



Canyon Creek Fish Survey May 6 – 8 and May 13, 2008



Survey Personnel:

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Objective:

To continue to assess the recovery of fish populations in Canyon Creek six years after the flooding impacts of the Rodeo-Chediski fire (July 2002). Specifically we examined fish species populations, noted in-stream habitat conditions, and compared them with similar surveys conducted from 2004 through 2007 and to the pre-fire data from the last completed fish survey from July 1998.

Methods:

Sample sites were selected by habitat type for each of the seven reaches (divisions established in 1987) within Canyon Creek from the springhead to the White Mountain Apache Reservation boundary, approximately 11.5 kilometers in length (Figure 1). Fixed survey site locations of one riffle, pool, and run per reach were repeated from the 2004 through 2007 surveys. Each habitat was blocked at the downstream and upstream end with a 1/8" seine. Fish collections were made using a Smith-Root model 12B POW backpack shocker and two dip netters. Delivered electricity was recorded in seconds and settings ranged from 0.20-0.40 amps at 200-300 volts and 60-70 milliseconds pulsed (900 seconds = 1 Electrofishing Unit = EFU). Fish were identified to species, measured for total length (mm), weighed to the nearest 2 grams, enumerated, and returned to the stream. A "two-pass" depletion method was used (< 50% of first pass catch rate). Total length and three stream widths were measured in meters at each site and fish densities/hectare were determined by: length (m) x average width (m) x 1 ha/10,000m². Nine depths (mm) were recorded along the three width cross-sections and averages established. Digital photographs were taken at each sample site (on file) and were marked with a handheld Garmin GPS unit (Table 1). Water quality measurements of temperature (°C), pH, and conductivity were recorded at each survey site. Previously placed temperature logger locations were checked to see if the units remained secure.

In addition to the annual habitat unit sampling, three longitudinal stations (> 150m) were repeated from 2006 and 2007 in the lower portion of three reaches (Reaches 2, 3, and 4) to conduct two-pass depletion estimates on trout. Population estimates were calculated using MicroFish 3.0 statistical software (Van Deventer and Platts 1985). Although population estimates could be calculated using the habitat unit sampling data, these estimates would likely be biased. Pools do not occur at the frequency sampled (riffle and run habitats dominate) and any estimates based on these would likely overestimate adult trout density. Sampling a continuous representative station provides a more accurate representation of overall trout density in a given reach. Prior to sampling, a block net was placed at the upstream and downstream portion of each station. The stations were established to begin and end at a transition between habitat types. All trout collected on the first pass were held in a live car until the second pass could be completed, at which time the fish were weighed to the nearest 2g, measured to the nearest mm, and released.

Results and Comparisons:

Habitat & Water Quality:

Depth measurements among habitats ranged from an average of 253mm for riffles to 594mm for pools (Table 2). Runs were intermediate in average depth at 393mm (Table 2). These results were deeper for all habitat compared to all past surveys (Table 2).

Water temperatures varied from 8.2°C in reach 4 to 17.5°C in reach 6, depending on time of day (Table 3). This is typical for the creek as previously collected loggers from the summer of 2007 revealed wide daily summer temperature variations in July from 15°-25°C (5A pool) to 19°-28°C (7C pool). Water pH ranged from 8.4 in reach 1 to 9.6 beginning in reach 6, generally increasing downstream (Table 3). Similarly, water conductivity increased in a downstream fashion. Conductivity ranged from 140µS/cm in reach 1 to 195µS/cm in reach 7; although the highest conductivity was measured in reach 4 at 200µS/cm (Table 3).

Fish Densities and Catch Per Unit Effort (CPUE):

Native fish

A total of 676 speckled dace were collected in 2008 compared to 1253 in 2007 and 1227 in 2006. Although the number were roughly half the 2006 and 2007 number there is still an almost 4-fold increase over pre-fire numbers of 1998 (Table 4). Speckled dace densities increased from 1284/ha in 2004, 3166/ha in 2005, 9069/ha in 2006, to 8979/ha in 2007. This year speckled dace densities dropped and were calculated to be 3986/ha, which is still a roughly 3-fold increase over the pre-fire survey in 1998 of 1148/ha (Table 5). Catch per unit effort (fish/EFU) had also increased each of the past four years. Catch per unit effort was calculated to be 16.6, 36.1, 92.4, and 113.5 in 2004, 2005, 2006, and 2007 respectively, surpassing the pre-fire mark of 21.5 in 1998 (Table 5). This year CPUE dropped to 43.8 fish/EFU but was still more than double the 1998 CPUE.

The number of desert suckers caught had increased every year from 2004 (3) to 2007 (461), but has dropped this year (260) (Table 4). Relative abundance of suckers had decreased from 21% of the fish population in 1998 to 1% in 2004. The last three years relative abundance has increased to 10% of the total fish population in 2005, 23% in 2006, and 24% in 2007. Desert sucker relative abundance remained basically the same as in 2006 and 2007 and was calculated to comprise 23% of the fish community. Desert sucker densities rebounded dramatically from 25/ha in 2004 to 460/ha in 2005 to 3126/ha in 2006 and 3303/ha in 2007 (Table 5). In 2008 those numbers dropped to 1533/ha. Catch per unit effort (fish/EFU) increased from 0.3 in 2004, 5.2 in 2005, 31.8 in 2006, to 41.8 in 2007 (Table 4). This year CPUE dropped to 16.9 but was still higher than the 12.2 calculated during the last pre-fire survey in 1998 (Table 4).

Trout

We collected 98 rainbow trout in 2008, similar to the 105 rainbow trout collected in 2007 and the 106 collected in 2006 (Table 4). Rainbow trout densities increased from 513/ha in 2005 to 783/ha in 2006, but showed a slight decrease to 752/ha in 2007 (Table 5). Rainbow trout densities declined again to 442/ha in 2008. Catch per unit effort had increased every year since 2004 until 2008 when it declined to 4.9 fish/EFU (Table 5). This marks the first survey since 2004 that rainbow trout CPUE was less than pre-fire levels (Table 5). Catch per unit effort was 4.9 in 2004, 5.8 in 2005, 8.0 in 2006, 9.5 in 2007, and 4.9 in 2008 (Table 5). Forty-seven, or 45%, of the rainbow trout collected in 2007 were young-of-the-year (YOY) rainbow trout; all were collected in reach 1. Interestingly, all were collected from the reach 1 run, which encompasses the hatchery discharge. This suggests that these fish were likely hatchery escapees. In 2006, sixty-one YOY were collected with at least one collected in all reaches (14 in reach 4 and 49 in reach 5) with the exceptions of reaches 2 and 7. No YOY rainbow trout were collected in 2008 (Table 6).

The number of brown trout collected in 2008 (121) was almost identical to 2007 (123) and nearly doubled the catch of 2006 (70) (Table 4). Brown trout densities had increased every year since 2004 but declined slightly in 2008. Brown trout densities are approaching pre-fire densities of 1998 (1074/ha); densities were 124/ha, 249/ha, 517/ha, 881/ha, and 713/ha in 2004, 2005, 2006, 2007, and 2008 respectively. Catch per unit effort (fish/EFU) for browns rose from 1.6 in 2004, to 2.8 in 2005, to 5.3 in 2006, to 11.1 in 2007, nearly doubling each year. This year brown trout CPUE declined to 7.8 and remains less than the 20.1 calculated in 1998 (Table 5). Twenty-five, or 20%, of the brown trout collected in 2007 were YOY. Young-of-the-year brown trout were collected in every reach through reach 5 in 2007. In 2006, forty-three or 61% of the brown trout collected were YOY. One YOY brown trout was collected in reach 4 in 2008 (Table 7).

