

ASSESSMENT OF STREAM REMEDIATION ON THE AQUATIC HABITAT AND FISH COMMUNITY OF COX CREEK, CASS COUNTY, ILLINOIS

INTRODUCTION

The Illinois Department of Natural Resources (IDNR) obtained a 15,574 acre parcel in Cass County from Commonwealth Edison in 1993. This area called “Site M” was subsequently named Jim Edgar Panther Creek State Fish and Wildlife Area. With the passage of Conservation 2000 the IDNR, Illinois Department of Agriculture and U.S. Natural Resources Conservation Service initiated watershed scale management and streambank stabilization activities on the property. Nearly one half of the Panther and Cox creek watershed was acquired with this site, representing a unique opportunity for management by IDNR and its partners.

Severe bank erosion prevalent at “Site M” was exemplified by the Cox Creek project area, approximately 500 feet upstream of the confluence with Panther Creek (Figure 1). Extensive erosion resulted in nearly vertical banks 15 to 20 feet high. In 1997 streambank stabilization and habitat enhancement measures were employed on Cox Creek. One rock riffle (Newbury & Gaboury 1993, Figure 2A) was placed on Panther Creek below the confluence and five were placed on the lower 1500 feet of Cox Creek. A total of over 2600 tons of stone (2000 tons RR6, 475 tons RR4 and 145 boulders) was employed. Riffles were designed to mimic the typical pool and riffle sequences while preventing stream channel downcutting and dissipating stream energy, thus reducing bank erosion. Lunker structures (Vetrano 1988, Roseboom et al. 1990, Figure 2B) and dormant willow posts (Roseboom et al. 1990, Figure 2C) were installed on three meander bends within the Cox Creek riffle reach. Approximately 65 lunker structures were placed instream to create undercut banks (Figure 2C). The lunker structures were made from timber harvested from the watershed in preparation for lake construction. Roughly 1000 dormant willow posts were obtained from nearby Sanganois State Fish and Wildlife Area and used to stabilize and revegetate the riparian zone.

Habitat measurements and fish population sampling were initiated in 1995, two years prior to project implementation, to measure changes in the physical instream environment as well as changes in the fish population. Water width, water depth and substrate were measured in transects along 1200 feet of the Cox Creek project area and in an adjacent Panther Creek reference reach. Fish populations were sampled prior to transect measurement. A before-after-control-impact (BACI) design (Wang et al. 2002, Stewart-Oaten et al. 1986) was used to determine if stream remediation produced measurable effects on biotic integrity, fish species richness, stream habitat quality, water depth, water width, and size of select fish species.

METHODS

Reaches of 1200 feet were established in both the project stream, Cox Creek, and the control stream, Panther Creek. The downstream limit of each station was characterized by an obstruction. The obstruction in Cox Creek was a gravel, low-water crossing which was transformed to a riffle crest after construction. The Panther Creek sample location contained concrete from a collapsed road crossing which acted as an obstruction similar to the low-water crossing in Cox Creek. Prior to remediation the upper 600 feet of each sample reach was markedly narrow and shallow in comparison to the lower 600 feet. Consequently each sample reach was divided into “Upper” and “Lower” segments. Sampling was conducted during low-flow conditions, typically in early September, between 1995 and 2003.

To characterize substrate type and instream habitat the Illinois Environmental Protection Agency (IEPA) quantitative method was employed using 11 transects per stream segment. Water width was measured at each transect and water depth and substrate type was recorded at either one or two foot intervals across the transect depending on stream width. In addition the Stream Habitat Assessment Procedure (SHAP) was used to qualitatively evaluate instream habitat (IEPA 1994).

Prior to riffle construction the fish population was sampled using a battery-powered, Dirigo Model 850B, pulse DC backpack electrofisher. Electrofishing was followed by supplemental seine hauls through the entire sampling reach using a 20 foot, 1/4 inch mesh minnow seine. Due to increased water width and depth post-project fish sampling was accomplished with a 30 ft. electric seine (Bailey et al. 1989, Day et al. 2003) powered by a 1- phase, 1600 watt AC generator.

Large fish were identified to species, weighed, measured and returned to the stream. Smaller specimens were preserved and processed in the laboratory. Voucher specimens were transferred to the Illinois Natural History Survey fish collection.

