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

2011 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2012/415

ON THE COVER
Capulin Creek after the Las Conchas Fire in 2011, Bandelier National Monument
Photograph courtesy of SCPN

Errata

Page number, and metric or text containing the error	Error	Correction
12 (Table 3, CAP01 site)		
Microhabitat level values for 2009:		
Mean depth (standard deviation)	0.25 (0.39)	0.08 (0.02)
Reach level values for 2011:		
Specific conductivity	212	265
Turbidity	7.5	7.3
Discharge	<0.1	0.6
13 (Table 4, CAP02 site)		
Reach level values for 2011:		
Specific conductivity	155	314
Turbidity	76.0	79
Discharge	<0.1	0.4
15 (Section 3.3)		
These three sentences reference the Table 3 and Table 4 values that were in error.	Specific conductivity was higher upstream at CAP01, measuring 212 µS/cm compared to 155 µS/cm downstream at CAP02. Turbidity was 7.5 NTU at CAP01 and 76.0 NTU at CAP02. Total discharge at CAP01 was 0.02 cfs, and 0.01 cfs at CAP02.	Specific conductivity was lower upstream at CAP01, measuring 265 µS/cm compared to 314 µS/cm downstream at CAP02. Turbidity was 7.3 NTU at CAP01 and 79 NTU at CAP02. Total discharge at CAP01 was 0.6 cfs, and 0.4 cfs at CAP02.
22 (Table 8)		
Reach level values for 2011:		
RIT02:		
Turbidity	4.3	4.2
Discharge	<0.1	1.5
RIT01:		
Specific conductivity	172	283
Turbidity	234	240
Discharge	<0.1	0.6

Errata (continued)

Page number, and metric or text containing the error	Error	Correction
24/25 (Section 3.6.1)		
These three sentences reference the Table 8 values that were in error.	Specific conductivity at RIT02 was 228 μS/cm and 172 μS/cm at RIT01. Turbidity at RIT02 averaged 4.3 NTU and 234 NTU at RIT01. In addition to these water quality parameters, we measured total discharge at RIT02 (0.04 cfs) and at RIT01 (0.02 cfs).	Specific conductivity at RIT02 was 228 μS/cm and 283 μS/cm at RIT01. Turbidity at RIT02 averaged 4.2 NTU and 240 NTU at RIT01. In addition to these water quality parameters, we measured total discharge at RIT02 (1.5 cfs) and at RIT01 (0.6 cfs).
26 (Section 4.2)		
These two sentences reference Table 4 and Table 8 values that were in error.	Turbidity at CAP02 averaged 1.9 NTU from 2007 to 2011, but jumped up to 76.0 NTU in 2011. At RIT01, pre-fire turbidity averaged 1.8 NTU, but then jumped up to 234 NTU in 2011.	Turbidity at CAP02 averaged 1.9 NTU from 2007 to 2011, but jumped up to 79 NTU in 2011. At RIT01, pre-fire turbidity averaged 1.8 NTU, but then jumped up to 240 NTU in 2011.

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

2011 Summary Report

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Natural Resource Stewardship and Science
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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to ensure the accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Funding for the SCPN water resources field crew was provided to Northern Arizona University by the National Park Service through Colorado Plateau CESU Agreement H1200090005 (Task NAU-365). 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).

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the Southern Colorado Plateau Network website (http://science.nature.nps.gov/im/units/scpn/) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).

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1 Introduction and background

The National Park Service Inventory and Monitoring Program was designed to determine the current status and monitor long-term trends in the condition of park natural resources, providing park managers with a scientific foundation for making decisions and working with other agencies and the public to protect park ecosystems. Hydrologic vital signs are the fundamental components defining overall riparian and aquatic ecosystem integrity. The Southern Colorado Plateau Network (SCPN) has identified 7 vital signs pertaining to riparian and spring ecosystems, the first 2 of which we focus on in this report: 1) aquatic macroinvertebrates, 2) stream water quality, 3) stream flow and depth to groundwater, 4) spring water quality, 5) channel morphology, 6) riparian vegetation, composition, and structure, and 7) spring, seep and tinaja ecosystems. These vital signs are closely related and are all included in the *Vital Signs Monitoring Plan for the Southern Colorado Plateau Network* (Thomas et al. 2006). The context and ecological significance of these vital signs are further explained in Brasher et al. 2011.

In 2007, SCPN implemented annual monitoring of aquatic macroinvertebrates and physical habitat at 2 sites on Capulin Creek in Bandelier National Monument (BAND) (Stumpf and Monroe 2009), and in 2009, the network implemented monitoring at 2 sites on the Rito de los Frijoles in BAND (fig. 1) (Stumpf and Monroe 2011).

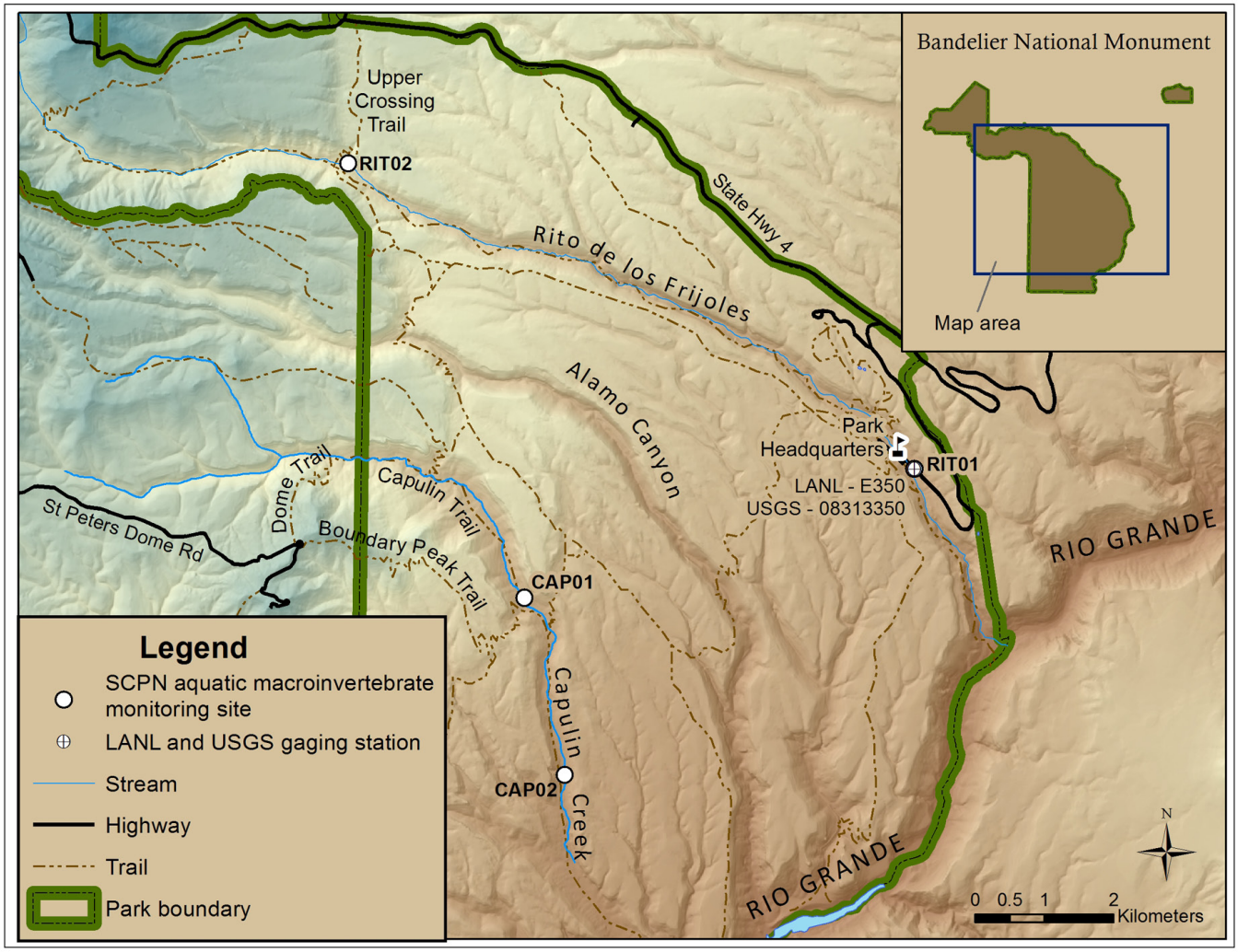


Figure 1. Locations of SCPN monitoring sites, CAP01 and CAP02, at Capulin Creek, and RIT01 and RIT02 at the Rito de los Frijoles in Bandelier National Monument, New Mexico, in 2011

During 2011 the SCPN water resources field crew collected aquatic macroinvertebrate samples and physical habitat data from 2 monitoring sites at Capulin Creek:

Capulin Creek at Base Camp Gaging 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 (USGS) streamflow gaging 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.), boxelder (*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 Dome 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, BAND, 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 2011, the SCPN water resources field crew also collected aquatic macroinvertebrate samples and physical habitat data from 2 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 gaging station (Los Alamos National Laboratory LANL-E350, USGS # 08313350, *Rito de los Frijoles in Bandelier Nat Mon, NM*) operated by Los Alamos National Laboratory (LANL) and the USGS (fig. 1). The gage maintained by LANL recorded base flows in the creek and was destroyed by a large flood on 21 August 2011. The USGS gage at the site records only peak flow events. 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 are 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 6070 ha

(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 weather in northern New Mexico during the winter and spring of 2011 was exceptionally dry and in the third week of June there was no flow in Rito de los Frijoles near the monument visitor center for the first time in about 10 years (Veenis 2012).

On 26 June 2011 the Las Conchas Fire ignited on private lands west of the park. The fire burned approximately 60% of the land within BAND, including the majority of upper portions of the Capulin Creek and Frijoles watersheds. RIT01 was the only 1 of the 4 SCPN aquatic macroinvertebrate monitoring sites that did not experience high severity fire. All canopy and understory vegetation was burned where the fire occurred along our monitoring sites. Subsequently, all 4 of our monitoring sites were affected by a large flood event that occurred on 21 August 2011, drastically changing the geomorphology of the streams within the park. Large volumes of sediment were mobilized and deposited in the channel at all of our monitoring sites. Stream depths and channel widths were greatly altered and these changes in physical habitat will undoubtedly affect aquatic macroinvertebrate diversity and abundance in the streams at BAND for years to come.

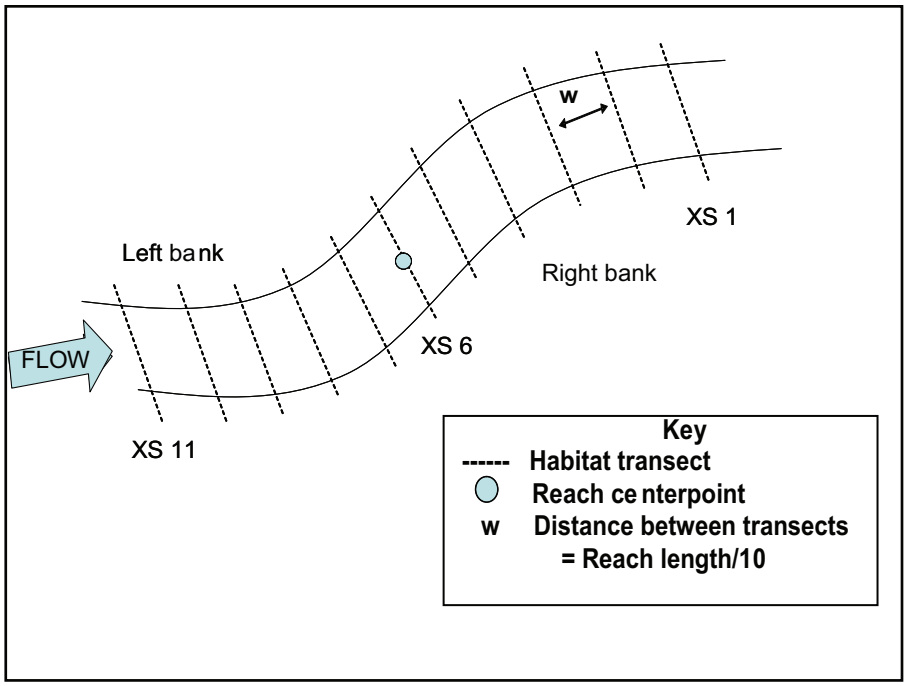
The primary purpose of this report is to (a) document SCPN aquatic macroinvertebrate monitoring activities that occurred at streams in BAND in 2011, (b) summarize data that were collected, and (c) where appropriate, place the data in the context of current environmental conditions.

