University of Connecticut
Office of the Vice President and Chief Operating Officer

Office of Environmental Policy

Richard A. Miller
Director

May 2, 2008

Betsey Wingfield, Bureau Chief
Bureau of Water Protection and Land Reuse
CT Department of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127

RE: FENTON RIVER MACROINVERTEBRATE RECOLONIZATION STUDY
2007 ANNUAL REPORT

Dear Ms. Wingfield:

I have enclosed the second annual report on the on-going Fenton River Macroinvertebrate Recolonization Study. Macroinvertebrates in the portions of the Fenton River along, up-stream, and down-stream of our wellfield have been monitored since the drought and subsequent flooding in 2005. The results are very encouraging. We saw an increase in population and diversity in 2006 followed by a consistent seasonal trend in 2007. These findings support a significant recovery of the macroinvertebrate community since the disturbance events.

Please contact me or Jason Coite, Environmental Compliance Analyst, at 860-486-9305 if you have any questions

Very truly yours,

Richard Miller

Enclosure

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Bill Hyatt, CT DEP (email)
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FENTON RIVER MACROINVERTEBRATE RE-COLONIZATION STUDY

2007 ANNUAL REPORT

MICHAEL B. COLE

Prepared for

UNIVERSITY OF CONNECTICUT
Storrs, Connecticut

Prepared by

ABR, INC.—ENVIRONMENTAL RESEARCH & SERVICES
Greenfield, Massachusetts

April 2008

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2007 ANNUAL REPORT

Prepared for

University of Connecticut
Office of Environmental Policy
31 Ledoyt Road, Unit 3055
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By

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April 2008

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 the local community. 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.

- Following the first macroinvertebrate sampling in September 2005, a flood event occurred in the Fenton River with flows peaking on October 15. The first year of sampling following these two extreme hydrologic events (drought followed by flood) suggested that macroinvertebrate communities were severely affected in all study reaches following the 2005 flood event. However, significant recovery of benthic communities was occurring; by summer 2006, macroinvertebrate community richness and abundance curves leveled off, suggesting that much recovery occurred in the first seven months following the disturbance events. Sampling in 2007 aimed to determine whether community conditions would continue to improve from those measured in 2006 and what effect any other extreme hydrologic events would have on benthic communities to provide further context to the effects of the events of 2005. This report documents conditions measured in 2007, representing the 2nd year of investigation of recovery dynamics.

- 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 sampled in April and November 2007. 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, and for differences from conditions measured at the same time of year in the previous year. 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).

- 2007 results supported earlier findings that macroinvertebrate communities largely recovered in the months immediately following the disturbance events, as seasonal

conditions measured in 2007 remained very similar to those measured in 2006. Conditions measured in April 2007 were similar to those measured in May 2006, suggesting that the community had largely recovered from the disturbance events by late spring 2006. Interestingly, November 2007 conditions were slightly depressed relative to those measured in November 2006, suggesting that the severe low-flow conditions occurring throughout the region in late summer 2007 may have had a measurable effect on benthic community conditions. However, these effects were relatively minimal and equally affected reaches throughout the river, as November measures of community similarity indicated no divergence in community conditions among reaches relative to the previous several sampling periods.

- Despite the apparently devastating initial 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 recovered to pre-disturbance conditions based on the shapes of recovery curves. This recovery pattern was first evident following the 2006 sampling year. Similarity of the macroinvertebrate community conditions measured in 2007 to those measured in 2006 further establishes that recovery primarily occurred in the months immediately following the disturbances and that communities throughout the river have largely returned to their pre-disturbance levels of richness and abundance.

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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 and Jason Coite of the University of Connecticut, Office of Environmental Policy for their oversight of the project.

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. Following the first macroinvertebrate sampling event in September 2005, a flood event occurred in the Fenton River with flows peaking on October 15. The first year of sampling following these two extreme hydrologic events (drought followed by flood) suggested that macroinvertebrate communities were severely affected in all study reaches following the 2005 flood event (Cole 2007). However, significant recovery of benthic communities was occurring; by summer 2006, macroinvertebrate community richness and abundance curves leveled off, suggesting that much recovery occurred in the first seven months following the disturbance events. Sampling in 2007 aimed to determine whether community conditions would continue to improve from those measured in 2006 and what effect any other extreme hydrologic events would have on benthic communities to provide further context to the effects of the events of 2005. This document reports on results of the second year of study, including April and November 2007 sampling events.

METHODS

SAMPLE SITE SELECTION

Five reaches were selected in 2005 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 where 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 2007 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). In 2007, sampling occurred in April and November to assess current-year conditions relative to those observed in 2005 and 2006 (see Cole 2007 for details of 2005 and 2006 sampling logistics). The first 2007 sampling event occurred on April 25, 2007, nine days following a storm event that resulted in a mean daily discharge that was approximately half of that which occurred during the October 2005 flood. Sampling occurred at this time to determine what effect this smaller peak-flow event had on the benthic community relative to the 2005 flood event. Fall sampling occurred in late November following resumption of flows from summer lows to those that were conducive to sampling with a kick net.

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. Data from 2007 were examined relative to 2005 and 2006 data 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 similar among the five reaches in both April and November 2007, ranging between 93 and 104 in April, and between 80 and 88 in November (Figure 1). Total taxonomic richness averaged 98 taxa across all sites in April 2007, compared to 87 in May 2006. However, total taxonomic richness in November 2007 (mean = 84) was slightly lower than that measured in November 2006 (mean = 96).

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) in April 2007 was highest in reaches three and five; each of these reaches supported significantly higher numbers of macroinvertebrates than did reaches 1, 2, or 4 (Figure 2, Appendices 1 & 2). In November, total abundance ranged from 834 organsims/m^2 in reach 1 to 2,724 organsims/m^2 in reach 4. Reaches 4 and 5 supported significantly higher numbers of organisms than did reach 1 or 2 (Appendix 2). Macroinvertebrate abundance in reach 3 was also significantly higher than in reach 1. Relative to abundances measured in 2006, macroinvertebrate abundance did not measurably increase in 2007 (Figure 2).

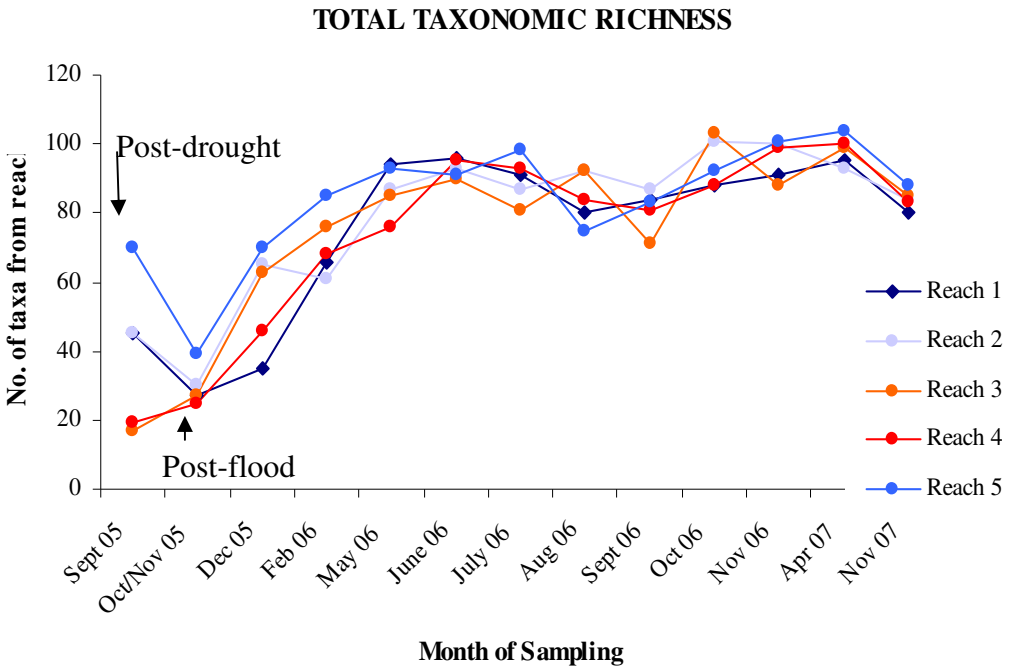

Figure 1. Total macroinvertebrate taxonomic richness of five Fenton River reaches sampled between September 2005 and November 2007. Total taxonomic richness was determined from the total number of taxa sampled in four replicate 1-m^2 kick samples from each reach on each sampling date.

