxa) from the two sample types and for the site as a whole (i.e., qualitative plus quantitative samples). To further assess the type of information provided by quantitative and qualitative macroinvertebrate samples, we classified the macroinvertebrates into functional behavioral groups and functional feeding groups, two metrics com-

monly used to describe macroinvertebrate communities.

2.5 Spatial and temporal variation among samples

Replicate quantitative samples were collected at Capulin Creek, Coyote Gulch, and the Mancos River in 2005 and 2006, to characterize spatial variation (among replicates and between streams) and temporal variation (across the sampling index period and between years) in macroinvertebrate community composition. To begin to assess natural variability in macroinvertebrate samples, four types of comparisons using replicate quantitative samples were made:

- 1) among (three of the four SCPN) sites,
- 2) between reaches (two sites at Capulin Creek),
- 3) intra-seasonal (three of the four SCPN sites) within the index period, and
- 4) inter-annual (between sampling years at three of the four SCPN sites in 2005 and in 2006).

Inter-stream (eight total sites from NCPN and SCPN) comparisons were also conducted using composited quantitative samples for the NCPN and combined replicate quantitative samples for the SCPN.

Analysis of Variance (ANOVA) was used to statistically determine between-site and within-site variability for macroinvertebrate density and richness in the replicate samples from Capulin Creek, Coyote Gulch, and the Mancos River. Prior to running the analyses, data were checked for normality and subsequently log transformed because the distribution was non-normal. Analysis of Similarity (ANOSIM) was conducted using the statistical package PRIMER (Clarke and Warwick 2001) to examine spatial and temporal variability in community composition. Macroinvertebrate data were square-root transformed to down-weight the importance of the most abundant species (so that the less-common species would also be taken into account in the analysis), and non-metric multidimensional scaling (NMDS) ordinations conducted with PRIMER were used to visually compare replicates.

For analyses using all samples (NCPN and SCPN data) collected during the pilot study, data from the SCPN replicate samples were combined, to make them comparable to the composited



Photo 2-5. Sampling site at North Creek, Zion National Park.

NCPN samples. Quantitative macroinvertebrate-community data for the eight streams were analyzed by first constructing distance matrices using Bray-Curtis similarities and then performing NMDS to visualize similarities in ordination space. Qualitative macroinvertebrate-community data were clustered using Jaccard's similarity and then NMDS. A hierarchical cluster analysis using group means was chosen to illustrate similarities among sites. Groups of sites were determined by the cluster analysis based on composition of dominant species using Similarity Percentage Analysis (SIMPER; Clarke and Warwick 2001).

Interpretation of the ordinations produced in PRIMER was assisted by the use of stress values (Clarke and Warwick 2001). For NMDS plots, stress values of less than 0.05 indicate that the ordination provides an excellent representation of the data. Ordinations with stress values of less than 0.1 are considered to be good representations with no real chance of misinterpretation. Stress values of less than 0.2 indicate potentially useful representations, especially if they are close to 0.1. Stress values of greater than 0.3 correspond to very poor representation of data and suggest

that the points in a two-dimensional ordination are close to being randomly placed.

2.6 Metrics selection

Of the hundreds of potential metrics that could be used for stream monitoring, a small subset (eight metrics) were selected a priori, at the request of the SCPN, for inclusion in the macroinvertebrate protocol (Brasher et al. in press). Consequently, these metrics are specifically discussed in this pilot implementation report (Table 2-4). These metrics were selected based on theoretical associations between community characteristics and environmental conditions and on empirical associations that have been published in the literature. While these metrics were selected because they are generally considered to be reliable indicators of water quality, it should be noted that they provide a starting point and the selection of metrics should be an ongoing process during the stream monitoring program.

Thirty-one additional metrics, selected based on existing studies of macroinvertebrate assemblages in the Colorado Plateau, preliminary analysis of

the pilot-study data, and best professional opinion, are also examined in this report to assess the potential performance of these for monitoring water quality and/or biodiversity. Many of these are variations (e.g., richness vs. percent richness vs. percent abundance of Ephemeroptera) of the metrics listed in Table 2-4. These variations were examined because one variation may perform better than another for monitoring purposes.

The 39 metrics were evaluated according to several criteria, including the ranges of values for each metric that occurred in SCPN pilot-study streams. The sensitivity of each metric to known stressors (flow velocity, fine-sediment deposition, and embeddedness) was evaluated using Spearman rank correlation analysis. The majority of the results presented here focus on the eight metrics presented in Table 2-4, and should be considered as an example to guide metrics selection when adequate data have been collected for such purposes, rather than an indication of metrics that should be used to describe the monitoring data over time.

This pilot study was not intended to produce metrics selection (and lacks adequate data to do so). However, to guide future efforts, we provide an example of that type of analysis. We followed the guidelines used by the Western EMAP, which eliminated metrics from consideration for use in monitoring using the following criteria: (1) richness metrics with ranges of less than four and

(2) any metrics that had the same values at 75% or more of the sites (Stoddard et al. 2005). Associations of selected metrics to microhabitat flow velocity and substrate embeddedness were analyzed with Spearman rank correlations in order to identify metrics that showed sensitivity to differences in flow and fine-sediment deposition (characterized by embeddedness measurements and percent fine sediments based on pebble counts). Sensitivity analyses were used to examine the influence of flow velocity and sediment within a reach using metrics calculated from replicate samples collected from SCPN sites, and among streams using metrics calculated from combined (SCPN) and composited (NCPN) quantitative samples collected at all sites.

2.7 Habitat characteristics and macroinvertebrates

Spearman rank correlation analysis of NMDS ordination axes (macroinvertebrate taxa) and habitat variables was performed using the statistical package PC-ORD (McCune and Mefford 1999) to examine associations among macroinvertebrate community structure and habitat characteristics at both the reach (transect data) and microhabitat (data collected at sample locations) spatial scales.

Table 2-4. Example of macroinvertebrate metrics to be considered for streams in NCPN and SCPN parks.

Metric type	Metric	Expected direction of response to water quality and habitat degradation
Richness/Diversity	Taxa Richness	Decrease
Tolerance	Percent Dominant Taxa	Increase
Functional-Feeding	Percent Scrapers	Decrease
Functional-Habit	Number of Clinger Taxa	Decrease
Composition	Percent Ephemeroptera	Decrease
	Percent Non-Insect Taxa	Increase
	Ratio of Hydroptilidae + Hydropsychidae: Trichoptera	Variable
	Percent Plecoptera ¹	Decrease

Brasher et al. in press

¹ Likely to be useful only in streams at >5,000 ft elevation

3 Results

3.1 Habitat characterization

3.1.1 Depth and velocity

Depth and velocity varied among streams (Figure 3-1), indicating diverse geomorphology. The Mancos River, the largest river in the pilot study, had the deepest and fastest-flowing water. North Creek and La Verkin Creek were also relatively deep and fast. Salt Creek, an intermittent stream, had a series of isolated pools with relatively deep water, but no measurable flow. Courthouse Wash, also an intermittent stream, consists of a series of shallow, isolated pools with low velocity. Halls Creek had the shallowest average depth, and the third-slowest average velocity, following Salt Creek and Courthouse Wash.

Figure 3-2 shows the cumulative average depth and standard deviation of all sites as transects are added. Depth was measured at five equally spaced intervals across each of the 11 transects. The mean and standard deviation levelled out at around 9–11 transects for depth measurements (Figure 3-2). Water velocity was measured at the same five points across each of the 11 transects where depth was measured. The mean and standard deviation for velocity appeared to level out at around five or six transects for most sites (Figure 3-3).

3.1.2 Percent canopy closure

Percent canopy closure (which can include cliffs and canyon walls, as a source of shading) and percent solar radiation showed a strong inverse correlation.[†] For example, at Capulin Creek Site 1 (a Rocky Mountain stream with large trees in the riparian zone), canopy closure was around 71% and solar radiation was approximately 37% (Figure 3-4). The Mancos River (which is relatively wide, reducing the amount of riparian vegetation directly influencing the stream channel) showed the opposite pattern, with little canopy closure (approximately 15%) and high levels of solar radiation (about 85%). North Creek, located in a watershed that burned just prior to sampling, largely eliminating all trees and other vegetation, had the

lowest measured canopy closure and the highest level of solar radiation. Capulin Creek Site 2, with downed trees due to an earlier fire, also had higher levels of solar radiation. In general, for a given site, the percent solar radiation and percent canopy cover added up to approximately 100%. Depending on the stream, the mean and standard deviation of percent canopy closure tended to level out at between five and six transects (Figure 3-5).

3.1.3 Pebble size and substrate

The standard deviation between pebble sizes decreased substantially as increasing numbers of pebbles were measured (Figure 3-6). Pebble size varied among the sites (Figure 3-7), with North Creek having the largest substrate (rocks and boulders), and Courthouse Wash the smallest (almost entirely sand and small gravel). Salt Creek, Halls Creek, and Coyote Gulch also had very small substrate, while Capulin Creek had larger gravel and cobbles, as well as relatively high diversity in substrate size.

Most of the sites, including Courthouse Wash, Coyote Gulch, Halls Creek, La Verkin Creek, and Salt Creek, were dominated (greater than 60% of the substrate) by extremely small substrate (sand). The Mancos River had a large percentage (43%) of sand, but cobble also made up a significant portion (28%) of the substrate. Capulin Creek and North Creek had high substrate heterogeneity, with substrate well distributed across the size classes. We found that doing pebble counts (actually measuring rocks) was more efficient than categorizing substrate in the field. Such data can then easily be translated into size (type) categories for analysis and presentation.

3.2 Macroinvertebrate abundance and richness

Overall, we collected 241 different taxa in 23 orders and 74 families. Complete species lists for each site are provided in Appendix F for quantitative samples, and Appendix G for qualitative samples. Both abundance (density) and richness (number of taxa) were highest at Capulin Creek (Table 3-1; Figure 3-8). Capulin Creek Site 1 had

[†]Solar Pathfinder measurements, used to determine the extent of solar radiation, were performed at a subset of sites (Appendix D) in order to complement the canopy-closure data. Although used less commonly than the densiometer in stream-habitat assessments, the Solar Pathfinder has been shown to be an effective tool for estimating solar radiation in streams across the West (T. Short, personal communication). We used the Solar Pathfinder at six sites during the pilot study, and were able to detect large differences in solar radiation among sites.

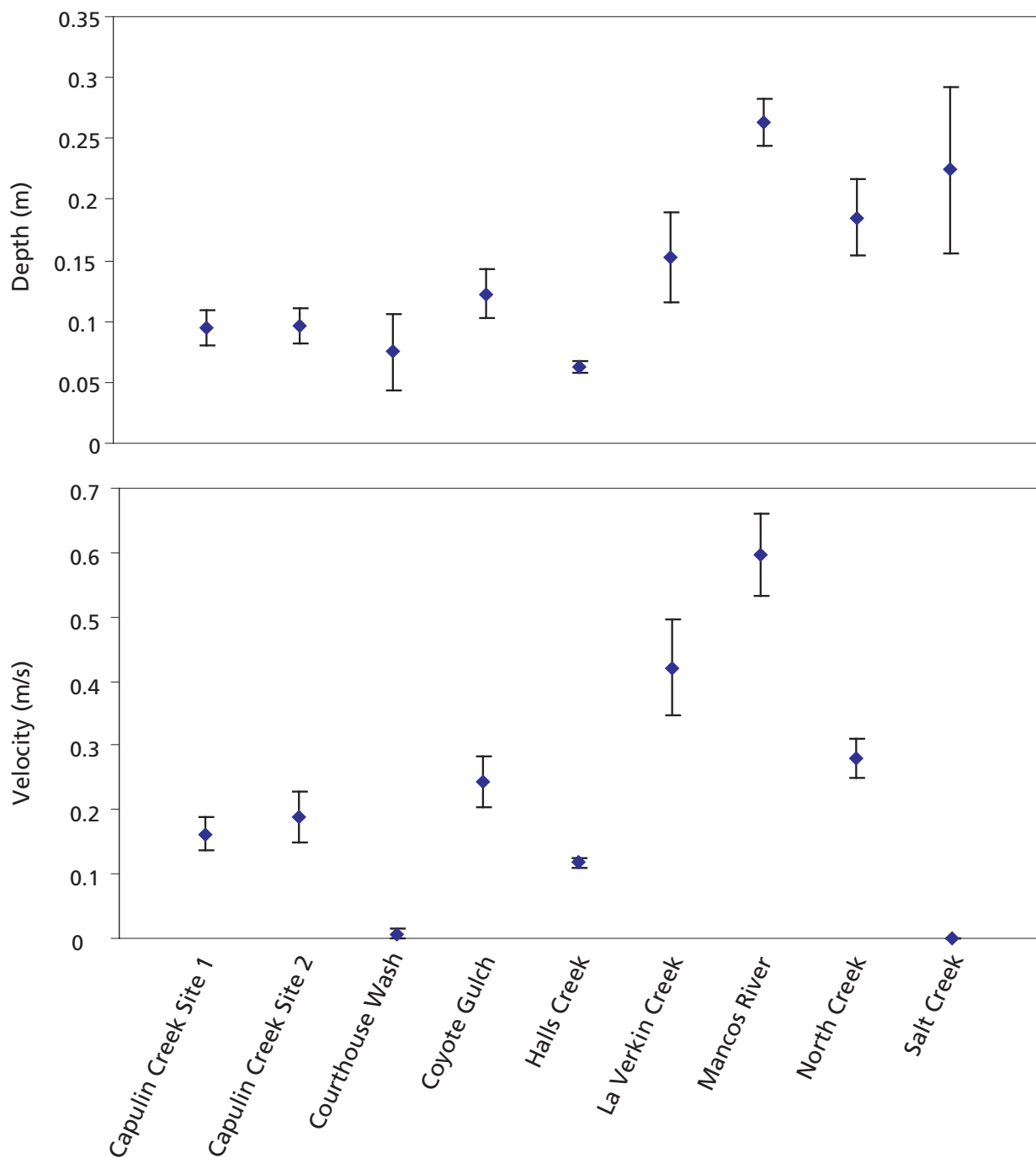


Figure 3-1. Depth and velocity (mean $\pm$ standard error) measured at five points across each transect.

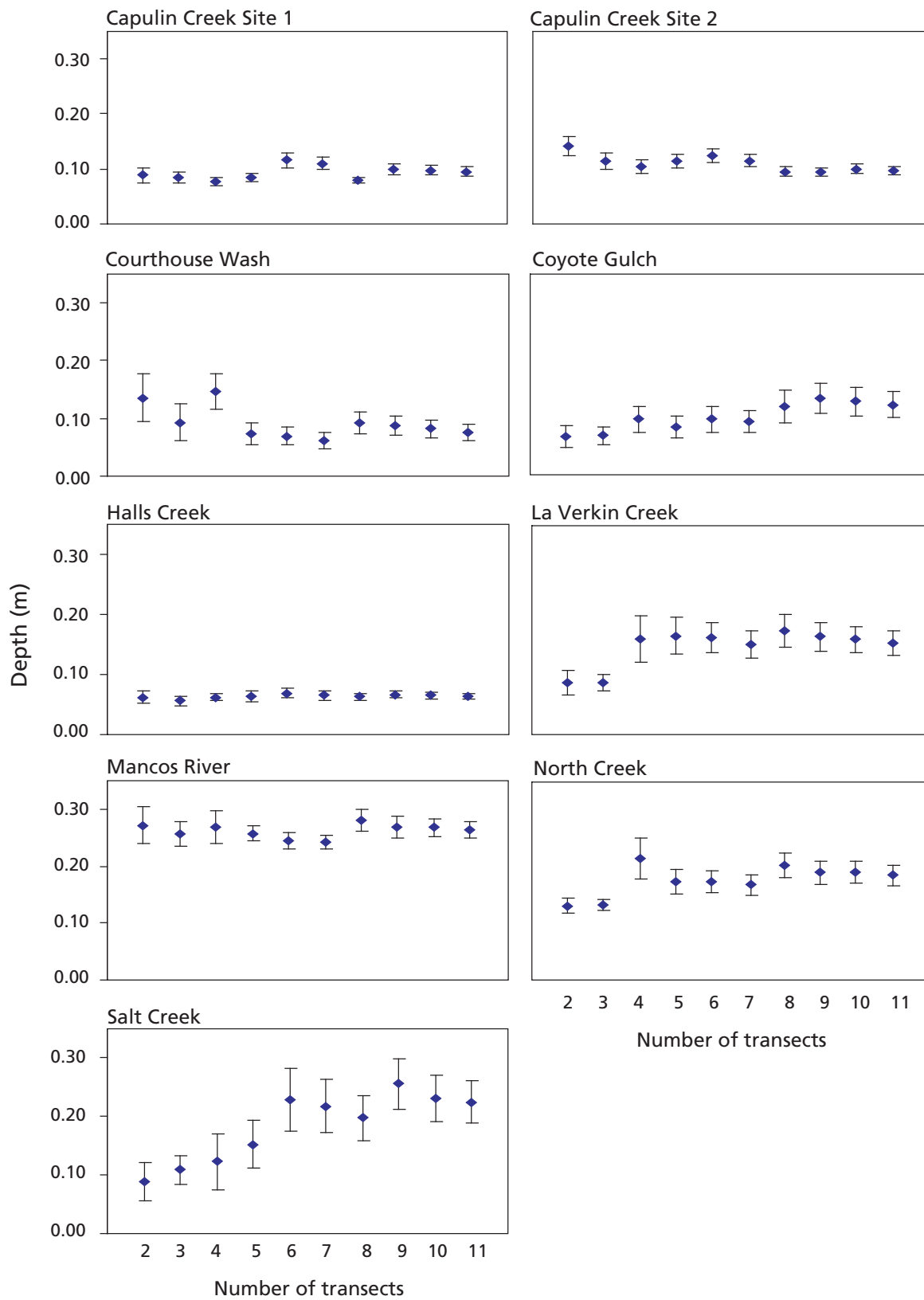


Figure 3-2. Depth (mean $\pm$ standard deviation) using 2–11 transects.

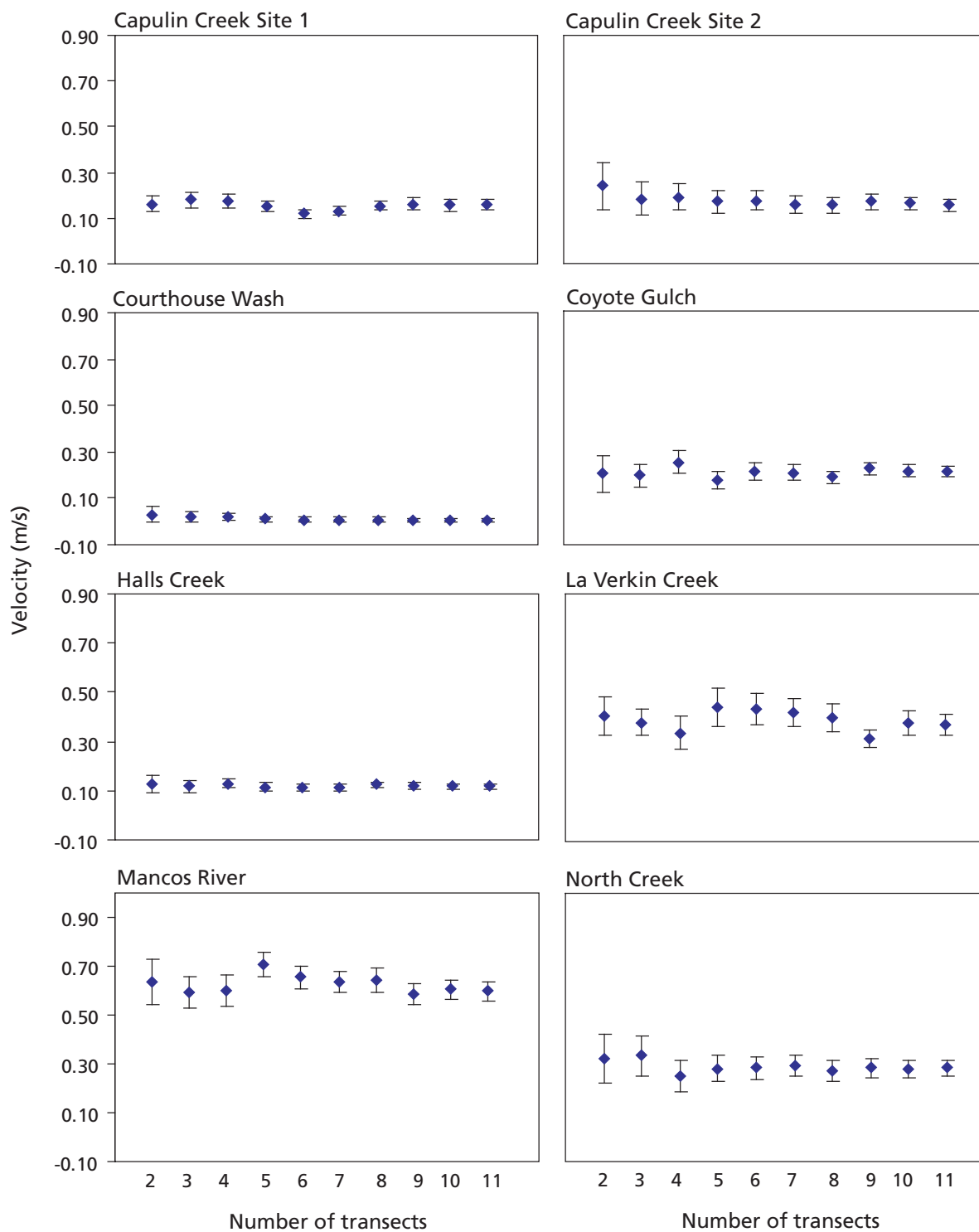


Figure 3-3. Velocity (mean $\pm$ standard deviation) using 2–11 transects.

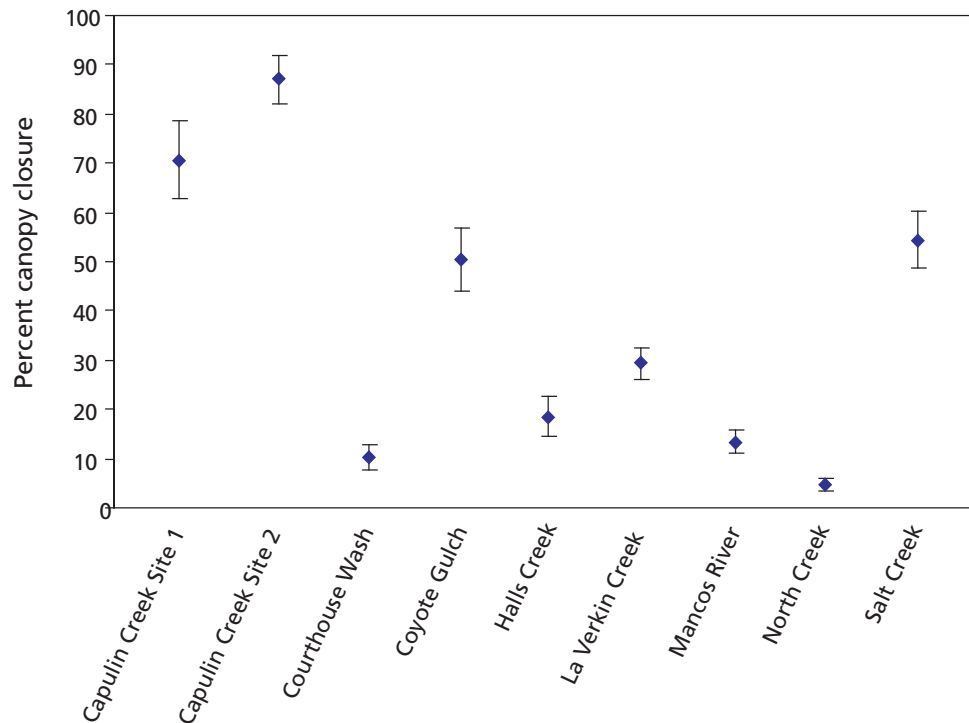
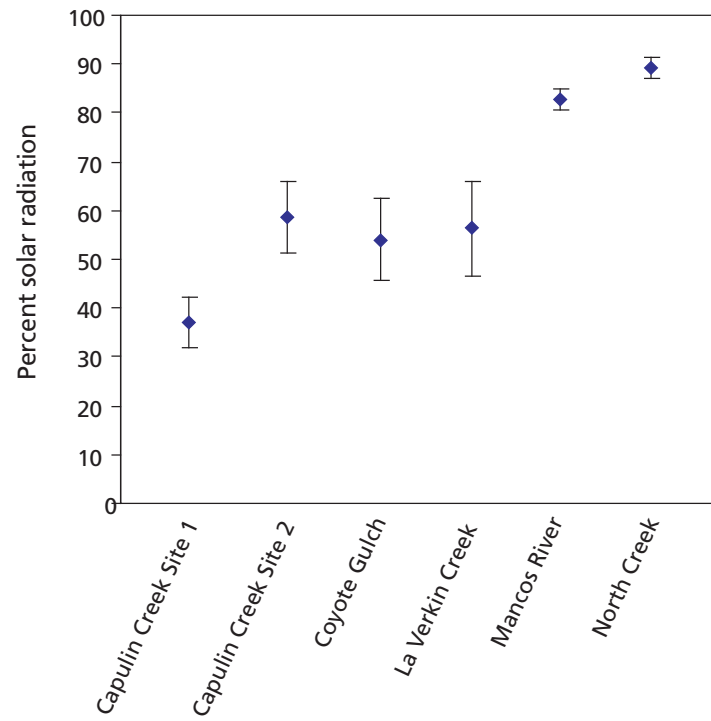


Figure 3-4. Solar radiation and canopy closure (mean $\pm$ standard error) at sampling sites where measured.

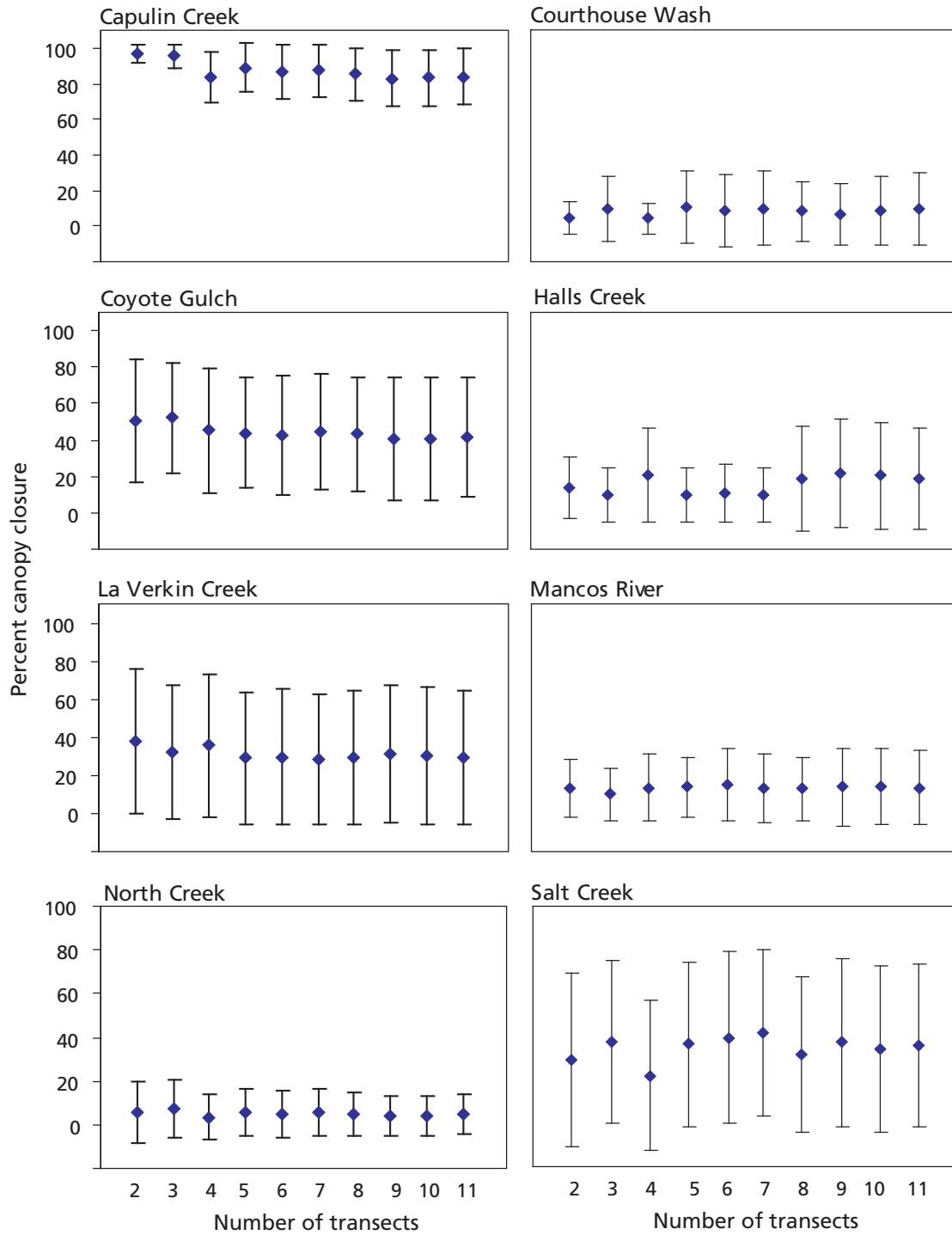


Figure 3-5. Canopy closure (mean $\pm$ standard deviation) using 2–11 transects.