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 18–21 October, 2011, 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).

Figure 2. General aquatic macroinvertebrate sampling reach layout



Two types of aquatic macroinvertebrate samples were collected at each site (except CAP02 where quantitative samples were not collected):

- Replicate quantitative samples were collected from 5 targeted riffle habitats to provide estimates of abundances of organisms. We used a Slack sampler to collect a timed sample from a 0.25 m^2 area at each targeted riffle.
- A qualitative sample was collected to develop a comprehensive list of species present in the reach. We used a Slack sampler to collect samples from all habitat types within the monitoring site, which we then compiled into one composite sample. A list of existing habitat types from which qualitative samples were collected can be found in section 3.2 of this report.

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

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

2.2 Laboratory methods

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

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

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

2.3 Data analysis

In this report we summarize aquatic macroinvertebrate data in terms of community structure and function. Genera were classified into functional feeding guilds using the classifications presented in Barbour et al. (1999). If functional class information was not available for a particular genus, we applied a more generalized, family-level classification.

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

3 Results

3.1 Aquatic macroinvertebrate community data for Capulin Creek

Key metrics are presented in Table 1 (qualitative) and Table 2 (quantitative), describing aquatic macroinvertebrate communities from samples collected at CAP01 and CAP02 from 2007 to 2011. For all tables and figures listed in this section, results are presented in left to right order corresponding to upstream to downstream position along the stream. Figures in this section refer to quantitative data unless otherwise noted, and error bars represent one standard deviation from the mean. Appendix C lists all aquatic macroinvertebrate species detected at the site, from both quantitative and qualitative methods.

The Las Conchas Fire in June 2011 and the subsequent large flood event that occurred in Capulin Creek during August 2011 greatly impacted our ability to sample according to our protocols. Because of the loss of cobble and pebble habitat, we were unable to collect a quantitative sample from CAP02. Additionally, all of the quantitative data presented from CAP01 are means collected from 3 targeted riffles rather than the 5 described in the Methods section of this document.

Abundance. Mean total abundance was 3.67 individuals at CAP01 (fig. 3). Samples ranged from a high of 7 individuals to a low of 1.

Taxa richness. Quantitative samples of aquatic macroinvertebrates at CAP01 averaged 3.00 taxa (fig. 4). Taxa richness at CAP01 ranged from a low of 2 taxa to a high of 4. Qualitative taxa richness at CAP01 was 16.

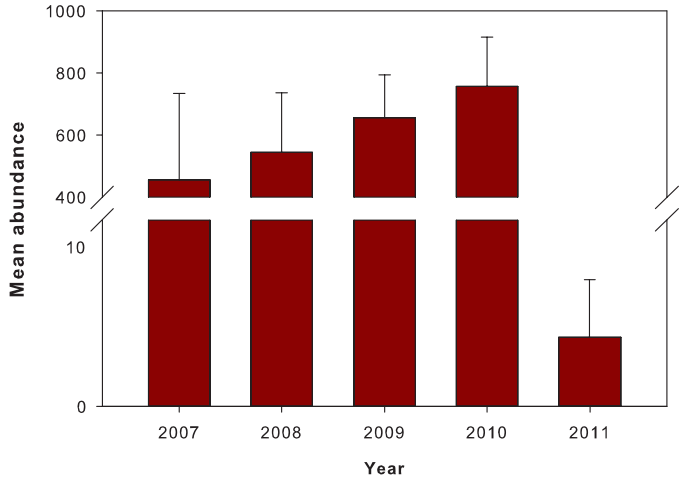


Figure 3. Total abundance expressed as the mean number of individuals per quantitative targeted riffle sample collected from CAP01 at Capulin Creek in BAND, 2007–2011

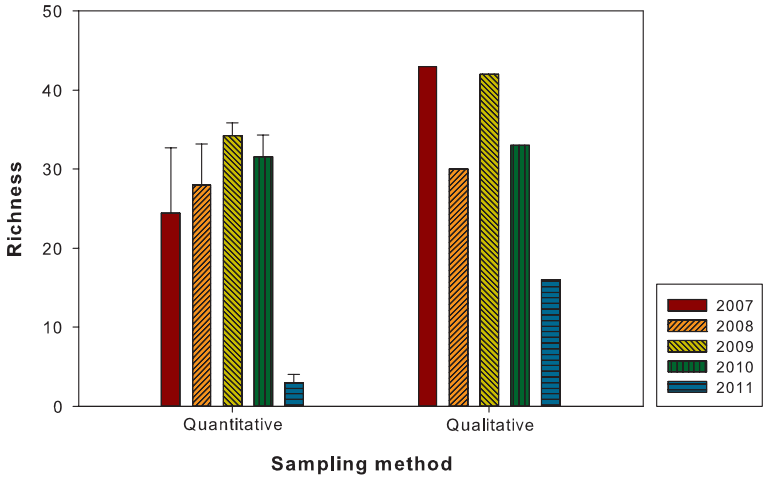


Figure 4. Mean taxa richness in quantitative targeted riffle samples and total taxa richness in qualitative multihabitat samples collected from CAP01 at Capulin Creek in BAND 2007–2011

Table 1. Qualitative metrics for aquatic macroinvertebrate samples collected from CAP01 and CAP02 at Capulin Creek in Bandelier National Monument, New Mexico, 2007-2011. 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**	**2011**	**2007**	**2008**	**2009**	**2010**	**2011**
Taxa richness	43	30	42	33	16	27	32	25	23	7
Tolerance group										
Richness of tolerant taxa (%)	9.30	7.41	15.00	6.67	21.43	11.54	25.81	26.09	4.76	14.29
Richness of moderately tolerant taxa (%)	23.26	25.93	30.00	36.67	50.00	42.31	25.81	56.52	52.38	57.14
Richness of intolerant taxa (%)	67.44	66.67	55.00	56.67	28.57	46.15	48.39	17.39	42.86	28.57
Functional group										
Richness of collector-filterers (%)	11.63	10.34	9.76	9.68	7.14	15.38	6.45	8.33	9.09	14.29
Richness of collector-gatherers (%)	32.56	27.59	31.71	38.71	50.00	30.77	22.58	37.50	27.27	28.57
Richness of scrapers (%)	9.30	6.90	12.20	9.68	7.14	3.85	6.45	4.17	4.55	0.00
Richness of shredders (%)	13.95	17.24	14.63	9.68	14.29	11.54	16.13	12.50	18.18	28.57
Richness of predators (%)	32.56	37.93	31.71	32.26	21.43	38.46	45.16	33.33	40.91	28.57
Taxonomic group										
Number of EPT taxa	19	14	15	13	2	8	10	4	6	1
Richness of EPT taxa (%)	44.19	46.67	35.71	39.39	12.50	29.63	31.25	16.00	26.09	14.29
Richness of Ephemeroptera (%)	16.28	16.67	9.52	12.12	6.25	7.41	9.38	8.00	4.35	0.00
Richness of Plecoptera (%)	9.30	10.00	9.52	12.12	6.25	7.41	12.50	4.00	8.70	14.29
Richness of Trichoptera (%)	18.60	20.00	16.67	15.15	0.00	14.81	9.38	4.00	13.04	0.00
Richness of noninsect taxa (%)	6.98[a]	3.33	11.90	9.09	18.75	7.41	6.25	20.00	13.04	0.00
Richness of Chironomid Diptera (%)	6.98	10.00	7.14	9.09	18.75	11.11	9.38	12.00	13.04	42.86
Richness of non-Chironomid Diptera (%)	4.65	20.00	26.19	27.27	43.75	7.41	37.50	32.00	30.43	42.86
Richness of Coleoptera (%)	16.23	10.00	11.90	12.12	6.25	18.52	12.50	20.00	13.04	0.00
Richness of Odonata (%)	6.98	10.00	7.14	3.03	0.00	7.41	3.13	0.00	4.35	0.00

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

Table 2. (left page, 2007–2009) Quantitative metrics for aquatic macroinvertebrate samples collected from CAP01 at Capulin Creek in Bandelier National Monument, New Mexico, 2007-2011. For a given order, tolerance or functional feeding group, abundance-based metrics are expressed as the percentage of individuals in the group, while richness-based metrics are expressed as the percentage of taxa in the group.

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

[a]Means and standard deviations were taken from a total of 3 riffles at CAP01 in 2011.
[b]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. (right page, 2010–2011) Quantitative metrics for aquatic macroinvertebrate samples collected from CAP01 at Capulin Creek in Bandelier National Monument, New Mexico, 2007-2011. For a given order, tolerance or functional feeding group, abundance-based metrics are expressed as the percentage of individuals in the group, while richness-based metrics are expressed as the percentage of taxa in the group.

	2010		2011[a]	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**
Total abundance	757.00	158.72	3.67	3.06
Total richness	31.60	2.70	3.00	1.00
Simpson's Diversity—taxonomic	0.87	0.03	0.46	0.40
Simpson's Diversity—functional group	0.73	0.01	0.32	0.33
Dominant taxa	23.78	4.41	47.62	17.17
Tolerance group				
Relative abundance of tolerant taxa (%)	0.16	0.16	0.00	0.00
Relative abundance of moderately tolerant taxa (%)	22.68	6.87	100.00	0.00
Relative abundance of intolerant taxa (%)	77.16	6.88	0.00	0.00
Richness of tolerant taxa (%)	2.66	1.51	0.00	0.00
Richness of moderately tolerant taxa (%)	37.65	2.10	100.00	0.00
Richness of intolerant taxa (%)	59.70	2.04	0.00	0.00
Functional group				
Relative abundance of collector-filterers (%)	26.84	9.55	29.63	33.95
Relative abundance of collector-gatherers (%)	32.42	5.68	61.90	26.51
Relative abundance of scrapers (%)	24.74	6.05	0.00	0.00
Relative abundance of shredders (%)	5.10	1.59	0.00	0.00
Relative abundance of predators (%)	10.91	1.67	8.47	7.50
Richness of collector-filterers (%)	10.12	2.44	25.00	25.00
Richness of collector-gatherers (%)	32.40	3.11	55.56	9.62
Richness of scrapers (%)	11.30	1.97	0.00	0.00
Richness of shredders (%)	12.62	4.36	0.00	0.00
Richness of predators (%)	33.56	4.29	19.44	17.35
Taxonomic group				
Number of EPT taxa	14.20	2.17	0.33	0.58
Relative abundance of EPT taxa (%)	62.47	6.87	11.11	19.25
Relative abundance of Ephemeroptera (%)	21.92	4.61	11.11	19.25
Relative abundance of Plecoptera (%)	7.37	0.79	0.00	0.00
Relative abundance of Trichoptera (%)	33.18	8.51	0.00	0.00
Relative abundance of noninsect taxa (%)	2.10	1.28	0.00	0.00
Relative abundance of Chironomid Diptera (%)	7.24	1.68	50.79	45.01
Relative abundance of non-Chironomid Diptera (%)	5.03	3.25	38.10	26.51
Relative abundance of Coleoptera (%)	20.26	4.72	0.00	0.00
Relative abundance of Odonata (%)	2.88	1.65	0.00	0.00

[a]Means and standard deviations were taken from a total of 3 riffles at CAP01 in 2011.
[b]Pre-2009 reports labeled the "noninsect" category as "Other". The "Other" category was less inclusive of species, resulting in a different richness count.