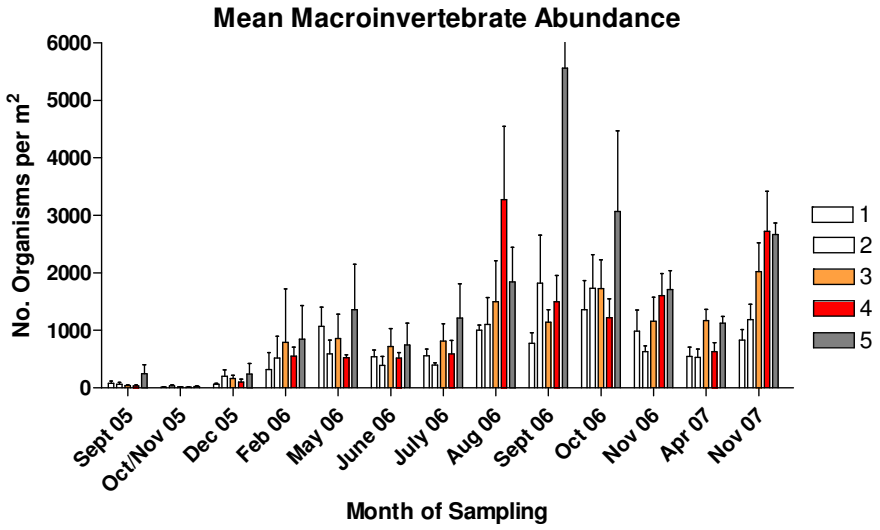

Figure 2. Mean (+SD, n = 4) macroinvertebrate abundance in five study reaches in the Fenton River, Connecticut between September 2005 and November 2007.

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 similar among the five reaches in both April and November 2007 (Figure 3, Appendices 1 & 2). April 2007 richness was slightly higher than was May 2006 richness, suggesting that recovery of some populations of macroinvertebrates may have occurred in that time; however, November 2007 richness was lower than November 2006 richness (Figure 3, Appendix 1). Low stream flows occurring throughout the region during late summer 2007 may explain the lower richness measured in November 2007 than in November 2006, but a lack of differences between reference (reaches 1, 2, and 5) and 2005-drought-affected reaches (reaches 3 and 4) suggests that any low-flow effect on invertebrates was independent of reach location relative to the 2005 drought-affected area.

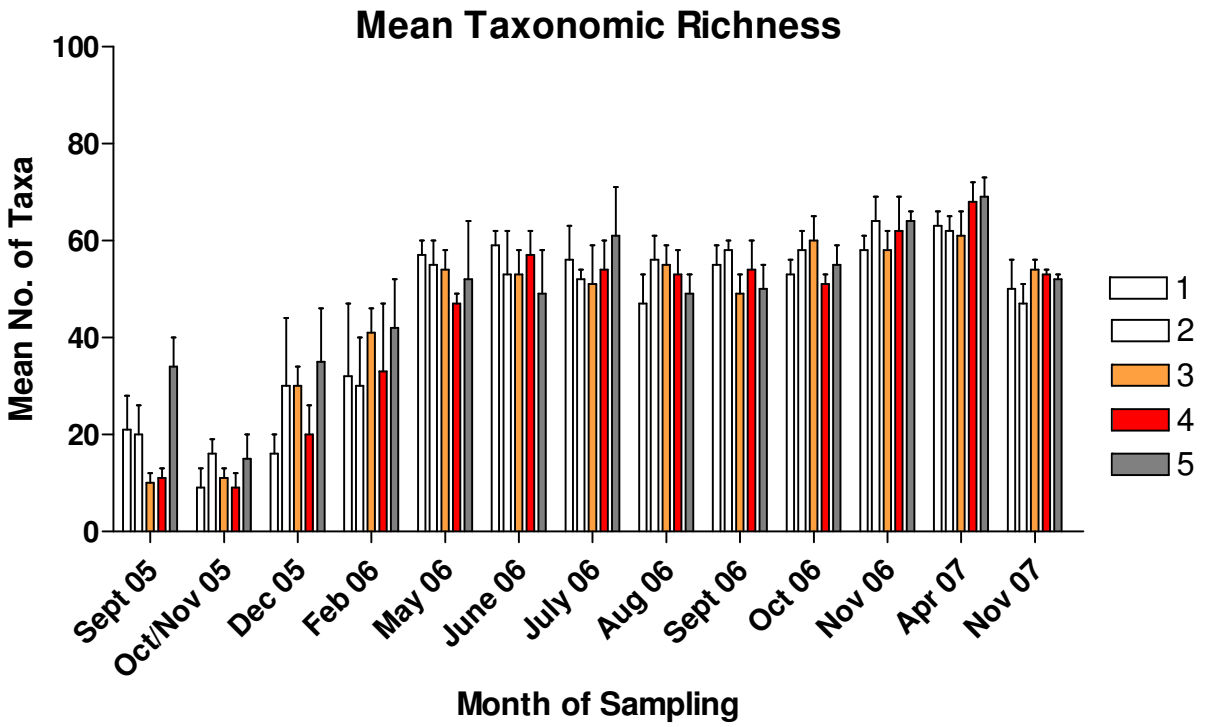

Figure 3. Mean (+SD, n = 4) taxonomic richness in five study reaches in the Fenton River, Connecticut between September 2005 and November 2007.

MEAN EPT RICHNESS

EPT taxonomic richness in April 2007 was higher in reach 4 than in reaches 1 or 3, while no significant differences occurred between any reaches in November 2007 (Figure 4, Appendices 1 & 2). Relative to spring (May) 2006, EPT richness in April 2007 was higher (Figure 4, Appendix 1); however, EPT richness was clearly lower in November 2007 compared to November 2006, again suggesting that low flows in late summer 2007 may have reduced abundance of some EPT taxa enough to result in lower richness estimates from samples collected throughout the river. A lack of significant differences among reaches in November 2007 suggests that any effect was independent of location relative to the 2005 drought-affected area.

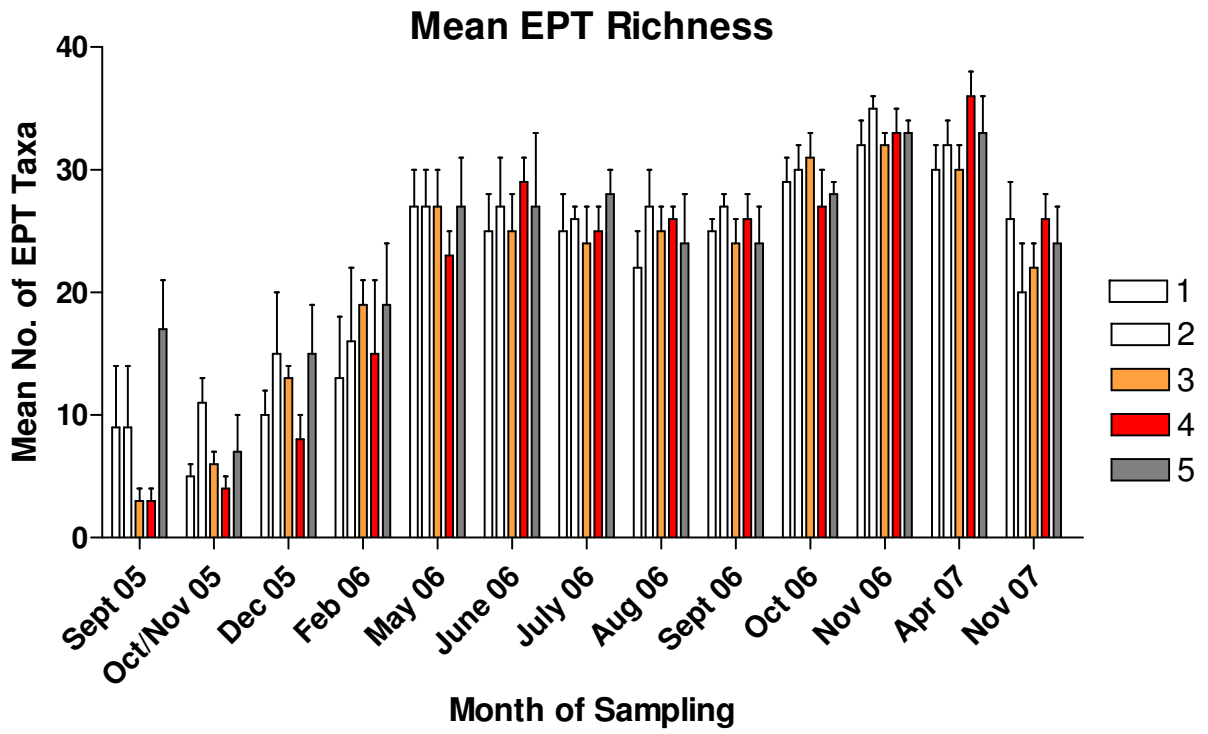

Figure 4. Mean (+SD, n = 4) EPT taxonomic richness in five study reaches in the Fenton River, Connecticut between September 2005 and November 2007.

