



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

2012 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2014/682



ON THE COVER

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

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

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1 Introduction and background

The National Park Service Inventory and Monitoring Program was designed to determine the current status and monitor long-term trends in the condition of park natural resources, providing park managers with a scientific foundation for making decisions and working with other agencies and the public to protect park ecosystems. Water-related vital signs are the fundamental components defining overall riparian and aquatic ecosystem integrity. The Southern Colorado Plateau Network (SCPN) has identified 7 vital signs pertaining to riparian and spring ecosystems, the first 2 of which we focus on in this report: 1) aquatic macroinvertebrates, 2) stream water quality, 3) stream flow and depth to groundwater, 4) spring water quality, 5) fluvial geomorphology, 6) riparian vegetation, composition, and structure, and 7) spring ecosystems. These vital signs are closely related and are all included in the *Vital Signs Monitoring Plan for the Southern Colorado Plateau Network* (Thomas et al. 2006). The context and ecological significance of these vital signs are further explained in Scott et al. (2005).

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 El Rito de los Frijoles in BAND (Figure 1) (Stumpf and Monroe 2011). Appendix A lists locations, codes, and common names of all sampling sites.

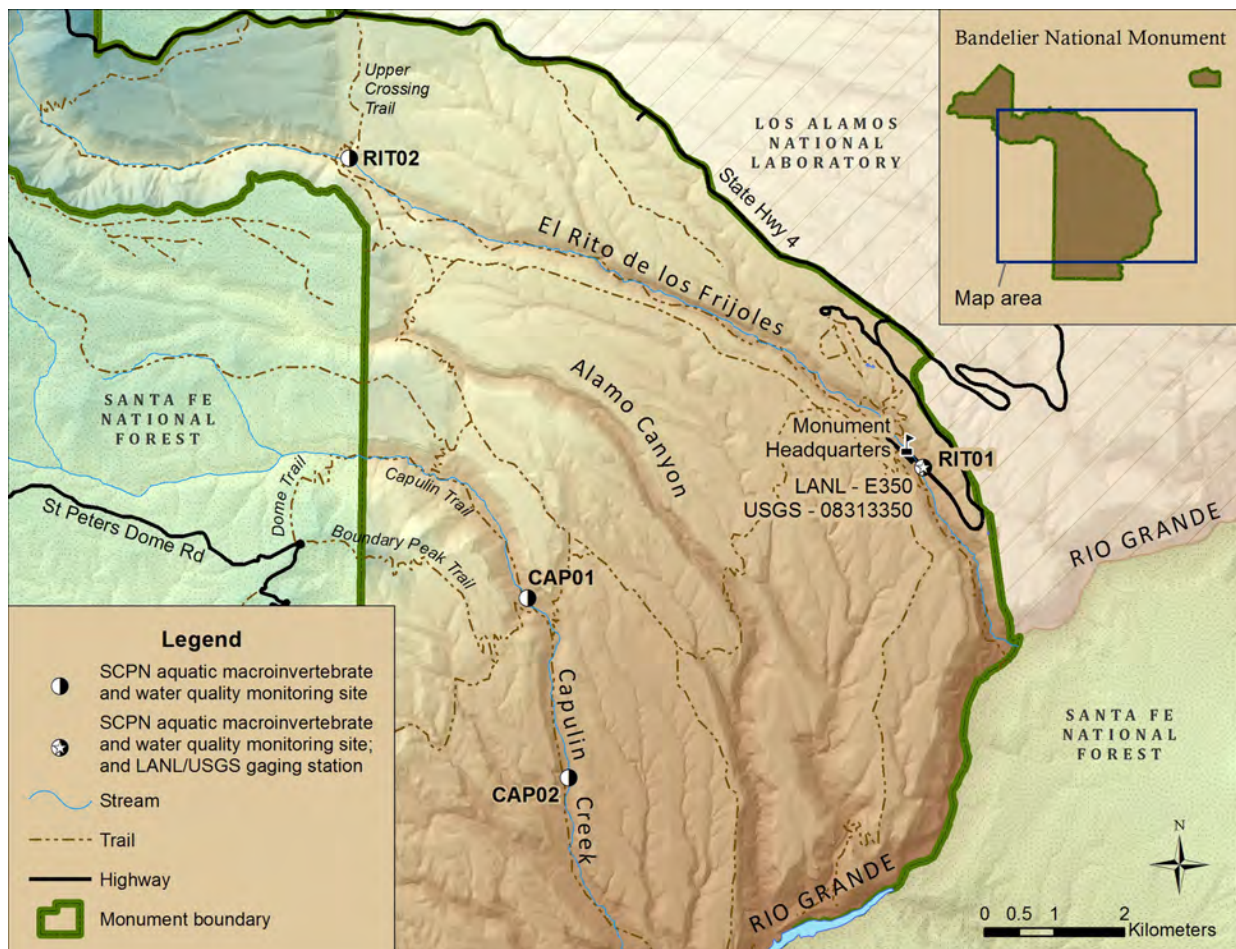


Figure 1. Locations of SCPN monitoring sites, CAP01 and CAP02, at Capulin Creek, and RIT01 and RIT02 at El Rito de los Frijoles in Bandelier National Monument, New Mexico, in 2012.

During 2012 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, is located less

than 0.3 km upstream from the backcountry ranger cabin and was selected to be co-located with an SCPN 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 fine sediments. Riparian vegetation was scoured from the site by the Las Conchas Fire and subsequent flooding.

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 stream at CAP02 flows through primarily fine/sand substrate. Riparian vegetation was scoured from the site by the Las Conchas Fire and subsequent flooding.

The Capulin Creek watershed is a designated wilderness area, managed for recreational use within park boundaries. The upper reaches of the watershed outside of park boundaries are managed for recreation and timber harvest by the U.S. Forest Service. In 1996 the Dome Fire burned several thousand acres in Capulin Creek watershed. Aquatic macroinvertebrates were sampled in streams at BAND before the Dome fire by Pippin and Pippin (1981), and postfire by Vieira et al. (2004). On 26 June 2011, the Las Conchas Fire ignited and ultimately burned approximately 60% of the land within BAND, including the majority of the upper portions of Capulin Creek. All canopy and understory vegetation was burned where the fire occurred, and subsequent flooding by a large event on 21 August 2011 drastically changed the geomorphology of Capulin Creek within the park. Large volumes of sediment were mobilized throughout the watershed, significantly altering channel morphology and physical habitat at our monitoring sites.

Native Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) populations were extirpated from Capulin Creek by large flood events following the Dome Fire. The New Mexico Department of Game and Fish, BAND, and the Santa Fe National Forest collaborated to reintroduce this species to the creek in 2006. The Las Conchas Fire in 2011 and subsequent flooding extirpated all fish from both Capulin Creek and El Rito de los Frijoles. Data collected in this report will support future decisions about reintroduction of fish species into both streams.

During 2012, the SCPN water resources field crew also collected aquatic macroinvertebrate samples and physical habitat data from 2 monitoring sites at El Rito de los Frijoles:

Rito de los Frijoles near Visitor Center (BANDRIT01) is identified in this report as RIT01. The site was selected to be co-located with an SCPN water quality monitoring site and a streamflow gaging station. Riparian vegetation 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. Riparian vegetation was scoured from the shores of El Rito de los Frijoles by the Las Conchas Fire and subsequent flooding.

El 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 El Rito de los Frijoles watershed. As a result of this fire, the frequency and magnitude of stormflows and suspended sediment concentrations increased along El Rito de los Frijoles (Veenhuis 2002). The 2011 Las Conchas Fire burned a large portion of the upper portion of the El Rito de los Frijoles watershed. A large flood event on 21 August 2011 significantly affected channel morphology and physical habitat at both SCPN monitoring sites on El Rito de los Frijoles.

The primary purpose of this report is to (a) document SCPN aquatic macroinvertebrate monitoring activities that occurred at streams in BAND in 2012, (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 23–26 October, 2012, we collected aquatic macroinvertebrate samples and physical habitat data at CAP01 and CAP02 on Capulin Creek, and at RIT01 and RIT02 on El Rito de los Frijoles. Each site consists of a 150 meter reach, composed of 11 transects, spaced 15 m apart (Figure 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).

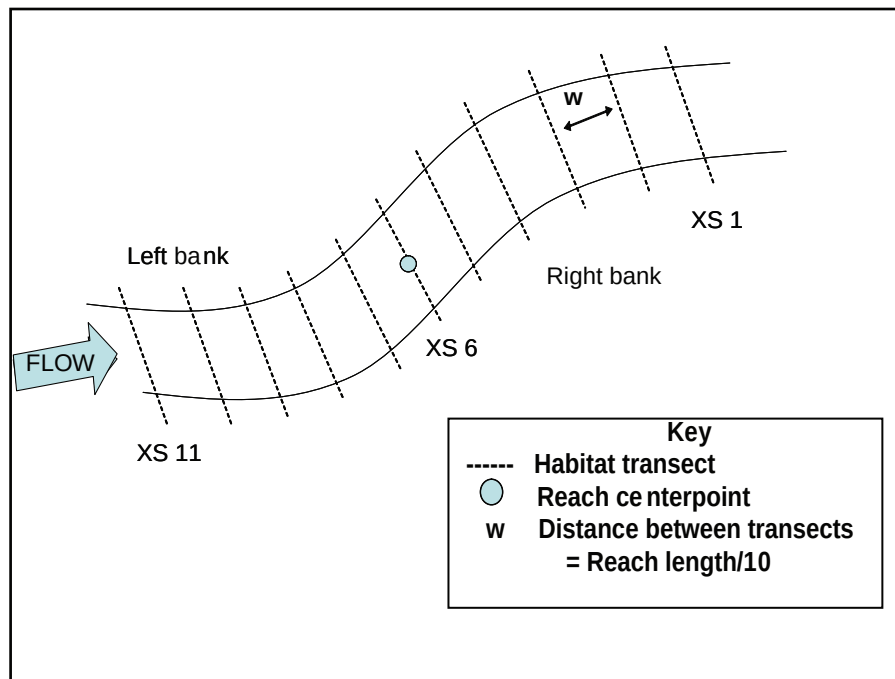


Figure 2. General aquatic macroinvertebrate sampling reach layout.

We collected 2 types of aquatic macroinvertebrate samples:

- Replicate quantitative samples were collected from 3 targeted riffle habitats to provide estimates of abundances of organisms. We used a Slack sampler to collect a timed sample from a 0.25 m² 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.

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

- For each of the targeted riffle micro habitats where quantitative samples are collected we
 - measured velocity
 - measured depth
 - measured substrate particle size
 - measured substrate particle embeddedness
- For each of the 11 transects, we
 - measured wetted and active channel widths
 - estimated canopy closure at both ends and at the center of each transect

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

2.2 Hydrologic data collection

Hydrologic data presented in this report are collected at a streamflow gaging station on El Rito de los Frijoles and from a group of weather stations in and near BAND.

Discharge data are available from a streamflow gaging station on El Rito de los Frijoles. An existing gage (LANL-E350) operated by Los Alamos National Laboratory (LANL) was destroyed by a large flood on 21 August 2011. A new streamflow gage (USGS # 08313350, *Rito de los Frijoles in Bandelier Nat Mon, NM*) was installed at the site by the USGS in 2012 (USGS 2013).

In 2012 an early warning system was installed in and near BAND. The system includes one weather station in the upper reaches of Capulin Canyon known as *Headwaters of Cochiti and Capulin Canyon* (#31045), and two in the El Rito de los Frijoles watershed, named *Dome Road* (#31058) and *Ponderosa C.G.* (#31057) (OneRain 2013).

2.3 Laboratory methods

Aquatic macroinvertebrate samples were sent to the National Aquatic Monitoring Center's Bug Lab, a Bureau of Land Management laboratory at Utah State University in Logan. 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).

2.4 Data analysis

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

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

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

3 Results

3.1 Aquatic macroinvertebrate community data for Capulin Creek

The following figures present key metrics calculated from qualitative sampling of aquatic macroinvertebrate communities from 2007 to 2012 at CAP01 and CAP02. All corresponding data values are available in table format in Appendix C (Table C1). Appendix D lists all aquatic macroinvertebrate species detected at the site in 2012 from qualitative sampling.

The large flood event that occurred at Capulin Creek in August 2011 altered channel morphology, depositing large volumes of fine sediments. Because of the lack of riffle habitat, we were unable to collect a quantitative sample from either site on Capulin Creek in 2012.

Taxa richness. Qualitative richness equaled 11 taxa at CAP01 and 14 taxa at CAP02 in 2012 (Figure 3).

Stress tolerance. Taxa that are moderately tolerant to disturbance dominated samples collected from both monitoring sites on Capulin Creek in 2012 (Figure 4). Moderately tolerant taxa accounted for 66.67% at CAP01 and 83.33% at CAP02. Tolerant taxa accounted for 22.22% of the taxa collected at CAP01 and 16.67% of the taxa collected at CAP02. Only 11.11% of the taxa collected at CAP01 were intolerant to disturbance. No intolerant taxa were found at CAP02 in 2012.

Figure 3. Taxa richness in qualitative samples from CAP01 and CAP02 in BAND, 2007–2012.