Diversity. We measured both taxonomic and functional diversity using the Simpson's Diversity Index. Taxonomic diversity of samples from CAP01 averaged 0.46 (fig. 5), and ranged from a low of 0 to a high of 0.71. Functional diversity averaged 0.32 at CAP01, and ranged from 0 to 0.67.

Stress tolerance. Individuals moderately tolerant to disturbance (100.00%) were the only type of taxa found in quantitative samples collected at CAP01 in 2011 (fig. 6).

EPT taxa. Only one ephemeropteran (mayflies) individual was found in our 3 quantitative samples from CAP01 in 2011 (fig. 7). No plecopterans (stoneflies) or trichopterans (caddisflies) were found in our samples.

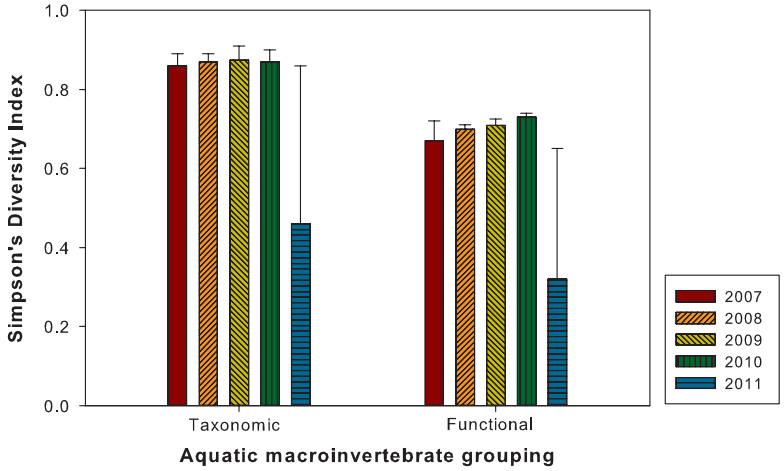


Figure 5. Simpson's Diversity Index for taxonomic and functional diversity in quantitative targeted riffle samples at Capulin Creek in BAND, 2007–2011

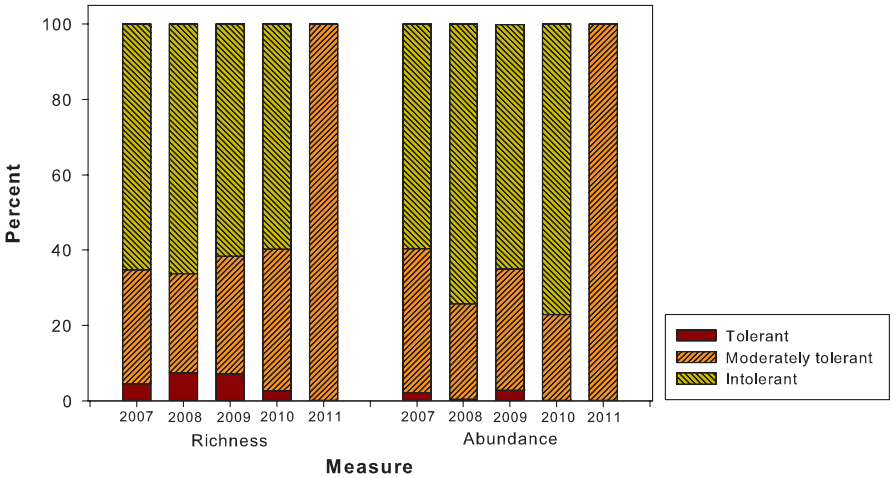


Figure 6. Mean richness and relative abundance of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from CAP01 at Capulin Creek in BAND, 2007–2011, based on their tolerance to perturbation

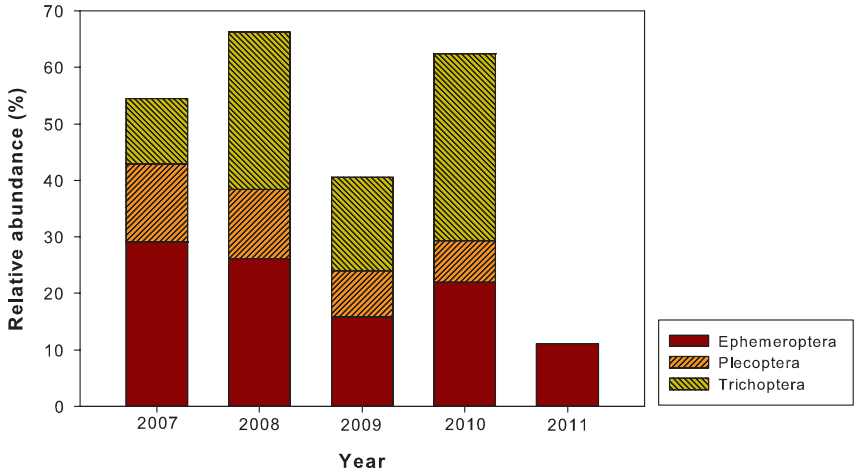


Figure 7. Relative abundance of EPT taxa in quantitative targeted riffle samples collected from CAP01 at Capulin Creek in BAND, 2007–2011

Aquatic macroinvertebrate orders. Ephemeropterans, chironomids(midges), and non-chironomid dipterans (flies) were the only 3 taxa groups found in our quantitative samples from CAP01 in 2011 (fig. 8). Of these 3, 50.79% were chironomids, and 38.10% were non-chironomid dipterans. The one ephemeropteran sampled accounted for 11.11% of the individuals sampled in 2011.

Functional feeding groups. Relative abundance within functional feeding groups was dominated by collector-gatherers in 2011 (fig. 9), at 61.90% of the individuals collected at CAP01. Collector-filterers were the second most abundant individuals at CAP01, averaging 29.63%. Predators accounted for 8.47% of the individuals collected. No scrapers or shredders were collected in 2011.

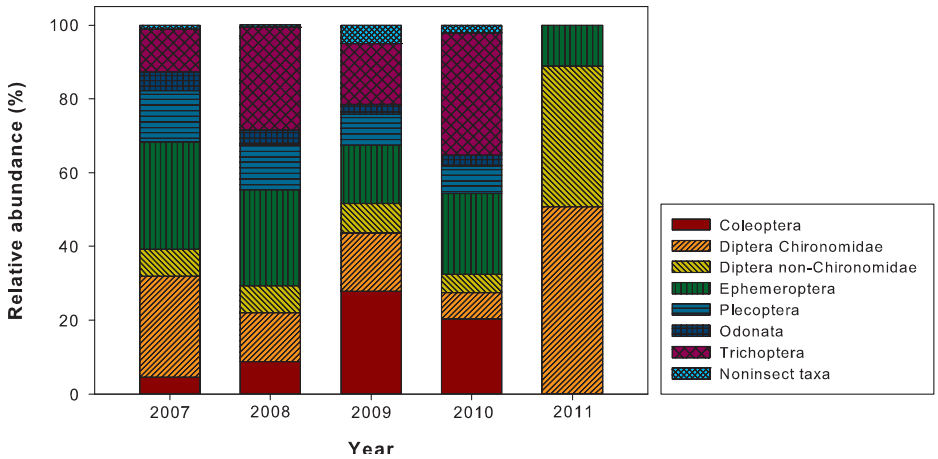


Figure 8. Relative abundance of individuals by taxonomic order in quantitative targeted riffle samples collected from CAP01 at Capulin Creek in BAND, 2007–2011

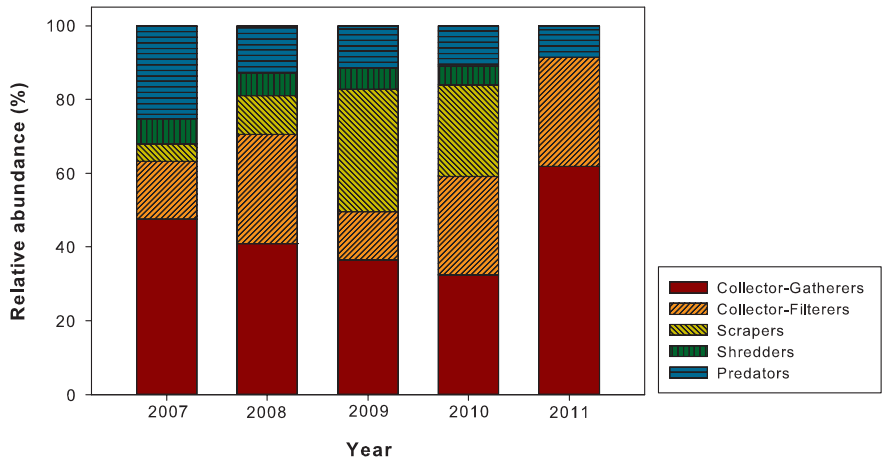


Figure 9. Relative abundance of functional feeding groups in quantitative targeted riffle samples collected from CAP01 at Capulin Creek in BAND, 2007–2011

3.2 Physical habitat characteristics for Capulin Creek

This section presents data describing physical habitat characteristics collected at CAP01 and CAP02 from 2007–2011. These data are summarized in Tables 3 and 4; additional transect data can be found in Appendix D.

Microhabitat level. Velocity averaged 0.38 m/s and depth averaged 0.07 at CAP01 (table 3). Mean embeddedness at CAP01 was 18.3%. Due to the large volume of fine sediments moving through the channel, few riffles were present and we were able to collect microhabitat data from only 3 riffle habitats at CAP01, rather than the standard 5 riffles. We were unable to measure microhabitat data at CAP02. Flooding replaced all riffle habitat with finer sediments along much of the monitoring site.

Transect level. Average stream depth along our physical habitat transects were 0.07 m at CAP01 and 0.03 m at CAP02 (tables 3, 4). Velocities were similar, with the average velocity measuring 0.30 m/s at CAP01 and 0.28 m/s at CAP02. Wetted channel width averaged 1.9 m at CAP01 and 2.9 m at CAP02. Because of the severity of the fire and an inability to determine extent of pre-fire riparian vegetation, we did not collect active channel widths at Capulin Creek. Because of a lack of live overstory trees after the fire, we were unable to measure canopy cover.

Table 3. Physical habitat and hydrologic data from CAP01 at Capulin Creek in Bandelier National Monument, New Mexico, 2007-2011. Particle embeddedness and canopy closure measurements are expressed as percentages.

	2007		2008		2009		2010		2011	
Physical habitat metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Microhabitat level										
Riffles										
Velocity (m/s)	0.23	0.10	0.35	0.20	0.33	0.17	0.36	0.19	0.38[a]	0.12
Depth (m)	0.07	0.02	0.09	0.02	0.25	0.39	0.08	0.03	0.07[a]	0.03
Embeddedness (%)	14.4	5.1	30.3	12.9	26.3	6.3	39.4	6.5	18.3[a]	16.6
Transect level										
Channel dimensions										
Velocity (m/s)	0.06	0.04	0.14	0.06	0.16	0.08	0.14	0.13	0.30	0.07
Depth (m)	0.07	0.05	0.06	0.04	0.07	0.03	0.07	0.03	0.05	0.02
Wetted channel width (m)	1.3	0.4	1.3	0.4	1.4	0.3	1.6	0.4	1.9	1.6
Active channel width (m)	2.3	0.9	5.5	2.3	9.6	5.1	10.1	4.4	—[b]	—[b]
Riparian cover										
Canopy closure (%)	87.4	21.0	91.1	20.9	92.0	11.1	96.3	7.2	—[b]	—[b]
Reach level										
Water quality	**Value**		**Value**		**Value**		**Value**		**Value**	
Temperature (°C)	11.5		11.4		9.7		8.9		13.4	
Specific conductivity (µS/cm)	—		151		146		145		212	
pH	—		8.0		8.0		7.9		8.2	
Dissolved oxygen (% saturation)	—		96.6		95.9		96.7		98.5	
Dissolved oxygen (mg/L)	—		10.5		8		8.9		8.2	
Turbidity (NTU)	—		0.50		1.3		1.0		7.5	
Discharge (cfs)	—		—		—		0.4		<0.1	

[a]Based on 3 riffles instead of the standard 5 riffles.
[b]Active channel width and canopy closure could not be measured because of effects from the fire.