Overall trout densities (fish/ha), rainbow and brown combined, had improved to about 120% of pre-fire densities in 2007 (Table 5). Densities showed a slight decline in 2008 and are currently about 85% of pre-fire densities. Although trout densities declined slightly compared to pre-fire levels brown trout densities remained similar even with only one YOY brown trout collected.

Fish Distribution:

Rainbow trout abundance was highest in reaches 1 and 2 (Table 8), attributed to stocking. Rainbow trout were found in all reaches sampled in 2008 except reach 3 and reach 7 (Table 7). The largest rainbow trout collected during habitat sampling was a 330mm fish collected in the reach 5 pool.

Brown trout were distributed throughout all reaches in 2008 (Table 8). This is an expansion since 2007 when brown trout were only collected through reach 5 (Table 9). Historically (1998 survey) brown trout were widespread from reaches 1-6 (Table 13). The largest brown trout sampled during the 2008 habitat sampling was a 649mm fish collected in the reach 3 run.

The distribution of speckled dace began in reach 2 (n=28) and became abundant in reaches 3 through 7 (Table 8). Overall dace numbers in reaches 4-7 have rebounded dramatically from 23 in 2004 (Table 12) to 582 in 2008 (Table 8).

Desert suckers were captured in reaches 2-7 (Table 8). Reach 7 had the highest densities of suckers in 2008; of note no desert suckers were collected in reach 7 in 2004 (Table 12). In 2008, suckers were widespread throughout reaches 2-7 and their numbers surpassed pre-fire numbers in all reaches (Tables 8 and 13).

Trends in fish distribution were increasing, particularly with native fishes in reaches 4-7 but have begun to level off or even drop. In 2004 only 24 fish were caught, all natives (Table 12). This year in the same reaches using the same relative amount of effort, 1132 fish were collected; all but 196 were native fish (Table 8). Brown trout numbers remain low in reaches 4 through 7 compared to 1998 (32 vs. 110) but have increased in reaches 1 through 3 (89 vs. 65) (Tables 8 and 12).

Habitat selection:

Rainbow trout were collected primarily in pools (956/ha) and were uncommon in runs (101/ha) and riffles (72/ha) in 2008 (Table 14). This is not surprising as the majority of rainbows collected were of hatchery origin. In 2007, Rainbow trout were collected primarily in runs (1151 fish/ha) and pools (529 fish/ha), and to a lesser extent riffles (239 fish/ha; Table 15). Although rainbows had the highest densities in runs, the average length of rainbow trout collected in runs was 119mm (Table 15). This indicates that the majority of rainbow trout collected in runs were YOY; most coming from the reach 1 run. The rainbow trout collected in pools averaged 251mm. These data suggest that although densities were lower in pools than in runs, adult rainbow trout concentrate in pools. In 2006, rainbow trout densities were highest in riffles (1048/ha) followed by pools (835/ha) and runs (572/ha; Table 16). Again, rainbow trout averaged 115mm and 125mm in length in riffles and runs respectively and 215mm in pools. In 2005, rainbow trout were collected in the deeper pools and runs (694 fish/ha and 640 fish/ha respectively), and to a lesser extent riffles (107 fish/ha; Table 17). In 2004 rainbow trout surveyed also preferred pools (761 fish/ha; Table 18). During the 1998 survey rainbows preferred runs (574 fish/ha) verses pools (171 fish/ha), although it should be noted that rainbows collected in pools averaged 274mm compared to 210mm in runs (Table 19).

Brown trout were collected primarily in pools (1028/ha) and were about half as common in runs (489/ha) and riffles (501/ha) in 2008 (Table 14). Brown trout in pools and runs average about 70 and 60mm larger, respectively, than those in riffles indicating the importance of riffles for juvenile fish (Table 14). In 2007, brown trout densities were similar in riffles and pools (1136/ha and 1074/ha respectively) and considerably lower in runs (324/ha; Table 15). Brown trout collected in pools were larger (224mm) than those collected in riffles (151mm) and runs (159mm; Table 15). Brown trout densities were higher in riffles (981 fish/ha) and runs (551 fish/ha) than in pools (261 fish/ha) in 2006 (Table 16). The average length of brown trout in riffles and runs was 160mm and 86mm respectively, suggesting their importance for the rearing of young fish. Brown trout in pools average 269mm, confirming the importance of pool habitat for adult fish. Brown trout were more common in pools (347 fish/ha) and runs (246

fish/ha) than in riffles (107 fish/ha) in 2005 (Table 17). While brown trout seemed to prefer runs and pools (167 and 145 fish/ha respectively) in 2004, the low numbers collected preclude making such assumptions (Table 18). Historically (from the 1998 survey), brown trout were abundant in all three habitat types (> 800 fish/ha), but had the highest densities in runs (1351 fish/ha; Table 19).

Desert suckers were collected at highest densities in pools (2158/ha) followed by runs (1383/ha) and riffles (1264/ha) in 2008 (Table 14). In 2007, desert suckers density was highest in riffles (3382/ha) and pools (3290/ha) and lowest in runs (2612/ha), although densities were high among all habitats (Table 15). Desert suckers were more frequent in runs (3516 fish/ha) and pools (3236 fish/ha) and slightly less prevalent in riffles (2401 fish/ha) in 2006 (Table 16). In 2005, desert suckers were collected more frequent in pools (603 fish/ha) and nearly evenly divided between riffles (402 fish/ha) and runs (320 fish/ha; Table 17). In 2004, no habitat conclusions for desert suckers could be identified as only 3 fish were captured (Table 18). The 1998 data suggest that suckers preferred runs (1233 fish/ha; Table 19).

Speckled dace densities were highest in runs (5650/ha) and riffle (4578/ha) and somewhat less common in pools (2158/ha) in 2008 (Table 14). In 2007, speckled dace had the highest densities in riffles (12352/ha) followed by runs (9696/ha) and pools (4824/ha; Table 15). Speckled dace were evenly abundant in riffles and runs (12547 and 12030 fish/ha respectively) and found in much lower densities (5011 fish/ha) in pools in 2006 (Table 16). This is similar to 2005 when speckled dace were most common in runs and riffles (5118 and 4853 fish/ha respectively) and much less common in pools (657 fish/ha; Table 17). From the 2004 surveys, dace overwhelmingly preferred runs by densities: runs 3183 fish/ha, riffles 933 fish/ha, and pools 254 fish/ha (Table 18). In 1998 dace were concentrated more in riffles (2799 fish/ha) than runs (1334 fish/ha; Table 19).

Trout Population Estimates:

Age-1+ brown trout density estimates increased in an upstream fashion. Estimates ranged from a low of 675/ha in reach 4 to 772/ha in reach 3 to a high of 1118/ha in reach 2 (Table 20). A similar trend was noted for biomass. Age-1+ brown trout biomass estimates were 83.4 kg/ha in reach 4, 81.1 kg/ha in reach 3, and 231.3 kg/ha in reach 2 (Table 20). No YOY brown trout were collected during population estimate sampling in 2008.