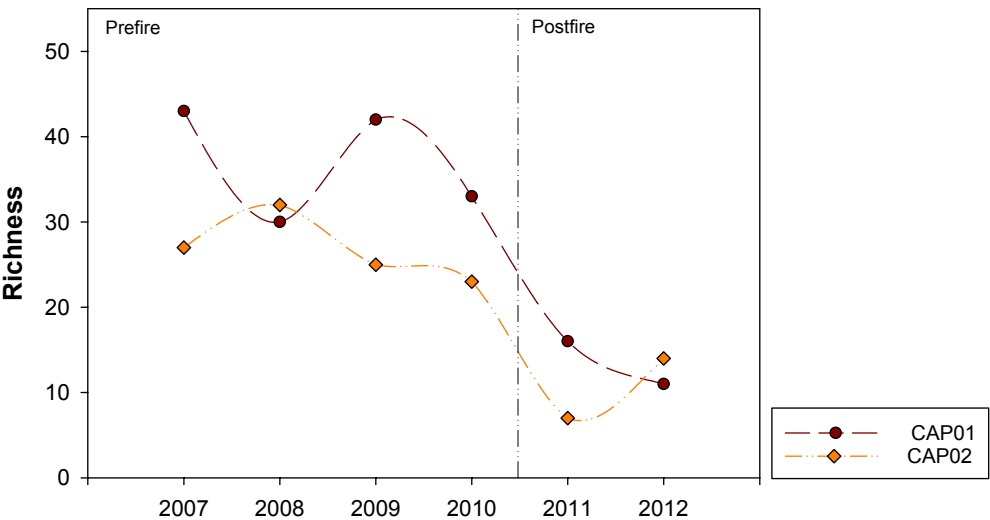
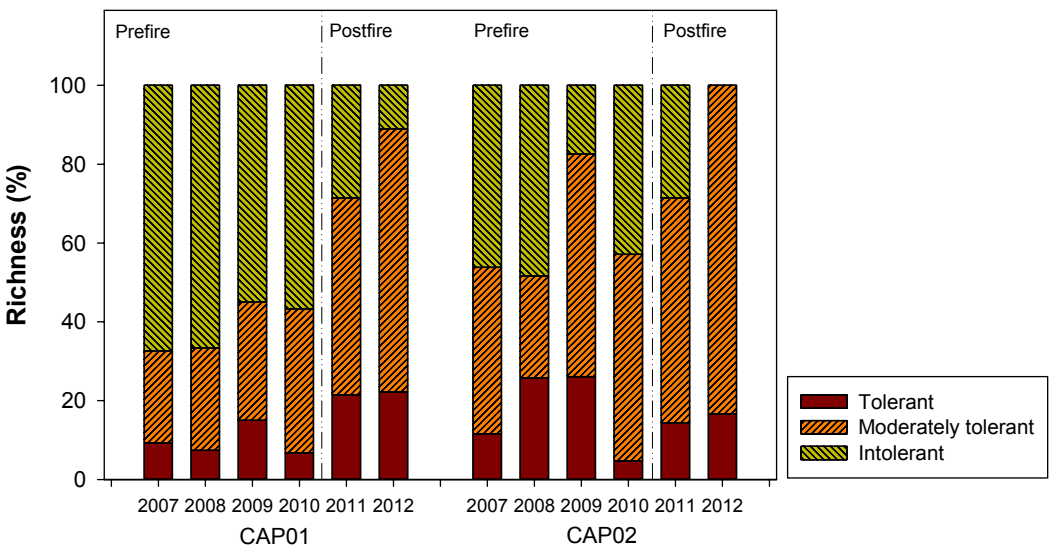


Figure 4. Percent taxa richness by tolerance group in qualitative samples from CAP01 and CAP02 at Capulin Creek in BAND, 2007–2012.



Functional feeding groups. Collector-gatherers made up the largest proportion of functional groups from taxa collected at both CAP01 and CAP02 in 2012, accounting for 45.45% and 53.85% of the sample, respectively (Figure 5). Predators were next, at 27.27% for CAP01, and 38.46% for CAP02. Collector-filterers, scrapers, and shredders each accounted for 9.09% of the sample from CAP01. At CAP02, collector-filterer taxa were found in the smallest proportion, at 7.69%. No scrapers or shredders were collected at CAP02 in 2012.

EPT taxa. Individuals representing 3 EPT taxa were collected from CAP01 in 2012, one from Ephemeroptera (mayfly), one from Plecoptera (stonefly) and one from Trichoptera (caddisfly) (Figure 6). Only 2 EPT individuals were collected from CAP02, both from Ephemeroptera.

Aquatic macroinvertebrate orders. Non-Chironomidae Diptera (flies) accounted for 27.27% of the taxa collected from CAP01 in 2012, the largest of any group collected at the site (Figure 7). Chironomidae (midges) and noninsect (worms and mites) taxa were at 18.18% and 18.18%, respectively. Each of the EPT taxa accounted for 9.09% of the total taxa richness, and Coleoptera (beetles) accounted for 9.09% of the sample at CAP01 as well. At CAP02, non-Chironomidae taxa accounted for the largest portion of taxa collected, at 35.71% of the qualitative sample. Noninsect (worms and mites) taxa accounted for 21.43% of the taxa collected. Chironomidae and Ephemeroptera each accounted for 14.29% of the sample, and Coleoptera and Odonata (damselflies and dragonflies) each accounted for 7.14% of the sample at CAP02 in 2012.

Figure 5. Percent taxa richness by functional feeding group in qualitative samples from CAP01 (top) and CAP02 (bottom) at Capulin Creek in BAND, 2007–2012.

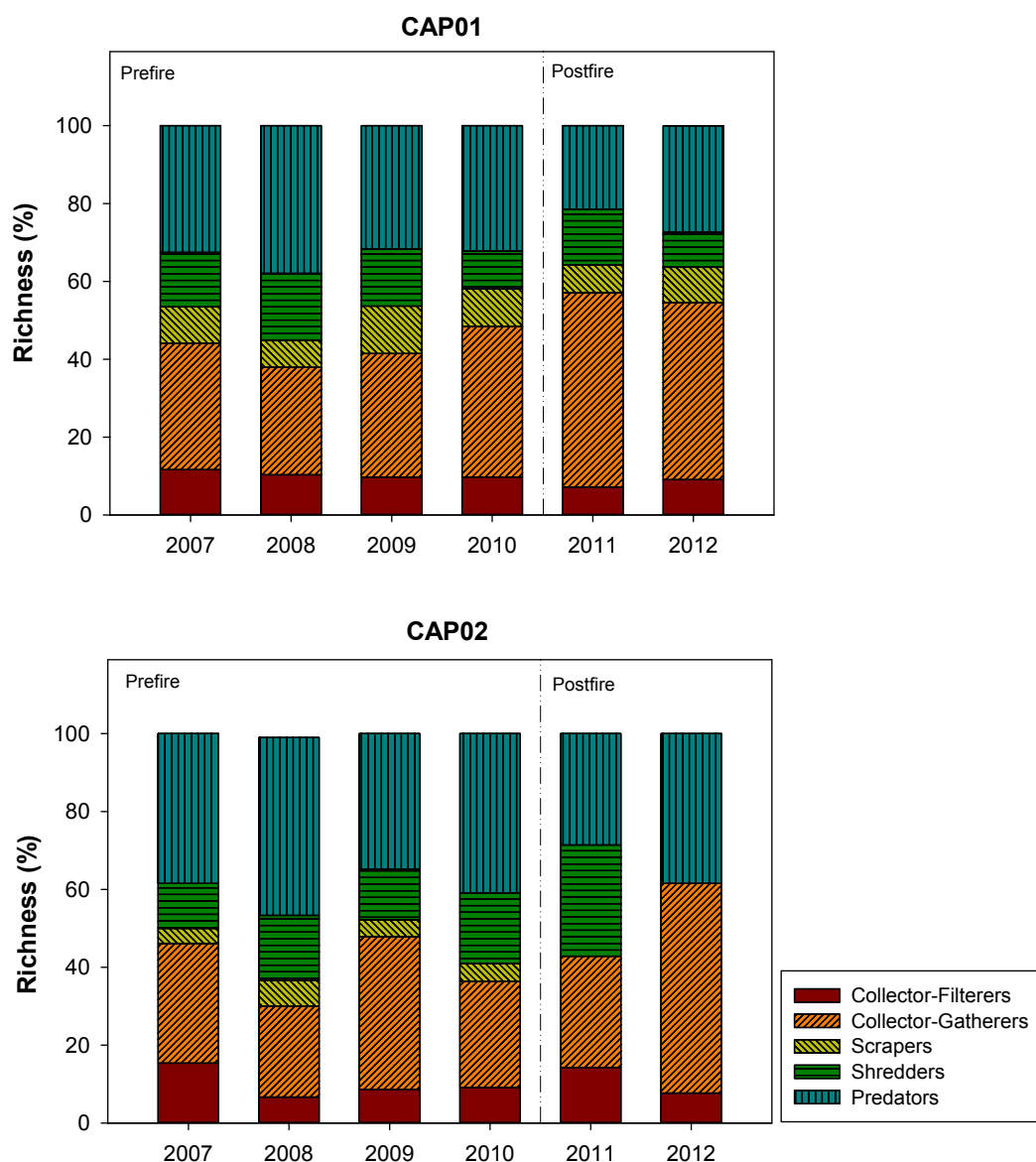


Figure 6. Percent richness of aquatic macroinvertebrates belonging to sensitive EPT orders in qualitative samples from CAP01 and CAP02 at Capulin Creek in BAND, 2007–2012.

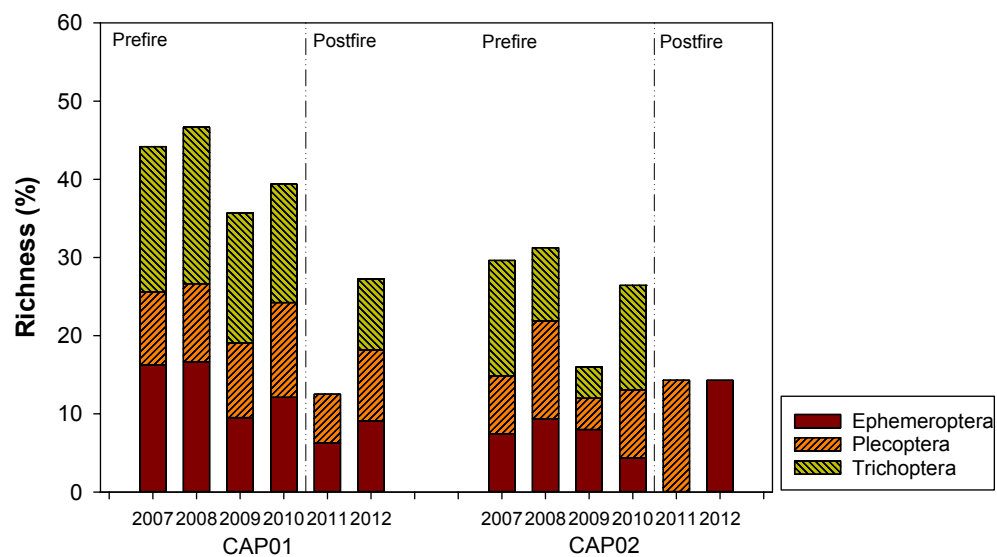
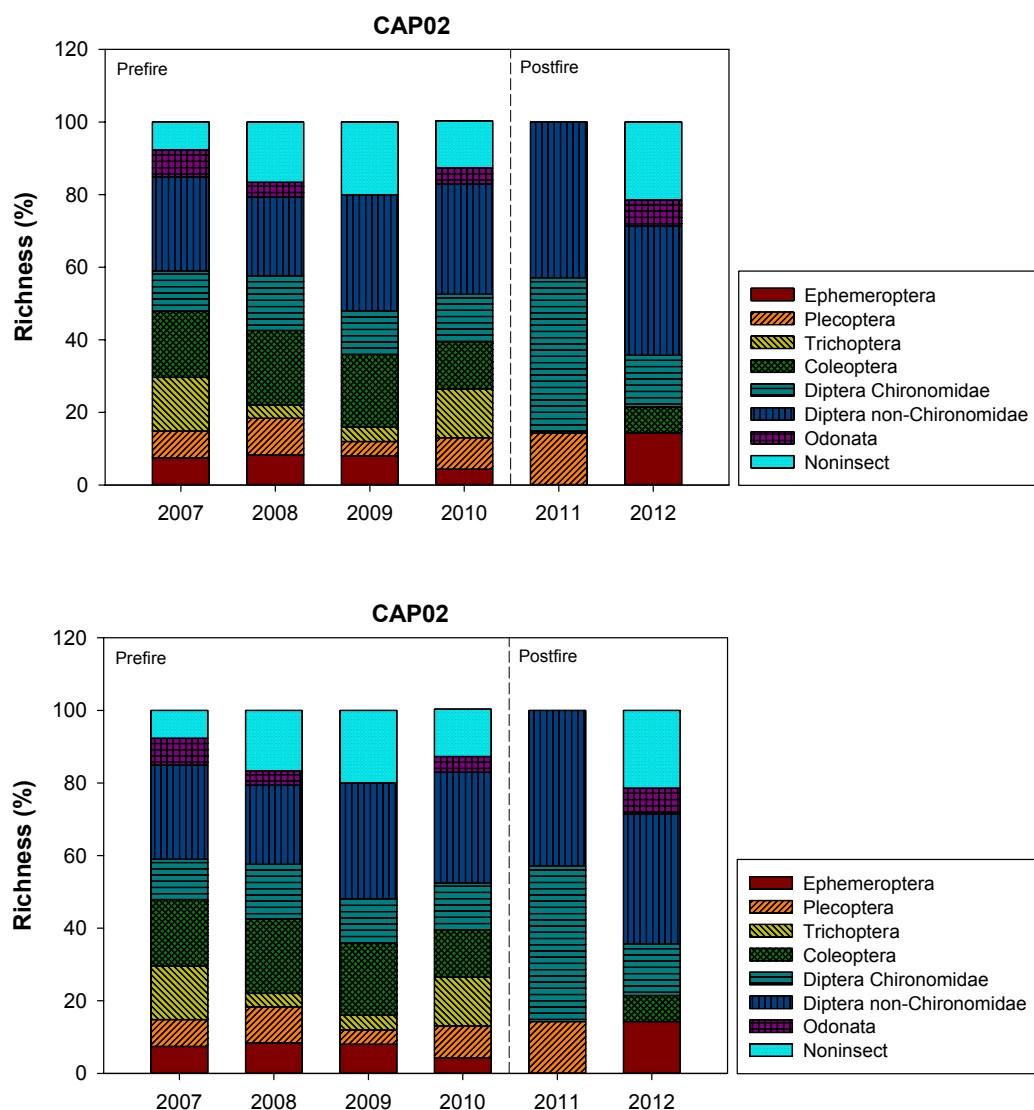


Figure 7. Percent richness by taxonomic order in qualitative samples from CAP01 (top) and CAP02 (bottom) at Capulin Creek in BAND, 2007–2012.