Table 4. Physical habitat and hydrologic data from CAP02 at Capulin Creek in Bandelier National Monument, New Mexico, 2007-2011. Particle embeddedness and canopy closure measurements are expressed as percentages.

	2007		2008		2009		2010		2011	
Physical habitat metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Microhabitat level										
Riffles										
Velocity (m/s)	0.19	0.23	0.21	0.14	0.01	0.12	0.22	0.09	—[a]	—[a]
Depth (m)	0.06	0.03	0.05	0.02	0.07	0.22	0.06	0.02	—[a]	—[a]
Embeddedness (%)	9.2	6.1	29.5	10.6	29.4	11.4	21.2	8.4	—[a]	—[a]
Transect level										
Channel dimensions										
Velocity (m/s)	0.04	0.03	0.02	0.02	0.29	0.38	0.08	0.03	0.28	0.10
Depth (m)	0.06	0.03	0.07	0.05	0.07	0.04	0.07	0.03	0.03	0.01
Wetted channel width (m)	1.2	0.4	0.9	0.4	3.9	3.5	2.1	3.3	2.9	1.5
Active channel width (m)	1.7	0.4	4.2	1.9	13.6	6.8	12.5	6.0	—[b]	—[b]
Riparian cover										
Canopy closure (%)	70.6	15.2	98.0	7.0	96.3	6.2	98.6	3.6	—[b]	—[b]
Reach level										
Water quality	**Value**		**Value**		**Value**		**Value**		**Value**	
Temperature (°C)	11.4		11.2		10.6		9.2		14.6	
Specific conductivity (µS/cm)	—		165		172		157		155	
pH	—		7.8		7.8		7.7		8.3	
Dissolved oxygen (% saturation)	—		96.4		96.1		95.1		99.8	
Dissolved oxygen (mg/L)	—		10.6		8.2		8.7		8.22	
Turbidity (NTU)	—		1.9		2.6		1.2		76.0	
Discharge (cfs)	—		—		—		0.1		<0.1	

[a]We were not able to collect quantitative data at the microhabitat level for CAP02.
[b]Active channel width and canopy closure could not be measured because of effects from the fire.

Appropriate aquatic macroinvertebrate habitat was absent from much of both monitoring sites in 2011 (fig. 10). Substrate fitting the category "Absence", meaning it lacked habitat that we define as appropriate for aquatic macroinvertebrates, occurred along 79.2% of CAP01 and 94.7% of CAP02. Rock made up 15.6% of CAP01 and 2.6% of CAP02. Root wads were found along 3.9% of CAP01 and 1.3% of CAP02. Algal mats were found along 1.3% of CAP01 and leaf packs were found along 1.3% of CAP02.

Reach level. Channel structure dynamics are represented by particle size distributions in Figures 11a (CAP01) and 11b (CAP02). Particle size was dominated by finer sediments at both sites. Sand and gravels were found along 85.6% of CAP01 and 89.3% of CAP02. Cobbles were found along 8.3% of CAP01 and 5.8% of CAP02.

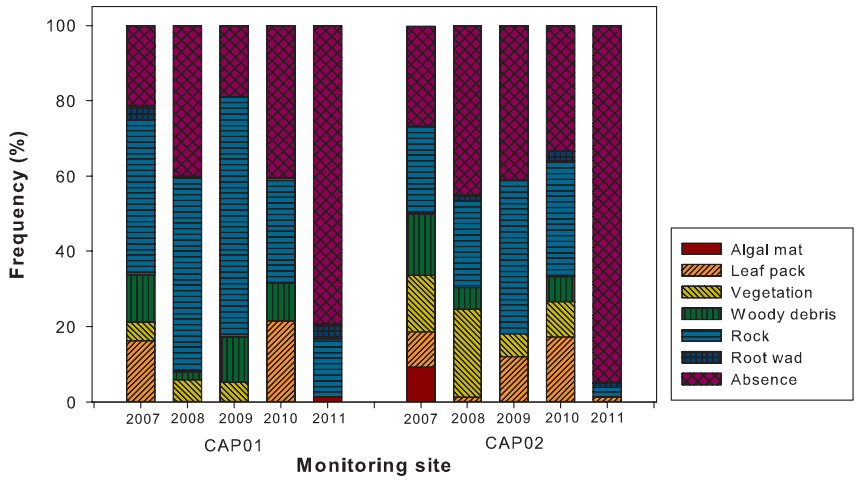


Figure 10. Aquatic macroinvertebrate habitat characterization based upon line point intercept data along transects from CAP01 and CAP02 at Capulin Creek in BAND, 2007–2011

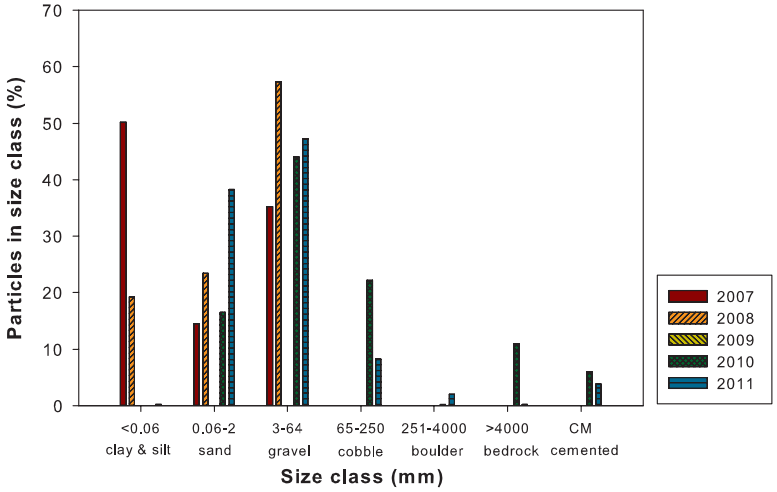


Figure 11a. Particle size distribution, based on modified Wolman pebble counts (minimum 400 particles), from CAP01 at Capulin Creek in BAND, 2007–2011

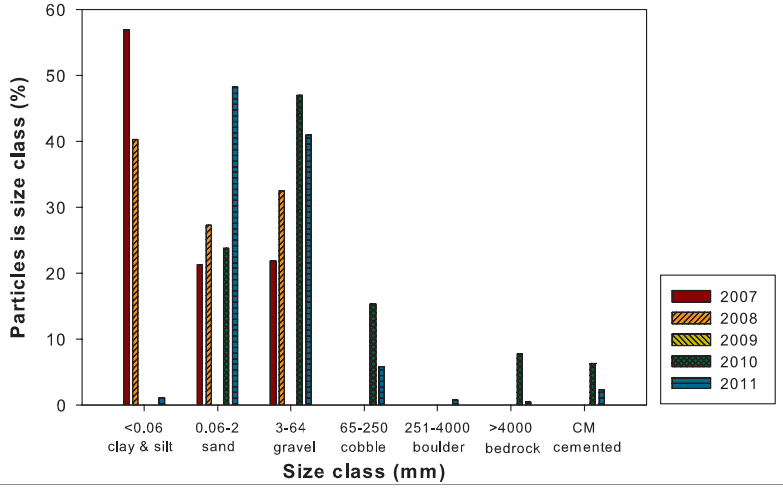


Figure 11b. Particle size distribution, based on modified Wolman pebble counts (minimum 400 particles), from CAP02 at Capulin Creek in BAND, 2007–2011

Runs were the dominant geomorphic channel units (GCU) at both monitoring sites (fig. 12). Runs made up 57.7% of the site along CAP01 and 61.0% at CAP02. The next most abundant GCU for each site was cascades (27.5%) at CAP01 and glides (29.0%) at CAP02.

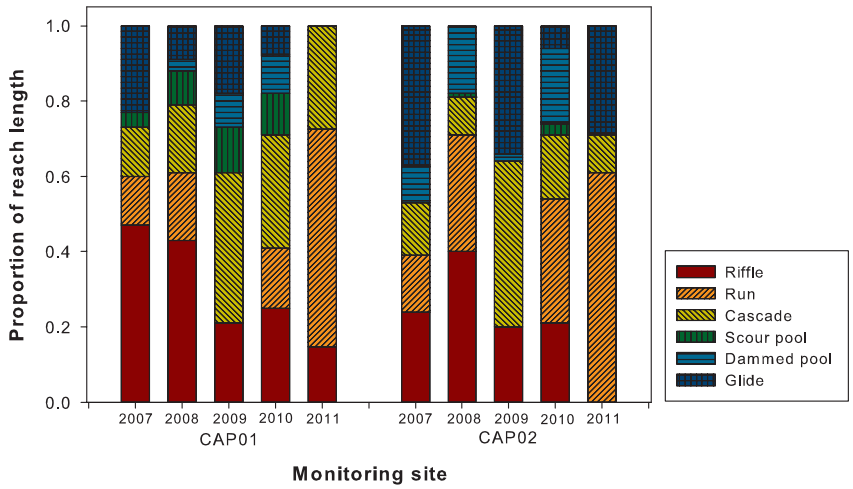


Figure 12. Geomorphic channel unit characterization of CAP01 and CAP02 at Capulin Creek in BAND, 2007–2011

3.3 Hydrologic conditions for Capulin Creek

Values presented in Tables 3 and 4 represent recorded measurements at or near midday of the sample date. The midday water temperature was 13.4°C at CAP01 and 14.6°C at CAP02. Specific conductivity was higher upstream at CAP01, measuring 212 µS/cm compared to 155 µS/cm downstream at CAP02. At CAP01, pH measured 8.2, and at CAP02 it was 8.3. Dissolved oxygen at CAP01 measured 98.5% saturation and 8.2 mg/L. Dissolved oxygen was slightly higher at CAP02, measuring 99.8% saturation and 8.2 mg/L. Turbidity was 7.5 NTU at CAP01 and 76.0 NTU at CAP02. In addition to these water quality parameters, we measured stream discharge at both monitoring sites. Total discharge at CAP01 was 0.02 cfs, and 0.01 cfs at CAP02.

3.4 Aquatic macroinvertebrate community data for the Rito de los Frijoles

Key metrics are presented in Table 5 (qualitative) and in Tables 6 and 7 (quantitative), describing aquatic macroinvertebrate communities from samples collected at RIT01 and RIT02 from 2009 to 2011. For all tables and figures listed in this section, results are presented in left to right order corresponding to upstream to downstream position along the stream. Figures in this section refer to quantitative data unless otherwise noted, and error bars in figures represent one standard deviation from the mean. RIT01 lacked sufficient riffle habitat, so means are taken from a sample of 3 riffles instead of the standard 5 described in the SCPN protocol. Appendix C lists all aquatic macroinvertebrate species detected at the site, from both quantitative and qualitative methods.

As a reminder of the context for 2011 conditions on this stream, the Las Conchas Fire burned through RIT02 but not RIT01; however, both monitoring sites were severely affected by large scale flooding in August of 2011 before we sampled them.

Abundance. Mean abundance of aquatic macroinvertebrates was greatest at our upstream site, RIT02 (fig. 13). Mean abundance from our quantitative targeted riffle samples averaged 25.33 individuals at RIT02 compared to 15.80 individuals at RIT01.