Rainbow trout, in addition to brown trout, were collected at all three reaches but were low in numbers. For this reason population estimates could not be calculated for rainbow trout in these reaches. Also, no age-0 rainbow trout were collected in any of the reaches in 2008. Therefore, age-1+ rainbow trout were used to calculate overall trout estimates for the three reaches. Density estimates for all age-1+ trout were 746/ha in reach 4, 815/ha in reach 3, and 1157/ha in reach 2 (Table 20). Trout densities increased in an upstream fashion. The same did not hold for biomass estimates as trout biomass was calculated at 102.0 kg/ha in reach 4 to 88.5 kg/ha in reach 3 to 237.0 kg/ha in reach 2 (Table 20).

Compared to 2007, brown trout densities increased in reaches 3 and 4 in 2008 (significantly in reach 4) but decrease slightly in reach 2 (Figure 2). All density estimates were higher than in

2006 and reach 3 and 4 were significantly higher (Figure 2). The reach 2 estimate may have been significant but the lack of error about the 2006 estimate precludes making that statement. The same trend did not hold for biomass estimates.

Biomass estimates declined in reaches 2 and 3, significantly in reach 3, and increased significantly in reach 4 from 2007 to 2008 (Figure 3). In 2008, reaches 3 and 4 were higher and reach 2 was lower than the 2006 biomass estimates. Again, although the decline in biomass from 2006 to 2008 at reach 2 may look significant the lack of error about the estimate precludes this making that statement.

Discussion:

It is impressive to witness the recovery of Canyon Creek over the past five years since the watershed was severely damaged after the Rodeo-Chediski fire of 2002. Habitat conditions continue to improve in the riparian corridor. In 2005, above normal late-winter and spring flooding of the stream flushed much of the silt from pools and scoured some run habitats to reduce bottom material embedment but also downcut the stream channel. The flooding created additional pools where several streamside trees had fallen into the stream. Vegetation continues to respond in the OW ungulate enclosure as willows, grasses, and aquatic plants continue to rebound. A new enclosure was also constructed in 2005 encompassing portions of reaches 4 and 5. Vegetation in this enclosure is already beginning to respond and should improve habitat condition in this section of stream.

Between habitat unit and population estimate sampling, 413 trout were collected in Canyon Creek, up slightly from just over 409 in 2007. Of these, 329 were brown trout and 84 were rainbow trout. Of the brown trout collected, one (0.3%) was age-0 or YOY fish (Figure 4). In 2007, 79 (28%) were age-0 or YOY fish. In 2006, we documented high numbers of YOY brown trout, especially in the lower portion of reach 2 and reach 3. The lack of YOY brown trout collected in 2008 compared to 2006 and 2007 could be related to two possible factors. First, due to scheduling conflicts the 2008 survey was moved up over a month. The YOY brown trout may have been too small to effectively sample at this time. The fact that the only YOY brown trout collected was only 43mm seems to support this. Typically, YOY brown trout collected in the past averaged 75mm. Second, Canyon Creek experienced a large flood event immediately after the peak of typical brown trout spawning. The floods may have scoured many of the redds created and caused a near failure of this year's spawn.

The increased number of brown trout collected in 2008 is primarily a reflection of natural reproduction by resident trout. The 2006 survey documented high densities of YOY brown trout for the first time since the Rodeo-Chediski fire of 2002. In 2007, we again noted natural reproduction of brown trout and excellent survival of the YOY from 2006, with numerous age-1 fish being collected. The size class structure of the brown trout population in 2008 again documented numerous age-1 and older fish, such that we should continue to see sufficient reproduction of brown trout each year barring catastrophic flooding.

Although no YOY rainbow trout were collected in 2008, we did collect some numerous age-2 rainbows; the result of survival of the YOY rainbows documented in 2006. The low numbers of age-2 rainbow trout that have survived since 2006 suggest that any further reproduction of wild rainbow trout may be limited in Canyon Creek. Rainbow trout typically reach sexual maturity at age 3 so we may see reproduction from this year class in spring 2009 if viable numbers of spawning-age fish remain.

Although natural reproduction of trout has been documented in Canyon Creek that past two years, redd counts conducted in December 2005 and 2006 noted low numbers of redds downstream of OW Bridge. Redd densities were 6.9 and 5.1 redds/km downstream of OW Bridge and 23.7 and 43.0 redds/km upstream of OW Bridge in 2005 and 2006. Interestingly, redd counts conducted in early December 2008 documented densities of 28.9 redds/km downstream of OW Bridge and 55.6/km upstream of OW Bridge. The redd densities below OW Bridge were more than quadruple the previous high densities documented in 2006. This may be contributed to the flooding from the previous winter cleaning and/or depositing spawning gravels in the stream or it may be contributed to the increase in spawning age fish. It is likely that both contributed to this increase. Although redd densities have increase downstream of OW Bridge densities in this section are still roughly half those upstream of OW Bridge. This section of stream may benefit from an addition of spawning gravel to the stream.

Native fish showed a decline in density for the first time since the Rodeo-Chediski fire in 2008 as did rainbow and brown trout. The decline in native fish densities is likely real and the increasing brown trout population is a likely cause. Some of the decline in native fish and trout densities is likely contributed to the high flows encountered during sampling in 2008. Flows looked to be almost double what they have been in the past. Increased flows will show a decline in fish densities by making that fish harder to capture, especially in riffles, and by increasing the overall area sampled. Although the same length of stream was sampled in 2008 the wetted width of the stream increased. Both of these will drive down density and biomass estimates. Looking at densities in numbers per kilometer trout densities remained relatively stable, even without any YOY trout collected, and are near pre-fire levels (Tables 8 and 13). Overall fish densities (fish/km and fish/ha), although declining in 2008 compared to 2007, are still more than double the pre-fire levels of 1998 (Tables 8, 9, and 13).

A significant portion of Canyon Creek is progressing toward an outstanding fishery. Brown trout recruitment in 2006 and 2007 increased the population size and provided ample numbers of catchable fish in 2008. Good numbers of larger ($\geq 300\text{mm}$) brown trout are present in Canyon Creek as 53 were collected in 2008, and increase from the 43 were collected in 2007, and the 36 collected in 2006. Reaches 6 and 7 currently are holding abundant numbers of speckled dace and desert suckers although their numbers seem to be declining some. Habitat in these lower reaches, however, is marginal for trout due to lack of cover and geomorphologic topography (exposed bedrock creating shallow wide-open glides). As streamside vegetation develops and if more logjams and resulting pools become established in the lower reaches, we would expect brown trout to increase in number in this section as well.