3.2 Physical habitat characteristics for Capulin Creek

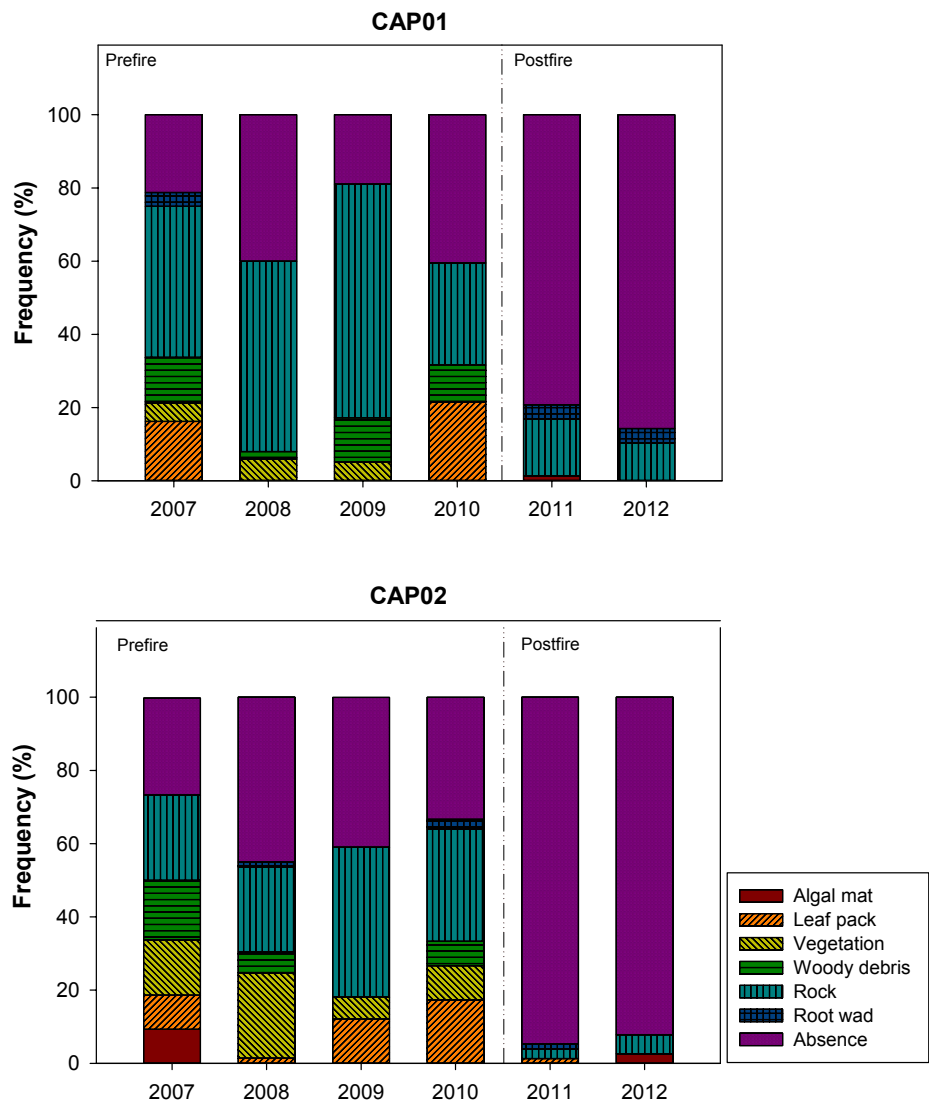
We present data in this section describing physical habitat characteristics at CAP01 and CAP02 from 2007 to 2012. These data are summarized in table format in Appendix C (Tables C2, C3); additional transect data can be found in Appendix E.

Microhabitat level. No microhabitat data were collected at Capulin Creek in 2012 because of a lack of riffle habitat.

Transect level. Average stream depths along our physical habitat transects were 0.03 m at CAP01 and 0.02 m at CAP02 in 2012. Velocities were greatest upstream at CAP01, averaging 0.34 m/s. Velocity at CAP02 averaged 0.24 m/s in 2012. Wetted channel width averaged 1.5 m at CAP01 and 2.4 m at CAP02. Streamside riparian vegetation has not yet recovered along our monitoring reaches at Capulin Creek, as such the active channel width at both sites was 0. Canopy closures at CAP01 and CAP02 were less than 1%.

Appropriate aquatic macroinvertebrate habitat was absent from much of both monitoring sites in 2012 (Figure 8). Substrate fitting the category “Absence”, meaning it lacked habitat that we define as appropriate for aquatic macroinvertebrates, occurred along 85.7% of CAP01 and 92.2% of CAP02. Rock made up 10.4% of CAP01 and 5.2% of CAP02. Root wads were found along 3.9% of CAP01, and leaf packs were found along 2.6% of CAP02.

Figure 8. Habitat characterization along transects at CAP01 (top) and CAP02 (bottom) at Capulin Creek in BAND, 2007–2012.



Reach level. Channel structure dynamics are represented by particle size distributions at CAP01 and CAP02. Finer sediments dominated both sites in 2012 (Figure 9). Sand and gravel were found along 83.5% of CAP01 and 93.0% of CAP02. Cobbles were found along 6.5% of CAP01 and 4.0% of CAP02. Boulders were found along 4.0% of CAP01 and 0.5% of CAP02. At CAP01, 6.0% of the particles sampled were too cemented to measure, and at CAP02, 2.5% of the particles were too cemented to measure.

Runs were the dominant geomorphic channel units (GCU) at both monitoring sites in 2012 (Figure 10). Runs made up 79.2% of the site along CAP01 and 80.2% at CAP02. The next most abundant GCU for each site was cascades, at 20.8% of CAP01 and 14.7% of CAP02. One shallow riffle was found, representing 2.4% of CAP02.

Figure 9. Particle size distribution along the CAP01 and CAP02 reaches at Capulin Creek in BAND, 2012.

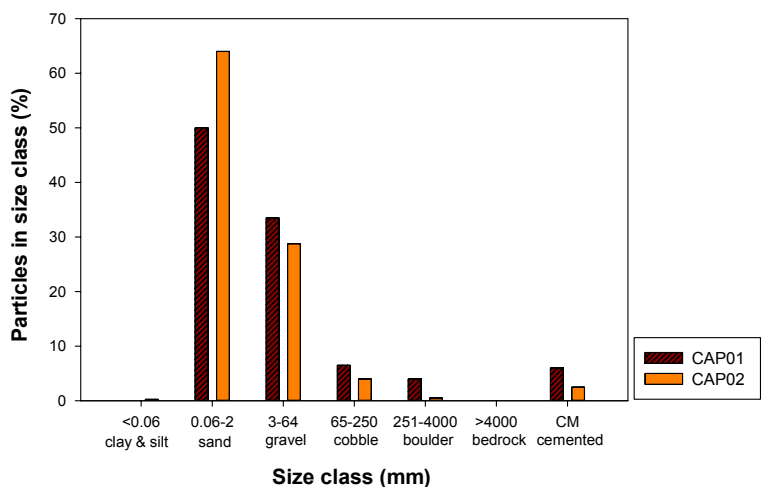
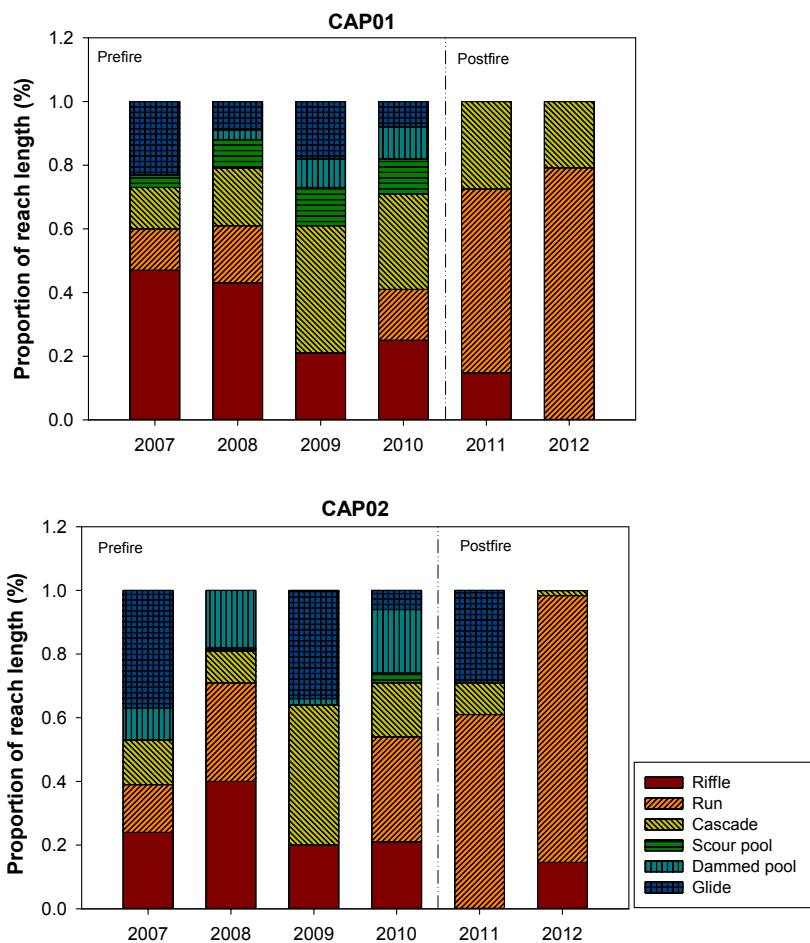


Figure 10. Geomorphic channel unit characterization of CAP01 (top) and CAP02 (bottom) at Capulin Creek in BAND, 2007–2012.



3.3 Hydrologic conditions for Capulin Creek

3.3.1 SCPN water quality core parameter data

We report hydrologic measurements collected at or near midday of the sample dates for Capulin Creek in 2012. Data from all years of sampling at Capulin Creek (2007–2012) are in table format in Appendix C (Tables C2, C3).

In 2012, the midday water temperature was 10.1°C at CAP01 and 14.0°C at CAP02. Specific conductivity was higher upstream at CAP01, measuring 193 $\mu\text{S}/\text{cm}$ compared with 134 $\mu\text{S}/\text{cm}$ downstream at CAP02. At both sites, pH measured 8.3. Dissolved oxygen at CAP01 measured 99.1% saturation and 9.0 mg/L. Dissolved oxygen was slightly lower at CAP02, measuring 95.9% saturation and 8.0 mg/L. Turbidity was 47 NTU at CAP01 and 210 NTU at CAP02 (Figure 11). In addition to these water quality parameters, we measured stream discharge at both monitoring sites. Total discharge at CAP01 was 0.3 cfs, and 0.4 cfs at CAP02.

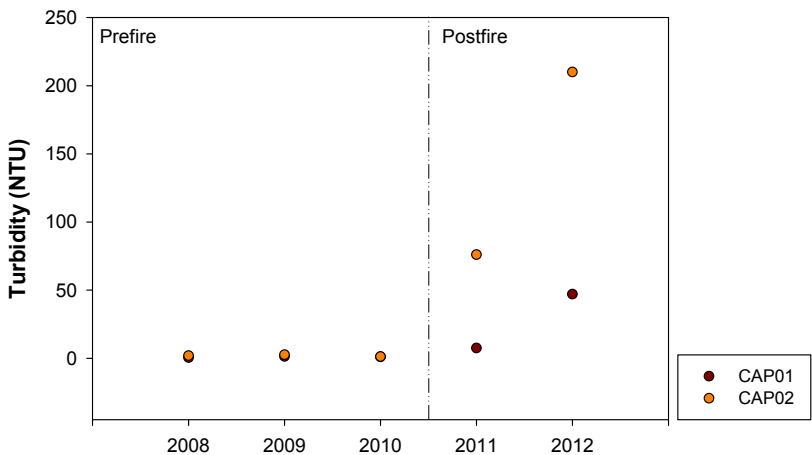


Figure 11. Turbidity at CAP01 and CAP02 on Capulin Creek in BAND, 2012.

3.3.2 USGS precipitation data

Data from the early warning system weather station *Headwaters of Cochiti and Capulin Canyon* (#31045) (OneRain 2013) are shown in Figure 12. These data show the majority of measurable events occurred during the mid-summer months (July–September), typical of the North American monsoon pattern. This station also recorded a large post-monsoon rainfall event in mid-October.

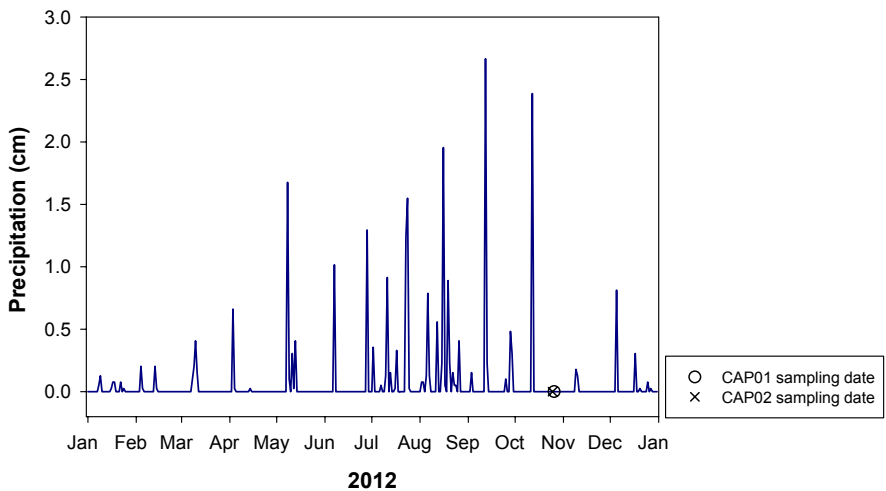


Figure 12. Total daily precipitation from the *Headwaters of Cochiti and Capulin Canyon* USGS rain gage (#31045) outside the western boundary of BAND, 2012.

