FENTON RIVER MACROINVERTEBRATE RE-COLONIZATION STUDY

2006 ANNUAL REPORT

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EXECUTIVE SUMMARY

- The Fenton River, located in Tolland and Windham counties, Connecticut, is a locally valuable ecological and recreational resource. Flowing adjacent to the University of Connecticut's Storrs campus for a portion of its length, an aquifer underneath the Fenton River serves as a water source for the University and local residents. In September 2005, when peak water demand coincided with severe drought conditions, flow ceased and the streambed dried in a 1/6-mile reach of the Fenton River adjacent to the University of Connecticut pumping well fields. Owing to concerns over the damage to the aquatic communities within the dried reach of river, the University of Connecticut initiated and contracted a study of re-colonization by macroinvertebrates of the dried river reach. The goal of the study was to determine what effect the drying of the reach of the Fenton River between September 5 and 15, 2005 had on the macroinvertebrate community and to assess re-colonization by macroinvertebrates of the reach subsequent to the event.

- Five reaches – two occurring within the dried reach, two occurring upriver of the dried reach (upriver reference reaches), and one occurring downriver of the dried reach (downriver reference reach) – were selected for this investigation. Macroinvertebrates were sampled from each of these reaches monthly (excepting March and April 2006) between September 2005 and November 2006. Data were examined for spatial and temporal patterns in macroinvertebrate community composition in the Fenton River with a focus on examining the data for differences in community composition among reaches inside and outside the dried section of river. Response variables included measures of community similarity (Jaccard Community Similarity Index and the Coefficient of Community Loss), measures of taxonomic richness (total richness and EPT richness), total macroinvertebrate abundance, and total EPT abundance (EPT = Ephemeroptera, Plecoptera, and Trichoptera, the scientific names for the mayfly, stonefly, and caddisfly insect orders, respectively).

- The results indicate that macroinvertebrate communities were significantly impaired in the dried reach immediately following the September 2005 drought. However, these impacts were relatively short-lived as they were effectively masked by the subsequent flooding that occurred in October 2005. This flood event equally, perhaps even more severely, disturbed the benthic fauna of the Fenton River and resulted in lower abundance and richness in the reaches that maintained surface flow during the September 2005 drought event.

- Data collected following the October 2005 flood showed a primary recovery period of approximately seven months (October through May), during which time community richness and abundance steadily increased and measures of community similarity converged. Communities inside and outside the dried reaches followed similar recovery trajectories. Total macroinvertebrate abundance, EPT abundance, and EPT taxonomic richness appeared to continue to increase into fall 2006, but at a much lower rate than during the initial seven-month recovery period.

- Despite the initially apparently devastating effects of these combined disturbance events on the macroinvertebrate communities of the Fenton River, this study demonstrated the resilience of these communities to such disturbances, as the communities appear to have largely recovered to pre-disturbance conditions, based on the shapes of recovery curves. Monitoring is presently scheduled to occur twice a year between 2007 and 2009. If no significant disturbances occur between the present and 2007 sampling events, we may gain an even better understanding of whether summer and fall 2006 Fenton River macroinvertebrate communities were fully recovered from the fall 2005 disturbance events. However, given the apparent degree to which recovery has already occurred, sampling for an additional two years beyond 2007 is not likely to shed any further light on the effects of the 2005 drought on the macroinvertebrate communities in the Fenton River.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACKNOWLEDGMENTS

This study was contracted to ABR, Inc. by the University of Connecticut. I am grateful to Dr. Jason Vokoun, Assistant Professor of Fisheries Management in the Department of Natural Resources Management and Engineering at the University of Connecticut, for developing the study design and sampling methodology for this project. Dr. Vokoun also collected the first five months of samples for the project. I would also like to thank Richard Miller, Director of Environmental Policy for the University of Connecticut, for his oversight of the project. Macroinvertebrate samples were sorted by ABR technicians Adam Harris and Nick Haxton.

INTRODUCTION

The Fenton River, located in Tolland and Windham counties, Connecticut, is a locally valuable ecological and recreational resource. Flowing adjacent to the University of Connecticut's Storrs campus for a portion of its length, an aquifer underneath the Fenton River serves as a water source for the University and local residents. In September 2005, when peak water demand coincided with severe drought conditions, flow ceased and the streambed dried in a 1/6-mile reach of the Fenton River adjacent to the University pumping well fields.

Owing to concerns over the damage to the aquatic communities within the dried reach of river, the University of Connecticut initiated and contracted a study of re-colonization by macroinvertebrates of the dried river reach. The goal of the study was to determine what effect the drying of the reach of the Fenton River between September 5 and 15, 2005 had on the macroinvertebrate community and to assess re-colonization by macroinvertebrates of the reach subsequent to the event. This document reports on results of the first year of study, September 2005 to November 2006.

METHODS

SAMPLE SITE SELECTION

Five reaches were selected for this study by Dr. Jason Vokoun, Assistant Professor in the Department of Natural Resources Management and Engineering, University of Connecticut (Table 1). Two reaches were established within the section of the Fenton River that ran dry (herein referred to as reaches 3 and 4). Two upriver reference reaches were established approximately 1.9 and 4.0 kilometers upriver (reaches 1 and 2) in reaches in which cessation of flow did not occur during the September 2005 drought. Additionally, one downriver reference reach (reach 5), which also remained flowing during the drought, was established approximately 3.6 kilometers downriver of the dried reach.

