National Park Service
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Natural Resource Stewardship and Science

Aquatic Macroinvertebrate and Physical Habitat Monitoring for Capulin Creek and the Rito de los Frijoles in Bandelier National Monument

2010 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2012/236

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Bandelier National Monument
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Aquatic Macroinvertebrate and Physical Habitat Monitoring for Capulin Creek and the Rito de los Frijoles in Bandelier National Monument

2010 Summary Report

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February 2012

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

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

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Please cite this publication as:

Stumpf, S. E., and S. A. Monroe. 2012. Aquatic macroinvertebrate and physical habitat monitoring for Capulin Creek and the Rito de los Frijoles in Bandelier National Monument: 2010 summary report. Natural Resource Data Series NPS/SCPN/NRDS—2012/236. National Park Service, Fort Collins, Colorado.

NPS 315/112707, February 2012

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1 Introduction and background

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

In 2007, SCPN implemented annual monitoring of aquatic macroinvertebrates and physical habitat at two sites on Capulin Creek in Bandelier National Monument (BAND) (Stumpf and Monroe 2009), and in 2009, the network implemented monitoring at two sites on the Rito de los Frijoles in BAND (fig. 1).

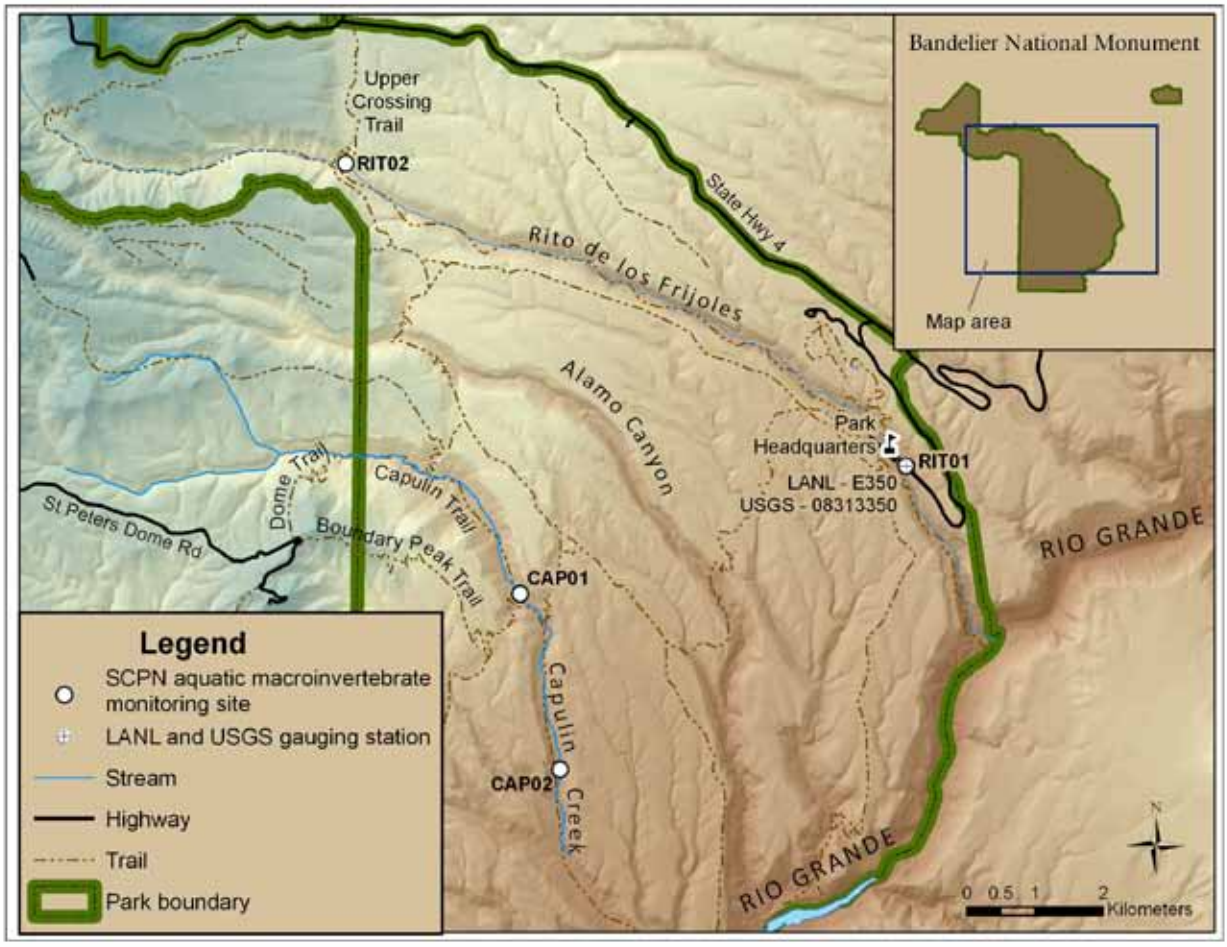


Figure 1. Map showing locations of SCPN monitoring sites CAP01 and CAP02 in Capulin Creek, and RIT01 and RIT02 in the Rito de los Frijoles at Bandelier National Monument, New Mexico, in 2010

During 2010 the SCPN water resources field crew collected aquatic macroinvertebrate samples and physical habitat data from two monitoring sites at Capulin Creek:

Capulin Creek at Base Camp Gauging Station (BANDCAP01), identified in this report as CAP01 (see appendix A for list of locations, codes, and common names of monitoring sites), is located less than 0.3 km upstream from the backcountry ranger cabin and was selected to be co-located with a network water quality monitoring site. The site is located at a discontinued U.S. Geological Survey streamflow gauging station (*Capulin Canyon at Ranger Cabin*, # 083133655). The channel substrate at this site is primarily cobble, and the stream flows through an alder (*Alnus* sp.), box-elder (*Acer negundo*) and narrowleaf cottonwood (*Populus angustifolia*) woodland.

Capulin Creek above Painted Cave (BANDCAP02), identified in this report as CAP02, is located 1.8 km up canyon from the Painted Cave and 2.6 km downstream from base camp. This site was selected using the Generalized Random-Tessellation Stratified (GRTS) design. The riparian community includes ponderosa pine (*Pinus ponderosa*), alder, boxelder, New Mexico olive (*Forestiera pubescens*), and has a mostly fine/sand substrate.

The Capulin Creek watershed is a designated wilderness area, managed for recreational use within park boundaries. The U.S. Forest Service manages land in the upper reaches of the watershed for recreation and timber harvest. In 1996 the Dome Fire burned several thousand acres in Capulin Creek watershed, and, although terrestrial and aquatic communities appear to have been recovering over the past 10 years, effects of the fire are still apparent. Large quantities of woody debris have accumulated on the floodplain and in the stream channel, and fine sediments are abundant and mobile in the system. Roads and timber harvest on the Santa Fe National Forest also have the potential to affect the stream ecosystem. Aquatic macroinvertebrates were sampled in streams at BAND, before the fire, by Pippin and Pippin (1981), and post-fire by Vieira et al. (2004).

Native Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) populations were extirpated from Capulin Creek by flood events following the Dome Fire. The New Mexico Department of Game and Fish, Bandelier National Monument, and the Santa Fe National Forest have been collaborating to reintroduce this species to the creek. One hundred Rio Grande cutthroat trout were reintroduced in March 2006, and land managers have been evaluating whether to reintroduce native Rio Grande Sucker (*Catostomus plebeius*) and native Rio Grande Chub (*Gila pandora*) in Capulin Creek as well (NPS, S. Fettig, Wildlife Biologist, phone conversation with Stephen Monroe, NPS, Flagstaff, 27 February 2008).

During 2010, the SCPN water resources field crew also collected aquatic macroinvertebrate samples and physical habitat data from two monitoring sites at the Rito de los Frijoles:

Rito de los Frijoles near Visitor Center (BANDRIT01) is identified in this report as RIT01 (appendix A lists locations, codes, and common names of sampling sites). The site was co-located with a SCPN water quality monitoring site and a streamflow gauging station (Los Alamos National Laboratory LANL-E350, USGS # 08313350, *Rito de los Frijoles in Bandelier Nat Mon, NM*) currently operated by Los Alamos National Laboratory in cooperation with USGS (fig. 1). Riparian vegetation at the site is dominated by narrowleaf cottonwood, box elder, and New Mexico olive.

Rito de los Frijoles at Upper Crossing (BANDRIT02), identified in this report as RIT02, is located at the intersection with Upper Crossing Trail . Vegetation is dominated by a Ponderosa Pine/ Broadleaf Mixed Montane Riparian Forest.

The Rito de los Frijoles is a perennial stream flowing eastward from the Sierra de los Valles to the Rio

Grande. The upper reaches of the watershed is a designated wilderness area, managed for recreational use within park boundaries. The BAND visitor center and numerous archeological sites are located near the stream in the lower portion of the watershed, resulting in high levels of visitor use. In 1977 the La Mesa Fire burned about 15,000 acres in and near the Rito de los Frijoles watershed. As a result of this fire, the frequency and magnitude of stormflows, and suspended sediment concentrations, increased along the Rito de los Frijoles (Veenhuis 2002).

The primary purpose of this report is to (a) document the monitoring activities of the water resources crew that occurred at streams in Bandelier National Monument 2010, (b) summarize data that were collected, and (c) where appropriate, place these data in the context of aquatic habitat, biological condition, and management actions within the park through time.

2 Methods

2.1 Field methods

In New Mexico, the state has identified the aquatic macroinvertebrate sampling window as August to mid-November (New Mexico Environment Department, Surface Water Quality Bureau 2007). On October 24–28, 2010, we collected aquatic macroinvertebrate samples and physical habitat data at CAP01 and CAP02 on Capulin Creek, and at RIT01 and RIT02 on the Rito de los Frijoles. Each site consists of a 150 meter reach, composed of 11 transects, spaced 15 m apart (fig. 2). A brief description of field methods is provided here, and a detailed description of sampling methods can be found in Brasher et al. (2011).

Two types of aquatic macroinvertebrate samples were collected at each site:

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

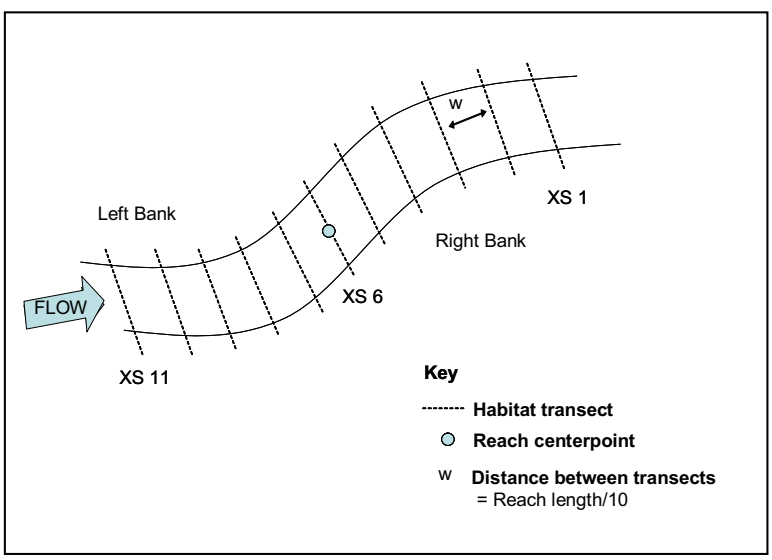


Figure 2. General aquatic macroinvertebrate sampling reach layout

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

- For each of the quantitative targeted riffle microhabitats, we
  - measured velocity
  - measured depth
  - measured substrate particle size
  - measured substrate particle embeddedness
- For each of the 11 transects, we
  - measured wetted and active channel widths
  - measured water depth, velocity, and canopy closure at five equally spaced points along each transect
  - observed and recorded the presence or absence, and types of aquatic macroinvertebrate habitats, represented by point data (5 points/transect) across the entire reach
  - measured geomorphic channel units (GCU) at five equally spaced points along each transect
- For the entire reach, we
  - identified and measured the length of GCUs (reach characterization data represents the proportion of the reach characterized by that particular GCU)
  - identified the dominant vegetation and land cover
  - recorded descriptions of flow conditions
  - recorded weather conditions
  - observed and recorded evidence of anthropogenic or natural disturbances
  - measured NPS core water quality parameters of temperature, specific conductivity, pH, dissolved oxygen, turbidity, and stream discharge
  - conducted a zig-zag pebble count measuring the size of a minimum of 400 randomly-selected particles across the length of the entire reach (this reach based pebble count method differs from transect based methods conducted in 2007–2008)

2.2 Laboratory methods

Aquatic macroinvertebrate samples were sent to the National Aquatic Monitoring Center's Bug Lab, a Bureau of Land Management laboratory at Utah State University in Logan. Samples were sorted under a dissecting scope at 10x magnification, and a 500-organism, fixed-count method was used for sub-sampling large samples. Ten percent of the sorted samples were re-sorted for quality assurance.

A taxonomist, certified by the North American Benthological Society, identified all aquatic macroinvertebrates to the family or genus level. To ensure data quality, 10 percent of the identified samples were re-identified by a second certified taxonomist.

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

2.3 Data analysis

In this report we summarize aquatic macroinvertebrate data in terms of community structure and function. Genera were classified into functional feeding guilds using the classifications presented in

Barbour et al. (1999). If functional class information was not available for a particular genus, we applied a more generalized, family-level classification.

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

3 Results

3.1 Aquatic macroinvertebrate community data for Capulin Creek

Key metrics are presented in Table 1 (qualitative) and in Tables 2 and 3 (quantitative), describing aquatic macroinvertebrate communities from samples collected at CAP01 and CAP02 from 2007 to 2010. For all tables and figures listed in this section, results are presented in left to right order corresponding to upstream to downstream position along the stream. Figures in this section refer to quantitative data unless otherwise noted, and error bars represent one standard deviation from the mean. Appendix C lists all aquatic macroinvertebrate species detected at the site, from both quantitative and qualitative methods.

Abundance. Mean total abundance was highest at CAP01, averaging 757.00 individuals per sample. Mean total abundance at CAP02 was 559.60 individuals (fig. 3).

Taxa richness. Samples of aquatic macroinvertebrates at CAP01 averaged 31.60 different taxa (fig.4). CAP02 averaged 21.40 taxa. Total taxa richness from qualitative multihabitat samples was slightly higher at both monitoring sites. Richness was 33 taxa at CAP01 and 23 taxa at CAP02.