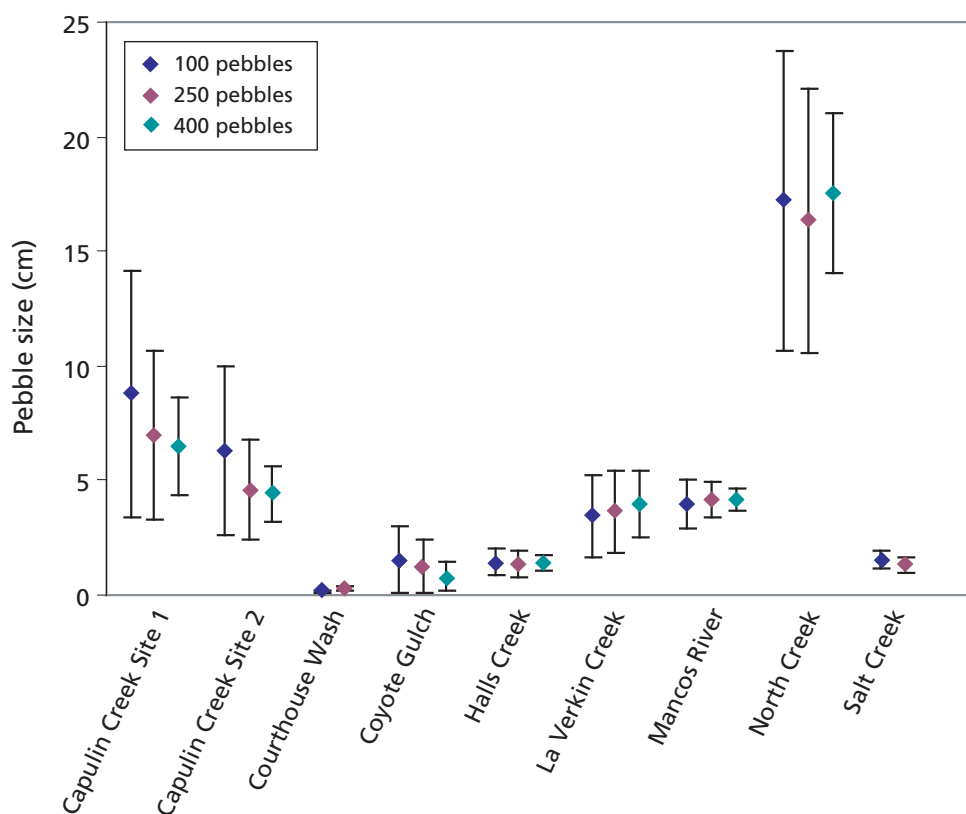


Figure 3-6. Pebble size (mean $\pm$ standard deviation) measured at the nine sampling sites, comparing 100, 250, and 400 pebbles drawn from the sample of total pebbles measured at a given site.

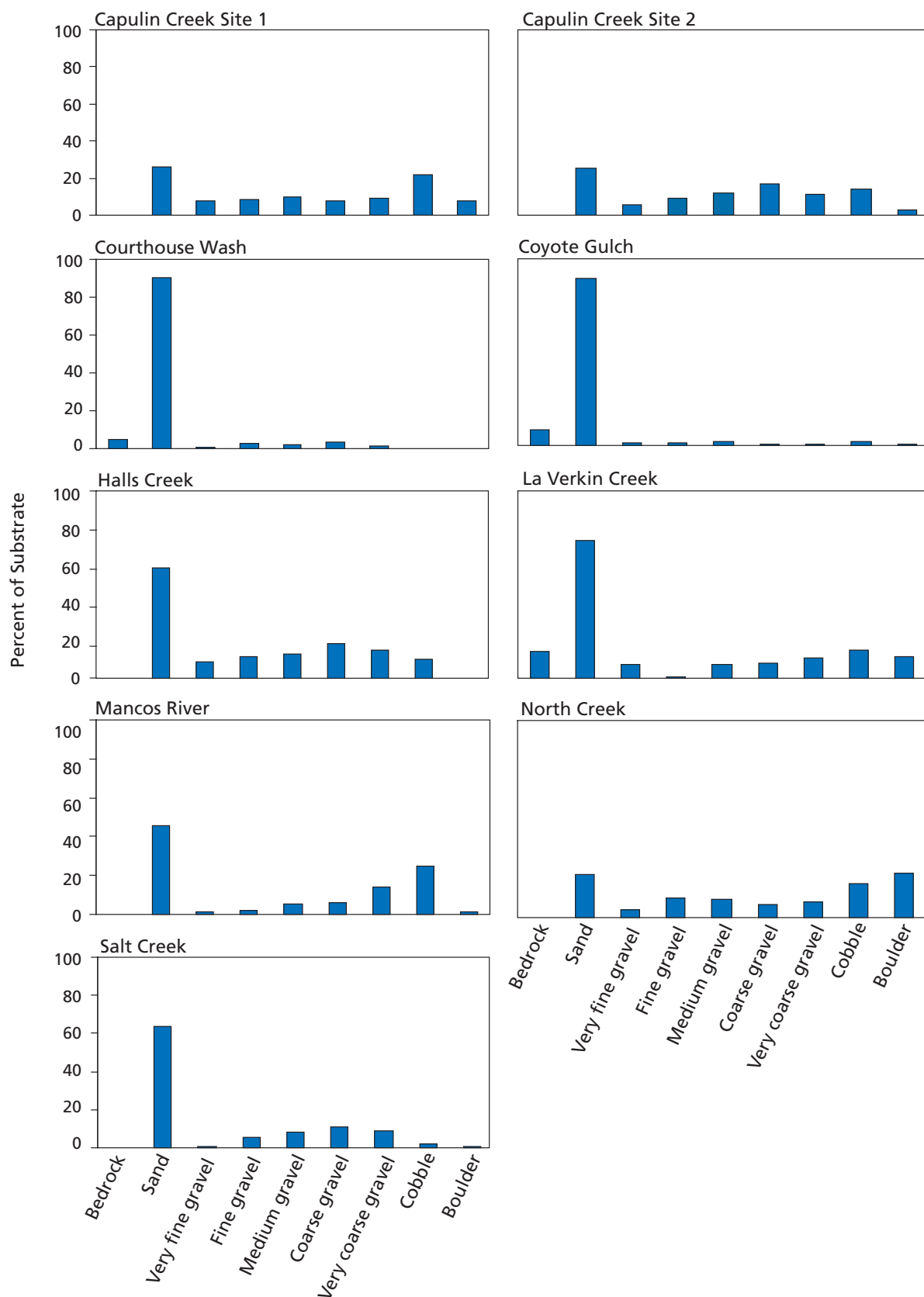


Figure 3-7. Substrate size from pebble counts grouped into standard size classes (bins)

more than 2,900 individuals per square meter, in comparison to the site with the lowest density, the Mancos River, with only 406 individuals per square meter. Coyote Gulch had the second-highest density (906 individuals per square meter), while North Creek had the second-lowest (636 individuals per square meter). The other four sites each had approximately 750 individuals per square meter.

Capulin Creek Site 1 had the highest total richness (quantitative plus qualitative), with 65 different taxa, followed by North Creek (53 taxa). Coyote Gulch, Halls Creek, and the Mancos River each had approximately 45 taxa, while Courthouse Wash, La Verkin Creek, and Salt Creek each had approximately 35 taxa.

Relative abundances of potential indicator taxa at each site are summarized graphically in Figure 3-9. The intermittent streams, Courthouse Wash and Salt Creek, were composed primarily of Chironomidae (midges), Ostracoda (seed shrimp), non-midge Diptera (flies), Oligochaeta (worms), and *Physa* sp. (snails) that are well adapted to pool habitat and/or non-flowing (lentic) conditions. Halls Creek was dominated by Oligochaeta

(52%), and non-midge Diptera (26%). The dominant taxa of La Verkin Creek was Ephemeroptera (mayflies, 71%), followed by non-midge Diptera (20%). There were no Plecopterans (stoneflies) and relatively few Trichopterans (caddisflies) at La Verkin Creek. The dominant taxon in North Creek was Chironomidae (48%). North Creek also had a relatively high percentage (18%) of Simuliidae (black flies) compared to the other sites.

The two Capulin Creek sites were dominated by EPT taxa (Ephemeroptera, Plecoptera, and Trichoptera) at ~70%. Coyote Gulch had a macroinvertebrate community primarily composed of non-midge Diptera (35%) and Ephemeroptera (25%). The macroinvertebrate community of the Mancos River was dominated by Chironomidae (45%).

3.3 Comparison of quantitative and qualitative samples

In many stream ecosystems, data collected from target riffles and reach-wide samples are similar (Rehn et al. 2006). During this study, however, quantitative riffle samples consistently had fewer

Table 3-1. Macroinvertebrate abundance, richness, and dominant taxa of NCPN and SCPN streams.

Stream	Abundance (individuals/m ²)	Richness (# different taxa)	Dominant taxa
NCPN sites			
Courthouse Wash	750	35	Chironomidae (midges), Ostracoda (seed shrimp), non-midge Diptera (flies), Oligochaeta (worms)
Halls Creek	750	45	Oligochaeta (52%), non-midge Diptera (true flies; 26%)
La Verkin Creek	750	35	Ephemeroptera (71%), non-midge Diptera (20%)
North Creek	636	53	Chironomidae (48%)
Salt Creek	750	35	Chironomidae, non-midge Diptera, Oligochaeta, <i>Physa</i> sp.
SCPN sites			
Capulin Creek Site 1	>2,900	65	EPT (Ephemeroptera, mayflies; Plecoptera, stoneflies; and Trichoptera, caddisflies) (~70%)
Coyote Gulch	906	45	non-midge Diptera (35%), Ephemeroptera (25%)
Mancos River	406	45	Chironomidae (45%)

Data in table are rounded for readability.

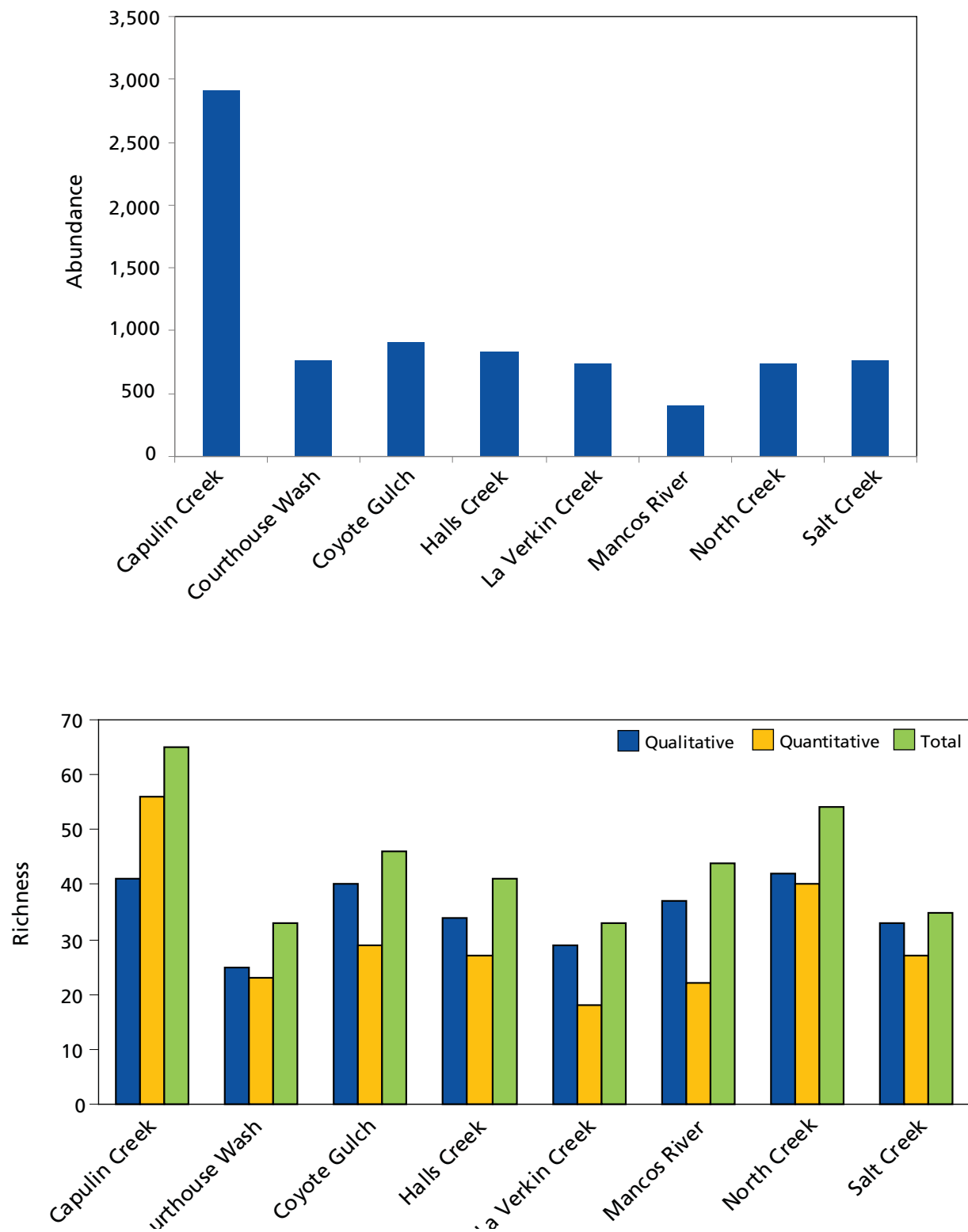


Figure 3-8. (a) Macroinvertebrate abundance (density) from quantitative samples (first sampling date 2006), and (b) macroinvertebrate taxa richness for quantitative and qualitative sampling, using 2005 SCPN (replicate samples combined) and 2006 NCPN samples. Capulin Creek abundance and richness data are from Site 1.

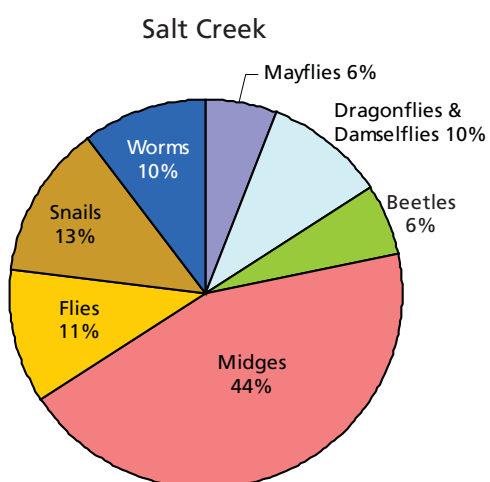
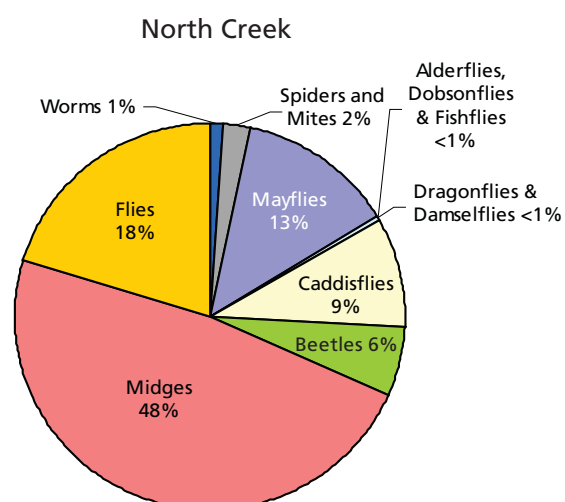
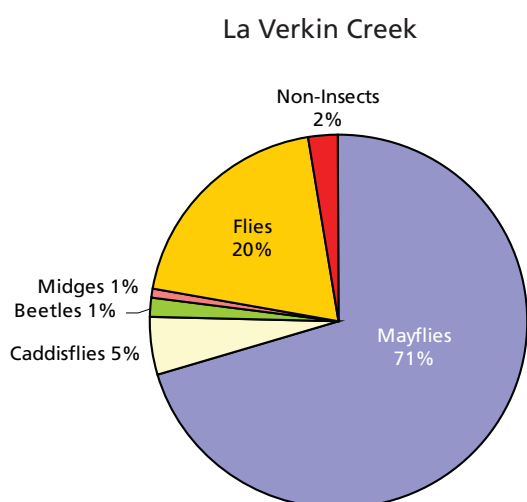
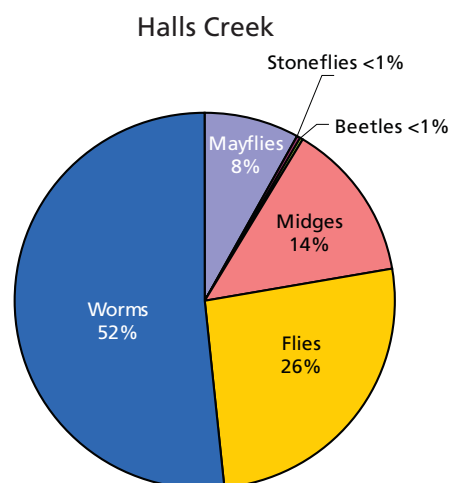
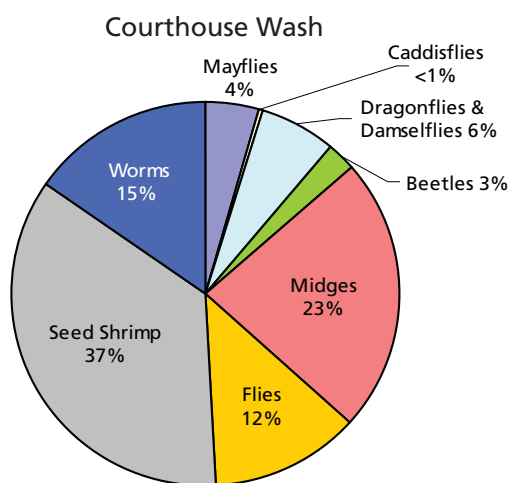


Figure 3-9. Relative abundance of macroinvertebrate taxa in Northern Colorado Plateau Network sites.

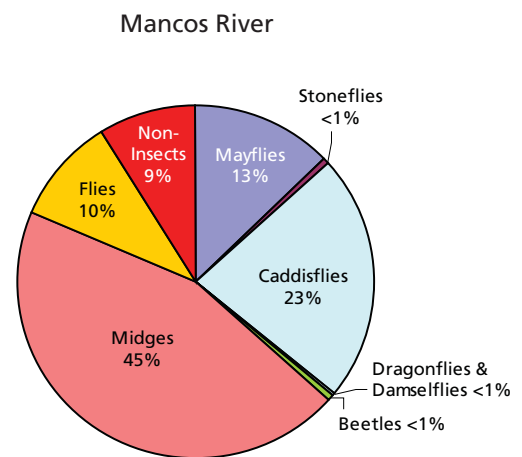
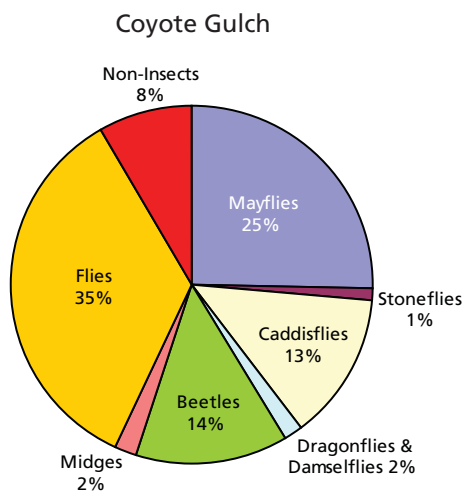
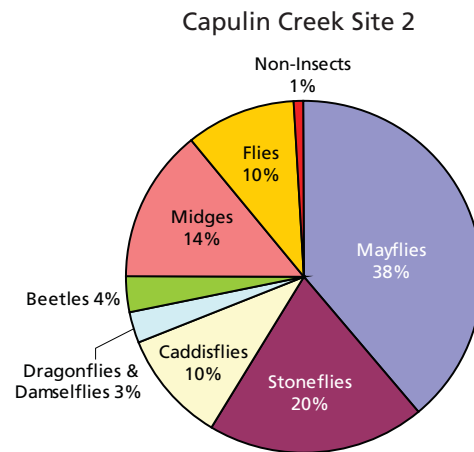
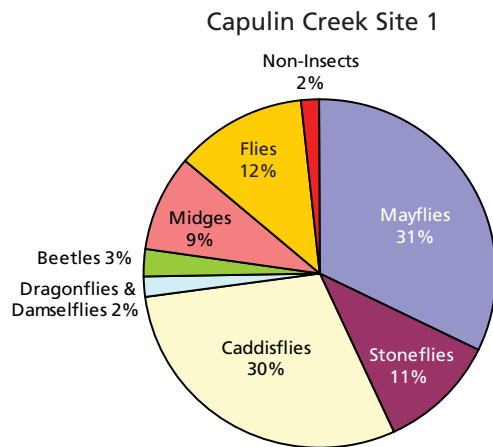


Figure 3-9 cont. Relative abundance of macroinvertebrate taxa in Southern Colorado Plateau Network sites.

taxa (lower richness) than qualitative multi-habitat samples (Figure 3-8b). The exception was Capulin Creek, which, geomorphologically, most resembles the type of stream where these kinds of studies have previously been conducted. In Capulin Creek, richness was higher in the quantitative samples than in the qualitative samples. At the Mancos River and La Verkin Creek, quantitative samples contained substantially fewer species than qualitative samples. Generally, combining the two types of samples (quantitative plus qualitative) provided the highest total richness, although at Salt Creek, the richness of qualitative samples was nearly the same as total richness.

Qualitative and quantitative samples generally had the same relative proportion of both functional behavior groups (Figure 3-10) and functional feeding groups (Figure 3-11) at a given sampling location.

Macroinvertebrates from quantitative samples, such as clingers, were associated with faster velocity and larger substrate. This was expected, as riffles can be defined as having faster velocity and larger substrate, and there were very few clingers at the intermittent sites that lacked riffles. There were relatively high proportions of burrowers at sites with high amounts of fine sediment, which provides habitat for burrowers. At the intermittent streams of Courthouse Wash and Salt Creek, there was a high proportion of predators (e.g., predaceous beetles, dragonflies, damselflies), typical of low-flow habitats.

3.4 Spatial and temporal variation among macroinvertebrate samples

3.4.1 Replicate analysis (SCPN streams)

3.4.1.1 Spatial variation

One-way Analysis of Similarity (ANOSIM) results indicate that variation among replicate samples was less than that among streams ($R=0.859$, $p=0.01$). All pairwise comparisons between streams were statistically significant ($p=0.01$), with R values of 0.727 (Coyote Gulch and the Mancos River), 0.972 (Capulin Creek Site 1 and the Mancos River), and 0.84 (Capulin Creek Site 1 and Coyote Gulch). A second reach on Capulin Creek (Site 2) was sampled in late 2006. This allowed us to assess variability among riffles over a larger segment of the stream (within-stream variability between sites 1 and 2). Within-stream

variability between Capulin sites 1 and 2 was low ($R=0.28$).

3.4.1.2 Within-season variation

Within a given site, there were statistically significant differences in macroinvertebrate community composition between sampling dates ($p=0.01$) for all but three pairs of dates (Table 3-2), indicating seasonal changes in community composition. The two Coyote Gulch samples from 2005 were only marginally different from each other ($p=0.04$), as were the last two samples from the Mancos River ($p=0.05$). The two post-flood Coyote Gulch samples were very similar to each other ($R=0.06$, $p=0.29$), primarily because only a few individuals remained in the stream after the flooding.

3.4.1.3 Annual variation

Average annual variation in the macroinvertebrate community between 2005 and 2006 was identical to average within-season variation during 2006 at Capulin Creek Site 1 (both average $R=0.67$; Table

Table 3-2. ANOSIM results describing within-season variation between samples at SCPN sites.

Site	Sample date 1	Sample date 2	R -statistic	p -value
Capulin Creek Site 1	9/24/2005	9/6/2006	0.74	0.01
		10/1/2006	0.50	0.01
		10/27/2006	0.77	0.01
	9/6/2006	10/1/2006	0.63	0.01
		10/27/2006	1.00	0.01
	10/1/2006	10/27/2006	0.74	0.01
Coyote Gulch	9/20/2005	10/31/2005	0.40	0.04
		9/22/2006	0.57	0.01
		10/12/2006	0.87	0.01
		11/3/2006	0.95	0.01
	10/31/2005	9/22/2006	0.54	0.02
		10/12/2006	0.80	0.01
		11/3/2006	0.80	0.01
	9/22/2006	10/12/2006	0.65	0.01
Mancos River	10/12/2006	11/3/2006	0.71	0.01
		10/12/2006	0.06	0.29
		11/3/2006	0.06	0.29
	9/12/2005	9/1/2006	0.80	0.01
		9/28/2006	0.76	0.01
		10/25/2006	0.41	0.02
	9/1/2006	9/28/2006	0.62	0.02
		10/25/2006	0.79	0.01
	9/28/2006	10/25/2006	0.38	0.05

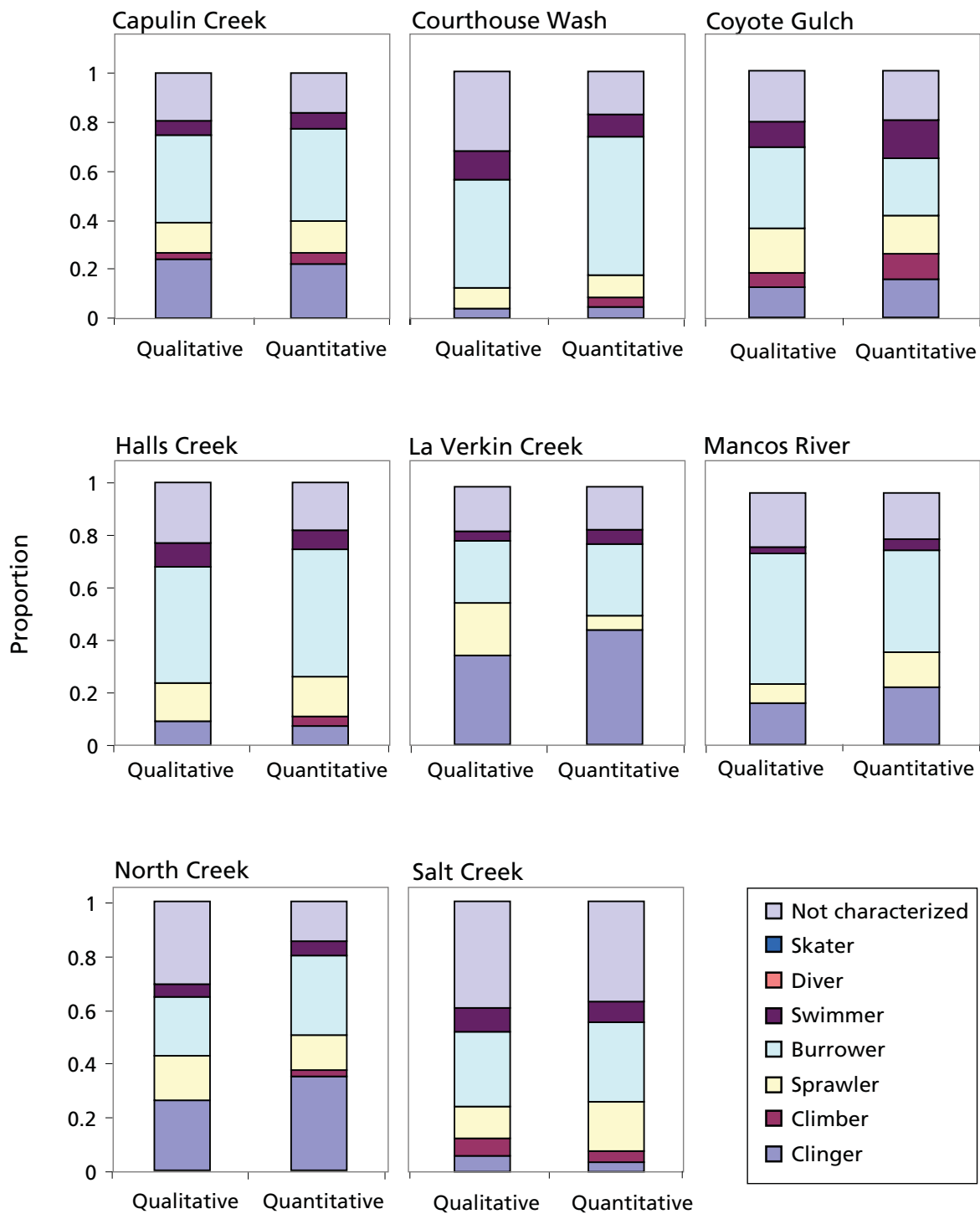


Figure 3-10. Richness based on functional behavioral group and sample type (qualitative and quantitative). Capulin Creek data are from Site 1.

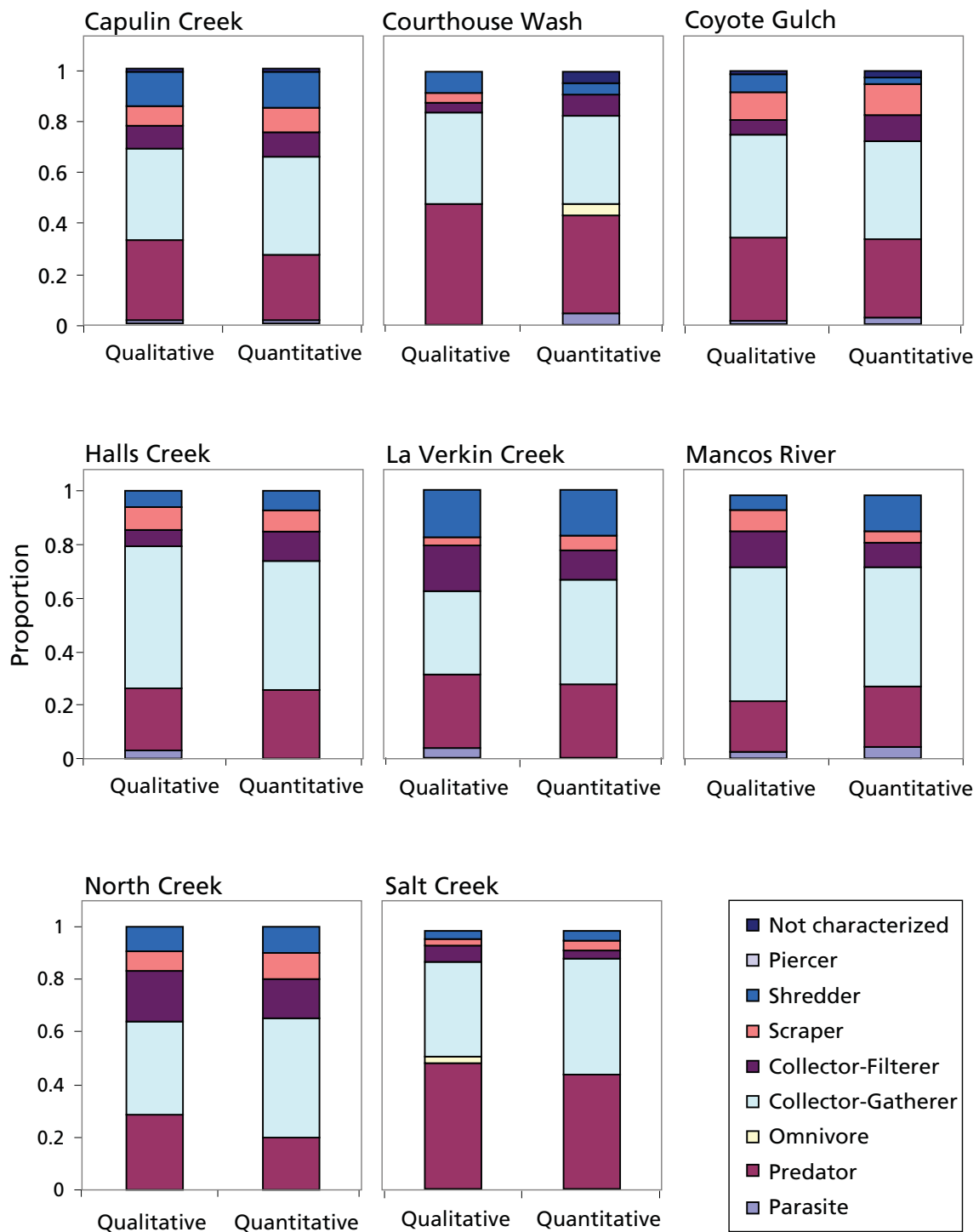


Figure 3-11. Richness based on functional feeding group and sample type (qualitative and quantitative). Capulin Creek data are from Site 1.