The revised version (Smogor 2000) of the Index of Biotic Integrity (IBI) was used to assess stream quality based on the fish sample data. A before-after-control-impact (BACI) design (Wang et al. 2002, Stewart-Oaten et al. 1986) was used to assess whether stream remediation produced effects on biotic integrity, fish species richness, stream habitat quality, water depth, water width, and size of select fish species. Data from September 1997 samples were eliminated from statistical analyses because 6 months appeared to be insufficient time for significant fish colonization following March construction. The two sample t-test assuming equal variances in Quattro Pro 10 (Corel Corporation, Copyright 2001) was used, with $P < 0.1$ considered as the level of significance (Wang et al. 2002). Average values for both “Upper” and “Lower” segments of the study reaches were included in analyses for all but fish size comparison, where average size per stream and year was used.

RESULTS AND DISCUSSION

Aquatic Habitat

The potential for bank erosion has been greatly reduced in the Cox Creek study area by the installation of riffles, Lunker structures and dormant willow posts (Figure 3A,B,C) but is still prevalent in the Panther Creek control reach (Figure 4A, B, C). Increased erosion potential in Panther Creek is indicated by nearly vertical bank slopes that do not support woody vegetation. Typical low-flow water width increased moderately and water depths were substantially increased with riffle installations. Those conditions resulted in a change of fish sampling method deemed most effective for post-project sampling. Prior to riffle installation the Upper Cox Creek station had mean water widths of 9.4 and 12 feet and mean depths from 0.2 to 0.5 feet (Table 1), with areas reduced to 1 foot wide and depths of less than 0.1 feet. Water width in Upper Cox Creek after riffle installation averaged 22 to 23 feet and depths averaged 1 to 1.3 feet. Average widths in the Lower Cox Creek segment were slightly less, from 13.9 and 15.2 feet pre-project to a 18.9 - 22.7 foot post-project range. Average water depths in the Lower Cox station were doubled by the riffle project, ranging from 0.5 to 0.7 feet pre-project to 1.2 and 1.3 feet in the last three sample years. Maximum depth readings in Lower Cox were also 2 to 2.5 times greater in post-project assessments (Table 1).

In BACI analyses of stream habitat transect values mean depth ($t=-2.64$, $P=0.03$) and maximum depth ($t=-3.39$, $P=0.01$) were significantly different in post-project Cox Creek (both Upper and Lower segments included) relative to Panther Creek values. Mean width was not significantly different however ($t=-0.57$, $P=0.59$). Water depth was greater in the Cox Creek study reach after riffle installation, as expected, when compared to the Panther Creek control reach. Water width and depth also increased in post-project Panther Creek (Table 1). Average widths of Lower Panther transects was 20.4 to 20.9 prior to 1997, 24.1 to 27.1 in 1997 and 1998, and 25.6 to 27.4 after 1999. Panther Creek width increase appeared to coincide with the initial Cox Creek project in 1997 but the cause for such a change is unknown. Subsequently, 12 riffles were installed from the Cox Creek confluence to the lower limit of the study reach in 1999. Riffle height at the old bridge site (downstream limit of our control reach) was designed to maintain the pre-project elevation, however. Perhaps beaver dams raised water levels in 1997 and then the Panther Creek riffles in 1999 made the higher water levels permanent.

Habitat type was recorded in two ways during stream transect surveys. The percent of each habitat type between transect intervals (usually 30 ft.) was estimated qualitatively. In addition, the habitat type was recorded at each transect location. Data for Cox Creek revealed an obvious increase in riffle habitat from 1996 pre-project to 1998 post-project transect data (Table 2). Lower Cox Creek had no riffles in 1996, with an estimated 22.4% of station and 31 (or 13.3%) of transects recorded as riffle habitat in 1998. The Upper Cox Creek reach had some riffle habitat prior to project implementation but Panther Creek was nearly devoid of riffle habitat altogether.

Run habitat was largely unchanged in the Lower Cox Creek reach based on transect data. In Upper Cox Creek, however, run habitat was decreased from an estimated 79.5% of station in 1996 to 13.8% in 1998 as shallow runs were replaced with constructed riffles and deep pools (Table 2). Pool habitat increased the most in Upper Cox segment from an estimated 29% in 1996 to 69.5% in 1998. Run habitat was also diminished in Upper Panther Creek in 1998 and replaced with pool habitat, apparently a result of raised water level elevation downstream (Table 2).