Diversity. We measured both taxonomic and functional diversity using the Simpson's Diversity Index. Taxonomic diversity was higher than functional diversity at both monitoring sites. Taxonomic diversity averaged 0.87 and 0.80 per sample at CAP01 and CAP02 respectively (fig. 5a). Functional diversity averaged 0.73 at CAP01 and 0.67 at CAP02 in 2010 (fig. 5b). *Continued on page 10*

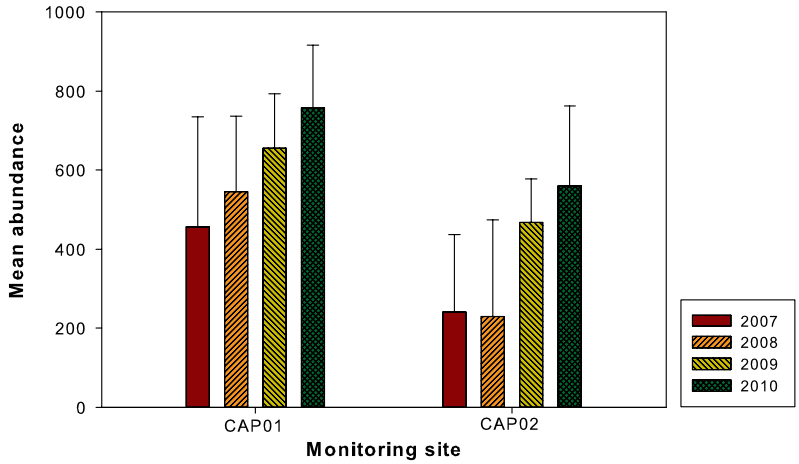


Figure 3. Total abundance expressed as the mean number of individuals per quantitative targeted riffle samples collected from CAP01 and CAP02 at Capulin Creek in BAND, 2007–2010

Table 1. Qualitative metrics for aquatic macroinvertebrate samples collected from CAP01 and CAP02 at Capulin Creek in Bandelier National Monument, New Mexico, 2007-2010. Richness-based metrics are expressed as the percentage of taxa in a given order, tolerance or functional feeding group.

	CAP01				CAP02			
Qualitative metric	**2007**	**2008**	**2009**	**2010**	**2007**	**2008**	**2009**	**2010**
Taxa richness	43	30	42	33	27	32	25	23
Tolerance group								
Richness of tolerant taxa (%)	9.30	7.41	15.00	6.67	11.54	25.81	26.09	4.76
Richness of moderately tolerant taxa (%)	23.26	25.93	30.00	36.67	42.31	25.81	56.52	52.38
Richness of intolerant taxa (%)	67.44	66.67	55.00	56.67	46.15	48.39	17.39	42.86
Functional group								
Richness of collector-filterers (%)	11.63	10.34	9.76	9.68	15.38	6.45	8.33	9.09
Richness of collector-gatherers (%)	32.56	27.59	31.71	38.71	30.77	22.58	37.50	27.27
Richness of scrapers (%)	9.30	6.90	12.20	9.68	3.85	6.45	4.17	4.55
Richness of shredders (%)	13.95	17.24	14.63	9.68	11.54	16.13	12.50	18.18
Richness of predators (%)	32.56	37.93	31.71	32.26	38.46	45.16	33.33	40.91
Taxonomic group								
Number of EPT taxa	19	14	15	13	8	10	4	6
Richness of EPT taxa (%)	44.19	46.67	35.71	39.39	29.63	31.25	16.00	26.09
Richness of Ephemeroptera (%)	16.28	16.67	9.52	12.12	7.41	9.38	8.00	4.35
Richness of Plecoptera (%)	9.30	10.00	9.52	12.12	7.41	12.50	4.00	8.70
Richness of Trichoptera (%)	18.60	20.00	16.67	15.15	14.81	9.38	4.00	13.04
Richness of noninsect taxa (%)	6.98[a]	3.33	11.90	9.09	7.41	6.25	20.00	13.04
Richness of Chironomid Diptera (%)	6.98	10.00	7.14	9.09	11.11	9.38	12.00	13.04
Richness of non-Chironomid Diptera (%)	4.65	20.00	26.19	27.27	7.41	37.50	32.00	30.43
Richness of Coleoptera (%)	16.23	10.00	11.90	12.12	18.52	12.50	20.00	13.04
Richness of Odonata (%)	6.98	10.00	7.14	3.03	7.41	3.13	0.00	4.35

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

Table 2. Quantitative metrics for aquatic macroinvertebrate samples collected from CAP01 at Capulin Creek in Bandelier National Monument, New Mexico, 2007-2010. For a given order, tolerance or functional feeding group, abundance-based metrics are expressed as the percentage of individuals in the group, while richness-based metrics are expressed as the percentage of taxa in the group.

	2007		2008		2009		2010	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Total abundance	456.30	278.53	545.00	191.79	655.60	137.52	757.00	158.72
Total richness	24.40	8.26	28.00	5.15	34.20	1.64	31.60	2.70
Simpson's Diversity—taxonomic	0.86	0.03	0.87	0.02	0.87	0.04	0.87	0.03
Simpson's Diversity—functional group	0.67	0.05	0.70	0.01	0.71	0.02	0.73	0.01
Dominant taxa	28.95	8.78	22.58	4.00	25.59	6.21	23.78	4.41
Tolerance group								
Relative abundance of tolerant taxa (%)	2.23	3.78	0.47	0.27	2.77	4.01	0.16	0.16
Relative abundance of moderately tolerant taxa (%)	38.11	13.37	25.27	4.07	32.26	6.04	22.68	6.87
Relative abundance of intolerant taxa (%)	59.66	12.31	74.26	0.27	64.96	9.75	77.16	6.88
Richness of tolerant taxa (%)	4.61	4.89	7.41	3.96	7.16	3.04	2.66	1.51
Richness of moderately tolerant taxa (%)	30.24	3.08	26.33	5.03	31.14	5.60	37.65	2.10
Richness of intolerant taxa (%)	65.15	5.01	66.26	3.60	61.70	4.90	59.70	2.04
Functional group								
Relative abundance of collector-filterers (%)	15.84	3.20	29.64	9.83	13.07	7.92	26.84	9.55
Relative abundance of collector-gatherers (%)	47.45	8.48	40.86	6.13	36.50	4.84	32.42	5.68
Relative abundance of scrapers (%)	4.64	2.11	10.49	6.38	33.25	8.39	24.74	6.05
Relative abundance of shredders (%)	6.75	1.65	6.18	2.06	5.70	4.47	5.10	1.59
Relative abundance of predators (%)	25.32	6.60	12.84	2.28	11.48	5.16	10.91	1.67
Richness of collector-filterers (%)	14.50	2.97	11.87	3.95	10.10	1.36	10.12	2.44
Richness of collector-gatherers (%)	22.12	6.14	30.49	4.11	29.79	3.36	32.40	3.11
Richness of scrapers (%)	12.88	3.10	14.73	3.19	15.37	3.40	11.30	1.97
Richness of shredders (%)	15.61	2.82	10.46	4.70	11.32	2.48	12.62	4.36
Richness of predators (%)	34.90	3.51	32.43	4.09	33.42	5.27	33.56	4.29
Taxonomic group								
Number of EPT taxa	11.40	2.70	12.80	1.92	13.20	0.84	14.20	2.17
Relative abundance of EPT taxa (%)	54.41	12.45	66.28	12.87	40.55	9.04	62.47	6.87
Relative abundance of Ephemeroptera (%)	29.10	10.08	26.11	4.79	15.88	3.25	21.92	4.61
Relative abundance of Plecoptera (%)	13.80	6.65	12.25	3.24	8.17	2.46	7.37	0.79
Relative abundance of Trichoptera (%)	11.61	3.84	27.91	10.41	16.50	5.79	33.18	8.51
Relative abundance of noninsect taxa (%)	0.69[a]	1.18[a]	0.68[a]	0.30[a]	5.00	3.30	2.10	1.28
Relative abundance of Chironomid Diptera (%)	27.49	12.60	13.33	8.85	15.90	7.79	7.24	1.68
Relative abundance of non-Chironomid Diptera (%)	7.33	6.44	7.16	5.32	7.94	5.02	5.03	3.25
Relative abundance of Coleoptera (%)	4.52	1.49	8.77	3.23	27.81	7.29	20.26	4.72
Relative abundance of Odonata (%)	5.12	1.21	3.78	1.09	2.80	1.83	2.88	1.65

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

Table 3. Quantitative metrics for aquatic macroinvertebrate samples collected from CAP02 at Capulin Creek in Bandelier National Monument, New Mexico, 2007-2010. For a given order, tolerance or functional feeding group, abundance-based metrics are expressed as the percentage of individuals in the group, while richness-based metrics are expressed as the percentage of taxa in the group.

	2007		2008		2009		2010	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Total abundance	240.40	196.25	229.20	245.08	467.60	110.44	559.60	203.46
Total richness	13.40	7.09	17.40	9.07	17.20	2.68	21.40	3.29
Simpson's Diversity—taxonomic	0.73	0.06	0.80	0.13	0.60	0.06	0.80	0.05
Simpson's Diversity—functional group	0.65	0.05	0.62	0.09	0.57	0.04	0.67	0.07
Dominant taxa	43.57	7.79	37.05	17.50	59.28	6.34	31.92	8.73
Tolerance group								
Relative abundance of tolerant taxa (%)	7.02	9.87	6.87	6.99	3.43	0.91	2.11	1.98
Relative abundance of moderately tolerant taxa (%)	38.00	11.60	48.08	22.48	23.24	6.81	50.66	10.69
Relative abundance of intolerant taxa (%)	54.98	15.54	6.87	6.99	73.34	6.54	47.23	11.99
Richness of tolerant taxa (%)	10.78	7.25	16.88	7.33	13.21	5.08	7.46	2.76
Richness of moderately tolerant taxa (%)	49.75	17.14	35.25	18.36	46.86	6.32	46.77	4.47
Richness of intolerant taxa (%)	39.48	15.92	47.87	7.33	39.93	5.62	45.77	6.58
Functional group								
Relative abundance of collector-filterers (%)	4.85	4.71	2.07	3.18	1.68	0.81	4.39	4.34
Relative abundance of collector-gatherers (%)	31.19	11.44	50.76	15.75	23.86	7.72	44.19	10.49
Relative abundance of scrapers (%)	2.59	2.95	22.24	13.48	10.47	3.47	28.61	11.82
Relative abundance of shredders (%)	44.69	7.76	6.85	7.44	59.62	6.36	13.28	4.68
Relative abundance of predators (%)	16.68	9.85	18.08	9.11	4.38	0.81	9.54	2.08
Richness of collector-filterers (%)	13.56	10.81	7.06	6.54	9.10	2.01	8.87	2.83
Richness of collector-gatherers (%)	31.22	8.11	30.59	5.45	31.26	7.87	28.26	4.65
Richness of scrapers (%)	6.40	5.95	15.14	6.69	10.84	3.70	7.53	3.65
Richness of shredders (%)	14.04	4.79	13.06	7.33	16.10	3.09	17.33	3.13
Richness of predators (%)	34.78	10.58	34.15	5.49	32.69	5.30	38.00	4.76
Taxonomic group								
Number of EPT taxa	4.60	3.05	4.80	4.82	5.20	0.84	7.20	1.30
Relative abundance of EPT taxa (%)	52.33	13.17	15.63	13.47	63.12	5.96	16.30	4.41
Relative abundance of Ephemeroptera (%)	1.14	0.92	5.55	5.69	3.15	1.54	1.20	0.74
Relative abundance of Plecoptera (%)	49.07	11.56	9.35	8.70	59.78	6.38	14.50	3.68
Relative abundance of Trichoptera (%)	2.12	4.02	0.73	1.01	0.19	0.23	0.59	0.39
Relative abundance of noninsect taxa (%)	1.15	1.52	7.59[a]	7.38[a]	3.25	1.37	5.98	2.83
Relative abundance of Chironomid Diptera (%)	35.73	17.62	41.97	20.50	18.45	6.40	39.05	11.26
Relative abundance of non-Chironomid Diptera (%)	6.55	3.77	9.17	2.46	1.62	0.59	8.50	4.17
Relative abundance of Coleoptera (%)	4.15	2.96	24.45	13.31	13.48	3.46	30.16	10.77
Relative abundance of Odonata (%)	0.09	0.12	2.70	3.15	0.08	0.11	0.02	0.06

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

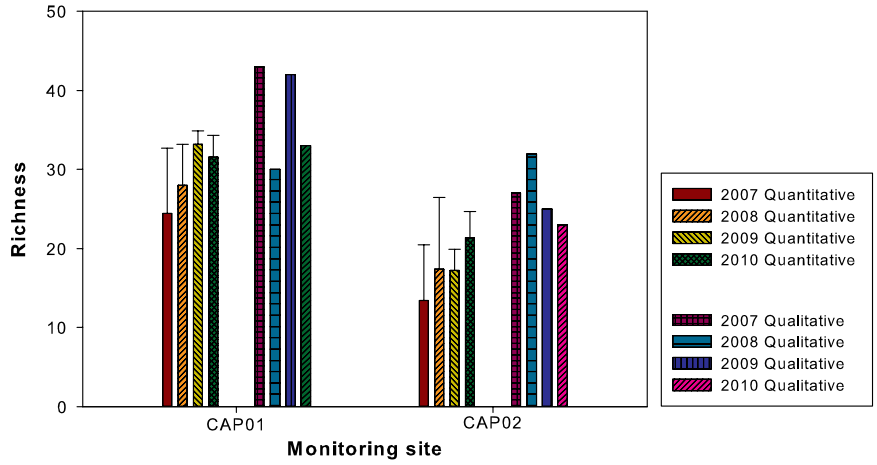


Figure 4. Mean taxa richness in quantitative targeted riffle samples and total taxa richness in qualitative multihabitat samples collected from CAP01 and CAP02 at Capulin Creek in BAND 2007–2010

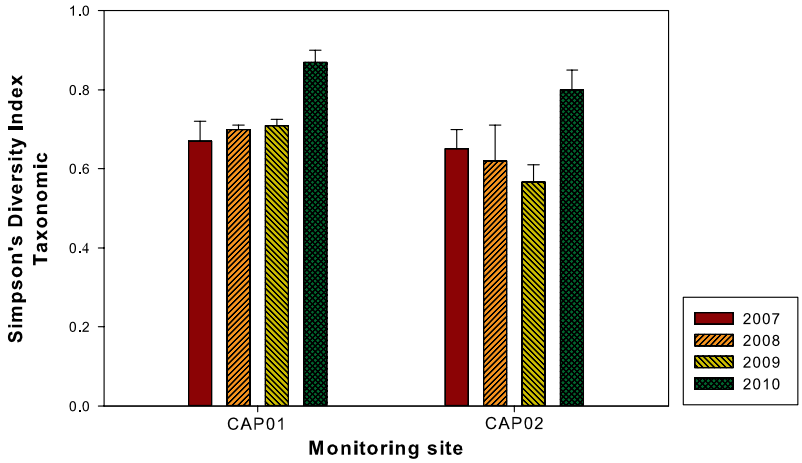


Figure 5a. Simpson's Diversity Index for taxonomic diversity in quantitative targeted riffle samples at Capulin Creek in BAND, 2007–2010. Values are expressed as means of all samples collected from the sites.

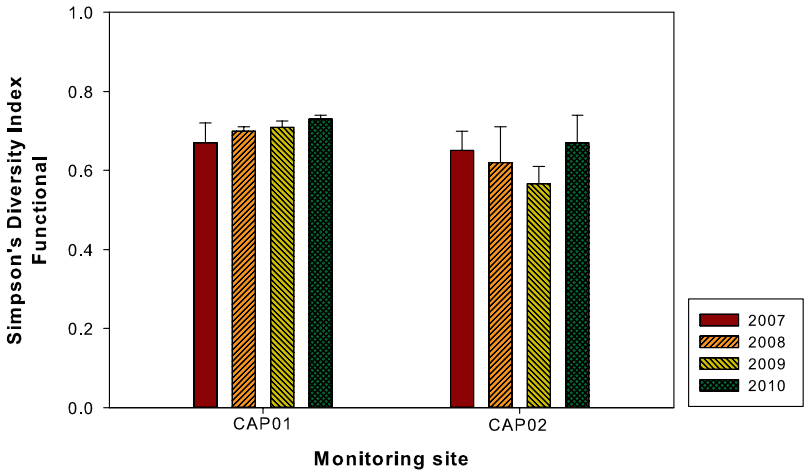


Figure 5b. Simpson's Diversity Index for functional feeding groups in quantitative targeted riffle samples at Capulin Creek in BAND, 2007–2010. Values are expressed as means of all samples collected from the sites.