Reach Number	Reach Type	Location
1	Upriver reference	Adjacent to Eldridge Road above confluence with Eldridge Brook
2	Upriver reference	Old Turnpike Road crossing
3	Impacted by drought	U Conn. well field above well A
4	Impacted by drought	U Conn. well field below well A
5	Downriver reference	Along Chaffeeville Road approximately 1 km south of Wildwood Road intersection

Table 1. Reach number, treatment type, and location of five Fenton River reaches sampled between September 2005 and November 2006 to examine macroinvertebrate re-colonization following drying of a section of the river in September 2005.

FIELD AND LABORATORY METHODS

Field sampling followed protocols established by Dr. Jason Vokoun, who collected macroinvertebrate samples for the first five months of study (September 2005 through February 2006). Samples were collected monthly by ABR between May and November 2006. Sampling began in late September 2005, approximately two weeks following the drying event. The second sampling event occurred in late October 2005, approximately two weeks after a severe flood event occurred in the Fenton River. No sampling occurred in March or April 2006, but was otherwise performed monthly for the entire period between September 2005 and November 2006.

During each sampling event, four 1-m^2 samples were collected with a rectangular-frame, 500-µm kicknet from erosional habitats within each reach. An aluminum frame measuring 1 m^2 was placed on the river bottom at each sample replicate collection location and the area inside the frame was disturbed by hand to allow dislodged macroinvertebrates and debris to drift into the net. Once collected, samples were transferred into wide-mouth polyethylene bottles and preserved in 80% ethanol.

Macroinvertebrates were subsampled from the original field sample using a Caton, 30-square gridded tray to achieve a 500-organism (+/- 10%) subsample from each sample. First, the sample contents were evenly distributed over the entire tray area and then macroinvertebrates were removed from randomly-selected squares under 7X magnification until 500 macroinvertebrates were removed. Following subsampling, the remaining unsorted sample material was scanned for macroinvertebrates that were not encountered during subsampling (commonly referred to as a "large/rare" search).

All subsampled organisms were identified to genus or species (excepting oligochaetes and water mites, owing to their low abundance and diversity), depending on the taxonomic group and the maturity and condition of each specimen. All identification work was performed by ABR's project manager, Dr. Michael Cole. A reference collection of taxa identified for the project was assembled using material from project samples. Numerous taxonomic literature sources were consulted for this project and are listed at the end of this report.

DATA ANALYSIS

All raw taxonomic data were entered into Excel spreadsheets and crosschecked against paper copies of the data for errors and omissions before the data were analyzed. September 2005 through November 2006 data were examined for spatial and temporal patterns in macroinvertebrate community composition in the Fenton River with a focus on examining the data for differences in community composition among reaches inside and outside the dried section of river. Response variables included measures of community similarity, including the Jaccard Community Similarity Index and the Coefficient of Community Loss (Courtemanch and Davies 1987), measures of taxonomic richness (total richness and EPT richness), total macroinvertebrate abundance, and total EPT abundance (EPT = Ephemeroptera, Plecoptera, and Trichoptera, the scientific names for the mayfly, stonefly, and caddisfly insect orders, respectively). Differences in these attributes among reaches were examined using one-way ANOVAs ($n = 4$) and using $\alpha = 0.05$. Post-hoc multiple comparisons were performed using Tukey's test when equal variance occurred among treatments and using the nonparametric

Tamhane's T2 test when tests for unequal variances were significant. All statistics were run in SPSS version 11.5 (SPSS 2002).

RESULTS

ANALYSIS OF COMMUNITY ATTRIBUTES

TOTAL TAXONOMIC RICHNESS

Total taxonomic richness (the total number of taxa collectively represented by the four replicate samples collected from each reach on each date) was lower in the dried reaches than in reference reaches following the September 2005 drought (Figure 1). Total richness in reaches 3 and 4 (the dried reaches) was 17 and 19 taxa, respectively, compared to 45, 45, and 70 taxa in reaches 1, 2, and 5, respectively (Figure 1). Total taxonomic richness was reduced in reference reaches 1, 2, and 5 following the October 2005 flood, resulting in similar richness among all reaches (Figure 1). Richness increased between October and June in all reaches and has since leveled off up through the November 2006 sampling, as indicated in Figure 1.

MACROINVERTEBRATE ABUNDANCE

Macroinvertebrate abundance (the number of organisms per m^2, calculated as an average of the four replicates collected from each reach on each sample date) was lowest in reaches 3 and 4 following the drying of the river, but small sample sizes and large standard deviations resulted in low power of statistical tests (Figure 2, Appendix 1). Consequently, only the largest differences between reach 5 and all other reaches were statistically significant (Figure 2, Appendix 2).