Recommendations:

- 1) Continue to conduct annual fish surveys, including two-pass depletion estimates for trout in all reaches, to document fish abundance, distribution, and recruitment.
- 2) Continue to conduct fall brown trout redd counts (initiated in 2005) in late November or early December to document numbers of redds and to identify important spawning areas.
- 3) Continue stocking rainbow trout April-September in upper Canyon Creek above the OW Bridge.
- 4) Promote both trout fisheries and highlight the “Catch and Release” portion of Canyon Creek below the OW.
- 5) Monitor post monsoon rain/flooding impacts and habitat conditions during photo point survey in August 2009.
- 6) Continue to work with the US Forest Service to implement streamside vegetation development practices through prescriptions of fences and enclosures (Canyon Creek Riparian Restoration Project) and possibly willow/cottonwood shoot plantings.
- 7) Initiate spawning gravel enhancement downstream of OW Bridge in fall 2009 to determine if we can increase brown redd densities in this section of stream.
- 8) Secure temperature loggers in November 2008 to download information designating daily temperature variations within Canyon Creek. Reinstall in early spring (March 2009) to document spring and summer seasonal temperature variations.

Submitted by: Curt Gill
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Literature cited:

Van Deventer, J. S. and W. S. Platts. 1985. A computer software system for entering, managing, and analyzing fish capture data from streams. USDA Forest Service Research Note INT-352. Intermountain Research Station, Ogden, Utah. 12 pp.

Figure 1. Vicinity Map

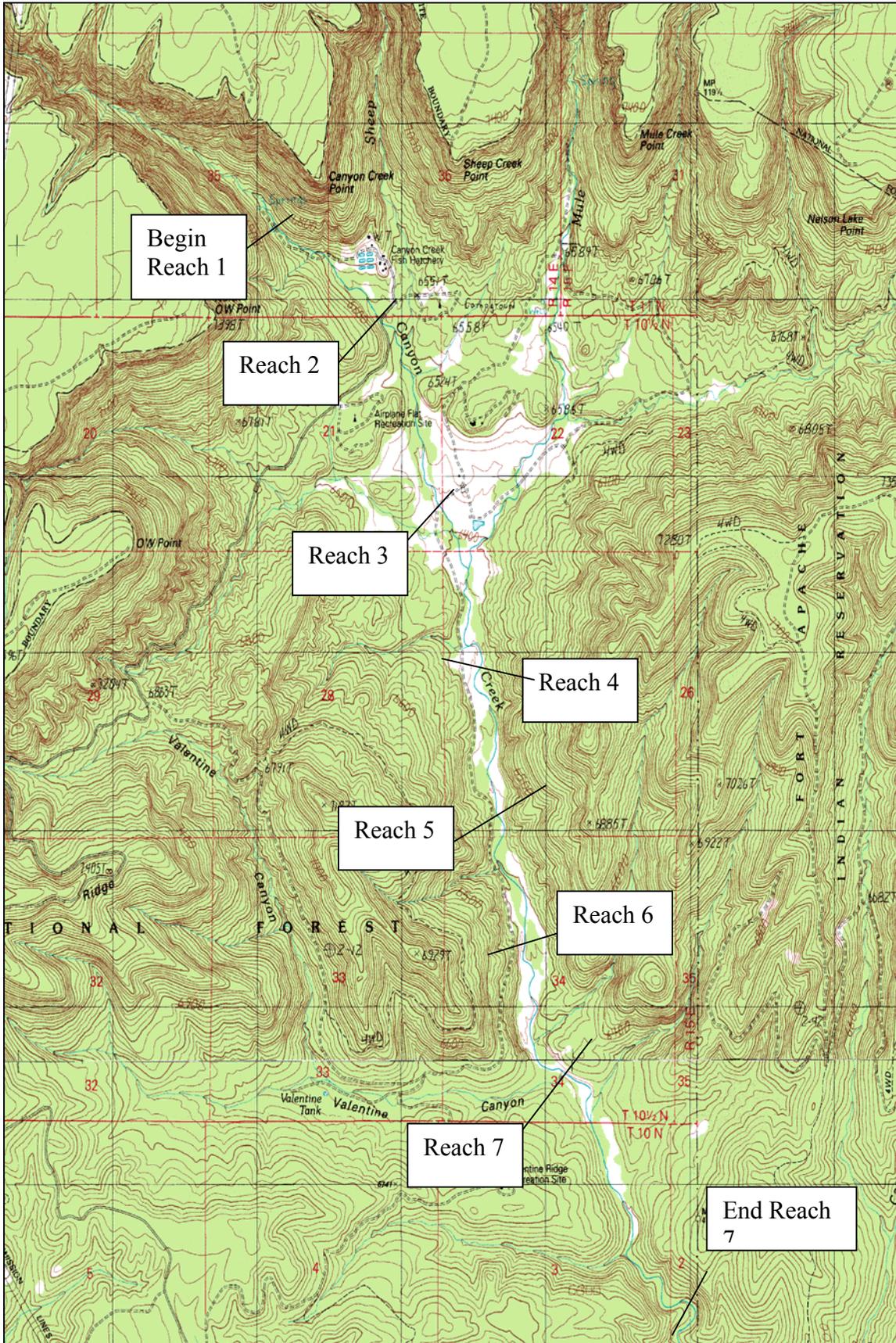


Figure 2. Comparison of 2006 , 2007, and 2008 age-1+ brown trout densities at reaches 2, 3, and 4 (95% confidence intervals included with lower confidence interval set equal to catch; electrofishing unit ran out of battery life after first pass in reach 2 during 2006, therefore no 95% confidence intervals could be calculated).

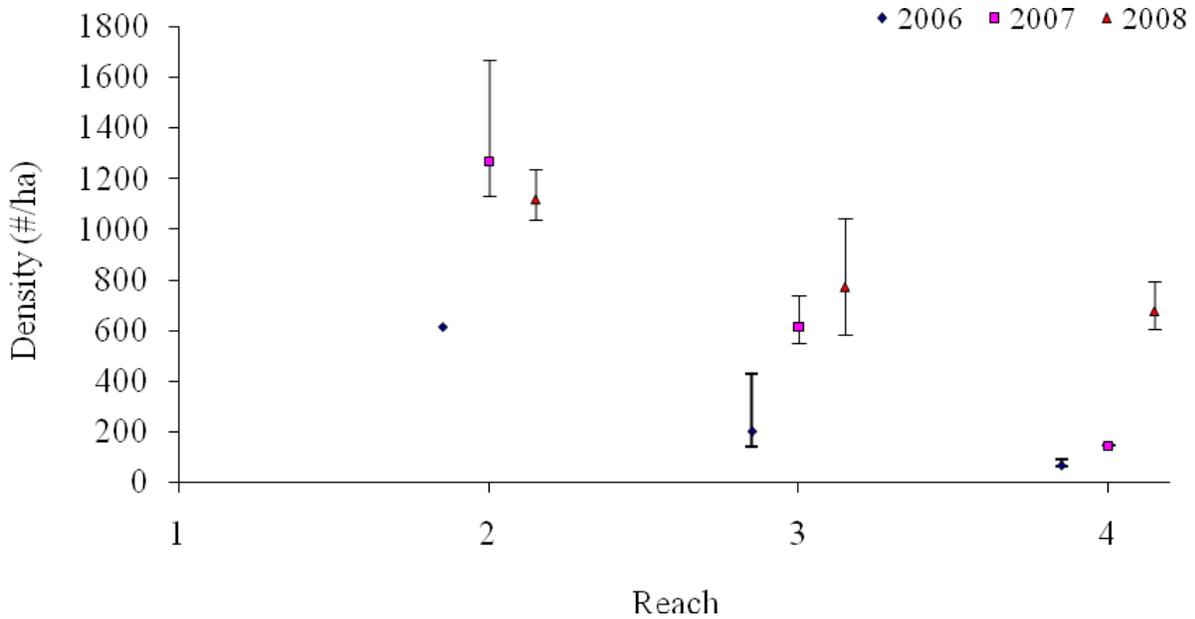


Figure 3. Comparison of 2006, 2007, and 2008 age-1+ brown trout biomass at reaches 2, 3, and 4 (95% confidence intervals included with lower confidence interval set equal to catch; electrofishing unit ran out of battery life after first pass in reach 2 during 2006, therefore no 95% confidence intervals could be calculated).

