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Aquatic Macroinvertebrate and Physical Habitat Monitoring for Tsaile Creek in Canyon de Chelly National Monument

2009 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2011/285

ON THE COVER
Canyon de Chelly National Monument
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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.

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1 Introduction and background

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

Little or no data are available describing the aquatic ecology of perennial streams in Canyon de Chelly National Monument (CACH). SCPN selected Tsaile Creek for long-term monitoring of aquatic macroinvertebrates in CACH. Additional monitoring sites on other streams may be added in the future.

In 2008 SCPN implemented annual aquatic macroinvertebrate monitoring for the first time at one site on Tsaile Creek in CACH. Our monitoring site, Tsaile Creek below Tsaile Dam (CACHTSA01), is identified in this report as TSA01 (see appendix A for list of location, code, and common name of monitoring site). The site, located approximately 0.95 km downstream from the Tsaile Dam, was selected using Generalized Random-Tesselation Stratified design (fig. 1).

The primary purpose of this report is to (a) document the monitoring activities that occurred at TSA01 in 2009, (b) summarize data that were collected, and (c) where appropriate, place these data in the context of aquatic habitat, biological condition, and management actions within the park through time.

Tsaile Creek flows across the western side of the Defiance Plateau, with headwaters in the Chuska Mountains. The watershed is approximately 42,395 ha (104,760 acres) and is located entirely on Navajo Nation lands. Tsaile Dam was constructed in 1963 for irrigation and recreational purposes and forms Tsaile Lake. The lake separates the upper portion and lower portions of the watershed. The approximate boundary of CACH passes through Tsaile Lake. Tsaile Creek enters Canyon del Muerto in the monument immediately downstream of the dam (NRCS 2000). The Tsaile Creek watershed receives most of its moisture in the spring, as snowmelt from the nearby Chuska Mountains, and in summer, as monsoon rains. Summer monsoons are responsible for approximately 40% of the annual precipitation (Rydout 1983).

In 1996, the Navajo Nation Watershed Prioritization Study identified the Tsaile Creek watershed as a top conservation priority because of the natural and cultural resources that exist there and the need to protect these resources from the many threats that exist (NRCS 1996). For example, the Navajo Nation has concerns about the status and threats to several native species found within the watershed, including the northern leopard frog (*Rana pipens*), speckled dace (*Rhinichthys osculus*), and the federally endangered blueheaded sucker (*Catostomus discobolus*). Additionally, archeological sites dating as far back as 350 to 1300 AD are found throughout Canyon del Muerto.

Aquatic macroinvertebrates face multiple threats in Tsaile Creek watershed, including flow regulation and invasion by exotic plant and animal species. Water diverted by Tsaile Dam is used for irrigation upstream of the monument, eliminating peak flows and altering the hydrologic regime of Tsaile Creek. Streamflow data for Tsaile Creek below Tsaile Dam is not available, but recent observations indicate that about 7.2 km (4.5 miles) of the creek flow perennially between the dam and approximately Middle Trail Canyon. Introductions of invasive species pose another threat to aquatic life along Tsaile Creek. Two invasive riparian species, salt cedar (*Tamarix ramosissima*) and Russian olive

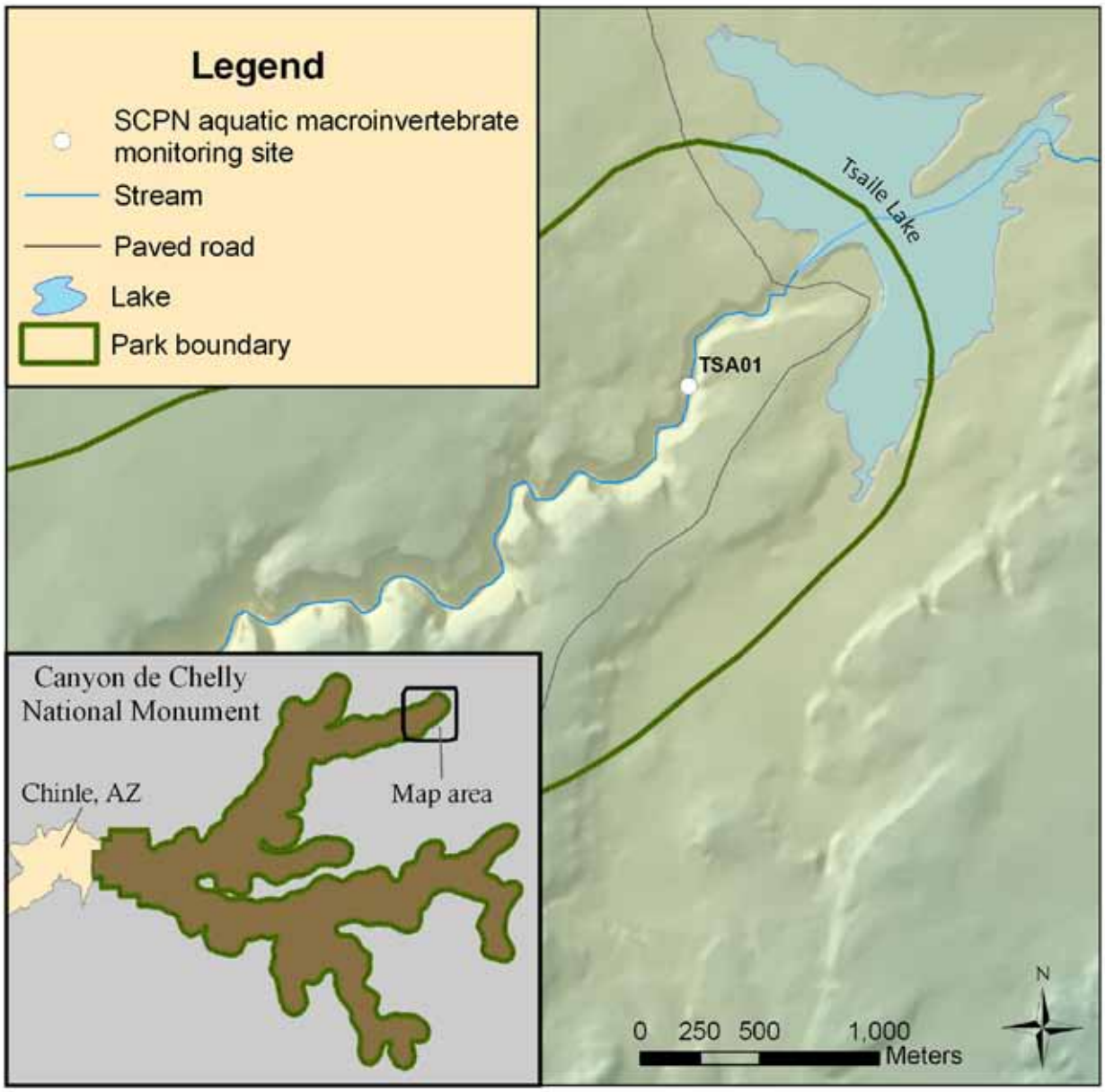


Figure 1. Location map of monitoring site TSA01 at Tsaile Creek in Canyon de Chelly National Monument, Arizona, 2009