Continued from page 5

Anthropogenic stress tolerance. Relative abundance and richness of intolerant taxa dominated the tolerance classes at CAP01 (figs. 6a and 6b). We found that 77.16% of all individuals and 59.70% of all taxa collected at CAP01 were designated as intolerant to perturbation. Relative abundance of moderately tolerant individuals averaged 22.68% while taxa richness averaged 37.65%. Tolerant organisms were the least abundant and species rich at CAP01. Tolerant individuals made up 0.16% of the sample, and only 2.66% of the taxa collected. Downstream at CAP02, moderately tolerant individuals and taxa were the most abundant. Relative abundance of moderately tolerant individuals averaged 50.66% of each sample. Intolerant individuals were the next most abundant at 47.23%, followed by tolerant individuals at 2.11%. Taxa richness at CAP02 followed a similar pattern. Moderately tolerant taxa were the most species rich at 46.77% followed by intolerant taxa at 45.77% and tolerant taxa at 7.46%.

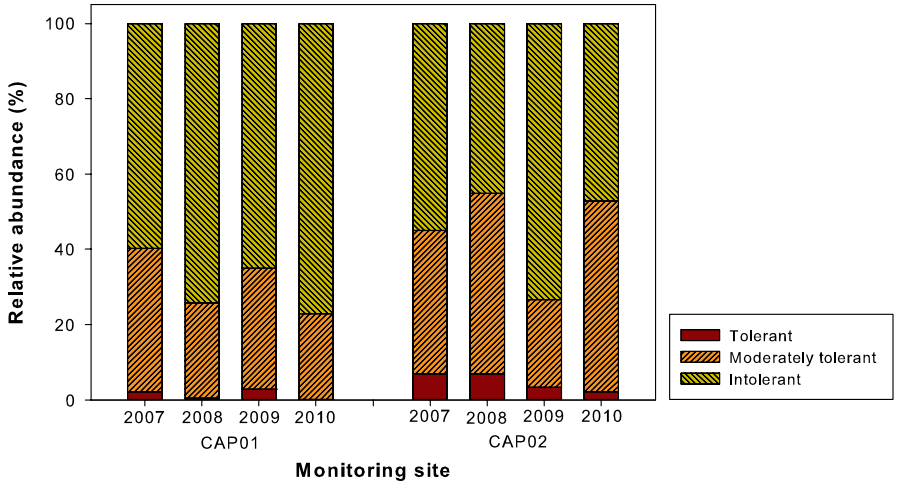


Figure 6a. Mean relative abundance of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from CAP01 and CAP02 at Capulin Creek in BAND, 2007–2010, based on their tolerance to perturbation

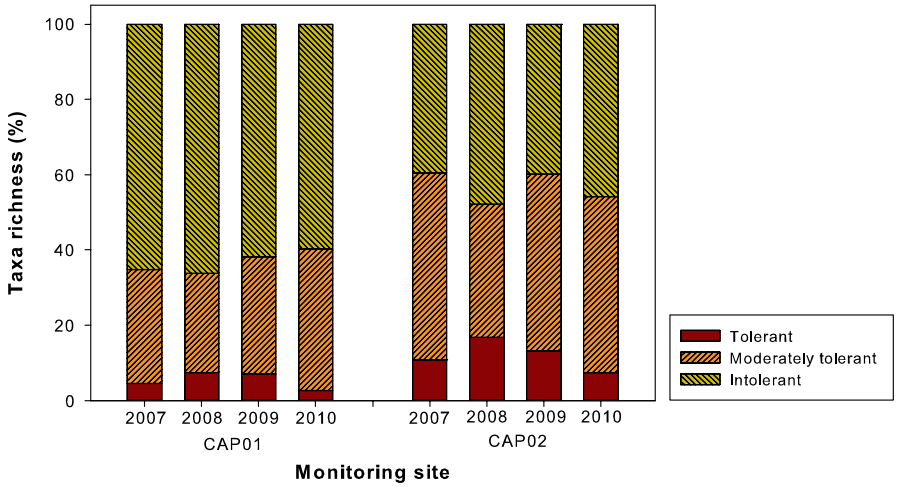


Figure 6b. Mean richness of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from CAP01 and CAP02 at Capulin Creek in BAND, 2007–2010, based on their tolerance to perturbation

EPT taxa. Relative abundance of EPT taxa—those belonging to the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) —averaged 62.47% of the individuals collected at CAP01 and 16.30% at CAP02 (fig. 7). Of the 62.47% of EPT taxa found at CAP01, 33.18% belonged to Trichoptera, 21.92% were Ephemeroptera and 7.37% were Plecoptera. At CAP02 Plecoptera dominated, at 14.50% of the sample, followed by Ephemeroptera at 1.20%, and Trichoptera at 0.59%.

Aquatic macroinvertebrate orders. Trichoptera was the most abundant order sampled at CAP01 (fig. 8). Ephemeroptera were the second most abundant at 21.92%, followed by Coleoptera (beetles) at 20.26%. Chironomids (midges) and non-chironomid dipterans (flies) averaged 7.24% and 5.03% of the sample, respectively. Odonates (damselflies and dragonflies) and noninsect taxa (worms, water mites, and pea clams) were the least abundant at CAP01, at 2.88% and 2.10%, respectively. At CAP02, chironomids were the most abundant individuals, at 39.05%. Coleopterans were the second most abundant at 30.16%, followed by plecopterans at 14.50%, non-chironomid dipterans at 8.49%, and noninsect taxa at 5.98%. Odonata was the least abundant order at CAP02, making up only 0.02% of the individuals collected.

Functional feeding groups. Relative abundance of functional feeding groups was dominated by collector-gatherers at both monitoring sites (fig. 9). Collector-gatherers made up 32.42% of the indi-viduals collected at CAP01 and 44.19% of the individuals at CAP02. Collector-filterers were the second most abundant at CAP01, averaging 26.84%. Scrapers averaged 24.74% at CAP01 followed by predators at 10.91% and shredders at 5.10%. Scrapers were the second most abundant group at CAP02, averaging 28.61% of the individuals collected, followed by shredders at 13.28%, predators at 9.54%, and collector-filterers at 4.39%.

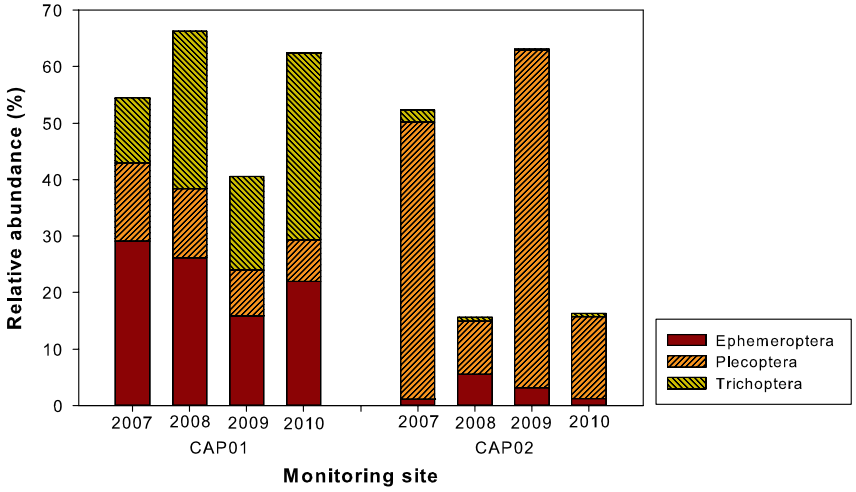


Figure 7. Relative abundance of EPT taxa in quantitative targeted riffle samples collected from CAP01 and CAP02 at Capulin Creek in BAND, 2007–2010

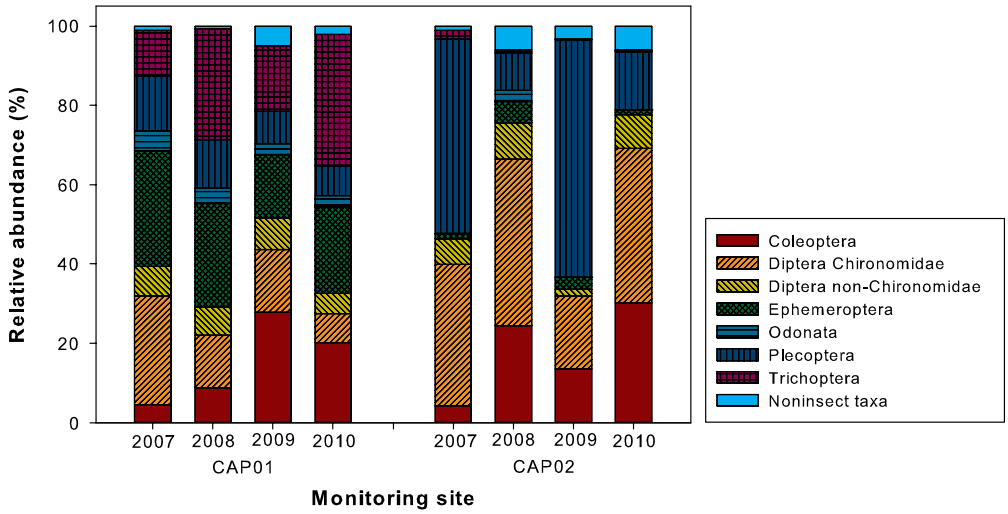


Figure 8. Relative abundance of individuals by taxonomic order in quantitative targeted riffle samples collected from CAP01 and CAP02 at Capulin Creek in BAND, 2007–2010

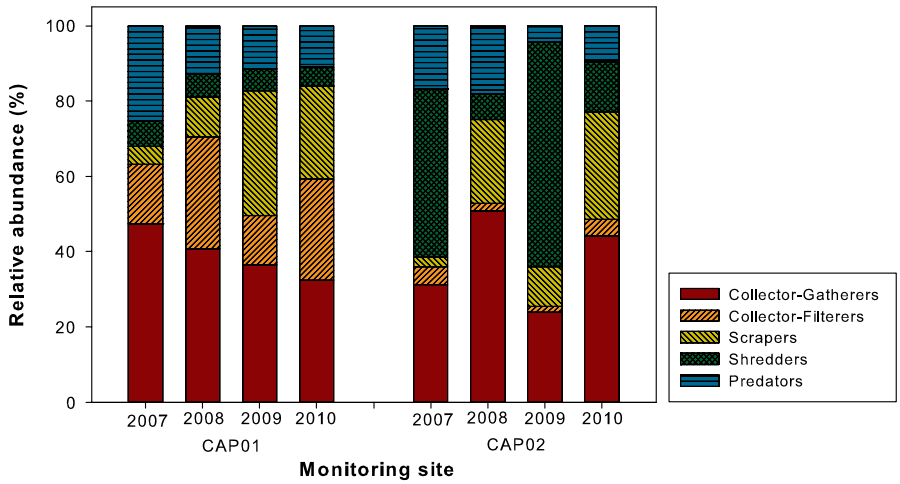


Figure 9. Relative abundance of functional feeding groups in quantitative targeted riffle samples collected from CAP01 and CAP02 at Capulin Creek in BAND, 2007–2010

3.2 Physical habitat characteristics for Capulin Creek

This section presents data describing physical habitat characteristics collected at CAP01 and CAP02 from 2007–2010. These data are summarized in Tables 4 and 5; additional transect data can be found in Appendix D.

Microhabitat level. Mean velocity and depth at targeted riffle sampling locations were slightly higher at CAP01 than CAP02 (tables 4, 5). Velocity averaged 0.36 m/s at the upstream site compared to 0.22 m/s at CAP02. Depth averaged 0.08 m at CAP01 and 0.06 m at CAP02. The largest difference between riffle habitat at the two sites was in substrate embeddedness. The embeddedness of individual particles at CAP01 averaged 39.4% while particles at CAP02 had an average of 21.2%.

Transect level. Stream channel widths were much wider at our downstream site than the upstream site (tables 4, 5). Active channel widths averaged 12.5 m at CAP02 compared to 10.1 m at CAP01. The gap between wetted channel widths was less, with the average wetted channel width at CAP02 equaling 2.1 m and only 1.6 m at CAP01. Average depths measured along each transect were identical for both sites, measuring 0.07 m. Stream flow velocities were larger at CAP01 than CAP02. The average velocity measured along the physical habitat transects were 0.14 m/s at CAP01 and only 0.08 m/s at CAP02.

Additionally, we measured riparian canopy cover along each transect. Riparian cover was slightly higher at CAP02, averaging 98.6% cover. Riparian cover at CAP01 averaged 96.3%.

Aquatic macroinvertebrate habitat was more diverse downstream at CAP02. We found six different habitat types along transects at CAP02 compared to four habitat types at CAP01 (fig. 10). Rock was the dominant habitat type at both monitoring sites, averaging 27.8% at CAP01 and 30.6% at CAP02. Approximately 40% of CAP01 and 33% of CAP02 lacked habitat (Absence) that fit into one of our habitat types defined as appropriate for aquatic macroinvertebrates.

Reach level. Channel structure dynamics are represented by particle size distributions in Figures 11a and 11b, based on modified Wolman pebble counts. Particle size distributions were well distributed across all size classes at both sampling reaches. Cobbles (64–128 mm) and fine particles (<2 mm) dominated the CAP01 reach. Cobbles made up 17.5% of the reach while fine particles were found along 15.8% of the reach. Fine particles (<2 mm) and very coarse gravels (32–64 mm) were the most abundant size classes at CAP02, making up 22.3% and 13.3% of the reach respectively.

Table 4. Physical habitat and hydrologic data from CAP01 at Capulin Creek in Bandelier National Monument, New Mexico, 2007-2010. Particle embeddedness and canopy closure measurements are expressed as percentages.

	2007		2008		2009		2010	
Physical habitat metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Microhabitat level								
Riffles								
Velocity (m/s)	0.23	0.10	0.35	0.20	0.33	0.17	0.36	0.19
Depth (m)	0.07	0.02	0.09	0.02	0.25	0.39	0.08	0.03
Embeddedness (%)	14.4	5.1	30.3	12.9	26.3	6.3	39.4	6.5
Transect level								
Channel dimensions								
Velocity (m/s)	0.06	0.04	0.14	0.06	0.16	0.08	0.14	0.13
Depth (m)	0.07	0.05	0.06	0.04	0.07	0.03	0.07	0.03
Wetted channel width (m)	1.3	0.4	1.3	0.4	1.4	0.3	1.6	0.4
Active channel width (m)	2.3	0.9	5.5	2.3	9.6	5.1	10.1	4.4
Riparian cover								
Canopy closure (%)	87.4	21.0	91.1	20.9	92.0	11.1	96.3	7.2
Reach level								
Water quality	**Value**		**Value**		**Value**		**Value**	
Temperature (°C)	11.5		11.4		9.7		8.9	
Specific conductivity (µS/cm)	—		151		146		145	
pH	—		8.0		8.0		7.9	
Dissolved oxygen (% saturation)	—		96.6		95.9		96.7	
Dissolved oxygen (mg/L)	—		10.5		8		8.9	
Turbidity (NTU)	—		0.50		1.3		1.0	
Discharge (cfs)	—		—		—		0.4	

Table 5. Physical habitat and hydrologic data from CAP02 at Capulin Creek in Bandelier National Monument, New Mexico, 2007-2010. Particle embeddedness and canopy closure measurements are expressed as percentages.