3-3). At Coyote Gulch, the average annual variation between 2005 and 2006 ($R=0.76$) was larger than average within-season variation during 2006 ($R=0.47$). Similarly, in the Mancos River, average annual variation between 2005 and 2006 ($R=0.66$) was larger than average seasonal variation during 2006 ($R=0.60$).

3.4.1.4 Variation in density and taxa richness

To further evaluate between- and within-site variability in macroinvertebrate community structure, we compared density (abundance) and taxa

for Coyote Gulch show how the floods affected macroinvertebrate community structure (Figure 3-15). Plots of the samples from 2005 and early 2006 were visibly similar in community structure. However, samples taken in October and November 2006, following a scouring event, showed a different community structure. The Mancos River showed no consistent annual or seasonal pattern in community structure (Figure 3-16).

3.4.2 Cluster analysis (all streams)

Overall, considerable differences were observed in macroinvertebrate community composition among sites. Ordination using hierarchical cluster analysis of taxa composition produced plots in which sites with similar taxa grouped closer together. Ordination using composited (for the NCPN) or combined (for the SCPN) quantitative samples showed four main groups (Table 3-4, Figure 3-17).

SIMPER analysis, using cluster analysis based on group averages and Bray-Curtis similarities between quantitative samples, indicated communities that were more than 30% similar (Clark and Warwick 2001). These are shown by the group circles in Figure 3-17. Courthouse Wash and Salt Creek, intermittent streams, formed one group. The five samples from Capulin Creek, a high-elevation stream located in the Rocky Mountain ecoregion, formed a second group. The third group included samples from the Mancos River (a degraded stream) and the post-flood Coyote Gulch samples, which had very few taxa. The fourth group included the perennial reaches of Halls Creek, La Verkin Creek, North Creek, and the pre-flood Coyote Gulch samples. The strength of this ordination would likely be increased with a larger sample size.

Table 3-4 summarizes the characteristic species in the groups that were at least 30% similar to each other, by showing the average density and percent contribution of each taxa to a given group. The distinction of Courthouse Wash and Salt Creek may be explained by the lack of the three species common to all other groups; *Simulium* sp. (a blackfly), *Baetis* sp. (a mayfly), and *Hydropsyche* sp. (a caddisfly). Instead, this group was dominated by oligochaete worms, true flies, and a mayfly species (*Callibaetis* sp.) adapted to low velocities and characteristic of intermittent streams. Capulin Creek was highly diverse, and included varieties of stonefly, mayfly, caddisfly, dragonfly,

Table 3-3. ANOSIM results describing variation over the index period (seasonal variation) and between years at SCPN sites.

Monitoring site	Average <i>R</i> -statistic	
	Annual variation (2005–2006 comparisons)	Seasonal variation (2006 sample comparisons)
Capulin Creek Site 1	0.67	0.67
Coyote Gulch	0.76	0.47
Mancos River	0.66	0.60

richness among the three sites and at each site during three sampling events across the index period. Macroinvertebrate density and richness showed different patterns among streams. Capulin Creek Site 1 had substantially higher density than Coyote Gulch and the Mancos River (Figure 3-12). There was also considerable change in density over the index period (September to November, Figure 3-12). Density increased at Capulin Creek and decreased at Coyote Gulch and the Mancos River.

Capulin Creek Site 1 also had significantly higher macroinvertebrate taxa richness than the other two streams (Figure 3-13). Coyote Gulch and the Mancos River showed substantial decreases in taxa richness over the index period, while taxa richness remained stable at Capulin Creek.

3.4.1.5 NMDS ordination

Non-metric multidimensional scaling ordinations indicated that replicate samples collected on a given day grouped closer to each other than samples collected on different dates in Capulin Creek Site 1 (Figure 3-14). Sites that grouped closer together had more similar macroinvertebrate communities. The NMDS ordinations

Table 3-4. Characteristic species of groups defined as 30% similar by group-averaged hierarchical cluster analysis of composited (NCPN) or combined (SCPN) quantitative samples.

Stream type	Taxa	Common name	Average density	Percent contribution	Cumulative percent contribution	Average Bray-Curtis similarity (%)
Courthouse Wash and Salt Creek						
Intermittent	Oligochaeta	Aquatic worm	94.67	20.06	20.06	40.01
	Dasyhelea sp.	Midge	77.97	19.25	39.31	
	Callibaetis sp.	Mayfly	38.81	13.17	52.48	
	Tanytarsus sp.	Midge	29.70	9.85	62.34	
Capulin Creek						
Perennial	Hydropsyche sp.	Caddisfly	602.21	11.88	11.88	58.83
	Baetis sp.	Mayfly	422.71	9.65	21.53	
	Simulium sp.	Black fly	191.55	7.48	29.01	
	Ephemerella sp.	Mayfly	286.96	7.27	36.28	
	Tvetenia sp.	Midge	118.81	5.56	41.84	
	Zapada sp.	Stonefly	81.36	4.78	46.62	
	Optioservus sp.	Aquatic beetle	77.09	4.38	51.00	
	Eukiefferiella sp.	Midge	51.27	4.24	55.24	
	Paraleptophlebia sp.	Mayfly	124.99	3.68	58.93	
	Oplonaeschna sp.	Dragonfly	35.40	3.36	62.29	
Mancos River and Coyote Gulch (Post-flood 2006)						
Perennial (Degraded/ Disturbed)	Hydropsyche sp.	Caddisfly	47.06	28.77	28.77	44.52
	Baetis sp.	Mayfly	13.76	13.71	42.49	
	Oligochaeta	Aquatic worm	12.11	10.47	52.96	
	Simulium sp.	Black fly	6.05	9.95	62.91	
Halls Creek, La Verkin Creek, North Creek, Coyote Gulch (2005 and pre-flood 2006)						
Perennial	Simulium sp.	Black fly	258.57	24.23	24.23	43.34
	Baetis sp.	Mayfly	140.66	18.21	42.44	
	Hydropsyche sp.	Caddisfly	54.02	7.66	50.10	
	Microcylloepus sp.	Aquatic beetle	54.61	6.72	56.82	
	Sperchon sp.	Arachnid	22.37	6.05	62.87	

and true fly species that were unique to this site during this study. The Mancos River and post-flood Coyote Gulch sites were characterized by low abundances of the regionally most-common species. The Mancos River is degraded by several environmental factors, including erosion and high concentrations of fine sediment. Consequently, this site had low taxa abundance. A large scouring event at Coyote Gulch in early October caused the low abundance and species richness at this site. This disturbance resulted in samples that were more similar to those collected from the degraded Mancos River.

Ordination plots of qualitative macroinvertebrate samples were similar to the quantitative samples (Figure 3-18). The intermittent streams, Courthouse Wash and Salt Creek, formed one group, samples from Capulin Creek formed a second group, and the remaining sites loosely formed a third group. The presence/absence data of the qualitative samples do not rely on abundances; therefore, the post-flood Coyote Gulch and Mancos River samples look more similar to the other sites than they did with the quantitative samples.

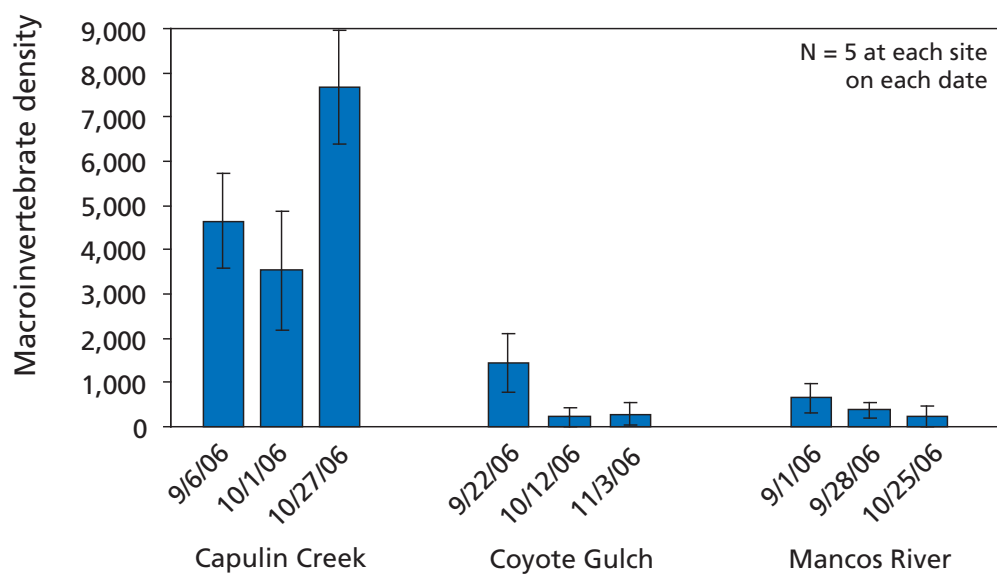
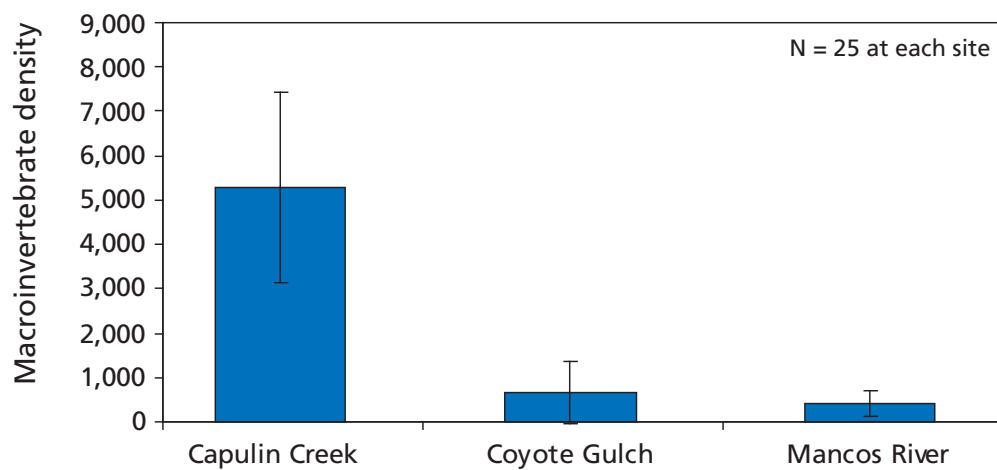


Figure 3-12. Macroinvertebrate density (mean $\pm$ standard deviation) relative to (a) among-site variability and (b) within-site (across the index period) variability.

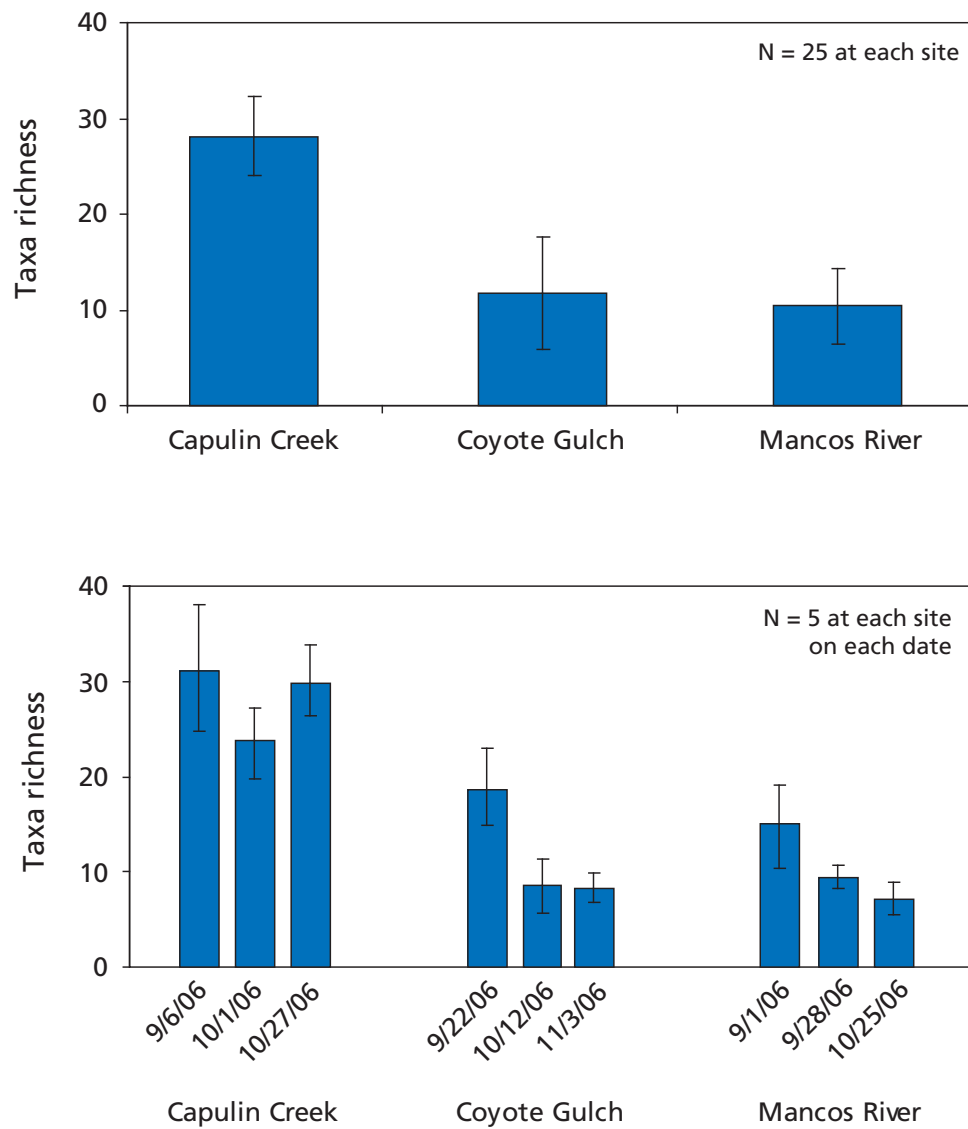


Figure 3-13. Taxa richness (mean $\pm$ standard deviation) relative to (a) among-site variability and (b) within-site (across the index period) variability.

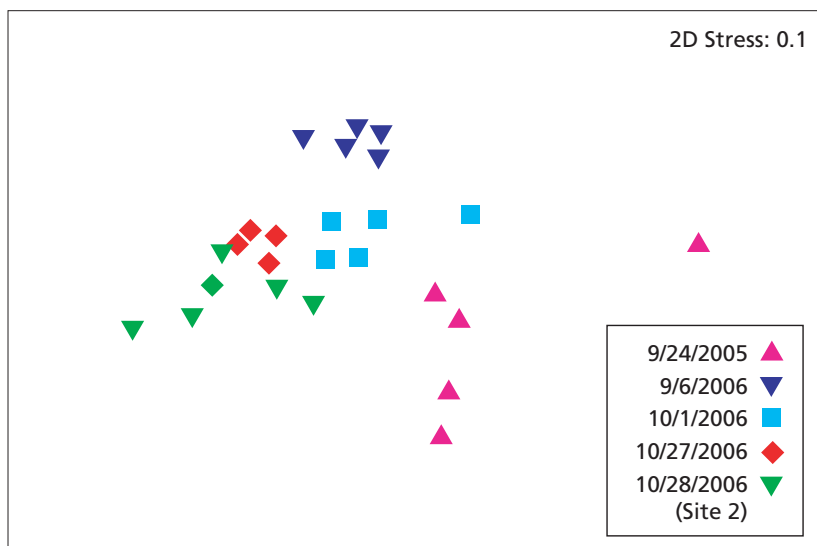


Figure 3-14. Ordination (NMSD) of Capulin Creek replicate samples from 2005 and 2006.

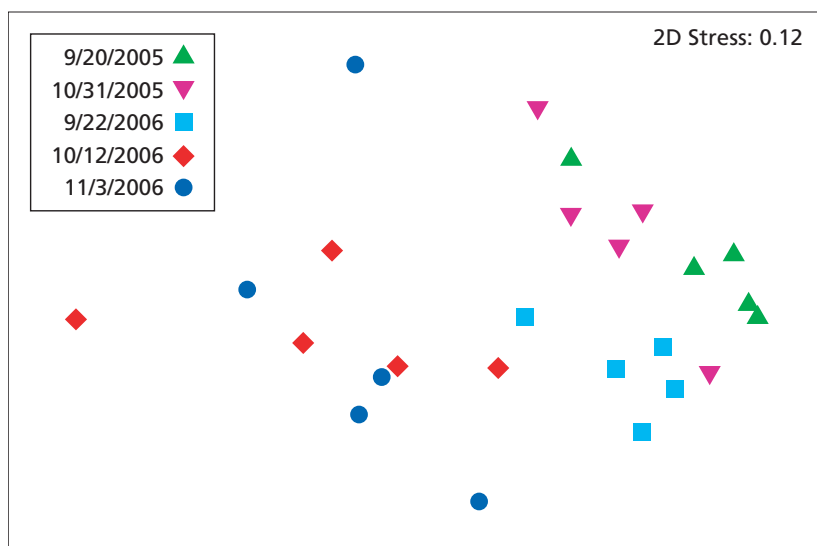


Figure 3-15. Ordination (NMSD) of Coyote Gulch replicate samples from 2005 and 2006.

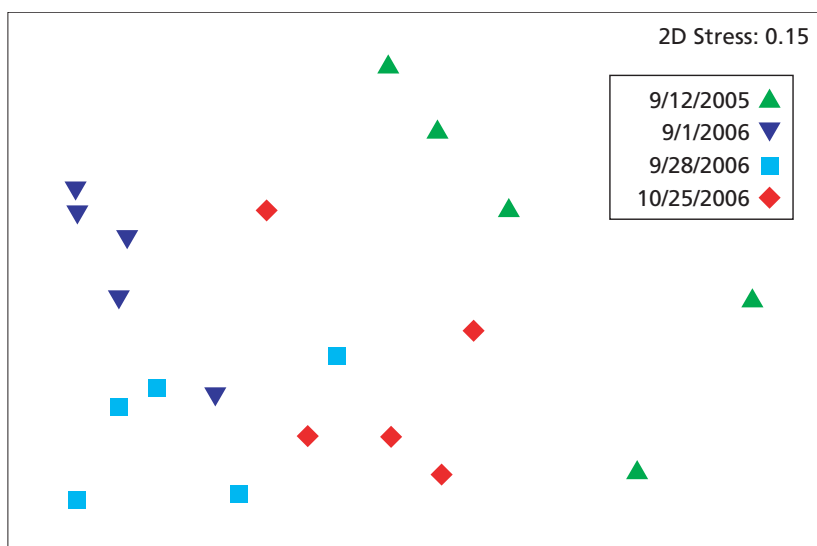


Figure 3-16. Ordination (NMSD) of Mancos River replicate samples from 2005 and 2006.

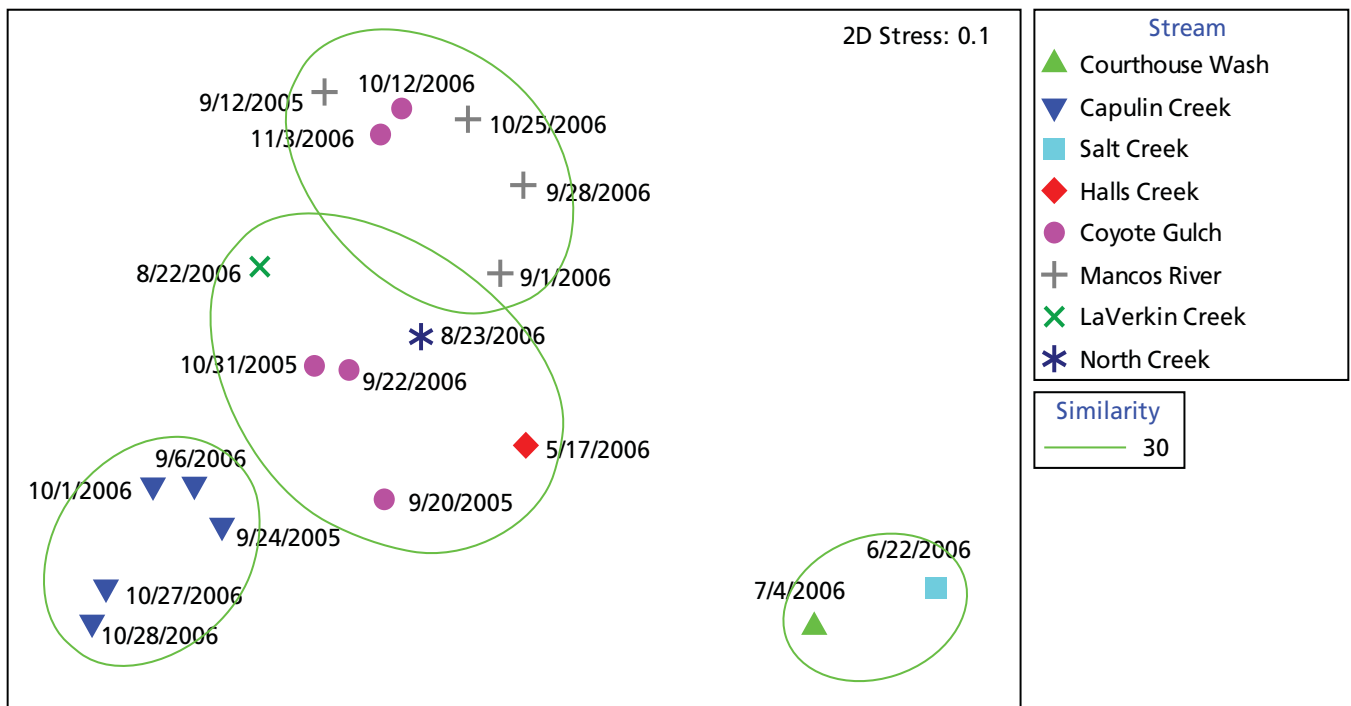


Figure 3-17. Ordination plot of hierarchical cluster analysis of quantitative macroinvertebrate samples. Sites with more similar macroinvertebrate species composition grouped closer together.

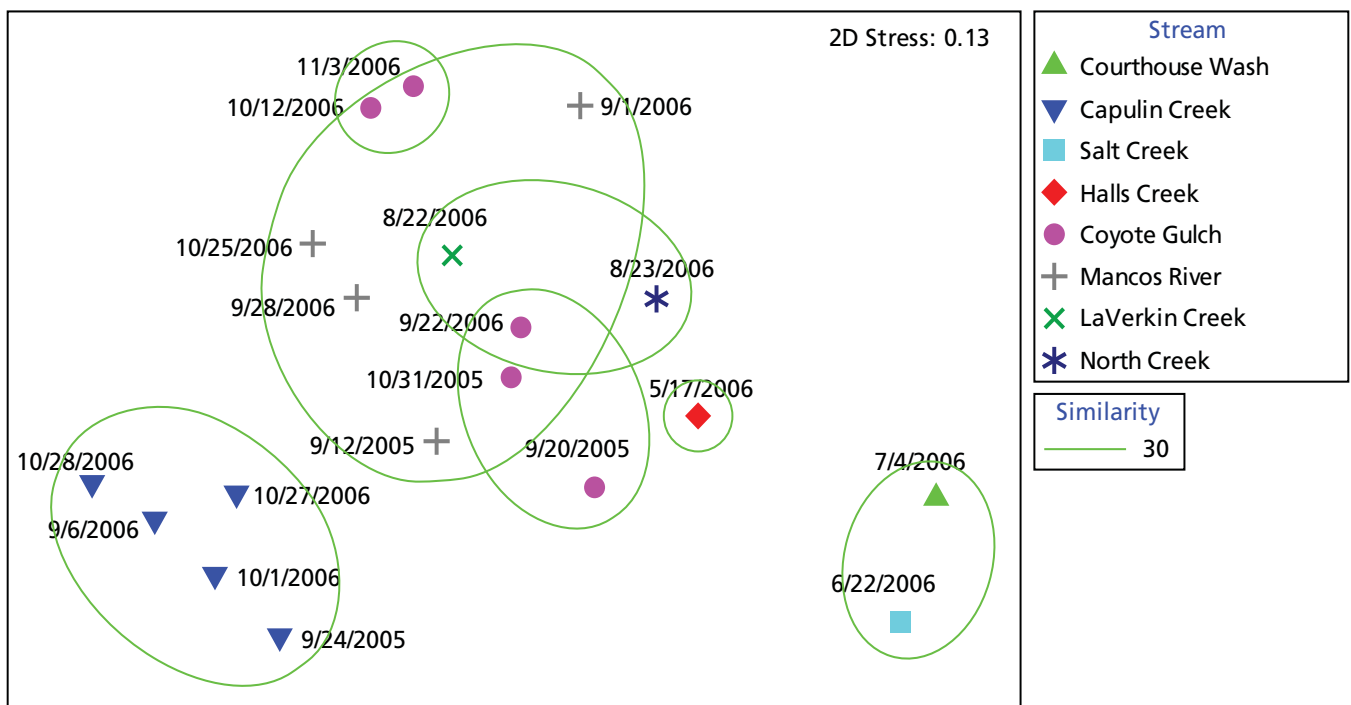


Figure 3-18. Ordination plot of hierarchical cluster analysis of qualitative macroinvertebrate samples. Sites with more similar macroinvertebrate species composition group closer together.

3.5 Macroinvertebrate metrics

Mean values at the SCPN sites for the eight metrics included in the monitoring (see Table 2-4) are provided in Table 3-5. Compared to Coyote Gulch and the Mancos River, Capulin Creek Site 1 had higher average values for taxa richness, percent scrapers, number of clinger taxa, percent Ephemeroptera, and percent Plecoptera. Capulin Creek also had lower average values for percent tolerant dominant taxa and percent non-insect taxa relative to those two sites. Coyote Gulch had average values for most metrics that fell between the average values for Capulin Creek and the Mancos River. These results, in combination with the “expected direction of response to water quality habitat degradation” listed in Table 2-4, suggest that of the three sites, Capulin Creek (a mountain stream) has the highest water quality and least amount of degraded habitat. The Mancos River, which has relatively poor water quality and more degraded habitat, scored lowest on these metrics.

Associations of selected metrics to microhabitat velocity, percent substrate embeddedness, and percent fine sediments were analyzed using Spearman rank correlation for both within-stream and between-stream samples (Appendix H). For samples collected in Capulin Creek, percent Plecoptera was significantly correlated with percent embeddedness, while percent scraper abundance and percent Ephemeroptera were significantly correlated with velocity. For samples collected in Coyote Gulch, none of the eight met-

rics was significantly correlated with percent embeddedness, while taxa richness, percent scraper abundance, and percent Ephemeroptera were all significantly correlated with velocity. For samples collected in the Mancos River, taxa richness and percent scraper abundance were significantly correlated with percent embeddedness, while none of the eight metrics was significantly correlated with velocity.

The between-stream analysis was used to identify those metrics that are sensitive to differences in flow and fine-sediment deposition. Of the eight metrics, only taxa richness was significantly correlated with mean velocity between streams. None of the eight metrics listed in Table 2-4 was significantly correlated with mean embeddedness between streams, whereas clinger richness, percent non-insects, percent Plecoptera, and the ratio of Hydroptilidae plus Hydropsychidae to Trichoptera were significantly correlated with percent fine sediments between streams.

Using the Western EMAP criteria described in Section 2.6 (i.e., richness metrics with ranges of less than four and any metrics that had the same values at 75% or more of the sites; Stoddard et al. 2005), we determined that of the 39 metrics evaluated, the Oligochaete richness metric would not be appropriate for the pilot-study streams. More detailed information on the example metrics that we calculated for the qualitative and quantitative samples from the pilot study is available in Appendix I.

Table 3-5. Mean and standard deviation (SD) for the eight example metrics provided in the macroinvertebrate protocol.

Metric type	Metric	Capulin Creek (n=5)		Coyote Gulch (n=5)		Mancos River (n=4)	
		Mean	SD	Mean	SD	Mean	SD
Richness/ Diversity	Taxa richness	52.8	7.2	28.0	12.8	19.5	5.1
Tolerance	Percent dominant taxa	28.8	12.3	37.7	9.8	42.7	15.6
Functional–Feeding	Percent scrapers	6.4	3.2	2.5	1.8	0.4	0.5
Functional–Habit	Number of clinger taxa	18.4	2.3	9.1	3.2	5.7	0.9
Composition	Percent Ephemeroptera	33.6	12.0	16.6	11.9	12.8	8.6
	Percent non-insect taxa	1.4	0.3	10.3	3.8	8.9	1.6
	Hydroptilidae + Hydropsychidae: Trichoptera	0.9	0.1	1.0	0.01	1.0	0.0
	Percent Plecoptera	12.5	5.1	2.9	5.5	0.4	0.5

SD = standard deviation.

Values were based on combining replicate samples from each sampling event. Samples were collected during fall 2005 and fall 2006.

3.6 Habitat characteristics and macroinvertebrates

3.6.1 Quantitative samples

The association between variation in macroinvertebrate community structure and habitat characteristics among the eight streams was examined using NMDS based on quantitative macroinvertebrate samples, and is displayed as a bi-plot in Figure 3-19. Samples that grouped closer together had more similar macroinvertebrate communities. Habitat variables included those measured at each transect, and at each of the quantitative macroinvertebrate collection sites (microhabitat).

Variation across Axis 1 was largely due to variation in microhabitat velocity and percent riffles among the streams, with higher velocity and more riffle habitat in streams on the left of the plot, and low microhabitat velocities on the right (Salt Creek and Courthouse Wash).

Variation across Axis 2 was explained by stream size (transect width, depth, and velocity), habitat variability (geomorphic channel units, e.g., number of riffles, runs, pools), and riparian shading (canopy cover). Capulin Creek (in the upper left of the plot) had denser canopy cover and higher habitat variability, and is a relatively small stream. The Mancos River (at the lower part of the plot) had little riparian shading, low habitat variability, and higher velocity, width, and depth.