(*Elaeagnus angustifolia*), introduced to control erosion (NRCS 2000), are abundant in the lower realms of Tsaile Creek and can outcompete and replace native vegetation, as well as deplete groundwater resources. Furthermore, nonnative aquatic species in Tsaile Creek, including goldfish (*Carassius auratus*), fathead minnow (*Pimephales promelas*), and virile crayfish (*Orconectes virilis*) have the potential to harm the aquatic macroinvertebrate community within Tsaile Creek (Trammell 2008).

2 Methods

2.1 Field methods

In Arizona, macroinvertebrate samples are collected from cold water perennial sites (above 1,500 m elevation), such as Tsaile Creek, during May–June (Arizona Department of Environmental Quality,

Water Quality Division 2006). Because of spring water releases from Tsaile Lake and the resulting high flows through our monitoring site, we were unable to sample during the window described by the state of Arizona. On September 20, 2009, the SCPN water resources field crew collected aquatic macroinvertebrate samples and physical habitat data from the monitoring site (TSA01), comprised by a 150 m reach on Tsaile Creek within CACH (see fig. 2 for reach layout diagram). This site is located approximately 0.95 km downstream from the Tsaile Dam. The creek here flows through a *Poa pratensis*, *Scirpus* spp., and *Pascopyrum* spp. meadow and channel substrate in the reach is primarily coarse gravel. A brief description of field methods is provided here, and a detailed description of sampling methods can be found in Brasher et al. (in press).

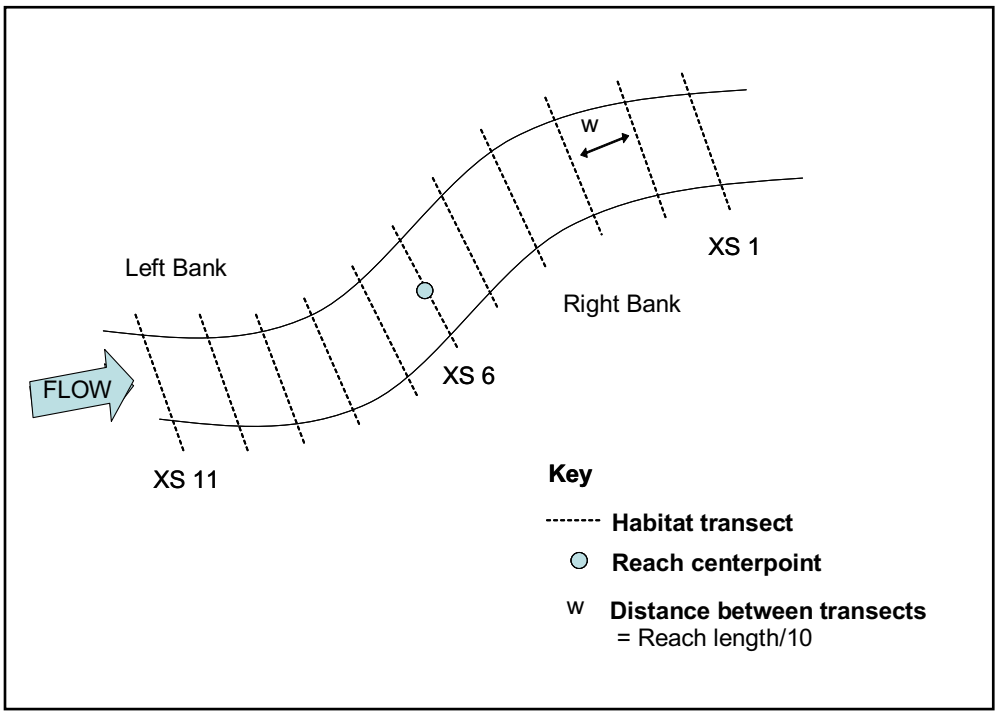


Figure 2. General aquatic macroinvertebrate sampling reach layout

We collected two types of aquatic macroinvertebrate samples at TSA01 in 2009. These were:

- Replicate quantitative samples from five targeted riffle habitats to provide estimates of abundances of organisms. We used a Slack sampler to collect a timed sample from a 0.25 m^2 area at each targeted riffle.
- A qualitative sample to develop a comprehensive list of species present in the creek. A Slack sampler was used to collect samples from all habitat types within the sampling reach. These samples were compiled into one composite qualitative 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 three spatial scales: microhabitat, transect, and reach.

- For each of the targeted riffle microhabitats, we
  - measured depth

  - measured velocity
  - measured particle size
  - measured particle embeddedness
- For each of the 11 transects, we
  - measured wetted and active channel widths
  - measured water depth, velocity, and canopy closure at multiple points along each transect
  - observed and recorded the presence or absence, and types of macroinvertebrate habitats, represented by point data (5 points/transect) across the entire reach
  - measured geomorphic channel units (GCU) at multiple points along each transect
- For the entire reach, we
  - identified and measured the length of GCUs (reach characterization data represents the proportion of the reach characterized by that particular GCU)
  - identified the dominant vegetation and land cover
  - recorded descriptions of flow conditions
  - recorded weather conditions
  - observed and recorded evidence of anthropogenic or natural disturbances
  - measured NPS core water quality parameters of temperature, specific conductivity, pH, dissolved oxygen, and turbidity
  - 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 reach

2.2 Laboratory methods

Macroinvertebrate samples were sent to be sorted and identified at the Utah State University National Aquatic Monitoring Center's Bug Lab, a Bureau of Land Management laboratory based in Logan, Utah. Samples were sorted under a dissecting scope at 10× 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. Ten percent of the identified samples were re-identified by a second certified taxonomist to ensure data quality.

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

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

Key metrics are presented in Table 1 (qualitative) and in Table 2 (quantitative), describing aquatic macroinvertebrate communities from samples collected in 2008 and 2009 from the TSA01 monitoring site in CACH. All figures included in this section refer to data collected from quantitative targeted riffle habitat unless otherwise noted.