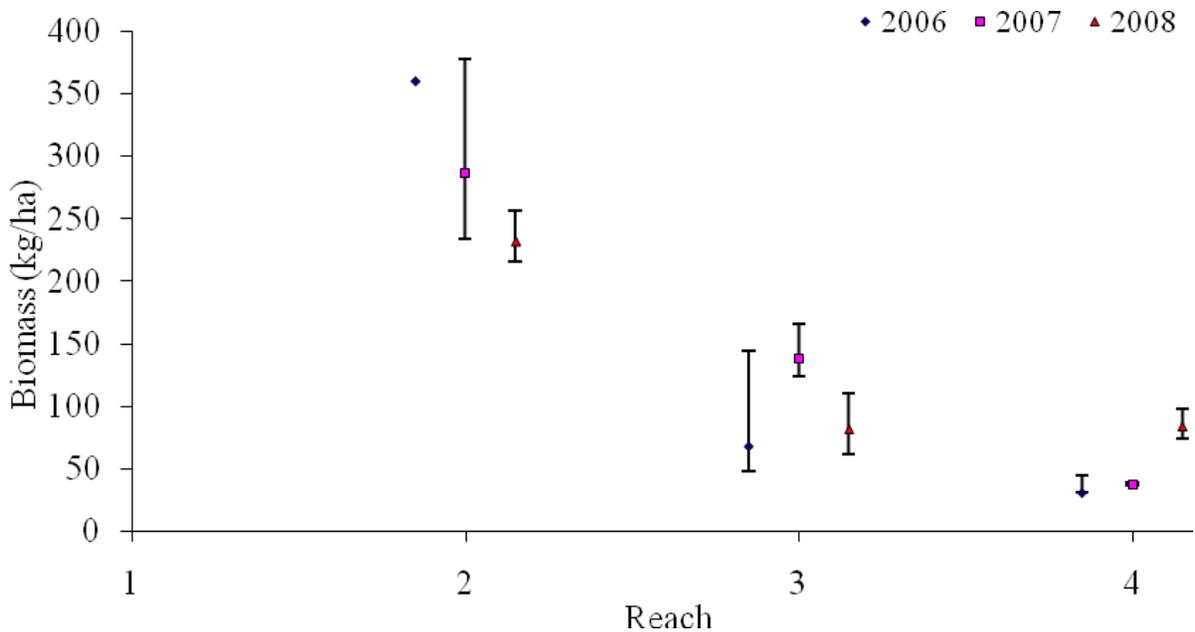


Figure 4. Length-frequency histogram for trout collected between habitat unit and population estimate sampling in Canyon Creek, May 6 – 13, 2008.

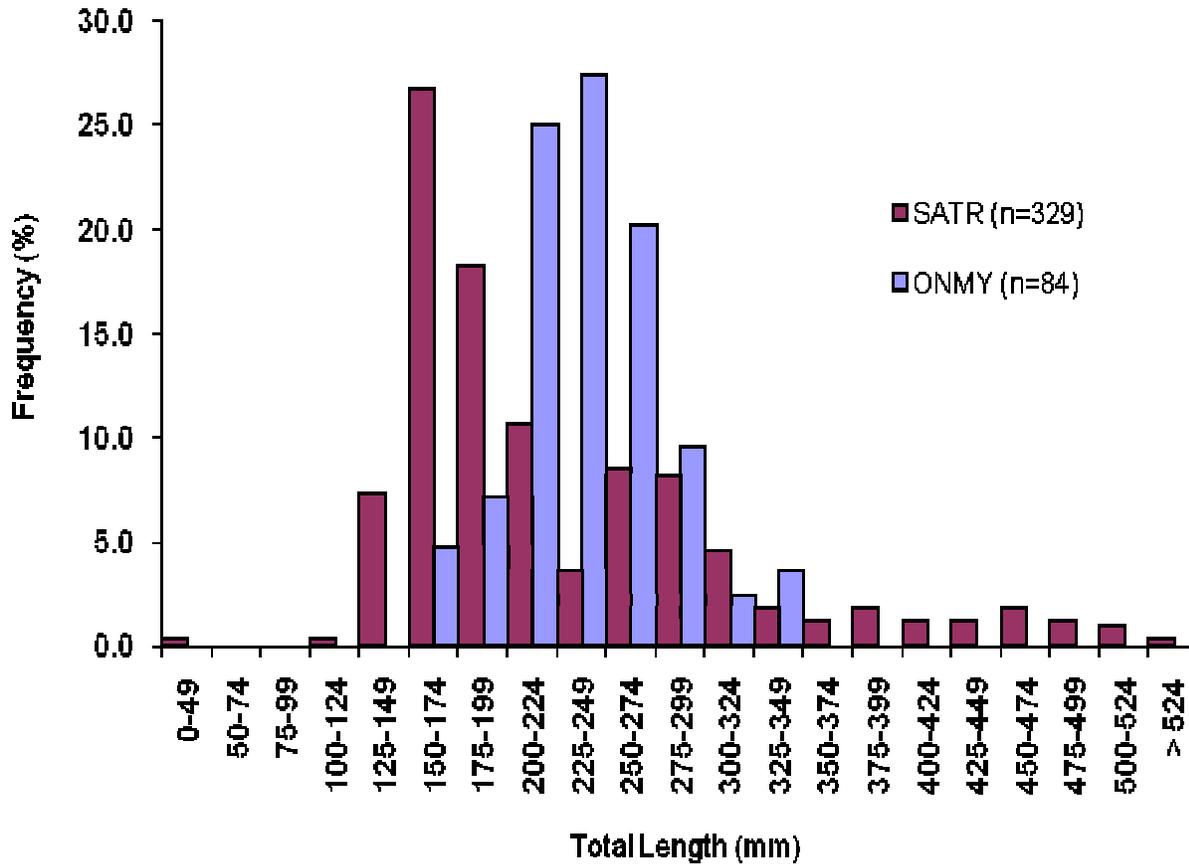


Table 1. Survey sampling site description and location, Canyon Creek, May 6 - 13, 2008.