3.4 Aquatic macroinvertebrate community data for El Rito de los Frijoles

We present key metrics calculated from aquatic macroinvertebrate community data collected from 2009 to 2012 at RIT01 and RIT02. Figures in this section refer to quantitative data unless otherwise noted. Error bars in figures represent one standard deviation from the mean. Due to dynamic movement of large volumes of fine sediments throughout Rito de los Frijoles, we were unable to collect 5 quantitative samples at each of our sampling sites in 2012. Data presented in this report represent means calculated from samples collected from 3 riffles instead of the standard 5 prescribed in the SCPN protocol. This pre and postfire difference in sample sizes is noted in the graphs on either side of the vertical line representing the Las Conchas Fire. All data values are provided in table format in Appendix F (Tables F1, F2, F3). Appendix D lists all aquatic macroinvertebrate species detected at the site in 2012 from both quantitative and qualitative methods.

Abundance. Like last year, mean abundance of aquatic macroinvertebrates was extremely low at both sites, with 2.33 individuals at RIT02 and 9.67 individuals at RIT01 (Figure 13).

Taxa richness. Total taxa richness for quantitative targeted riffle samples averaged 2.00 taxa and 3.00 taxa at RIT02 and RIT01, respectively, in 2012 (Figure 14). Taxa richness for the qualitative sample was higher at both sites: we found 5 taxa at RIT02 and 4 taxa at RIT01.

Diversity. We measured both taxonomic and functional diversity using the Simpson's Diversity Index. Taxonomic diversity averaged 0.33 at RIT02 and 0.69 at RIT01 in 2012 (Figure 15). Functional diversity was lower at both sites, averaging 0.40 at RIT02 and 0.67 at RIT01 (Figure 16).

Figure 13. Aquatic macroinvertebrate abundance in quantitative samples from RIT02 and RIT01 at El Rito de los Frijoles in BAND, 2009–2012.

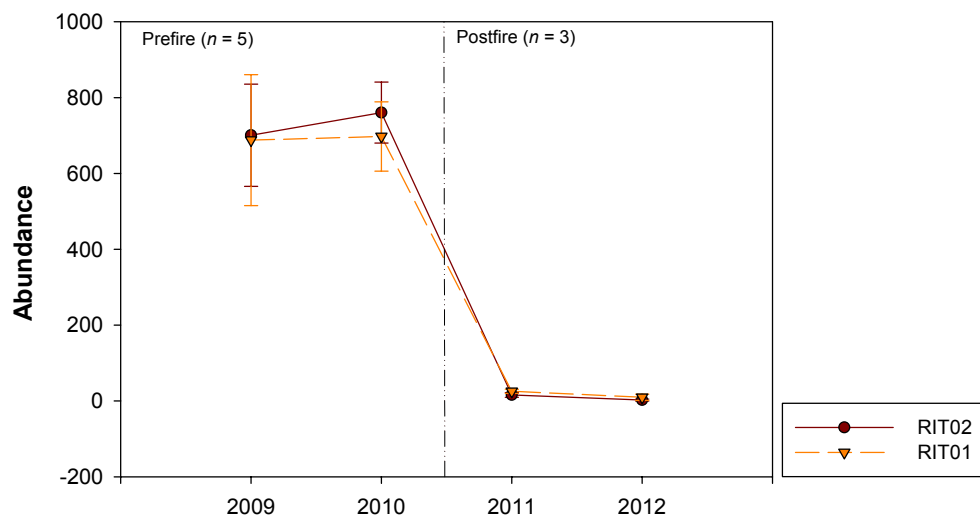
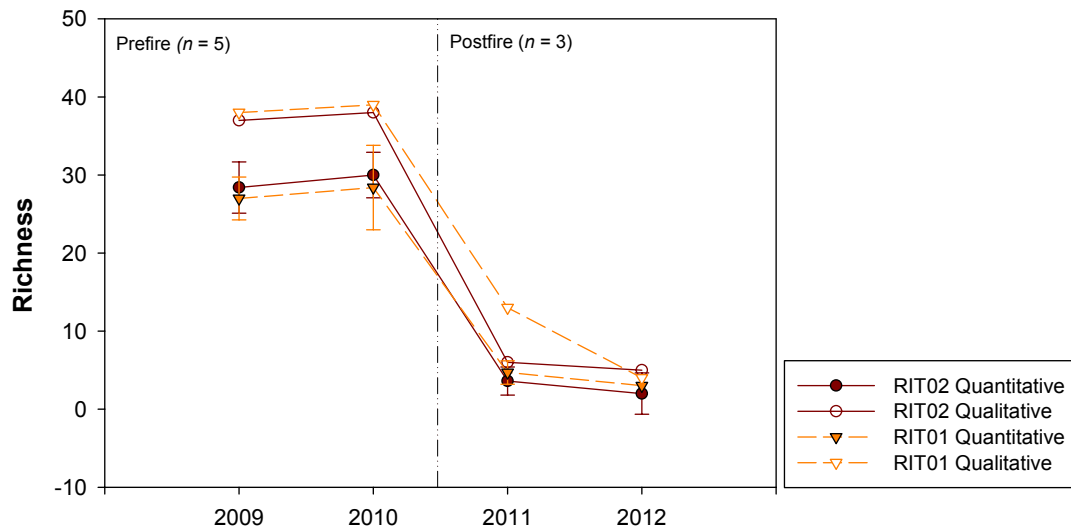


Figure 14. Taxa richness in quantitative and qualitative samples from RIT02 and RIT01 on El Rito de los Frijoles in BAND, 2009–2012.



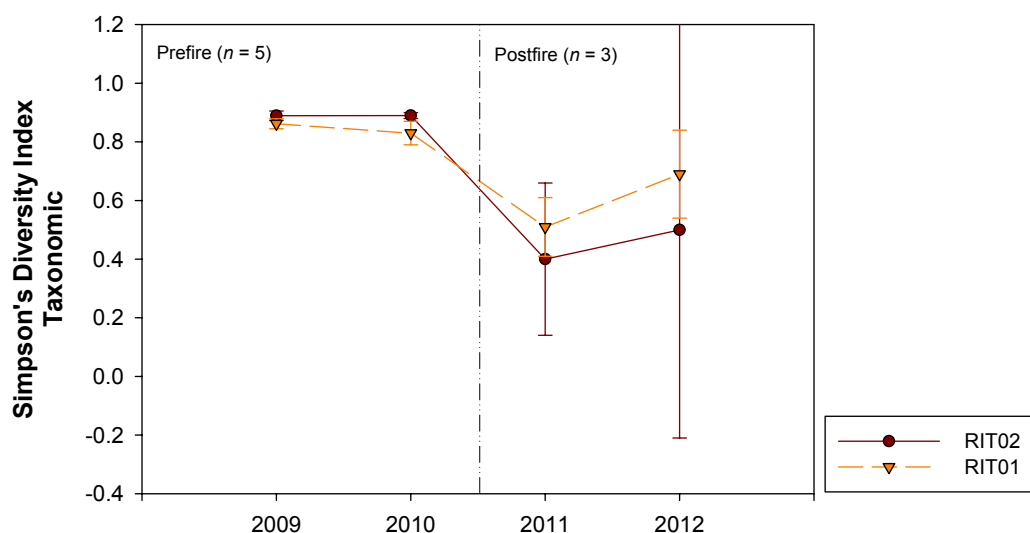


Figure 15. Taxonomic diversity in samples from RIT02 and RIT01 at El Rito de los Frijoles in BAND, 2009–2012.

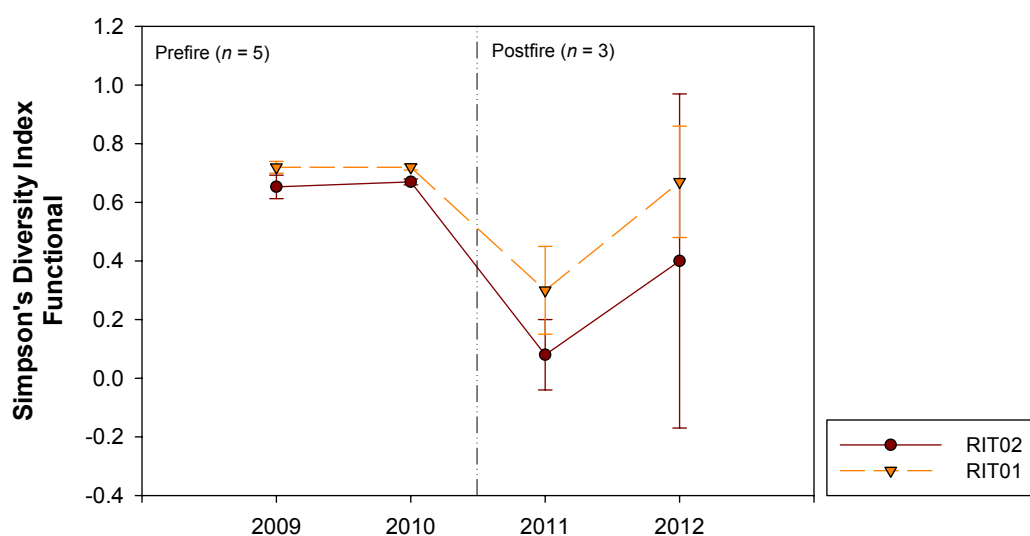


Figure 16. Functional diversity in samples from RIT02 and RIT01 at El Rito de los Frijoles in BAND, 2009–2012.

Stress tolerance. Individuals moderately tolerant to disturbance had the highest abundance at both sites in 2012 (Figures 17, 18). An average of 2.00 moderately tolerant individuals were collected per sample at RIT02 and 7.67 at RIT01. Intolerant individuals averaged 0.33 at RIT02 and 1.67 at RIT01. No tolerant individuals were found in 2012.

Functional feeding groups. Collector-gatherers dominated samples collected from both monitoring sites in 2012 (Figures 19, 20). Collectors-gatherers averaged 1.33 individuals per sample at RIT02 and 5.44 individuals per sample at RIT01. At RIT02, predators and collector-filterers averaged 0.67 and 0.33 individuals per sample, respectively. No scrapers or shredders were found at RIT02 in 2012. At RIT01, collector-filterers averaged 2.56 individuals per sample and shredders averaged 1.67. We collected no scrapers or predators at RIT01 in 2012.

EPT taxa. Sensitive EPT taxa were found in low abundances in 2012. EPT abundance averaged 0.67 individuals at RIT02 and 1.67 at RIT01 (Figures 21, 22). At RIT02, Ephemeroptera and Plecoptera each averaged 0.33 individuals per sample. At RIT01, Plecoptera comprised the entire sample. No Ephemeroptera were found at RIT01, and no Trichoptera were found at either of the 2 sites on El Rito de los Frijoles in 2012.

Aquatic macroinvertebrate orders. Chironomidae was the most abundant taxa collected at either site in 2012 (Figures 23, 24). Chironomidae averaged 1.00 individual per sample at RIT02 and 5.11 individuals at RIT01. Non-Chironomidae Diptera averaged 0.67 individuals at RIT02 and 2.56 at RIT01. No Coleoptera or Odonata were found at either site in 2012.

Figure 17. Mean abundance by tolerance group in aquatic macroinvertebrate samples from RIT02 at El Rito de los Frijoles in BAND, 2009–2012.

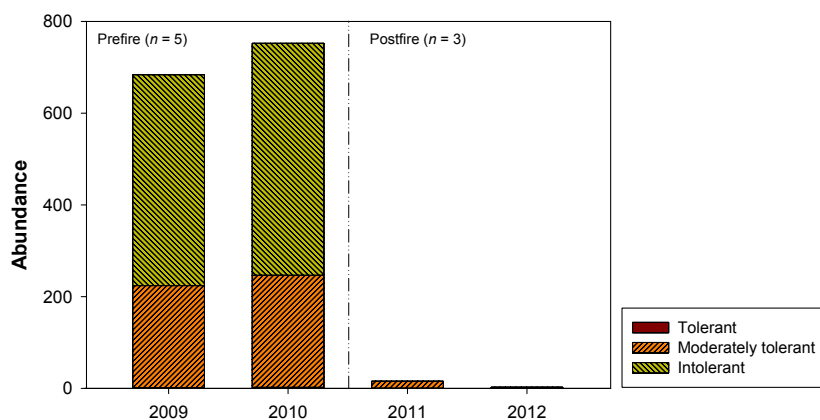


Figure 18. Mean abundance by tolerance group in aquatic macroinvertebrate samples from RIT01 at El Rito de los Frijoles in BAND, 2009–2012.

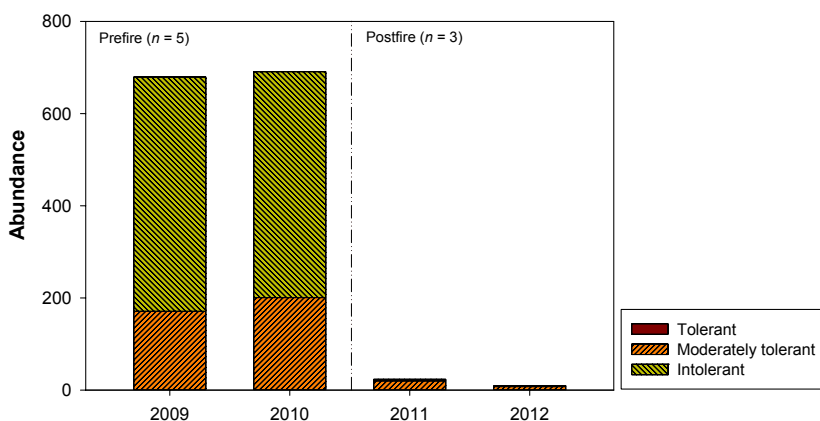


Figure 19. Mean abundance by functional feeding group in aquatic macroinvertebrate samples from RIT02 at El Rito de los Frijoles in BAND, 2009–2012.