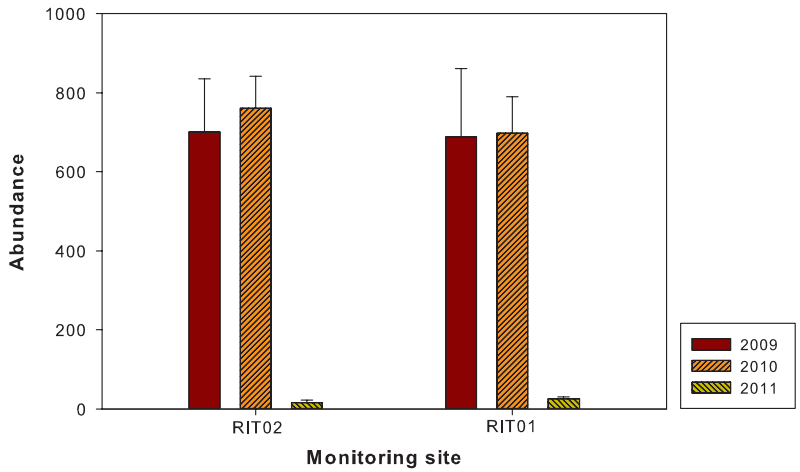
Taxa richness. Total taxa richness of quantitative targeted riffle samples averaged 3.60 taxa and 4.67 taxa at RIT02 and RIT01, respectively (fig. 14). Taxa richness of the qualitative multihabitat sample was higher at both sites. We found 6 taxa at RIT02 and 13 taxa at RIT01.

Diversity. We measured both taxonomic and functional diversity using the Simpson's Diversity Index. Taxonomic diversity averaged 0.40 at RIT02 and 0.51 at RIT01 (fig. 15a). Functional diversity was lower at both sites, averaging 0.08 at RIT02 and 0.30 at RIT01 (fig. 15b).

Table 5. Qualitative metrics for aquatic macroinvertebrate samples collected from RIT01 and RIT02 at the Rito de los Frijoles in Bandelier National Monument, New Mexico, 2009-2011. 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**	**2011**	**2009**	**2010**	**2011**
Taxa richness	37	38	6	38	39	13
Tolerance group						
Richness of tolerant taxa (%)	11.76	5.71	20.00	10.81	13.16	9.09
Richness of moderately tolerant taxa (%)	32.35	25.71	60.00	35.14	42.11	45.45
Richness of intolerant taxa (%)	55.88	68.57	20.00	54.05	44.74	45.45
Functional group						
Richness of collector-filterers (%)	10.81	10.81	0.00	10.53	10.53	9.09
Richness of collector-gatherers (%)	29.73	35.14	60.00	26.32	28.95	45.45
Richness of scrapers (%)	8.11	13.51	0.00	10.53	2.63	9.09
Richness of shredders (%)	10.81	10.81	20.00	18.42	13.16	18.18
Richness of predators (%)	40.54	29.73	20.00	34.21	44.74	18.18
Taxonomic group						
Number of EPT taxa	15	17	0	15	15	1
Richness of EPT taxa (%)	40.54	44.74	0.00	39.47	38.46	7.69
Richness of Ephemeroptera (%)	10.81	13.16	0.00	13.16	10.26	0.00
Richness of Plecoptera (%)	8.11	13.16	0.00	13.16	15.38	7.69
Richness of Trichoptera (%)	21.62	18.42	0.00	13.16	12.82	0.00
Richness of noninsect taxa (%)	13.51	10.53	16.67	10.53	7.69	15.38
Richness of Chironomid Diptera (%)	8.11	7.89	33.33	7.89	7.69	23.08
Richness of non-Chironomid Diptera (%)	18.92	28.95	50.00	26.32	30.77	38.46
Richness of Coleoptera (%)	13.51	5.26	0.00	13.16	10.26	15.38
Richness of Odonata (%)	5.41	2.63	0.00	2.63	5.13	0.00

Figure 13. Total abundance expressed as the mean number of individuals per quantitative targeted riffle sample collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2011



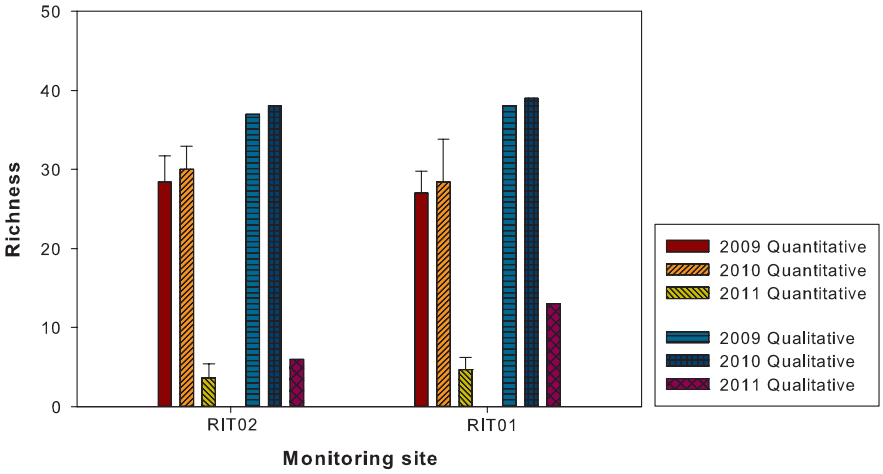


Figure 14. Mean taxa richness in quantitative targeted riffle samples and total taxa richness in qualitative multihabitat samples collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2011

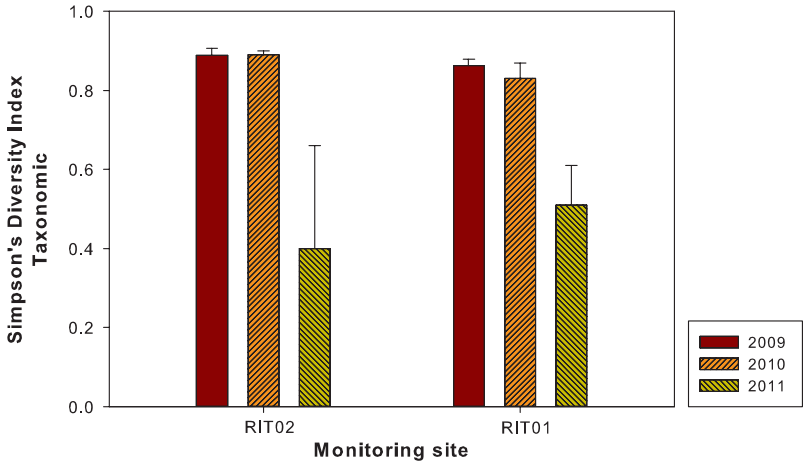


Figure 15a. Simpson's Diversity Index for taxonomic diversity in quantitative targeted riffle samples from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2011

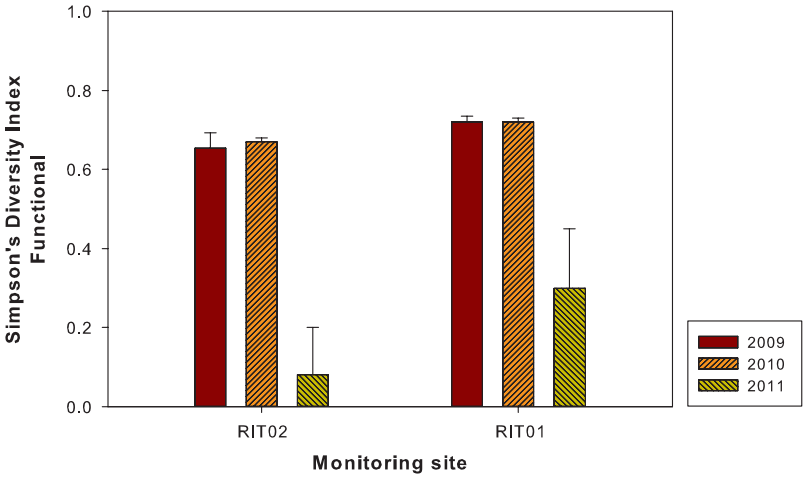


Figure 15b. Simpson's Diversity Index for functional diversity in quantitative targeted riffle samples from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2011

Stress tolerance. Relative abundance was dominated by individuals moderately tolerant to disturbance at both sites (fig. 16a). Moderately tolerant individuals averaged 97.63% of the samples collected at RIT02 and 87.27% at RIT01. Tolerant individuals accounted for the remaining 2.37% of the samples collected at RIT02, and intolerant individuals accounted for the remaining 12.7% of the individuals collected from RIT01. No tolerant individuals were found at RIT01 in 2011, and no intolerant individuals were found at RIT02.

Moderately tolerant taxa dominated samples from both monitoring sites as well (fig. 16b). Moderately tolerant taxa accounted for 90.00% of the taxa collected from RIT02 and 58.89% of the taxa collected from RIT01. Tolerant taxa accounted for the remaining 10.00% of taxa at RIT02 and intolerant taxa accounted for the remaining 41.11% of taxa collected from RIT01.

Table 6. Quantitative metrics for aquatic macroinvertebrate samples collected from RIT02 at the Rito de los Frijoles in Bandelier National Monument, New Mexico, 2009-2011. For a given order, tolerance or functional feeding group, abundance-based metrics are expressed as the percentage of individuals in the group, while richness-based metrics are expressed as the percentage of taxa in the group.

	RIT02					
	2009		2010		2011	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Total abundance	700.90	134.75	760.60	80.43	15.80	6.22
Total richness	28.40	3.29	30.00	2.92	3.60	1.82
Simpson's Diversity—taxonomic	0.89	0.02	0.89	0.01	0.40	0.26
Simpson's Diversity—functional group	0.65	0.04	0.67	0.01	0.08	0.12
Dominant taxa	20.16	3.93	23.25	3.11	72.30	21.46
Tolerance group						
Relative abundance of tolerant taxa (%)	0.20	0.32	0.26	0.39	2.37	3.25
Relative abundance of moderately tolerant taxa (%)	31.52	8.14	32.56	5.77	97.63	3.25
Relative abundance of intolerant taxa (%)	68.28	8.04	67.18	5.93	0.00	0.00
Richness of tolerant taxa (%)	2.87	2.88	2.97	3.11	10.00	13.69
Richness of moderately tolerant taxa (%)	24.43	3.22	26.11	2.32	90.00	13.69
Richness of intolerant taxa (%)	72.70	5.44	70.92	2.65	0.00	0.00
Functional group						
Relative abundance of collector-filterers (%)	21.18	9.31	18.49	3.29	1.00	2.24
Relative abundance of collector-gatherers (%)	48.11	7.55	47.95	2.90	95.57	6.12
Relative abundance of scrapers (%)	23.50	3.41	23.83	5.91	0.00	0.00
Relative abundance of shredders (%)	1.12	0.70	3.40	1.63	0.00	0.00
Relative abundance of predators (%)	6.09	1.31	6.33	2.27	3.43	5.34
Richness of collector-filterers (%)	14.35	3.21	14.39	0.89	4.00	8.94
Richness of collector-gatherers (%)	38.53	2.95	36.31	5.44	82.00	24.90
Richness of scrapers (%)	18.71	3.16	14.43	1.46	0.00	0.00
Richness of shredders (%)	4.84	1.29	10.21	1.79	0.00	0.00
Richness of predators (%)	23.57	6.32	24.65	4.63	14.00	21.91
Taxonomic group						
Number of EPT taxa	14.40	1.52	15.80	0.84	0.00	0.00
Relative abundance of EPT taxa (%)	41.54	11.16	51.30	10.30	0.00	0.00
Relative abundance of Ephemeroptera (%)	25.30	6.87	30.36	5.56	0.00	0.00
Relative abundance of Plecoptera (%)	4.76	1.58	6.06	2.58	0.00	0.00
Relative abundance of Trichoptera (%)	11.48	4.41	14.88	2.96	0.00	0.00
Relative abundance of noninsect taxa (%)	14.49	11.10	7.03	2.54	0.95	2.13
Relative abundance of Chironomid Diptera (%)	6.08	2.29	9.03	5.68	90.57	8.08
Relative abundance of non-Chironomid Diptera (%)	2.73	1.11	2.96	1.55	7.30	7.84
Relative abundance of Coleoptera (%)	35.12	4.71	29.63	8.49	1.18	2.63
Relative abundance of Odonata (%)	0.04	0.09	0.05	0.07	0.00	0.00

Table 7. Quantitative metrics for aquatic macroinvertebrate samples collected from RIT01 at the Rito de los Frijoles in Bandelier National Monument, New Mexico, 2009-2011. For a given order, tolerance or functional feeding group, abundance-based metrics are expressed as the percentage of individuals in the group, while richness-based metrics are expressed as the percentage of taxa in the group.