Table 1. Qualitative metrics for aquatic macroinvertebrate samples collected from TSA01 at Tsaile Creek in Canyon de Chelly National Monument, Arizona, 2008–2009. Richness-based metrics are expressed as the percentage of taxa in a given order, tolerance or functional feeding group.

Qualitative metric	2008	2009
Taxa richness	20.00	15.00
Tolerance group		
Richness of tolerant taxa (%)	26.32	50.00
Richness of moderately tolerant taxa (%)	52.63	50.00
Richness of intolerant taxa (%)	21.05	0.00
Functional group		
Richness of collector-filterers (%)	15.79	6.67
Richness of collector-gatherers (%)	31.58	40.00
Richness of scrapers (%)	10.53	20.00
Richness of shredders (%)	10.53	0.00
Richness of predators (%)	31.58	33.33
Taxonomic group		
Number of EPT taxa	3.00	1.00
Richness of EPT taxa (%)	15.00	6.67
Richness of Ephemeroptera (%)	5.00	6.67
Richness of Plecoptera (%)	0.00	0.00
Richness of Trichoptera (%)	10.00	0.00
Richness of noninsect taxa (%)	35.00[a]	53.33
Richness of Chironomid Diptera (%)	15.00	20.00
Richness of non-Chironomid Diptera (%)	20.00	6.67
Richness of Coleoptera (%)	5.00	6.67
Richness of Odonata (%)	10.00	6.67

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

Table 2. Quantitative metrics for aquatic macroinvertebrate samples collected from TSA01 at Tsaile creek in Canyon de Chelly National Monument, Arizona, 2008–2009. 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.

	2008		2009	
Quantitative metric	**Mean**	**SD**	**Mean**	**SD**
Total abundance	311.80	229.80	541.00	213.07
Total richness	11.60	4.04	15.00	3.54
Simpson's Diversity—taxonomic	0.51	0.09	0.63	0.14
Simpson's Diversity—functional group	0.22	0.09	0.38	0.12
Dominant taxa	63.83	12.80	53.28	17.04
Tolerance group				
Relative abundance of tolerant taxa (%)	27.78	12.83	52.97	20.42
Relative abundance of moderately tolerant taxa (%)	71.77	13.06	46.79	20.26
Relative abundance of intolerant taxa (%)	0.45	0.54	0.25	0.23
Richness of tolerant taxa (%)	36.88	7.86	36.67	9.03
Richness of moderately tolerant taxa (%)	54.44	7.43	57.87	7.06
Richness of intolerant taxa (%)	8.68	8.59	5.46	3.31
Functional group				
Relative abundance of collector-filterers (%)	2.10	1.73	5.26	6.01
Relative abundance of collector-gatherers (%)	87.82	5.32	75.76	10.63
Relative abundance of scrapers (%)	2.29	1.56	5.62	4.51
Relative abundance of shredders (%)	0.18	0.25	0.09	0.13
Relative abundance of predators (%)	7.62	5.02	13.27	11.74
Richness of collector-filterers (%)	10.98	7.44	15.46	6.13
Richness of collector-gatherers (%)	45.81	11.02	32.89	9.32
Richness of scrapers (%)	10.85	2.21	14.92	7.60
Richness of shredders (%)	4.17	5.79	3.55	5.50
Richness of predators (%)	28.19	8.74	33.17	2.03
Taxonomic group				
Number of EPT taxa	1.80	1.48	1.60	1.14
Relative abundance of EPT taxa (%)	1.21	1.27	1.29	1.68
Relative abundance of Ephemeroptera (%)	0.36	0.45	0.00	0.00
Relative abundance of Plecoptera (%)	0.00	0.00	0.00	0.00
Relative abundance of Trichoptera (%)	0.86	1.38	1.29	1.68
Relative abundance of noninsect taxa (%)	24.96	15.85	57.27	22.26
Relative abundance of Chironomid Diptera (%)	69.64	16.35	37.48	22.39
Relative abundance of non-Chironomid Diptera (%)	1.64	0.67	1.10	1.16
Relative abundance of Coleoptera (%)	0.26	0.25	0.15	0.21
Relative abundance of Odonata (%)	2.30	1.43	2.71	2.14

Abundance. Mean abundance for our quantitative targeted riffle samples was 541.0 individuals (fig. 3). Sample abundances ranged from a low of 294 individuals to a high of 732 individuals.

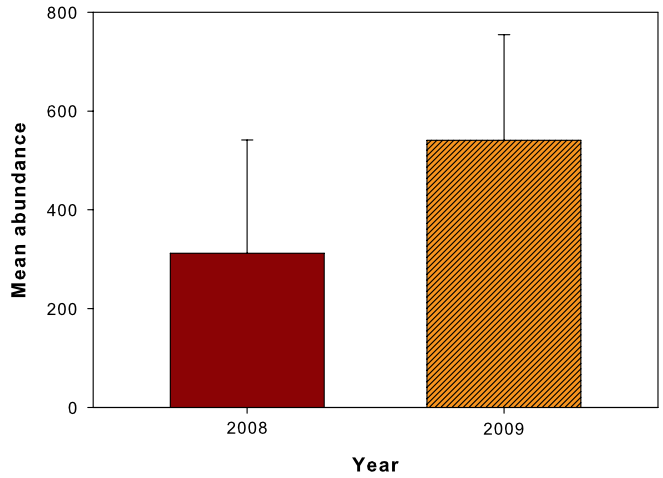


Figure 3. Total abundance expressed as the mean number of individuals per quantitative targeted riffle sample collected from TSA01 at Tsaile Creek in CACH, 2008–2009

Richness. Taxa richness for quantitative targeted riffle samples averaged 15 taxa per sample. Taxa richness in these samples ranged from a low of 11 taxa to a high of 20 taxa. Total richness of the qualitative multihabitat sample was 15 taxa (fig. 4).

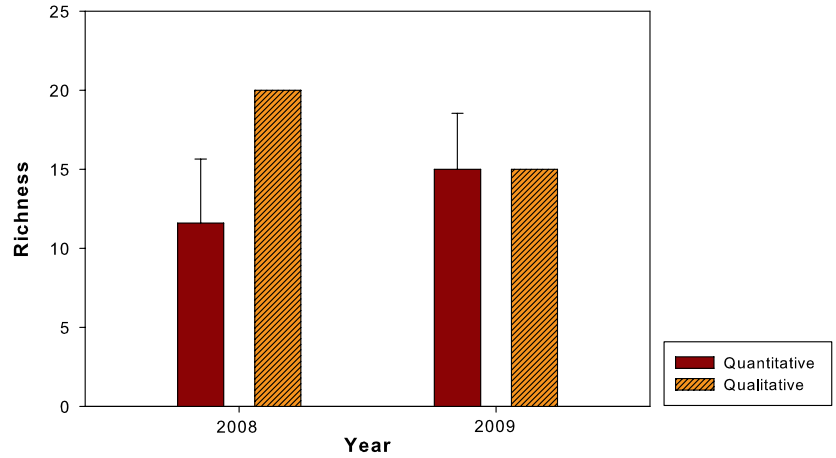


Figure 4. Mean taxa richness in qualitative multihabitat and quantitative targeted riffle samples collected from TSA01 at Tsaile Creek in CACH, 2008–2009

Diversity. We used the Simpson's Diversity Index to measure taxonomic and functional diversity of quantitative targeted riffle samples. The average diversity value was 0.63 for taxonomic diversity and 0.38 for functional diversity (figs. 5a, 5b).