Site Number and Habitat	Location	GPS Coord. (UTM NAD27)
1A – Riffle	Just above 1A photo sign	12S 0517115E 3794454N
1B – Pool	Pool below upper road crossing	12S 0517458E 3794261N
1C – Run	Just above 1C photo sign & below outfall	12S 0517532E 3794177N
2A – Riffle	At 2A photo sign	12S 0517879E 3793860N
2A – Pool	Just above low water crossing road	12S 0517860E 3793875N
2C – Run	50 yds. above old beaver dam above OW bridge	12S 0518169E 3792986N
3A – Run	Just below OW exclosure fence below bridge	12S 0518287E 3792813N
3A – Riffle	At 3A1 photo sign	12S 0518269E 3792834N
3C – Pool	Below 3C photo sign	12S 0518435E 3792333N
4A – Riffle	Below 4A photo sign	12S 0518508E 3792042N
4A – Run	About 50 yds. below 4A riffle site	12S 0518525E 3791870N
4B – Pool	Above 4B photo sign, large pool at bend	12S 0518532E 3791786N
5A – Pool	At 5A photo sign	12S 0518655E 3791125N
5A – Riffle	30 yds. below 5A site	12S 0518665E 3791064N
5A – Run	Immediately below 5A riffle site	12S 0518682E 3791046N
6A – Pool	Bedrock pool below 6A photo site at bend in stream	12S 0518816E 3790382N
6B – Riffle	50 yds. above 6B photo sign	12S 0518902E 3790153N
6B – Run	Upstream of 6B photo sign	12S 0518887E 3790117N
7C – Run	At 7C photo sign	12S 0519401E 3789041N
7C – Riffle	Immediately below 7C run site	12S 0519404E 3789030N
7C – Pool	Pool just below 7C photo sign	12S 0519408E 3789021N

Table 2. Habitat sites and average depths (mm) collected during fish surveys at Canyon Creek June 30 – July 1, 2004, July 6 – July 7, 2005, June 27 – June 28, 2006, June 20 – 21, 2007, and May 6 – 13, 2008.

<i>Location</i>	Habitat Type, Year Sampled, and Average Depth (mm)														
	Riffle					Run					Pool				
	2004	2005	2006	2007	2008	2004	2005	2006	2007	2008	2004	2005	2006	2007	2008
Reach 1	115	125	217	267	359	170	225	172	183	356	450	677	738	697	983
Reach 2	127	178	136	189	244	205	280	272	247	383	275	452	394	339	403
Reach 3	153	213	194	200	332	275	295	233	283	419	465	366	461	489	619
Reach 4	130	181	153	136	284	258	324	244	225	283	250	596	583	547	708
Reach 5	120	206	137	147	241	247	275	220	247	512	330	600	363	319	667
Reach 6	142	114	138	139	118	225	261	228	200	445	315	266	331	245	367
Reach 7	92	123	133	144	191	153	265	228	219	354	282	343	422	378	409
Average	126	163	158	175	253	219	275	228	229	393	338	471	470	431	594

Table 3. Water temperature, pH, and conductivity measurements taken during habitat sampling at Canyon Creek May 6 - 13, 2008.

Location	Temperature (°C)	pH	Conductivity (μS/cm)
1A Riffle	10.0	8.4	140
1B Pool	14.7	8.8	127
1C Run	12.3	8.5	116
2A Pool	12.9	8.8	124
2A Riffle	12.9	8.8	124
2C Run	15.2	9.1	142
3A Riffle	15.6	9.1	143
3A Run	15.8	9.1	140
3C Pool	16.8	8.9	178
4A Riffle	8.2	8.8	200
4B Run	8.2	8.8	200
4B Pool	8.2	8.8	200
5A Riffle	17.0	9.3	192
5A Pool	17.0	9.3	192
5A Run	17.0	9.3	192
6A Pool	17.5	9.5	182
6B Run	15.9	9.6	185
6B Riffle	15.9	9.6	185
7C Riffle	12.0	9.4	195
7C Run	12.0	9.4	195
7C Pool	12.0	9.4	195

[Species code: **ONMY**= Rainbow trout, **SATR**= Brown trout, **CACL**= Desert sucker, **RHOC**= Speckled dace]

Table 4. Total fish collected and relative abundance by species from habitat sampling at Canyon Creek by year.

Species	Number						Relative Abundance (%)						
	Year→	1998	2004	2005	2006	2007	2008	1998	2004	2005	2006	2007	2008
ONMY		48	46	68	106	105	75	9	21	12	6	5	6
SATR		175	15	33	70	123	121	34	7	6	4	6	11
CACL		106	3	61	423	461	260	21	1	10	23	24	23
RHOS		187	155	420	1227	1253	676	36	71	72	67	65	60
Trout only		223	61	101	176	228	196	43	28	18	10	12	17
TOTAL		516	219	582	1826	1942	1132	100	100	100	100	100	100

Table 5. Density and catch/unit effort (CPUE) from habitat sampling at Canyon Creek by year.

Species	Density (fish/ha)						CPUE (fish/EFU)						
	Year→	1998	2004	2005	2006	2007	2008	1998	2004	2005	2006	2007	2008
ONMY		295	381	513	783	752	442	5.5	4.9	5.8	8.0	9.5	4.9
SATR		1074	124	249	517	881	713	20.1	1.6	2.8	5.3	11.1	7.8
CACL		651	25	460	3126	3303	1533	12.2	0.3	5.2	31.8	41.8	16.9
RHOS		1148	1284	3166	9069	8979	3986	21.5	16.6	36.1	92.4	113.5	43.8
Trout only		1369	505	761	1301	1634	1156	25.7	6.5	8.6	13.3	20.7	12.7
TOTAL		3168	1814	4387	13496	13916	6674	59.4	23.4	50	137.5	176.0	73.4
Total area sampled (ha)		0.16	0.12	0.13	0.14	0.14	0.17						
Total EFU								8.69	9.34	11.65	13.28	11.04	15.42

Table 6. Length-frequency data by reach for rainbow trout collected during habitat sampling at Canyon Creek from May 6 - 13, 2008.

Length Range (mm)	Reach						
	1	2	3	4	5	6	7
0-99	0	0	0	0	0	0	0
100-149	0	0	0	0	0	0	0
150-199	4	6	0	0	0	0	0
200-249	24	16	0	0	1	0	0
250-299	12	5	0	0	2	1	0
300-349	0	0	0	1	2	1	0
350-399	0	0	0	0	0	0	0
400-449	0	0	0	0	0	0	0
450-499	0	0	0	0	0	0	0
500-549	0	0	0	0	0	0	0
550-600	0	0	0	0	0	0	0
Total	40	27	0	1	5	2	0

Table 7. Length-frequency data by reach for brown trout collected during habitat sampling at Canyon Creek from May 6 - 13, 2008.

Length Range (mm)	Reach						
	1	2	3	4	5	6	7
0-99	0	0	0	1	0	0	0
100-149	4	0	3	0	0	0	0
150-199	10	6	12	7	0	2	0
200-249	12	4	3	1	1	0	0
250-299	4	8	6	1	4	0	0
300-349	2	1	3	2	2	1	1
350-399	1	0	3	0	0	0	0
400-449	0	1	1	1	3	0	0
450-499	0	1	2	2	0	1	0
500-549	0	0	0	2	0	0	0
550-600	0	0	1	0	0	0	0
>600	0	0	1	0	0	0	0
Total	33	21	35	17	10	4	1

Table 8. Fish collections by reach, sample area, length, and fish densities in Canyon Creek May 6 – 13, 2008.