	RIT01					
	2009		2010		2011	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Total abundance	688.00	172.57	697.60	91.52	25.33	5.51
Total richness	27.00	2.74	28.40	5.41	4.67	1.53
Simpson's Diversity—taxonomic	0.86	0.02	0.83	0.04	0.51	0.08
Simpson's Diversity—functional group	0.72	0.02	0.72	0.01	0.30	0.15
Dominant taxa	26.42	4.22	31.65	7.42	69.06	6.12
Tolerance group						
Relative abundance of tolerant taxa (%)	0.12	0.13	0.13	0.14	0.00	0.00
Relative abundance of moderately tolerant taxa (%)	25.19	3.98	29.02	10.79	87.27	4.62
Relative abundance of intolerant taxa (%)	74.68	4.00	70.85	10.74	12.73	4.62
Richness of tolerant taxa (%)	2.33	2.15	3.20	3.35	0.00	0.00
Richness of moderately tolerant taxa (%)	30.01	4.85	27.58	4.40	58.89	8.39
Richness of intolerant taxa (%)	67.66	5.27	69.23	4.43	41.11	8.39
Functional group						
Relative abundance of collector-filterers (%)	17.91	7.10	26.51	4.31	4.46	7.73
Relative abundance of collector-gatherers (%)	29.45	6.89	26.55	5.51	82.81	9.17
Relative abundance of scrapers (%)	36.90	5.51	35.85	5.29	0.00	0.00
Relative abundance of shredders (%)	10.34	4.29	5.73	2.09	11.40	6.76
Relative abundance of predators (%)	5.40	3.63	5.35	2.46	1.33	2.31
Richness of collector-filterers (%)	11.29	1.20	13.46	3.68	8.33	14.43
Richness of collector-gatherers (%)	29.27	4.30	30.47	2.38	50.56	22.38
Richness of scrapers (%)	15.90	4.89	12.48	1.95	0.00	0.00
Richness of shredders (%)	14.67	4.66	15.99	3.53	34.44	15.03
Richness of predators (%)	28.86	4.84	27.59	6.60	6.67	11.55
Taxonomic group						
Number of EPT taxa	11.80	1.64	15.00	2.45	1.00	0.00
Relative abundance of EPT taxa (%)	43.70	4.83	46.92	3.69	8.69	7.45
Relative abundance of Ephemeroptera (%)	14.53	5.11	19.90	3.09	0.00	0.00
Relative abundance of Plecoptera (%)	12.81	2.74	6.05	1.88	7.50	8.84
Relative abundance of Trichoptera (%)	16.37	5.72	20.97	6.42	1.19	2.06
Relative abundance of noninsect taxa (%)	1.60	1.57	1.18	1.15	8.83	8.06
Relative abundance of Chironomid Diptera (%)	10.80	4.65	4.05	2.69	74.40	10.93
Relative abundance of non-Chironomid Diptera (%)	4.86	2.09	14.11	4.08	6.88	8.89
Relative abundance of Coleoptera (%)	38.55	4.43	33.66	7.62	0.00	0.00
Relative abundance of Odonata (%)	0.49	0.92	0.08	0.12	1.19	2.06

Figure 16a. 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, 2009–2011, based on their tolerance to perturbation

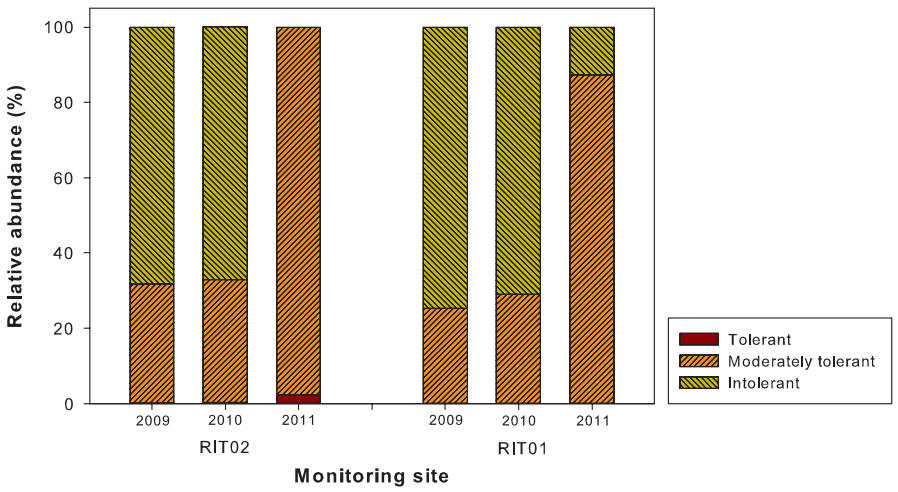
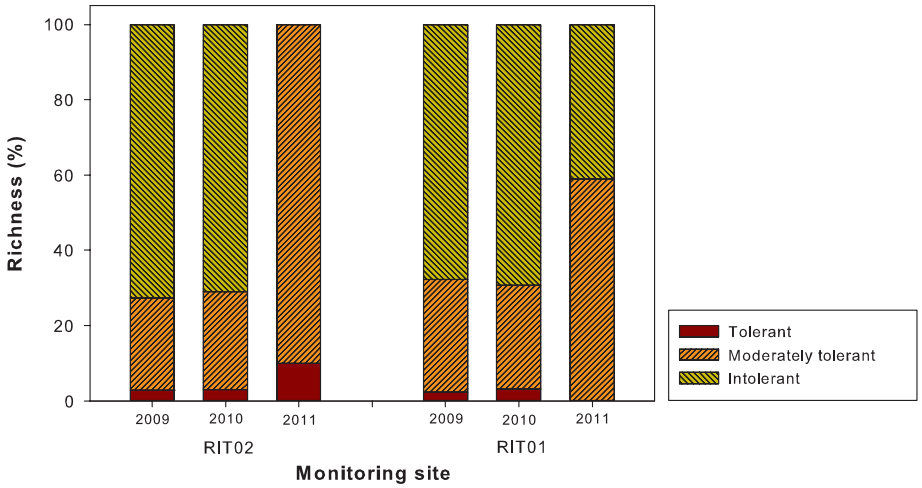


Figure 16b. Mean richness of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2011, based on their tolerance to perturbation



EPT taxa. Sensitive EPT taxa accounted for 8.69% of the individuals collected from RIT01 in 2011(fig. 17). Plecopterans were the dominant taxa, accounting for 7.50% of individuals collected. The remaining 1.19% of EPT individuals collected from RIT01 were trichopterans. No ephemeropterans were found at RIT01. No EPT taxa were collected from RIT02.

Aquatic macroinvertebrate orders. Dipterans belonging to the family Chironomidae dominated the taxa collected at both monitoring sites in 2011 (fig. 18). Chironomids accounted for 90.57% of the taxa collected from RIT02 and 74.40% of the taxa collected from RIT01. At RIT02, non-chironomid dipterans were the second most abundant taxa (7.30%), followed by coleopterans (1.18%) and then noninsect taxa, which in this case were all nematodes (0.95%). At RIT01, noninsect taxa in the class, Clitellata, (segmented worms) were the second most abundant taxa, accounting for 8.83% of the taxa collected. Plecopterans accounted for 7.50% of the taxa collected, followed by non-chironomid dipterans (6.88%), trichopterans (1.19%), and odonates (1.19%).

Functional feeding groups. Collector-gatherers dominated samples collected from both monitoring sites (fig. 19). Collector-gatherers accounted for 95.57% of the sample from RIT02 and 82.81% of the sample at RIT01. At RIT02, predators (3.43%) and collector-filterers (1.00%) were collected, but no scrapers or shredders found. At RIT01, shredders were the second most abundant functional group collected, accounting for 11.40% of the organisms. Collector-filterers (4.46%) and predators (1.33%) were also collected from RIT01. No scrapers were collected from RIT01.

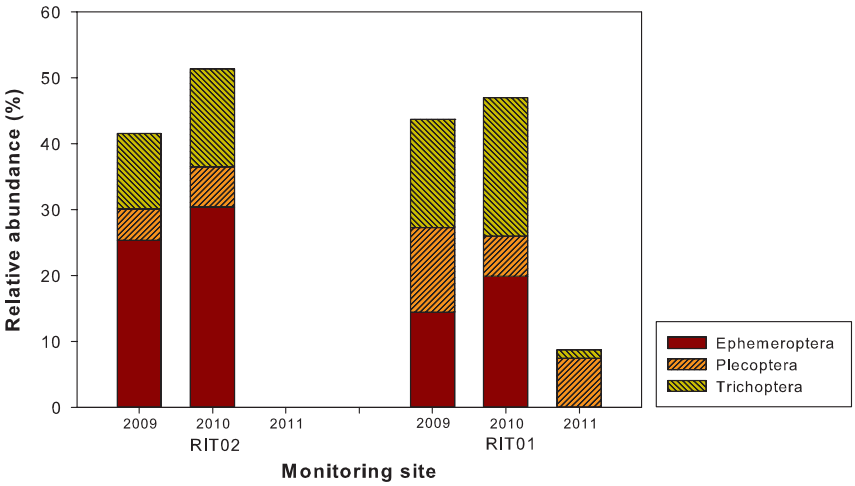


Figure 17. Relative abundance of EPT taxa in quantitative targeted riffle samples collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2011. No EPT taxa were collected from RIT02 in 2011.

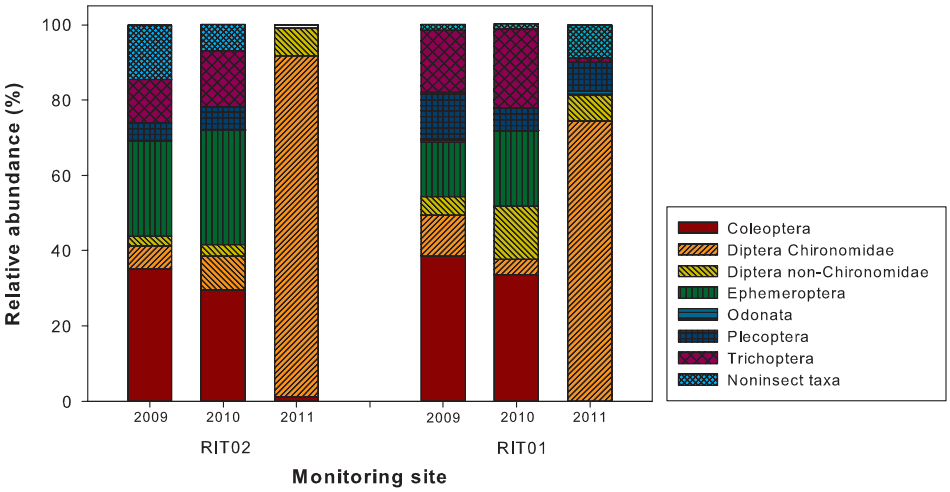


Figure 18. Relative abundance of individuals by taxonomic order in quantitative targeted riffle samples collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2011

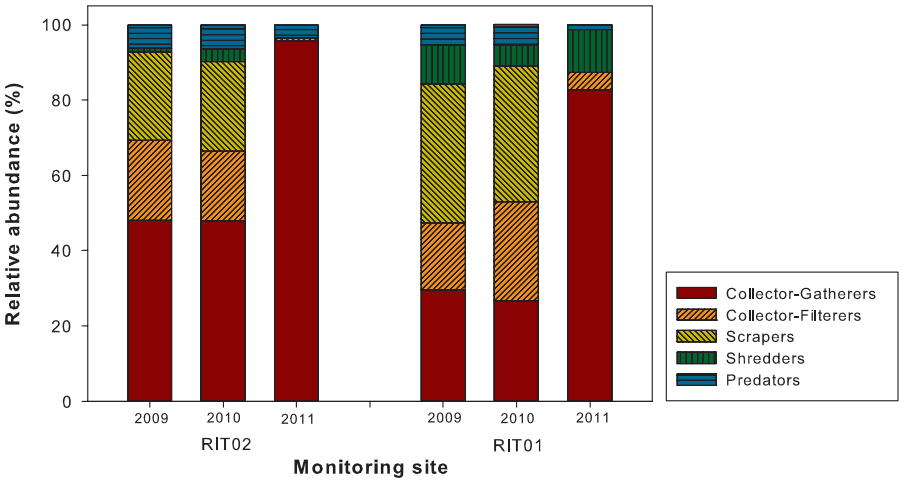


Figure 19. Relative abundance of functional feeding groups in quantitative targeted riffle samples collected from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2011

3.5 Physical habitat characteristics for the Rito de los Frijoles

This section presents data describing physical habitat characteristics collected during 2009–2011 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). Note, however, that we were able to collect microhabitat data from

Table 8. Physical habitat and hydrologic data from RIT01 and RIT02 at the Rito de los Frijoles in Bandelier National Monument, New Mexico, 2009-2011. Particle embeddedness and canopy closure measurements are expressed as percentages.