Tolerant taxa. Relative abundance by tolerance class was dominated by tolerant taxa, which averaged 53.0%. Moderately tolerant taxa were the second most abundant at 46.8%, and intolerant taxa were the least abundant at 0.4% (fig. 6a). Moderately tolerant taxa had the highest richness, averaging 57.9% of each sample collected. Tolerant taxa richness averaged 36.7% per sample. Intolerant taxa were the least rich, averaging 5.5% (fig. 6b).

EPT taxa. No individuals belonging to sensitive taxa of the orders Ephemeroptera (mayflies) and Plecoptera (stoneflies) were found in our samples. Trichopterans (caddisflies) were found in a small abundance, averaging 1.3% of each sample (fig. 7).

Figure 5a. Simpson's Diversity Index for taxonomic diversity in quantitative targeted riffle samples collected from TSA01 at Tsaile Creek in CACH, 2008–2009. Values expressed are means of all quantitative samples collected from the monitoring site.

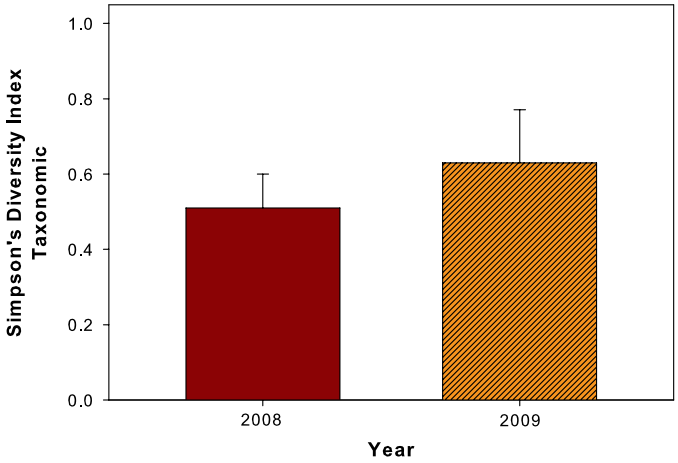


Figure 5b. Simpson's Diversity Index for functional diversity in quantitative targeted riffle samples collected from TSA01 at Tsaile Creek in CACH, 2008–2009. Values expressed are means of all quantitative samples collected from the monitoring site.

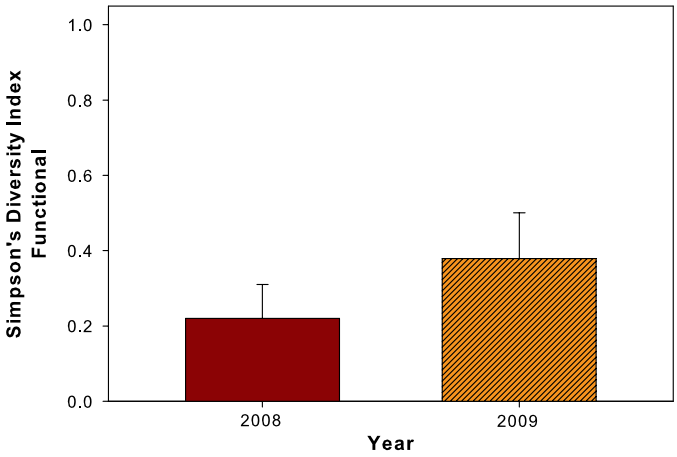
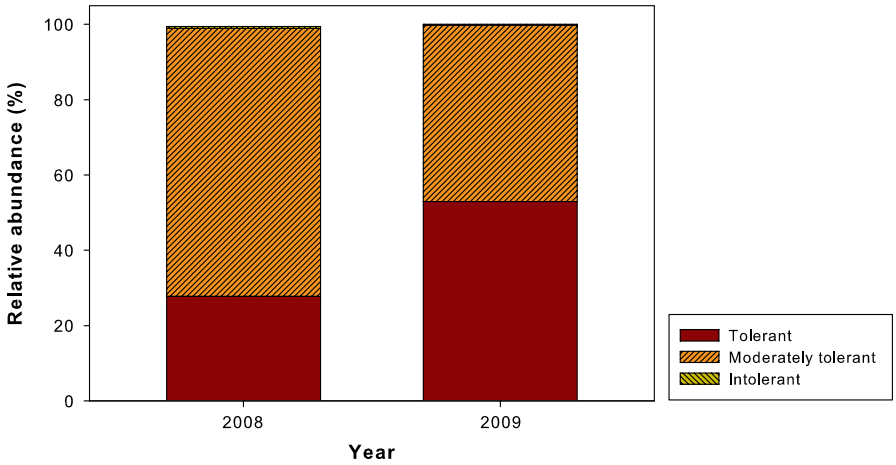


Figure 6a. Mean relative abundance of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from TSA01 at Tsaile Creek in CACH, 2008–2009, based on their tolerance to perturbation. Intolerant taxa in 2009 were observed at 0.4%.