Reach	ONMY	SATR	CACL	RHOS	Area (m ²)	Length (m)	Density (fish/km)	Density (trout/km)	Density (fish/ha)	Density (trout/ha)
1	40	33	0	0	222.5	32.5	2246	2246	3281	3281
2	27	21	8	28	317.1	47.7	1761	1006	2649	1514
3	0	35	21	66	284.1	48.9	2495	716	4294	1232
4	1	17	36	52	195.1	34.6	3064	520	5434	923
5	5	10	55	204	198.4	55.5	4937	270	13810	756
6	2	4	36	146	243.4	43.2	4352	139	7725	247
7	0	1	104	180	196.5	49.4	5769	20	14502	51
Total	75	121	260	676	1657.1	311.8	3631	629	6831	1183

Table 9. Fish collections by reach, sample area, length, and fish densities in Canyon Creek June 20 – June 21, 2007.

Reach	ONMY	SATR	CACL	RHOS	Area (m ²)	Length (m)	Density (fish/km)	Density (trout/km)	Density (fish/ha)	Density (trout/ha)
1	62	47	0	0	172.5	39.2	2781	2781	6319	6319
2	22	17	9	23	118.8	27.5	2582	1418	5975	3282
3	5	22	16	91	146.0	35.4	3785	763	9177	1849
4	9	22	132	215	176.8	41.6	9087	745	21376	1753
5	7	15	99	424	318.4	65.3	8346	337	17117	691
6	0	0	61	216	182.3	53.2	5207	0	15193	0
7	0	0	144	284	280.7	68.2	6276	0	15249	0
Total	105	123	461	1253	1395.5	330.4	5878	690	13916	1634

Table 10. Fish collections by reach, sample area, length, and fish densities in Canyon Creek June 27 – June 28, 2006.

Reach	ONMY	SATR	CACL	RHOS	Area (m ²)	Length (m)	Density (fish/km)	Density (trout/km)	Density (fish/ha)	Density (trout/ha)
1	30	19	0	0	187.9	41.7	1175	1175	2607	2607
2	9	7	6	31	156.1	31.0	1710	516	3395	1025
3	9	35	40	184	178.7	35.2	7614	1250	14999	2463
4	16	8	94	253	200.9	43.2	8588	556	18467	1195
5	40	1	96	376	242.5	58.6	8754	700	21158	1691
6	1	0	62	217	106.1	31.7	8833	32	26392	94
7	1	0	125	166	270.4	55.5	5261	18	10800	37
Total	106	70	423	1227	1343	296.9	6150	593	13601	1311

Table 11. Fish collections by reach, sample area, length, and fish densities in Canyon Creek July 6 – July 7, 2005.

Reach	ONMY	SATR	CACL	RHOS	Area (m ²)	Length (m)	Density (fish/km)	Density (trout/km)	Density (fish/ha)	Density (trout/ha)
1	43	10	0	0	177.3	35.1	1510	1510	2989	2989
2	17	7	0	61	196.6	40.1	2120	599	4323	1221
3	0	12	0	76	229	39.5	2228	304	3843	524
4	0	0	3	27	136.2	39.6	758	0	2203	0
5	8	4	11	109	194.5	55.4	2383	217	6787	617
6	0	0	8	102	174.6	44.4	2477	0	6300	0
7	0	0	39	47	218.3	48.6	1770	0	3940	0
Total	68	33	61	420	1327	303	1923	334	4387	761

Table 12. Fish collections by reach, sample area, length, and fish densities in Canyon Creek June 30 – July 1, 2004 (young-of-the-year dace not reported).

Reach	ONMY	SATR	CACL	RHOS	Area (m ²)	Length (m)	Density (fish/km)	Density (trout/km)	Density (fish/ha)	Density (trout/ha)
1	39	13	0	0	98.3	20.1	2587	2587	5290	5290
2	5	2	1	62	187.3	33.0	2121	212	3737	374
3	2	0	1	70	132.7	28.9	2526	69	5501	151
4	0	0	0	10	197.6	45.0	222	0	506	0
5	0	0	0	6	158.7	45.2	133	0	378	0
6	0	0	1	7	163.3	52.1	154	0	490	0
7	0	0	0	0	269.5	56.0	0	0	0	0
Total	46	15	3	155	1207	280	781	218	1814	505

Table 13. Fish collections by reach, sample area, length, and fish densities in Canyon Creek July 28-30, 1998.

Reach	ONMY	SATR	CACL	RHOS	Area (m ²)	Length (m)	Density (fish/km)	Density (trout/km)	Density (fish/ha)	Density (trout/ha)
1	36	23	0	0	142	24.6	2398	2398	4155	4155
2	7	19	4	0	329	55.6	540	468	912	790
3	2	23	5	24	170	37.1	1456	674	3176	1471
4	2	47	21	21	237	55.6	1637	881	3840	2068
5	0	23	6	53	298	67.9	1208	339	2752	772
6	1	37	5	35	241	47.5	1642	800	3237	1577
7	0	3	65	54	203	45.7	2670	66	6010	148
Total	48	175	106	187	1629	334	1545	668	3168	1369

Table 14. Summary of fish collected, by habitat type, from Canyon Creek, May 6 – 13, 2008.

Species	No. Fish	Relative Abun. %	Mean Weight (g)	Mean Length (mm)	Length Range (mm)	Fish Density (fish/ha)
Runs (n=7)					Total area sampled = 593 m ²	
ONMY	6	1	154.0	232.5	174-300	101
CACL	82	18	52.2	158.4	44-213	1383
RHOS	335	74	2.7	71.2	34-109	5650
SATR	29	6	313.8	262.6	146-552	489
Total EFU =4.80		Trout/ha =590	Trout/EFU =7.3	Fish/ha =7623	Fish/EFU =94.1	
Pools (n=7)					Total area sampled = 690 m ²	
ONMY	66	16	152.4	234.0	163-330	956
CACL	125	30	76.3	173.9	114-215	1811
RHOS	149	36	4.4	71.8	37-98	2158
SATR	71	17	328.5	272.8	43-649	1028
Total EFU =6.74		Trout/ha =1985	Trout/EFU =20.3	Fish/ha =5954	Fish/EFU =61.0	
Riffles (n=7)					Total area sampled = 419 m ²	
ONMY	3	1	116.0	226.0	220-230	72
CACL	53	20	52.1	155.5	120-210	1264
RHOS	192	71	3.6	71.7	48-100	4578
SATR	21	8	120.7	203.2	129-365	501
Total EFU =3.87		Trout/ha =572	Trout/EFU =6.2	Fish/ha =6414	Fish/EFU =69.5	

Table 15. Summary of fish collected, by habitat type, from Canyon Creek, June 20- June 21, 2007.

Species	No. Fish	Relative Abun. %	Mean Weight (g)	Mean Length (mm)	Length Range (mm)	Fish Density (fish/ha)
Runs (n=7)					Total area sampled = 556 m ²	
ONMY	64	8	68.6	118.8	47-310	1151
CACL	188	23	77.6	160.8	69-265	3382
RHOS	539	67		70.4	50-97	9696
SATR	18	2	148.0	159.4	62-341	324
Total EFU =3.80		Trout/ha =1475	Trout/EFU =21.6	Fish/ha =14553	Fish/EFU =212.8	
Pools (n=7)					Total area sampled = 624 m ²	
ONMY	33	6	174.2	251.3	198-401	529
CACL	163	29	83.6	161.4	90-275	2612
RHOS	301	53		68.5	50-100	4824
SATR	67	12	221.6	224.5	56-458	1074
Total EFU =4.39		Trout/ha =1603	Trout/EFU =22.8	Fish/ha =9039	Fish/EFU =128.4	
Riffles (n=7)					Total area sampled = 334 m ²	
ONMY	8	1	186.5	250.9	192-300	239
CACL	110	19	74.2	168.5	115-210	3290
RHOS	413	73		71.4	55-95	12352
SATR	38	7	83.6	151.2	54-251	1136
Total EFU =2.83		Trout/ha =1376	Trout/EFU =16.2	Fish/ha =17017	Fish/EFU =200.8	

Table 16. Summary of fish collected, by habitat type, from Canyon Creek, June 27- June 28, 2006.