Spearman rank correlations indicated associations between the ordination axes and individual habitat variables (Table 3-6). These correlations indicated that variables driven by stream size and discharge (velocity, depth, width, and percent canopy closure) were largely responsible for controlling the community composition of macroinvertebrates at the sampling sites.

3.6.2 Qualitative samples

The association between variation in macroinvertebrate community structure and variation in habitat characteristics among the eight streams was also examined using NMDS based on the qualitative macroinvertebrate samples (Figure 3-20). Relative to quantitative samples, there was more overlap of qualitative samples between sites, likely due to the wide variety of habitat types sampled. Again, samples that grouped closer together had more similar macroinvertebrate communities. Habitat variables for the qualitative macro-

invertebrate ordination included those measured at each transect (no microhabitat measurements were taken during the qualitative sampling).

Sites grouped in a very similar pattern to that of the quantitative samples. Axis 1 separated sites along a gradient of velocity and percent riffles, with sites to the left (Capulin Creek, the Mancos River, and La Verkin Creek) having faster flow and more riffles, those in the middle (Coyote Gulch, North Creek, and Halls Creek) having moderate velocity and some riffles, and those on the far right (Salt Creek and Courthouse Wash, the two intermittent streams) having little-to-no flowing water and consisting mostly of isolated pools.

Table 3-6. Spearman rank correlations of habitat variables to ordination axes in Figure 3-19.

Variable	Axis 1	Axis 2
Elevation (m)	0.172	-0.209
Reach		
Percent riffle	0.575	0.25
Percent pool	0.148	0.448
Number of geomorphic channel units	0.262	0.661
Transect		
Percent canopy closure	0.312	0.701
Mean velocity (m/s)	0.505	-0.618
Mean depth (m)	0.131	-0.556
Mean width (m)	0.332	-0.739
Standard deviation of velocity (m/s)	0.561	-0.391
Standard deviation of depth (m)	0.124	-0.018
Standard deviation of width (m)	0.104	-0.655
Median substrate size (cm)	0.415	0.043
Percent fine sediments	0.424	-0.25
Microhabitat		
Mean microhabitat velocity (m/s)	0.522	-0.426
Mean microhabitat depth (m)	0.016	-0.656
Mean microhabitat substrate size (cm)	0.372	-0.285
Mean microhabitat % embeddedness	0.129	-0.494
Standard deviation of microhabitat velocity (m/s)	-0.48	-0.214
Standard deviation of microhabitat depth (m)	0.364	-0.311
Standard deviation of microhabitat substrate size (cm)	0.239	-0.062
Standard deviation of microhabitat % embeddedness	0.256	-0.093

Standard deviations represent variability in that characteristic.

Bold indicates strong correlations between a habitat variable and that particular axis.

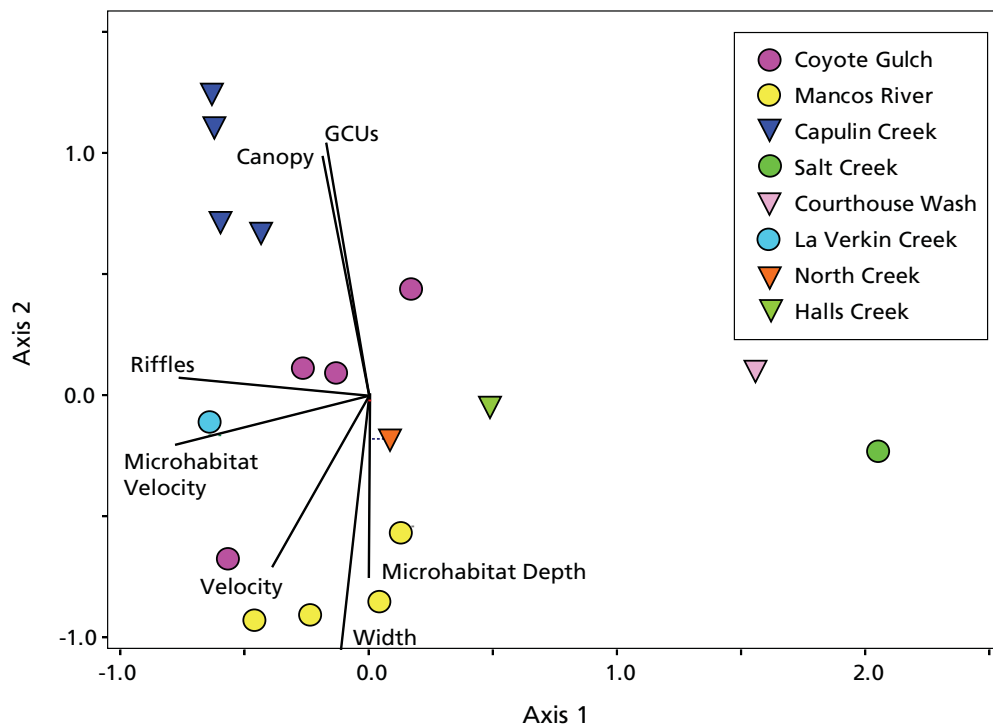


Figure 3-19. Bi-plot of quantitative macroinvertebrate sample ordination using non-metric multi-dimensional scaling (NMDS). Variation across Axis 1 was largely due to variation in microhabitat velocity and percent riffles among the streams, with higher velocity and more riffle habitat in streams on the left of the plot, and low microhabitat velocities on the right. Variation across Axis 2 was explained by stream size (transect width, depth, and velocity), habitat variability (i.e., number of riffles, runs, pools), and riparian shading (canopy cover).

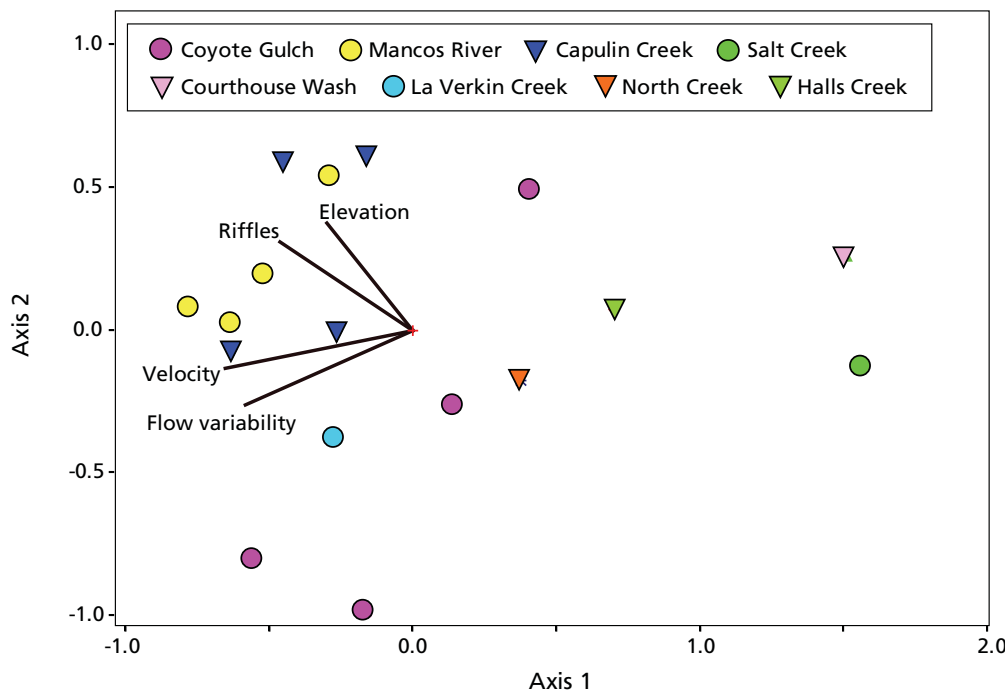


Figure 3-20. Bi-plot of qualitative macroinvertebrate sample ordination using non-metric multi-dimensional scaling (NMDS) and Spearman rank correlations of habitat variables with ordination axes. Axis 1 separated sites along a gradient of velocity and percent riffles, with those sites on the left having faster flow and more riffles. Axis 2 primarily separated sites by elevation.

Axis 2 primarily separated sites by elevation. Spearman rank correlations indicated associations between the ordination axes and individual habitat variables (Table 3-7), and indicated that

differences between qualitative samples were attributable mainly to stream elevation, percent riffles, and transect velocity.

Table 3-7. Spearman rank correlations of variables to ordination axes in Figure 3-20.

Variable	Axis 1	Axis 2
Elevation (m)	0.441	-0.525
Reach		
Percent riffle	0.556	-0.45
Percent pool	-0.46	-0.179
Number of geomorphic channel units	0.138	0.197
Transect		
Percent canopy closure	0.125	-0.189
Mean velocity (m/s)	0.649	0.284
Mean depth (m)	0.219	0.074
Mean width (m)	0.478	0.057
Standard deviation (variability) velocity (m/s)	0.618	0.41
Standard deviation (variability) depth (m)	-0.15	0.274
Standard deviation (variability) width (m)	0.137	0.314
Median substrate size (cm)	0.415	-0.388
Percent fine sediments	-0.45	0.286

Standard deviations represent variability in that characteristic. Bold indicates strong correlations between a habitat variable and that particular axis.

4 Discussion

Little has been published about macroinvertebrate communities in streams of the Colorado Plateau. This pilot implementation study for the National Park Service Inventory and Monitoring program provides new information on species composition and abundance (macroinvertebrate community structure) in eight streams in seven national parks of the Colorado Plateau. Results from the pilot study suggest that macroinvertebrate communities are strongly associated with habitat conditions, and can be used as indicators of stream and watershed quality. Because macroinvertebrates provide a vital link in the food chain between primary producers (algae and plants) and larger vertebrates, such as fish and birds, the status of macroinvertebrate communities is important to resource managers and to the general public interested in park resources.

This study assessed the utility of macroinvertebrates as indicators of water and stream quality as part of a long-term monitoring program designed to detect trends and provide relevant information to managers about aquatic ecosystems. In addition to providing baseline information on macroinvertebrate community structure in eight streams in the Colorado Plateau, results from this pilot implementation study addressed a number of specific issues regarding (1) sampling methodology, (2) data analysis for trend detection (spatial and temporal variation, and replication), and (3) interpretation of macroinvertebrate community structure (using metrics) and associations among habitat characteristics and macroinvertebrates. In addition to associations among habitat characteristics and macroinvertebrates, it is recommended that interpretation of macroinvertebrate monitoring data also include analyses of water quality and more detailed hydrology.

4.1 Habitat characterization

Because environmental heterogeneity and observer variation can have a large effect on efforts to quantify stream habitat characteristics, it is important to control for these during long-term monitoring programs (Roper et al. 2002). It is recommended that variability associated with measuring habitat characteristics at different sites be considered, and that field crews be well-trained, to ensure that consistent data collection techniques are utilized to minimize inter-observer variability.

4.1.1 Transect analysis

Although the NAWQA and EMAP programs both characterize habitat along a reach at 11 evenly spaced transects where key characteristics (depth, velocity, substrate, stream width, and canopy cover) are measured and recorded, field testing of these protocols during this pilot study indicated that it may not be possible to complete both macroinvertebrate sampling and transect habitat characterization during a single day. Consequently, we evaluated the results of using fewer transects. Additional data are needed to assess year-to-year variability in habitat characteristics, but our results suggest that habitat characteristics can be recorded at a minimum of 7–9 transects and still be effective for the goals of this program, if the habitat data are to be used primarily to evaluate macroinvertebrate communities or potential sources of change in macroinvertebrate community structure. However, 11 transects are recommended for comparability with the national assessment and monitoring programs.

4.1.2 Pebble count

EMAP estimates the size of 105 pebbles per reach (Nick Paretti, personal communication), while NAWQA estimates dominate substrate at three locations along each transect (33 estimates). Preliminary field tests during this pilot study showed that the time required to measure pebbles was consistently less than the time required to estimate size and place pebbles in size classes. We also found that estimation of pebble size had more potential for error than direct measurement of pebble size. Consequently, the protocol calls for actual pebble measurements rather than estimates, and those are the data presented in this report. Such data can either be binned (as presented here) or analyzed as continuous data.

Analysis of the pebble count data indicated that the mean was fairly stable across pebble counts from 100 to 400 pebbles, but the standard deviation decreased substantially when using a 400-pebble count versus a 100-pebble count. However, the information gained by doing a 400-pebble count may not be worth the additional cost and effort for the purposes of NPS I&M invertebrate monitoring. A 100-pebble count would likely be adequate to characterize substrate at a site.



Photo 4-1. Large boulder substrate.



Photo 4-2. Sand and gravel substrate.

4.2 Sampling methodology

4.2.1 Sample collection

We evaluated two different types of sampling nets for collecting macroinvertebrates: a modified Surber sampler (0.25-m² sampling area per sampling location) and a D-frame net (0.09-m² sampling area per sampling location). Because many of the sampling sites in Colorado Plateau national parks require a multi-day backpacking trip, the size of the net is an important consideration. During field testing of the protocol for this pilot implementation study, we switched from using a modified Surber sampler, which allows for larger samples to be collected at a single sampling location, to a D-frame net that is easier to transport while backpacking long distances in the field. However, fewer individuals will be collected from smaller sampling areas using the D-frame net, which may result in low species counts and high variability among replicates—particularly in the more depauperate streams. In addition, samples with fewer than 200 individuals may underestimate true species richness (Vinson and Hawkins 1996).

In general, we recommend using the modified Surber sampler because of its larger size; collecting larger-sized samples containing more individuals may improve the ability to detect change in metrics at all sites. However, at remote field sites, we recommend the use of the D-frame net. By increasing the number of D-frame net samples collected, it is possible to sample the same area as can be sampled by a Surber sampler. To increase sample size (number of organisms), a number of samples can be collected and composited to form a single replicate. Regardless of which sampling net is used, the net should have a frame that delineates the sampling area (if you purchase the

modified Surber sampler at this time, it will already have a sampling frame attached). Collecting from several locations and compositing the sample into one replicate would also increase the sample size (number of individuals in the sample). The larger the composited sample, the lower the among-sample variability, which will increase the ability to detect change.

4.2.2 Sample timing

Index periods for collecting macroinvertebrate samples are established to avoid confounding sample collection with seasonal variation. Sampling in the Colorado Plateau national parks should ideally coincide with index sampling periods established by NAWQA, EMAP, and the individual states on the Colorado Plateau. Most states collect samples in the late summer/early fall; however, the Arizona Department of Environmental Quality collects samples during the spring index period (April–May for warm water streams and May–June for cold water streams) (ADEQ 2008).

Our experiences at Coyote Gulch during the 2006 sampling season showed that floods may occur toward the end of the index period (August–October) at lower-elevation streams in southern Utah, resulting in flashy streamflow patterns and high disturbance potential. Samples at Coyote Gulch following the flood of 2006 were significantly lower in both density and taxa richness than the early season 2006 sample, confirming the scouring effects of a large flood event. Consequently, we recommend that samples be collected late enough in the season that macroinvertebrates will be common in the sample (e.g., following freezing weather and/or snowmelt flows), but prior to any large, flushing floods.

Although index periods are typically calendar-based, it would be more effective and appropriate to identify the index period relative to the preceding rain and flow conditions rather than by established months and dates. As a guiding principle, however, the sampling index period should end before August, because large floods occur at many of the Colorado Plateau sites in August and September. It might also be necessary to avoid the monsoonal period in July. A study with seasonal sampling (April through November) could help to further define the appropriate index period for these sites.

4.2.3 Replication of macroinvertebrate samples

Replication of samples in a single reach provides information on means and variances that are required for many statistical analyses. Replication of samples can be costly, and consequently the majority of the federal and state macroinvertebrate sampling programs in the Colorado Plateau composite samples rather than analyze individual replicates. The decision to replicate or composite will be made by each network based on their objectives and constraints. As the monitoring program is implemented, an adequate number of samples will be collected and statistical power analysis can be run on the data to determine the number of samples (quantitative or semi-quantitative) required to detect change over time (trends) at a given site.

4.3 Macroinvertebrate community structure

Analysis of samples collected during this pilot study showed that macroinvertebrate communities varied across the eight sampling streams, and that this variation was associated with differences in habitat conditions among streams. Abundance (density), richness (number of taxa), and taxa composition of macroinvertebrates was highly variable among sites, and the taxa found at each site matched what would be expected based on stream type. Both abundance and taxa richness were highest at Capulin Creek, while the Mancos River had the lowest abundance, with approximately one-seventh the number of individuals at Capulin Creek. These differences may be driven by the fact that Capulin Creek is a relatively pristine mountain stream, whereas the habitat of the Mancos River is more degraded, particularly by high rates of erosion and high concentrations of fine sediment.



Photo 4-3. Intermittent stream, Halls Creek Narrows, Capitol Reef National Park.

Among-site heterogeneity was intentionally incorporated into the study design to test the protocol at a variety of stream types. Consequently, the macroinvertebrate communities, which are largely structured by the physical habitat conditions at a site, grouped by stream type. The ability to detect differences in macroinvertebrate fauna among streams suggests that this monitoring protocol will also be able to detect differences (changes) in macroinvertebrate communities over time—especially changes associated with alterations to habitat characteristics.

4.4 Comparison of quantitative and qualitative samples

When collecting macroinvertebrates, one can collect a quantitative sample, a qualitative sample, or both. In many stream ecosystems, data collected from target riffles and reach-wide samples are similar (Rehn et al. 2006). However, it should be noted that different sampling protocols have been shown to result in statistically significant differences in certain metrics. For example, in a study comparing benthic macroinvertebrate data collected following the NAWQA and EMAP sampling protocols in streams in Wyoming, Colorado, and Montana, it was demonstrated that certain macroinvertebrate metrics were more sensitive

than others to the sampling protocol used (Peterson and Zumberge 2006).

The time and cost for collecting and processing either quantitative or qualitative samples is similar; however, the training requirements and necessary level of field-crew expertise are greater for qualitative sample collection. While quantitative samples target one specific, easily recognizable habitat (riffles), qualitative sampling requires the knowledge and experience to recognize the range of habitats present, and the ability to sample these habitats appropriately. The main disadvantage of quantitative targeted-riffle sampling is that species that prefer other habitat types will not be well represented in this type of sample. While the majority of species may be captured in targeted-riffle samples in some streams, such as Capulin Creek, species may be more widely distributed among multiple habitat types in other streams (such as Coyote Gulch and La Verkin Creek). This is especially true in streams that do not have a lot of riffle habitat. Larger numbers of taxa were consistently obtained from qualitative samples than from quantitative samples collected during this study.

Quantitative samples provide a standardized comparison of macroinvertebrate communities among different streams and over time, which enables better detection of spatial and temporal variation. Quantitative samples also provide density information, which is required for many statistical analyses (to compare among sites or detect trends over time). Qualitative samples provide reach-scale information on species presence and can be used to create species lists (biodiversity),



Photo 4-5. Sorting a macroinvertebrate sample at North Creek.



Photo 4-4. Collecting a qualitative macroinvertebrate sample at Coyote Gulch.

derive similarity indices based on species presence, and calculate richness-based metrics.

Based on this pilot study, collection of both quantitative samples (replicate or composite) and a qualitative sample is recommended for implementation in the I&M monitoring program. Quantitative samples require less experience to collect than qualitative samples. Additionally, quantitative samples provide information on abundances which are useful for many statistical analyses, and a standardized sampling area and habitat that can be compared among streams and over time. Qualitative samples provide more complete species lists because they include all available habitat types. A single well-collected qualitative sample should provide a comprehensive species list for a given stream reach.

Current studies underway suggest that a semi-quantitative multi-habitat sample (that provides abundance estimates) may be the most appropriate sampling strategy for streams in the semi-arid Colorado Plateau. Results of this pilot study show that for the majority of the streams in the Colorado Plateau, quantitative samples have much lower taxa richness than qualitative samples. Qualitative samples provide important information on biodiversity, and also allow monitoring of a wider range of taxa than quantitative samples collected from riffles only. Consequently, qualitative samples will increase the ability to detect change in taxa composition of the aquatic communities.

4.5 Spatial and temporal variation in macroinvertebrate community structure

Results from this pilot study show that replicate macroinvertebrate samples from a given site were more similar to each other than to samples from other sites, and within-site variability among samples was much less than between-site variability. This was expected, because for the pilot study, we specifically chose streams representing a range of geomorphic conditions—from high-gradient Capulin Creek, of the Rocky Mountain ecoregion (with high velocities, large substrate, and dense canopy cover), to Salt Creek and Courthouse Wash, which are both intermittent streams with small substrate (sand and gravel) and minimum flow. Analyses reflected these differences in habitat conditions and, consequently, macroinvertebrate community structure.

To assess variation across the index period, we analyzed replicate quantitative macroinvertebrate samples from Capulin Creek, Coyote Gulch, and the Mancos River collected in fall 2005 and fall 2006. In addition to annual variation, two separate sampling events occurred during the sampling window (index period) at Coyote Gulch in 2005, and all three streams were sampled three times in 2006. In most cases, variability among sampling times in the same year was larger than variability among replicates at a given site during a single sampling occasion. In other words, there were changes in macroinvertebrate communities over the sampling index period.

In both years, samples from Coyote Gulch showed decreased richness and density between samples collected in September and late October. In 2006, this was due to a large flood that occurred in early October; it is unknown whether there were also seasonal differences among samples collected in early and late fall for this site, or if the decrease was driven solely by disturbance. Although post-flood samples were collected for this pilot study, sampling for the monitoring program should not

occur following large, scouring floods. Capulin Creek showed steady species richness across all sample times, with densities increasing significantly between September and late October. The Mancos River showed a decline in species richness and density over the index period. Overall, these results indicated that changes in species richness and abundance may occur across the index period, reflecting seasonal changes even over a couple of months. Multiple years of data will be required to put these changes into perspective.

4.6 Metrics

Metrics describing key characteristics of macroinvertebrate communities are commonly used in monitoring programs as a tool to assess the status of aquatic systems. Metrics can be evaluated both in terms of their relevance to the sampling location and monitoring objectives. For the pilot study, we selected sites with an array of geomorphology, flow, and anthropogenic impacts in the Colorado Plateau. The utility of different metrics for monitoring streams in the Colorado Plateau networks was assessed according to the range of values across a gradient of conditions, and the sensitivity of the metric to environmental degradation (characterized by the habitat variables of flow velocity and sedimentation).

Of the eight metrics originally presented in the protocol, the following should generally work well as indicator metrics for streams sampled in the Northern and Southern Colorado Plateau: taxa richness, number of clinger taxa, the ratio of Hydropsychidae plus Hydroptilidae to Trichoptera, richness of tolerant taxa, abundance of tolerant taxa, and percent EPT.

The pilot data suggested that of the compositional metrics, changes in percent richness (rather than percent abundance) of Ephemeroptera, non-insects, and Plecoptera would be more likely to detect change and are thus better metrics to use for evaluating monitoring data. These results corroborated other studies that have shown higher

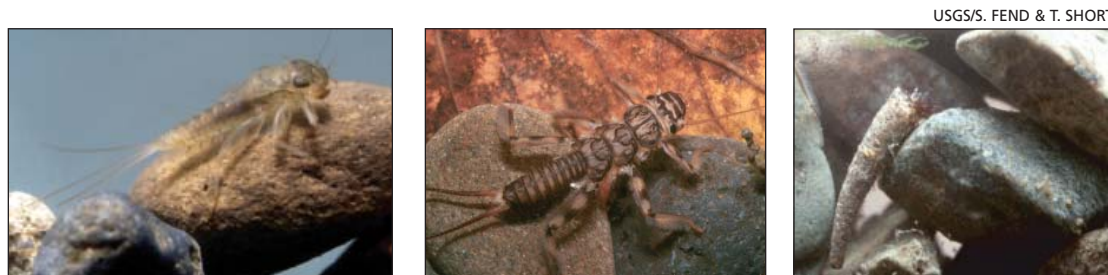


Photo 4-6. Water-quality sensitive taxa include mayflies, stoneflies, and caddisflies.

variability in abundance-based metrics, and greater stability with richness-based metrics (Carlisle and Clements 1999).

The pilot study analyses recommended a few changes to the metrics listed in the protocol. These included using a tolerance (as opposed to dominance) index as a measure of tolerance, percent filter-collector richness instead of percent scrapers, and percent richness metrics, rather than percent abundance metrics, for monitoring compositional attributes. Evaluation and selection of metrics should be an ongoing process.

Results of this analysis also point to the importance of selecting metrics and developing indices that are appropriate for streams of the semi-arid Colorado Plateau. The eight metrics provided in the protocol are generally accepted nationally as useful indicators of water quality and watershed health. However, absent any regional context, the values for these example metrics incorrectly suggested that Coyote Gulch was of intermediate water quality and habitat degradation (as compared to Capulin Creek and the Mancos River)—when in fact, those values simply represented the habitat characteristics (and resultant invertebrate communities) typical of this region: relatively small substrate, low flows, and intermittent reaches (although the sampling reach itself is perennial). Further study is planned to develop and evaluate metrics and indices that will work best for streams of the semi-arid southwest.

On an even more local scale, the community ordination and cluster analyses of quantitative macroinvertebrate samples presented in this report suggest that different metrics will be appropriate for assessing sites with different types of habitats. For example, it may be more important to use different metrics for evaluating intermittent streams, like Courthouse Wash and Salt Creek, than for perennial streams on the Colorado Plateau. Different metrics may also be appropriate for sites like Capulin Creek, located at high elevations and outside the Colorado Plateau ecoregion. It is important to use similar metrics if sites are going to be compared; however, that is not a goal of the I&M program, which is investigating long-term trends at a given system.

Different metrics appear to work better for different types of stream systems, and we recommend that the networks consider using different metrics for assessing each stream type. Over time, with the accumulation of monitoring data, the

networks will be able to select appropriate metrics for streams within their area. Additional data would strengthen this analysis and thus better assess the sensitivity of these particular macroinvertebrate metrics, as well as others not discussed in this report, as indicators of stream quality.

4.7 Habitat characteristics and macroinvertebrates

Macroinvertebrate communities varied among the eight streams, and this variation was correlated with habitat characteristics at a given site. The NMDS plots demonstrated this relationship and showed between-site variability to be higher than within-site variability. The multivariate ordination showed variation in microhabitat velocity and percent riffles among the streams; macroinvertebrate communities in Capulin Creek, La Verkin Creek, Coyote Gulch, the Mancos River, and North Creek were associated with higher velocity and more riffle habitat. The Salt Creek and Courthouse Wash communities were associated with low microhabitat velocities. Sites also grouped by stream size, habitat variability, and riparian shading. For example, macroinvertebrate samples from Capulin Creek, which has denser canopy cover, higher habitat variability, and is a relatively small stream, formed one group. Samples from the Mancos River, with little riparian shading, low habitat variability, and larger flow (i.e., higher velocity, width, and depth) formed a separate group. In addition, the degraded Mancos River had notably lower macroinvertebrate densities and species richness than the other sites. North Creek, Halls Creek, Courthouse Wash, and Salt Creek were also distinguished by having smaller substrate (percent fine sediment). These findings demonstrate the potential for multivariate approaches to condense large amounts of data into information that is meaningful for identifying habitat characteristics that are important drivers of change in macroinvertebrate community composition.

4.8 Summary

Metrics commonly used to assess water and stream quality in other ecoregions (including those in the Pacific Northwest and southeastern U.S.) may not be applicable in the Southwest. For example, EPT taxa are considered an indicator of good stream condition elsewhere, but are naturally underrepresented (especially the order Plecoptera) in streams of the Colorado Plateau ecoregion. Little work has been done to quantify

associations among physical habitat characteristics and macroinvertebrate community structure across the Colorado Plateau. This pilot study provides not only baseline data for the NPS to begin a long-term monitoring program in selected streams, but also provides information specific to macroinvertebrate assemblages in the semi-arid southwestern United States.

This pilot study showed a strong association among physical habitat characteristics (flow velocity, substrate, and riparian canopy closure) and macroinvertebrate community structure. Preliminary analyses of this small set of baseline data indicate a clear gradient of macroinvertebrate responses to flow conditions (from small intermittent streams to larger perennial systems) and elevation (representing different ecoregions). Collection of additional baseline data along a gradient of habitat conditions in the Colorado Plateau, supplemented by collaboration with macroinvertebrate monitoring activities already underway (such as those by state environmental quality agencies), will allow the development of metrics and indices specific to this area.

From a management perspective, this study showed that macroinvertebrates will work well as a vital sign indicator of stream quality conditions. Macroinvertebrates are well distributed in aquatic systems, are relatively easy to collect, and are able to integrate water quality conditions over time. By simultaneously collecting information on habitat conditions, a monitoring program can provide information about how changing habitat characteristics result in changes in macroinvertebrate community structure, and can inform management strategies that can act to influence habitat conditions.

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Appendix A. Park Sampling Locations

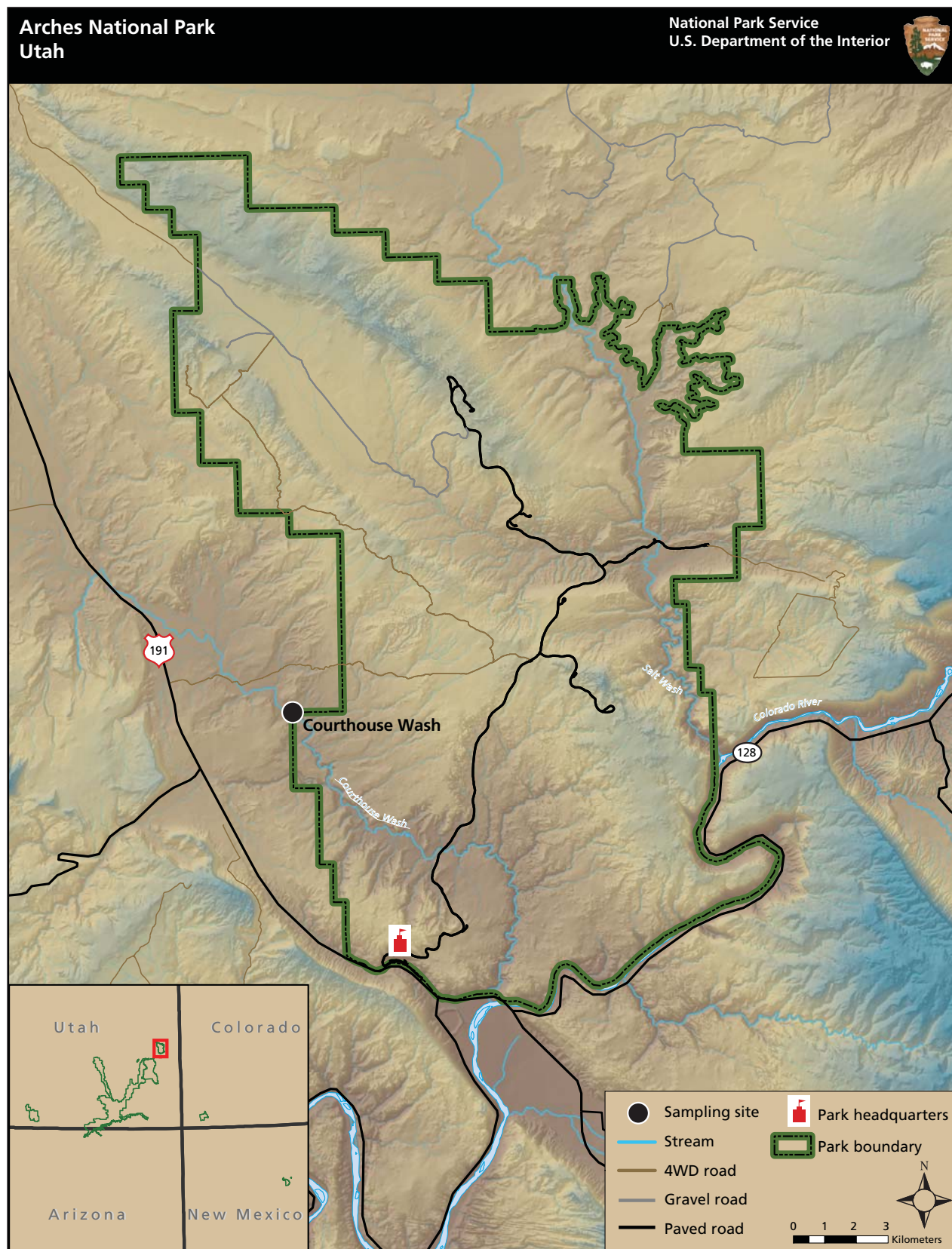


Figure A1. Map showing the sampling location in Courthouse Wash, Arches National Park.