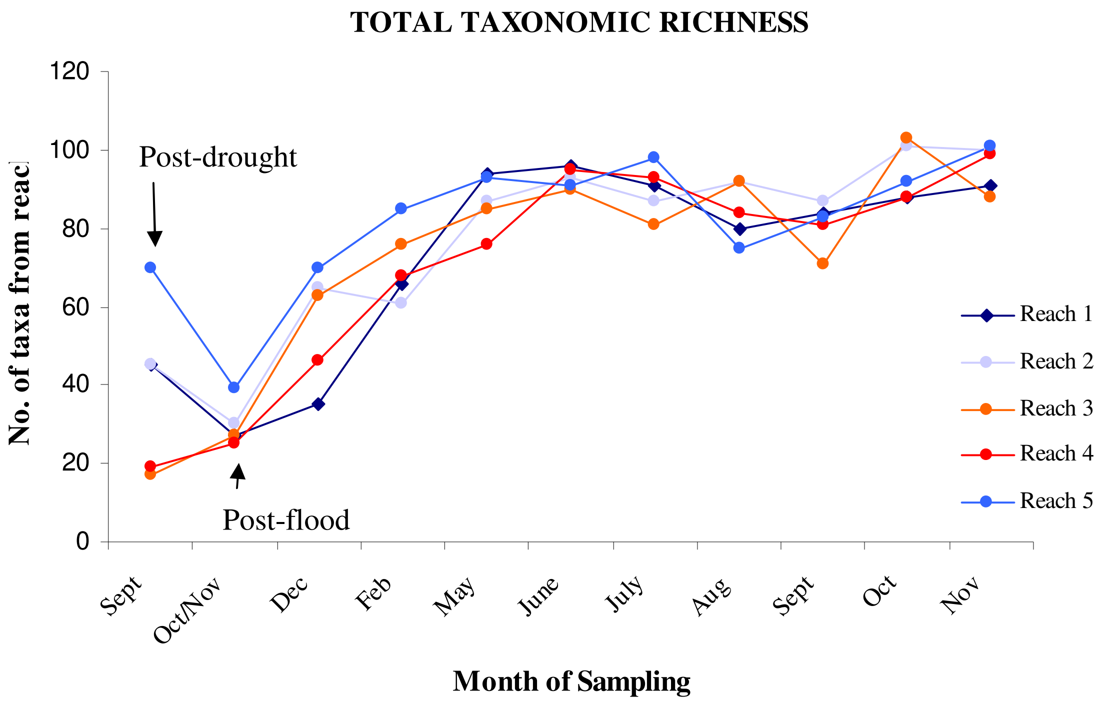


Figure 1. Total macroinvertebrate taxonomic richness of five Fenton River reaches sampled between September 2005 and November 2006. Total taxonomic richness was determined from the total number of taxa sampled in four replicate 1-m^2 kick samples from each reach on each sampling date.

Relative to the September 2005 results, abundance was most reduced in reference reaches 1 and 5 following the October 2005 flood, resulting in significant abundance differences between reach 2 and all other reaches (Appendix 2). Abundance in all reaches appears to have steadily increased between the fall 2005 disturbance events and fall 2006 (Figure 2). No significant differences in total abundance occurred between treatment and reference reaches from December 2005 to October 20006. Large variation in abundance among sample replicates likely contributed to the lack of significant differences during this time period (Figure 2). Abundance was significantly lower in the reference reach 2 than in reaches 3, 4, or 5 in November 2006 (Figure 2, Appendix 2).

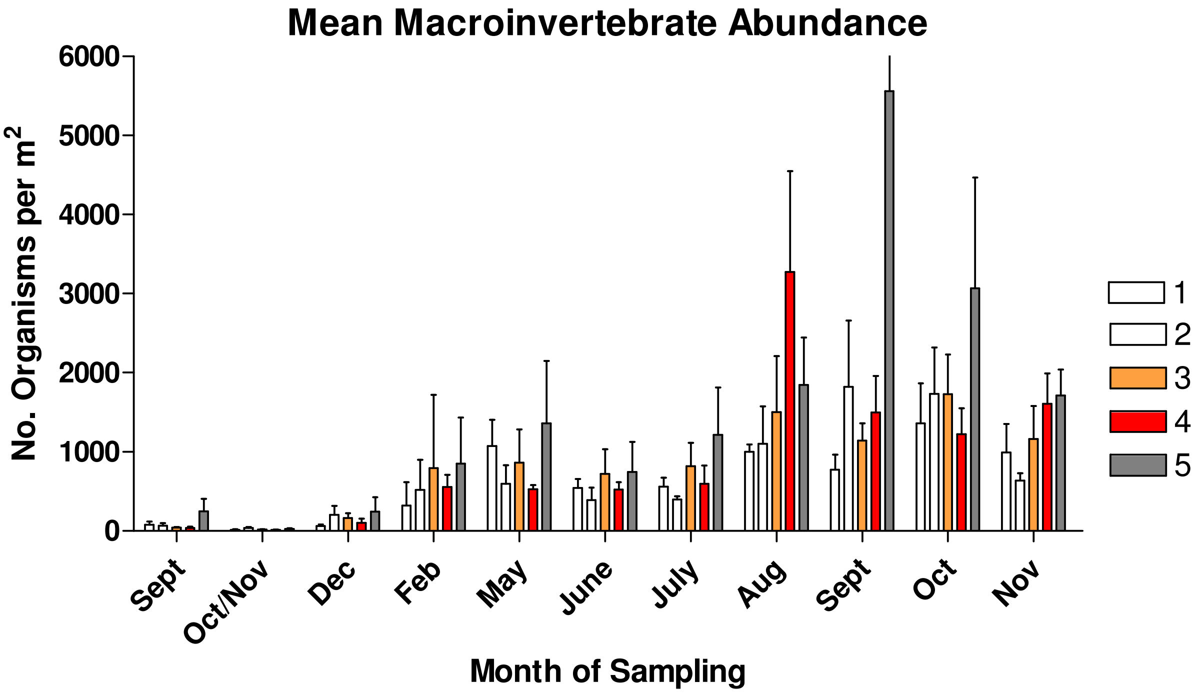


Figure 2. Mean (+SD, n = 4) macroinvertebrate abundance in five study reaches in the Fenton River, Connecticut between September 2005 and November 2006.

MEAN TAXONOMIC RICHNESS

Taxonomic richness (the average number of taxa occurring in each sample from each site, calculated as an average of the four replicates collected from each reach on each sample date) was lowest in reaches 3 and 4 following the drying of the river, but small sample sizes limited the power of statistical tests (Figure 3, Appendix 1). As a result, only the largest differences between reach 5 and the other four reaches were statistically significant, although richness in the dried reaches was half of that in the upriver reference reaches (Figure 3, Appendices 1 & 2).