Species	No. Fish	Relative Abun. (%)	Mean Weight (g)	Mean Length (mm)	Length Range (mm)	Fish Density (fish/ha)
			Runs (n=7)		Total area sampled = 472 m ²	
ONMY	27	3.4	38	125	70-255	572
CACL	166	21.1	-	115	56-171	3516
RHOS	568	72.2	-	73	34-115	12030
SATR	26	3.3	23	86	62-311	551
Total EFU = 4.50		Trout/ha = 1123	Trout/EFU = 11.8	Fish/ha = 16669	Fish/EFU = 174.8	
			Pools (n=7)		Total area sampled = 575 m ²	
ONMY	48	8.9	172	215	81-385	835
CACL	186	34.6	-	128	51-261	3236
RHOS	288	53.6	-	60	46-86	5011
SATR	15	2.8	346	269	68-550	261
Total EFU = 5.42		Trout/ha = 1096	Trout/EFU = 11.6	Fish/ha = 9344	Fish/EFU = 99.1	
			Riffles (n=7)		Total area sampled = 296 m ²	
ONMY	31	6.2	43	115	70-340	1048
CACL	71	14.1	-	150	84-185	2401
RHOS	371	73.9	-	78	40-115	12547
SATR	29	5.8	91	160	64-355	981
Total EFU = 3.36		Trout/ha = 2029	Trout/EFU = 17.9	Fish/ha = 16977	Fish/EFU = 149.5	

Table 17. Summary of fish collected, by habitat type, from Canyon Creek, July 6- July 7, 2005.

Species	No. Fish	Relative Abun. (%)	Mean Weight (g)	Mean Length (mm)	Length Range (mm)	Fish Density (fish/ha)
			Runs (n=7)		Total area sampled = 406 m ²	
ONMY	26	10	-	148	52-336	640
CACL	13	5	85	173	125-221	320
RHOS	208	78	-	72	52-115	5118
SATR	10	7	215	247	180-440	246
Total EFU= 4.24 Trout/ha = 886 Trout/EFU= 8.5 Fish/ha = 6324 Fish/EFU= 63.0						
			Pools (n=7)		Total area sampled = 548 m ²	
ONMY	38	30	364	262	150-350	694
CACL	33	26	418	125	85-234	603
RHOS	36	29	-	44	13-101	657
SATR	19	15	36	280	190-440	347
Total EFU= 3.76 Trout/ha = 1041 Trout/EFU= 15.2 Fish/ha = 2301 Fish/EFU= 33.5						
			Riffles (n=7)		Total area sampled = 373 m ²	
ONMY	4	2	-	185	58-310	107
CACL	15	7	-	140	140	402
RHOS	181	89	4	68	55-100	4853
SATR	4	2	56	176	160-196	107
Total EFU= 3.64 Trout/ha = 214 Trout/EFU= 2.2 Fish/ha = 5469 Fish/EFU = 56.0						

Table 18. Summary of fish collected, by habitat type, from Canyon Creek, June 30 - July 1, 2004.

Species	No. Fish	Relative Abun. (%)	Mean Weight (g)	Mean Length (mm)	Length Range (mm)	Fish Density (fish/ha)
Runs (n=7)						Total area sampled = 355 m ²
ONMY	4	3	-	179	155-200	113
CACL	1	1	-	190	190	28
RHOS	113	94	-	65	30-95	3183
SATR	2	2	-	247	215-280	56
Total EFU=3.41		Trout/ha = 169	Trout/EFU=1.8	Fish/ha = 3380	Fish/EFU=35.2	
Pools (n=7)						Total area sampled =552 m ²
ONMY	42	64	-	218	150-600	761
CACL	2	3	-	175	120-230	36
RHOS	14	21	-	70	40-100	254
SATR	8	12	-	81	75-85	145
Total EFU=3.13		Trout/ha = 906	Trout/EFU=16.0	Fish/ha = 1196	Fish/EFU=21.1	
Riffles (n=7)						Total area sampled = 300 m ²
ONMY	0	0	-	-	-	0
CACL	0	0	-	-	-	0
RHOS	28	85	-	77	38-98	933
SATR	5	15	-	67	28-162	167
Total EFU=2.79		Trout/ha = 167	Trout/EFU=1.8	Fish/ha = 1100	Fish/EFU=11.82	

Table 19. Summary of fish collected, by habitat type, from Canyon Creek, July 28 - 30, 1998.

Species	No. Fish	Relative Abun. (%)	Mean Weight (g)	Mean Length (mm)	Length Range (mm)	Fish Density (fish/ha)
Runs (n=8)						Total area sampled = 592 m ²
ONMY	34	13	127	210	55-275	574
CACL	73	27	89	-	33-230	1233
RHOS	79	30	4.4	-	45-108	1334
SATR	80	30	321	261	65-542	1351
Total EFU = 3.06		Trout/ha = 1925	Trout/EFU = 37.3	Fish/ha = 4492	Fish/EFU = 86.9	
Pools (n=8)						Total area sampled = 761 m ²
ONMY	13	11	357	274	175-605	171
CACL	12	10	90	197	32-229	158
RHOS	33	28	4.5	-	33-90	434
SATR	61	51	294	273	90-568	802
Total EFU = 3.75		Trout/ha = 973	Trout/EFU = 19.7	Fish/ha = 1565	Fish/EFU = 31.7	
Riffles (n=6)						Total area sampled = 268 m ²
ONMY	1	1	164	258	258	37
CACL	21	16	60	181	94-202	784
RHOS	75	57	13.5	-	26-91	2799
SATR	34	26	135	205	80-357	1269
Total EFU = 1.88		Trout/ha = 1306	Trout/EFU = 18.6	Fish/ha = 4889	Fish/EFU = 69.7	

Table 20. Population estimates for age-1+ brown trout and age-1+ trout (brown + rainbow) in Canyon Creek, May 6, 2008 (95% confidence intervals in parentheses with the lower confidence interval set equal to catch).

Age Group	Species	Reach		
		2	3	4
Age 1+				
	<u>SATR</u>			
	Density (#/ha)	1118 (1040, 1236)	772 (585, 1045)	675 (603, 795)
	Biomass (kg/ha)	231.3 (215.2, 255.9)	81.1 (61.5, 109.7)	83.4 (74.5, 98.2)
	<u>SATR + ONMY</u>			
	Density (#/ha)	1157 (1066, 1288)	815 (602, 1122)	746 (654, 889)
	Biomass (kg/ha)	237.0 (218.3, 264.0)	88.5 (65.4, 121.9)	102.0 (89.4, 121.5)