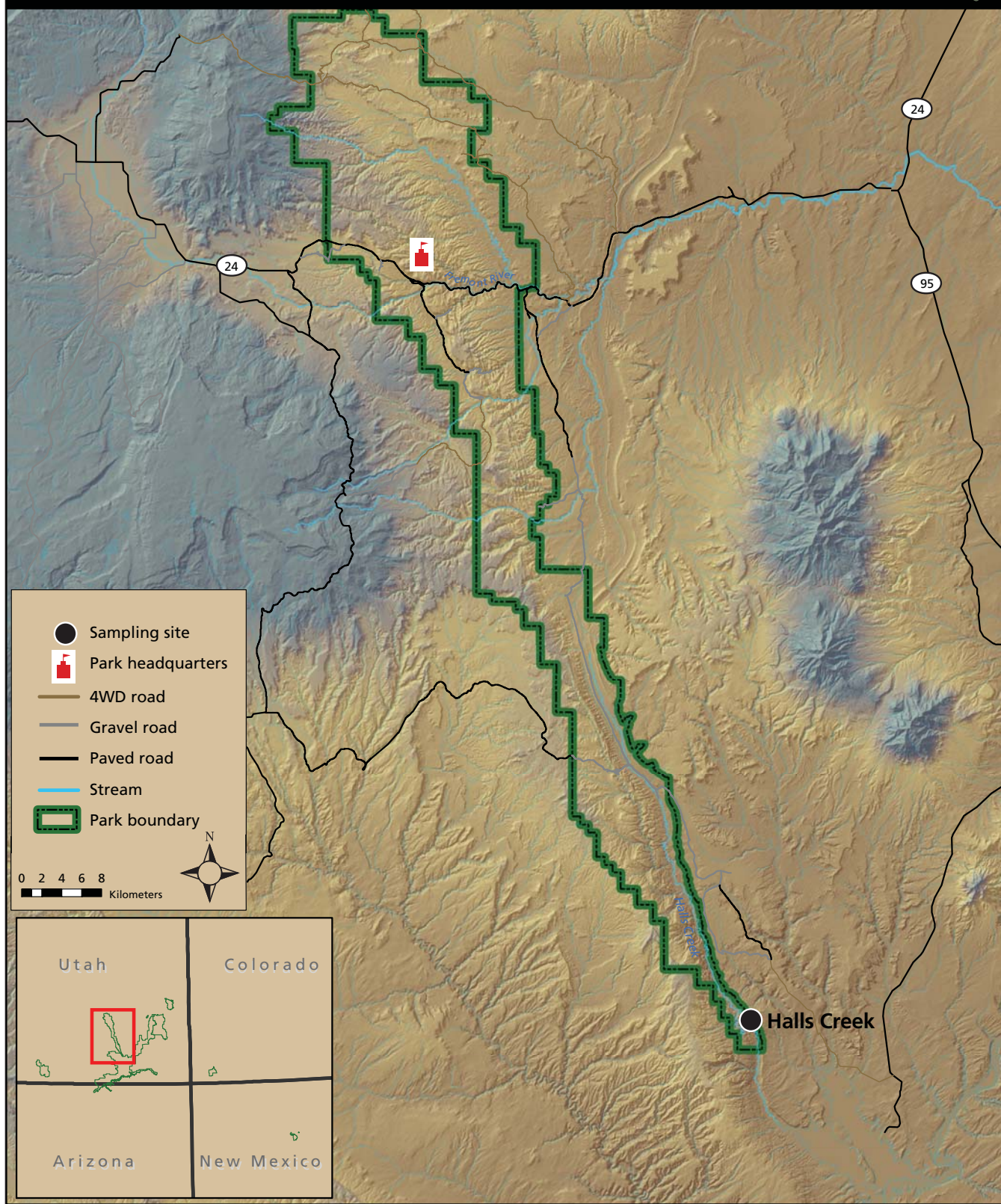


Figure A2. Map showing the sampling location in Halls Creek, Capitol Reef National Park.

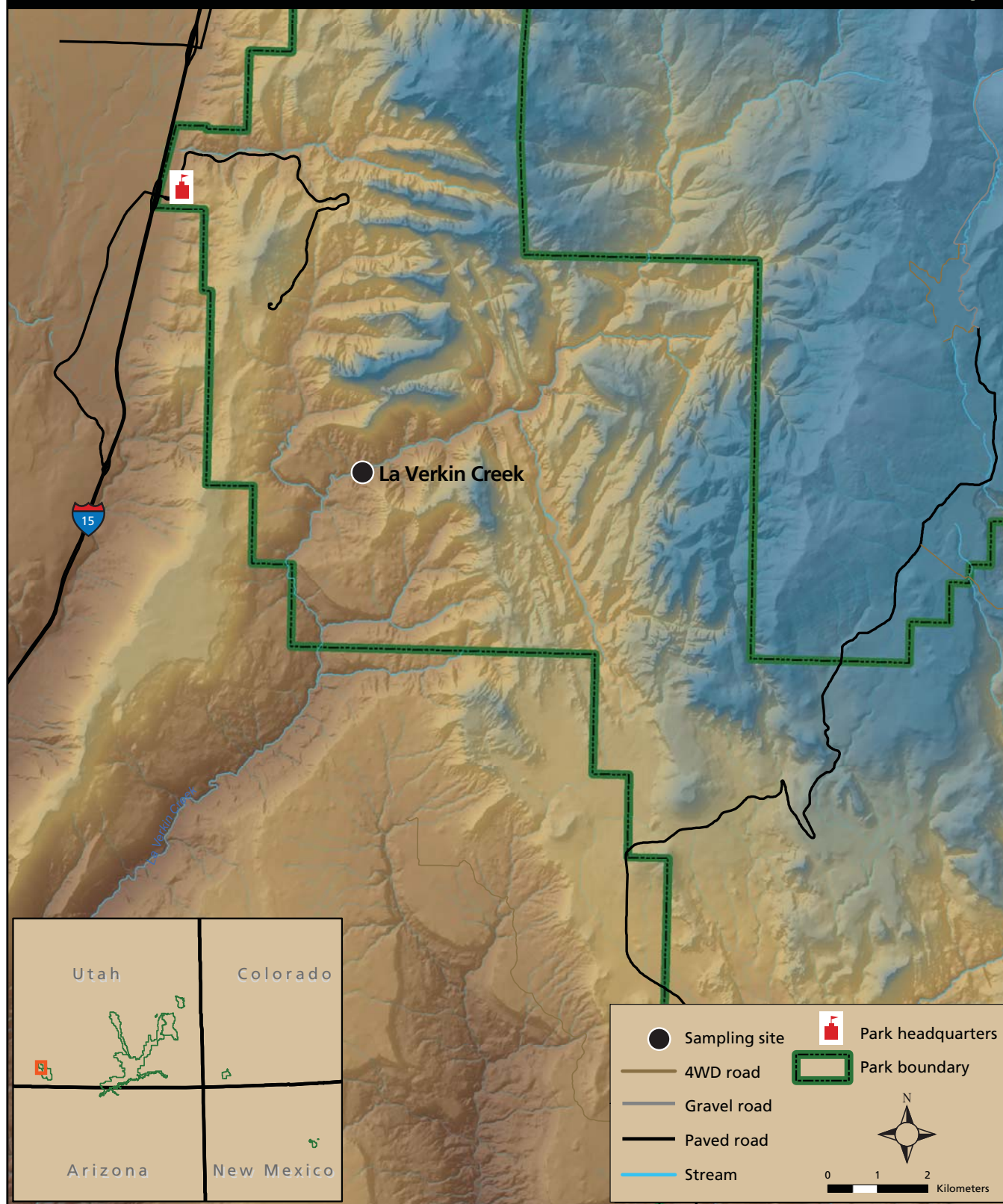


Figure A3. Map showing the sampling location in La Verkin Creek, Zion National Park.

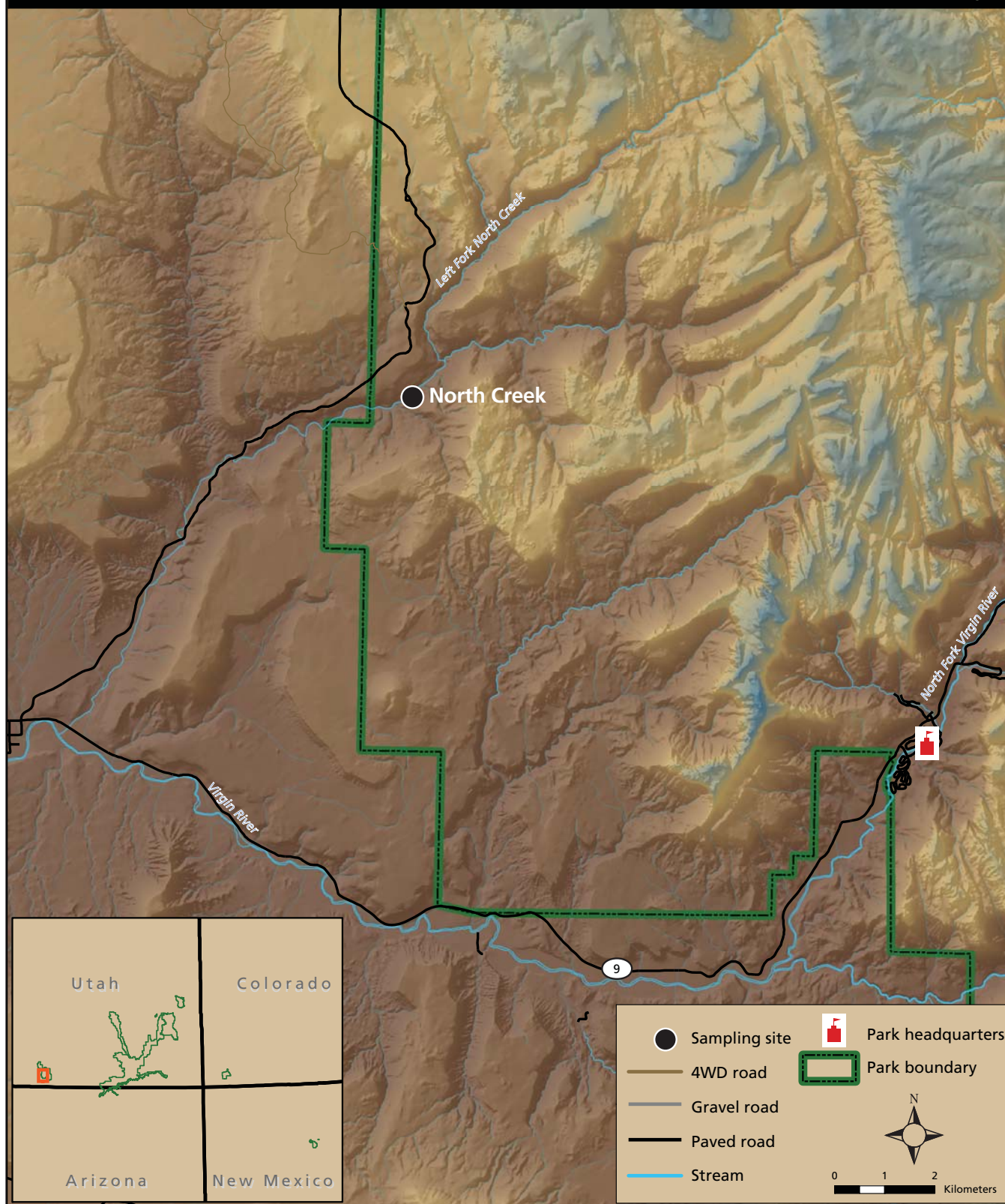


Figure A4. Map showing the sampling location in North Creek, Zion National Park.

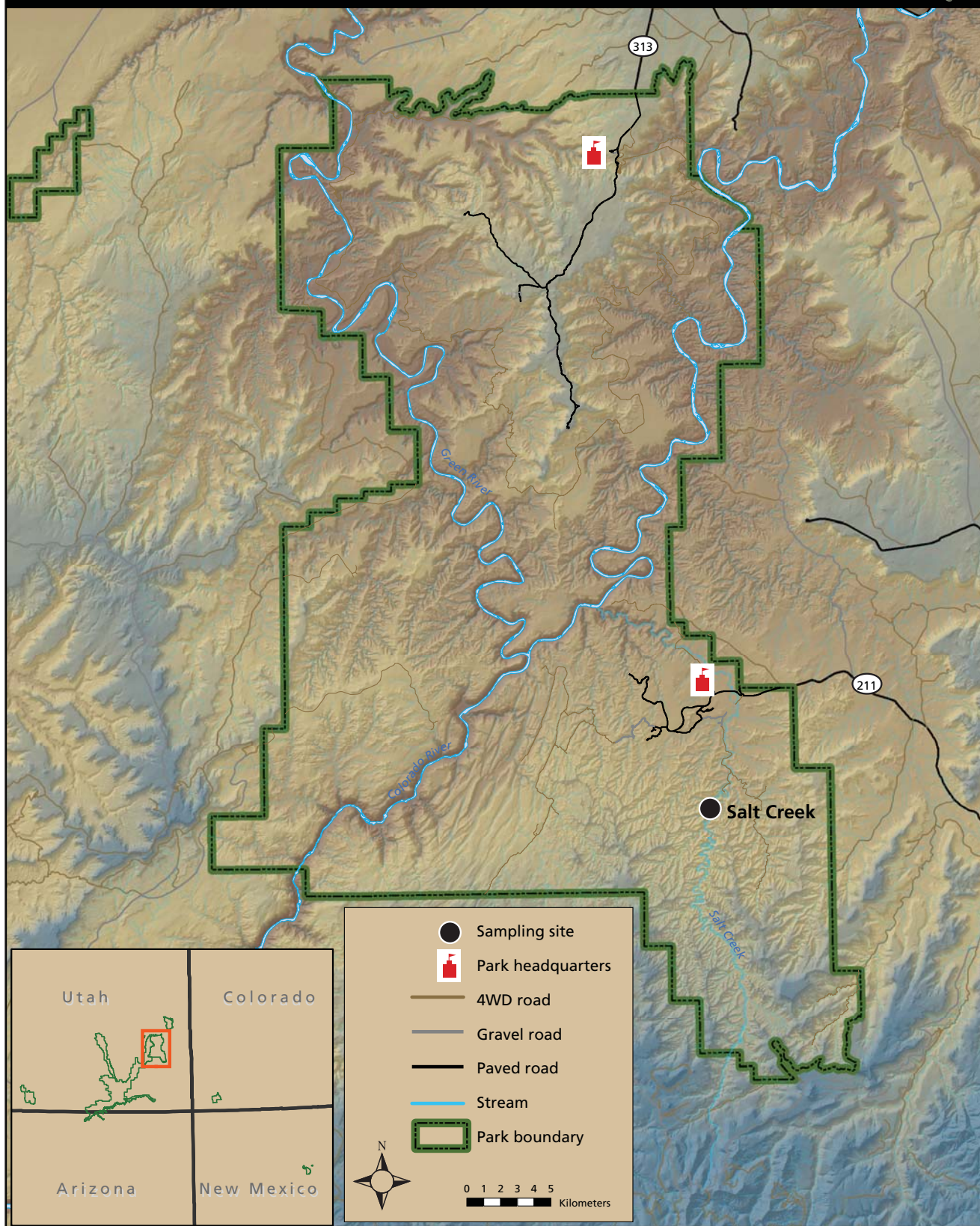


Figure A5. Map showing the sampling location in Salt Creek, Canyonlands National Park.

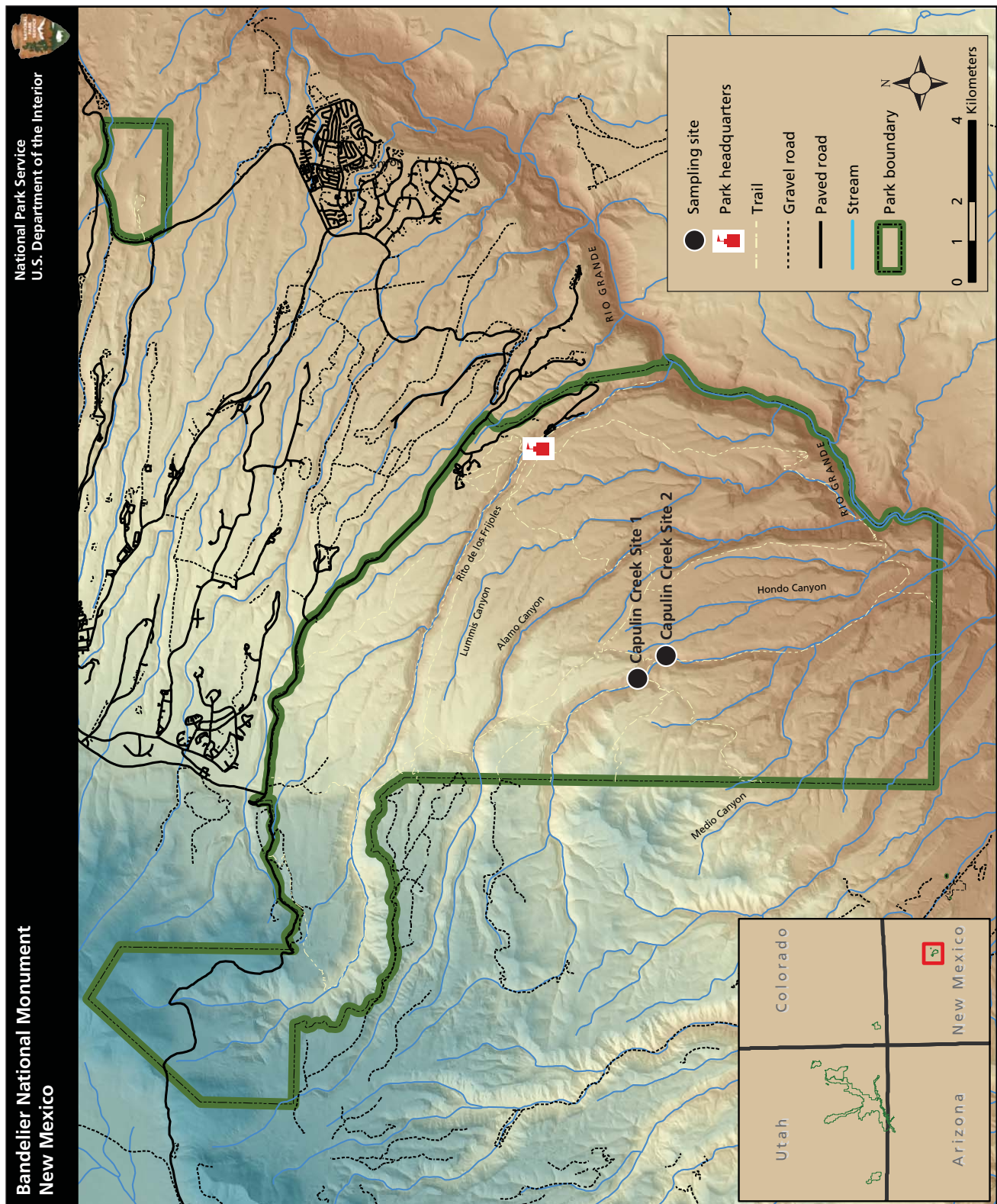


Figure A6. Map showing the two sampling locations in Capulin Creek, Banderlier National Monument.

Glen Canyon National Recreation Area
Arizona, Utah

National Park Service
U.S. Department of the Interior

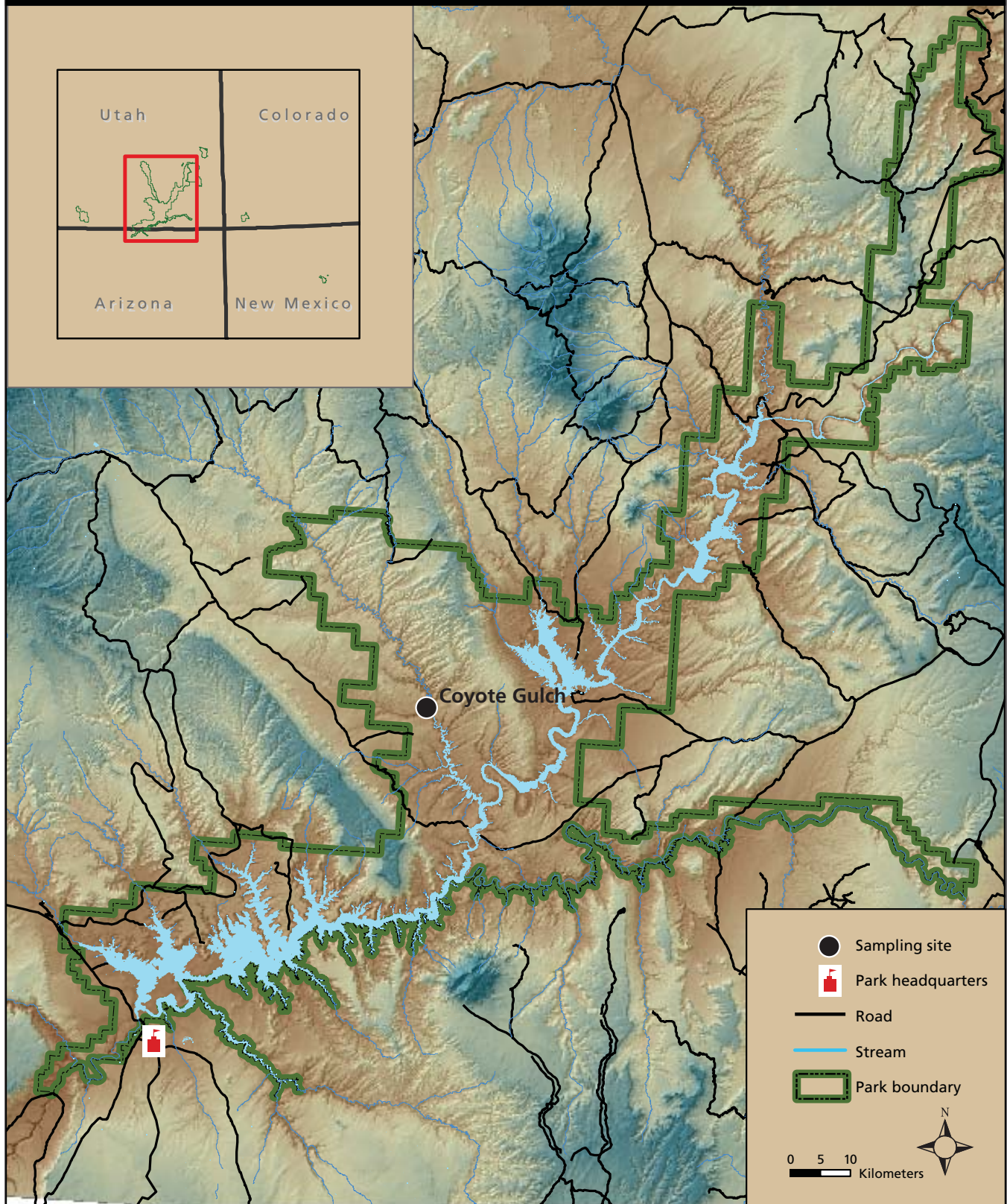


Figure A7. Map showing the sampling location in Coyote Gulch, Glen Canyon National Recreation Area.

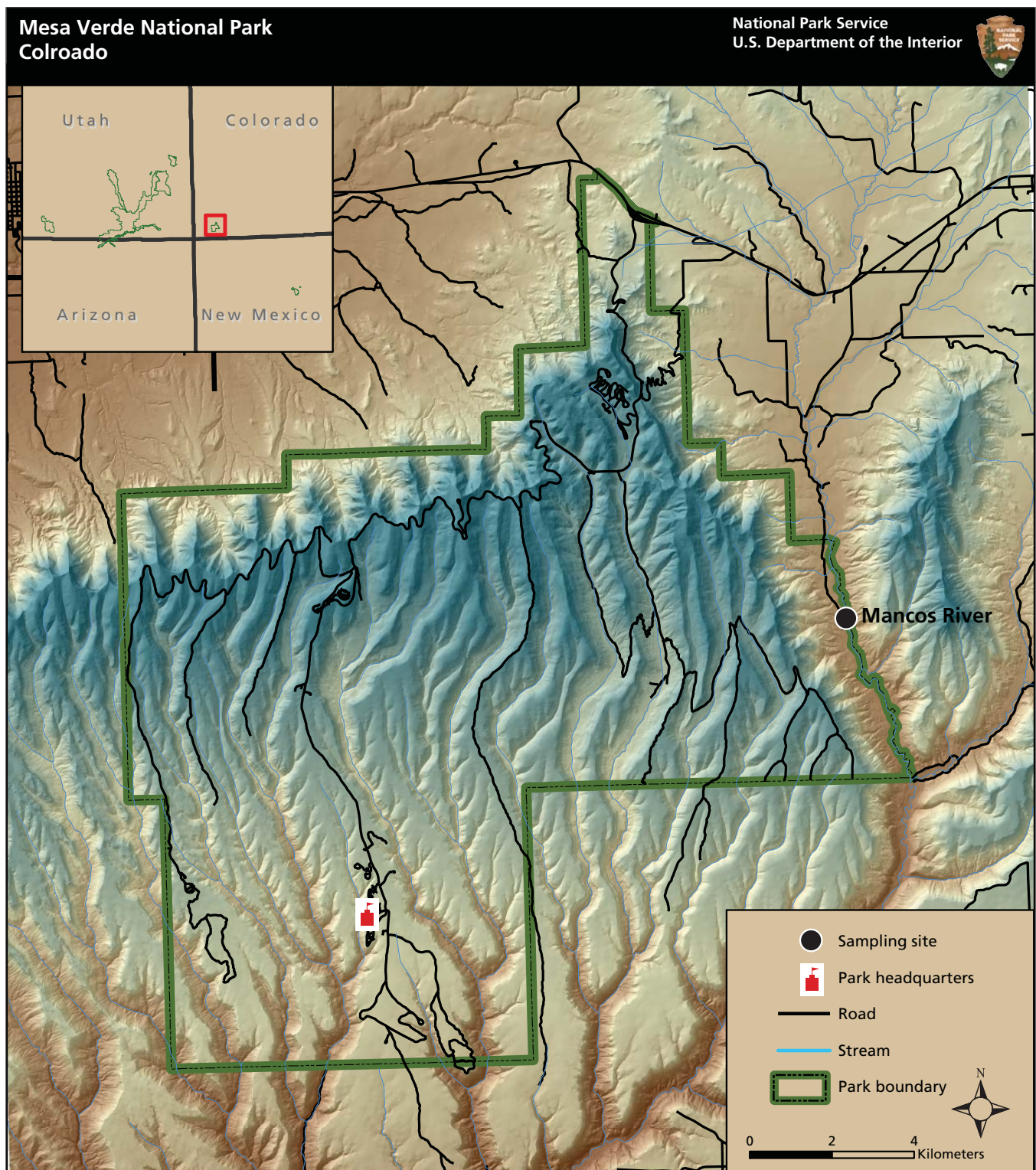


Figure A8. Map showing the sampling location in the Mancos River, Mesa Verde National Park.