Taxonomic richness was reduced in all three reference reaches following the October 2005 flood, resulting in similar numbers of taxa in all reaches in late October (no significant differences between treatment types). Pre- and post-flood richness was similar in the dried reaches, presumably because of the pre-existing stressed condition of the community following the drying of the river (Figure 3). Richness steadily increased from October through May in all reaches and then appears to have remained relatively stable though summer and fall 2006 (Figure 3).

Significant differences in taxonomic richness occurred between reaches in August, September, and October 2006 (Appendix 2); however, richness was significantly higher in the drought-effected reaches than in the reference reaches more frequently than it was significantly lower (Figure 3, Appendix 2), suggesting a lack of any longer-term drought effect on this community attribute.

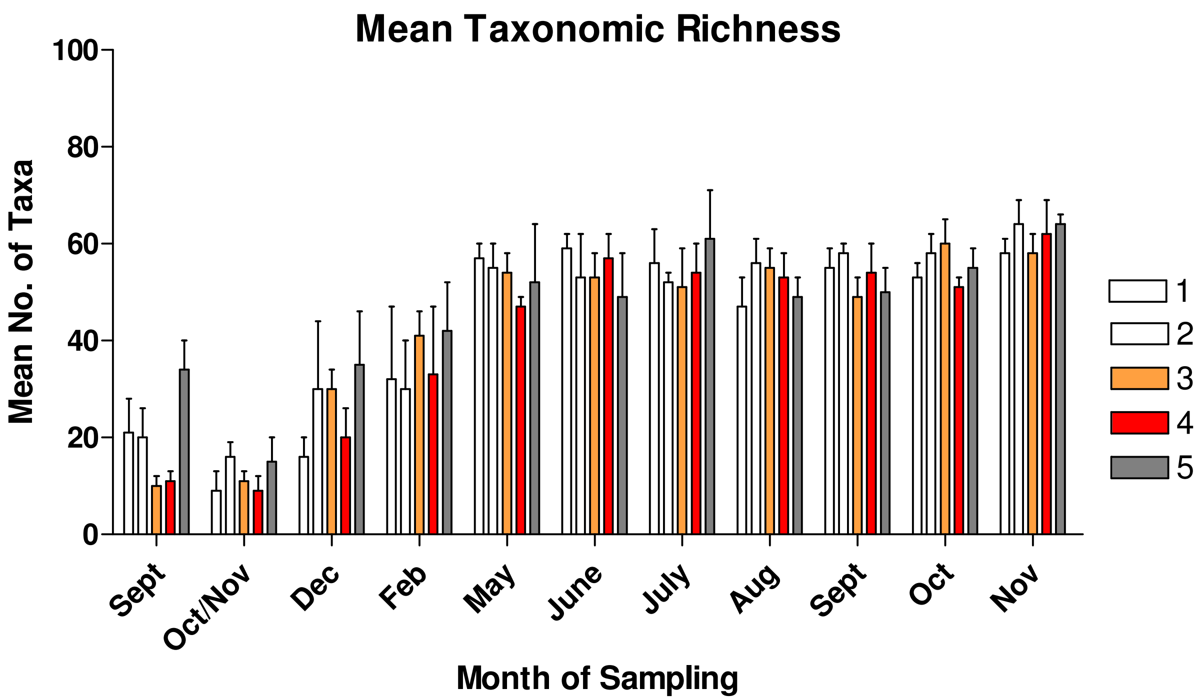


Figure 3. Mean (+SD, n = 4) taxonomic richness in five study reaches in the Fenton River, Connecticut between September 2005 and November 2006.

MEAN EPT RICHNESS

EPT taxonomic richness was lowest in reaches 3 and 4 immediately following the drying of the river, but small sample sizes reduced power of statistical tests (Figure 4, Appendices 1 & 2). Consequently, only the largest differences between reach 5 and reaches 3 and 4 were statistically significant, although average EPT richness in samples collected from the dried reaches was less than half of that from those collected from the upriver reference reaches (Figure 4, Appendix 1).

EPT taxonomic richness was reduced in reference reaches 1 and 5 following the October 2005 flood, resulting in the occurrence of similar numbers of taxa in all reaches in late October (no significant differences among treatments were detected). EPT taxonomic richness appears to have slightly increased in the dried reaches following the floods, potentially resulting from redistribution of organisms into reaches 3 and 4 during the high-water events (Figure 4, Appendix 1). EPT richness in all reference reaches increased between October 2005 and May 2006, while richness in the dried reaches appears to have been increasing from September 2005 into May 2006 (Figure 4).

EPT richness remained similar among all reaches between June and November 2006 (Figure 4, Appendices 1 & 2); few reach pairs showed significant differences in EPT richness and, of those, significant differences occurred between reference reaches as often as they did between reference and treatment reaches (Appendix 2).