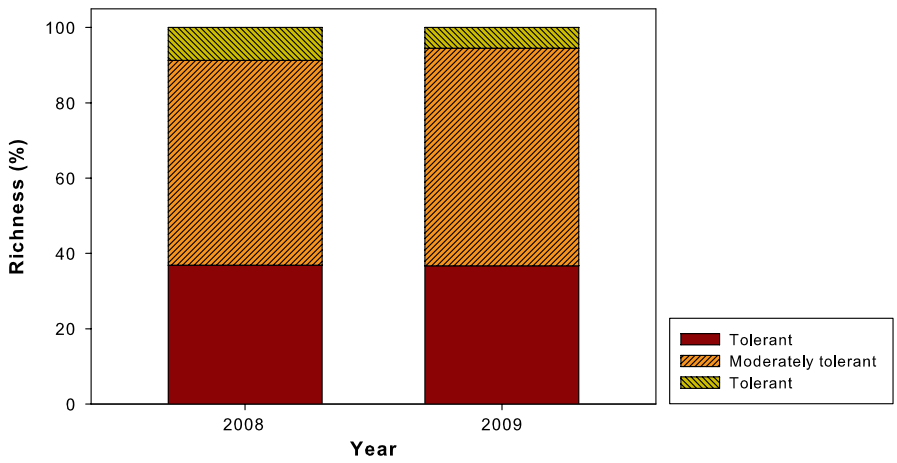


Figure 6b. Mean richness of aquatic macroinvertebrate taxa in quantitative targeted riffle samples collected from TSA01 at Tsaile Creek in CACH, 2008–2009, based on their tolerance to perturbation

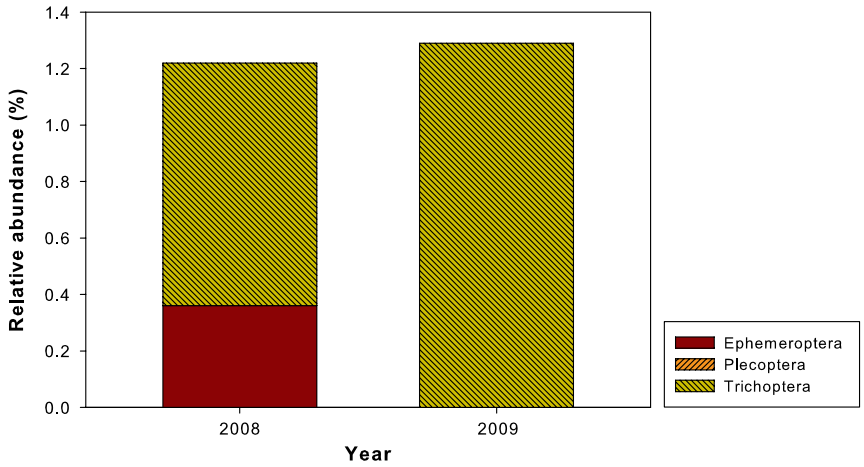


Figure 7. Relative abundance of sensitive EPT orders in quantitative targeted riffle samples collected from TSA01 at Tsaile Creek in CACH, 2008–2009

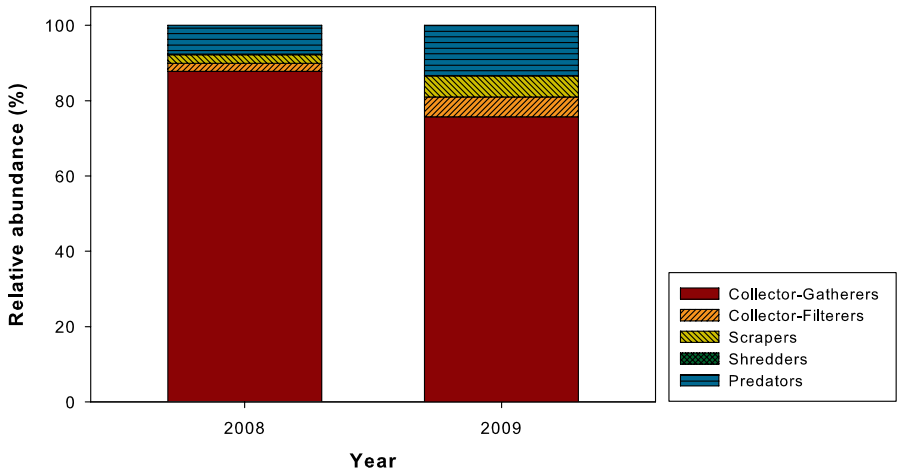
Aquatic macroinvertebrate orders. Relative abundance for aquatic macroinvertebrate orders was dominated by the category we classify as "noninsect" (fig. 8). These taxa are typically aquatic obligates, and for this site, were organisms belonging to the orders Amphipoda, Decapoda, Basommatophora and Veneroida (i.e., crusteaceans, snails, and bivalves). "Noninsect" taxa made up 57.3% of the individuals collected from our monitoring site. Dipterans (midges) were the second most abun-

Figure 8. Relative abundance of individuals by taxonomic order in quantitative targeted riffle samples collected from TSA01 at Tsaile Creek in CACH, 2008–2009

dant order at 37.5%. Odonates (damselflies and dragonflies) and Trichopterans were also collected and represented 2.7% and 1.3% respectively, of the individuals collected. Coleopterans (beetles) were the least abundant of the orders, at 0.15%.

Functional feeding groups. Collector-gatherers were the most abundant functional group in our samples. Nearly 76% of the individuals collected from our monitoring site belonged to this group. Predators were the second most abundant group at 13.3%. Scrapers and shredders were the least abundant groups, at 5.6% and 0.1%, respectively, of the individuals collected at Tsaile Creek (fig. 9).

Figure 9. Relative abundance of functional feeding groups in quantitative targeted riffle samples collected from TSA01 at Tsaile Creek in CACH, 2008–2009



3.2 Physical habitat characteristics for Tsaile Creek

Physical habitat data collected at TSA01 in 2009 are presented in Table 3. Additional transect and microhabitat data can be found in Appendix D. Particle size distribution data are presented as the proportion of particles counted across the entire length of the reach. Aquatic macroinvertebrate habitat cover represents point data (5 points/transect) across the entire reach. Geomorphic channel units (GCU) are described as the proportion of the reach characterized by a particular GCU.

Microhabitat. Mean stream velocity at the targeted riffles averaged 0.27 m/s. The average stream depth at sampled riffle habitat was 0.06 m. Riffle particles sampled belonged to three different size classes. Cobbles were the dominant size class at 52%, followed by coarse gravels at 44%. Boulder/Bedrock accounted for 4% of the particles sampled. Embeddedness of riffle particles averaged 24.9% (table 3).

Transect. Mean velocity along each transect averaged 0.01 m/s. Stream depth at our habitat transects averaged 0.12 m. Wetted and active channel widths averaged 2.5 m and 5.7 m respectively. Riparian canopy closure averaged 16.5% within the monitoring site (table 3).

We found only two types of aquatic macroinvertebrate habitat structures along our monitoring site. Thirty-six percent of the site was composed of vegetation, while 61% of the site was composed of rock. The remaining 3% of the site did not fall into one of our delineated aquatic macroinvertebrate habitat types ("Other" in fig. 10).

Reach. Channel structure dynamics are represented by particle size distributions in Figure 11. Based on modified Wolman pebble counts with a minimum of 400 particles sampled, coarse gravels (16–64 mm) and cobbles (64–256 mm) dominated the sampling reach, making up 70% of the particles measured. Fines (<2 mm) were the next most abundant size class at 8%.