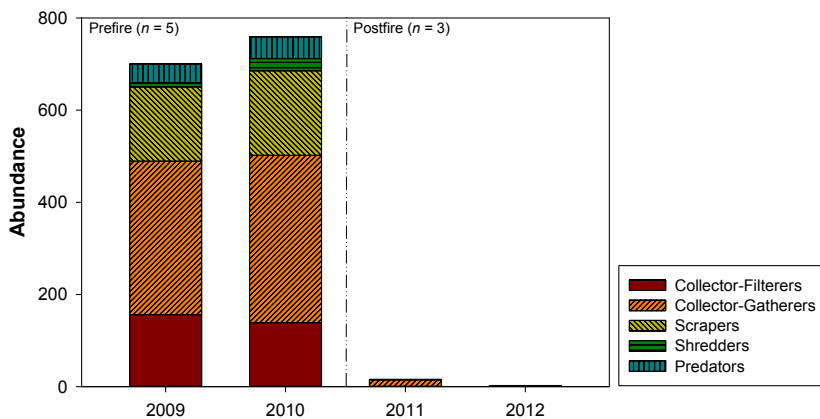
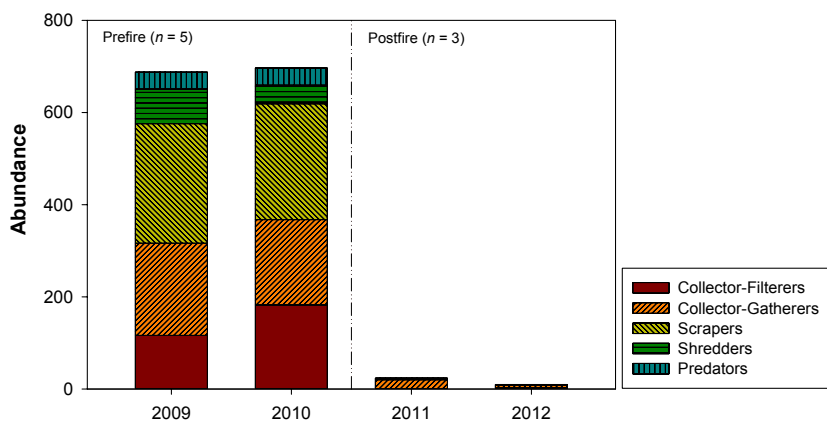


Figure 20. Mean abundance by functional feeding group in aquatic macroinvertebrate samples from RIT01 at El Rito de los Frijoles in BAND, 2009–2012.



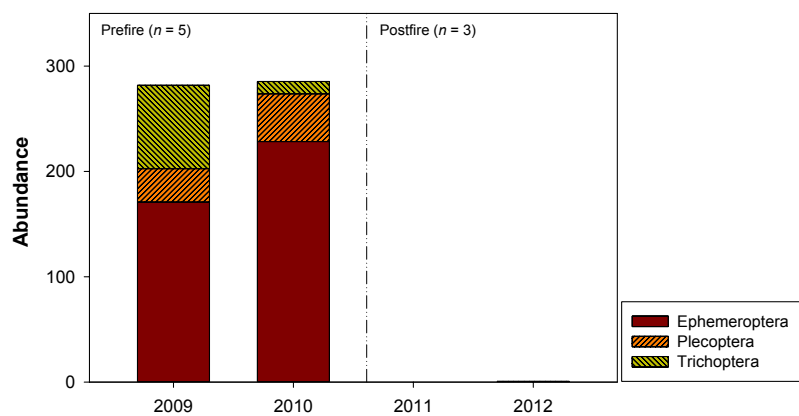


Figure 21. Mean abundance of aquatic macroinvertebrates belonging to sensitive EPT orders in samples from RIT02 at El Rito de los Frijoles in BAND, 2009–2012.

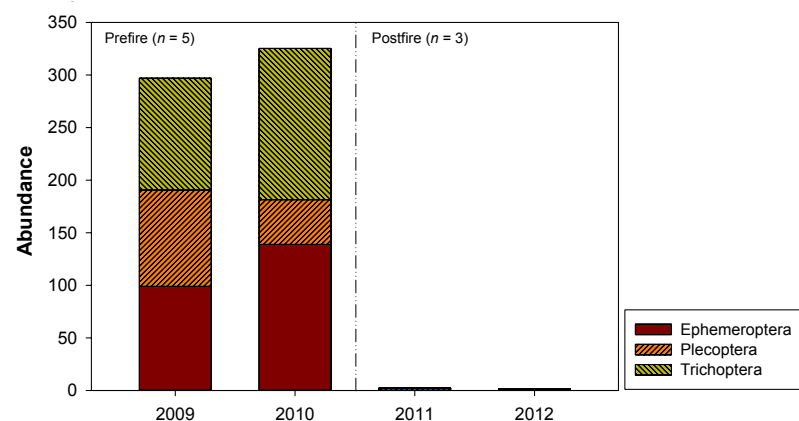


Figure 22. Mean abundance of aquatic macroinvertebrates belonging to sensitive EPT orders in samples from RIT01 at El Rito de los Frijoles in BAND, 2009–2012.

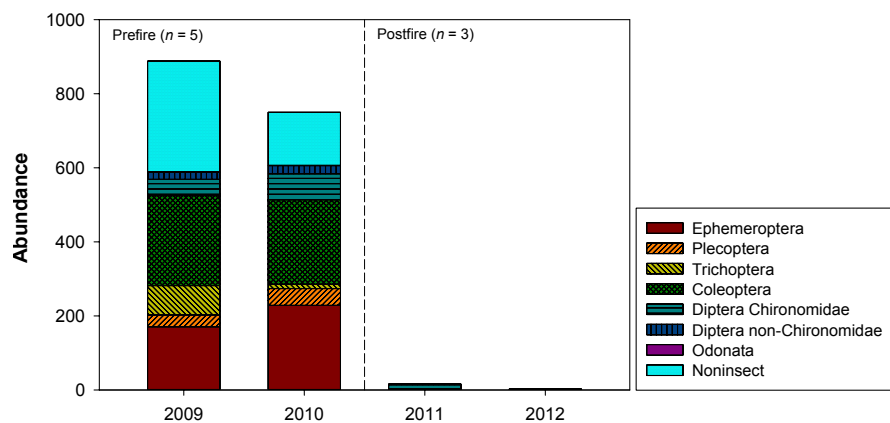


Figure 23. Mean abundance by taxonomic order in samples from RIT02 at El Rito de los Frijoles in BAND, 2009–2012.

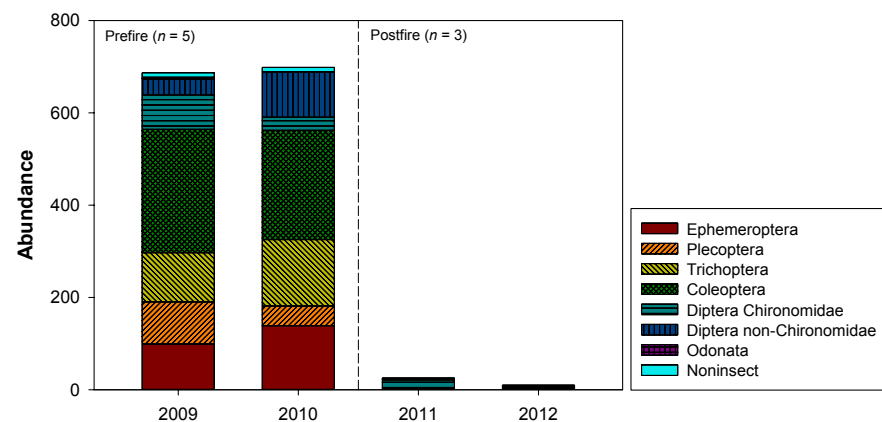


Figure 24. Mean abundance by taxonomic order in samples from RIT01 at El Rito de los Frijoles in BAND, 2009–2012.

3.5 Physical habitat characteristics for El Rito de los Frijoles

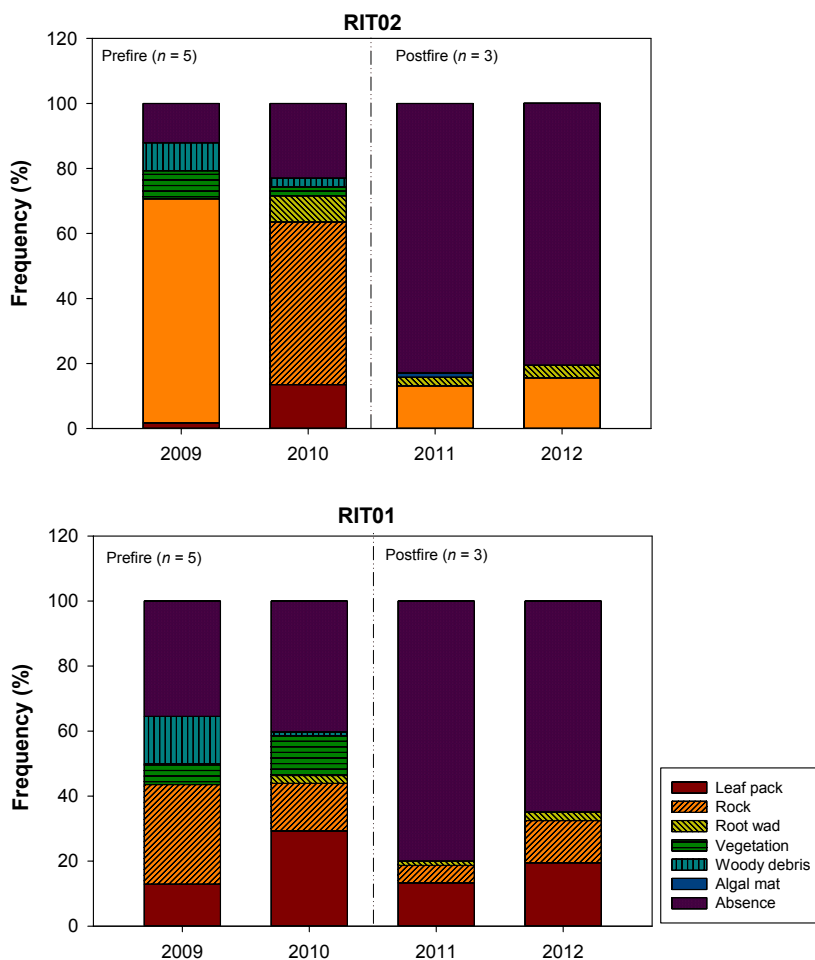
This section presents data describing physical habitat characteristics collected from 2009 to 2012 at RIT01 and RIT02. These data are summarized in table format in Appendix F (Table F4); additional transect data can be found in Appendix E.

Microhabitat level. Microhabitat data are from 3 riffle habitats rather than the standard 5 riffles in 2012. Flow velocities averaged 0.73 m/s at RIT02 and 0.54 m/s at RIT01. The depth at riffles averaged 0.08 m at RIT02 and 0.11 m at RIT01. Substrate embeddedness was greater downstream at RIT01, where 20.7% of each particle was embedded on average, while an average of 6.0% of each particle was embedded at RIT02.

Transect level. Stream velocities along our physical habitat transects were greater upstream in 2012. Velocity averaged 0.36 m/s at RIT02 and 0.29 m/s at RIT01. Stream depth averaged 0.06 m at RIT02 and 0.07 m at RIT01. Wetted channel width averaged 1.7 m at RIT02 and 1.5 m at RIT01. Active channel width averaged 23.8 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 25.1% at RIT01. Canopy cover at RIT02 was 0.

Aquatic macroinvertebrate habitat was absent from much of both monitoring sites in 2012 (Figure 25). Substrate fitting the category “Absence”, meaning it lacked habitat that we define as appropriate for aquatic macroinvertebrates, occurred along 80.6% of RIT02 and 64.9% of RIT01. Rock was found along 15.6% of RIT02. Root wads accounted for the remaining habitat found at RIT02, at 3.9%. Leaf packs (19.5%), rock (13.0%), and root wads (2.6%) accounted for the remaining habitat at RIT01.

Figure 25. Habitat characterization expressed as frequency of occurrence along transects at RIT02 (top) and RIT01 (bottom) on El Rito de los Frijoles in BAND, 2009–2012. Not all habitat structure types were observed.



Reach level. Channel structure dynamics are represented by particle size distributions at RIT01 and RIT02. In 2012, particle size distributions were dominated by finer sediments at both monitoring sites (Figure 26). Sand and gravels, combined, accounted for 88.8% of the particles measured at RIT02 and 92.5% of RIT01. Cobbles were found along 9.3% of RIT02 and 4.0% of RIT01. Boulders were found along 1.3% of RIT02 and 1.5% of RIT01. Few cemented particles were found along either sampling reach, only 0.8% of RIT02 and 2.0% of RIT01.

Riffles, cascades, and runs were the only GCUs found along either monitoring site in 2012 (Figure 27). Runs dominated both sites, accounting for 73.0% of RIT02 and 77.9% of RIT01. Cascades were found along 15.8% of RIT02 and 17.9% of RIT01. Riffles were found along 11.3% of RIT02 and 4.1% of RIT01. For a complete description of GCUs, see Brasher et al. (2011).