	2007		2008		2009		2010	
Physical habitat metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Microhabitat level								
Riffles								
Velocity (m/s)	0.19	0.23	0.21	0.14	0.01	0.12	0.22	0.09
Depth (m)	0.06	0.03	0.05	0.02	0.07	0.22	0.06	0.02
Embeddedness (%)	9.2	6.1	29.5	10.6	29.4	11.4	21.2	8.4
Transect level								
Channel dimensions								
Velocity (m/s)	0.04	0.03	0.02	0.02	0.29	0.38	0.08	0.03
Depth (m)	0.06	0.03	0.07	0.05	0.07	0.04	0.07	0.03
Wetted channel width (m)	1.2	0.4	0.9	0.4	3.9	3.5	2.1	3.3
Active channel width (m)	1.7	0.4	4.2	1.9	13.6	6.8	12.5	6.0
Riparian cover								
Canopy closure (%)	70.6	15.2	98.0	7.0	96.3	6.2	98.6	3.6
Reach level								
Water quality	**Value**		**Value**		**Value**		**Value**	
Temperature (°C)	11.4		11.2		10.6		9.2	
Specific conductivity (µS/cm)	—		165		172		157	
pH	—		7.8		7.8		7.7	
Dissolved oxygen (% saturation)	—		96.4		96.1		95.1	
Dissolved oxygen (mg/L)	—		10.6		8.2		8.7	
Turbidity (NTU)	—		1.9		2.6		1.2	
Discharge (cfs)	—		—		—		0.1	

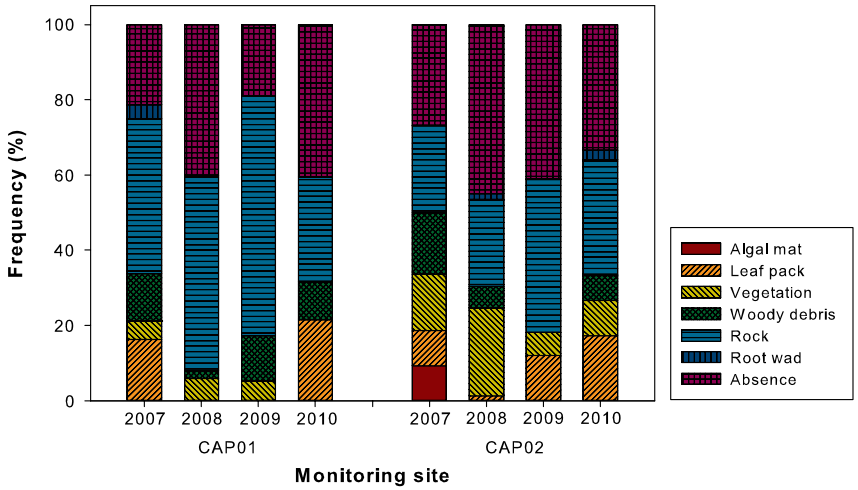


Figure 10. Aquatic macroinvertebrate habitat characterization based upon line point intercept data along transects from CAP01 and CAP02 at Capulin Creek in BAND, 2007–2010

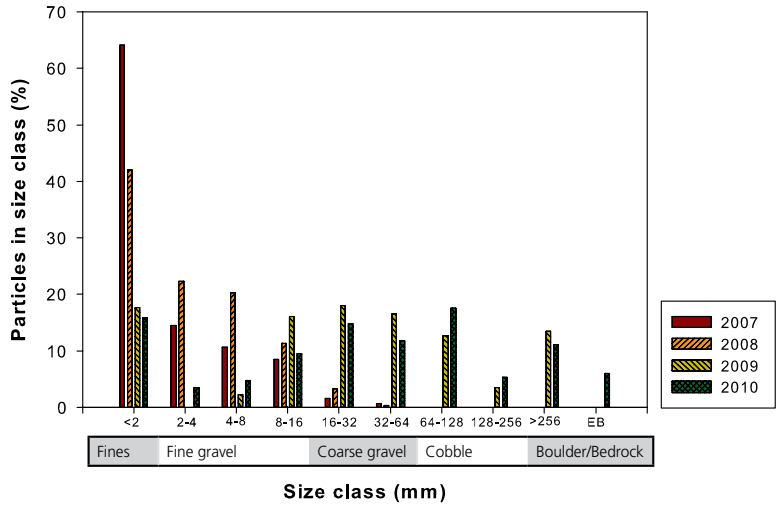


Figure 11a. Particle size distribution, based on a minimum of 400 particles, from CAP01 at Capulin Creek in BAND, 2007–2010. EB represents particles that are completely embedded into the stream channel, which precludes size measurements.

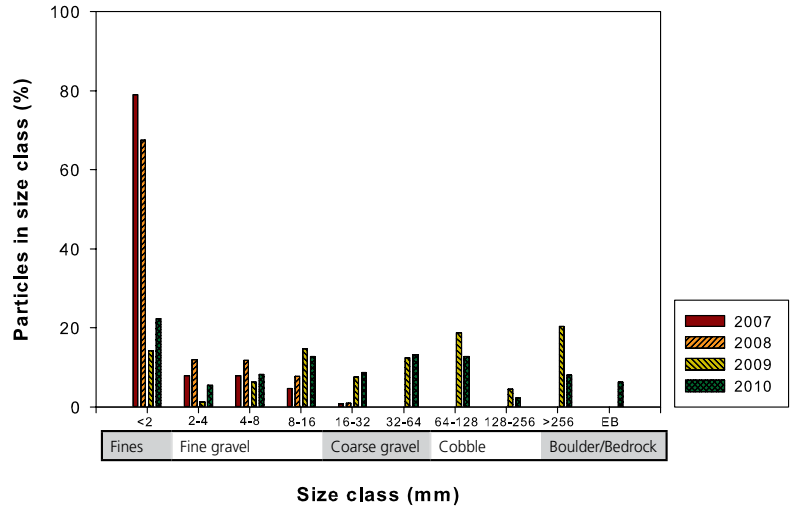


Figure 11b. Particle size distribution, based on a minimum of 400 particles, from CAP02 at Capulin Creek in BAND, 2007–2010. EB represents particles that are completely embedded into the stream channel, which precludes size measurements.

Cascades and riffles were the dominant geomorphic channel units (GCU) at CAP01 (fig. 12). Cascades made up 29.9% of the monitoring sites while riffles made up 25.1%. At CAP02, runs and riffles were the dominant GCU's, averaging 33.2% and 20.6% of the site respectively.

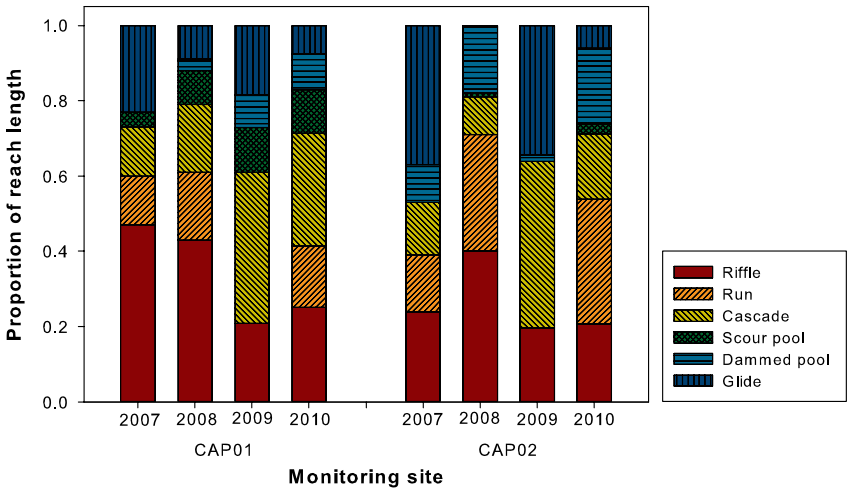


Figure 12. Geomorphic channel unit characterization from CAP01 and CAP02 at Capulin Creek in BAND, 2007–2010

3.3 Hydrologic conditions for Capulin Creek

This was the third consecutive year in which we collected water quality data while sampling aquatic macroinvertebrates at Capulin Creek. Values presented in Tables 4 and 5 represent recorded measurements at or near midday of the sample date. The midday temperature was 8.9°C at CAP01 and 9.2°C at CAP02. Specific conductivity was higher downstream at CAP02, measuring 157 µS/cm compared to 145 µS/cm at CAP01. pH measured 7.9 at CAP01 and 7.7 at CAP02. Dissolved oxygen at CAP01 measured 96.7% saturation and 8.9 mg/L. Dissolved oxygen was slightly lower at CAP02, measuring 95.1% saturation and 8.7 mg/L. Turbidity was 1.0 NTU at CAP01 and 1.2 NTU at CAP02. In addition to these water quality parameters, we measured stream discharge along both monitoring sites. Total discharge at CAP01 was 0.4 cfs, and 0.1 cfs at CAP02.

We recorded air and water temperatures quarter-hourly at Capulin Creek, and daily averages are presented in Figures 13a and b, and 14a and b, for 2010. The average air and water temperatures at CAP01 during 2010 were 9.9°C and 8.9°C, respectively. Air temperature reached a high of 35.1°C on 17 June, and a low temperature of -16.8°C on 31 December. Water temperatures were milder at

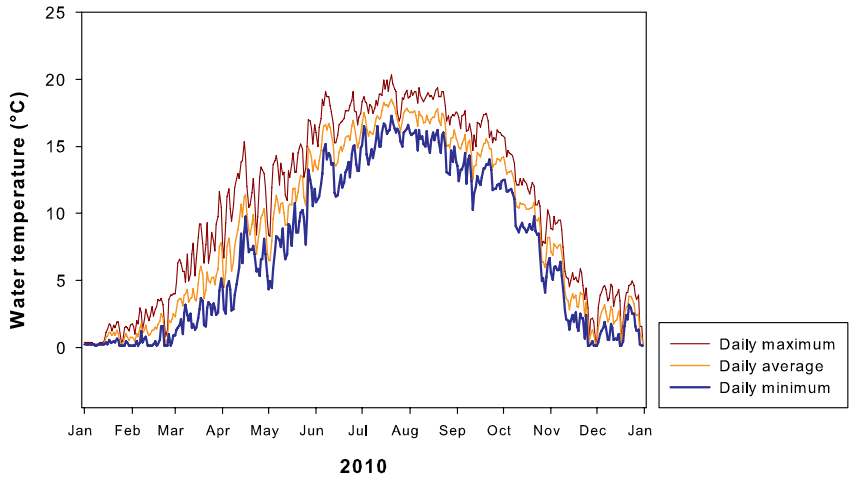


Figure 13a. Daily water temperature statistics from CAP01 at Capulin Creek in BAND, 2010

CAP01, reaching a high of 20.3°C on 20 June and low of 0.12°C on 8 January. Average air and water temperatures at CAP02 in 2010 were 12.1°C and 10.5°C respectively. Air temperatures at CAP02 ranged from a high of 36.1°C on 25 April to a low of -14.0°C on 8 January. The high water temperature at CAP02 was 26.8°C on 23 June. The low water temperature at CAP02 was 0.12°C on 8 January. The dataset for CAP02 is incomplete because we were unable to download 2010 data past November.

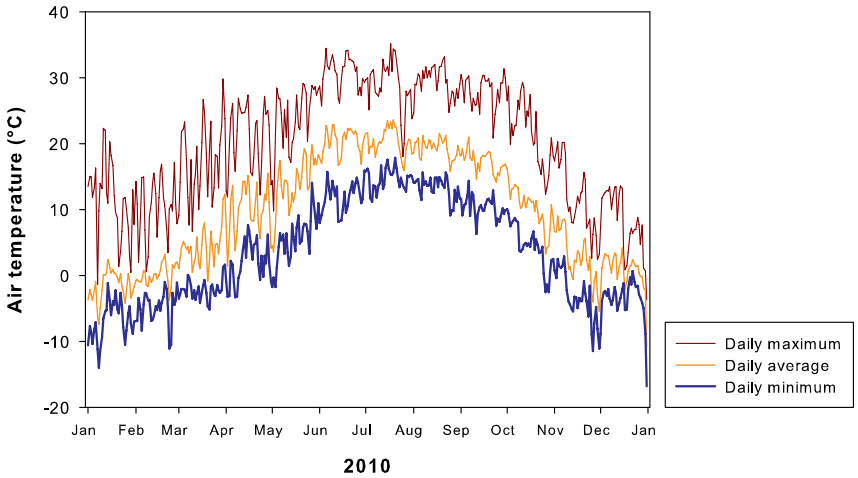


Figure 13b. Daily air temperature statistics from CAP01 at Capulin Creek in BAND, 2010

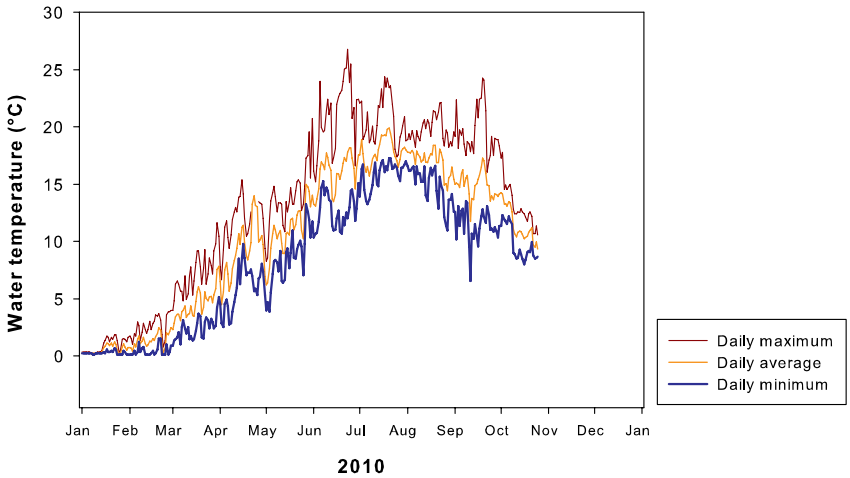


Figure 14a. Daily water temperature statistics from CAP02 at Capulin Creek in BAND, 2010. Spike in daily maximum is a result of the datalogger being removed from the site.