Appendix B. Estimates of Time to Complete Various Fieldwork Components

Task	NCPN sites (base location)				SCPN sites (base location)			
	Courthouse Wash (Park main entrance)	Halls Creek (Park visitor center)	La Verkin Creek (Kolob Canyons Visitor Center)	North Creek (Hwy 9 and Kolob Rd in Virgin, UT)	Salt Creek (Hwy 191 & Needles District Turnoff)	Capulin Creek (Park main entrance)	Coyote Gulch (Hole in the Rock Rd & Hwy 12)	Mancos River (Park main entrance)
Drive time to site or trailhead (each way)	1 hr	2 hrs	20 min	30 min	1 hr	1.5	1.5 hr	45 min
Hike (each way)	45 min	3 hrs	≤2 hrs	≤30 min	45 min	≤2 hrs	≤1.5 hrs	na
Reach set-up	30 min	1 hr	1 hr	1 hr	1 hr	1.5 hr	1 hr	1 hr
Quantitative sample collection	1 hr	1.5 hrs	1 hr	1 hr	1 hr	1.5 hr	1 hr	1 hr
Quantitative sample sort	30 min	45 min	1 hr	1 hr	45 min	2 hrs	45 min	30 min
Quantitative sample replication method	8 composited	8 composited	8 composited	8 composited	8 composited	5 replicates	5 replicates	5 replicates
Qualitative sample collection	30 min	30 min	30 min	30 min	30 min	45 min	30 min	30 min
Qualitative sample sort	45 min	1 hr	45 min	45 min	1 hr	2 hr	45 min	30 min
Habitat characterization	3 hrs	3.5 hrs	3.5 hrs	3.5 hrs	3 hrs	4 hrs	3.5 hrs	3.5 hrs
Wrap-up	45 min	45 min	45 min	45 min	45 min	45 min	45 min	45 min
Total sampling time (including travel time)	8.75 hrs	14 hrs	11.17 hrs	10.5 hrs	9.75 hrs	19.5 hrs	14.25 hrs	9.25 hrs

Appendix C. Habitat Data Collected by State and Federal Agencies in the Colorado Plateau

Parameter	State/Federal agency				
	Arizona	Colorado	New Mexico	Utah	NAWQA
Number of transects (or measurement points)	3 riffle or run sections/ reach	10 transects	11 transects	11 transects	11 transects
Number of velocity measurements	3 (at each cross section)	1 (for discharge)	15 (measured solely for discharge across one carefully chosen cross-section)	1 (for discharge)	33 (3 per transect; at thalweg and 2 evenly spaced points on either side)
Number of depth measurements	3 (at each cross section)	1 (for discharge)	100 (thalweg of each transect and 10 evenly spaced intervals between transects)	165 (5 times across transect and thalweg depth 10 times between transects)	33 (3 per transect; at thalweg and 2 evenly spaced points on either side)
Number of canopy-closure measurements (per transect)	4 (one in each direction)	Not measured	6 (four at mid-channel (one in each direction) and one on each bank)	6 (four at mid-channel (one in each direction) and one on each bank)	2 (one at each bank)
Number of pebble counts	100 (zig-zag method throughout entire reach)	400 (40 per transect)	105 (5 at each transect and 5 at midpoint between transects)	105 (5 at each transect and 5 at midpoint between transects)	275–1,100 (25–100 per transect)
					105 (5 at each transect and 5 at midpoint between transects)

Appendix D. Summary Statistics for Habitat Data at Three Spatial Scales: Reach, Transect, and Microhabitat

Reach Data Summary

Stream	Date	Number of geomorphic channel units	% riffle	% pool
Capulin Creek Site 1	9/26/2005	10	75.8	3.2
	10/1/2006	20	70.3	0.0
	10/29/2006	19	61.1	3.2
Capulin Creek Site 2	10/29/2006	20	59.2	6.9
Courthouse Wash	7/4/2006	4	0.0	23.9
Coyote Gulch	9/20/2005	10	21.3	14.9
	9/23/2006	13	23.1	4.5
	10/12/2006	11	16.3	0.0
	11/3/2006	10	20.1	0.0
Halls Creek	5/17/2006	10	27.3	3.5
La Verkin Creek	8/22/2006	11	37.7	0.0
Mancos River	9/12/2005	4	54.5	0.0
	9/1/2006	6	56.7	0.0
	9/29/2006	6	61.2	0.0
	10/25/2006	6	58.7	0.0
North Creek	8/23/2006	9	62.0	5.5
Salt Creek	6/22/2006	13	0.0	0.0

Transect Data Summary

Stream	Date	# transects	% canopy closure	Velocity (m/s)		Depth (m)		Width		Substrate size (cm)			% fine sediment (<2 mm)	Solar radiation	
				Average	Standard deviation	Average	Standard deviation	Average	Standard deviation	Median	Average	Standard deviation		Average (%)	Standard deviation
NCPN sites															
Courthouse Wash	7/4/06	11	10	0.01	0.05	0.08	0.10	1.60	1.07	0.1	0.3	0.6	72.2	-	-
Halls Creek	5/17/06	11	19	0.12	0.07	0.06	0.04	2.70	1.33	0.1	1.5	2.9	69.0	-	-
La Verkin Creek	8/22/06	11	29	0.42	0.36	0.15	0.15	4.46	3.13	0.1	4.3	10.2	29.3	58	19
North Creek	8/23/06	11	5	0.28	0.25	0.19	0.13	4.78	1.67	2.4	17.5	29.0	63.4	90	5
Salt Creek	6/22/06	11	56	-	-	0.22	0.27	1.16	0.70	0.1	1.1	2.7	89.9	-	-
SCPN sites															
Capulin Creek Site 1	9/26/05	11	94	0.11	0.10	0.08	0.04	1.42	0.54	2.0	8.8	15.3	15.0	-	-
	9/6/06	na ¹	97	-	-	-	-	-	-	-	-	-	-	-	-
	10/1/06	11	84	0.16	0.17	0.10	0.06	1.60	0.51	1.3	6.8	11.9	26.4	17	9
	10/29/06	6	71	0.15	0.16	0.13	0.12	1.59	0.41	1.6	5.3	15.0	23.5	38	11
Capulin Creek Site 2	10/29/06	11	87	0.16	0.17	0.10	0.06	1.57	0.41	1.3	4.5	12.3	26.2	58	16
Coyote Gulch	9/20/05	11	56	0.21	0.21	0.17	0.12	2.45	1.82	0.1	4.4	13.1	88.8	-	-
	9/23/06	11	48	0.24	0.20	0.12	0.08	1.78	1.15	0.1	0.8	4.4	81.4	54	17
	10/12/06	11	36	0.41	0.25	0.16	0.12	3.16	1.65	0.1	3.2	10.5	69.3	54	14
	11/3/06	6	35	0.36	0.31	0.12	0.08	2.41	1.22	0.1	0.3	1.3	56.4	53	12
Mancos River	9/12/05	6	34	0.49	0.25	0.28	0.10	7.56	1.12	1.9	5.0	7.2	64.0	-	-
	9/1/06	8 ¹	17	0.21	0.12	0.12	0.09	5.53	1.54	0.1	3.5	6.7	45.6	80	9
	9/29/06	11	13	0.60	0.28	0.26	0.11	5.96	1.35	1.0	4.2	5.9	16.0	84	5
	10/25/06	6	5	0.66	0.31	0.28	0.09	5.96	1.99	2.7	4.7	6.2	21.9	87	3

¹Left site for safety reasons during a lightning storm before habitat transects were completed.

Microhabitat Data Summary

		Velocity (m/s)		Depth (m)		Embeddedness (%)		Substrate size (cm)	
		Average	Standard deviation	Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
Stream	Date								
NCPN sites									
Courthouse Wash	7/4/06	0.05	0.06	0.04	0.03	15	25	0.1	0.1
Halls Creek	5/17/06	0.39	0.15	0.07	0.03	6	5	7.5	5.8
La Verkin Creek	8/22/06	0.53	0.17	0.13	0.03	40	12	7.2	5.6
North Creek	8/23/06	0.60	0.41	0.15	0.04	39	11	7.2	7.5
Salt Creek	6/22/06	0.00	0.00	0.23	0.23	70	23	1.4	1.7
SCPN sites									
Capulin Creek Site 1	9/26/05	0.22	0.08	0.09	0.03	22	27	10.6	5.3
	9/6/06	0.53	0.18	0.07	0.03	13	4	11.5	3.7
	10/1/06	0.52	0.22	0.09	0.02	18	11	10.4	3.0
	10/27/06	0.39	0.09	0.10	0.01	24	17	7.6	2.8
Capulin Creek Site 2	10/28/06	0.54	0.17	0.11	0.01	2	4	6.9	2.7
Coyote Gulch	9/20/05	0.46	0.46	0.17	0.06	34	28	15.4	5.3
	10/26/05	0.83	0.59	0.19	0.07	56	38	17.3	14.2
	9/22/06	0.76	0.35	0.13	0.05	22	13	11.5	4.3
	10/12/06	0.97	0.36	0.21	0.03	26	21	8.2	4.6
	11/3/06	0.56	0.33	0.15	0.06	36	22	11.4	9.5
Mancos River	9/12/05	0.59	0.22	0.24	0.04	70	19	12.5	6.4
	9/1/06	0.40	0.07	0.11	0.02	85	8	15.4	5.3
	9/28/06	0.79	0.27	0.22	0.05	44	4	13.0	4.6
	10/25/06	0.68	0.23	0.22	0.02	8	29	8.4	3.6

Appendix E. Macroinvertebrate Data Collected by State and Federal Agencies in the Colorado Plateau

Parameter	State/Federal agency					Pilot study
	Arizona	Colorado	New Mexico	Utah	NAWQA	EMAP
Targeted-habitat samples						
Sampling apparatus	D-frame kick net	D-frame kick net	Hess or Surber sampler	Modified Surber sampler	Modified Surber sampler	Modified Surber sampler D-frame kick net
Sampling area (per replicate, in m ²)	N/A	1	0.09	0.09	0.25	0.25
Mesh size (μm)	500	500–600	500	500	500	500
Habitat type sampled	Riffle	Riffle or Run	Any (consistent across sampling locations)	Riffle	Riffle	Riffle
Number of sampling locations	3	≥2		8	5	5
Replication strategy for discrete samples	Composited	Replicates	Replicates	Composited	Composited	Replicates
Sampling location selection method	Targeted	Targeted Random/ Systematic	Targeted	Targeted Random/ Systematic	Targeted	Targeted
Sampling effort standardization method	3-minute timed kick	Area	Area	Area	Area	Area
Multihabitat samples						
Quantification method	NA	Qualitative	Qualitative	Quantitative (fixed area)	Qualitative	Quantitative
Sampling location selection method	NA	All habitat types	All habitat types	Random/ Systematic	All habitat types	Random/ Systematic All habitat types

Appendix F. Macroinvertebrates in Quantitative Samples

Courthouse Wash (Arches National Park)

Taxonomic information	04-Jul-06
Nematoda	3
Annelida	
Oligochaeta	113
Arthropoda	
Ostracoda	272
Insecta	
Ephemeroptera	
Baetidae	
<i>Callibaetis</i> sp.	34
Odonata	
Anisoptera	
Libellulidae	12
Zygoptera	
Coenagrionidae	
<i>Argia</i> sp.	35
Trichoptera	
Hydroptilidae	3
Coleoptera	
Dytiscidae	
<i>Agabus</i> sp.	1
Hydrophilidae	
<i>Laccobius</i> sp.	15
<i>Tropisternus</i> sp.	4
Diptera	
Ceratopogonidae	
<i>Dasyhelea</i> sp.	84
Ceratopogoninae	11
Chironomidae	
Chironominae	
Chironomini	
<i>Apedilum</i> sp.	12
<i>Paratendipes</i> sp.	7
<i>Polypedilum</i> sp.	62
<i>Stictochironomus</i> sp.	1
Pseudochironomini	
Tanytarsini	
<i>Rheotanytarsus</i> sp.	1
<i>Tanytarsus</i> sp.	43

Taxonomic information	04-Jul-06
Diamesinae	
Orthoclaadiinae	
<i>Limnophyes</i> sp.	1
<i>Orthocladus</i> sp.	4
Podonominae	
Tanypodinae	
Macropelopiini	1
Pentaneurini	
<i>Larsia</i> sp.	1
<i>Pentaneura</i> sp.	44

Halls Creek (Capitol Reef National Park)

Taxonomic information	17-May-06
Annelida	
Oligochaeta	429
Arthropoda	
Arachnida	
Trombidiformes	
Prostigmata	
Hygrobatidae	
<i>Atractides</i> sp.	4
Sperchontidae	
<i>Sperchon</i> sp.	2
Ostracoda	1
Insecta	
Ephemeroptera	
Baetidae	
<i>Baetis</i> sp.	18
<i>Baetis notos</i>	48
<i>Pseudocloeon</i> sp.	1
Trichoptera	
Hydroptilidae	
<i>Hydroptila</i> sp.	3
Coleoptera	
Hydrophilidae	
<i>Tropisternus</i> sp.	1
Diptera	
Ceratopogonidae	
<i>Bezzia/Palpomyia</i> sp.	9
<i>Dasyhelea</i> sp.	6
Chironomidae	
Chironominae	
Chironomini	
<i>Apedilum</i> sp.	11
Pseudochironomini	
<i>Pseudochironomus</i> sp.	5
Tanytarsini	
<i>Cladotanytarsus</i> sp.	1
<i>Tanytarsus</i> sp.	28
Orthocladiinae	
<i>Cricotopus</i> sp.	6
<i>Eukiefferiella</i> sp.	1
<i>Eukiefferiella brehmi</i>	5
<i>Eukiefferiella claripennis</i>	15
<i>Eukiefferiella devonica</i>	11
<i>Limnophyes</i> sp.	1
<i>Orthocladius</i> sp.	8

Taxonomic information	17-May-06
<i>Parametriocnemus</i> sp.	6
<i>Thienemanniella</i> sp.	6
<i>Tvetenia bavarica</i>	4
Tanypodinae	
Pentaneurini	
<i>Pentaneura</i> sp.	1
<i>Thienemannimyia</i> sp.	1
Empididae	
<i>Hemerodromia</i> sp.	3
Simuliidae	
<i>Simulium</i> sp.	198
Tipulidae	
<i>Limonia</i> sp.	1

La Verkin Creek (Zion National Park)

Taxonomic information		22-Aug-06
Annelida		
Oligochaeta		4
Arthropoda		
Arachnida		
Trombidiformes		
Prostigmata		
Sperchontidae		
<i>Sperchon</i> sp.		13
Insecta		
Ephemeroptera		
Baetidae		
<i>Baetis</i> sp.		95
<i>Baetis tricaudatus</i>		420
Odonata		
Megaloptera		
Corydalidae		
<i>Corydalus</i> sp.		4
Trichoptera		
Hydropsychidae		
Hydropsychinae		
<i>Hydropsyche</i> sp.		12
Hydroptilidae		
<i>Hydroptila</i> sp.		15
<i>Ochrotrichia</i> sp.		9
Coleoptera		
Dryopidae		
<i>Helichus</i> sp.		1
<i>Postelichus</i> sp.		7
Elmidae		
<i>Microcylloepus</i> sp.		3
Diptera		
Ceratopogonidae		
<i>Bezzia/Palpomyia</i> sp.		1
Chironomidae		
Chironominae		
Chironomini		
<i>Polypedilum</i> sp.		1
Orthocladiinae		
<i>Cardiocladius</i> sp.		1
<i>Eukiefferiella devonica</i>		1
<i>Heleniella</i> sp.		1
<i>Parametriocnemus</i> sp.		1
Simuliidae		
<i>Simulium</i> sp.		143
Tipulidae		
<i>Dicranota</i> sp.		1

North Creek (Zion National Park)

Taxonomic Information	23-Aug-06
Annelida	
Oligochaeta	8
Arthropoda	
Arachnida	
Trombidiformes	
Prostigmata	
Sperchontidae	
<i>Sperchon</i> sp.	16
Insecta	
Ephemeroptera	
Baetidae	
<i>Acentrella insignificans</i>	3
<i>Baetis</i> sp.	47
<i>Baetis notos</i>	11
<i>Baetis tricaudatus</i>	8
<i>Baetodes edmundsi</i> .	3
<i>Fallceon quilleri</i>	13
Leptohyphidae	
<i>Tricorythodes</i> sp.	7
Leptophlebiidae	
<i>Choroterpes</i> sp.	5
Odonata	
Zygoptera	
Coenagrionidae	
<i>Argia</i> sp.	1
Megaloptera	
Corydalidae	
<i>Corydalus</i> sp.	1
Trichoptera	
Brachycentridae	
<i>Micrasema</i> sp.	3
Hydropsychidae	
Hydropsychinae	
<i>Cheumatopsyche</i> sp.	11
<i>Hydropsyche</i> sp.	47
Hydroptilidae	
<i>Hydroptila</i> sp.	3
<i>Neotrichia</i> sp.	1
<i>Ochrotrichia</i> sp.	1
Philopotamidae	3
Coleoptera	
Dryopidae	
<i>Postelichus</i> sp.	4

Taxonomic Information	23-Aug-06
Elmidae	
<i>Microcylloepus</i> sp.	38
Diptera	
Ceratopogonidae	
<i>Bezzia/Palpomyia</i> sp.	3
<i>Dasyhelea</i> sp.	9
Chironomidae	
Chironominae	
Chironomini	
<i>Phaenopsectra</i> sp.	1
<i>Polypedilum</i> sp.	101
Pseudochironomini	
<i>Pseudochironomus</i> sp.	4
Tanytarsini	
<i>Cladotanytarsus</i> sp.	1
<i>Rheotanytarsus</i> sp.	1
Orthocladiinae	
<i>Cardiocladius</i> sp.	15
<i>Cricotopus</i> sp.	41
<i>Cricotopus bicinctus</i>	1
<i>Eukiefferiella</i> sp.	3
<i>Eukiefferiella brehmi</i>	9
<i>Orthocladius</i> sp.	114
<i>Rheocricotopus</i> sp.	20
<i>Tempisquitoneura merrillorum</i>	36
<i>Thienemanniella</i> sp.	5
Tanypodinae	
Pentaneurini	0
<i>Thienemannimyia</i> sp.	3
Empididae	
<i>Hemerodromia</i> sp.	4
Ephydriidae	1
Psychodidae	
<i>Maruina</i> sp.	1
Simuliidae	
<i>Simulium</i> sp.	131
Tabanidae	
<i>Atylotus/Tabanus</i> sp.	1
Tipulidae	
<i>Limonia</i> sp.	1

Salt Creek (Canyonlands National Park)

Taxonomic Information	22-Jun-06
Annelida	
Oligochaeta	78
Mollusca	
Gastropoda	
Basommatophora	
Physidae	
<i>Physa</i> sp.	97
Arthropoda	
Arachnida	
Trombidiformes	
Prostigmata	
Arrenuridae	
<i>Arrenurus</i> sp.	1
Malacostraca	
Amphipoda	
Talitridae	
<i>Hyalella</i> sp.	1
Ostracoda	1
Insecta	
Ephemeroptera	
Baetidae	
<i>Callibaetis</i> sp.	44
Odonata	
Anisoptera	
Libellulidae	11
Zygoptera	
Coenagrionidae	63
Lestidae	
<i>Archilestes grandis</i>	3
Coleoptera	
Dytiscidae	
<i>Liodessus</i> sp.	7
<i>Stictotarsus</i> sp.	5
Hydroporinae	17
Hydrophilidae	
<i>Enochrus</i> sp.	7
<i>Laccobius</i> sp.	7
Diptera	
Ceratopogonidae	
<i>Bezzia/Palpomyia</i> sp.	12

Taxonomic Information	22-Jun-06
<i>Dasyhelea</i> sp.	72
Chironomidae	
Chironominae	
Chironomini	
<i>Apedilum</i> sp.	52
<i>Chironomus</i> sp.	12
<i>Paratendipes</i> sp.	11
<i>Polypedilum</i> sp.	12
Tanytarsini	
<i>Paratanytarsus</i> sp.	15
<i>Tanytarsus</i> sp.	19
Orthoclaadiinae	
<i>Diplocladius</i> sp.	3
<i>Psectrocladius</i> sp.	4
Tanypodinae	
Macropelopiini	
<i>Alotanypus</i> sp.	82
Pentaneurini	
<i>Paramerina</i> sp.	120
<i>Thienemannimyia</i> sp.	8

Capulin Creek (Bandelier National Monument)

	Site 1				Site 2
	24-Sep-05	06-Sep-06	01-Oct-06	27-Oct-06	28-Oct-06
Taxonomic information					
Nematoda	1	1	3	1	2
Annelida					
Oligochaeta	0	8	1	4	6
Enchytraeidae	1	0	0	0	0
Naididae					
<i>Nais variabilis</i>	2	0	0	0	0
Tubificidae	2	0	0	0	0
Mollusca					
Bivalvia					
Veneroida					
Sphaeriidae	1	1	1	0	1
Gastropoda					
Basommatophora					
Planorbidae					
<i>Gyraulus</i> sp.	1	0	0	0	0
Arthropoda					
Arachnida					
Trombidiformes					
Prostigmata					
Hygrobatidae					
<i>Atractides</i> sp.	1	1	11	9	14
Sperchontidae					
<i>Sperchon</i> sp.	10	31	26	60	21
Insecta					
Ephemeroptera					
Ameletidae					
<i>Ameletus</i> sp.	0	0	0	0	2
Baetidae					
<i>Baetis</i> sp.	30	0	0	812	850
<i>Acentrella insignificans</i>	14	5	0	0	0
<i>Baetis magnus</i>	8	98	23	75	53
<i>Baetis tricaudatus</i>	75	223	184	2	0
<i>Fallceon quilleri</i>	4	4	4	1	5
Ephemerellidae					
<i>Ephemerella</i> sp.	347	11	191	824	410
Heptageniidae					
<i>Epeorus</i> sp.	0	0	0	7	5
<i>Nixe</i> sp.	9	143	28	0	0
Leptohyphidae					
<i>Tricorythodes</i> sp.	0	1	3	5	3

Capulin Creek (Bandelier National Monument), cont.

Taxonomic information	Site 1				Site 2
	24-Sep-05	06-Sep-06	01-Oct-06	27-Oct-06	28-Oct-06
Leptophlebiidae	0	24	0	0	0
<i>Paraleptophlebia</i> sp.	62	0	113	173	590
Odonata					
Anisoptera					
Aeshnidae					
<i>Oplonaeschna</i> sp.	9	50	20	37	26
<i>Oplonaeschna armata</i>	6	5	12	7	12
Cordulegastridae					
<i>Cordulegaster dorsalis</i>	2	3	1	0	0
Zygoptera					
Coenagrionidae					
<i>Argia</i> sp.	10	17	7	33	93
Plecoptera					
Capniidae	22	0	1	41	167
Chloroperlidae	5	0	0	0	0
<i>Sweltsa</i> sp.	0	1	7	74	174
Nemouridae	0	0	0	0	0
<i>Zapada</i> sp.	2	0	0	0	5
<i>Zapada cinctipes</i>	36	117	55	58	166
Perlodidae	0	66	152	0	0
<i>Isoperla</i> sp.	68	0	0	557	452
Trichoptera					
Calamoceratidae					
<i>Phylloicus</i> sp.	0	0	0	2	0
Glossosomatidae					
<i>Agapetus</i> sp.	1	0	0	0	0
<i>Glossosoma</i> sp.	0	13	4	329	19
Helicopsychidae					
<i>Helicopsyche</i> sp.	0	4	1	0	4
Hydropsychidae					
Hydropsychinae					
<i>Cheumatopsyche</i> sp.	2	5	4	13	55
<i>Hydropsyche</i> sp.	129	1,410	636	898	347
Hydroptilidae	1	0	0	0	0
<i>Leucotrichia</i> sp.	0	1	0	0	0
<i>Ochrotrichia</i> sp.	0	3	0	1	1
Lepidostomatidae					
<i>Lepidostoma</i> sp.	7	1	0	4	79
Leptoceridae					
<i>Oecetis disjuncta</i>	0	1	1	2	0

Capulin Creek (Bandelier National Monument), cont.

Taxonomic information	Site 1				Site 2
	24-Sep-05	06-Sep-06	01-Oct-06	27-Oct-06	28-Oct-06
Limnephilidae	0	0	0	0	4
Philopotamidae					
<i>Chimarra</i> sp.	0	0	0	1	0
<i>Wormaldia</i> sp.	2	35	0	0	0
Lepidoptera					
Pyrilidae					
<i>Petrophila</i> sp.	1	19	4	7	3
Coleoptera					
Dryopidae					
<i>Helichus</i> sp.	1	0	0	0	0
Dytiscidae					
<i>Agabus</i> sp.	2	0	1	1	16
Elmidae					
<i>Narpus</i> sp.	0	0	0	2	4
<i>Optioservus</i> sp.	18	59	71	124	153
<i>Zaitzevia</i> sp.	2	1	0	5	2
Hydrophilidae					
Diptera					
Ceratopogonidae					
<i>Bezzia/Palpomyia</i> sp.	1	1	0	0	0
<i>Stilobezzia</i> sp.	2	0	0	0	0
Chironomidae					
Chironominae					
Chironomini					
<i>Polypedilum</i> sp.	0	1	0	0	0
Pseudochironomini					
Tanytarsini					
<i>Micropsectra</i> sp.	2	8	3	4	66
<i>Micropsectra</i> sp./ <i>Tanytarsus</i> sp.	0	0	0	0	49
<i>Rheotanytarsus</i> sp.	0	32	0	0	0
<i>Stempellinella</i> sp.	8	0	0	0	0
<i>Tanytarsus</i> sp.	1	1	0	0	0
Diamesinae					
Diamesini					
<i>Pagastia</i> sp.	2	0	0	0	0
Orthocladiinae					
<i>Brillia</i> sp.	4	3	4	12	105
<i>Cardiocladius</i> sp.	0	0	0	1	0
<i>Corynoneura</i> sp.	2	0	0	2	23
<i>Cricotopus</i> sp.	8	5	5	0	0

Capulin Creek (Bandelier National Monument), cont.

Taxonomic information	Site 1				Site 2
	24-Sep-05	06-Sep-06	01-Oct-06	27-Oct-06	28-Oct-06
<i>Eukiefferiella</i> sp.	0	2	1	0	5
<i>Eukiefferiella brehmi</i>	29	40	81	47	46
<i>Eukiefferiella brevicar</i>	0	1	0	0	0
<i>Eukiefferiella claripennis</i>	2	0	1	2	0
<i>Eukiefferiella coerulescens</i>	2	0	0	0	0
<i>Eukiefferiella gracei</i>	1	0	1	1	0
<i>Heleniella</i> sp.	3	0	1	0	0
<i>Krenosmittia</i> sp.	1	0	0	0	0
<i>Limnophyes</i> sp.	0	0	0	0	20
<i>Lopescladius</i> sp.	0	0	8	24	16
<i>Orthocladius</i> sp.	4	3	2	0	0
<i>Orthocladius lignicola</i>	0	0	1	0	0
<i>Parachaetocladius</i> sp.	0	0	0	2	0
<i>Parametriocnemus</i> sp.	14	1	3	0	14
<i>Paraphaenocladius</i> sp.	1	0	0	0	0
<i>Thienemanniella</i> sp.	1	1	0	0	2
<i>Tvetenia</i> sp.	0	0	1	0	22
<i>Tvetenia bavarica</i>	82	52	136	69	308
Podonominae					
Podonomini					
<i>Parochlus</i> sp.	0	0	0	3	16
Tanypodinae					
Macropelopiini					
<i>Alotanypus</i> sp.	0	1	0	0	0
<i>Apsectrotanypus</i> sp.	0	1	0	0	0
Pentaneurini	0	1	0	0	0
<i>Ablabesmyia</i> sp.	1	0	0	0	0
<i>Larsia</i> sp.	1	0	0	0	0
<i>Pentaneura</i> sp.	0	0	0	0	3
<i>Thienemannimyia</i> sp.	1	0	0	0	0
<i>Zavrelimyia</i> sp.	1	0	0	0	0
Dixidae					
<i>Dixa</i> sp.	3	0	1	4	12
Empididae					
<i>Neoplasta</i> sp.	3	7	0	6	5
Psychodidae					
<i>Maruina</i> sp.	1	23	9	26	40
Simuliidae					
<i>Simulium</i> sp.	79	304	339	203	104
Stratiomyidae	0	1	0	0	6
Tabanidae	0	0	1	0	0

Capulin Creek (Bandelier National Monument), cont.

	Site 1				Site 2
	24-Sep-05	06-Sep-06	01-Oct-06	27-Oct-06	28-Oct-06
Taxonomic information					
<i>Atylotus/Tabanus</i> sp.	1	1	0	0	0
Tipulidae					
<i>Antocha</i> sp.	1	3	1	0	0
<i>Cryptolabis</i> sp.	3	7	15	132	137
<i>Dicranota</i> sp.	1	3	3	3	0
<i>Gonomyia</i> sp.	8	12	4	56	101
<i>Limnophila</i> sp.	0	1	0	1	6
<i>Pedicia</i> sp.	0	0	0	0	4
<i>Rhabdomastix fascigera</i>	0	0	0	2	0

Coyote Gulch (Glen Canyon National Recreation Area)

Taxonomic information	20-Sep-05	31-Oct-05	22-Sep-06	12-Oct-06	03-Nov-06
Nematoda	3	9	12	0	0
Annelida					
Oligochaeta	0	0	83	13	20
Enchytraeidae	0	1	0	0	0
Naididae					
<i>Nais variabilis</i>	0	3	0	0	0
Tubificidae	0	13	0	0	0
<i>Limnodrilus</i> sp.	13	0	0	0	0
<i>Limnodrilus hoffmeisteri</i>	1	0	0	0	0
Mollusca					
Gastropoda					
Basommatophora					
Physidae					
<i>Physa</i> sp.	12	3	4	0	0
Arthropoda					
Arachnida					
Trombidiformes					
Prostigmata					
Lebertiidae					
<i>Lebertia</i> sp.	6	4	4	1	1
Limnesiidae					
<i>Tyrrellia</i> sp.	0	0	1	0	0
Sperchontidae					
<i>Sperchon</i> sp.	88	38	15	1	5
Malacostraca					
Ostracoda	2	1	0	0	0
Insecta					
Ephemeroptera					
Baetidae					
<i>Acentrella insignificans</i>	322	22	28	0	0
<i>Baetis</i> sp.	6	19	109	9	1
<i>Baetis notos</i>	3	0	0	0	0
<i>Baetis tricaudatus</i>	102	107	0	0	0
<i>Callibaetis</i> sp.	6	0	0	0	0
<i>Camelobaetidius</i> sp.	31	1	4	0	0
<i>Fallceon quilleri</i>	153	19	44	0	1
<i>Paracloeodes minutus</i>	2	0	0	0	0
<i>Pseudocloeon</i> sp.	1	0	0	0	0
<i>Pseudocloeon apache</i>	0	0	5	0	0
Ephemerellidae					
<i>Ephemerella</i> sp.	0	2	0	0	0

Coyote Gulch (Glen Canyon National Recreation Area), cont.

Taxonomic information	20-Sep-05	31-Oct-05	22-Sep-06	12-Oct-06	03-Nov-06
Leptohyphidae					
<i>Tricorythodes</i> sp.	5	6	12	1	1
Odonata					
Anisoptera					
Gomphidae	0	0	0	1	1
<i>Erpetogomphus</i> sp.	0	9	0	0	0
Libellulidae	2	0	0	0	0
Zygoptera					
Calopterygidae					
<i>Hetaerina</i> sp.	3	0	0	0	0
Coenagrionidae					
<i>Argia</i> sp.	23	13	11	1	0
Plecoptera					
Nemouridae	0	1	0	0	0
Taeniopterygidae	0	0	0	0	23
<i>Taenionema</i> sp.	0	18	0	0	0
Hemiptera					
Naucoridae					
<i>Ambrysus</i> sp.	11	4	1	1	0
Trichoptera					
Helicopsychidae					
<i>Helicopsyche</i> sp.	0	0	1	0	0
Hydropsychidae					
Hydropsychinae					
<i>Hydropsyche</i> sp.	79	122	191	65	69
Hydroptilidae	1	0	0	0	0
<i>Hydroptila</i> sp.	0	3	0	0	0
<i>Neotrichia</i> sp.	0	1	4	0	0
<i>Ochrotrichia</i> sp.	0	0	2	0	0
Leptoceridae					
<i>Triaenodes</i> sp.	1	1	0	0	0
Lepidoptera					
Pyralidae					
<i>Petrophila</i> sp.	30	8	28	1	0
Coleoptera					
Dryopidae					
<i>Helichus</i> sp.	29	1	5	4	0
<i>Postelichus</i> sp.	0	0	1	0	0
Elmidae					
<i>Heterelmis</i> sp.	0	0	0	0	3
<i>Microcyloepus</i> sp.	110	141	202	17	38
<i>Stenelmis</i> sp.	2	1	1	1	0

Coyote Gulch (Glen Canyon National Recreation Area), cont.