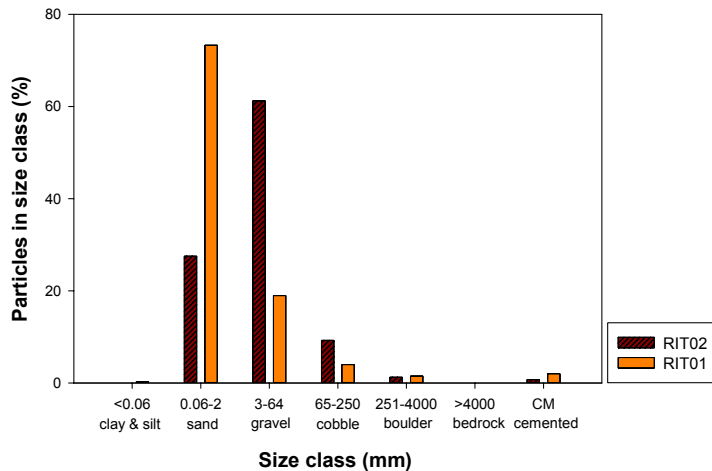


Figure 26. Particle size distribution along the reaches at RIT02 and RIT01 on El Rito de los Frijoles in BAND, 2012.

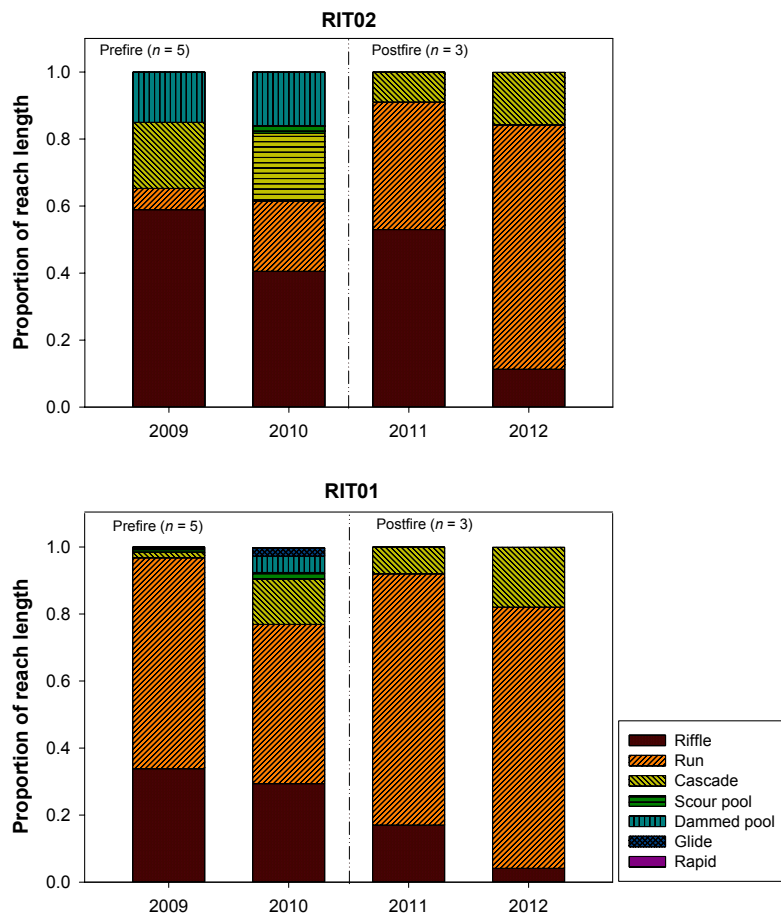


Figure 27. Geomorphic channel unit characterization of RIT02 (top) and RIT01 (bottom) at El Rito de los Frijoles in BAND, 2009–2012.

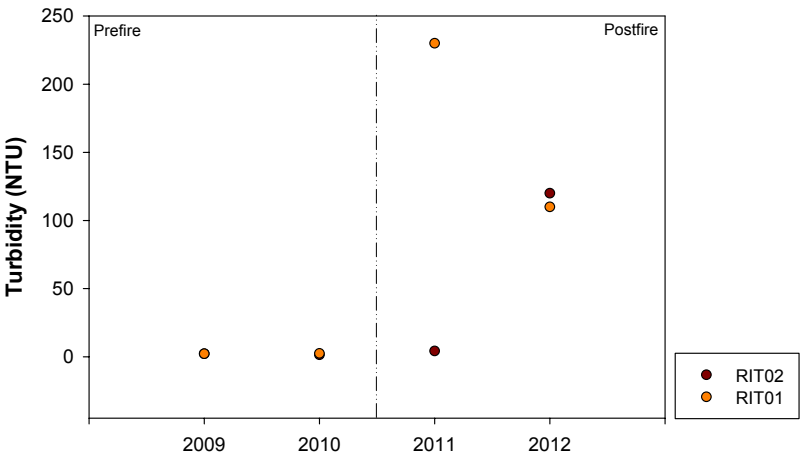
3.6 Hydrologic conditions for El Rito de los Frijoles

3.6.1 SCPN water quality core parameter data

We report hydrologic measurements collected at or near midday of the sample dates for El Rito de los Frijoles in 2012. Data from all years of sampling at El Rito de los Frijoles (2009–2012) are available in table format in Appendix F (Table F4).

In 2012, the midday water temperature was 13.3°C at RIT02 and 13.4°C RIT01. Specific conductivity at RIT02 was 166 $\mu\text{S}/\text{cm}$ and 215 $\mu\text{S}/\text{cm}$ at RIT01. At RIT02, pH was 8.1, and at RIT01, pH was 8.3. Dissolved oxygen at RIT02 was 95.4% saturation and 7.7mg/L. Dissolved oxygen at RIT01 measured 94.7% saturation and 7.9 mg/L. Turbidity at RIT02 averaged 120 NTU and 110 NTU at RIT01 (Figure 28). In addition to these water quality parameters, we measured total discharge at RIT02 (1.7 cfs) and at RIT01 (0.5 cfs).

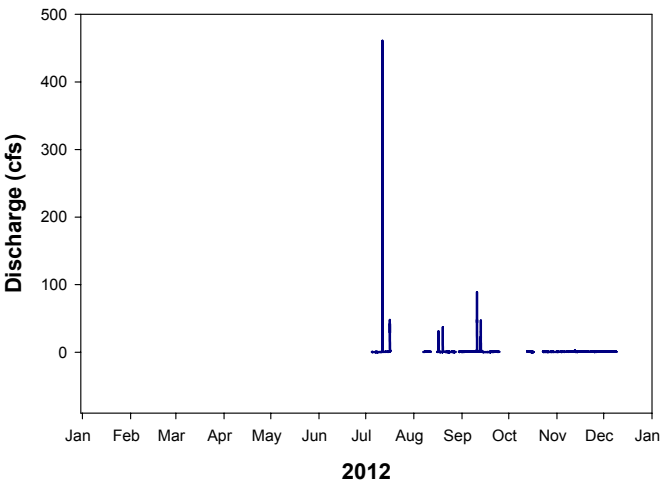
Figure 28. Turbidity at RIT01 and RIT02 on El Rito de los Frijoles in BAND, 2012.



3.6.2 USGS streamflow data

Streamflow data from the gage maintained by USGS during 2012 on El Rito de los Frijoles near the Bandelier National Monument Visitor Center (USGS 2013) are presented in Figure 29. The period of record for 2012 begins in July and data is spotty and interrupted periodically throughout the year. The largest recorded event occurred on 11 July, with an estimated peak of 461 cfs.

Figure 29. Discharge from streamflow gage USGS 08313350 on El Rito de los Frijoles near the BAND visitor center in 2012.



3.6.3 USGS precipitation data

Data from the early warning system weather stations *Ponderosa C.G.* (#31507) and *Dome Road* (#31508) (OneRain 2013) are shown in Figures 30 and 31. The pattern of rainfall events is similar at both stations. Much like the weather station in the Capulin watershed, these data show the majority of measurable events occurred during the mid-summer months (July-September), typical of the North American monsoon pattern, and a large post-monsoon rainfall event in mid-October.

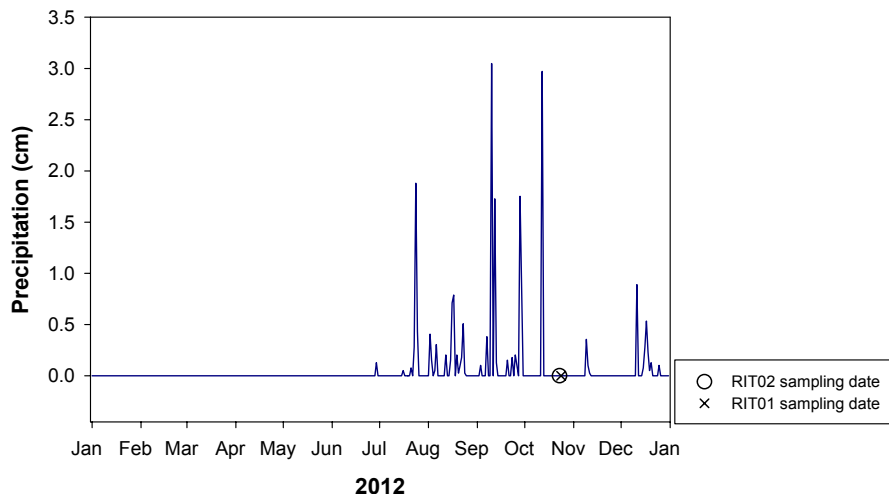


Figure 30. Total daily precipitation from the *Ponderosa C.G.* USGS rain gage (#31057) in BAND, 2012.

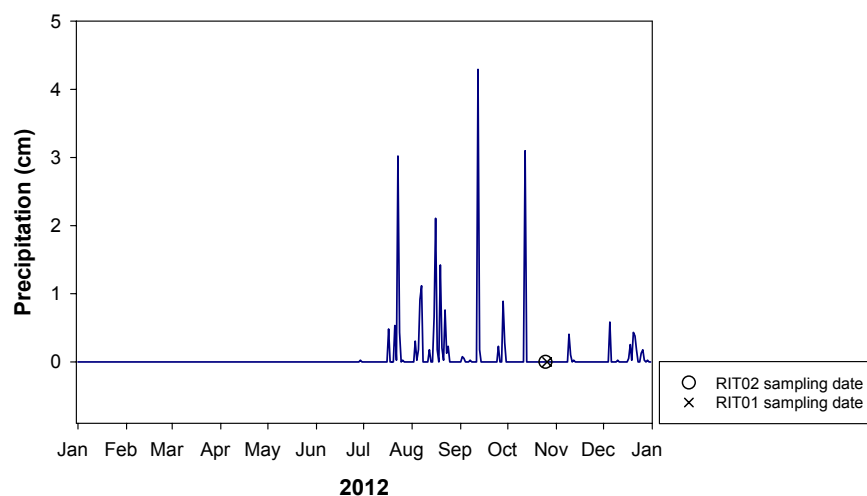


Figure 31. Total daily precipitation from the *Dome Road* USGS rain gage (#31058) in BAND, 2012.

4 Discussion

This report presents data from SCPN's sixth year of monitoring aquatic macroinvertebrates and physical habitat at Capulin Creek, as well as our fourth year of monitoring aquatic macroinvertebrates and physical habitat at El Rito de los Frijoles in Bandelier National Monument, New Mexico. We stress that any differences between sampling years and locations should not 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.

The effects of the Las Conchas Fire and subsequent flood events continue to impact the physical habitat and aquatic macroinvertebrate communities in Capulin Creek and Rito de los Frijoles. In 2012 we were unable to collect any quantitative samples from Capulin Creek due to large volumes of fine sediments moving through the stream channel and loss of appropriate riffle habitat. Similar conditions were present at Rito de los Frijoles; riffles, while present, were in low abundance there in 2012, limiting us to 3 quantitative samples from each of the 2 monitoring sites. Both streams are geomorphically unstable and are in a state of transition. Turbidity values were among the highest we have seen at any of the sites since monitoring began in 2007. Postfire flood events have scoured away much of the habitat required by the aquatic community. Habitat complexity is lacking across all of our monitoring sites, and habitats required by aquatic macroinvertebrates including riffles, woody debris, leaf packs, root wad, algal mats, and vegetation are virtually gone from these sites.

The lack of habitat heterogeneity and the degraded water quality across our monitoring sites are the driving forces restructuring the aquatic macroinvertebrate communities at BAND since the Las Conchas Fire. The majority of the taxa collected at both monitoring sites along El Rito de los Frijoles were Diptera species. Diptera taxa have high rates of dispersal and are typically the first organisms to recolonize a disturbed site (Vieira et al. 2004). They are generalists that can resist extreme changes in the aquatic environment and are dominant in degraded sites. While Ephemeroptera (*Baetis* sp.) and Plecoptera (Capniinae) taxa were found in 2012 at our sites, those same taxa were still present after the Dome Fire in 1996 (Viera et al. 2004) and are also generalists that can subsist on lower quality food resources post disturbance (Mihuc and Minshall 1995).

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 El Rito de los Frijoles.

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Appendix A: Southern Colorado Plateau Network aquatic macroinvertebrate monitoring sites on Capulin Creek and El Rito de los Frijoles in Bandelier National Monument, New Mexico, 2012

Site code	Common name	Report name	UTM Easting	UTM Northing	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

Note: Horizontal coordinates are reported in Universal Transverse Mercator (UTM) Projection, Zone 13, North American Datum of 1983 (NAD 83). Vertical (elevation) coordinates are referenced to the North American Vertical Datum of 1988 (NAVD 88).

Appendix B: Selected aquatic macroinvertebrate metrics

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

Source: Data from Brasher et al. (2011)

Appendix C: Aquatic macroinvertebrate community and physical habitat data from aquatic macroinvertebrate monitoring sites on Capulin Creek in Bandelier National Monument, New Mexico, 2007–2012

Table C1. Qualitative aquatic macroinvertebrate community metrics from CAP01 and CAP02 on Capulin Creek in Bandelier NM. Richness-based metrics are expressed as the percentage of taxa in a given order, tolerance or functional feeding group. Site ordering from left to right in the table corresponds to upstream to downstream position.