SHAP values were significantly higher in post-project Cox Creek ($t=-5.74$, $P=0.0006$) in comparison to Panther Creek. Pre-project Cox Creek SHAP scores ranged from 63 to 88, while post-project scores ranged from 104 to 127 (Table 1). Panther Creek score ranges were 61 to 78 pre-project and 68 to 83 post-project (Table 1). SHAP is a qualitative means of lotic habitat evaluation using features considered important to biotic integrity. The final score is a sum of 15 metric scores intended to assess bottom substrate type, channel morphology, hydrology and riparian features. Pool quality (depth), substrate (rip rap), instream cover (Lunker structures, boulders) and riparian (improved stability of bank vegetation) metric scores were increased by the project.

Fish Community

1. Biotic Integrity

Fish community sampling was undertaken to document changes in the fish population of Cox Creek following stream remediation. As previously noted, increased water depth and width after riffle installation prompted a change in fish sample methods from backpack electrofishing and supplemental minnow seine hauls, to electric seine sampling. Changes in the fish population were anticipated as well. Improved instream habitat diversity with the addition of rock riffles and deep pools should result in increased species diversity (Schlosser 1982). Although fish sample size decreased substantially when the electric seine was implemented (Tables 3, 4), species richness increased fairly consistently in Cox Creek samples (Table 3, Figure 5). This is unlikely to be a result of differing sample methods because increased stream size makes sampling generally less efficient, as reflected by the decline in sample sizes. The trend towards increased fish species richness in post-project Cox Creek samples was evident and not mirrored in Panther Creek samples, with the exception of 2001 (Figure 5). Upper and lower segment species lists were combined for Figure 5, but are listed by segment in Tables 3 and 4.

Species richness is a very simple measure of diversity that excludes relative abundance information (evenness). Nonetheless, it is a useful measure and an important aspect of biological integrity. Biological integrity may be defined as the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region (Karr 1991). The revised IBI score reflects the level of biological integrity using 10 metrics of the fish population including species richness, trophic structure, reproductive structure and tolerance to disturbance (Smogor 2000). Like the species richness trend, IBI values generally increased in Cox Creek after project implementation (Figure 6). The 1995 IBI

was quite high however and a review of the individual metric scores revealed no obvious fish community characteristic responsible for the high score. BACI analyses of simple species richness and IBI were comparable in this study, with the IBI t-test result very close to significance ($t=-1.40$, $P=0.10$) and species richness achieving significant difference ($t=-2.05$, $P=0.08$) in post-project samples. Establishing statistical relationships between habitat and diversity or between habitat and biological integrity remains elusive in these streams. The relationship between habitat diversity and species diversity is reportedly harder to predict in small streams dominated by small fish (Schlosser 1982) such as Cox and Panther creeks.

2. Fish Size

Increased water depth during low-flow conditions could be expected to allow larger individuals to inhabit the stream, during an otherwise limiting condition of warm and shallow water with low levels of dissolved oxygen. In one instance prior to riffle construction several white suckers were observed crowding around a shallow groundwater discharge of cooler water during the late summer drought. It appeared that the conversion to deep pools in that reach would reduce temperature-related dissolved oxygen stress to white suckers and other larger fishes in the stream reach.

A significant change in average total length of white sucker (-2.39 , $P=0.096$) was evident between pre- vs. post-project samples, however no significant size differences were found in hornyhead chub ($t=2.24$, $P=0.15$), golden redhorse ($t=1.19$, $P=0.32$), yellow bullhead ($t=0.71$, $-P=0.53$), green sunfish ($t=1.03$, $P=0.41$) or Johnny darter ($t=0.64$, $P=3.18$). White sucker average size was increased in post-project Cox Creek relative to the Panther Creek reference area. Pre-project samples of white sucker exhibited greater average total lengths in Panther Creek than in Cox Creek. In 1998 and 2001 however, both streams held similar-sized white suckers (Figure 7). Panther Creek white suckers averaged slightly longer again in 2003. Overall, size differences between pre- and post-project Cox Creek fishes were not well illustrated during this study period. Perhaps more time is required for fish size/age structures to respond to habitat changes.