Taxonomic information	20-Sep-05	31-Oct-05	22-Sep-06	12-Oct-06	03-Nov-06
Diptera					
Ceratopogonidae					
<i>Atrichopogon</i> sp.	1	0	0	0	0
<i>Bezzia/Palpomyia</i> sp.	3	3	0	1	0
<i>Dasyhelea</i> sp.	8	1	0	0	0
Ceratopogoninae	3	1	7	0	0
Chironomidae					
Chironominae					
Chironomini	3	0	0	0	0
<i>Dicrotendipes</i> sp.	0	1	0	0	0
<i>Paratendipes</i> sp.	0	0	0	0	1
<i>Polypedilum</i> sp.	0	1	3	0	0
Tanytarsini					
<i>Micropsectra</i> sp.	0	1	0	0	0
<i>Rheotanytarsus</i> sp.	1	6	0	0	0
<i>Tanytarsus</i> sp.	1	1	0	0	0
Diamesinae					
Orthocladiinae					
<i>Cardiocladius</i> sp.	0	2	0	0	0
<i>Cricotopus</i> sp.	0	1	0	0	0
<i>Cricotopus trifascia</i>	0	2	0	0	0
<i>Eukiefferiella</i> sp.	0	2	0	0	0
<i>Eukiefferiella brevicar</i>	0	0	0	0	1
<i>Eukiefferiella claripennis</i>	13	15	1	0	1
<i>Eukiefferiella devonica</i>	0	1	1	0	0
<i>Limnophyes</i> sp.	2	0	0	0	0
<i>Orthocladius</i> sp.	0	0	0	0	1
<i>Parametriocnemus</i> sp.	0	1	0	0	0
<i>Thienemanniella</i> sp.	0	0	1	0	0
<i>Tvetenia discoloripes</i>	3	0	0	0	0
Pentaneurini					
<i>Pentaneura</i> sp.	2	0	0	0	0
<i>Thienemannimyia</i> sp.	2	0	0	0	0
Empididae					
<i>Hemerodromia</i> sp.	7	14	3	0	0
Simuliidae					
<i>Simulium</i> sp.	848	362	120	13	11
Tipulidae					
<i>Tipula</i> sp.	0	1	0	0	0

Mancos River (Mesa Verde National Park)

	12-Sep-05	01-Sep-06	28-Sep-06	25-Oct-06
Taxonomic information				
Nematoda	2	1	0	0
Nemertea				
Enopla				
Tetrastemmatidae				
<i>Prostoma</i> sp.	1	0	0	0
Annelida				
Oligochaeta	0	40	16	5
Enchytraeidae	2	0	0	0
Tubificidae	1	0	0	0
Arthropoda				
Arachnida				
Trombidiformes				
Prostigmata				
Sperchontidae				
<i>Sperchon</i> sp.	6	5	1	7
Malacostraca				
Decapoda				
Cambaridae				
<i>Orconectes</i> sp.	0	0	1	0
Isopoda				
Asellidae				
<i>Caecidotea</i> sp.	1	0	0	0
Insecta				
Ephemeroptera				
Baetidae				
<i>Baetis</i> sp.	24	25	5	14
<i>Baetis notos</i>	0	4	3	7
<i>Baetis tricaudatus</i>	1	1	0	3
<i>Fallceon quilleri</i>	0	0	1	0
Leptohyphidae				
<i>Tricorythodes</i> sp.	1	3	0	0
Odonata				
Anisoptera				
Zygoptera				
Coenagrionidae				
<i>Argia</i> sp.	0	3	0	0
Plecoptera				
Perlidae				
<i>Hesperoperla pacifica</i>	1	0	0	0
<i>Isoperla</i> sp.	0	0	0	1

Mancos River (Mesa Verde National Park), cont.

Taxonomic information	12-Sep-05	01-Sep-06	28-Sep-06	25-Oct-06
Trichoptera				
Hydropsychidae				
Hydropsychinae				
<i>Cheumatopsyche</i> sp.	0	0	1	0
<i>Hydropsyche</i> sp.	52	78	22	17
Hydroptilidae				
<i>Hydroptila</i> sp.	0	4	0	0
<i>Ochrotrichia</i> sp.	0	0	1	0
Coleoptera				
Elmidae				
<i>Microcyloepus</i> sp.	1	0	0	0
<i>Optioservus</i> sp.	1	0	0	0
<i>Zaitzevia</i> sp.	0	0	1	0
Diptera				
Ceratopogonidae				
<i>Bezzia/Palpomyia</i> sp.	0	4	1	4
<i>Dasyhelea</i> sp.	0	1	0	0
Ceratopogoninae	3	0	1	0
Chironomidae				
Chironominae				
Chironomini				
<i>Paracladopelma</i> sp.	2	0	0	0
<i>Polypedilum</i> sp.	1	12	0	0
Tanytarsini				
<i>Micropsectra</i> sp.	0	4	0	0
<i>Rheotanytarsus</i> sp.	0	1	1	0
<i>Tanytarsus</i> sp.	0	4	0	0
Orthocladiinae				
<i>Cardiocladius</i> sp.	0	0	0	1
<i>Cricotopus</i> sp.	2	76	19	0
<i>Cricotopus bicinctus</i>	3	7	1	0
<i>Eukiefferiella</i> sp.	0	2	4	0
<i>Eukiefferiella brehmi</i>	0	0	0	1
<i>Eukiefferiella brevicar</i>	0	0	1	1
<i>Eukiefferiella claripennis</i>	0	1	0	0
<i>Eukiefferiella devonica</i>	0	0	1	0
<i>Limnophyes</i> sp.	1	0	0	0
<i>Nanocladius</i> sp.	0	1	0	0
<i>Orthocladius</i> sp.	2	55	133	65
<i>Orthocladius rivicola</i>	0	0	1	1
<i>Parakiefferiella</i> sp.	0	19	1	0
<i>Parametriocnemus</i> sp.	2	7	1	0

Mancos River (Mesa Verde National Park), cont.

Taxonomic information	12-Sep-05	01-Sep-06	28-Sep-06	25-Oct-06
<i>Tvetenia bavarica</i>	0	0	1	0
Empididae				
<i>Hemerodromia</i> sp.	1	36	4	0
<i>Neoplasta</i> sp.	0	0	5	7
Simuliidae				
<i>Simulium</i> sp.	2	4	3	7
Tipulidae				
<i>Gonomyia</i> sp.	1	0	0	0
<i>Hexatoma</i> sp.	0	7	0	0

Appendix G. Macroinvertebrates in Qualitative Samples

Courthouse Wash (Arches NP)

Taxonomic Information	7/4/2006
Annelida	
Oligochaeta	1
Mollusca	
Gastropoda	
Basommatophora	
Physidae	
<i>Physa</i> sp.	1
Arthropoda	
Ostracoda	1
Insecta	
Ephemeroptera	
Baetidae	
<i>Callibaetis</i> sp.	1
Odonata	
Anisoptera	
Libellulidae	
<i>Pantala flavescens</i>	1
Zygoptera	
Coenagrionidae	
<i>Argia</i> sp.	1
Hemiptera	
Corixidae	
<i>Hesperocorixa</i> sp.	1
Notonectidae	
<i>Notonecta</i> sp.	1
Coleoptera	
Dytiscidae	
<i>Agabus</i> sp.	1
Hydroporinae	1
Hydrophilidae	0
<i>Laccobius</i> sp.	1
<i>Tropisternus</i> sp.	1
Diptera	
Ceratopogonidae	
<i>Dasyhelea</i> sp.	1
Ceratopogoninae	1
Chironomidae	
Chironominae	
Chironomini	
<i>Apedilum</i> sp.	1

Taxonomic Information	7/4/2006
<i>Chironomus</i> sp.	1
<i>Paratendipes</i> sp.	1
<i>Polypedilum</i> sp.	1
Pseudochironomini	
<i>Pseudochironomus</i> sp.	1
Tanytarsini	
<i>Tanytarsus</i> sp.	1
Orthocladiinae	
<i>Cricotopus</i> sp.	1
Tanypodinae	
Macropelopiini	1
Pentaneurini	
<i>Paramerina</i> sp.	1
<i>Pentaneura</i> sp.	1
Ephydridae	1

Halls Creek (Capitol Reef NP)

Taxonomic Information	5/17/2006
Nematoda	1
Annelida	
Oligochaeta	1
Arthropoda	
Arachnida	
Trombidiformes	
Prostigmata	
Sperchontidae	
<i>Sperchon</i> sp.	1
Malacostraca	
Decapoda	
Cambaridae	1
Ostracoda	1
Insecta	
Ephemeroptera	
Baetidae	
<i>Baetis</i> sp.	1
<i>Baetis notos</i>	1
<i>Callibaetis</i> sp.	1
<i>Pseudocloeon dardanum</i>	1
Trichoptera	
Hydroptilidae	
<i>Hydroptila</i> sp.	1
Coleoptera	
Hydrophilidae	
<i>Enochrus</i> sp.	1
<i>Laccobius</i> sp.	1
<i>Tropisternus</i> sp.	1
Diptera	
Ceratopogonidae	
<i>Atrichopogon</i> sp.	1
<i>Bezzia/Palpomyia</i> sp.	1
<i>Dasyhelea</i> sp.	1
Ceratopogoninae	1
Chironomidae	
Chironominae	
Chironomini	
<i>Apedilum</i> sp.	1
<i>Chironomus</i> sp.	1
<i>Phaenopsectra</i> sp.	1
<i>Polypedilum</i> sp.	1
Pseudochironomini	
<i>Pseudochironomus</i> sp.	1

Taxonomic Information	5/17/2006
Tanytarsini	
<i>Paratanytarsus</i> sp.	1
<i>Tanytarsus</i> sp.	1
Orthoclaadiinae	
<i>Corynoneura</i> sp.	1
<i>Cricotopus</i> sp.	1
<i>Eukiefferiella brehmi</i>	1
<i>Eukiefferiella claripennis</i>	1
<i>Eukiefferiella coerulescens</i>	1
<i>Eukiefferiella devonica</i>	1
<i>Limnophyes</i> sp.	1
<i>Orthocladus</i> sp.	1
<i>Paraphaenocladus</i> sp.	1
<i>Psectrocladius</i> sp.	1
<i>Thienemanniella</i> sp.	1
Tanypodinae	
Pentaneurini	
<i>Thienemannimyia</i> sp.	1
Empididae	
<i>Hemerodromia</i> sp.	1
Simuliidae	
<i>Simulium</i> sp.	1

La Verkin Creek (Zion NP)

Taxonomic Information	8/22/2006
Nematomorpha	1
Annelida	
Oligochaeta	1
Arthropoda	
Arachnida	
Trombidiformes	
Prostigmata	
Lebertiidae	
<i>Lebertia</i> sp.	1
Sperchontidae	
<i>Sperchon</i> sp.	1
Insecta	
Ephemeroptera	
Baetidae	
<i>Baetis</i> sp.	1
<i>Baetis flavistriga</i>	1
<i>Baetis tricaudatus</i>	1
Heptageniidae	
<i>Tricorythodes</i> sp.	1
Odonata	
Anisoptera	
Aeshnidae	
<i>Oplonaeschna armata</i>	1
Coenagrionidae	
<i>Argia</i> sp.	1
Plecoptera	
Nemouridae	
<i>Zapada cinctipes</i>	1
Megaloptera	
Corydalidae	
<i>Corydalis</i> sp.	1
Trichoptera	
Brachycentridae	
<i>Micrasema</i> sp.	1
Hydropsychidae	
Hydropsychinae	
<i>Hydropsyche</i> sp.	1
Hydroptilidae	
<i>Hydroptila</i> sp.	1
<i>Ochrotrichia</i> sp.	1
Coleoptera	
Dryopidae	
<i>Helichus</i> sp.	1
<i>Postelichus</i> sp.	1

Taxonomic Information	8/22/2006
Elmidae	
<i>Microcylloepus</i> sp.	1
Diptera	
Ceratopogonidae	
<i>Dasyhelea</i> sp.	1
Chironomidae	
Chironominae	
Chironomini	
<i>Polypedilum</i> sp.	1
Tanytarsini	
<i>Rheotanytarsus</i> sp.	1
<i>Tanytarsus</i> sp.	1
Orthocladiinae	
<i>Brillia</i> sp.	1
<i>Cardiocladius</i> sp.	1
<i>Orthocladius</i> sp.	1
<i>Parametriocnemus</i> sp.	1
<i>Rheocricotopus</i> sp.	1
Tanypodinae	
Pentaneurini	
<i>Thienemannimyia</i> sp.	1
Empididae	
<i>Hemerodromia</i> sp.	1
Simuliidae	
<i>Simulium</i> sp.	1

North Creek (Zion NP)

Taxonomic Information	8/23/2006
Annelida	
Oligochaeta	1
Mollusca	
Gastropoda	
Basommatophora	
Planorbidae	
<i>Gyraulus</i> sp.	1
Arthropoda	
Insecta	
Ephemeroptera	
Baetidae	
<i>Baetis</i> sp.	1
<i>Baetis notos</i>	1
<i>Baetis tricaudatus</i>	1
<i>Baetodes</i> sp.	1
<i>Callibaetis</i> sp.	1
<i>Fallceon quilleri</i>	1
Leptohyphidae	
<i>Tricorythodes</i> sp.	1
Leptophlebiidae	
<i>Choroterpes</i> sp.	1
Odonata	
Anisoptera	
Libellulidae	1
Megaloptera	
Corydalidae	
<i>Corydalis</i> sp.	1
Trichoptera	
Brachycentridae	
<i>Micrasema</i> sp.	1
Hydropsychidae	
Hydropsychinae	
<i>Cheumatopsyche</i> sp.	1
<i>Hydropsyche</i> sp.	1
Hydroptilidae	
<i>Hydroptila</i> sp.	1
<i>Neotrichia</i> sp.	1
Polycentropodidae	1
Coleoptera	
Dryopidae	
<i>Postelichus</i> sp.	1
Dytiscidae	
Hydroporinae	1
Elmidae	
<i>Microcyllloepus</i> sp.	1

Taxonomic Information	8/23/2006
Hydrophilidae	
<i>Laccobius</i> sp.	1
<i>Tropisternus</i> sp.	1
Diptera	
Ceratopogonidae	
<i>Bezzia/Palpomyia</i> sp.	1
<i>Dasyhelea</i> sp.	1
Chironomidae	
Chironominae	
Chironomini	
<i>Polypedilum</i> sp.	1
Tanytarsini	
<i>Tanytarsus</i> sp.	1
Orthocladiinae	
<i>Cardiocladius</i> sp.	1
<i>Cricotopus</i> sp.	1
<i>Eukiefferiella brehmi</i>	1
<i>Orthocladius</i> sp.	1
<i>Rheocricotopus</i> sp.	1
<i>Thienemanniella</i> sp.	1
Tanypodinae	
Pentaneurini	
<i>Nilotanypus</i> sp.	1
<i>Thienemannimyia</i> sp.	1
Culicidae	
<i>Anopheles</i> sp.	1
<i>Culex</i> sp.	1
Dolichopodidae	1
Empididae	
<i>Hemerodromia</i> sp.	1
Ephydriidae	1
Simuliidae	
<i>Simulium</i> sp.	1
Stratiomyidae	
<i>Euparyphus</i> sp.	1
Tabanidae	
<i>Atylotus/Tabanus</i> sp.	1
Tipulidae	
<i>Cryptolabis</i> sp.	1

Salt Creek (Canyonlands NP)

Taxonomic Information	6/22/2006
Annelida	
Oligochaeta	1
Mollusca	
Gastropoda	
Basommatophora	
Physidae	
<i>Physa</i> sp.	1
Arthropoda	
Arachnida	
Trombidiformes	
Prostigmata	
Arrenuridae	
<i>Arrenurus</i> sp.	1
Malacostraca	
Amphipoda	
Talitridae	
<i>Hyalella</i> sp.	1
Ostracoda	1
Insecta	
Ephemeroptera	
Baetidae	
<i>Callibaetis</i> sp.	1
Odonata	
Anisoptera	
Aeshnidae	
<i>Aeshna</i> sp.	1
Libellulidae	1
Zygoptera	
Coenagrionidae	1
Lestidae	
<i>Archilestes grandis</i>	1
Hemiptera	
Notonectidae	
<i>Notonecta</i> sp.	1
Coleoptera	
Dytiscidae	
<i>Agabus</i> sp.	1
<i>Liodessus</i> sp.	1
<i>Stictotarsus</i> sp.	1
Hydrophorinae	1
Gyrinidae	
<i>Gyrinus</i> sp.	1
Hydrophilidae	
<i>Enochrus</i> sp.	1
<i>Tropisternus</i> sp.	1

Taxonomic Information	6/22/2006
Diptera	
Ceratopogonidae	
<i>Bezzia/Palpomyia</i> sp.	1
<i>Dasyhelea</i> sp.	1
Chironomidae	
Chironominae	
Chironomini	
<i>Apedilum</i> sp.	1
<i>Chironomus</i> sp.	1
<i>Paratendipes</i> sp.	1
<i>Polypedilum</i> sp.	1
<i>Stictochironomus</i> sp.	1
Tanytarsini	
<i>Paratanytarsus</i> sp.	1
<i>Tanytarsus</i> sp.	1
Orthocladiinae	
<i>Psectrocladius</i> sp.	1
Tanypodinae	
Macropelopiini	
<i>Alotanypus</i> sp.	1
Pentaneurini	
<i>Paramerina</i> sp.	1
<i>Thienemannimyia</i> sp.	1
Simuliidae	
<i>Simulium</i> sp.	1
Stratiomyidae	
<i>Stratiomys</i> sp.	1

Capulin Creek (Bandelier NM)

Taxonomic information	9/24/2005	9/6/2006	10/1/2006	10/27/2006	10/28/2006
Nematoda	1	1	1	1	0
Annelida					
Hirudinea					
Arhynchobdellida					
Oligochaeta	0	0	0	1	1
Enchytraeidae	1	0	0	0	0
Naididae					
<i>Nais variabilis</i>	1	0	0	0	0
Tubificidae	1	0	0	0	0
Lumbricina	1	0	0	0	0
Mollusca					
Bivalvia					
Veneroida					
Sphaeriidae	0	1	0	1	0
Arthropoda					
Arachnida	0	0	1	0	0
Trombidiformes					
Prostigmata					
Arrenuridae					
<i>Arrenurus</i> sp.	0	0	0	0	1
Hygrobatidae					
<i>Atractides</i> sp.	1	0	1	1	1
Sperchontidae					
<i>Sperchon</i> sp.	1	1	1	1	1
Ostracoda	0	0	1	1	0
Insecta					
Ephemeroptera					
Baetidae					
<i>Acentrella</i> sp.	1	0	0	0	0
<i>Acentrella turbida</i>	1	0	0	0	0
<i>Baetis</i> sp.	1	0	0	1	1
<i>Baetis magnus</i>	1	1	1	0	0
<i>Baetis tricaudatus</i>	1	1	1	1	0
<i>Fallceon quilleri</i>	1	1	1	1	0
Ephemerellidae					
<i>Ephemerella</i> sp.	1	0	1	1	1
Heptageniidae					
<i>Nixe</i> sp.	1	1	1	0	0
Leptohyphidae	1	0	0	0	0
<i>Tricorythodes</i> sp.	0	1	1	1	1
Leptophlebiidae	0	1	0	1	1

Capulin Creek (Bandelier NM), cont.

Taxonomic information	9/24/2005	9/6/2006	10/1/2006	10/27/2006	10/28/2006
<i>Paraleptophlebia</i> sp.	1	0	1	0	0
Odonata					
Anisoptera					
Aeshnidae					
<i>Oplonaeschna armata</i>	1	1	1	1	1
Cordulegastridae					
<i>Cordulegaster dorsalis</i>	1	0	0	1	1
Zygoptera					
Calopterygidae					
<i>Hetaerina</i> sp.	0	1	1	0	0
Coenagrionidae					
<i>Argia</i> sp.	1	1	1	1	1
Lestidae					
<i>Archilestes</i> sp.					
Plecoptera					
Capniidae	1	0	1	0	0
Chloroperlidae					
<i>Sweltsa</i> sp.	1	0	1	1	1
Nemouridae					
<i>Zapada cinctipes</i>	1	1	1	0	1
Perlodidae					
<i>Isoperla</i> sp.	1	1	1	1	1
Hemiptera					
Lepidoptera					
Pyralidae					
<i>Petrophila</i> sp.	0	1	0	1	1
Trichoptera					
Calamoceratidae					
<i>Phylloicus</i> sp.	1	1	1	0	1
Glossosomatidae					
<i>Glossosoma</i> sp.	0	1	1	1	0
Helicopsychidae					
<i>Helicopsyche</i> sp.	1	1	0	0	1
Hydropsychidae					
Hydropsychinae					
<i>Cheumatopsyche</i> sp.	1	1	1	0	1
<i>Hydropsyche</i> sp.	1	1	1	1	1
Lepidostomatidae					
<i>Lepidostoma</i> sp.	1	0	0	0	0
Leptoceridae					
<i>Nectopsyche</i> sp.	1	0	0	0	0
<i>Oecetis disjuncta</i>	1	1	1	1	0

Capulin Creek (Bandelier NM), cont.

Taxonomic information	9/24/2005	9/6/2006	10/1/2006	10/27/2006	10/28/2006
Limnephilidae	0	0	0	1	0
Philopotamidae					
<i>Wormaldia</i> sp.	1	0	0	0	0
Sericostomatidae					
<i>Gumaga</i> sp.	0	1	0	0	0
Coleoptera					
Dryopidae					
<i>Helichus</i> sp.	1	0	0	0	0
Dytiscidae	0	1	0	1	1
<i>Agabus</i> sp.	1	0	1	0	0
Elmidae					
<i>Narpus</i> sp.	0	0	0	0	1
<i>Optioservus</i> sp.	1	1	1	1	1
<i>Zaitzevia</i> sp.	1	1	1	0	1
Hydrophilidae					
<i>Anacaena</i> sp.	1	0	1	1	1
Diptera					
Ceratopogonidae					
<i>Bezzia/Palpomyia</i> sp.	1	0	0	1	0
<i>Stilobezzia</i> sp.	1	0	0	0	0
Chironomidae					
Chironominae					
Chironomini					
<i>Chironomus</i> sp.	1	0	0	1	0
<i>Paracladopelma</i> sp.	1	0	0	0	0
<i>Phaenopsectra</i> sp.	1	0	0	0	0
<i>Polypedilum</i> sp.	1	0	1	1	0
Tanytarsini					
<i>Micropsectra</i> sp.	1	1	1	0	0
<i>Rheotanytarsus</i> sp.	1	0	0	0	0
<i>Stempellinella</i> sp.	1	1	1	0	0
<i>Tanytarsus</i> sp.	1	1	0	0	0
Orthocladiinae					
<i>Brillia</i> sp.	1	1	0	1	1
<i>Cardiocladius</i> sp.	1	0	0	0	0
<i>Corynoneura</i> sp.	1	0	1	0	0
<i>Eukiefferiella</i> sp.	0	0	1	0	0
<i>Eukiefferiella brehmi</i>	1	1	1	1	1
<i>Eukiefferiella claripennis</i>	1	0	0	0	1
<i>Eukiefferiella coerulescens</i>	1	0	0	0	0
<i>Heleniella</i> sp.	1	0	0	0	0
<i>Heterotrissocladius marcidus</i>	1	0	0	0	0

Capulin Creek (Bandelier NM), cont.

Taxonomic information	9/24/2005	9/6/2006	10/1/2006	10/27/2006	10/28/2006
<i>Limnophyes</i> sp.	0	0	1	0	0
<i>Lopescladius</i> sp.	0	0	1	0	0
<i>Metriocnemus</i> sp.	0	0	0	0	1
<i>Orthocladius</i> sp.	1	0	1	0	0
<i>Parachaetocladius</i> sp.	0	0	0	1	0
<i>Parametriocnemus</i> sp.	1	1	0	0	0
<i>Tvetenia</i> sp.	1	0	0	0	0
<i>Tvetenia bavarica</i>	1	1	1	1	1
Prodiamesinae					
<i>Odontomesa</i> sp.	0	0	1	0	0
Tanypodinae					
Macropelopiini					
<i>Alotanypus</i> sp.	0	0	0	1	0
<i>Apsectrotanypus</i> sp.	0	0	1	0	0
<i>Radotanypus</i> sp.	0	0	0	1	0
Pentaneurini	0	1	0	0	0
<i>Labrundinia</i> sp.	1	0	0	0	0
<i>Larsia</i> sp.	1	0	0	1	0
<i>Paramerina</i> sp.	1	0	1	0	0
<i>Pentaneura</i> sp.	1	0	0	0	0
<i>Thienemannimyia</i> sp.	1	0	0	0	0
Dixidae					
<i>Dixa</i> sp.	1	1	1	0	1
Empididae					
<i>Neoplasta</i> sp.	1	1	1	1	0
Psychodidae	0	1	0	0	0
<i>Maruina</i> sp.	1	1	1	1	1
<i>Pericoma/Telmatoscopus</i> sp.	1	0	0	0	0
Simuliidae					
<i>Simulium</i> sp.	1	1	1	1	1
Stratiomyidae	1	0	1	0	1
Tabanidae					
<i>Atylotus/Tabanus</i> sp.	1	0	0	0	0
Tipulidae					
<i>Cryptolabis</i> sp.	0	0	1	1	0
<i>Dicranota</i> sp.	1	1	1	0	0
<i>Gonomyia</i> sp.	1	1	1	0	0
<i>Limnophila</i> sp.	0	0	1	0	0
<i>Pedicia</i> sp.	0	1	0	0	0
<i>Tipula</i> sp.	1	1	1	1	1

Coyote Gulch (Glen Canyon NRA)

Taxonomic information	9/20/2005	10/31/2005	9/22/2006	10/12/2006	11/3/2006
Nematoda	1	1	1	0	0
Annelida					
Hirudinea					
Arhynchobdellida					
Erpobdellidae	0	0	1	0	0
Oligochaeta	0	0	1	1	1
Enchytraeidae	1	0	0	0	0
Naididae					
<i>Pristina leidy</i>	1	0	0	0	0
Tubificidae	1	1	0	0	0
Mollusca					
Gastropoda					
Basommatophora					
Physidae					
<i>Physa</i> sp.	1	1	1	0	0
Arthropoda					
Arachnida	0	0	0	0	1
Trombidiformes					
Prostigmata					
Hygrobatidae					
<i>Hygrobates</i> sp.	0	1	0	0	0
Lebertiidae					
<i>Lebertia</i> sp.	1	1	1	1	1
Limnesiidae					
<i>Limnesia</i> sp.	1	0	0	0	0
Sperchontidae					
<i>Sperchon</i> sp.	1	1	1	1	1
Ostracoda	1	0	1	0	0
Insecta					
Ephemeroptera					
Baetidae					
<i>Acentrella insignificans</i>	1	1	1	0	0
<i>Baetis</i> sp.	1	1	1	1	1
<i>Baetis magnus</i>	0	1	0	1	0
<i>Baetis notos</i>	1	1	0	0	0
<i>Baetis tricaudatus</i>	1	1	0	0	0
<i>Callibaetis</i> sp.	1	1	1	0	0
<i>Camelobaetidius</i> sp.	1	1	1	0	0
<i>Fallceon quilleri</i>	1	1	1	1	0
<i>Paracloeodes minutus</i>	1	0	0	0	0

Coyote Gulch (Glen Canyon NRA), cont.

Taxonomic information	9/20/2005	10/31/2005	9/22/2006	10/12/2006	11/3/2006
<i>Pseudocloeon apache</i>	0	0	1	1	0
Leptohyphidae					
<i>Tricorythodes</i> sp.	1	1	1	1	0
Odonata					
Anisoptera					
Gomphidae	1	1	0	0	0
<i>Erpetogomphus lampropeltis</i>	0	0	1	0	0
<i>Progomphus</i> sp.	0	0	1	0	1
Libellulidae	1	0	0	0	0
Zygoptera					
Calopterygidae	1	0	0	0	0
<i>Hetaerina</i> sp.	0	0	1	0	0
Coenagrionidae					
<i>Argia</i> sp.	1	1	1	1	1
Plecoptera					
Taeniopterygidae	0	0	0	1	1
<i>Taenionema</i> sp.	0	1	0	0	0
Hemiptera					
Naucoridae					
<i>Ambrysus</i> sp.	1	1	1	1	0
Lepidoptera					
Pyralidae					
<i>Petrophila</i> sp.	1	1	1	0	1
Trichoptera					
Hydropsychidae					
Hydropsychinae					
<i>Hydropsyche</i> sp.	1	1	1	1	1
Hydroptilidae					
<i>Hydroptila</i> sp.	1	1	1	0	0
<i>Neotrichia</i> sp.	1	0	0	0	0
<i>Ochrotrichia</i> sp.	0	0	1	0	0
Leptoceridae	1	0	0	0	0
<i>Triaenodes</i> sp.	0	1	0	0	0
Coleoptera					
Dryopidae					
<i>Helichus</i> sp.	1	1	1	1	0
<i>Postelichus</i> sp.	1	0	0	0	0
Dytiscidae					
<i>Hygrotus</i> sp.	1	0	0	0	0
<i>Liodessus</i> sp.	0	1	1	0	0

Coyote Gulch (Glen Canyon NRA), cont.