Table 3. Physical habitat transect data from TSA01 at Tsaile Creek in Canyon de Chelly National Monument, Arizona, 2008–2009. Particle embeddedness and canopy closure measurements are expressed as percentages.

	2008		2009	
Physical habitat metric	**Mean**	**SD**	**Mean**	**SD**
Microhabitat level				
Riffles				
Velocity (m/s)	0.00	0.09	0.27	0.17
Depth (m)	0.07	0.02	0.06	0.02
Embeddedness (%)	10.44	7.57	24.96	11.34
Transect level				
Channel dimensions				
Velocity (m/s)	0.00	0.02	0.01	0.02
Depth (m)	0.18	0.10	0.12	0.09
Wetted channel width (m)	2.73	1.16	2.48	1.24
Active channel width (m)	5.58	1.23	5.65	1.46
Riparian cover				
Canopy closure (%)	1.05[a]	2.01[a]	16.48	19.73
Reach level				
Water quality[b]	**Value**		**Value**	
Temperature (°C)	12.9		14.1	
Specific conductivity (µS/cm)	362		499	
pH	8.2		8.3	
Dissolved oxygen (% saturation)	108.7		106.5	
Dissolved oxygen (mg/L)	11.4		8.5	
Turbidity (NTU)	19.93		32.67	

Note: See Appendix B for detailed description of metrics in this table.
[a]Riparian canopy closure was recalculated in 2009 for 2007 and 2008 data, resulting in different values in this 2009 report than shown in the reports for those earlier years.
[b]One water quality measurement only is reported for the site, based on the sampling event closest to 12:00 noon on the sampling day.

We found only three geomorphic channel units (GCU) that occurred in our sampling reach in Tsaile Creek. Runs dominated the GCUs, making up 65% of the reach. Riffles were the next largest category of GCU, at 19%, followed by scour pools which made up 17% of the reach (fig. 12). For a complete description of GCUs see Brasher et al. (in press).

NPS water quality core parameters are reported as the measurements recorded at or close to midday on the day of our sampling event. Temperature measured was 14.1°C. Specific conductivity measured 499 µS/cm and pH was 8.3. Dissolved oxygen measured 85.2% saturation and 8.5 mg/L. Turbidity of stream water along our sampling reach averaged 32.7 NTU (table 3).

Figure 10. Macroinvertebrate habitat characterization based upon line point intercept data collected from habitat transects from TSA01 at Tsaile Creek, CACH, 2008–2009. Some habitat structure types were not observed.

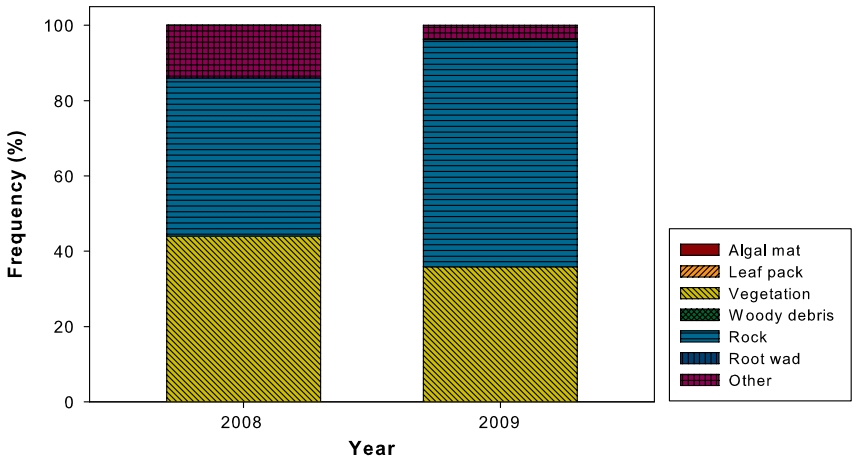


Figure 11. Particle size distribution, based on modified Wolman pebble counts, from TSA01 at Tsaile Creek in CACH, 2008–2009. Differences between years may be attributed to a change in methodology between sampling years.

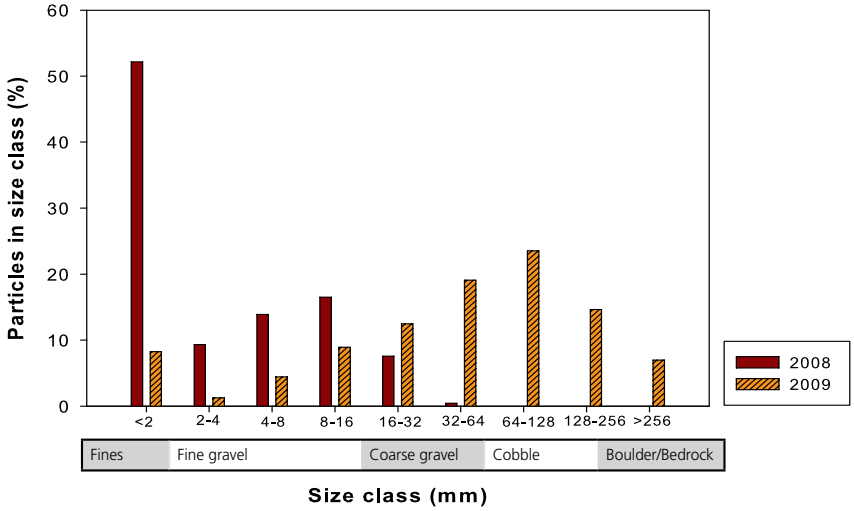
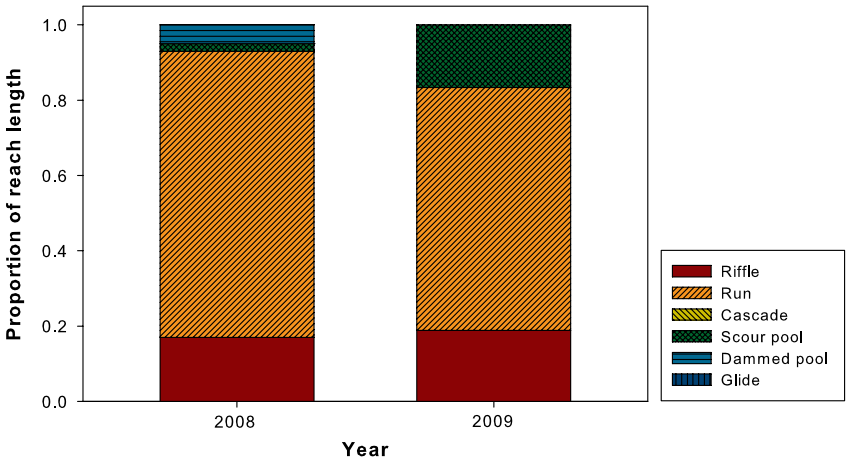