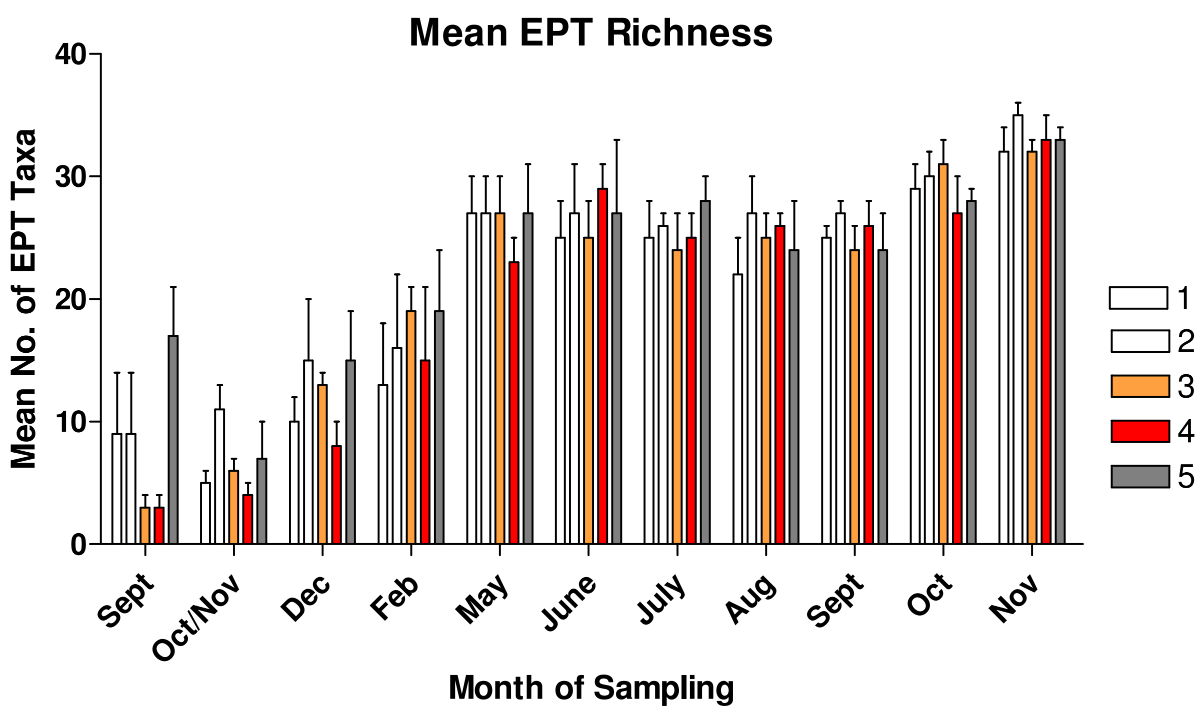


Figure 4. Mean (+SD, n = 4) EPT taxonomic richness in five study reaches in the Fenton River, Connecticut between September 2005 and November 2006.

MEAN EPT ABUNDANCE

EPT abundance appears to have been reduced in reaches 3 and 4 by the September 2005 drought, as the mean abundance in reaches 3 and 4 was 5 and 6 EPT organisms per m^2, respectively, versus 35, 36, and 122 per m^2 in the reference reaches (Figure 5, Appendix 1). However, statistical differences in EPT abundance did not occur among reaches following the September flood, likely because small sample sizes and large standard deviations resulted in low statistical power of tests (Appendices 1 & 2). In late October, EPT abundance was reduced in reaches 1 and 5 but was apparently minimally affected in reach 2 by the October 2005 flood, resulting in significant abundance differences between reach 2 and all other reaches.

EPT abundance steadily increased in all reaches from October 2005 through May 2006, and to a lesser extent, into fall 2006 (Figure 5). Large within-reach variation in EPT abundance occurred in the late-summer and early-fall months in some reaches, but significant differences still occurred between some reach pairs during this time (Figure 5, Appendices 1 & 2). These significant differences occurred almost as frequently between reference reaches as they did between treatment and reference reaches. Moreover, both treatment reaches had significantly higher EPT abundance than did reach 2 in November (Figure 5, Appendix 2).

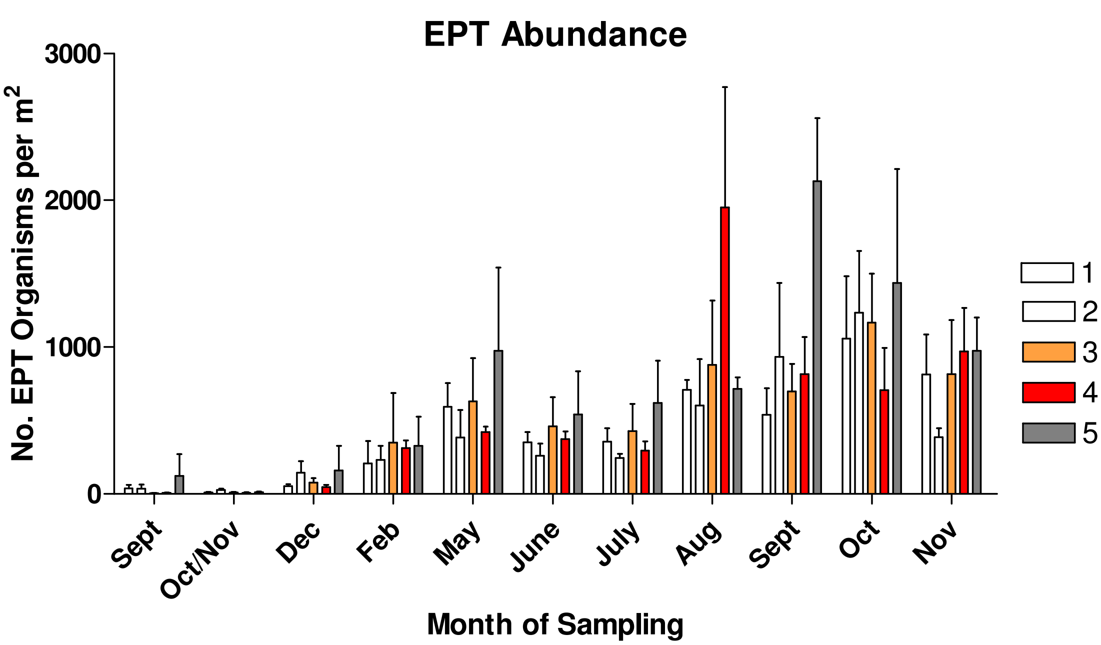
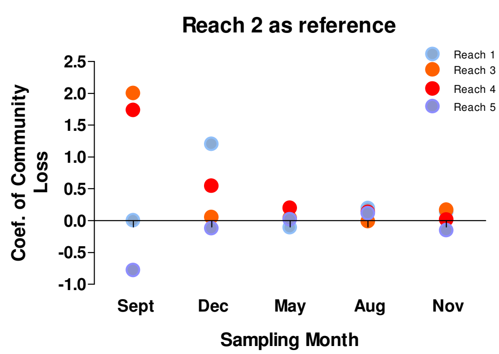


Figure 5. Mean (+SD, n = 4) EPT abundance in five study reaches in the Fenton River, Connecticut between September 2005 and November 2006.