MEAN EPT ABUNDANCE

In April 2007, EPT abundance was significantly higher in reaches 3 and 5 than in reaches 1, 2, or 4 (Figure 5, Appendices 1 & 2). In November 2007, EPT abundance was highest in reach 4 and lowest in reach 2. EPT abundance was significantly higher in reach 4 than in reaches 1 or 2 in November, but no other significant differences were found among reaches (Figure 5, Appendices 1 & 2). April and November 2007 EPT abundances were similar to May and November 2006 EPT abundances, respectively (Figure 5, Appendix 1).

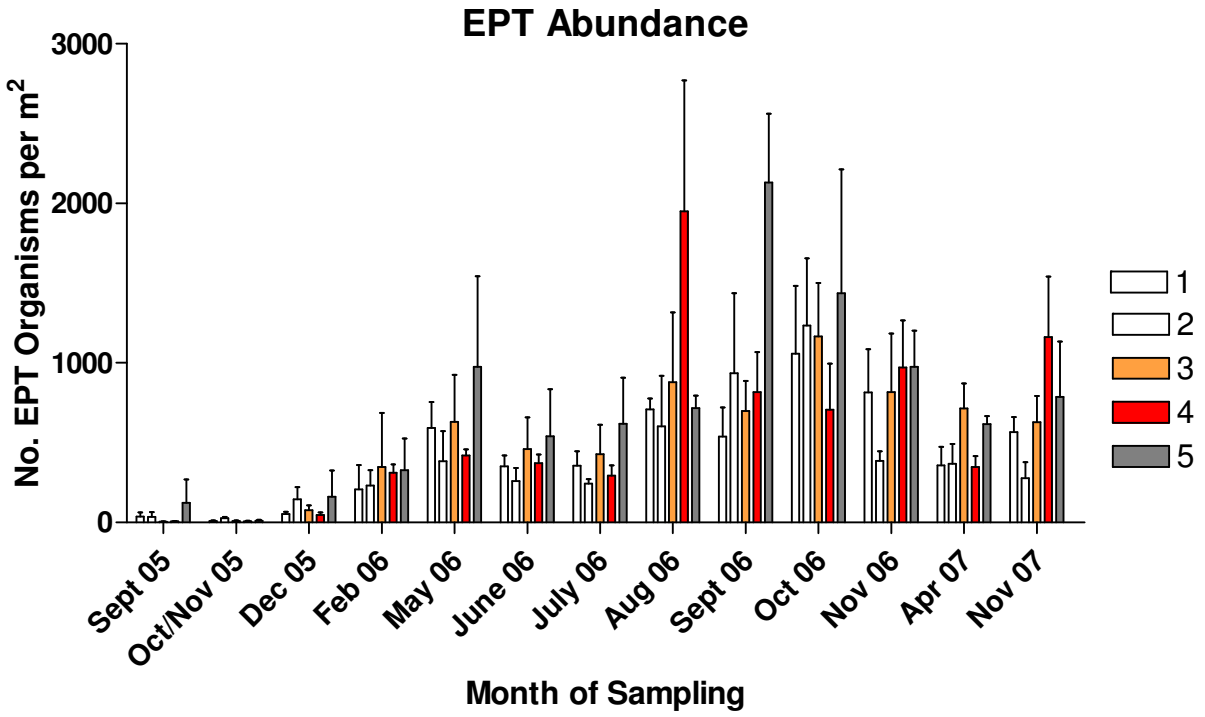

Figure 5. Mean (+SD, n = 4) EPT abundance in five study reaches in the Fenton River, Connecticut between September 2005 and November 2007.

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 2006 through November 2007 data are similar to those calculated from May 2006, suggesting that the communities have remained equally similar to each other from summer 2006 through fall 2007 and that the treatment-reach communities are no more dissimilar from the reference-reach communities than the reference-reach communities are from each other. In fact, Jaccard Coefficients suggest that the communities in reaches 3 and 4 are more similar to the downstream reference reach (reach 5) and the upstream reference reaches (reaches 1 and 2) than the upstream and downstream reaches are to each other (Figure 7). In the absence of a disturbance affect occurring only on the 2005-

drought-affected reaches, this pattern would be expected given the intermediate location of the 2005-drought-affected reaches relative to the reference reaches.

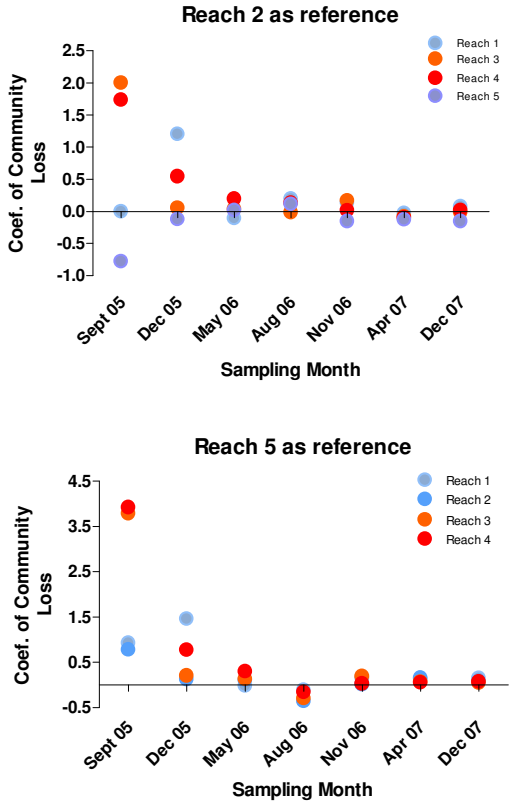

Figure 6. Coefficient of Community Loss of macroinvertebrate communities sampled from five study reaches in the Fenton River, Connecticut between September 2005 and November 2007. In the upper graph, reach 2 served as the reference community for all comparisons, while in the lower graph, reach 5 served as the reference reach.

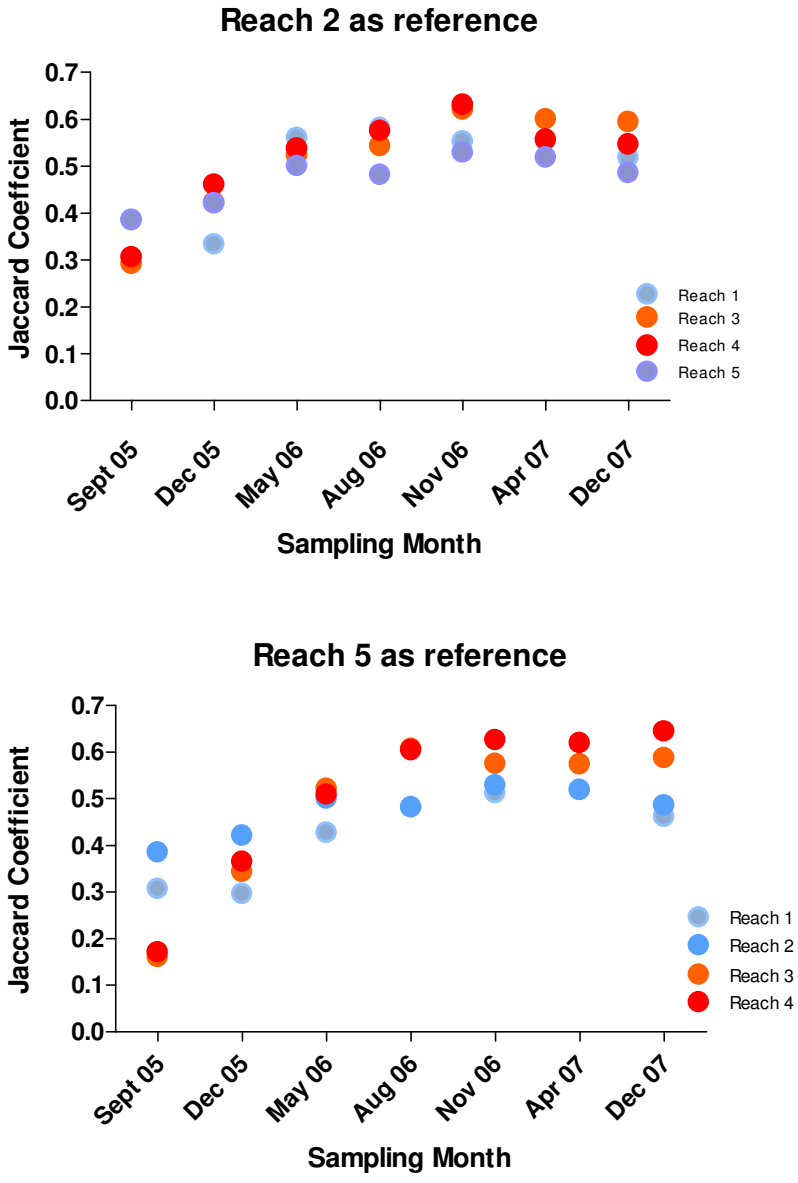

Figure 7. Jaccard Coefficient of Community Similarity of macroinvertebrate communities sampled from five study reaches in the Fenton River, Connecticut between September 2005 and November 2007. In the upper graph, reach 2 served as the reference community for all comparisons, while in the lower graph, reach 5 served as the reference reach.