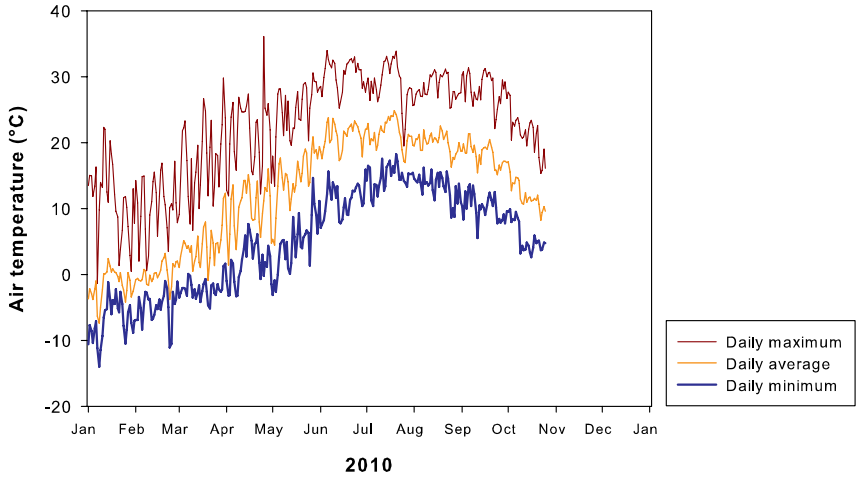


Figure 14b. Daily air temperature statistics from CAP02 at Capulin Creek in BAND, 2010

3.4 Aquatic macroinvertebrate community data for the Rito de los Frijoles

Key metrics are presented in Table 6 (qualitative) and in Table 7 (quantitative), describing aquatic macroinvertebrate communities from samples collected at RIT01 and RIT02 in 2010. For all tables and figures listed in this section, results are presented in left to right order corresponding to upstream to downstream position along the stream. Figures in this section refer to quantitative data unless otherwise noted, and error bars in figures represent one standard deviation from the mean.

Table 6. Qualitative metrics for aquatic macroinvertebrate samples collected from RIT01 and RIT02 at the Rito de los Frijoles in Bandelier National Monument, New Mexico, 2009-2010. Richness-based metrics are expressed as the percentage of taxa in a given order, tolerance or functional feeding group.

	RIT02		RIT01	
Qualitative metric	**2009**	**2010**	**2009**	**2010**
Taxa richness	37	38	38	39
Tolerance group				
Richness of tolerant taxa (%)	11.76	5.71	10.81	13.16
Richness of moderately tolerant taxa (%)	32.35	25.71	35.14	42.11
Richness of intolerant taxa (%)	55.88	68.57	54.05	44.74
Functional group				
Richness of collector-filterers (%)	10.81	10.81	10.53	10.53
Richness of collector-gatherers (%)	29.73	35.14	26.32	28.95
Richness of scrapers (%)	8.11	13.51	10.53	2.63
Richness of shredders (%)	10.81	10.81	18.42	13.16
Richness of predators (%)	40.54	29.73	34.21	44.74
Taxonomic group				
Number of EPT taxa	15	17	15	15
Richness of EPT taxa (%)	40.54	44.74	39.47	38.46
Richness of Ephemeroptera (%)	10.81	13.16	13.16	10.26
Richness of Plecoptera (%)	8.11	13.16	13.16	15.38
Richness of Trichoptera (%)	21.62	18.42	13.16	12.82
Richness of noninsect taxa (%)	13.51	10.53	10.53	7.69
Richness of Chironomid Diptera (%)	8.11	7.89	7.89	7.69
Richness of non-Chironomid Diptera (%)	18.92	28.95	26.32	30.77
Richness of Coleoptera (%)	13.51	5.26	13.16	10.26
Richness of Odonata (%)	5.41	2.63	2.63	5.13

Table 7. Quantitative metrics for aquatic macroinvertebrate samples collected from RIT01 and RIT02 at the Rito de los Frijoles in Bandelier National Monument, New Mexico, 2009-2010. For a given order, tolerance or functional feeding group, abundance-based metrics are expressed as the percentage of individuals in the group, while richness-based metrics are expressed as the percentage of taxa in the group.

	RIT02				RIT01			
	2009		2010		2009		2010	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Total abundance	700.90	134.75	760.60	80.43	688.00	172.57	697.60	91.52
Total richness	28.40	3.29	30.00	2.92	27.00	2.74	28.40	5.41
Simpson's Diversity—taxonomic	0.89	0.02	0.89	0.01	0.86	0.02	0.83	0.04
Simpson's Diversity—functional group	0.65	0.04	0.67	0.01	0.72	0.02	0.72	0.01
Dominant taxa	20.16	3.93	23.25	3.11	26.42	4.22	31.65	7.42
Tolerance group								
Relative abundance of tolerant taxa (%)	0.20	0.32	0.26	0.39	0.12	0.13	0.13	0.14
Relative abundance of moderately tolerant taxa (%)	31.52	8.14	32.56	5.77	25.19	3.98	29.02	10.79
Relative abundance of intolerant taxa (%)	68.28	8.04	67.18	5.93	74.68	4.00	70.85	10.74
Richness of tolerant taxa (%)	2.87	2.88	2.97	3.11	2.33	2.15	3.20	3.35
Richness of moderately tolerant taxa (%)	24.43	3.22	26.11	2.32	30.01	4.85	27.58	4.40
Richness of intolerant taxa (%)	72.70	5.44	70.92	2.65	67.66	5.27	69.23	4.43
Functional group								
Relative abundance of collector-filterers (%)	21.18	9.31	18.49	3.29	17.91	7.10	26.51	4.31
Relative abundance of collector-gatherers (%)	48.11	7.55	47.95	2.90	29.45	6.89	26.55	5.51
Relative abundance of scrapers (%)	23.50	3.41	23.83	5.91	36.90	5.51	35.85	5.29
Relative abundance of shredders (%)	1.12	0.70	3.40	1.63	10.34	4.29	5.73	2.09
Relative abundance of predators (%)	6.09	1.31	6.33	2.27	5.40	3.63	5.35	2.46
Richness of collector-filterers (%)	14.35	3.21	14.39	0.89	11.29	1.20	13.46	3.68
Richness of collector-gatherers (%)	38.53	2.95	36.31	5.44	29.27	4.30	30.47	2.38
Richness of scrapers (%)	18.71	3.16	14.43	1.46	15.90	4.89	12.48	1.95
Richness of shredders (%)	4.84	1.29	10.21	1.79	14.67	4.66	15.99	3.53
Richness of predators (%)	23.57	6.32	24.65	4.63	28.86	4.84	27.59	6.60
Taxonomic group								
Number of EPT taxa	14.40	1.52	15.80	0.84	11.80	1.64	15.00	2.45
Relative abundance of EPT taxa (%)	41.54	11.16	51.30	10.30	43.70	4.83	46.92	3.69
Relative abundance of Ephemeroptera (%)	25.30	6.87	30.36	5.56	14.53	5.11	19.90	3.09
Relative abundance of Plecoptera (%)	4.76	1.58	6.06	2.58	12.81	2.74	6.05	1.88
Relative abundance of Trichoptera (%)	11.48	4.41	14.88	2.96	16.37	5.72	20.97	6.42
Relative abundance of noninsect taxa (%)	14.49	11.10	7.03	2.54	1.60	1.57	1.18	1.15
Relative abundance of Chironomid Diptera (%)	6.08	2.29	9.03	5.68	10.80	4.65	4.05	2.69
Relative abundance of non-Chironomid Diptera (%)	2.73	1.11	2.96	1.55	4.86	2.09	14.11	4.08
Relative abundance of Coleoptera (%)	35.12	4.71	29.63	8.49	38.55	4.43	33.66	7.62
Relative abundance of Odonata (%)	0.04	0.09	0.05	0.07	0.49	0.92	0.08	0.12

Abundance. Mean abundance of aquatic macroinvertebrates was greatest at our upstream site, RIT02 (fig. 15). Mean abundance from our quantitative targeted riffle samples averaged 760.60 individuals at RIT02 compared to 697.60 individuals at RIT01.

Taxa richness. Taxa richness of quantitative targeted riffle samples averaged 30.00 taxa and 28.40 taxa at RIT02 and RIT01 respectively (fig. 16). Total richness of the qualitative multihabitat sample was higher at both sites. We found 38 taxa at RIT02 and 39 taxa at RIT01.

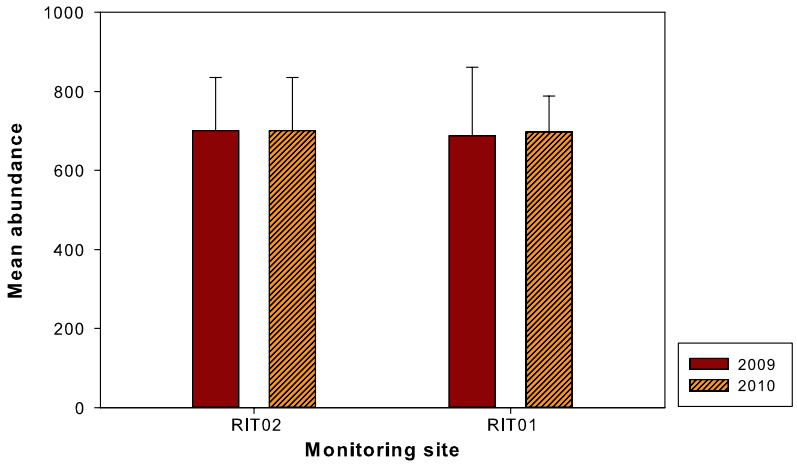


Figure 15. Total abundance expressed as the mean number of individuals per quantitative targeted riffle samples collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2010

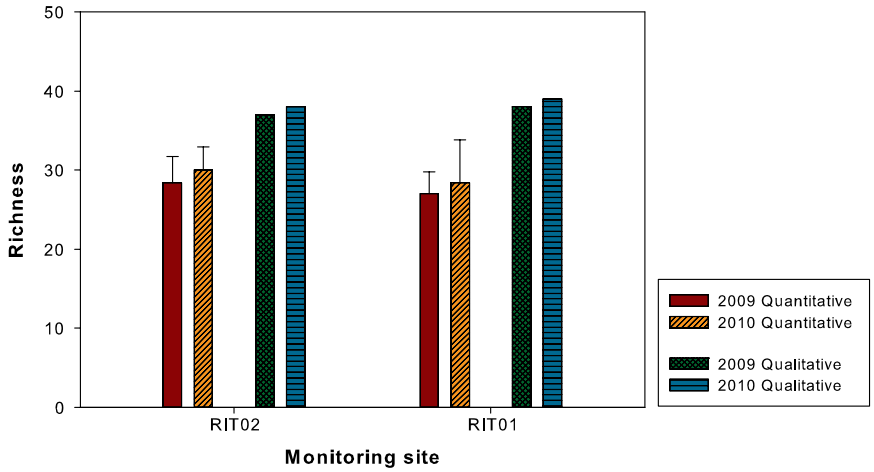


Figure 16. Mean taxa richness in quantitative targeted riffle and total taxa richness in qualitative multihabitat samples collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2010

Diversity. We measured both taxonomic and functional diversity using the Simpson's Diversity Index. Taxonomic diversity averaged 0.89 at RIT02 and 0.83 at RIT01 (fig. 17a). Functional diversity was lower at both sites, averaging 0.67 at RIT02 and 0.72 at RIT01 (fig. 17b).

Anthropogenic stress tolerance. Relative abundance was dominated by intolerant individuals at both sites (fig. 18a). Intolerant individuals averaged 67.18% of the samples collected at RIT02 and 70.85% at RIT01. Moderately tolerant individuals were the next most abundant at both sites, averaging 32.56% at RIT02 and 29.02% at RIT01. Tolerant individuals were found in abundances of 0.26% at RIT02 and 0.13 at RIT01. Taxa richness by tolerance class followed an identical pattern to abundance (fig. 18b). Intolerant taxa were the most species rich at both sampling sites, averaging 70.92% at RIT02 and 69.23% at RIT01. Moderately tolerant taxa averaged 26.11% and 27.58% at RIT02 and RIT01, respectively. Tolerant taxa averaged 2.97% at RIT02 and 3.20% at RIT01.

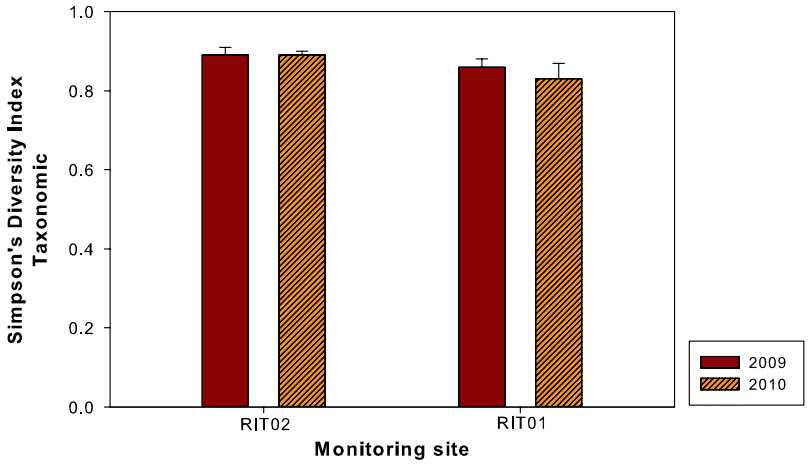


Figure 17a. Simpson's Diversity Index for taxonomic diversity in quantitative targeted riffle samples from RIT02and RIT01 at the Rito de los Frijoles in BAND, 2009–2010

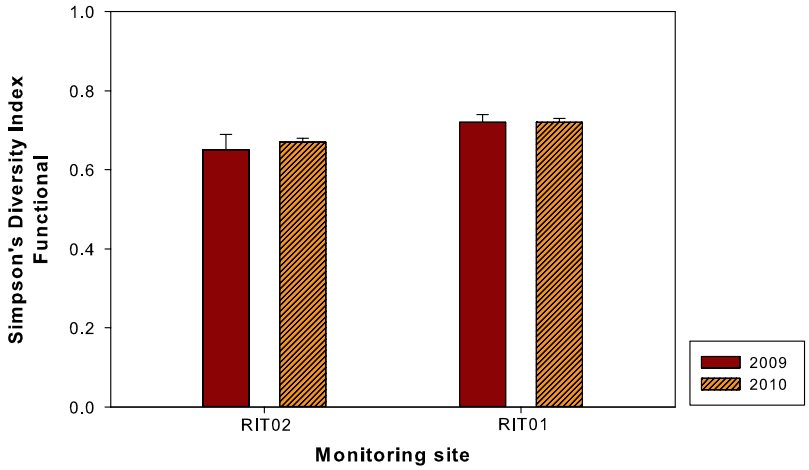


Figure 17b. Simpson's Diversity Index for functional diversity in quantitative targeted riffle samples from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2010