	CAP01						CAP02					
Qualitative metric	2007	2008	2009	2010	2011	2012	2007	2008	2009	2010	2011	2012
Taxa richness	43	30	42	33	16	11	27	32	25	23	7	14
Tolerance group												
Richness of tolerant taxa (%)	9.30	7.41	15.00	6.67	21.43	22.22	11.54	25.81	26.09	4.76	14.29	16.67
Richness of moderately tolerant taxa (%)	23.26	25.93	30.00	36.67	50.00	66.67	42.31	25.81	56.52	52.38	57.14	83.33
Richness of intolerant taxa (%)	67.44	66.67	55.00	56.67	28.57	11.11	46.15	48.39	17.39	42.86	28.57	0.00
Functional group												
Richness of collector-filterers (%)	11.63	10.34	9.76	9.68	7.14	9.09	15.38	6.67	8.70	9.09	14.29	7.69
Richness of collector-gatherers (%)	32.56	27.59	31.71	38.71	50.00	45.45	30.77	23.33	39.13	27.27	28.57	53.85
Richness of scrapers (%)	9.30	6.90	12.20	9.68	7.14	9.09	3.85	6.67	4.35	4.55	0.00	0.00
Richness of shredders (%)	13.95	17.24	14.63	9.68	14.29	9.09	11.54	16.67	13.04	18.18	28.57	0.00
Richness of predators (%)	32.56	37.93	31.71	32.26	21.43	27.27	38.46	46.66	34.78	40.91	28.57	38.46
Taxonomic group												
Number of EPT taxa	19	14	15	13	2	3	8	10	4	6	1	2
Richness of EPT taxa (%)	44.19	46.67	35.71	39.39	12.50	27.27	29.63	31.25	16.00	26.09	14.29	14.29
Richness of Ephemeroptera (%)	16.28	16.67	9.52	12.12	6.25	9.09	7.41	9.38	8.00	4.35	0.00	14.29
Richness of Plecoptera (%)	9.30	10.00	9.52	12.12	6.25	9.09	7.41	12.50	4.00	8.70	14.29	0.00
Richness of Trichoptera (%)	18.60	20.00	16.67	15.15	0.00	9.09	14.81	9.38	4.00	13.04	0.00	0.00
Richness of noninsect taxa (%)	6.98 ^a	3.33	11.90	9.09	18.75	18.18	7.41	6.25	20.00	13.04	0.00	21.43
Richness of Chironomidae Diptera (%)	6.98	10.00	7.14	9.09	18.75	18.18	11.11	9.38	12.00	13.04	42.86	14.29
Richness of non-Chironomidae Diptera (%)	4.65	20.00	26.19	27.27	43.75	27.27	7.41	37.50	32.00	30.43	42.86	35.71
Richness of Coleoptera (%)	16.23	10.00	11.90	12.12	6.25	9.09	18.52	12.50	20.00	13.04	0.00	7.14
Richness of Odonata (%)	6.98	10.00	7.14	3.03	0.00	0.00	7.41	3.13	0.00	4.35	0.00	7.14

^aPre-2009 reports labeled the “noninsect” category as “Other”. The “Other” category was less inclusive of species, resulting in a different richness count.

Table C2. Physical habitat and hydrologic data from CAP01 on Capulin Creek in Bandelier NM. Particle embeddedness and canopy closure measurements are expressed as percentages.

Physical habitat metric	2007		2008		2009		2010		2011		2012	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Microhabitat level (n = 5)												
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	— ^b	— ^b
Depth (m)	0.07	0.02	0.09	0.02	0.08	0.02	0.08	0.03	0.07 ^a	0.03	— ^b	— ^b
Embeddedness (%)	14.4	5.1	30.3	12.9	26.3	6.3	39.4	6.5	18.3 ^a	16.6	— ^b	— ^b
Transect level (n = 11)												
Channel dimensions												
Velocity (m/s)	0.07	0.04	0.14	0.05	0.14	0.07	0.10	0.07	0.24	0.11	0.34	0.17
Depth (m)	0.07	0.05	0.06	0.04	0.06	0.03	0.06	0.03	0.04	0.02	0.03	0.01
Wetted channel width (m)	1.3	0.4	1.3	0.4	1.4	0.3	1.6	0.4	1.9	1.6	1.5	0.9
Active channel width (m)	2.3	0.9	5.5	2.3	9.6	5.1	10.1	4.4	0.0	0.0	0.0	0.0
Riparian cover												
Canopy closure (%)	87.4	21.0	91.1	20.8	92.0	11.1	94.7	10.3	0.0	0.0	0.1	0.8
Reach level (n = 1)												
Water quality	Value		Value		Value		Value		Value		Value	
Temperature (°C)	11.5		11.4		9.7		8.9		13.4		10.1	
Specific conductivity (µS/cm)	—		151		146		145		212		193	
pH	—		8.0		8.0		7.9		8.2		8.3	
Dissolved oxygen (% saturation)	—		96.6		95.9		96.7		98.5		99.1	
Dissolved oxygen (mg/L)	—		10.5		8.4		8.9		8.2		9.0	
Turbidity (NTU)	—		0.50		1.3		1.0		7.5		47	
Discharge (cfs)	—		—		—		0.4		0.6		0.3	

^aBased on 3 riffles instead of the standard 5 riffles.^bNo data available because of lack of appropriate riffle habitat.

Table C3. Physical habitat and hydrologic data from CAP02 on Capulin Creek in Bandelier NM. Particle embeddedness and canopy closure measurements are expressed as percentages.

Physical habitat metric	2007		2008		2009		2010		2011		2012	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Microhabitat level (n = 5)												
Riffles												
Velocity (m/s)	0.19	0.23	0.21	0.14	0.22	0.12	0.22	0.09	— ^a	— ^a	— ^a	— ^a
Depth (m)	0.06	0.03	0.05	0.02	0.07	0.01	0.06	0.03	— ^a	— ^a	— ^a	— ^a
Embeddedness (%)	9.2	6.1	29.5	10.6	29.4	11.4	21.2	8.4	— ^a	— ^a	— ^a	— ^a
Transect level (n = 11)												
Channel dimensions												
Velocity (m/s)	0.05	0.04	0.02	0.02	0.08	0.07	0.07	0.04	0.19	0.13	0.24	0.18
Depth (m)	0.06	0.03	0.07	0.05	0.04	0.05	0.06	0.04	0.02	0.01	0.02	0.01
Wetted channel width (m)	1.2	0.4	0.9	0.4	3.9	3.5	2.1	3.3	2.9	1.6	2.4	1.6
Active channel width (m)	1.7	0.4	4.2	1.9	13.6	6.8	12.5	6.0	0.0	0.0	0.0	0.0
Riparian cover												
Canopy closure (%)	70.6	15.2	97.9	7.0	96.3	6.2	98.6	3.5	0.2	1.0	0.1	0.8
Reach level (n = 1)												
Water quality	Value		Value		Value		Value		Value		Value	
Temperature (°C)	11.4		11.2		10.6		9.2		14.6		14.0	
Specific conductivity (µS/cm)	—		165		172		157		155		134	
pH	—		7.8		7.8		7.7		8.3		8.3	
Dissolved oxygen (% saturation)	—		96.4		96.1		95.1		99.8		95.9	
Dissolved oxygen (mg/L)	—		10.6		8.2		8.7		8.2		8.0	
Turbidity (NTU)	—		1.9		2.6		1.2		76		210	
Discharge (cfs)	—		—		—		0.1		0.4		0.4	

^aNo data available because of lack of appropriate riffle habitat.

Appendix D: Aquatic macroinvertebrate species list from aquatic macroinvertebrate monitoring sites on Capulin Creek and El Rito de los Frijoles in Bandelier National Monument, New Mexico, 2012

Phylum	Class	Order	Family	SubFamily	Genus	Common name	Funct group ^a	Tol group ^b	CAP01	CAP02	RIT01	RIT02
Annelida						segmented worms	coll-gath	n/a	x	x	x	
Arthropoda	Arachnida	Trombidiformes	Sperchonidae		<i>Sperchon</i> sp.	water mites	pred	n/a	x			
Arthropoda	Arachnida					water mites	n/a	n/a		x		
Arthropoda	Entognatha	Collembola				springtails	n/a	n/a		x		
Arthropoda	Insecta	Coleoptera	Dytiscidae	Agabinae	<i>Agabus</i> sp.	predaceous diving beetle	pred	tol	x			
Arthropoda	Insecta	Coleoptera	Dytiscidae			predaceous diving beetle	pred	mod tol	x	x		
Arthropoda	Insecta	Diptera	Empididae	Hemerodromiinae	<i>Hemerodromia</i> sp.	dance flies	pred	mod tol			NEW	
Arthropoda	Insecta	Diptera	Empididae		<i>Neoplasta</i> sp.	dance flies	pred	mod tol		x		
Arthropoda	Insecta	Diptera	Muscidae			house flies	pred	mod tol	x	x		x
Arthropoda	Insecta	Diptera	Stratiomyidae		<i>Nemotelus</i> sp.	soldier flies	coll-gath	tol			NEW	
Arthropoda	Insecta	Diptera	Stratiomyidae			soldier flies	coll-gath	tol	x			
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae		midges	coll-gath	mod tol	x	x		
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		midges	coll-gath	mod tol	x	x	x	x
Arthropoda	Insecta	Diptera	Chironomidae	Tanytopodinae		midges	pred	tol				x
Arthropoda	Insecta	Diptera	Chironomidae			midges	coll-gath	mod tol	x	x		x
Arthropoda	Insecta	Diptera	Simuliidae	Simuliinae	<i>Simulium</i> sp.	black flies	coll-filt	mod tol	x	x		x
Arthropoda	Insecta	Diptera	Simuliidae			black flies	coll-filt	mod tol			x	
Arthropoda	Insecta	Diptera				flies	n/a	tol		x	x	x
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae		<i>Tricorythodes</i> sp.	little stout crawler mayflies	coll-gath	mod tol		x		
Arthropoda	Insecta	Ephemeroptera	Baetidae		<i>Baetis</i> sp.	small minnow mayflies	coll-gath	mod tol	x	x	x	x
Arthropoda	Insecta	Odonata	Coenagrionidae		<i>Argia</i> sp.	narrow-winged damselflies	pred	mod tol			NEW	
Arthropoda	Insecta	Plecoptera	Capniidae	Capniinae		small winter stoneflies	shredder	intol	x	x	x	x
Arthropoda	Insecta	Plecoptera	Perlidae			common stoneflies	pred	intol				x
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptilinae	<i>Hydroptila</i> sp.	microcaddisflies	scraper	mod tol	NEW			

Note: "NEW" under the site column denotes a new record for this SCPN monitoring site.

^aFunctional group abbreviations: coll-gath = collector-gatherer, coll-filt = collector-filterer, pred = predator.

^bTolerance group abbreviations: tol = tolerant, mod tol = moderately tolerant, intol = intolerant.

Appendix E: Stream velocity and channel characteristics from aquatic macroinvertebrate monitoring sites on Capulin Creek and El Rito de los Frijoles in Bandelier National Monument, New Mexico, 2012

Transect	Velocity (m/s) (n = 5)		Depth (m) (n = 5)		Wetted channel width (m)	Active channel width (m)
	Mean	Std Dev	Mean	Std Dev	Value	Value
CAP01						
1	0.18	0.26	0.01	0.02	3.0	0.0
2	0.52	0.12	0.03	<0.01	0.9	0.0
3	0.65	0.22	0.03	0.01	0.7	0.0
4	0.05	0.12	0.01	0.02	3.3	0.0
5	0.40	0.22	0.03	0.01	0.8	0.0
6	0.45	0.16	0.03	0.01	0.8	0.0
7	0.23	0.18	0.02	0.01	1.3	0.0
8	0.35	0.14	0.03	0.02	1.6	0.0
9	0.21	0.16	0.04	0.03	0.9	0.0
10	0.35	0.11	0.03	0.01	1.4	0.0
11	0.31	0.31	0.02	0.03	2.1	0.0
CAP02						
1	0.34	0.07	0.03	0.01	1.1	0.0
2	0.26	0.04	0.02	0.01	1.1	0.0
3	0.15	0.15	0.02	0.02	1.4	0.0
4	0.22	0.05	0.04	0.02	1.2	0.0
5	0.18	0.13	0.02	0.01	1.7	0.0
6	0.15	0.07	0.02	0.01	3.4	0.0
7	0.13	0.11	0.02	0.01	5.7	0.0
8	0.03	0.08	0.01	0.01	4.4	0.0
9	0.72	1.38	0.02	0.02	3.6	0.0
10	0.31	0.14	0.03	0.02	0.8	0.0
11	0.16	0.12	0.02	0.01	1.9	0.0
RIT01						
1	0.44	0.22	0.08	0.03	1.1	22.8
2	0.29	0.23	0.10	0.04	0.9	20.4
3	0.51	0.15	0.07	0.02	0.8	19.5
4	0.35	0.29	0.06	0.03	1.4	16.0
5	0.16	0.37	0.03	0.05	2.4	16.2
6	0.31	0.12	0.10	0.07	1.0	22.5
7	0.36	0.11	0.06	0.02	1.1	32.0
8	0.29	0.18	0.20	0.34	1.9	26.9
9	0.10	0.22	0.04	0.08	1.3	33.8
10	0.16	0.22	0.03	0.04	2.9	30.5
11	0.26	0.43	0.03	0.05	1.3	21.7

Transect	Velocity (m/s) (n = 5)		Depth (m) (n = 5)		Wetted channel width (m)	Active channel width (m)
	Mean	Std Dev	Mean	Std Dev	Value	Value
RIT02						
1	0.43	0.22	0.05	0.01	1.3	0.0
2	0.34	0.34	0.06	0.06	2.0	0.0
3	0.38	0.30	0.04	0.02	1.5	0.0
4	0.24	0.14	0.04	0.02	1.9	0.0
5	0.40	0.16	0.05	0.01	1.3	0.0
6	0.36	0.22	0.07	0.04	1.1	0.0
7	0.30	0.36	0.04	0.04	2.2	0.0
8	0.57	0.24	0.07	0.02	1.1	0.0
9	0.43	0.28	0.09	0.04	1.1	0.0
10	0.30	0.35	0.06	0.05	2.0	0.0
11	0.21	0.24	0.04	0.05	2.9	0.0

Appendix F: Aquatic macroinvertebrate community and physical habitat data from aquatic macroinvertebrate monitoring sites on El Rito de los Frijoles in Bandelier National Monument, New Mexico, 2009–2012

Table F1. Quantitative aquatic macroinvertebrate community metrics from RIT02 on El Rito de los Frijoles in Bandelier NM. For a given order, tolerance or functional feeding group, abundance-based metrics are expressed as the total number of individuals in the group, while richness-based metrics for all years are expressed as the percentage of taxa in the group.