Taxonomic information	9/20/2005	10/31/2005	9/22/2006	10/12/2006	11/3/2006
Elmidae					
<i>Heterelmis</i> sp.	1	0	0	0	1
<i>Microcyloepus</i> sp.	1	1	1	1	1
<i>Stenelmis</i> sp.	0	1	1	0	0
Hydrophilidae	0	0	0	1	0
<i>Laccobius</i> sp.	1	0	0	0	0
<i>Tropisternus</i> sp.	1	0	0	0	1
Diptera					
Ceratopogonidae					
<i>Atrichopogon</i> sp.	1	0	0	0	0
<i>Bezzia/Palpomyia</i> sp.	1	1	1	1	1
<i>Culicoides</i> sp.	1	0	0	0	0
<i>Dasyhelea</i> sp.	1	1	1	0	0
<i>Forcipomyia</i> sp.	1	1	0	0	0
Ceratopogoninae	1	1	0	0	0
Chironomidae					
Chironominae					
Chironomini					
<i>Apedilum</i> sp.	1	0	0	0	0
<i>Cryptochironomus</i> sp.	1	0	0	0	0
<i>Paratendipes</i> sp.	1	1	0	0	0
<i>Phaenopsectra</i> sp.	1	0	0	0	0
<i>Polypedilum</i> sp.	1	1	1	0	0
Tanytarsini					
<i>Micropsectra</i> sp.	0	1	0	0	0
<i>Rheotanytarsus</i> sp.	1	1	0	0	0
<i>Stempellina</i> sp.	1	0	0	0	0
<i>Tanytarsus</i> sp.	1	0	0	0	0
Orthocladiinae					
<i>Cardiocladius</i> sp.	0	1	1	0	0
<i>Cricotopus</i> sp.	1	1	1	0	1
<i>Cricotopus trifascia</i>	1	1	0	0	0
<i>Eukiefferiella</i> sp.	0	1	0	0	0
<i>Eukiefferiella claripennis</i>	1	1	1	0	0
<i>Eukiefferiella devonica</i>	1	0	0	0	0
<i>Heleniella</i> sp.	1	0	0	0	0
<i>Limnophyes</i> sp.	1	1	1	0	0
<i>Orthocladius</i> sp.	0	1	1	0	1
<i>Parametriocnemus</i> sp.	1	1	0	0	0
<i>Paraphaenocladius</i> sp.	1	1	0	0	0

Coyote Gulch (Glen Canyon NRA), cont.

Taxonomic information	9/20/2005	10/31/2005	9/22/2006	10/12/2006	11/3/2006
<i>Rheocricotopus</i> sp.	1	1	1	0	0
<i>Thienemanniella</i> sp.	1	1	1	0	0
Tanypodinae					
Pentaneurini					
<i>Ablabesmyia</i> sp.	1	0	0	0	0
<i>Paramerina</i> sp.	1	0	0	0	0
<i>Pentaneura</i> sp.	1	0	1	0	0
<i>Thienemannimyia</i> sp.	1	1	0	0	0
Procladiini					
<i>Procladius</i> sp.	1	0	0	0	0
Culicidae	1	0	0	0	0
Dixidae					
<i>Dixella</i> sp.	0	1	0	0	0
Dolichopodidae	1	1	0	0	0
Empididae					
<i>Hemerodromia</i> sp.	1	1	0	1	0
<i>Neoplasta</i> sp.	0	1	0	0	0
Psychodidae					
<i>Pericoma/</i> <i>Telmatoscopus</i> sp.	1	1	0	0	0
Simuliidae					
<i>Simulium</i> sp.	1	1	1	1	1
Tipulidae	0	0	1	0	0
<i>Gonomyia</i> sp.	1	1	0	0	0
<i>Limonia</i> sp.	0	0	0	1	0
<i>Rhabdomastix</i> <i>tricophora</i>	1	0	0	0	0

Mancos River (Mesa Verde NP)

Taxonomic information	9/12/2005	9/1/2006	9/28/2006	10/25/2006
Nematoda	1	0	0	0
Annelida				
Oligochaeta	0	1	1	1
Enchytraeidae	1	0	0	0
Naididae				
<i>Nais variabilis</i>	1	0	0	0
Tubificidae	1	0	0	0
Mollusca				
Bivalvia				
Veneroida				
Sphaeriidae	1	0	0	0
Gastropoda				
Basommatophora				
Physidae				
<i>Physa</i> sp.	1	0	0	0
Arthropoda				
Arachnida				
Trombidiformes				
Prostigmata				
Sperchontidae				
<i>Sperchon</i> sp.	1	0	1	1
Malacostraca				
Amphipoda				
Talitridae				
<i>Hyaella</i> sp.	1	1	1	0
Decapoda				
Cambaridae				
<i>Orconectes</i> sp.	0	1	1	0
Ostracoda	1	0	1	0
Insecta				
Ephemeroptera				
Baetidae				
<i>Acentrella insignificans</i>	0	0	0	1
<i>Baetis</i> sp.	1	0	1	1
<i>Baetis notos</i>	0	0	1	1
<i>Baetis tricaudatus</i>	1	0	1	1
<i>Centroptilum</i> sp.	0	0	0	1
<i>Fallceon quilleri</i>	1	1	1	1
Leptohyphidae				
<i>Tricorythodes</i> sp.	1	1	1	1

Mancos River (Mesa Verde NP), cont.

Taxonomic information	9/12/2005	9/1/2006	9/28/2006	10/25/2006
Odonata				
Anisoptera				
Gomphidae	1	0	0	0
<i>Ophiogomphus severus</i>	0	1	0	0
Zygoptera				
Coenagrionidae				
<i>Argia</i> sp.	1	0	1	0
Plecoptera				
Perlodidae	1	0	0	0
<i>Isoperla</i> sp.	0	0	0	1
Taeniopterygidae	0	0	0	1
Trichoptera				
Hydropsychidae				
Hydropsychinae				
<i>Cheumatopsyche</i> sp.	1	0	0	1
<i>Hydropsyche</i> sp.	1	1	1	1
Hydroptilidae				
<i>Hydroptila</i> sp.	1	1	0	1
<i>Ochrotrichia</i> sp.	0	0	0	1
Diptera				
Ceratopogonidae				
<i>Probezzia</i> sp.	0	1	0	0
Ceratopogoninae	1	1	0	0
Chironomidae				
Chironominae				
Chironomini				
<i>Apedilum</i> sp.	1	0	0	0
<i>Cryptochironomus</i> sp.	0	1	0	0
<i>Microtendipes pedellus</i>	1	0	0	0
<i>Paracladopelma</i> sp.	1	0	0	0
<i>Phaenopsectra</i> sp.	1	0	0	0
<i>Polypedilum</i> sp.	1	1	0	0
Tanytarsini				
<i>Micropsectra</i> sp.	1	1	1	1
<i>Rheotanytarsus</i> sp.	0	0	1	0
Orthocladiinae				
<i>Cricotopus</i> sp.	1	1	1	1
<i>Cricotopus bicinctus</i>	1	0	1	1
<i>Cricotopus trifascia</i>	0	0	1	0
<i>Eukiefferiella</i> sp.	0	0	0	1
<i>Eukiefferiella brehmi</i>	0	0	0	1
<i>Eukiefferiella brevicealcar</i>	0	0	1	1

Mancos River (Mesa Verde NP), cont.

Taxonomic information	9/12/2005	9/1/2006	9/28/2006	10/25/2006
<i>Eukiefferiella claripennis</i>	1	0	0	0
<i>Eukiefferiella coerulescens</i>	0	0	1	0
<i>Eukiefferiella devonica</i>	0	0	1	0
<i>Eukiefferiella gracei</i>	0	0	0	1
<i>Limnophyes</i> sp.	0	1	0	0
<i>Orthocladius</i> sp.	1	1	1	1
<i>Parakiefferiella</i> sp.	1	0	1	1
<i>Parametriocnemus</i> sp.	1	0	1	1
<i>Pseudosmittia</i> sp.	0	0	0	1
<i>Rheocricotopus</i> sp.	1	0	1	0
<i>Thienemanniella</i> sp.	1	0	0	0
<i>Tvetenia bavarica</i> .	1	0	1	0
Tanypodinae				
Pentaneurini				
<i>Thienemannimyia</i> sp.	0	0	0	1
Empididae				
<i>Hemerodromia</i> sp.	1	1	1	1
<i>Neoplasta</i> sp.	0	0	1	1
Psychodidae				
<i>Pericoma/Telmatoscopus</i> sp.	1	0	0	0
Simuliidae				
<i>Simulium</i> sp.	1	1	1	1
Tabanidae	0	0	0	1
Tipulidae				
<i>Hexatoma</i> sp.	1	0	0	1

Appendix H. Within and Across-stream Sensitivity Analysis

Within-stream sensitivity analysis results based on Spearman rank correlations between metrics calculated from replicate samples and microhabitat variables.

Metric	Capulin Creek (n=25)		Coyote Gulch (n=25)		Mancos River (n=20)	
	Microhabitat % embeddedness	Microhabitat velocity	Microhabitat % embeddedness	Microhabitat velocity	Microhabitat % embeddedness	Microhabitat velocity
Richness						
Richness	0.21	-0.08	0.10	0.43	-0.40	0.33
Tolerance						
% dominant taxa	0.01	0.03	0.22	0.19	-0.01	-0.07
Tolerance (Richness)	0.15	0.23	0.41	0.17	0.38	-0.27
Tolerance (Abundance)	-0.22	-0.15	-0.05	-0.15	0.47	0.09
Functional-Feeding						
Filter-collector richness	-0.09	0.11	-0.05	-0.10	0.41	0.05
Scraper richness	-0.05	0.45	0.09	-0.35	0.46	-0.34
Filter-collector % richness	0.06	0.12	0.00	0.18	-0.14	0.06
Scraper % richness	0.11	0.54	0.10	-0.41	0.47	-0.35
Filter-collector % abundance	0.20	0.11	-0.22	0.70	0.01	0.21
Scraper % abundance	0.04	0.61	-0.04	-0.60	0.47	-0.35
Functional-Habit						
Burrower richness	-0.04	-0.05	-0.06	0.12	0.52	-0.17
Clinger richness	-0.16	0.21	0.01	-0.07	0.18	0.04
Burrower % richness	0.05	0.13	-0.02	0.34	0.13	-0.11
Clinger % richness	0.00	0.27	-0.14	0.13	-0.42	0.24
Burrower % abundance	0.00	0.04	0.06	-0.05	-0.08	-0.05
Clinger % abundance	0.22	-0.01	-0.16	0.75	-0.05	0.16
Composition (Richness)						
Chironomidae	-0.13	-0.06	0.11	-0.08	0.43	0.00
Ephemeroptera	-0.14	-0.30	-0.10	-0.26	0.34	-0.01
EPT	-0.25	-0.19	-0.01	-0.26	0.20	0.03
Non-insects	-0.04	0.23	0.07	-0.30	0.38	0.00
Oligochaeta	0.05	0.06	-0.04	0.17	0.20	-0.08
Plecoptera	-0.18	-0.15	0.10	-0.16	-0.16	0.23
Trichoptera	-0.10	0.08	0.06	-0.20	0.24	-0.22
Composition (Percent Richness)						
Chironomidae	-0.01	-0.01	0.05	-0.10	0.28	-0.01
Ephemeroptera	0.00	-0.31	-0.12	-0.31	-0.26	-0.04
EPT	-0.06	-0.12	0.07	-0.40	-0.49	0.02
Non-insects	0.05	0.23	0.26	0.12	-0.20	0.01

Within-stream sensitivity analysis results based on Spearman rank correlations between metrics calculated from replicate samples and microhabitat variables, cont.

Metric	Capulin Creek (n=25)		Coyote Gulch (n=25)		Mancos River (n=20)	
	Microhabitat % embeddedness	Microhabitat velocity	Microhabitat % embeddedness	Microhabitat velocity	Microhabitat % embeddedness	Microhabitat velocity
Composition (Percent Richness), cont.						
Oligochaeta	0.10	0.11	0.15	0.24	-0.07	-0.07
Plecoptera	-0.06	-0.08	0.08	-0.22	-0.17	0.23
Trichoptera	0.03	0.20	0.10	-0.21	-0.31	-0.30
Composition (Percent Abundance)						
Chironomidae	-0.11	-0.05	0.13	-0.07	-0.19	0.05
Ephemeroptera	0.02	-0.39	0.13	-0.45	-0.07	-0.13
EPT	0.20	-0.08	-0.19	-0.59	0.05	-0.03
Non-insects	0.05	0.06	0.29	-0.17	0.25	-0.17
Oligochaeta	0.01	0.02	0.19	0.09	0.32	-0.19
Plecoptera	-0.33	0.17	0.04	-0.27	-0.17	0.23
Trichoptera	0.27	0.18	-0.24	0.12	0.01	0.05
Other Compositional						
Hydroptilidae+ Hydropsychidae/ Trichoptera (Abundance)	0.03	0.07	-0.14	-0.25	--	--
Hydroptilidae/ Trichoptera (Abundance)	-0.14	-0.02	0.09	-0.19	0.29	-0.26

Significant correlations at $\alpha=0.10$ level are in bold.

Across-stream sensitivity analysis results based on Spearman rank correlations between composite quantitative sample metrics and microhabitat variables.

Metric	Mean microhabitat velocity	Mean microhabitat embeddedness	% fine sediments
Richness			
Richness	-0.45	-0.31	-0.34
Tolerance			
% dominant taxa	0.33	0.00	0.19
Tolerance (Richness)	-0.24	0.24	0.50
Tolerance (Abundance)	-0.23	0.27	0.42
Functional-Feeding			
Filter-Collector richness	-0.16	-0.27	-0.42
Scraper richness	-0.07	-0.34	-0.18
Filter-Collector % richness	0.45	0.18	-0.15
Scraper % richness	0.15	-0.28	0.04
Filter-Collector % abundance	0.39	0.11	0.16
Scraper % abundance	-0.31	-0.01	-0.03
Functional-Habit			
Burrower richness	-0.65	-0.39	-0.38
Clinger richness	0.25	-0.23	-0.51
Burrower % richness	-0.45	0.06	-0.05
Clinger % richness	0.71	-0.10	-0.22
Burrower % abundance	-0.08	-0.09	-0.15
Clinger % abundance	0.30	-0.14	-0.05
Composition (Richness)			
Chironomidae	-0.68	-0.23	-0.34
Ephemeroptera	0.09	-0.24	-0.28
EPT	0.09	-0.20	-0.54
Non-insects	-0.23	-0.14	-0.04
Oligochaeta	-0.13	0.11	-0.39
Plecoptera	-0.10	-0.40	-0.72
Trichoptera	0.07	-0.21	-0.47
Composition (Percent Richness)			
Chironomidae	-0.47	0.05	-0.03
Ephemeroptera	0.48	-0.11	-0.10
EPT	0.32	-0.33	-0.44
Non-insects	0.31	0.20	0.32
Oligochaeta	0.31	0.31	0.09
Plecoptera	0.01	-0.43	-0.70
Trichoptera	0.37	0.05	-0.39
Composition (Percent Abundance)			
Chironomidae	-0.15	0.06	-0.43
Ephemeroptera	-0.12	-0.26	-0.40
EPT	0.16	-0.03	-0.36
Non-insects	-0.06	0.10	0.65
Oligochaeta	-0.05	0.12	0.60

Across-stream sensitivity analysis results based on Spearman rank correlations between composite quantitative sample metrics and microhabitat variables, cont.

Metric	Mean microhabitat velocity	Mean microhabitat embeddedness	% fine sediments
<i>Composition (Percent Abundance), cont.</i>			
Plecoptera	-0.06	-0.39	-0.67
Trichoptera	0.53	0.08	-0.14
Other Compositional			
Hydroptilidae+ Hydropsychidae/ Trichoptera (Abundance)	0.10	0.33	0.46
Hydroptilidae/ Trichoptera (Abundance)	-0.47	0.13	0.36

Significant correlations at $\alpha=0.10$ level are in bold.

Metrics that were included in the protocol are highlighted.

Appendix I. Calculated Metrics for Quantitative and Qualitative Macroinvertebrate Samples Collected at Eight Study Sites

Calculated metrics for quantitative samples.

Metric	NCPN sites					SCPN sites															Minimum	Maximum	Range
	Courthouse Wash	Halls Creek	La Verkin Creek	North Creek	Salt Creek	Capulin Creek					Coyote Gulch					Mancos River							
						04-Jul-06	17-May-06	22-Aug-06	23-Aug-06	22-Jun-06	24-Sep-05	06-Sep-06	01-Oct-06	27-Oct-06	28-Oct-06	20-Sep-05	31-Oct-05	22-Sep-06	12-Oct-06	03-Nov-06			
Richness																							
Richness	23	27	18	40	27	63	56	44	49	52	39	42	29	15	15	22	23	21	12	12.0	63.0	51.0	
Tolerance																							
% dominant taxa	35.5	51.3	70.0	17.6	15.7	29.7	48.5	28.9	18.7	18.3	43.7	36.7	22.3	48.0	38.1	47.1	20.5	57.0	46.2	15.7	70.0	54.3	
Tolerance (Richness)	6.3	5.9	4.5	5.0	6.5	4.4	4.4	4.0	4.0	4.2	5.8	5.4	5.0	4.7	4.7	5.5	5.3	5.1	5.2	4.0	6.5	2.5	
Tolerance (Abundance)	6.7	5.2	4.8	5.1	6.4	3.4	4.0	3.9	3.2	3.3	4.8	4.8	4.4	4.4	4.0	4.7	5.2	5.1	4.9	3.2	6.7	3.5	
Functional-Feeding																							
Filter-collector richness	2	3	2	6	1	6	7	4	4	5	4	4	2	2	2	2	4	4	2	1.0	7.0	6.0	
Scraper richness	0	2	1	4	1	6	7	6	5	6	5	6	6	2	0	1	1	0	0	0.0	7.0	7.0	
Filter-collector % richness	9.1	11.1	11.1	15.0	3.7	9.7	12.5	9.1	8.3	9.6	10.5	9.5	7.1	13.3	13.3	9.1	17.4	19.0	16.7	3.7	19.0	15.3	
Scraper % richness	0.0	7.4	5.6	10.0	3.7	9.7	12.5	13.6	10.4	11.5	13.2	14.3	21.4	13.3	0.0	4.5	4.3	0.0	0.0	0.0	21.4	21.4	
Filter-collector % abundance	5.8	27.3	21.0	26.3	2.5	18.2	61.5	44.5	23.2	11.3	47.9	49.9	34.3	58.0	44.0	49.3	21.5	11.4	17.0	2.5	61.5	59.1	
Scraper % abundance	0.0	0.5	2.0	0.9	12.7	2.6	9.0	5.4	10.3	4.6	2.4	3.4	4.9	2.0	0.0	0.7	1.0	0.0	0.0	0.0	12.7	12.7	
Functional-Habit																							
Burrower richness	16	16	6	14	13	29	25	18	16	19	11	16	7	3	6	11	13	11	5	2.7	28.5	25.8	
Clinger richness	1	2	10	16	2	17	20	15	21	19	8	12	12	8	5	6	5	7	5	1.2	20.8	19.6	
Burrower % richness	68.4	59.1	33.3	35.3	47.1	45.3	44.7	40.5	32.5	36.6	29.0	38.2	23.8	18.2	41.7	50.0	55.0	50.0	44.4	18.2	68.4	50.2	

Calculated metrics for quantitative samples, cont.

Metric	NCPN sites				SCPN sites												Minimum	Maximum	Range			
	Courtthouse Wash	Halls Creek	La Verkin Creek	North Creek	Salt Creek	Capulin Creek					Coyote Gulch					Mancos River						
						24-Sep-05	06-Sep-06	01-Oct-06	27-Oct-06	28-Oct-06	20-Sep-05	31-Oct-05	22-Sep-06	12-Oct-06	03-Nov-06	12-Sep-05				01-Sep-06	28-Sep-06	25-Oct-06
Functional-Habit, cont.																						
Clinger % richness	5.3	9.1	53.3	41.2	5.9	26.4	36.2	35.1	42.5	36.6	19.4	29.4	42.9	54.5	33.3	27.8	20.0	31.3	44.4	5.3	54.5	49.3
Burrower % abundance	64.2	65.3	1.3	49.4	44.1	15.7	7.6	13.5	8.2	19.8	2.4	6.5	11.8	11.5	15.6	16.5	58.2	81.4	60.2	1.3	81.4	80.1
Clinger % abundance	7.4	24.5	26.4	37.2	2.4	59.6	74.9	68.2	66.4	39.2	65.6	71.6	65.2	79.2	69.5	55.9	22.4	12.6	21.5	2.4	79.2	76.8
Composition (Richness)																						
Chironomidae	11	14	5	13	11	19	14	9	9	12	8	9	3	0	3	6	10	7	4	0.0	19.0	19.0
Ephemeroptera	1	2	1	6	1	6	7	6	6	7	8	6	6	2	3	2	2	2	1	1.0	8.0	7.0
EPT	2	3	4	13	1	16	19	15	18	18	11	12	10	3	5	4	4	5	3	1.0	19.0	18.0
Non-insects	2	4	2	2	5	7	4	4	3	4	5	7	5	3	3	4	2	3	2	2.0	7.0	5.0
Oligochaeta	1	1	1	1	1	3	1	1	1	1	1	3	1	1	1	2	1	1	1	1.0	3.0	2.0
Plecoptera	0	0	0	0	0	4	3	4	4	4	0	2	0	0	1	1	0	0	1	0.0	4.0	4.0
Trichoptera	1	1	3	7	0	6	9	5	8	7	3	4	4	4	1	1	2	3	1	0.0	9.0	9.0
Composition (Percent richness)																						
Chironomidae	47.8	51.9	27.8	32.5	40.7	30.2	25.0	20.5	18.4	23.1	20.5	21.4	10.3	0.0	20.0	27.3	43.5	33.3	33.3	0.0	51.9	51.9
Ephemeroptera	4.3	7.4	5.6	15.0	3.7	9.5	12.5	13.6	12.2	13.5	20.5	14.3	20.7	13.3	20.0	9.1	8.7	9.5	8.3	3.7	20.7	17.0
EPT	8.7	11.1	22.2	32.5	3.7	25.4	33.9	34.1	36.7	34.6	28.2	28.6	34.5	20.0	33.3	18.2	17.4	23.8	25.0	3.7	36.7	33.0
Non-Insects	8.7	14.8	11.1	5.0	18.5	11.1	7.1	9.1	6.1	7.7	12.8	16.7	17.2	20.0	20.0	18.2	8.7	14.3	16.7	5.0	20.0	15.0
Oligochaeta	4.3	3.7	5.6	2.5	3.7	4.8	1.8	2.3	2.0	1.9	2.6	7.1	3.4	6.7	6.7	9.1	4.3	4.8	8.3	1.8	9.1	7.3
Plecoptera	0.0	0.0	0.0	0.0	0.0	6.3	5.4	9.1	8.2	7.7	0.0	4.8	0.0	0.0	6.7	4.5	0.0	0.0	8.3	0.0	9.1	9.1
Trichoptera	4.3	3.7	16.7	17.5	0.0	9.5	16.1	11.4	16.3	13.5	7.7	9.5	13.8	6.7	6.7	4.5	8.7	14.3	8.3	0.0	17.5	17.5
Composition (Percent abundance)																						
Chironomidae	23.4	13.5	0.9	48.0	44.2	14.4	5.4	11.3	3.5	14.1	1.3	3.4	0.7	0.0	3.0	10.9	46.7	70.9	50.0	0.0	70.9	70.9
Ephemeroptera	4.4	8.0	70.0	13.0	5.8	47.0	17.5	24.8	39.6	38.9	32.5	17.9	22.4	8.0	2.2	23.2	7.9	4.0	16.0	2.2	70.0	67.8
EPT	4.7	8.4	75.0	22.3	5.8	70.5	74.6	63.9	80.9	68.8	36.7	32.7	44.2	56.0	53.0	71.0	28.1	14.3	29.2	4.7	80.9	76.2

Metric	NCPN sites					SCPN sites												Minimum	Maximum	Range			
	Wash Courthouse	Halls Creek	La Verkin Creek	North Creek	Salt Creek	Capulin Creek				Coyote Gulch				Mancos River									
Non-Insects Oligochaeta Plecoptera Trichoptera	50.3	52.1	2.4	3.3	23.4	1.4	1.4	0.6-Sep-05	01-Oct-06	27-Oct-06	28-Oct-06	20-Sep-05	31-Oct-05	22-Sep-06	12-Oct-06	03-Nov-06	12-Sep-05	01-Sep-06	28-Sep-06	25-Oct-06	0.9	52.1	51.2
	14.8	51.3	0.5	1.1	10.2	0.4	0.3	0.1	0.1	0.1	0.1	0.7	1.7	9.2	10.0	11.2	2.2	9.9	6.9	3.8	0.1	51.3	51.2
	0.0	0.0	0.0	0.0	0.0	11.4	6.3	9.8	15.2	19.6	19.6	0.0	0.0	1.9	0.0	0.0	12.7	0.7	0.0	0.0	0.0	19.6	19.6
	0.4	0.3	4.9	9.2	0.0	12.1	50.7	29.3	26.1	10.3	4.2	12.9	21.8	48.0	38.1	47.1	20.2	10.3	12.3		0.0	50.7	50.7
Other Compositional																							
Hydroptilidae+ Hydropsychidae / Trichoptera	1.00	1.00	1.00	0.92	--	0.93	0.96	0.99	0.73	0.79		0.99	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	0.7	1.0	0.3
	1.00	1.00	0.67	0.08	--	0.01	0.00	0.00	0.00	0.00		0.01	0.03	0.03	0.00	0.00	0.00	0.05	0.06	0.00	0.0	1.0	1.0

Calculated metrics for qualitative samples.

Metric	NCPN sites					SCPN sites										Minimum	Maximum	Range				
	Courthouse Wash	Halls Creek	La Verkin Creek	North Creek	Salt Creek	Capulin Creek					Coyote Gulch								Mancos River			
						17-May-06	22-Aug-06	25-Oct-06	23-Aug-06	22-Jun-06	24-Sep-05	06-Sep-06	01-Oct-06	27-Oct-06	28-Oct-06				20-Sep-05	25-Oct-05	22-Sep-06	12-Oct-06
Richness	25	34	29	26	42	33	68	41	49	39	33	67	49	40	18	17	37	18	22	17	68	51
Tolerance																						
Tolerance (Richness)	6.7	6.1	4.7	4.8	5.5	6.7	4.9	4.4	4.3	4.8	4.1	5.9	5.4	5.3	5.0	4.9	5.9	5.3	5.4	4.1	6.7	2.6
Functional-Feeding																						
Filter-collector richness	1	2	5	3	8	2	6	5	3	3	3	4	3	2	2	2	5	2	3	1.0	8.0	7.0
Scraper richness	1	3	1	1	3	1	5	6	4	4	4	7	6	5	1	1	3	1	0	0.0	7.1	7.1
Filter-collector % richness	4.0	5.9	17.2	11.5	19.0	6.1	9.0	12.8	6.3	7.7	9.4	6.1	6.1	5.0	11.1	11.8	13.5	11.1	13.6	4.0	19.0	15.0
Scraper % richness	4.0	8.8	3.4	3.8	7.1	3.0	7.5	15.4	8.3	10.3	12.5	10.6	12.2	12.5	5.6	5.9	8.1	5.6	0.0	0.0	15.4	15.4
Functional-Habit																						
Burrower richness	16	20	8	8	13	15	31	15	21	15	9	28	20	15	3	6	24	11	12	2.8	30.9	28.1
Clinger richness	1	4	12	7	16	3	20	16	17	14	16	10	11	12	7	7	8	4	4	1.5	19.8	18.3
Burrower % richness	64.7	57.7	29.2	30.4	31.0	45.0	45.5	35.5	43.2	39.3	28.0	41.5	40.5	38.7	15.4	33.3	65.5	60.0	56.3	15.4	65.5	50.1
Clinger % richness	5.9	11.5	41.7	26.1	37.9	10.0	29.1	38.7	35.1	35.7	48.0	15.1	21.6	29.0	38.5	41.7	20.7	20.0	18.8	5.9	48.0	42.1
Composition (Richness)																						
Chironomidae	10	16	9	8	10	11	22	8	12	9	4	21	14	9	0	2	14	6	9	0.0	22.0	22.0
Ephemeroptera	1	3	2	5	6	1	7	5	6	5	4	7	6	7	4	1	3	2	3	1.0	7.0	6.0
EPT	1	4	7	11	12	1	19	14	15	11	11	11	10	10	6	3	7	4	4	1.0	19.0	18.0
Non-Insects	3	4	3	2	2	5	6	2	4	5	4	8	5	6	3	4	8	3	5	2.0	8.0	6.0

Calculated metrics for qualitative samples, cont.

Metric	NCPN sites					SCPN sites										Minimum	Maximum	Range					
	Courthouse Wash	Halls Creek	La Verkin Creek	North Creek	Salt Creek	Capulin Creek					Coyote Gulch								Mancos River				
						04-Jul-06	17-May-06	22-Aug-06	25-Oct-06	23-Aug-06	22-Jun-06	24-Sep-05	06-Sep-06	01-Oct-06	27-Oct-06				28-Oct-06	20-Sep-05	25-Oct-05	22-Sep-06	12-Oct-06
Oligochaeta	1	1	1	1	1	1	4	0	0	1	1	3	1	1	1	1	3	1	1	1	0.0	4.0	4.0
Plecoptera	0	0	1	2	0	0	4	2	4	2	3	0	1	0	1	1	0	1	0	0	0.0	4.0	4.0
Trichoptera	0	1	4	4	6	0	8	7	5	4	4	4	3	3	1	1	4	3	2	1	0.0	8.0	8.0
Composition (Percent richness)																							
Chironomidae	40.0	47.1	31.0	30.8	23.8	33.3	32.4	19.5	24.5	23.1	12.1	31.3	28.6	22.5	0.0	11.8	37.8	33.3	40.9	0.0	47.1	47.1	
Ephemeroptera	4.0	8.8	6.9	19.2	14.3	3.0	10.3	12.2	12.2	12.8	12.1	10.4	12.2	17.5	22.2	5.9	8.1	11.1	13.6	3.0	22.2	19.2	
EPT	4.0	11.8	24.1	42.3	28.6	3.0	27.9	34.1	30.6	28.2	33.3	16.4	20.4	25.0	33.3	17.6	18.9	22.2	18.2	3.0	42.3	39.3	
Non-insects	12.0	11.8	10.3	7.7	4.8	15.2	8.8	4.9	8.2	12.8	12.1	11.9	10.2	15.0	16.7	23.5	21.6	16.7	22.7	4.8	23.5	18.8	
Oligochaeta	4.0	2.9	3.4	3.8	2.4	3.0	5.9	0.0	0.0	2.6	3.0	4.5	2.0	2.5	5.6	5.9	8.1	5.6	4.5	0.0	8.1	8.1	
Plecoptera	0.0	0.0	3.4	7.7	0.0	0.0	5.9	4.9	8.2	5.1	9.1	0.0	2.0	0.0	5.6	5.9	2.7	0.0	0.0	0.0	9.1	9.1	
Trichoptera	0.0	2.9	13.8	15.4	14.3	0.0	11.8	17.1	10.2	10.3	12.1	6.0	6.1	7.5	5.6	5.9	8.1	11.1	4.5	0.0	17.1	17.1	

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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