DISCUSSION

This second year of sampling macroinvertebrate communities in the Fenton River occurred approximately one-and-a-half years (April 2007) and two years (November 2007) following two extreme hydrologic events: the drought of September 2005 and the flood of October 2005. Results from 2005 and 2006 suggested that macroinvertebrate communities were significantly impaired in the dried reach immediately following the September 2005 drought, but those impacts were relatively brief in duration as they were effectively masked by the subsequent flooding that occurred in October of that same year. Data collected through 2006 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. Data collected through the latter half of 2006 suggested that the recovery trajectory from these pulse disturbances started to flatten out (as determined both by measures of richness and abundance) by mid-year 2006.

Data collected in 2007 also suggest that recovery of the community primarily occurred in the months following the events, as 2007 seasonal conditions remained very similar to those measured in 2006. Conditions measured in April 2007 were similar to those measured in May 2006, suggesting that the community had largely recovered from the disturbance events by late spring 2006. April 2007 sampling occurred within nine days of a peak-flow event that was larger than any other following the October 2005 floods. Although no Fenton River discharge data are available for the October 2005 flood, data from the neighboring Mount Hope River suggest that the April 2007 flood (mean discharge on 4-25-07 = 1080 cfs) discharge was approximately half that which occurred during the October 2005 flood (mean discharge on 10-15-05 = 2080). In comparison to data collected following the October 2005 floods, the Fenton River macroinvertebrate community appeared to be minimally affected by the 2007 spring-time peak-flow conditions

Interestingly, November 2007 conditions were slightly depressed relative to those measured in November 2006, suggesting that the severe low-flow conditions occurring throughout the region in late summer 2007 may have measurably affected benthic community conditions. In spite of these low-flow conditions occurring in the Fenton River in late summer

and early fall 2007, no differences in macroinvertebrate community conditions were found between treatment and control reaches in November that would suggest that the treatment reaches experienced more severe hydrologic conditions than did the control reaches during the low-flow period. No water was pumped from the Fenton well field to the University of Connecticut water system from July 27, 2007 to January 10, 2008. Flows were low throughout the entire Fenton River drainage during late summer 2007; discharge at the USGS gage station at Old Turnpike Road was less than one cfs at times in August, September, and October. These conditions appear to have affected macroinvertebrate communities relatively minimally and equally throughout the river, as November measures of similarity indicated no divergence in community conditions among reaches relative to the previous several sampling periods.

The overall recovery patterns measured in this two-year 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 than those observed.

Despite the apparently devastating initial 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 recovered to pre-disturbance conditions based on the shapes of recovery curves. This recovery pattern was first evident following the 2006 sampling year. Similarity of the macroinvertebrate community conditions measured in 2007 to those measured in 2006 further establishes that recovery primarily occurred in the months immediately following the disturbances and that communities throughout the river have largely returned to their pre-disturbance levels of richness and abundance.

Additional monitoring may further elucidate any longer-term recovery of benthic communities, particularly that of organisms that require several years of larval development before reaching maturation. Continued study may also allow the effects of the 2005 drought and flood events to be further contextualized in relation to the severity of the disturbance events that occurred by continuing to sample following less extreme hydrologic events such as those that occurred in 2007. Despite the potential merits of continued investigation, it should be noted that these data from the past two years suggest that the most significant recovery period has passed and the macroinvertebrate communities of the Fenton River are likely very similar to those that occurred in the river prior to the 2005 disturbance events.

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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 2007.

Total 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	Apr '07	Nov '07
1	78 (39)	14 (7)	62 (20)	321 (292)	1075 (332)	541 (115)	557 (118)	1003 (92)	775 (187)	1361 (504)	990 (364)	548 (160)	834 (182)
2	66 (32)	39 (9)	203 (111)	518 (380)	594 (237)	391 (156)	399 (37)	1100 (473)	1821 (838)	1735 (583)	633 (96)	528 (146)	1188 (265)
3	40 (8)	19 (3)	163 (58)	793 (927)	863 (417)	722 (312)	819 (296)	1501 (709)	1141 (219)	1729 (501)	1160 (416)	1168 (198)	2023 (503)
4	36 (17)	12 (5)	101 (53)	554 (154)	526 (50)	521 (92)	595 (232)	3273 (1277)	1497 (461)	1221 (329)	1604 (384)	630 (157)	2724 (694)
5	246 (161)	24 (8)	243 (184)	849 (586)	1363 (787)	745 (379)	1214 (598)	1845 (602)	5563 (1360)	3071 (1400)	1713 (328)	1126 (117)	2665 (203)

Total 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	Apr '07	Nov '07
1	21 (7)	9 (4)	16 (4)	32 (15)	56 (2)	59 (3)	56 (7)	47 (6)	55 (4)	53 (3)	58 (3)	63 (3)	50 (6)
2	20 (6)	16 (3)	30 (14)	30 (10)	55 (5)	52 (9)	52 (2)	56 (5)	58 (2)	58 (4)	64 (5)	62 (3)	47 (4)
3	10 (2)	11 (2)	30 (4)	41 (5)	54 (4)	53 (5)	51 (8)	55 (4)	49 (4)	60 (5)	58 (4)	61 (5)	54 (2)
4	11 (2)	9 (3)	20 (6)	33 (14)	47 (2)	57 (5)	54 (6)	53 (5)	54 (6)	51 (2)	62 (7)	68 (4)	53 (1)
5	34 (6)	15 (5)	35 (11)	42 (10)	52 (12)	49 (9)	61 (10)	49 (4)	50 (5)	55 (4)	64 (2)	65 (5)	51 (1)

Appendix 1. (Continued)

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	Apr '07	Nov '07
1	9 (5)	5 (1)	10 (2)	13 (5)	27 (3)	25 (3)	25 (3)	22 (3)	25 (1)	29 (2)	32 (2)	30 (2)	26 (3)
2	9 (5)	11 (2)	15 (5)	16 (6)	27 (3)	27 (4)	26 (1)	27 (3)	27 (1)	30 (2)	35 (1)	32 (2)	20 (4)
3	3 (1)	6 (1)	13 (1)	19 (2)	27 (3)	25 (3)	24 (3)	25 (2)	24 (2)	31 (2)	32 (1)	30 (2)	22 (2)
4	3 (1)	4 (1)	8 (2)	15 (6)	23 (2)	29 (2)	25 (2)	26 (1)	26 (2)	27 (3)	33 (2)	36 (2)	26 (2)
5	17 (4)	7 (3)	15 (4)	19 (5)	27 (4)	27 (6)	28 (2)	24 (4)	24 (3)	28 (1)	33 (1)	33 (2)	24 (3)

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	Apr '07	Nov '07
1	36 (27)	8 (5)	52 (14)	209 (151)	593 (161)	352 (68)	357 (90)	708 (69)	539 (182)	1058 (425)	814 (273)	359 (116)	566 (95)
2	35 (30)	27 (8)	145 (77)	232 (97)	385 (188)	260 (82)	244 (29)	603 (315)	935 (501)	1234 (420)	387 (60)	368 (125)	278 (100)
3	5 (2)	9 (3)	77 (30)	349 (338)	631 (294)	461 (198)	428 (185)	879 (437)	698 (189)	1166 (335)	817 (367)	715 (156)	629 (164)
4	6 (3)	6 (4)	47 (15)	312 (52)	420 (39)	373 (54)	294 (65)	1950 (821)	816 (253)	706 (288)	970 (297)	349 (68)	1162 (379)
5	122 (149)	11 (6)	161 (166)	329 (198)	975 (568)	540 (295)	618 (288)	717 (77)	2130 (431)	1436 (776)	975 (227)	617 (50)	786 (348)

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 in April and November 2007. All values reported were calculated using Tukey's LSD.

Total Abundance

Month/Year	Comparison Pair	p-value
Apr '07	1 vs. 3	<0.001
Apr '07	1 vs. 5	0.001
Apr '07	2 vs. 3	<0.001
Apr '07	2 vs. 5	0.001
Apr '07	3 vs. 4	0.002
Apr '07	4 vs. 5	0.004
Nov '07	1 vs. 3	0.008
Nov '07	1 vs. 4	<0.001
Nov '07	1 vs. 5	<0.001
Nov '07	2 vs. 4	0.001
Nov '07	2 vs. 5	0.001

Total Richness

Month/Year	Comparison Pair	Significance level
No comparisons were significantly different in 2007		

Appendix 2. (Continued.)