MEASURES OF COMMUNITY SIMILARITY

Using reaches 2 and 5 as reference reaches, both the Coefficient of Community Loss (of which larger numbers indicate divergence of test community composition from that of the reference community) and the Jaccard Coefficient of Community Similarity (of which larger numbers indicate more similar communities) show a convergence of macroinvertebrate community conditions among the study reaches between September 2005 and May 2006 (Figures 6 and 7). Coefficients calculated from August and November 2006 data are similar to those calculated from May, suggesting that the communities have remained equally similar to each other through the summer and fall 2006 months and that the treatment-reach communities are no more dissimilar from the reference-reach communities than the reference-reach communities are from each other.



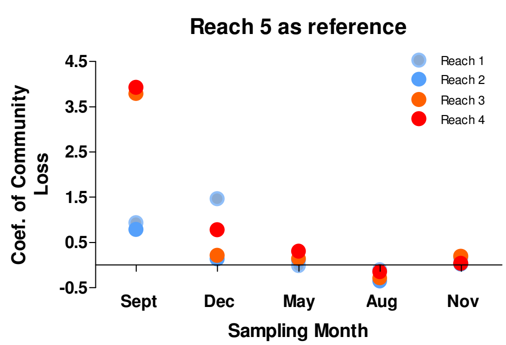


Figure 6. Coefficient of Community Loss of macroinvertebrate communities sampled from five study reaches in the Fenton River, Connecticut between September 2005 and November 2006. In the upper graph, reach 2 served as the reference community for all comparisons, while in the lower graph, reach 5 served as the reference reach.

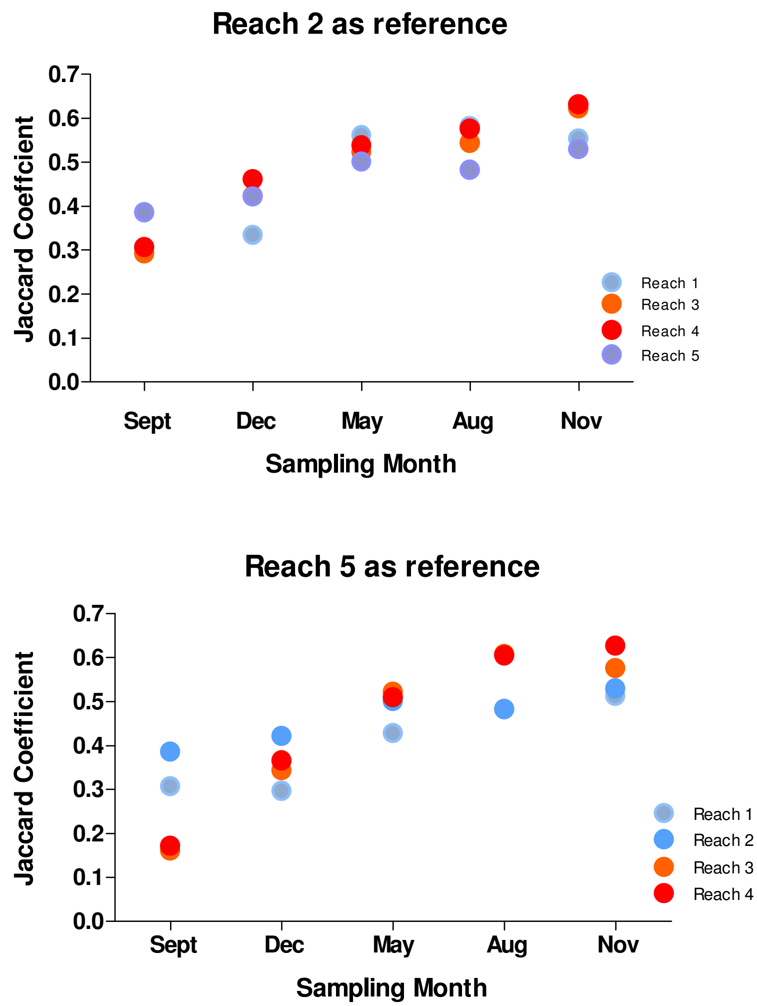


Figure 7. Jaccard Coefficient of Community Similarity of macroinvertebrate communities sampled from five study reaches in the Fenton River, Connecticut between September 2005 and November 2006. In the upper graph, reach 2 served as the reference community for all comparisons, while in the lower graph, reach 5 served as the reference reach.

DISCUSSION

This study represents an intensive sampling effort to characterize and document the recovery of the macroinvertebrate community in a reach of the Fenton River that dried up in September 2005. The results of this study suggest that macroinvertebrate communities were significantly impaired in the dried reach immediately following the September 2005 drought. However, these impacts were relatively short-lived as they were effectively masked by the subsequent flooding that occurred in October 2005. This flood event equally, perhaps even more severely, disturbed the benthic fauna of the Fenton River and resulted in measurably lower abundance and richness in the reaches that maintained surface flow during the September drought event.

