Evaluation of Newbury Weirs (Rock Riffles) for Improving Habitat Quality and Biotic Diversity in Illinois Streams.

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Introduction

In predominately agricultural watersheds, such as those in Illinois, remediation techniques have been used for reducing nonpoint source pollution (see Gale et al. 1993). Since 1998, the Illinois Natural History Survey in conjunction with the Illinois Department of Natural Resources (IDNR) has been collecting baseline data on four Illinois watersheds which will have extensive remediation practices implemented. One watershed in the Spoon River basin has completed the implementation phase. As part of our study on the effects of watershed-wide remediation, we also began assessing the effects of two sets of Newbury weirs (rock riffle structures installed in summer 2001 and a second set in spring 2003) on abiotic and biotic parameters of stream quality. From a scientific and management perspective, there is still a great deal to be learned about the relative effectiveness of individual practices in particular environmental settings and how fish and invertebrate assemblages respond to these practices under various environmental conditions. By assessing individual practices, we can inform watershed planning committees which types of practices will have the greatest impact on stream quality, thus, aiding their decisions in watershed remediation planning.

The goal of this study was to increase our understanding of riffle structures for improving stream quality in Illinois watersheds. Our specific objectives were to assess changes in physical habitat due to installation of Newbury weirs and assess the response of macroinvertebrate and fish assemblages to this particular type of remediation practice.

Study Site and Methods

Our study sites were located in the Court Creek Watershed, a tributary to the Spoon River basin. In 2001 and 2003, Newbury weirs (rock riffle structures) were installed in two separate stream reaches on North Creek (tributary to Court Creek), Knox County, IL. We monitored these two weir sites and a reference site before and after weir installation. At the site in which Newbury weirs were installed in 2001 (NW1), we monitored habitat, fish, and invertebrates twice before (fall 2000 and spring 2001) and seven times after (late summer and spring 2001-2004) weir placement. At the second set of weirs installed in 2003 (NW2), we collected habitat, fish, and invertebrate data twice before (fall 2002 and spring 2003) and three times after (late summer and spring 2003-2004) weir implementation. The "control" or reference site on North Creek was also sampled at approximately the same time as the two treated sites. Length of both treated and reference sites were approximately 20 times mean bankfull width (Gough 1997) to ensure that at least one riffle-run-pool sequence was sampled. At all three sites, physical habitat and bank/riparian cover was measured using a quantitative point/transect method (Stanfield et al.1998). Fish were collected using IDNR's standard protocol of a single pass with an AC electric seine using block nets to enclose the stream reach (Bayley et al. 1989). Macroinvertebrates were quantitatively sampled using a stratified random sampling design whereby habitats were sampled in proportion to their availability. We used a coring device in pool areas and a Hess sampler in riffles. At the NW1 site, changes in physical habitat and fish assemblages were assessed by comparing habitat and fish assemblage characteristics before and after implementation. At the NW2 site, shifts in habitat and fish assemblages were assessed through comparisons before and after implementation between the treated and reference sites (BACIP, Stewart-Oaten et al.1986). Changes in macroinvertebrate communities at both weir sites were assessed through comparisons of composition, abundance, and biotic indices using the BACIP design. Analysis of Variance was used to determine significant differences in habitat and biota between before and after time periods.

Results

We found significant changes in habitat and biotic communities at these Newbury weir sites on North Creek. At the first set of weirs installed in 2001 (NW1 site), we found that both point substrate and maximum substrate sizes significantly increased after weir installation due to placement of large rock in the stream to simulate natural riffles ($p_{point\ sub.} = 0.04$, $p_{max\ sub.} = 0.02$). Although depth did not significantly increase in the post-weir period, we found that width and width/depth ratio was marginally significantly different ($p < 0.10$) with average width increasing and width/depth ratio decreasing after weir installation. Average surface area sampled increased significantly ($p = 0.04$) following weir construction, possibly due to readjusting and shifting of the stream bed and banks, creating a wider and deeper channel. Percent habitat composition and in-stream vegetation changed more with season than between time periods. In late summer/early fall, habitat consisted primarily of pools with smaller amounts of run and slow riffle habitat. On the dates sampled in late spring, habitat composition was more diverse with larger percent run, slow riffle, and fast riffle habitat. Conversely, the amount of in-stream vegetation showed an opposite trend with higher percentage and more diverse types of vegetation in late summer/early fall than in late spring samples with the exception of the spring 2004 date. These trends in habitat composition and vegetation are probably due to higher water levels in the spring creating riffle and run habitat and preventing in-stream vegetation from becoming established; while, in the late summer, water levels are lower creating more slow flowing pooled areas and allowing vegetation to establish in the stream. As a result of these seasonal trends, we found no significant differences in habitat composition and only a marginally significant difference ($p < 0.10$) in filamentous algae between pre- and post-weir dates.