Figure 12. Geomorphic channel unit characterization from TSA01 at Tsaile Creek in CACH, 2008–2009



3.3 Antecedent conditions

Daily air and water temperatures were recorded for 2009 at 15 minute intervals at Tsaile Creek and are presented in Figure 13 for the fall sampling window chosen by SCPN. Air temperature reached a low of -14.0°C at 0515 hrs on October 10. The highest air temperature recorded at the monitoring site was 32.6°C at 1745 hrs on August 4. Air temperature at the site averaged 10.8°C. Water temperature reached a low of 0.34°C on November 18 at 0515 hrs. A temperature of 25.6°C was the high at our monitoring site, and recorded at 1900 hrs on August 3. Water temperature averaged 11.3°C.

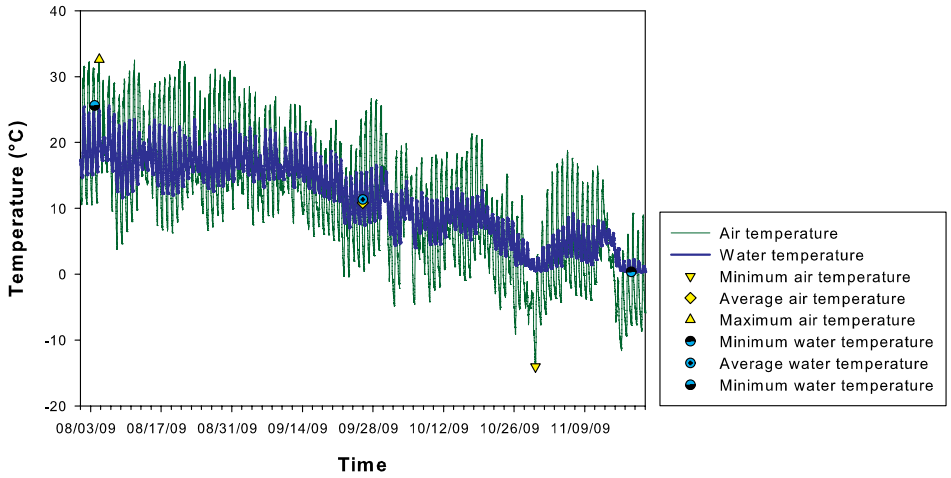


Figure 13. Air and water temperatures recorded at 15 minute intervals for the TSA01 monitoring site at Tsaile Creek in CACH, 2009

4 Discussion

This report presents data from SCPN's second year of monitoring aquatic macroinvertebrates and physical habitat at Tsaile Creek in Canyon de Chelly National Monument, Arizona. We stress that the differences between sampling years and locations are not to be interpreted as ecologically significant trends, as trends cannot be determined with confidence from two years of sampling data. Differences may be attributed to multiple factors, including ecological variability and sampling error. Differences in physical habitat metrics, such as geomorphic channel units, canopy closure, and particle embeddedness may be a result of observer bias. SCPN attempts to minimize such error by thoroughly training crew members in the proper field techniques prior to each sampling season.

4.1 Aquatic macroinvertebrate communities

The data for this year suggest that overall abundance of aquatic macroinvertebrates is relatively high, with an average of over 500 individuals collected per quantitative sample. Overall, taxa richness remains low for this site. One possible explanation for this could be the lack of heterogeneity of appropriate habitat types existing at our monitoring site. We found only two types of habitat: vegetation and rock. A lack of habitat heterogeneity can reduce possible foraging habitats as well as habitat types used as protection from predation. Additionally, crayfish, which are present in Tsaile Creek, have been shown to greatly reduce diversity and abundance of aquatic macroinvertebrate communities (Stenroth & Nyström 2003; Usio and Towsend 2004). Crayfish are polytrophic, feeding at multiple trophic levels in a food web. This can affect aquatic macroinvertebrates not only through direct predation but by reducing available food resources as well.

Taxonomic diversity remains moderate for this site. We did find that taxonomic diversity in 2009 was

higher than during the previous sampling year. Much of that increase can be attributed to the corresponding increase in aquatic macroinvertebrate taxa that fit into the "noninsect" category. Crayfish, snails and bivalves were found in high abundance this year.

4.2 Functional roles in aquatic communities

Functional feeding groups allow aquatic ecologists to categorize aquatic macroinvertebrate taxa based on morphological differences in feeding appendages. These groups describe how energy in the system is utilized and transferred by the macroinvertebrate community. A detailed description of functional grouping and trophic organization in aquatic ecosystems can be found in Merritt and Cummins (1984). Diversity of functional feeding groups remained low for this reach (table 2). Samples were overwhelmingly dominated by collector-gatherer taxa (75%). This result is unusual in that we found quite a bit of vegetation growing in the stream (36% of the habitat structure was vegetation). Collector-gatherer taxa primarily act as detritivores, feeding on decomposing fine organic materials. It is expected that in streams where there is an abundance of vegetative growth, shredder taxa would be more dominant as they are the functional group responsible for breaking down in-stream primary production.

4.3 Sensitive taxa

In 2009 we found few taxa that were sensitive to perturbation and declining water quality. Intolerant taxa were found in very low abundance, at <1%. Similarly, sensitive taxa belonging to the order Ephemeroptera were absent from samples in 2009, after being present in low quantities at 2008. No Plecoptera were found at our monitoring site again this year.

4.4 Particle size

Particle size distributions for 2009 differed greatly from our 2008 findings. In 2008, particle sizes were heavily weighted towards the smaller size classes (<2 mm through the 8–16 mm class) with no particles larger than the 32–64 mm size class found that year. In 2009, size classes between 32 and 256 mm were the most abundant classes. This difference in particle sizes is most likely due to a change in methodology between sampling seasons. After our first few years of sampling particles along physical habitat transects at multiple sites on the Colorado Plateau, it became apparent that this method was biased towards the smaller size classes. As a result we decided to change our particle sampling methods from focusing on particles along our habitat transects to a reach-wide particle count. This new methodology is conducted by walking a zig-zag pattern from bank to bank allowing us to sample more of the vertical length of our reach.

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 within this report are provisional and subject to change. When sufficient data are available, SCPN plans to produce an interpretive report including trend analysis of macroinvertebrate metrics and physical habitat data for Tsaile Creek.