Quantitative metric	2009 (n = 5)		2010 (n = 5)		2011 (n = 5)		2012 (n = 3)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total abundance	700.90	134.75	760.60	80.43	15.80	6.22	2.33	2.52
Total richness	28.40	3.29	30.00	2.92	3.60	1.82	2.00	2.65
Simpson's Diversity—taxonomic	0.89	0.02	0.89	0.01	0.40	0.26	0.33	0.58
Simpson's Diversity—functional group	0.65	0.04	0.67	0.01	0.08	0.12	0.40	0.57
Dominant taxa	20.16	3.93	23.25	3.11	72.30	21.46	40.00	52.92
Tolerance group								
Total abundance of tolerant taxa	1.42	2.09	2.10	3.13	0.41	0.57	0.00	0.00
Total abundance of moderately tolerant taxa	222.59	89.09	244.51	45.43	15.19	5.89	2.00	2.00
Total abundance of intolerant taxa	459.89	51.45	5050.89	71.41	0.00	0.00	0.33	0.58
Richness of tolerant taxa (%)	2.87	2.88	2.97	3.11	10.00	13.69	0.00	0.00
Richness of moderately tolerant taxa (%)	24.43	3.22	26.11	2.32	90.00	13.69	60.00	52.92
Richness of intolerant taxa (%)	72.70	5.44	70.92	2.65	0.00	0.00	6.67	11.55
Functional group								
Total abundance of collector-filterers	156.26	91.35	138.81	17.69	0.20	0.45	0.33	0.58
Total abundance of collector-gatherers	333.01	60.02	363.22	36.71	14.79	5.63	1.33	1.15
Total abundance of scrapers	161.64	19.73	183.82	57.69	0.00	0.00	0.00	0.00
Total abundance of shredders	8.09	6.09	26.20	13.69	0.00	0.00	0.00	0.00
Total abundance of predators	41.49	5.71	47.04	12.70	0.61	0.92	0.67	1.15
Richness of collector-filterers (%)	14.35	3.21	14.39	0.89	4.00	8.94	6.67	11.55
Richness of collector-gatherers (%)	38.53	2.95	36.31	5.44	82.00	24.90	46.67	50.33
Richness of scrapers (%)	18.71	3.16	14.43	1.46	0.00	0.00	0.00	0.00
Richness of shredders (%)	4.84	1.29	10.21	1.79	0.00	0.00	0.00	0.00
Richness of predators (%)	23.57	6.32	24.65	4.63	14.00	21.91	13.33	23.09
Taxonomic group								
Number of EPT taxa	14.40	1.52	15.80	0.84	0.00	0.00	0.67	1.15
Total abundance of EPT taxa	281.8	44.32	385.40	41.55	0.00	0.00	0.67	1.15
Total abundance of Ephemeroptera	170.8	23.75	228.40	26.97	0.00	0.00	0.33	0.58
Total abundance of Plecoptera	31.8	3.96	45.40	17.62	0.00	0.00	0.33	0.58
Total abundance of Trichoptera	79.2	30.33	11.60	13.69	0.00	0.00	0.00	0.00
Total abundance of noninsect taxa	299.5	256.57	143.60	59.37	0.20	0.45	0.00	0.00
Total abundance of Chironomidae Diptera	43.8	19.20	70.20	47.10	14.00	5.10	1.00	1.00
Total abundance of non-Chironomidae Diptera	19.8	9.34	22.00	9.92	1.40	1.52	0.67	1.15
Total abundance of Coleoptera	243.4	40.72	228.60	76.60	0.20	0.45	0.00	0.00
Total abundance of Odonata	0.2	0.45	0.40	0.55	0.00	0.00	0.00	0.00

Table F2. Quantitative aquatic macroinvertebrate community metrics from RIT01 on El Rito de los Frijoles in Bandelier NM. For a given order, tolerance or functional feeding group, abundance-based metrics are expressed as the total number of individuals in the group, while richness-based metrics for all years are expressed as the percentage of taxa in the group.

Quantitative metric	2009 (n = 5)		2010 (n = 5)		2011 (n = 3)		2012 (n = 3)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total abundance	688.00	172.57	697.60	91.52	25.33	5.51	9.67	8.14
Total richness	27.00	2.74	28.40	5.41	4.67	1.53	3.00	0.00
Simpson's Diversity—taxonomic	0.86	0.02	0.83	0.04	0.51	0.08	0.69	0.15
Simpson's Diversity—functional group	0.72	0.02	0.72	0.01	0.30	0.15	0.67	0.19
Dominant taxa	26.42	4.22	31.65	7.42	69.06	6.12	54.39	7.60
Tolerance group								
Total abundance of tolerant taxa	0.83	0.82	0.87	0.87	0.00	0.00	0.00	0.00
Total abundance of moderately tolerant taxa	169.93	42.69	199.89	73.65	20.31	5.55	7.67	8.96
Total abundance of intolerant taxa	508.84	142.55	490.31	106.19	3.02	1.71	1.67	1.53
Richness of tolerant taxa (%)	2.33	2.15	3.20	3.35	0.00	0.00	0.00	0.00
Richness of moderately tolerant taxa (%)	30.01	4.85	27.58	4.40	58.89	8.39	77.78	19.25
Richness of intolerant taxa (%)	67.66	5.27	69.23	4.43	41.11	8.39	22.22	19.25
Functional group								
Total abundance of collector-filterers	116.30	29.55	182.37	19.78	0.71	1.24	2.56	2.99
Total abundance of collector-gatherers	199.82	57.16	185.33	43.59	19.60	6.79	5.44	6.55
Total abundance of scrapers	259.76	101.16	251.60	60.55	0.00	0.00	0.00	0.00
Total abundance of shredders	75.30	49.13	40.20	14.59	2.69	2.31	1.67	1.53
Total abundance of predators	36.63	27.22	37.39	17.27	0.33	0.58	0.00	0.00
Richness of collector-filterers (%)	11.29	1.20	13.46	3.68	8.33	14.43	33.33	0.00
Richness of collector-gatherers (%)	29.27	4.30	30.47	2.38	50.56	22.38	44.44	19.25
Richness of scrapers (%)	15.90	4.89	12.48	1.95	0.00	0.00	0.00	0.00
Richness of shredders (%)	14.67	4.66	15.99	3.53	34.44	15.03	22.22	19.25
Richness of predators (%)	28.86	4.84	27.59	6.60	6.67	11.55	0.00	0.00
Taxonomic group								
Number of EPT taxa	11.80	1.64	15.00	2.45	1.00	0.00	0.67	0.58
Total abundance of EPT taxa	197.00	62.86	325.40	31.26	2.33	2.31	1.67	1.53
Total abundance of Ephemeroptera	99.00	41.88	138.80	26.68	0.00	0.00	0.00	0.00
Total abundance of Plecoptera	91.60	42.94	42.60	15.54	2.00	2.65	1.67	1.53
Total abundance of Trichoptera	106.40	19.45	144.00	37.84	0.33	0.58	0.00	0.00
Total abundance of noninsect taxa	9.60	10.06	9.20	8.67	2.00	1.73	0.33	0.58
Total abundance of Chironomidae Diptera	74.80	35.84	28.40	17.20	19.25	6.54	5.11	5.98
Total abundance of non-Chironomidae Diptera	34.60	22.90	98.00	27.30	1.42	1.64	2.56	2.99
Total abundance of Coleoptera	267.40	87.81	237.00	68.98	0.00	0.00	0.00	0.00
Total abundance of Odonata	3.60	6.94	0.60	0.89	0.33	0.58	0.00	0.00

Table F3. Qualitative aquatic macroinvertebrate community metrics from RIT01 and RIT02 on El Rito de los Frijoles in Bandelier NM. Richness-based metrics are expressed as the percentage of taxa in a given order, tolerance or functional feeding group. Site ordering from left to right in the table corresponds to upstream to downstream position.

Qualitative metric	RIT02				RIT01			
	2009	2010	2011	2012	2009	2010	2011	2012
Taxa richness	37	38	6	5	38	39	13	4
Tolerance group								
Richness of tolerant taxa (%)	11.76	5.71	20.00	20.00	10.81	13.16	9.09	0.00
Richness of moderately tolerant taxa (%)	32.35	25.71	60.00	60.00	35.14	42.11	45.45	66.67
Richness of intolerant taxa (%)	55.88	68.57	20.00	20.00	54.05	44.74	45.45	33.33
Functional group								
Richness of collector-filterers (%)	10.81	10.81	0.00	20.00	10.53	10.53	9.09	0.00
Richness of collector-gatherers (%)	29.73	35.14	60.00	20.00	26.32	28.95	45.45	75.00
Richness of scrapers (%)	8.11	13.51	0.00	0.00	10.53	2.63	9.09	0.00
Richness of shredders (%)	10.81	10.81	20.00	20.00	18.42	13.16	18.18	25.00
Richness of predators (%)	40.54	29.73	20.00	40.00	34.21	44.74	18.18	0.00
Taxonomic group								
Number of EPT taxa	15	17	0	1	15	15	1	2
Richness of EPT taxa (%)	40.54	44.74	0.00	20.00	39.47	38.46	7.69	50.00
Richness of Ephemeroptera (%)	10.81	13.16	0.00	0.00	13.16	10.26	0.00	25.00
Richness of Plecoptera (%)	8.11	13.16	0.00	20.00	13.16	15.38	7.69	25.00
Richness of Trichoptera (%)	21.62	18.42	0.00	0.00	13.16	12.82	0.00	0.00
Richness of noninsect taxa (%)	13.51	10.53	16.67	0.00	10.53	7.69	15.38	25.00
Richness of Chironomidae Diptera (%)	8.11	7.89	33.33	40.00	7.89	7.69	23.08	25.00
Richness of non-Chironomidae Diptera (%)	18.92	28.95	50.00	40.00	26.32	30.77	38.46	0.00
Richness of Coleoptera (%)	13.51	5.26	0.00	0.00	13.16	10.26	15.38	0.00
Richness of Odonata (%)	5.41	2.63	0.00	0.00	2.63	5.13	0.00	0.00

Table F4. Physical habitat and hydrologic data from RIT02 and RIT01 on El Rito de los Frijoles in Bandelier National Monument, New Mexico, 2009–2012. Particle embeddedness and canopy closure measurements are expressed as percentages. Site ordering from left to right in the table corresponds to upstream to downstream position.

RIT02									RIT01							
	2009		2010		2011		2012		2009		2010		2011		2012	
Physical habitat metric	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Microhabitat level (<i>n</i> = 5)																
Riffles																
Velocity (m/s)	0.50	0.18	0.40	0.16	0.67	0.29	0.73 ^a	0.22	0.46	0.13	0.39	0.15	0.46 ^a	0.11	0.54 ^a	0.18
Depth (m)	0.12	0.03	0.08	0.02	0.11	0.01	0.08 ^a	0.03	0.12	0.02	0.11	0.02	0.10 ^a	0.02	0.11 ^a	0.02
Embeddedness (%)	30.6	13.8	33.0	16.0	23.2	13.3	6.0 ^a	6.0	50.0	24.4	51.0	20.1	36.7 ^a	6.7	20.7 ^a	17.5
Transect level (<i>n</i> = 11)																
Channel dimensions																
Velocity (m/s)	0.20	0.08	0.20	0.05	0.25	0.20	0.36	0.10	0.23	0.15	0.19	0.09	0.37	0.09	0.29	0.12
Depth (m)	0.09	0.05	0.09	0.05	0.04	0.03	0.06	0.02	0.10	0.05	0.08	0.03	0.04	0.01	0.07	0.05
Wetted channel width (m)	2.3	0.6	2.1	0.6	2.8	1.6	1.7	0.6	2.3	2.4	1.5	0.7	1.9	1.5	1.5	0.7
Active channel width (m)	4.2	0.8	5.8	1.4	0.0	0.0	0.0	0.0	10.5	3.2	11.9	3.3	16.7	7.5	23.8	6.1
Riparian cover																
Canopy closure (%)	73.9	15.0	63.0	17.7	0.0	0.0	0.0	0.0	79.6	14.1	70.0	25.2	28.1	21.1	25.1	23.2
Reach level (<i>n</i> = 1)																
Water quality	Value		Value		Value		Value		Value		Value		Value		Value	
Temperature (°C)	10.3		5.8		11.4		13.3		12.3		5.8		9.1		13.4	
Specific conductivity (µS/cm)	107		114		228		166		111		108		172		215	
pH	7.9		7.6		8.1		8.1		7.8		7.9		8.2		8.3	
Dissolved oxygen (% saturation)	94.7		102.5		98.8		95.4		94.4		98.5		97.8		94.7	
Dissolved oxygen (mg/L)	8.2		10.1		8.4		7.7		7.8		9.6		9.1		7.9	
Turbidity (NTU)	2.2		1.4		4.2		120		2.2		2.4		230		110	
Discharge (cfs)	—		1.2		1.5		1.7		—		0.7		0.6		0.5	

^aBased on 3 riffles instead of the standard 5 riffles.

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