	RIT02						RIT01					
	2009		2010		2011		2009		2010		2011	
Physical habitat metric	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Microhabitat level												
Riffles												
Velocity (m/s)	0.50	0.18	0.40	0.16	0.67	0.29	0.46	0.13	0.39	0.15	0.46[a]	0.11
Depth (m)	0.12	0.03	0.08	0.02	0.11	0.01	0.12	0.02	0.11	0.02	0.1[a]	0.02
Embeddedness (%)	30.6	13.8	33.0	16.0	23.2	13.3	50.0	24.4	51.0	20.1	36.7[a]	6.7
Transect level												
Channel dimensions												
Velocity (m/s)	0.25	0.12	0.23	0.08	0.40	0.18	0.20	0.17	0.20	0.08	0.39	0.07
Depth (m)	0.09	0.05	0.10	0.04	0.07	0.02	0.09	0.06	0.08	0.03	0.05	0.02
Wetted channel width (m)	2.3	0.6	2.1	0.6	2.8	1.6	2.3	2.4	1.5	0.7	1.9	1.5
Active channel width (m)	4.2	0.8	5.8	1.4	—[b]	—[b]	10.5	3.2	11.9	3.3	16.7	7.5
Riparian cover												
Canopy closure (%)	72.9	22.4	61.9	20.3	—[b]	—[b]	79.6	14.1	69.9	25.3	28.9	21.2
Reach level												
Water quality	**Value**		**Value**		**Value**		**Value**		**Value**		**Value**	
Temperature (°C)	10.3		5.8		11.4		12.3		5.8		9.1	
Specific conductivity (µS/cm)	107		114		228		111		108		172	
pH	7.9		7.6		8.1		7.8		7.9		8.2	
Dissolved oxygen (% saturation)	94.7		102.5		98.8		94.4		98.5		97.8	
Dissolved oxygen (mg/L)	8.2		10.1		8.4		7.8		9.6		9.1	
Turbidity (NTU)	2.2		1.4		4.3		2.2		2.4		234	
Discharge (cfs)	—		1.2		<0.1				0.7		<0.1	

[a]Based on 3 riffles instead of the standard 5 riffles.
[b]Active channel width and canopy closure could not be measured because of effects from the fire.

only 3 riffle habitats at RIT01, rather than the standard 5 riffles. Flow velocities averaged 0.67 m/s at RIT02 and 0.46 m/s at RIT01. The depth at riffles averaged 0.11 m at RIT02 and 0.10 m at RIT01. Substrate embeddedness was greater downstream at RIT01, where 36.7% of each particle was embedded on average, while an average of 23.2% of each particle was embedded at RIT02.

Transect level. Stream velocities along our physical habitat transects were similar at both monitoring sites. Velocity averaged 0.40 m/s at RIT02 and 0.39 m/s at RIT01 (table 8). Stream depth averaged 0.07 m at RIT02 and 0.05 m at RIT01. Wetted channel width averaged 2.8 m at RIT02 and 1.9 m at RIT01. Active channel width averaged 16.7 m at RIT01. We were unable to measure active channel width at RIT02 because the fire made it impossible to discern between riparian and upland tree species.

Canopy closure averaged 28.9% at RIT01. We were unable measure canopy closure at RIT02 because of the fire.

Appropriate aquatic macroinvertebrate habitat was absent from much of both monitoring sites in 2011 (fig. 20). Substrate fitting the category "Absence", meaning it lacked habitat that we define as appropriate for aquatic macroinvertebrates, occurred along 82.9% of RIT02 and 80.0% of RIT01. Rock was found along 13.2% of RIT02. Root wads and algal mats accounted for the remaining habitat found at RIT02, at 2.6% and 1.3%, respectively. Leaf packs (13.3%), rock (5.3%), and root wads (1.3%) accounted for the remaining habitat at RIT01.

Reach level. Channel structure dynamics are represented by particle size distributions in Figures 21a (RIT02) and 21b (RIT01). In 2011, particle size distributions were dominated by finer sediments at both monitoring sites. Sand and gravels accounted for 81.8% of the particles measured at RIT02 and 89.5% of RIT01. Cobbles were found along 15.8% of RIT02 and 4.5% of RIT01. Because the method for collecting particle size data in 2009 was not comparable to succeeding years, that year's data are not presented in this report.

Riffles (53.0%) and runs (38.0%) were the dominant GCU's along RIT02 (fig. 22). Further downstream, runs (75.0%) dominated RIT01, followed by riffles, which made up 17.0% of the reach. For a complete description of GCUs see Brasher et al. (2011).

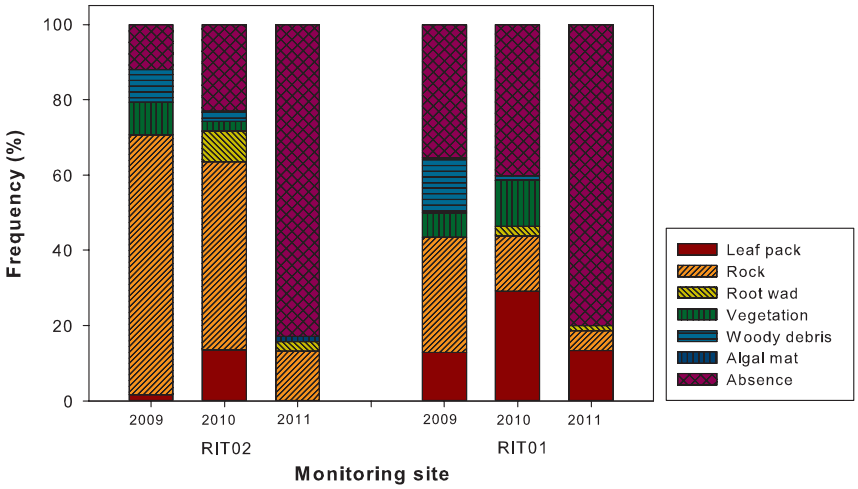


Figure 20. Aquatic macroinvertebrate habitat characterization based upon line point intercept data collected at habitat transects in quantitative targeted riffle samples from RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2011. Not all habitat structure types were observed.

Figure 21a. Particle size distribution, based on modified Wolman pebble counts (minimum 400 particles), from RIT02 at the Rito de los Frijoles in BAND, 2010–2011

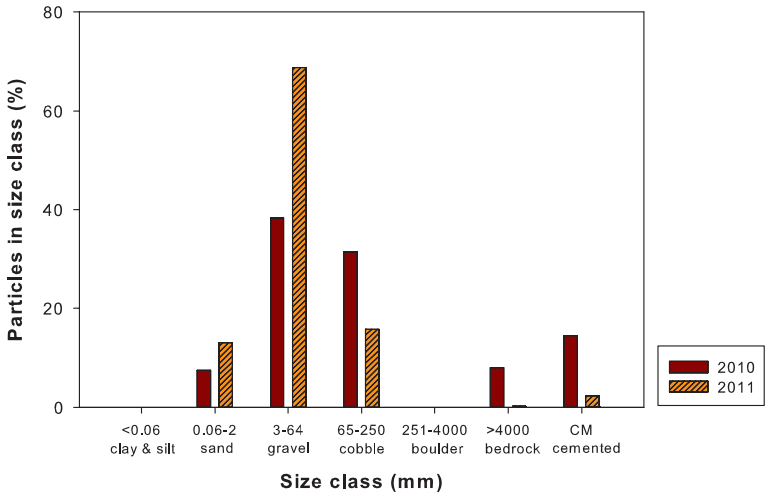


Figure 21b. Particle size distribution, based on modified Wolman pebble counts (minimum 400 particles), from RIT01 at the Rito de los Frijoles in BAND, 2010–2011

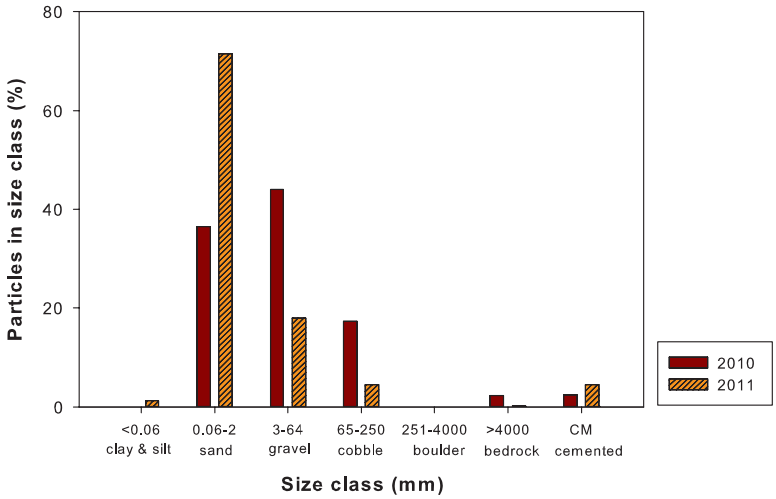
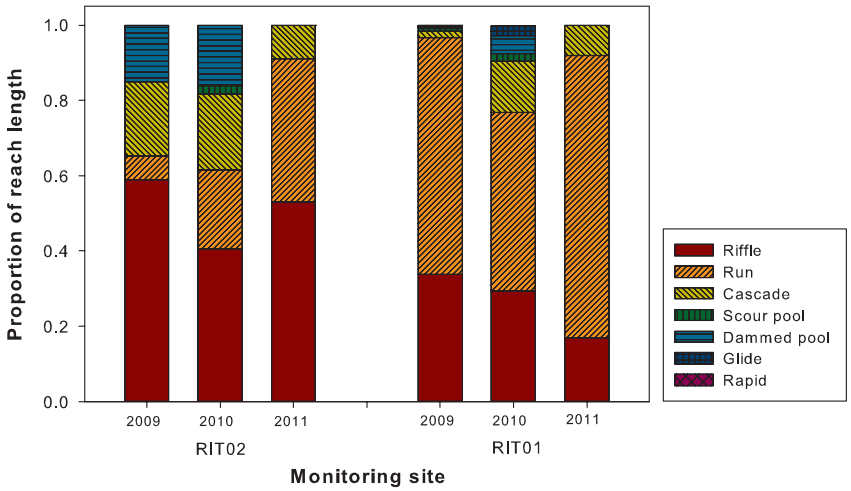


Figure 22. Geomorphic channel unit characterization of RIT02 and RIT01 at the Rito de los Frijoles in BAND, 2009–2011



3.6 Hydrologic conditions for the Rito de los Frijoles

3.6.1 SCPN field data

Table 8 presents recorded measurements at or near midday of the sample date. The midday water temperature was 11.4°C at RIT02 and 9.1°C RIT01. Specific conductivity at RIT02 was 228 µS/cm and 172 µS/cm at RIT01. At RIT02, pH was 8.1, and at RIT01, pH was 8.2. Dissolved oxygen at RIT02 was 98.8% saturation and 8.4 mg/L.