At the NW1 site, fish species richness, CPUE, and Index of Biotic Integrity (IBI) did not significantly change after weir installation. However, we observed a dramatic decline in CPUE a year following weir placement and then steady increase through time to numbers more similar to pre-weir conditions. We also found a shift in community composition after the weirs were installed. Percent composition of catostomids and centrarchids were marginally significantly higher after weir placement ($p_{catostomids} = 0.07$, $p_{centrarchids} = 0.08$). Since installation of these weirs, three new ictalurid species have been found at NW1 (black bullhead, channel catfish, and stonecat).

At the first set of weirs and the reference site, we analyzed macroinvertebrate samples from two pre-weir dates (Fall 2000 and Spring 2001) and four post-weir dates (Fall 2001, Summer 2002, Spring 2004 and Fall 2004) to determine initial and long-term impacts of these structures on invertebrate communities. Total taxa richness and taxa richness within riffles significantly increased after weir placement compared to the reference site ($p_{tot\ richness} = 0.01$, $p_{riffle\ richness} = 0.02$). Although no other invertebrate parameters significantly changed between the two time periods, we did see some shifts in community composition and abundance. Before weir placement, abundance in the reference site was twice as high as the NW1 site, but immediately after weir installation, total abundance became similar to the reference site. Abundance was also greater at NW1 compared to the reference site three years after weir installation. In the pre-weir period, percent Ephemeroptera, Plecoptera, and Trichoptera taxa (%EPT) and Family Biotic Index (FBI) values were similar between the two sites with water quality rated as poor to fairly poor at both sites. However, one year following weir installation, %EPT increased substantially compared to the reference and water quality was rated as fair at NW1 site After three years post-weir, we found percent EPT and FBI scores at the NW1 site became more similar to the reference site.

At the second set of weirs installed in 2003 (NW2), we found significant changes in channel morphology characteristics when compared to the reference site. After weir placement, both average width and depth significantly increased compared to the reference ($p_{width} = 0.02$, $p_{depth} = 0.01$). Average sample area also significantly increased at NW2 compared to the reference site ($p = 0.01$) due to the increases in width and depth. We found no significant changes in fish assemblage parameters after weir installment at the NW2 site. However, we did find similar shifts in assemblage composition as seen at the NW1 site. We found a substantial increase in numbers of catostomids and centrarchids in the post-weir sample dates. We also found an increase in numbers of darters which was not observed at the NW1 site. Although we did not find significant changes 15 months after weir implementation at the NW2 site, continued shifts in channel morphology, substrate, and bank stability are likely to occur, potentially affecting fish assemblages at this site.

Conclusions

Results from monitoring of Newbury weirs supports the idea that these structures change channel morphology characteristics of the stream by increasing the amount of stable substrate and creating wider and deeper pool areas. In addition to changes in habitat, we found shifts and trends in fish and invertebrate community composition following weir placement indicating that these structures do create important habitat and improve the quality of the stream for sensitive taxa (smallmouth bass, darters, mayflies, etc.). We found similar changes in channel morphology and fish composition at both weir sites and expect that over time the channel will continue to shift and adjust as a result of these weirs changing the habitat and fish composition. However, when comparing the two weir sites, we did find some differences in their effects on stream fish when these structures are located at different drainage areas. At the NW1 site (located at a larger drainage area), shifts in fish assemblages included increased number of ictalurids; whereas at the NW3, the number of darters increased after weir placement. Through assessment of these riffle structures at two different drainage areas within a watershed, we obtained a more comprehensive examination of how these structures affect stream ecosystems in different environmental settings allowing managers to predict the effectiveness of these structures in other Illinois watersheds of similar size.

Literature Cited

Bayley, P. B., R. W. Larimore, and D. C. Dowling. 1989. Electric seine as fish sampling gear in streams. Transactions of the American Fisheries Society 118:447-453.

Gale, J. A., D. E. Line, D. L. Osmond, S. W. Coffey, J. Spooner, J. A. Arnold, T. J. Hoban, and R. C. Wimberly. 1993. Evaluation of the experimental rural clean water program. National Water Quality Evaluation Project, NCSU Water Quality Group, Biological and Agricultural Engineering Department, North Carolina State University, Raleigh, NC, USA.

Gough, S. C. 1997. Stream classification and assessment. The Nature Conservancy, Peoria, Illinois Field Office, Peoria, Illinois, USA.

Stanfield, L., M. Jones, M. Stoneman, B. Kilgour, J. Parish, G. Wichert. 1998. Stream assessment protocol for Ontario. v. 2.1.

Stewart-Oaten, A., W. W. Murdoch, and K. R. Parker. 1986. Environmental impact assessment: "pseudoreplication" in time? Ecology 67:929-940.