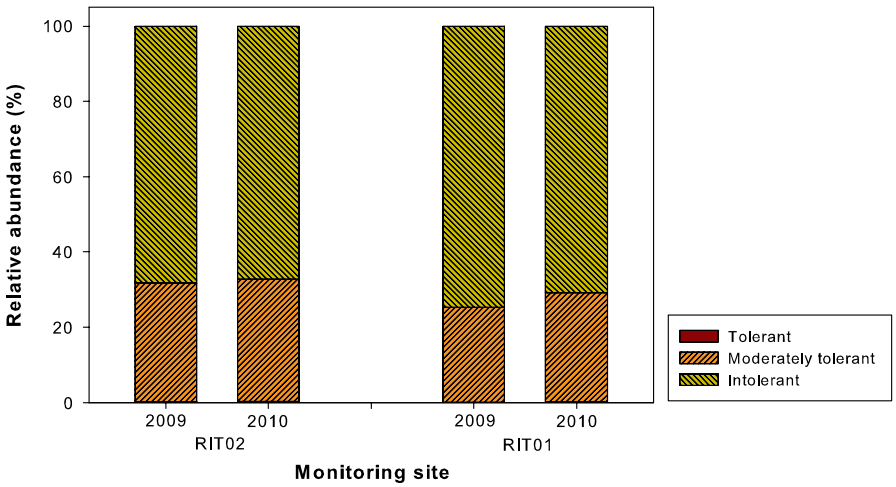
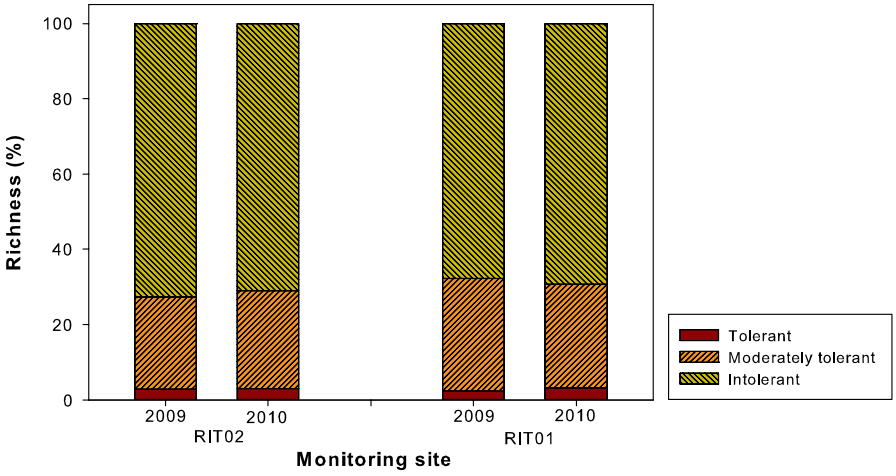


Figure 18a. Mean relative abundance of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2010, based on their tolerance to perturbation

Figure 18b. Mean richness of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2010, based on their tolerance to perturbation



EPT taxa. EPT taxa were abundant at both monitoring sites in 2010 (fig. 19). Relative abundance of EPT taxa was 51.30% at RIT02 and 46.92% at RIT01. At RIT02, Ephemeroptera dominated EPT individuals, at 30.36% of the sample collected. Trichopterans averaged 14.88% and plecopterans 6.06%. Trichopterans were the most abundant EPT taxa at RIT01, averaging 20.97% of the individuals col-lected. Ephemeropterans and plecopterans averaged 19.90% and 6.05%, respectively.

Aquatic macroinvertebrate orders. Ephemeropterans were the most abundant order sampled at RIT02 in 2010 (fig. 20). Coleopterans were the second most abundant at 29.63%, followed by trichopterans at 14.88%, chironomids at 9.03%, and noninsect taxa at 7.03%. Non-chironomid dipterans and odonates were the least abundant orders at RIT02, averaging 2.96% and 0.05%, respectively. At RIT01, coleopterans were the most abundant order sampled, averaging 33.66% of the individuals collected, followed by trichopterans, and then ephemeropterans. Non-chironomid dipterans averaged 14.11%, and chironomids averaged 4.05% of the individuals collected at RIT01. Noninsect taxa and odonates were the least abundant orders sampled at RIT01, averaging 1.18% and 0.08% respectively.

Functional feeding groups. Collector-gatherers were the most abundant functional feeding group collected at RIT02, averaging 47.95% of the individuals collected (fig. 21). Scrapers averaged 23.83% of the individuals at RIT02 followed by collector-filterers (18.49%), predators (6.33%), and shredders (3.40%). Scrapers were the most abundant functional group sampled at RIT01, averaging 35.85% of the individuals collected. Collector-gatherers and collector-filterers were similar in their abundances, averaging 26.55% and 26.51% respectively. Shredders and predators were the least abundant of the functional feeding groups, at 5.73% and 5.35%, respectively.

3.5 Physical habitat characteristics for the Rito de los Frijoles

This section presents data describing physical habitat characteristics collected during 2009 and 2010 at RIT01 and RIT02. These data are summarized in Table 8; additional transect data can be found in Appendix D.

Microhabitat level. Mean velocity and depths at quantitative targeted riffles did not differ greatly at the Rito de los Frijoles monitoring sites (table 8). Flow velocities averaged 0.40 m/s at RIT02 and 0.39 m/s at RIT01. The depth at riffles averaged 0.08 m at RIT02 and 0.11 m at RIT01. Substrate embeddeness was greater downstream at RIT01, where on average 51% of each particle was embedded while an average of 33% of each particle was embedded at RIT02.

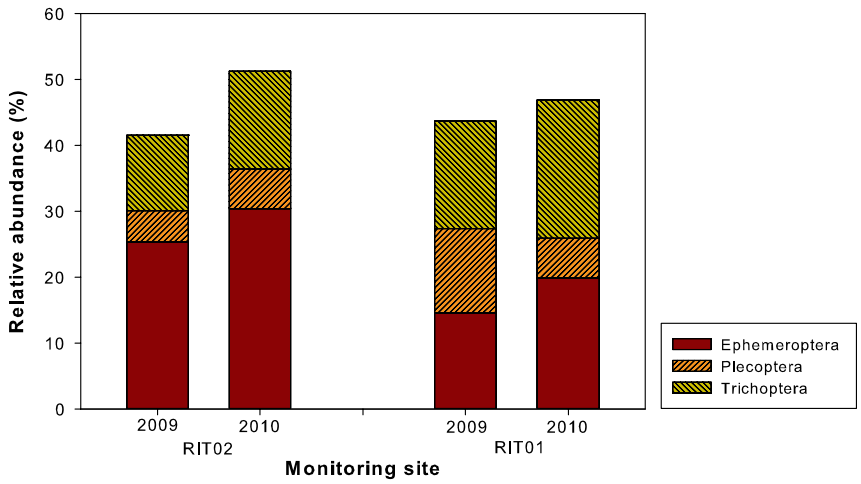


Figure 19. Relative abundance of EPT taxa in quantitative targeted riffle samples collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2010

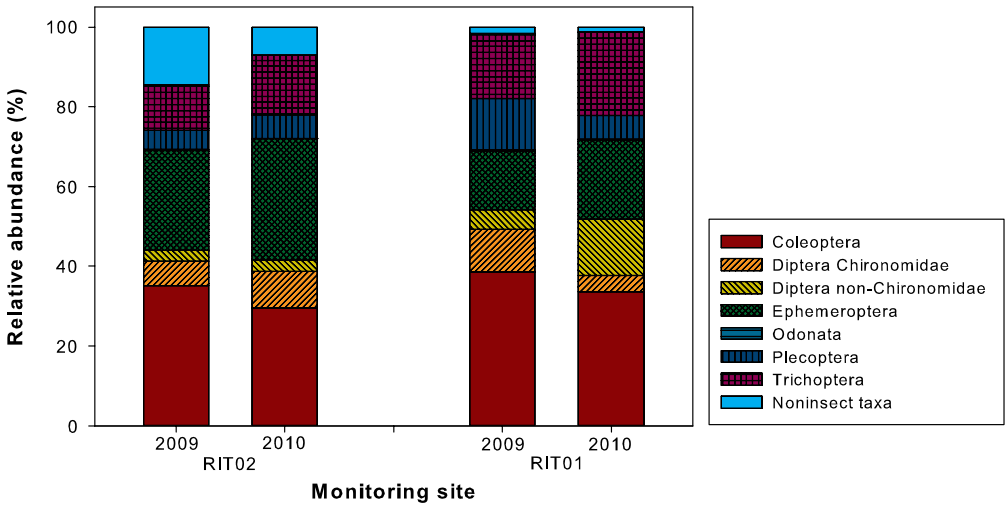


Figure 20. Relative abundance of individuals by taxonomic order in quantitative targeted riffle samples collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2010

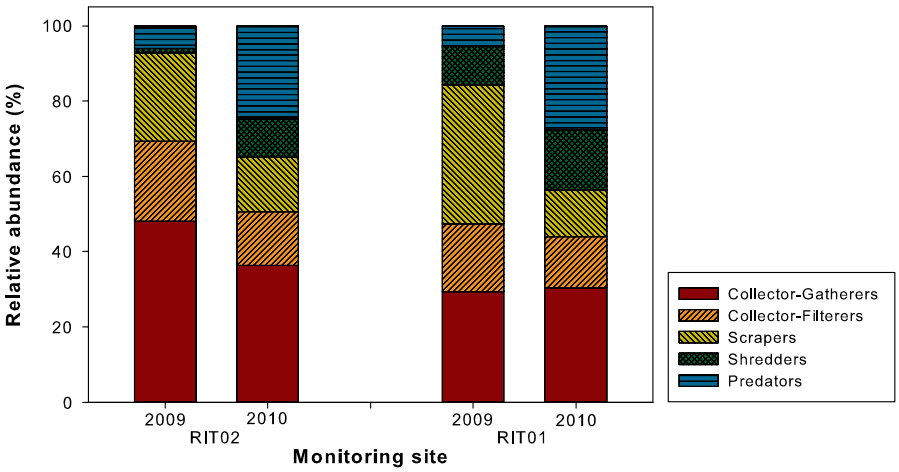


Figure 21. Relative abundance of functional feeding groups in quantitative targeted riffle samples collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2010

Table 8. Physical habitat and hydrologic data from RIT01 and RIT02 at the Rito de los Frijoles in Bandelier National Monument, New Mexico, 2009-2010. Particle embeddedness and canopy closure measurements are expressed as percentages.

	RIT02				RIT01			
	2009		2010		2009		2010	
Physical habitat metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Microhabitat level								
Riffles								
Velocity (m/s)	0.50	0.18	0.40	0.16	0.46	0.13	0.39	0.15
Depth (m)	0.12	0.03	0.08	0.02	0.12	0.02	0.11	0.02
Embeddedness (%)	30.6	13.8	33.0	16.0	50.0	24.4	51.0	20.1
Transect level								
Channel dimensions								
Velocity (m/s)	0.25	0.12	0.23	0.08	0.20	0.17	0.20	0.08
Depth (m)	0.09	0.05	0.10	0.04	0.09	0.06	0.08	0.03
Wetted channel width (m)	2.3	0.6	2.1	0.6	2.3	2.4	1.5	0.7
Active channel width (m)	4.2	0.8	5.8	1.4	10.5	3.2	11.9	3.3
Riparian cover								
Canopy closure (%)	72.9	22.4	61.9	20.3	79.6	14.1	69.9	25.3
Reach level								
Water quality	**Value**		**Value**		**Value**		**Value**	
Temperature (°C)	10.3		5.8		12.3		5.8	
Specific conductivity (µS/cm)	107		114		111		108	
pH	7.9		7.6		7.8		7.9	
Dissolved oxygen (% saturation)	94.7		102.5		94.4		98.5	
Dissolved oxygen (mg/L)	8.2		10.1		7.8		9.6	
Turbidity (NTU)	2.2		1.4		2.2		2.4	
Discharge (cfs)	—		1.2		—		0.7	

Transect level. Active and wetted channel widths differed between the two sites (table 8). Active channel width was narrower upstream, averaging 5.8 m at RIT02. In comparison, the active channel width at RIT01 averaged 11.9 m. Wetted channel width was wider upstream at RIT02, averaging 2.1 m compared to 1.5 m at RIT01. Stream flow and depth did not differ largely between the two sites. Stream flows averaged 0.23 m/s at RIT02 and 0.20 m/s at RIT01. Stream depth along transects was slightly deeper upstream at RIT02, averaging 0.10 m compared to 0.08 m downstream at RIT01.

Aquatic macroinvertebrate habitat types were dominated by rocks at RIT02, making up 50.0% of the site, and leaf packs at RIT01, which made up 29.3% (fig. 22). Forty percent of RIT01 and 23.0% of RIT02 lacked habitat that we have defined as appropriate for aquatic macroinvertebrates.

Reach level. Channel structure dynamics are represented by particle size distributions in Figure 23, and are based on modified Wolman pebble counts. In 2010, particle size distributions were dominated by cobbles (64–128 mm), making up 25.3% of RIT02, and fines (<2 mm) which made up 33.9% of RIT01. At RIT02, very coarse gravels (32–64 mm) and coarse gravels (16–32 mm) were the next most abundant size classes at 19.6% and 11.0%, respectively. Cobbles and very coarse gravels followed fines in abundance values at RIT01, making up 12.5% and 10.5% of the reach, respectively.

Riffles (40.5%) and runs (21.0%) were the dominant GCU's along RIT02 (fig. 24). Further downstream, runs (47.7%) dominated RIT01, followed by riffles, which made up 29.4% of the reach. For a complete description of GCUs see Brasher et al. (2011).

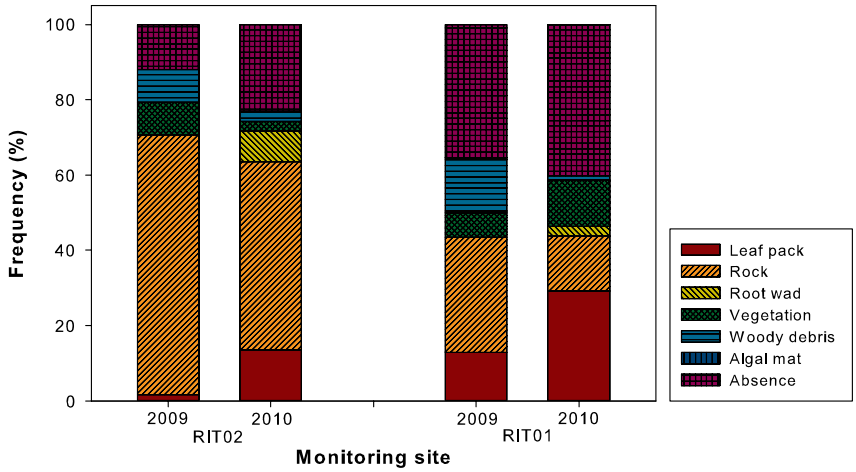


Figure 22. Aquatic macroinvertebrate habitat characterization based upon line point intercept data collected at habitat transects in quantitative targeted riffle samples from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2010. Not all habitat structure types were observed.