Dissolved oxygen at RIT01 measured 97.8% saturation and 9.1 mg/L. Turbidity at RIT02 averaged 4.3 NTU and 234 NTU at RIT01. In addition to these water quality parameters, we measured total discharge at RIT02 (0.04 cfs) and at RIT01 (0.02 cfs).

3.6.2 LANL, USGS, and SCPN streamflow gaging station data

Streamflow data from gages maintained by LANL, USGS, and SCPN during 2011 on the Rito de los Frijoles near the Bandelier National Monument visitor center are presented in Figure 23.

The LANL gage operated from the beginning of the year until it was destroyed by a flood on 21 August 2011. Approximately one month of data was lost because of flood damage. Available data recorded by the gage ranged from 14.4 cfs on 3 February 2011 to 0 cfs on many days between 13 June 2011 and 1 July 2011.

After the LANL gage was damaged, SCPN installed a pressure transducer at the same site to act as a temporary gage. The transducer collected gage height data during the period 27 August 2011 through 15 December 2011. Due to the large volume of sediment moving through the channel, discharge could not be accurately calculated based on the transducer data. SCPN did measure discharge directly several times during this period, and it ranged from 0.64 cfs on 21 October 2011 to 1.31 cfs on 18 December 2011.

The USGS gage—installed just before the August flood event—collects data only during large floods and begins recording data when water reaches approximately 4.7 feet above the channel. In 2011 this gage documented flow events on 21 August 2011 (gage height 11.43 feet; 7,000 cfs) and 4 September 2011 (7.50 gage height; 2,160 cfs).

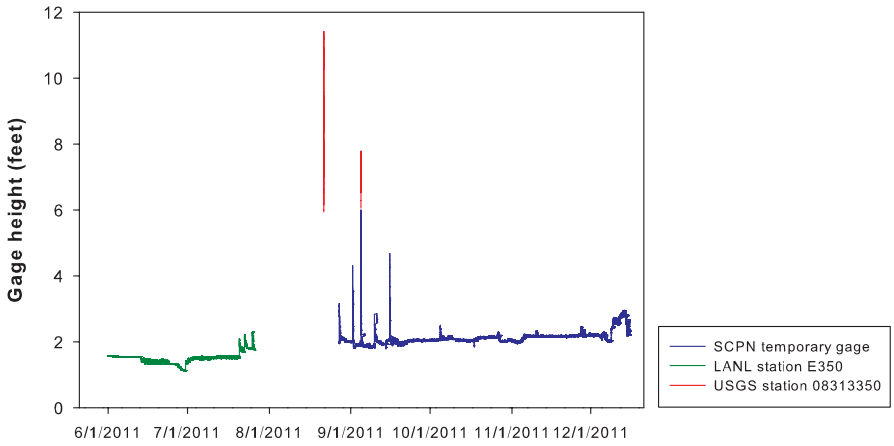


Figure 23. Gage heights from streamflow gages LANL-E350, USGS 08313350, and the temporary SCPN temporary gage on the Rito de los Frijoles near the BAND visitor center in 2011

4 Discussion

This report presents data from SCPN's fifth year of monitoring aquatic macroinvertebrates and physical habitat at Capulin Creek, as well as our third 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 community

The Las Conchas Fire was a major disturbance event that greatly impacted both Capulin Creek and the Rito de los Frijoles in 2011. Fire can lead to increases in water temperature as it burns along a stream, affecting aquatic communities. However, the large floods that took place in August (Minshall et al. 2001) most likely had the greatest impact on aquatic macroinvertebrates in our streams. Samples taken in October after the flood show that abundance values that once averaged over 700 individuals per sample in previous years plummeted to single digits. Taxonomic and functional diversity also saw large decreases at our monitoring sites in 2011. All orders of aquatic macroinverterbrates saw noteworthy declines, with the exception of the dipterans which are very quick to repopulate an area. Dipteran species are highly adapted to disturbance and should prove to be responsible for the majority of aquatic macroinvertebrate community abundance in the coming years.

4.2 Physical habitat and water quality

In addition to changes in the aquatic community, we found large changes in the physical characteristics of the streams as well. Most notably, water temperature increased by an average of 3.4°C at CAP01, CAP02, and RIT02. We did not find a difference in water temperature at RIT01, the site that was not directly impacted by the fire. Turbidity was another core parameter that saw large differences from pre-fire data. The downstream sites on both streams, CAP02 and RIT01, both saw the biggest changes in turbidity. Turbidity at CAP02 averaged 1.9 NTU from 2007 to 2011, but jumped up to 76.0 NTU in 2011. At RIT01, pre-fire turbidity averaged 1.8 NTU, but then jumped up to 234 NTU in 2011. We did not see large increases in turbidity at the upstream sites during our visit.

Streambeds that were once dominated by gravel and cobble substrates saw large increases in sand as result of the fire and flooding. Aquatic macroinvertebrate habitat was nearly non-existent at any of our monitoring sites in 2011.

4.3 Recovery

Recovery of the aquatic macroinvertebrate community to pre-fire conditions will typically occur on a decadal scale. Previous studies have shown large annual variation in aquatic community structure continuing through the first 10 years after a large fire, with community stability requiring in excess of 30 years to achieve (Minshall 2003, Arkle et al. 2010).

Annual variability of aquatic macroinvertebrate community structure is dependent on the variation in physical attributes in a stream. Sediment, large woody debris, riparian cover and organic debris appear to be the major influences on the post-fire recovery of the aquatic community (Arkle et al. 2010). Annual variation in these inputs can be expected to be reflected in the aquatic macroinvertebrate community. As the surrounding riparian and forest vegetation recover, fine sediment availability should decline as the primary input. As a result we should see a shift in the aquatic macroinvertebrate community away from one dominated by sediment- and disturbance-tolerant taxa and towards a more diverse community of taxa responsible for processing riparian organic matter. Given the extent and intensity of the Las Conchas Fire, it would be reasonable to expect a slow recovery of the aquatic macroinvertebrate community, especially in the upper reaches of Capulin Creek and the Rito de los Frijoles.

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Appendix A Monitoring sites at Bandelier National Monument, New Mexico, 2011

Site code	Common name	Report name	UTM X	UTM Y	Elevation (m)
BANDCAP01	Capulin Creek at Base Camp Gaging 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, 2011. "NEW" 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	Clitellata						segmented worms	x		x	x
Arthropoda	Arachnida	Trombidiformes					water mites	x			
Arthropoda	Insecta	Coleoptera	Dytiscidae		*Colymbetes* sp.		predaceous diving beetles	NEW			
Arthropoda	Insecta	Coleoptera	Dytiscidae				predaceous diving beetles	x			
Arthropoda	Insecta	Coleoptera	Elmidae		*Optioservus* sp.		riffle beetles			x	
Arthropoda	Insecta	Coleoptera	Elmidae		*Zaitzevia*	*parvulus* (Horn)	riffle beetles			x	
Arthropoda	Insecta	Coleoptera	Hydrophilidae		*Berosus* sp.		water scavenger beetles				NEW
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	Culicidae		*Culiseta* sp.		mosquitoes	x			x
Arthropoda	Insecta	Diptera	Culicidae				mosquitoes	x			
Arthropoda	Insecta	Diptera	Dixidae		*Dixa* sp.		meniscus midges	x		x	
Arthropoda	Insecta	Diptera	Ephydridae				shore flies	x		NEW	x
Arthropoda	Insecta	Diptera	Muscidae				house flies	x	x	NEW	x
Arthropoda	Insecta	Diptera	Psychodidae		*Pericoma* sp.		moth flies			x	
Arthropoda	Insecta	Diptera	Psychodidae				moth and sand flies				NEW
Arthropoda	Insecta	Diptera	Simuliidae	Simuliinae	*Simulium* sp.		black flies	x	x	x	x
Arthropoda	Insecta	Diptera	Simuliidae				black flies	x			
Arthropoda	Insecta	Diptera	Tipulidae				large crane flies	x	x	x	x
Arthropoda	Insecta	Diptera					flies	x	x	x	x
Arthropoda	Insecta	Ephemeroptera	Baetidae		*Baetis* sp.		small minnow mayflies	x			
Arthropoda	Insecta	Lepidoptera	Crambidae	Nymphulinae	*Petrophila* sp.		crambid snout moths	x			
Arthropoda	Insecta	Odonata	Aeshnidae				darners			x	
Arthropoda	Insecta	Plecoptera	Capniidae	Capniinae			small winter stoneflies	x	x	x	
Arthropoda	Insecta	Trichoptera	Limnephilidae				northern caddisflies			x	
Nemata							nematodes			x	x

Appendix D Measured velocity and channel characteristics at 4 monitoring sites in Bandelier National Monument, New Mexico, 2011

	Velocity (m/s)		Depth (m)		Wetted channel width (m)	Active channel width (m)
Transect	Mean	Std Dev	Mean	Std Dev	Value	Value
CAP01						
1	0.31	0.09	0.01	<0.01	1.7	—[a]
2	0.36	0.21	0.02	<0.01	1.4	—[a]
3	0.26	0.08	0.05	0.04	1.9	—[a]
4	0.31	0.22	0.06	0.04	1.4	—[a]
5	—	—	—	—	6.8	—[a]
6	0.35	0.27	0.07	0.06	0.9	—[a]
7	0.40	0.12	0.05	0.02	1.3	—[a]
8	0.18	0.26	0.09	0.01	1.3	—[a]
9	0.28	0.20	0.04	0.03	1.3	—[a]
10	0.19	0.36	0.03	0.04	1.7	—[a]
11	0.34	0.14	0.05	0.03	1.2	—[a]
CAP02						
1	0.32	0.09	0.02	0.01	1.6	—[a]
2	0.44	0.21	0.03	0.02	1.0	—[a]
3	0.33	0.29	0.05	0.04	0.9	—[a]
4	0.34	0.14	0.04	0.02	1.0	—[a]
5	0.08	0.18	0.02	0.01	3.2	—[a]
6	0.27	0.18	0.03	0.01	3.2	—[a]
7	0.18	0.04	0.01	0.01	4.3	—[a]
8	0.19	0.01	0.02	0.01	5.1	—[a]
9	0.38[b]	n/a[b]	0.04[b]	n/a[b]	4.6	—[a]
10	0.23	0.01	0.03	0.01	4.0	—[a]
11	0.32	0.27	0.03	0.02	3.0	—[a]
RIT01						
1	0.35	0.12	0.05	0.03	1.2	22.0
2	0.45	0.19	0.04	0.02	1.1	20.6
3	0.52	0.04	0.06	0.01	1.1	16.8
4	0.36	0.10	0.04	0.02	1.6	8.3
5	0.47	0.03	0.05	0.01	1.6	9.6
6	0.37	0.19	0.04	0.03	0.9	25.0
7	0.37	0.10	0.05	0.01	1.3	25.8
8	0.27	0.17	0.04	0.02	2.0	24.9
9	0.32	0.14	0.03	0.01	2.4	4.6
10	0.44	0.18	0.11	0.08	6.1	14.0
11	0.36	0.26	0.04	0.03	1.8	11.8

[a]No data collected because of the fire and a lack of discernible riparian vegetation.
[b]Only one reading was possible on this transect, therefore, standard deviation is not applicable.

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	—	—	—	—	4.3	—[a]
2	0.01[b]	n/a[b]	0.06[b]	n/a[b]	3.5	—[a]
3	0.34	0.43	0.03	0.02	2.3	—[a]
4	0.52	0.19	0.08	0.00	2.6	—[a]
5	0.41	0.37	0.10	0.12	1.8	—[a]
6	0.50	0.19	0.06	0.05	1.4	—[a]
7	0.30	0.02	0.05	0.04	3.5	—[a]
8	0.51	0.24	0.06	0.03	1.4	—[a]
9	—	—	—	—	6.8	—[a]
10	0.61	0.14	0.10	0.02	2.7	—[a]
11	0.44	0.33	0.09	0.04	1.2	—[a]

[a]No data collected because of the fire and a lack of discernible riparian vegetation.
[b]Only one reading was possible on this transect, therefore, standard deviation is not applicable.