Data collected following the October 2005 flood showed a primary recovery period of approximately seven months (October through May), during which time community richness and abundance steadily increased and measures of community similarity converged. Because no sampling occurred in March or April 2006, it should be noted that community attributes may have improved during those intervening months to levels measured in May 2006. Total macroinvertebrate abundance, EPT abundance, and EPT taxonomic richness appeared to continue to increase into fall 2006, but at a much lower rate than during the initial seven-month recovery period. It's not currently known whether the continued improvements in these attributes are related to further recovery from the October 2005 floods or result from regularly occurring seasonal changes to the macroinvertebrate community.

The recovery patterns measured in this study are consistent with those reported by others investigating the effects of floods on macroinvertebrate communities. The community richness recovery towards an asymptote, as evidenced in Figure 2 and, to a lesser extent in 4, is a pattern typical of post-flood recovery dynamics of macroinvertebrate communities (Minshall and Peterson (1985). Lake (2000) contends that while the resistance of aquatic communities to floods is low, their resilience (capacity to recover) is high. The rate of re-colonization is dictated by the timing, duration, and intensity of the disturbance; the extent of area disturbed; the availability of colonists; and the composition of the biota (Lake 2000). In the case of the events that occurred in the Fenton River in fall 2005, without pre-drying-event data it is difficult to precisely ascertain the relative effect of the drying of the river to that of the flood, but it is clear that the flood exerted its effect over a significantly larger spatial scale. Consequently, the major patterns of recovery measured in this study result primarily from the conditions created by the fall 2005 flood event. It has been noted that recovery from drought by invertebrates and fish takes more time than recovery from floods (Niemi et al. 1990); however, most studies examining the effects of drought on macroinvertebrate communities have examined recovery following drying of areas larger than single stream reaches measuring hundreds of meters and for periods lasting months to years, rather than less than two weeks (Lake 2000). Accordingly, even in the absence of the flood of October 2005, given the relatively small spatial and short temporal scales of the Fenton River drying event, re-colonization by downstream drift from the upriver portions that remained flowing would have likely served to result in similar, if not even more rapid, re-colonization rates to those observed.

Interestingly, an examination of the September 2005 data in the context of the entire data set spanning more than 13 months reveals that community conditions in the reference reaches were well below their seasonal optima in late September 2005, suggesting that although not dry, conditions in the reference reaches during or before the drought of September 2005 were sufficiently stressful to affect the benthic communities. Despite the effects of the drought on these reaches – and most notably of those on the dried reaches – the October floods had an even more pronounced effect at a larger scale. Despite the initially apparently devastating effects of these combined events on the macroinvertebrate communities of the Fenton River, this study demonstrated the resilience of these communities to such disturbances, as the communities appear to have largely recovered to pre-disturbance conditions, based on the shapes of recovery curves. Monitoring is presently scheduled to occur twice a year between 2007 and 2009. If no significant disturbances occur between the present and 2007 sampling events, we may gain an even better understanding of whether summer and fall 2006 Fenton River macroinvertebrate communities were fully recovered from the fall 2005 disturbance events. However, given the apparent degree to which recovery has already occurred, sampling for an additional two years beyond 2007 is not likely to shed any further light on the effects of the 2005 drought on the macroinvertebrate communities in the Fenton River.

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Appendix 1. Mean and standard deviation (n = 4) of total macroinvertebrate abundance, community richness, mayfly/stonefly/caddisfly (EPT) abundance, and EPT richness in five study reaches in the Fenton River, Connecticut between September 2005 and November 2006.

Total Macroinvertebrate Abundance

	Mean (SD)										
Reach	Sept '05	Oct/Nov '05	Dec '05	Feb '06	May '06	June '06	July '06	Aug '06	Sept '06	Oct '06	Nov '06
1	78 (39)	14 (7)	62 (20)	321 (292)	1075 (332)	541 (115)	557 (118)	1003 (92)	775 (187)	1361 (504)	990 (364)
2	66 (32)	39 (9)	203 (111)	518 (380)	594 (237)	391 (156)	399 (37)	1100 (473)	1821 (838)	1735 (583)	633 (96)
3	40 (8)	19 (3)	163 (58)	793 (927)	863 (417)	722 (312)	819 (296)	1501 (709)	1141 (219)	1729 (501)	1160 (416)
4	36 (17)	12 (5)	101 (53)	554 (154)	526 (50)	521 (92)	595 (232)	3273 (1277)	1497 (461)	1221 (329)	1604 (384)
5	246 (161)	24 (8)	243 (184)	849 (586)	1363 (787)	745 (379)	1214 (598	1845 (602)	5563 (1360)	3071 (1400)	1713 (328)

Community Richness

	Mean (SD)										
Reach	Sept '05	Oct/Nov '05	Dec '05	Feb '06	May '06	June '06	July '06	Aug '06	Sept '06	Oct '06	Nov '06
1	21 (7)	9 (4)	16 (4)	32 (15)	56 (2)	59 (3)	56 (7)	47 (6)	55 (4)	53 (3)	58 (3)
2	20 (6)	16 (3)	30 (14)	30 (10)	55 (5)	52 (9)	52 (2)	56 (5)	58 (2)	58 (4)	64 (5)
3	10 (2)	11 (2)	30 (4)	41 (5)	54 (4)	53 (5)	51 (8)	55 (4)	49 (4)	60 (5)	58 (4)
4	11 (2)	9 (3)	20 (6)	33 (14)	47 (2)	57 (5)	54 (6)	53 (5)	54 (6)	51 (2)	62 (7)
5	34 (6)	15 (5)	35 (11)	42 (10)	52 (12)	49 (9)	61 (10)	49 (4)	50 (5)	55 (4)	64 (2)

Appendix 1. (Continued)