EPT Richness

Month/Year	Comparison Pair	Significance level
Apr ‘07	1 vs. 4	0.006
Apr ‘07	3 vs. 4	0.012

EPT Abundance

Month/Year	Comparison Pair	Significance level
Apr ‘07	1 vs. 3	0.003
Apr ‘07	1 vs. 5	0.033
Apr ‘07	2 vs. 3	0.004
Apr ‘07	2 vs. 5	0.041
Apr ‘07	3 vs. 4	0.002
Apr ‘07	4 vs. 5	0.025
Nov ‘07	1 vs. 4	0.029
Nov ‘07	2 vs. 4	0.001

FENTON RIVER MACROINVERTEBRATE RE-COLONIZATION STUDY

2007 ANNUAL REPORT

Prepared for

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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 the local community. 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.

- Following the first macroinvertebrate sampling in September 2005, a flood event occurred in the Fenton River with flows peaking on October 15. The first year of sampling following these two extreme hydrologic events (drought followed by flood) suggested that macroinvertebrate communities were severely affected in all study reaches following the 2005 flood event. However, significant recovery of benthic communities was occurring; by summer 2006, macroinvertebrate community richness and abundance curves leveled off, suggesting that much recovery occurred in the first seven months following the disturbance events. Sampling in 2007 aimed to determine whether community conditions would continue to improve from those measured in 2006 and what effect any other extreme hydrologic events would have on benthic communities to provide further context to the effects of the events of 2005. This report documents conditions measured in 2007, representing the 2nd year of investigation of recovery dynamics.

- 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 sampled in April and November 2007. 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, and for differences from conditions measured at the same time of year in the previous year. 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).

- 2007 results supported earlier findings that macroinvertebrate communities largely recovered in the months immediately following the disturbance events, as seasonal

conditions measured in 2007 remained very similar to those measured in 2006. Conditions measured in April 2007 were similar to those measured in May 2006, suggesting that the community had largely recovered from the disturbance events by late spring 2006. Interestingly, November 2007 conditions were slightly depressed relative to those measured in November 2006, suggesting that the severe low-flow conditions occurring throughout the region in late summer 2007 may have had a measurable effect on benthic community conditions. However, these effects were relatively minimal and equally affected reaches throughout the river, as November measures of community similarity indicated no divergence in community conditions among reaches relative to the previous several sampling periods.

- Despite the apparently devastating initial 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 recovered to pre-disturbance conditions based on the shapes of recovery curves. This recovery pattern was first evident following the 2006 sampling year. Similarity of the macroinvertebrate community conditions measured in 2007 to those measured in 2006 further establishes that recovery primarily occurred in the months immediately following the disturbances and that communities throughout the river have largely returned to their pre-disturbance levels of richness and abundance.

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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 and Jason Coite of the University of Connecticut, Office of Environmental Policy for their oversight of the project.

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. Following the first macroinvertebrate sampling event in September 2005, a flood event occurred in the Fenton River with flows peaking on October 15. The first year of sampling following these two extreme hydrologic events (drought followed by flood) suggested that macroinvertebrate communities were severely affected in all study reaches following the 2005 flood event (Cole 2007). However, significant recovery of benthic communities was occurring; by summer 2006, macroinvertebrate community richness and abundance curves leveled off, suggesting that much recovery occurred in the first seven months following the disturbance events. Sampling in 2007 aimed to determine whether community conditions would continue to improve from those measured in 2006 and what effect any other extreme hydrologic events would have on benthic communities to provide further context to the effects of the events of 2005. This document reports on results of the second year of study, including April and November 2007 sampling events.

METHODS

SAMPLE SITE SELECTION

Five reaches were selected in 2005 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 where 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 2007 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). In 2007, sampling occurred in April and November to assess current-year conditions relative to those observed in 2005 and 2006 (see Cole 2007 for details of 2005 and 2006 sampling logistics). The first 2007 sampling event occurred on April 25, 2007, nine days following a storm event that resulted in a mean daily discharge that was approximately half of that which occurred during the October 2005 flood. Sampling occurred at this time to determine what effect this smaller peak-flow event had on the benthic community relative to the 2005 flood event. Fall sampling occurred in late November following resumption of flows from summer lows to those that were conducive to sampling with a kick net.

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. Data from 2007 were examined relative to 2005 and 2006 data 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 similar among the five reaches in both April and November 2007, ranging between 93 and 104 in April, and between 80 and 88 in November (Figure 1). Total taxonomic richness averaged 98 taxa across all sites in April 2007, compared to 87 in May 2006. However, total taxonomic richness in November 2007 (mean = 84) was slightly lower than that measured in November 2006 (mean = 96).

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) in April 2007 was highest in reaches three and five; each of these reaches supported significantly higher numbers of macroinvertebrates than did reaches 1, 2, or 4 (Figure 2, Appendices 1 & 2). In November, total abundance ranged from 834 organsims/m^2 in reach 1 to 2,724 organsims/m^2 in reach 4. Reaches 4 and 5 supported significantly higher numbers of organisms than did reach 1 or 2 (Appendix 2). Macroinvertebrate abundance in reach 3 was also significantly higher than in reach 1. Relative to abundances measured in 2006, macroinvertebrate abundance did not measurably increase in 2007 (Figure 2).

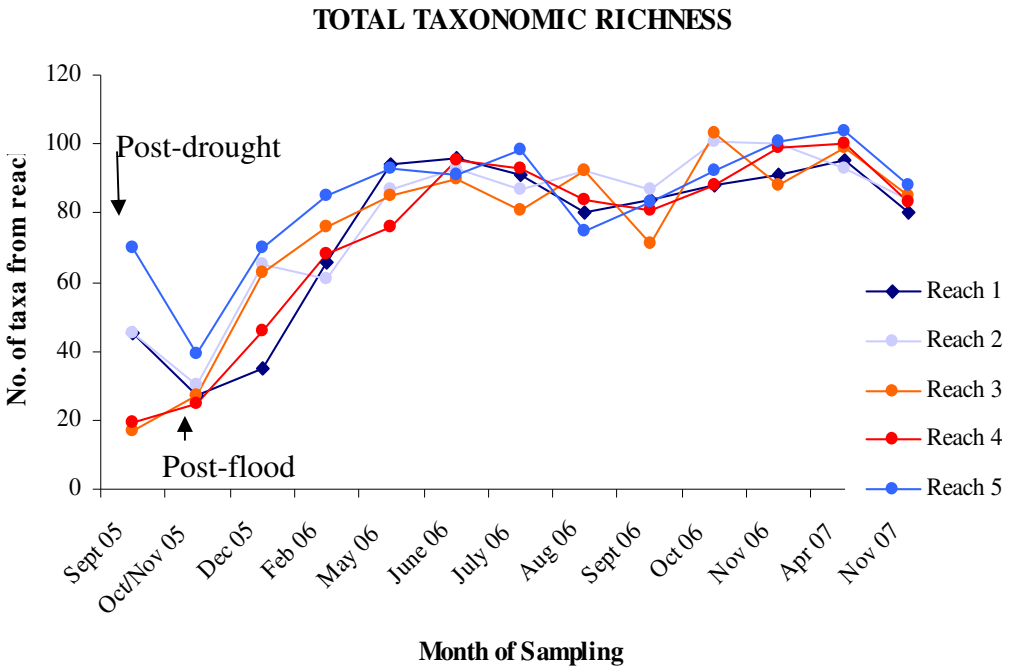

Figure 1. Total macroinvertebrate taxonomic richness of five Fenton River reaches sampled between September 2005 and November 2007. Total taxonomic richness was determined from the total number of taxa sampled in four replicate 1-m^2 kick samples from each reach on each sampling date.

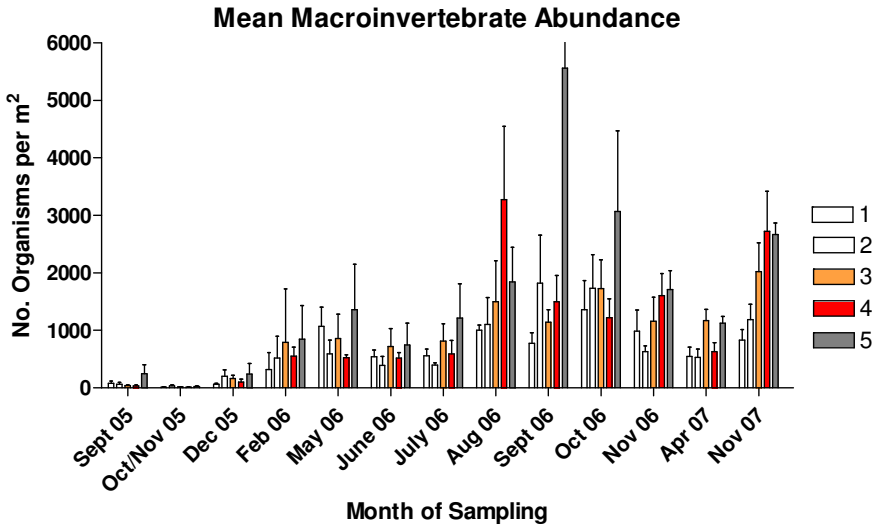

Figure 2. Mean (+SD, n = 4) macroinvertebrate abundance in five study reaches in the Fenton River, Connecticut between September 2005 and November 2007.