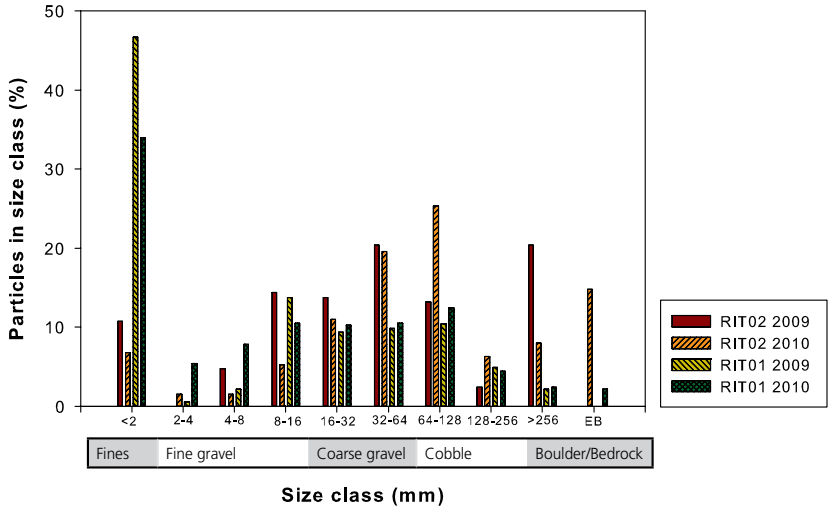
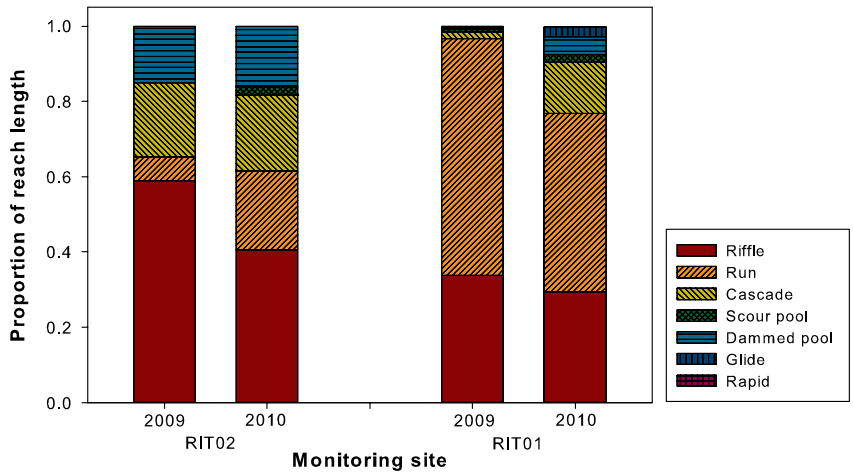


Figure 23. Particle size distribution, based on a minimum of 400 particles, from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2010

Figure 24. Geomorphic channel unit characterization of RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2010



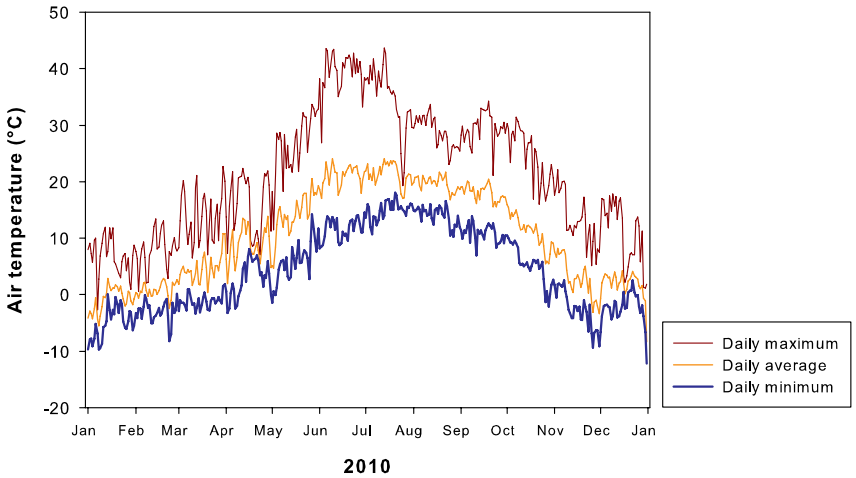
3.6 Hydrologic conditions for the Rito de los Frijoles

3.6.1 SCPN field data

This was the third consecutive year we collected water quality data while sampling aquatic macroinvertebrates at the Rito de los Frijoles. Table 8 presents recorded measurements at or near midday of the sample date. The midday temperature was 5.8°C for both RIT02 and RIT01. Specific conductivity at RIT02 was 114 µS/cm and 108 µS/cm at RIT01. pH at RIT01 was 7.9 and 7.6 at RIT02. Dissolved oxygen at RIT02 was 102.5% saturation and 10.1 mg/L. Dissolved oxygen at RIT01 measured 98.5% saturation and 9.6 mg/L. Turbidity at RIT01 averaged 2.4 NTU and 1.4 NTU at RIT02. In addition to these water quality parameters, we measured total discharge at RIT02 (1.2 cfs) and at RIT01 (0.7 cfs).

Air and water temperatures are recorded quarter-hourly at the Rito de los Frijoles. The average air and water temperatures at RIT01 were 10.4°C and 8.9°C, respectively. Air temperature reached a maximum of 43.6°C on 13 July and a minimum of -12.2°C on 31 December (fig. 25a). Water temperature at RIT01 reached a maximum of 19.2°C on 05 September and minimum of -5.5°C on 31 January (fig. 25b). The spike in water temperature values at RIT01 from June to late July, similar to air datalogger values for that same time period, indicates that the water datalogger was not submerged during that time period. Additionally, from late July to mid September daily maximum, average, and minimum air temperatures are similar, indicating that the datalogger may have been buried by sediments brought downstream from a precipitation event.

Figure 25a. Daily air temperature statistics from RIT01 at the Rito de los Frijoles in BAND, 2010



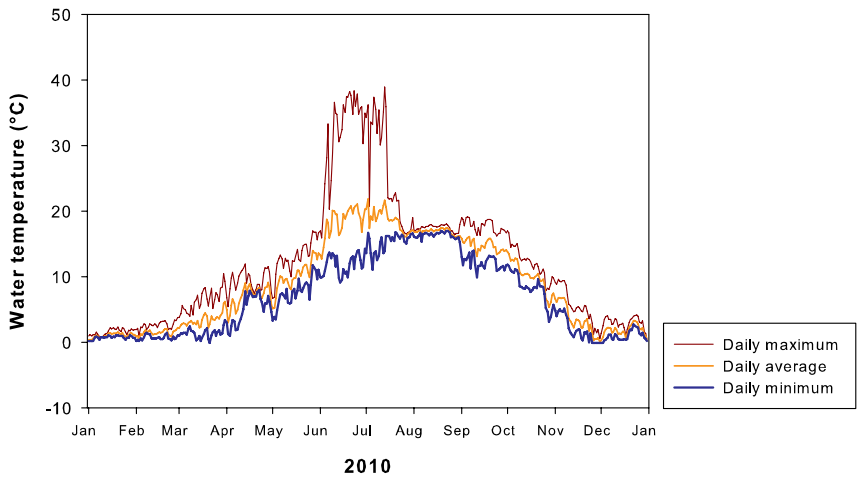


Figure 25b. Daily water temperature statistics from RIT01 at the Rito de los Frijoles in BAND, 2010

At RIT02, the average air temperature and water temperature was 6.8°C and 9.0°C, respectively. Air temperature reached a maximum of 34.9°C on 5 June and minimum of -18.8°C on 31 December (fig. 26a). Water temperature at RIT02 reached at maximum of 18.7°C on 17 July and minimum of 0.01°C on 31 December (fig. 26b).

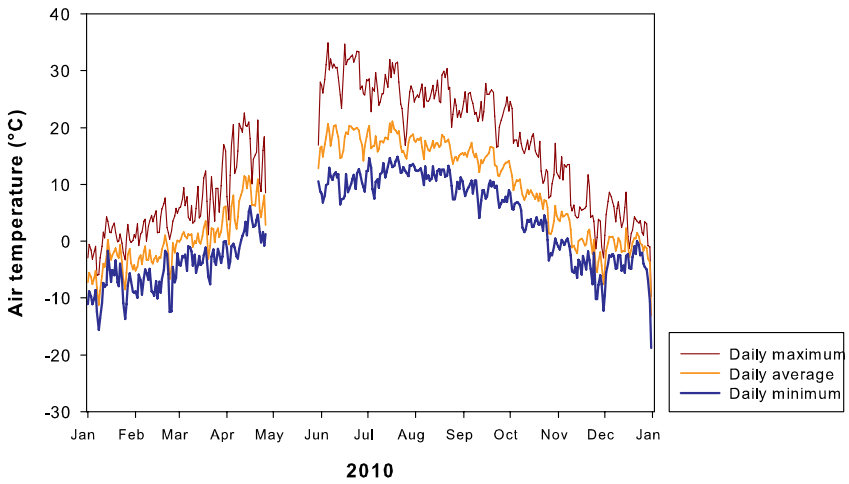


Figure 26a. Daily air temperature statistics from RIT02 at the Rito de los Frijoles in BAND, 2010. The gaps between May and June indicate missing data for that period.

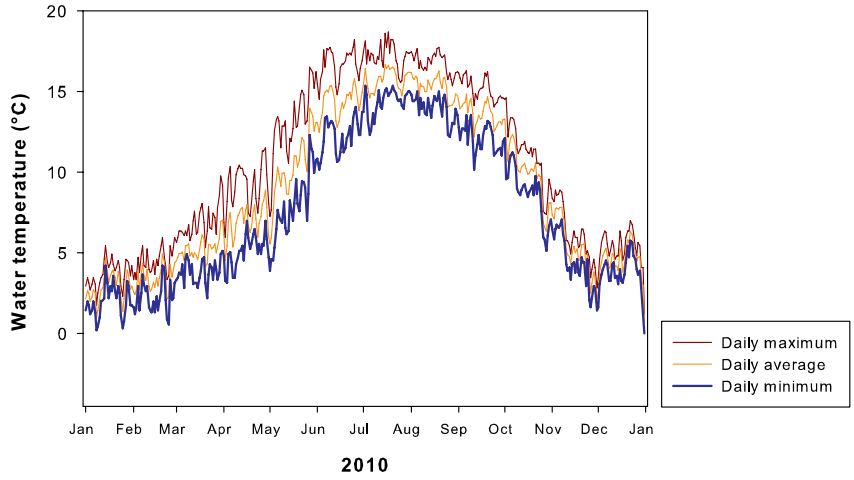


Figure 26b. Daily water temperature statistics from RIT02 at the Rito de los Frijoles in BAND, 2010

3.6.2 LANL station data

Mean daily stream discharge from the gauging station, LANL-E350, is presented in Figure 27.

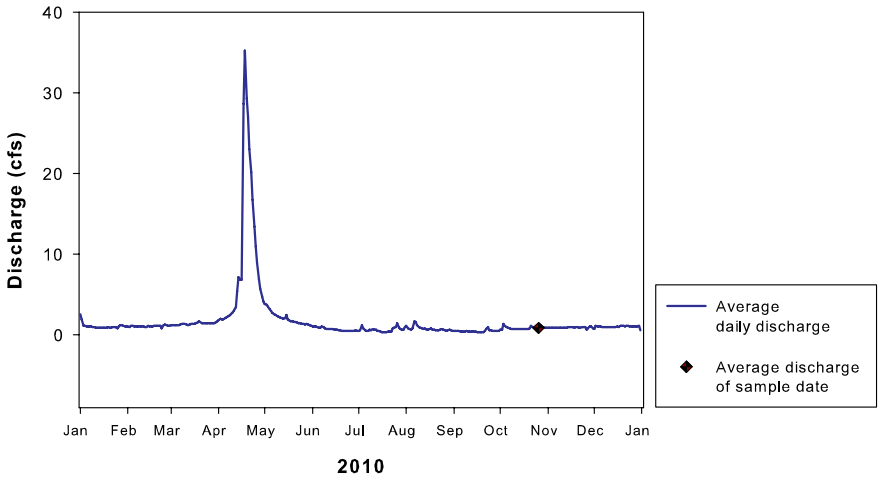


Figure 27. Mean daily discharge from LANL-E350 at the Rito de los Frijoles in BAND, 2010

4 Discussion

This report presents data from SCPN's fourth year of monitoring aquatic macroinvertebrates and physical habitat at Capulin Creek, as well as our second year of monitoring aquatic macroinvertebrates and physical habitat at the Rito de los Frijoles in Bandelier National Monument, New Mexico. We stress that any differences between sampling years and locations should not to be interpreted as an ecologically significant trend, as trends cannot be determined with confidence by a few years of sampling data.

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

4.1 Aquatic macroinvertebrate communities

Data collected from Capulin Creek show a steady increase in aquatic macroinvertebrate abundance at both monitoring sites during the past four years (tables 2, 3). Likewise, abundance values increased at both sites on the Rito de los Frijoles between 2009 and 2010 (table 7). Taxonomic diversity remains high at all sites in 2010, ranging from a low of 0.80 at CAP02, to a high of 0.89 at RIT02.

Overall, CAP01 is the most species rich, and most diverse of the two monitoring sites on Capulin Creek. Quantitative targeted riffle samples, on average, have nearly 200 more individuals per sample than samples collected at CAP02. On average, samples collected from CAP01 had 10 more taxa than CAP02 for both quantitative and qualitative samples. On the Rito de los Frijoles, the RIT02 site averaged 63 more individuals and two more taxa per quantitative sample. Taxonomic diversity was greater at RIT02, but functional diversity was greater at RIT01.

4.2 Anthropogenic stress tolerance of aquatic communities

Aquatic macroinvertebrate taxa differ in their abilities to withstand anthropogenic perturbations to the aquatic environment. Separating taxa based on their tolerance to perturbation allows us to make inferences about the response of aquatic macroinvertebrate populations to stream conditions during our sampling period. Intolerant individuals and taxa overwhelmingly dominated samples collected

from CAP01 (table 2). At CAP02, abundance and richness was evenly split between moderately tolerant and intolerant organisms. While our data does not suggest that a disturbance is occurring at CAP02, it does suggest that there is some component or suite of components, abiotic or biotic, of the ecosystem that allow for more favorable conditions for aquatic macroinvertebrates at CAP01. The abundance of intolerant taxa and individuals at both sites along the Rito de los Frijoles suggest that this stream may have been experiencing very little stress or disturbance in 2010. Approximately 70% of all taxa and individuals collected at both sites along the Rito de los Frijoles belonged to the group of intolerant taxa. Tolerant taxa abundances at these sites were less than 1%.

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

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Appendix A Monitoring sites at Bandelier National Monument, New Mexico, 2010

Site code	Common name	Report name	UTM X	UTM Y	Elevation (m)
BANDCAP01	Capulin Creek at Base Camp Gauging Station	CAP01	379713	3958026	1904
BANDCAP02	Capulin Creek above Painted Cave	CAP02	380300	3955457	1791
BANDRIT01	Rito de los Frijoles near Visitor Center	RIT01	385363	3959889	1840
BANDRIT02	Rito de los Frijoles at Upper Crossing	RIT02	377109	3964316	2151

Appendix B Selected aquatic macroinvertebrate metrics

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

Source: Data from Brasher et al. (2011)

Appendix C Aquatic macroinvertebrate species list from all monitoring sites in Bandelier National Monument, New Mexico, 2010. A bold **X** under the site column denotes a new record for this SCPN monitoring site.