EPT Abundance

Reach	Mean (SD)										
	Sept '05	Oct/Nov '05	Dec '05	Feb '06	May '06	June '06	July '06	Aug '06	Sept '06	Oct '06	Nov '06
1	36 (27)	8 (5)	52 (14)	209 (151)	593 (161)	352 (68)	357 (90)	708 (69)	539 (182)	1058 (425)	814 (273)
2	35 (30)	27 (8)	145 (77)	232 (97)	385 (188)	260 (82)	244 (29)	603 (315)	935 (501)	1234 (420)	387 (60)
3	5 (2)	9 (3)	77 (30)	349 (338)	631 (294)	461 (198)	428 (185)	879 (437)	698 (189)	1166 (335)	817 (367)
4	6 (3)	6 (4)	47 (15)	312 (52)	420 (39)	373 (54)	294 (65)	1950 (821)	816 (253)	706 (288)	970 (297)
5	122 (149)	11 (6)	161 (166)	329 (198)	975 (568)	540 (295)	618 (288)	717 (77)	2130 (431)	1436 (776)	975 (227)

EPT Richness

Reach	Mean (SD)										
	Sept '05	Oct/Nov '05	Dec '05	Feb '06	May '06	June '06	July '06	Aug '06	Sept '06	Oct '06	Nov '06
1	9 (5)	5 (1)	10 (2)	13 (5)	27 (3)	25 (3)	25 (3)	22 (3)	25 (1)	29 (2)	32 (2)
2	9 (5)	11 (2)	15 (5)	16 (6)	27 (3)	27 (4)	26 (1)	27 (3)	27 (1)	30 (2)	35 (1)
3	3 (1)	6 (1)	13 (1)	19 (2)	27 (3)	25 (3)	24 (3)	25 (2)	24 (2)	31 (2)	32 (1)
4	3 (1)	4 (1)	8 (2)	15 (6)	23 (2)	29 (2)	25 (2)	26 (1)	26 (2)	27 (3)	33 (2)
5	17 (4)	7 (3)	15 (4)	19 (5)	27 (4)	27 (6)	28 (2)	24 (4)	24 (3)	28 (1)	33 (1)

Appendix 2. Significant results from post-hoc multiple comparisons of four macroinvertebrate community attributes (presented in separate tables) – total abundance, community richness, mayfly/stonefly/caddisfly (EPT) abundance, and EPT richness – calculated from kick-samples collected from five study reaches in the Fenton River, Connecticut between September 2005 and November 2006. Asterisks (*) denote p-values calculated from the nonparametric Tamhene's T2 multiple comparisons test. All other values reported were calculated using Tukey's LSD.

Total Abundance

Month/Year	Site Pair Comparison	p-value
Sept '05	1 vs. 5	0.045
Sept '05	2 vs.5	0.030
Sept '05	3 vs. 5	0.012
Sept '05	4 vs. 5	0.010
Oct/Nov '05	1 vs. 2	0.001
Oct/Nov '05	3 vs. 2	0.005
Oct/Nov '05	4 vs. 2	0.000
Oct/Nov '05	5 vs. 2	0.046
Nov '06	1 vs. 4	0.021
Nov '06	1 vs. 5	0.008
Nov '06	2 vs. 3	0.043
Nov '06	2 vs. 4	0.001
Nov '06	2 vs. 5	<0.001

Appendix 2. (Continued.)

Total Richness

Month/Year	Comparison Pair	p-value
Sept ‘05	1 vs. 5	0.018
Sept ‘05	2 vs. 5	0.016
Sept ‘05	3 vs. 5	0.000
Sept ‘05	4 vs. 5	0.000
Dec ‘05	1 vs. 5	0.045
Aug ‘06	1 vs. 2	0.013
Aug ‘06	1 vs. 3	0.029
Aug ‘06	2 vs. 5	0.045
Sept ‘06	2 vs. 3	0.013
Sept ‘06	2 vs. 5	0.021
Oct ‘06	1 vs. 3	0.016
Oct ‘06	2 vs. 4	0.011
Oct ‘06	3 vs. 4	0.002
Oct ‘06	3 vs. 5	0.042

Appendix 2. (Continued)

EPT Richness

Month/Year	Comparison Pair	p-value
Sept ‘05	3 vs. 5	0.000
Sept ‘05	4 vs. 5	0.001
Oct/Nov ‘05	1 vs. 2	0.010
Oct/Nov ‘05	3 vs. 2	0.021
Oct/Nov ‘05	4 vs. 2	0.002
Dec ‘05	2 vs. 4	0.028
Dec ‘05	5 vs. 4	0.035
Jul ‘06	3 vs. 5	0.048
Aug ‘06	1 vs. 2	0.018
Aug ‘06	1 vs. 4	0.039
Oct ‘06	3 vs. 4	0.014
Nov ‘06	2 vs. 5	0.039*

Appendix 2. (Continued)

EPT Abundance

Month/Year	Comparison Pair	p-value
Oct/Nov '05	1 vs. 2	0.002
Oct/Nov '05	3 vs. 2	0.003
Oct/Nov '05	4 vs. 2	0.001
Oct/Nov '05	5 vs. 2	0.006
Jul '06	1 vs. 5	0.037
Jul '06	2 vs. 5	0.005
Jul '06	4 vs. 5	0.012
Sept '06	1 vs. 5	0.023*
Sept '06	3 vs. 5	0.033*
Sept '06	4 vs. 5	0.036*
Oct '06	4 vs. 5	0.048
Nov '06	1 vs. 2	0.038
Nov '06	2 vs. 3	0.037
Nov '06	2 vs. 4	0.007
Nov '06	2 vs. 5	0.007