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 similar among the five reaches in both April and November 2007 (Figure 3, Appendices 1 & 2). April 2007 richness was slightly higher than was May 2006 richness, suggesting that recovery of some populations of macroinvertebrates may have occurred in that time; however, November 2007 richness was lower than November 2006 richness (Figure 3, Appendix 1). Low stream flows occurring throughout the region during late summer 2007 may explain the lower richness measured in November 2007 than in November 2006, but a lack of differences between reference (reaches 1, 2, and 5) and 2005-drought-affected reaches (reaches 3 and 4) suggests that any low-flow effect on invertebrates was independent of reach location relative to the 2005 drought-affected area.

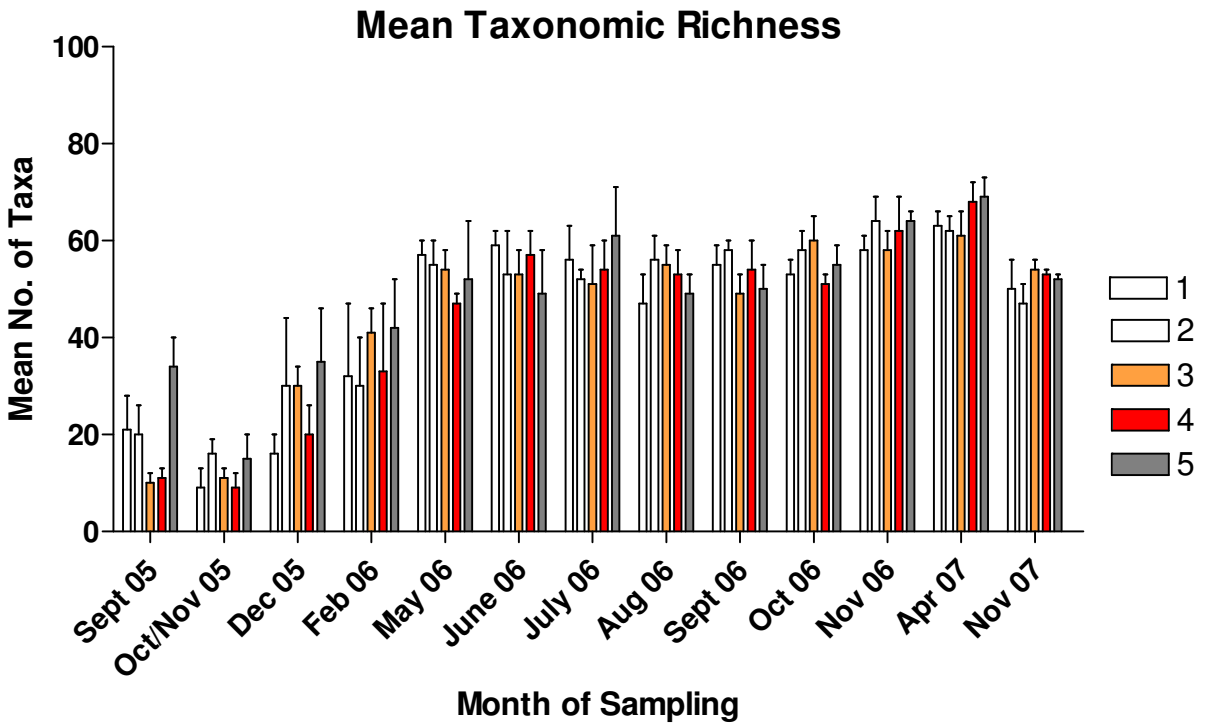

Figure 3. Mean (+SD, n = 4) taxonomic richness in five study reaches in the Fenton River, Connecticut between September 2005 and November 2007.

MEAN EPT RICHNESS

EPT taxonomic richness in April 2007 was higher in reach 4 than in reaches 1 or 3, while no significant differences occurred between any reaches in November 2007 (Figure 4, Appendices 1 & 2). Relative to spring (May) 2006, EPT richness in April 2007 was higher (Figure 4, Appendix 1); however, EPT richness was clearly lower in November 2007 compared to November 2006, again suggesting that low flows in late summer 2007 may have reduced abundance of some EPT taxa enough to result in lower richness estimates from samples collected throughout the river. A lack of significant differences among reaches in November 2007 suggests that any effect was independent of location relative to the 2005 drought-affected area.

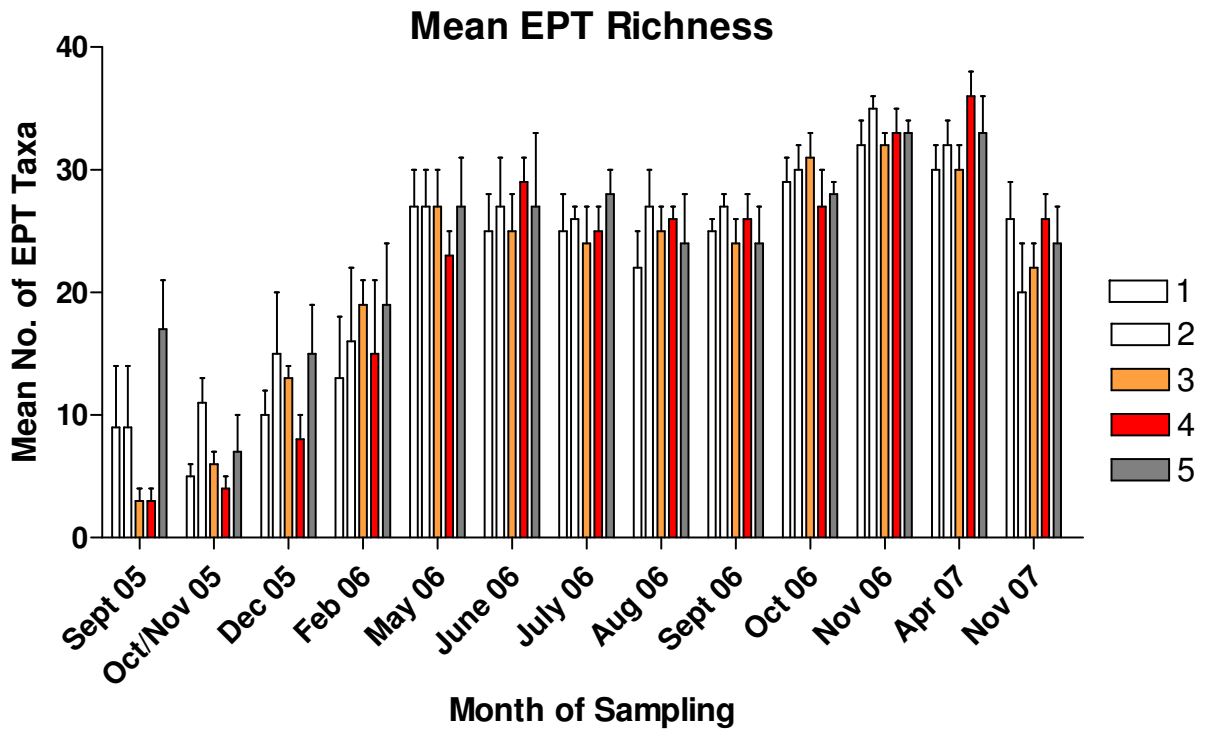

Figure 4. Mean (+SD, n = 4) EPT taxonomic richness in five study reaches in the Fenton River, Connecticut between September 2005 and November 2007.

MEAN EPT ABUNDANCE

In April 2007, EPT abundance was significantly higher in reaches 3 and 5 than in reaches 1, 2, or 4 (Figure 5, Appendices 1 & 2). In November 2007, EPT abundance was highest in reach 4 and lowest in reach 2. EPT abundance was significantly higher in reach 4 than in reaches 1 or 2 in November, but no other significant differences were found among reaches (Figure 5, Appendices 1 & 2). April and November 2007 EPT abundances were similar to May and November 2006 EPT abundances, respectively (Figure 5, Appendix 1).