Phylum	Class	Order	Family	SubFamily	Genus	Species	Common name	CAP01	CAP02	RIT01	RIT02
Annelida							segmented worms	X	X	X	X
Arthropoda	Arachnida	Trombidiformes	Hydryphantidae		*Protzia* sp.		water mites			**X**	**X**
Arthropoda	Arachnida	Trombidiformes	Hygrobatidae		*Hygrobates*		water mites	X			
Arthropoda	Arachnida	Trombidiformes	Hygrobatidae				water mites			X	X
Arthropoda	Arachnida	Trombidiformes	Sperchonidae		*Sperchon* sp.		water mites	X	X	X	X
Arthropoda	Arachnida	Trombidiformes	Sperchonidae		*Sperchonopsis* sp.		water mites				X
Arthropoda	Arachnida	Trombidiformes	Sperchonidae				water mites	X	X	X	
Arthropoda	Arachnida	Trombidiformes	Torrenticolidae		*Torrenticola* sp.		water mites			**X**	
Arthropoda	Arachnida	Trombidiformes	Torrenticolidae				water mites				X
Arthropoda	Arachnida	Trombidiformes					water mites	X			
Arthropoda	Insecta	Coleoptera	Dytiscidae	Agabinae	*Agabus* sp.		predaceous diving beetle		X	X	
Arthropoda	Insecta	Coleoptera	Dytiscidae	Hydroporinae			predaceous diving beetle		**X**		
Arthropoda	Insecta	Coleoptera	Dytiscidae				predacious diving beetle	X	X	X	
Arthropoda	Insecta	Coleoptera	Elmidae		*Narpus*	*concolor*	riffle beetles	X			X
Arthropoda	Insecta	Coleoptera	Elmidae		*Optioservus*	*quadrimaculatus*	riffle beetles	X	X	X	X
Arthropoda	Insecta	Coleoptera	Elmidae		*Optioservus* sp.		riffle beetles	X	X	X	X
Arthropoda	Insecta	Coleoptera	Elmidae		*Zaitzevia*	*parvula* (Horn)	riffle beetles	X	X	X	X
Arthropoda	Insecta	Coleoptera	Elmidae				riffle beetles	X	X	X	X
Arthropoda	Insecta	Coleoptera	Hydraenidae		*Hydraena* sp.		minute moss beetle	**X**	X		
Arthropoda	Insecta	Coleoptera	Hydrophilidae		*Paracymus* sp.		water scavenger beetles		X	X	
Arthropoda	Insecta	Diptera	Empididae	Hemerodromiinae	*Chelifera* sp.		dance flies	X	X		
Arthropoda	Insecta	Diptera	Empididae		*Neoplasta* sp.		dance flies		X	X	X
Arthropoda	Insecta	Diptera	Empididae				dance flies	X	X	X	
Arthropoda	Insecta	Diptera	Stratiomyidae		*Caloparyphus* sp.		solider flies	X		X	
Arthropoda	Insecta	Diptera	Stratiomyidae		*Euparyphus* sp.		solider flies			X	
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae	*Probezzia* sp.		biting midges	X	X	X	X
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae			biting midges		X		
Arthropoda	Insecta	Diptera	Ceratopogonidae	Dasyheleinae	*Dasyhelea*		biting midges		X	**X**	X
Arthropoda	Insecta	Diptera	Ceratopogonidae	Forcipomyiinae	*Atrichopogon* sp.		biting midges			**X**	

Appendix C (*continued*)

Phylum	Class	Order	Family	SubFamily	Genus	Species	Common name	CAP01	CAP02	RIT01	RIT02
Arthropoda	Insecta	Diptera	Ceratopogonidae				biting midges		X	X	X
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae			midges	X	X	X	X
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae			midges	X	X	X	X
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae			midges	X	X	X	X
Arthropoda	Insecta	Diptera	Chironomidae				midges	**X**	X	X	X
Arthropoda	Insecta	Diptera	Dixidae		*Dixa* sp.		meniscus midges	X	X	X	X
Arthropoda	Insecta	Diptera	Dixidae				meniscus midges	X	X		
Arthropoda	Insecta	Diptera	Psychodidae		*Maruina* sp.		moth flies	X	X	X	X
Arthropoda	Insecta	Diptera	Psychodidae		*Pericoma* sp.		moth flies	X		X	X
Arthropoda	Insecta	Diptera	Ptychopteridae		*Ptychoptera* sp.		phantom crane flies				X
Arthropoda	Insecta	Diptera	Simuliidae	Simuliinae	*Simulium* sp.		black flies	X	X	X	X
Arthropoda	Insecta	Diptera	Simuliidae				black flies	**X**	X	X	X
Arthropoda	Insecta	Diptera	Tipulidae	Limoniinae	*Antocha*	*monticola*	crane flies	**X**			X
Arthropoda	Insecta	Diptera	Tipulidae	Limoniinae	*Erioptera* sp.		crane flies	**X**			
Arthropoda	Insecta	Diptera	Tipulidae	Limoniinae	*Limnophila* sp.		crane flies	**X**		X	**X**
Arthropoda	Insecta	Diptera	Tipulidae	Limoniinae	*Rhabdomastix* sp.		crane flies			X	
Arthropoda	Insecta	Diptera	Tipulidae	Tipulinae	*Tipula* sp.		crane flies	X	X	X	X
Arthropoda	Insecta	Diptera	Tipulidae		*Dicranota* sp.		crane flies	**X**	X	X	X
Arthropoda	Insecta	Diptera	Tipulidae		*Hexatoma* sp.		crane flies	X		X	
Arthropoda	Insecta	Diptera	Tipulidae		*Pedicia* sp.		crane flies	X	X		
Arthropoda	Insecta	Diptera	Tipulidae				crane flies	X	X	X	
Arthropoda	Insecta	Diptera					flies		X		
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae		*Drunella*	*grandis*	spiny crawler mayflies			X	**X**
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae		*Drunella* sp.		spiny crawler mayflies			X	
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae		*Ephemerella* sp.		spiny crawler mayflies	X	X	X	X
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae				spiny crawler mayflies		X	X	X
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae		*Tricorythodes* sp.		little stout crawler mayflies	X		X	
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae		*Paraleptophlebia* sp.		pronggilled mayflies	X		X	X
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae				pronggilled mayflies	X			X

Appendix C (*continued*)

Phylum	Class	Order	Family	SubFamily	Genus	Species	Common name	CAP01	CAP02	RIT01	RIT02
Arthropoda	Insecta	Ephemeroptera	Ameletidae		*Ameletus* sp.		combmouthed minnow mayflies			X	X
Arthropoda	Insecta	Ephemeroptera	Baetidae		*Acentrella* sp.		small minnow mayflies			X	
Arthropoda	Insecta	Ephemeroptera	Baetidae		*Baetis* sp.		small minnow mayflies	X	X	X	X
Arthropoda	Insecta	Ephemeroptera	Baetidae		*Diphetor*	*Diphetor hageni*	small minnow mayflies				X
Arthropoda	Insecta	Ephemeroptera	Baetidae		*Fallceon*	*quilleri*	small minnow mayflies	X		X	
Arthropoda	Insecta	Ephemeroptera	Baetidae				small minnow mayflies		X	X	X
Arthropoda	Insecta	Ephemeroptera	Heptageniidae		*Cinygmula* sp.		stream mayflies				X
Arthropoda	Insecta	Ephemeroptera	Heptageniidae		*Epeorus* sp.		stream mayflies	**X**		X	X
Arthropoda	Insecta	Ephemeroptera	Heptageniidae				stream mayflies				X
Arthropoda	Insecta	Hemiptera	Gerridae	Gerrinae	*Aquarius* sp.		water striders			**X**	
Arthropoda	Insecta	Hemiptera	Veliidae	Microveliinae	*Microvelia* sp.		small water striders	X		X	
Arthropoda	Insecta	Lepidoptera	Crambidae	Nymphulinae	*Petrophila* sp.		crambid snout moths			X	
Arthropoda	Insecta	Odonata	Aeshnidae		*Aeshna* sp.		mosaic darners	**X**			
Arthropoda	Insecta	Odonata	Aeshnidae		*Oplonaeschna*	*armata*	riffle darners	X		X	**X**
Arthropoda	Insecta	Odonata	Aeshnidae				darners	X	X	X	
Arthropoda	Insecta	Odonata	Cordulegastridae		*Cordulegaster*	*dorsalis*	pacific spiketails	X			**X**
Arthropoda	Insecta	Odonata	Libellulidae				skimmers			**X**	
Arthropoda	Insecta	Odonata	Coenagrionidae		*Argia* sp.		dancers			X	
Arthropoda	Insecta	Odonata	Coenagrionidae				winged damselflies	X			
Arthropoda	Insecta	Odonata					damselflies/dragonflies	X			
Arthropoda	Insecta	Plecoptera	Capniidae	Capniinae			small winter stoneflies	**X**	X	X	**X**
Arthropoda	Insecta	Plecoptera	Nemouridae		*Zapada*	*cintipes*	spring stoneflies	**X**	X	X	X
Arthropoda	Insecta	Plecoptera	Nemouridae				spring stoneflies		X	X	X
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Chloroperlinae			green stoneflies	X	**X**	**X**	
Arthropoda	Insecta	Plecoptera	Chloroperlidae		*Sweltsa* sp.		green stoneflies	X	X	X	X
Arthropoda	Insecta	Plecoptera	Perlidae		*Hesperoperla*	*pacifica*	golden stonefies			X	X
Arthropoda	Insecta	Plecoptera	Perlidae				common stoneflies				X
Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperlinae	*Isoperla* sp.		green-winged stoneflies	X	X		X
Arthropoda	Insecta	Plecoptera	Perlodidae				perlodid stoneflies	X	X	X	X
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcyinae	*Pteronarcella*	*badia*	giant stoneflies			X	

Appendix C (*continued*)

Phylum	Class	Order	Family	SubFamily	Genus	Species	Common name	CAP01	CAP02	RIT01	RIT02
Arthropoda	Insecta	Plecoptera					stoneflies	X	X	X	X
Arthropoda	Insecta	Trichoptera	Brachycentridae		*Brachycentrus*	*americanus*	humpless casemaker caddisflies			X	
Arthropoda	Insecta	Trichoptera	Brachycentridae		*Brachycentrus* sp.		humpless casemaker caddisflies			**X**	
Arthropoda	Insecta	Trichoptera	Brachycentridae		*Micrasema* sp.		humpless casemaker caddisflies				X
Arthropoda	Insecta	Trichoptera	Brachycentridae				humpless casemaker caddisflies			**X**	
Arthropoda	Insecta	Trichoptera	Calamoceratidae				caddisflies	X			
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosomatinae	*Glossosoma* sp.		little black caddisflies	X		X	X
Arthropoda	Insecta	Trichoptera	Glossosomatidae				little black caddisflies	X		X	X
Arthropoda	Insecta	Trichoptera	Helicopsychidae		*Helicopsyche* sp.		snail-case caddisflies	X	X		
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	*Cheumatopsyche* sp.		netspinning caddisflies	**X**			
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	*Hydropsyche* sp.		netspinning caddisflies	X		X	X
Arthropoda	Insecta	Trichoptera	Hydropsychidae				netspinning caddisflies	X		X	X
Arthropoda	Insecta	Trichoptera	Hydroptilidae				microcaddisflies		X	X	
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostomatinae	*Lepidostoma* sp.		bizarre caddisflies	X	X	X	X
Arthropoda	Insecta	Trichoptera	Leptoceridae	Leptocerinae	*Oecetis* sp.		longhorned caddisflies	X			
Arthropoda	Insecta	Trichoptera	Limnephilidae	Limnephilinae	*Hesperophylax* sp.		northern caddisflies			**X**	
Arthropoda	Insecta	Trichoptera	Limnephilidae				northern caddisflies	X	X	X	X
Arthropoda	Insecta	Trichoptera	Philopotamidae	Philopotaminae	*Dolophilodes* sp.		fingernet caddisflies				X
Arthropoda	Insecta	Trichoptera	Philopotamidae	Philopotaminae	*Wormaldia* sp.		fingernet caddisflies				X
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropo-dinae	*Polycentropus* sp.		tube maker caddisflies	X		**X**	
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropo-dinae			tube maker caddisflies	X			
Arthropoda	Insecta	Trichoptera	Rhyacophilidae		*Rhyacophila* sp.		green sedges				X
Arthropoda	Insecta	Trichoptera	Uenoidae		*Oligophlebodes* sp.		stone case caddisflies				X
Arthropoda	Insecta	Trichoptera					caddisflies	X	X	X	X
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidiinae	*Pisidium* sp.		pea clam mussels	X	X	X	X
Nemata							nematodes				X

Appendix D Measured velocity and channel characteristics at four monitoring sites in Bandelier National Monument, New Mexico, 2010

	Velocity (m/s)		Depth (m)		Wetted channel width (m)	Active channel width (m)
Transect	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Value**	**Value**
CAP01						
1	0.13	0.10	0.06	0.04	1.6	4.7
2	0.12	0.07	0.12	0.04	1.0	7.6
3	0.07	0.06	0.09	0.03	1.4	15.7
4	0.10	0.06	0.08	0.04	1.1	15.8
5	0.05	0.11	0.07	0.03	2.3	16.3
6	0.04	0.10	0.10	0.01	2.0	5.3
7	0.05	0.09	0.06	0.03	1.4	6.7
8	0.20	0.11	0.06	0.02	1.2	6.2
9	0.11	—	0.06	—	1.8	9.0
10	0.51	0.01	0.03	0.02	1.9	11.0
11	0.12	0.10	0.03	0.02	2.1	12.7
CAP02						
1	0.09	0.07	0.04	0.03	1.0	7.3
2	0.04	0.09	0.09	0.06	1.0	7.5
3	0.14	0.10	0.04	0.01	1.0	3.7
4	0.05	0.04	0.14	0.01	0.6	7.2
5	0.07	0.08	0.03	0.03	0.7	16.9
6	0.04	0.02	0.08	0.02	1.4	24.2
7	0.05	0.05	0.08	0.03	1.4	18.8
8	0.12	0.07	0.03	0.02	1.2	11.8
9	—	—	—	—	12.0	13.2
10	0.09	0.05	0.07	0.02	0.8	15.3
11	0.07	0.05	0.06	0.02	1.9	11.2
RIT01						
1	0.28	0.14	0.07	0.02	1.3	16.3
2	0.27	0.21	0.07	0.03	1.1	16.1
3	0.27	0.17	0.05	0.03	1.3	7.8
4	0.14	0.11	0.08	0.04	1.7	12.1
5	0.36	0.19	0.06	0.02	0.8	9.0
6	0.09	0.15	0.12	0.03	1.5	13.7
7	0.24	0.09	0.06	0.02	1.6	10.2
8	0.18	0.17	0.10	0.02	1.2	6.9
9	0.13	0.15	0.04	0.02	3.4	9.7
10	0.14	0.18	0.14	0.04	1.0	13.5
11	0.12	0.13	0.09	0.05	1.7	15.3

Appendix D (*continued*)

	Velocity (m/s)		Depth (m)		Wetted channel width (m)	Active channel width (m)
Transect	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Value**	**Value**
RIT02						
1	0.18	0.17	0.07	0.03	3.5	6.4
2	0.24	0.09	0.08	0.03	2.2	5.4
3	0.28	0.11	0.09	0.04	1.9	7.2
4	0.28	0.18	0.07	0.03	1.8	5.9
5	0.23	0.14	0.05	0.03	2.5	4.1
6	0.17	0.18	0.09	0.02	2.2	6.5
7	0.17	0.14	0.11	0.06	1.6	5.5
8	0.11	0.13	0.12	0.06	2.1	3.3
9	0.18	0.05	0.22	0.04	0.9	5.1
10	0.23	0.08	0.09	0.04	2.0	5.5
11	0.42	0.23	0.09	0.04	2.1	8.6