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Appendix A Tsaile Creek monitoring site at Canyon de Chelly National Monument, Arizona, 2009

Site code	Common name	Report name	UTM X	UTM Y	Elevation (m)
CACHTSA01	Tsaile Creek below Tsaile Dam	TSA01	660576.39	4015393.36	2125

Appendix B Selected aquatic macroinvertebrate metrics

Metric type	Metric	Definition
Abundance	Total abundance	Total number of individuals.
Richness	Taxa richness	Total number of taxa (measures the overall diversity of macroinvertebrates in a sample).
Diversity	Simpson's diversity	A measure of the variety of taxa that takes into account the relative abundance of each taxon. $DS = 1-[(\sum n(n-1))/(N(N-1))]$
Tolerance	Dominant taxa	Measures the dominance of the most abundant taxa. Typically calculated as dominant 2, 3, 4, or 5 taxa.
	Relative abundance for tolerant taxa	Percent of individuals considered to be tolerant to perturbation.
	Percent richness for tolerant taxa	Percent of taxa considered to be tolerant 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 finer substrates).
	Percent richness burrowers	Percent of taxa that move between substrate particles (typically finer 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.
	Relative abundance of Hydroptilidae or Hydropsychidae within Trichoptera	Percent of Trichopteran individuals belonging to Hydroptilidae or Hydropsychidae families (ratio of tolerant caddisfly abundance to total caddisfly abundance).
	Relative abundance non-insect taxa	Percent of individuals that are not insects.
	Relative abundance Chironomidae	Percent of individuals that are midges.

Source: Data from Brasher et al. (in press)

Appendix C Aquatic macroinvertebrate species list from the TSA01 monitoring site, Canyon de Chelly National Monument, Arizona, 2009

Phylum	Class	Order	Family	SubFamily	Genus	Species	Common name
Annelida							segmented worms
Annelida	Clitellata						segmented worms
Annelida	**Clitellata**	**Rhynchobdellida**	**Glossiphoniidae**	**Haementeriinae**	***Helobdella***	***stagnalis***	leeches
Arthropoda	**Arachnida**	**Trombidiformes**					water mites
Arthropoda	**Entognatha**	**Collembola**					spring tails
Arthropoda	**Insecta**	**Coleoptera**	**Dryopidae**		***Helichus* sp.**		long toed water beetles
Arthropoda	Insecta	Coleoptera	Dytiscidae				predaceous diving beetles
Arthropoda	Insecta	Coleoptera	Dytiscidae	Agabinae	*Agabus* sp.		predaceous diving beetles
Arthropoda	**Insecta**	**Coleoptera**	**Helophoridae**		***Helophorus* sp.**		water scavenger beetles
Arthropoda	Insecta	Diptera					flies
Arthropoda	Insecta	Diptera	Ceratopogonidae				biting midges
Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae	*Probezzia* sp.		biting midges
Arthropoda	**Insecta**	**Diptera**	**Ceratopogonidae**	**Forcipomyiinae**	***Forcipomyia* sp.**		biting midges
Arthropoda	Insecta	Diptera	Chironomidae				non-biting midges
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae			non-biting midges
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae			non-biting midges
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae			non-biting midges
Arthropoda	**Insecta**	**Diptera**	**Culicidae**				mosquitoes
Arthropoda	**Insecta**	**Diptera**	**Empididae**		***Neoplasta* sp.**		dance flies
Arthropoda	**Insecta**	**Diptera**	**Simuliidae**				black flies
Arthropoda	Insecta	Diptera	Simuliidae	Simuliinae	*Simulium* sp.		black flies
Arthropoda	Insecta	Ephemeroptera	Baetidae		*Callibaetis* sp.		small minnow mayflies
Arthropoda	Insecta	Hemiptera	Corixidae				water boatmen
Arthropoda	Insecta	Hemiptera	Corixidae	Corixinae	*Sigara* sp.		water boatmen
Arthropoda	Insecta	Odonata	Coenagrionidae				narrow winged damselflies
Arthropoda	Insecta	Odonata	Coenagrionidae		*Argia* sp.		narrow winged damselflies
Arthropoda	**Insecta**	**Trichoptera**	**Hydropsychidae**				netspinning caddisflies
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	*Cheumatopsyche* sp.		netspinning caddisflies

Appendix C (*cont'd.*)

Phylum	Class	Order	Family	SubFamily	Genus	Species	Common name
Arthropoda	Insecta	Trichoptera	Hydroptilidae				microcaddisflies
Arthropoda	**Insecta**	**Trichoptera**	**Leptoceridae**	**Leptocerinae**	***Oecetis* sp.**		longhorned caddisflies
Arthropoda	**Insecta**	**Trichoptera**	**Limnephilidae**				northern caddisflies
Arthropoda	Malacostraca	Amphipoda	Hyalellidae		*Hyalella* sp.		amphipods
Arthropoda	Malacostraca	Decapoda	Cambaridae				crayfish
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidiinae	*Pisidium* sp.		peaclams
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Lymnaeinae			freshwater snails
Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Lymnaeinae	*Lymnaea* sp.		freshwater snails
Mollusca	Gastropoda	Basommatophora	Physidae	Physinae	*Physa* sp.		bladder snails
Mollusca	Gastropoda	Basommatophora	Planorbidae				ramshorn snails
Mollusca	Gastropoda	Basommatophora	Planorbidae		*Gyraulus* sp.		ramshorn snails
Nemata							nematodes

Note: Bold denotes a new record for this SCPN monitoring site.

Appendix D Channel characteristics at the TSA01 monitoring site, Canyon de Chelly National Monument, Arizona, 2009

	Velocity (m/s)		Depth (m)		Wetted channel width (m)	Active channel width (m)
Transect	Mean	Std Dev	Mean	Std Dev	Value	Value
1[a]	0.00	0.00	0.02	0.02	1.66	4.95
2	0.05	0.06	0.04	0.01	1.39	3.65
3	0.01	0.00	0.25	0.07	4.08	5.40
4[a]	0.00	0.00	0.13	0.10	2.59	8.80
5[a]	0.00	0.00	0.08	0.02	1.34	3.80
6[a]	0.00	0.00	0.04	0.02	0.99	7.08
7[a]	0.00	0.00	0.09	0.05	2.75	5.40
8	n/a	n/a	0.16	0.05	3.49	5.19
9[a]	0.00	0.01	0.26	0.09	4.72	6.05
10[a]	0.00	0.00	0.21	0.03	2.90	5.30
11[a]	0.00	0.00	0.02	0.02	1.36	6.58

[a]Flow was only measurable to the thousandth m/s.