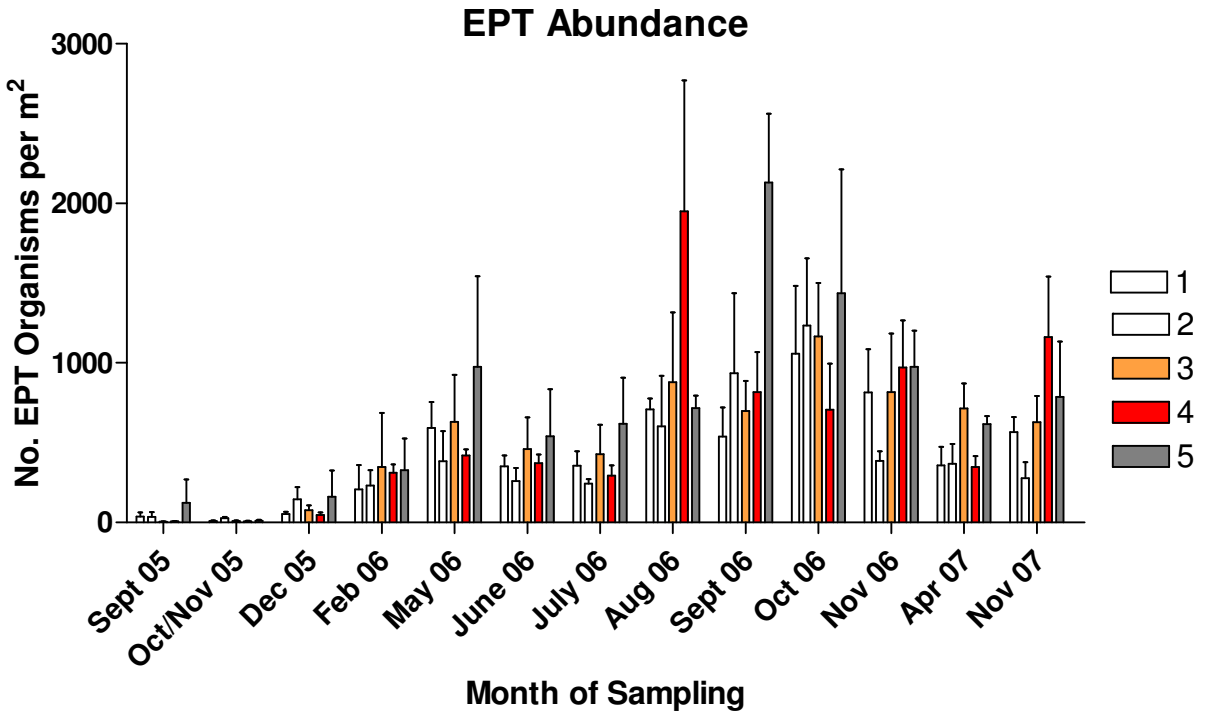

Figure 5. Mean (+SD, n = 4) EPT abundance in five study reaches in the Fenton River, Connecticut between September 2005 and November 2007.

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 2006 through November 2007 data are similar to those calculated from May 2006, suggesting that the communities have remained equally similar to each other from summer 2006 through fall 2007 and that the treatment-reach communities are no more dissimilar from the reference-reach communities than the reference-reach communities are from each other. In fact, Jaccard Coefficients suggest that the communities in reaches 3 and 4 are more similar to the downstream reference reach (reach 5) and the upstream reference reaches (reaches 1 and 2) than the upstream and downstream reaches are to each other (Figure 7). In the absence of a disturbance affect occurring only on the 2005-

drought-affected reaches, this pattern would be expected given the intermediate location of the 2005-drought-affected reaches relative to the reference reaches.

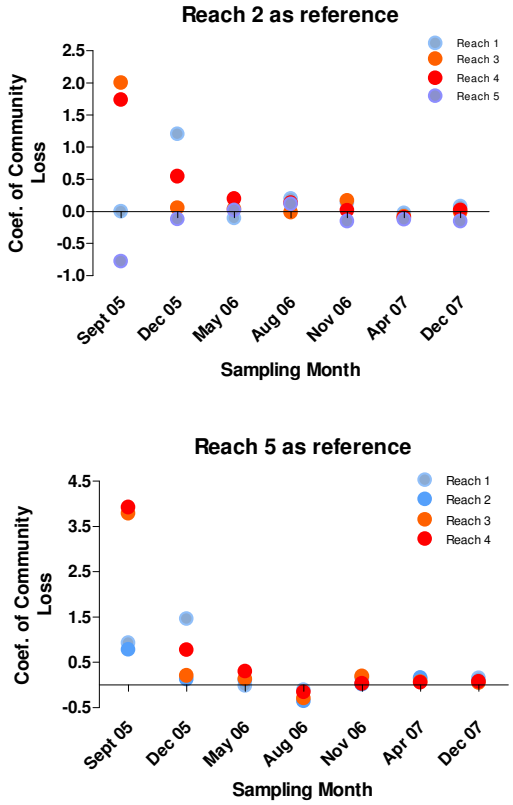

Figure 6. Coefficient of Community Loss of macroinvertebrate communities sampled from five study reaches in the Fenton River, Connecticut between September 2005 and November 2007. In the upper graph, reach 2 served as the reference community for all comparisons, while in the lower graph, reach 5 served as the reference reach.

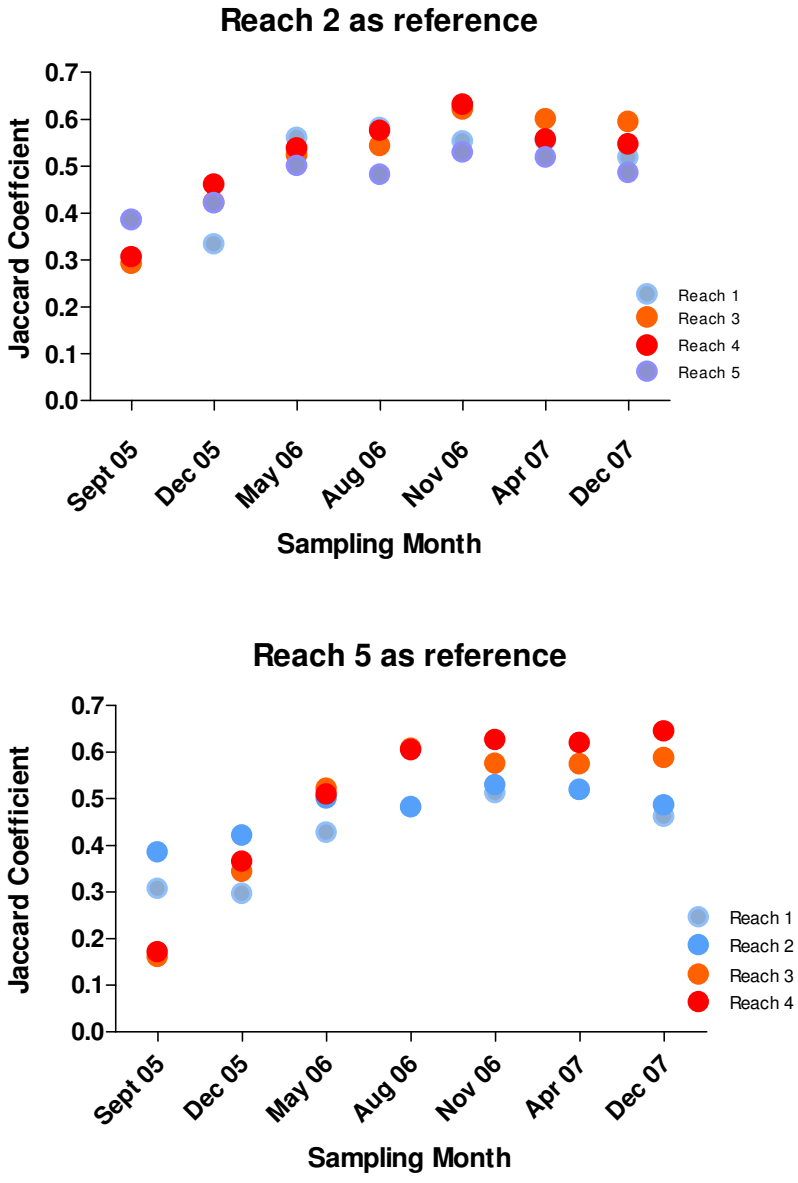

Figure 7. Jaccard Coefficient of Community Similarity of macroinvertebrate communities sampled from five study reaches in the Fenton River, Connecticut between September 2005 and November 2007. In the upper graph, reach 2 served as the reference community for all comparisons, while in the lower graph, reach 5 served as the reference reach.

DISCUSSION

This second year of sampling macroinvertebrate communities in the Fenton River occurred approximately one-and-a-half years (April 2007) and two years (November 2007) following two extreme hydrologic events: the drought of September 2005 and the flood of October 2005. Results from 2005 and 2006 suggested that macroinvertebrate communities were significantly impaired in the dried reach immediately following the September 2005 drought, but those impacts were relatively brief in duration as they were effectively masked by the subsequent flooding that occurred in October of that same year. Data collected through 2006 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. Data collected through the latter half of 2006 suggested that the recovery trajectory from these pulse disturbances started to flatten out (as determined both by measures of richness and abundance) by mid-year 2006.

Data collected in 2007 also suggest that recovery of the community primarily occurred in the months following the events, as 2007 seasonal conditions remained very similar to those measured in 2006. Conditions measured in April 2007 were similar to those measured in May 2006, suggesting that the community had largely recovered from the disturbance events by late spring 2006. April 2007 sampling occurred within nine days of a peak-flow event that was larger than any other following the October 2005 floods. Although no Fenton River discharge data are available for the October 2005 flood, data from the neighboring Mount Hope River suggest that the April 2007 flood (mean discharge on 4-25-07 = 1080 cfs) discharge was approximately half that which occurred during the October 2005 flood (mean discharge on 10-15-05 = 2080). In comparison to data collected following the October 2005 floods, the Fenton River macroinvertebrate community appeared to be minimally affected by the 2007 spring-time peak-flow conditions

Interestingly, November 2007 conditions were slightly depressed relative to those measured in November 2006, suggesting that the severe low-flow conditions occurring throughout the region in late summer 2007 may have measurably affected benthic community conditions. In spite of these low-flow conditions occurring in the Fenton River in late summer

and early fall 2007, no differences in macroinvertebrate community conditions were found between treatment and control reaches in November that would suggest that the treatment reaches experienced more severe hydrologic conditions than did the control reaches during the low-flow period. No water was pumped from the Fenton well field to the University of Connecticut water system from July 27, 2007 to January 10, 2008. Flows were low throughout the entire Fenton River drainage during late summer 2007; discharge at the USGS gage station at Old Turnpike Road was less than one cfs at times in August, September, and October. These conditions appear to have affected macroinvertebrate communities relatively minimally and equally throughout the river, as November measures of similarity indicated no divergence in community conditions among reaches relative to the previous several sampling periods.

The overall recovery patterns measured in this two-year 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 than those observed.

Despite the apparently devastating initial 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 recovered to pre-disturbance conditions based on the shapes of recovery curves. This recovery pattern was first evident following the 2006 sampling year. Similarity of the macroinvertebrate community conditions measured in 2007 to those measured in 2006 further establishes that recovery primarily occurred in the months immediately following the disturbances and that communities throughout the river have largely returned to their pre-disturbance levels of richness and abundance.

Additional monitoring may further elucidate any longer-term recovery of benthic communities, particularly that of organisms that require several years of larval development before reaching maturation. Continued study may also allow the effects of the 2005 drought and flood events to be further contextualized in relation to the severity of the disturbance events that occurred by continuing to sample following less extreme hydrologic events such as those that occurred in 2007. Despite the potential merits of continued investigation, it should be noted that these data from the past two years suggest that the most significant recovery period has passed and the macroinvertebrate communities of the Fenton River are likely very similar to those that occurred in the river prior to the 2005 disturbance events.

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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 2007.

Total 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	Apr '07	Nov '07
1	78 (39)	14 (7)	62 (20)	321 (292)	1075 (332)	541 (115)	557 (118)	1003 (92)	775 (187)	1361 (504)	990 (364)	548 (160)	834 (182)
2	66 (32)	39 (9)	203 (111)	518 (380)	594 (237)	391 (156)	399 (37)	1100 (473)	1821 (838)	1735 (583)	633 (96)	528 (146)	1188 (265)
3	40 (8)	19 (3)	163 (58)	793 (927)	863 (417)	722 (312)	819 (296)	1501 (709)	1141 (219)	1729 (501)	1160 (416)	1168 (198)	2023 (503)
4	36 (17)	12 (5)	101 (53)	554 (154)	526 (50)	521 (92)	595 (232)	3273 (1277)	1497 (461)	1221 (329)	1604 (384)	630 (157)	2724 (694)
5	246 (161)	24 (8)	243 (184)	849 (586)	1363 (787)	745 (379)	1214 (598)	1845 (602)	5563 (1360)	3071 (1400)	1713 (328)	1126 (117)	2665 (203)

Total 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	Apr '07	Nov '07
1	21 (7)	9 (4)	16 (4)	32 (15)	56 (2)	59 (3)	56 (7)	47 (6)	55 (4)	53 (3)	58 (3)	63 (3)	50 (6)
2	20 (6)	16 (3)	30 (14)	30 (10)	55 (5)	52 (9)	52 (2)	56 (5)	58 (2)	58 (4)	64 (5)	62 (3)	47 (4)
3	10 (2)	11 (2)	30 (4)	41 (5)	54 (4)	53 (5)	51 (8)	55 (4)	49 (4)	60 (5)	58 (4)	61 (5)	54 (2)
4	11 (2)	9 (3)	20 (6)	33 (14)	47 (2)	57 (5)	54 (6)	53 (5)	54 (6)	51 (2)	62 (7)	68 (4)	53 (1)
5	34 (6)	15 (5)	35 (11)	42 (10)	52 (12)	49 (9)	61 (10)	49 (4)	50 (5)	55 (4)	64 (2)	65 (5)	51 (1)

Appendix 1. (Continued)

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	Apr '07	Nov '07
1	9 (5)	5 (1)	10 (2)	13 (5)	27 (3)	25 (3)	25 (3)	22 (3)	25 (1)	29 (2)	32 (2)	30 (2)	26 (3)
2	9 (5)	11 (2)	15 (5)	16 (6)	27 (3)	27 (4)	26 (1)	27 (3)	27 (1)	30 (2)	35 (1)	32 (2)	20 (4)
3	3 (1)	6 (1)	13 (1)	19 (2)	27 (3)	25 (3)	24 (3)	25 (2)	24 (2)	31 (2)	32 (1)	30 (2)	22 (2)
4	3 (1)	4 (1)	8 (2)	15 (6)	23 (2)	29 (2)	25 (2)	26 (1)	26 (2)	27 (3)	33 (2)	36 (2)	26 (2)
5	17 (4)	7 (3)	15 (4)	19 (5)	27 (4)	27 (6)	28 (2)	24 (4)	24 (3)	28 (1)	33 (1)	33 (2)	24 (3)

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	Apr '07	Nov '07
1	36 (27)	8 (5)	52 (14)	209 (151)	593 (161)	352 (68)	357 (90)	708 (69)	539 (182)	1058 (425)	814 (273)	359 (116)	566 (95)
2	35 (30)	27 (8)	145 (77)	232 (97)	385 (188)	260 (82)	244 (29)	603 (315)	935 (501)	1234 (420)	387 (60)	368 (125)	278 (100)
3	5 (2)	9 (3)	77 (30)	349 (338)	631 (294)	461 (198)	428 (185)	879 (437)	698 (189)	1166 (335)	817 (367)	715 (156)	629 (164)
4	6 (3)	6 (4)	47 (15)	312 (52)	420 (39)	373 (54)	294 (65)	1950 (821)	816 (253)	706 (288)	970 (297)	349 (68)	1162 (379)
5	122 (149)	11 (6)	161 (166)	329 (198)	975 (568)	540 (295)	618 (288)	717 (77)	2130 (431)	1436 (776)	975 (227)	617 (50)	786 (348)

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 in April and November 2007. All values reported were calculated using Tukey's LSD.

Total Abundance

Month/Year	Comparison Pair	p-value
Apr '07	1 vs. 3	<0.001
Apr '07	1 vs. 5	0.001
Apr '07	2 vs. 3	<0.001
Apr '07	2 vs. 5	0.001
Apr '07	3 vs. 4	0.002
Apr '07	4 vs. 5	0.004
Nov '07	1 vs. 3	0.008
Nov '07	1 vs. 4	<0.001
Nov '07	1 vs. 5	<0.001
Nov '07	2 vs. 4	0.001
Nov '07	2 vs. 5	0.001

Total Richness

Month/Year	Comparison Pair	Significance level
No comparisons were significantly different in 2007		

Appendix 2. (Continued.)

EPT Richness

Month/Year	Comparison Pair	Significance level
Apr ‘07	1 vs. 4	0.006
Apr ‘07	3 vs. 4	0.012

EPT Abundance

Month/Year	Comparison Pair	Significance level
Apr ‘07	1 vs. 3	0.003
Apr ‘07	1 vs. 5	0.033
Apr ‘07	2 vs. 3	0.004
Apr ‘07	2 vs. 5	0.041
Apr ‘07	3 vs. 4	0.002
Apr ‘07	4 vs. 5	0.025
Nov ‘07	1 vs. 4	0.029
Nov ‘07	2 vs. 4	0.001