3. Fish Colonization

The recolonization rate of an improved stream reach should be related to the degree of isolation of that reach from potential colonizers. Time periods for recovery of lotic macroinvertebrate communities range from 60 days to 10 years (Fuchs & Statzner 1990). A general indicator of fish colonization is species richness. There was no increase in Cox Creek species richness within the first six months. Notable increases were evident in 1.5 years (1998 sample) with further increases in 4.5 years (2001 sample). Species richness appeared to level out in 2003 (Figure 5).

Colonization of the study reach by new species was evident from 1998 through 2003 however. One individual southern redbelly dace was captured in Cox Creek in 1997, but has not appeared since. An inhabitant of rocky, usually spring-fed, pools of headwaters and creeks (Page & Burr 1991) this

species probably is not a common inhabitant of lower Cox Creek. The southern redbelly dace could be present in the upper drainage but there are no additional records for the watershed. In 1998 emerald shiner, redbfin shiner, fathead minnow and river carpsucker first appeared in the Cox Creek samples. All of those species with the exception of fathead minnows appeared in subsequent samples. Species collected from Cox Creek in 2001, but not in the four previous sample efforts, were highfin carpsucker, slenderhead darter and mud darter. The “new species” list continued to grow in 2003 with the addition of channel catfish, freckled madtom, blackstripe topminnow and freshwater drum.

In all 12 new fish species have been documented in the Cox Creek study area since installation of riffles, Lunker structures and dormant willow posts. It appears that many of those species may persist in the sample reach. Riffle inhabiting species that have colonized the reach are freckled madtom, slenderhead darter and mud darter, although the freckled madtom also may inhabit structure along runs and undercut banks (Page & Burr 1991). The remaining species are primarily pool inhabitants.

A species first recorded from the Panther Creek control reach in 1997 was blackside darter. It was collected in Panther Creek only once again in 2001, but was seen in every Cox Creek sample. Fish species first observed in Panther Creek in 2001 were redbfin shiner, black crappie and warmouth. Redfin shiners were also collected from Cox Creek, but black crappie and warmouth were not previously or subsequently taken from either stream. White crappie was added to the Panther Creek species list in 2003. The species “new” to the Panther Creek study reach are sluggish water/lacustrine species (white crappie, black crappie and warmouth) or inhabitants of pools with slight (redfin shiner) moderate (blackside darter) current (Page & Burr 1991).

Colonization from downstream sources would require migration from the lower Sangamon River through a 1.4 mile straightened floodplain reach of Panther Creek, then up 3 meandering stream miles to the confluence of Cox Creek. Upstream sources from Panther Creek include approximately 14 miles of free flowing stream, a 25 acre tributary impoundment (Gridley Lake) 10 miles upstream of project area and several smaller ponds in the 50 acre watershed (exclusive of Cox Creek). Cox Creek is free flowing for its entire 11.7 miles, with a 200+ acre tributary impoundment (Prairie Lake) about 4 miles upstream from the project area, a smaller tributary impoundment (Drake Lake) within 3 miles, and several small ponds throughout the 25 acre watershed.

Migration from the lower Sangamon River is most likely during spring high water periods because the channel is typically wide and shallow and is unlikely to offer good fish refugia in low water periods of summer, fall and winter. Colonizers would then need to pass through the channelized lower Panther Creek to reach the project area. Fortunately, flood control plans for Chandlerville were revised to replace a proposed sheet-pile drop structure in Panther Creek, an upstream migration barrier, with rock riffles.

In summary migration upstream from the Sangamon River is possible but perhaps impeded by shallow

water in the Sangamon proper and a channelized lower Panther Creek channel. Colonization from downstream sources may take years until the proper water levels and fish populations are present to move into the watershed due to a less than optimal migration route. Migration from upstream sources is largely unimpeded except for various impoundments in tributary streams. If adequate winter and drought refugia are present upstream, migration into the project area should be relatively easy.

Sport fish species including channel catfish and black crappie have just appeared in the study area in recent years. Largemouth bass, bluegill and yellow bullhead have been present throughout the study period but are yet to reach population levels to support a substantial sport fishery. Numbers of bluegill and largemouth bass collected have increased substantially in 2001 and 2003 post-project samples (Tables 3, 4). Overflow from impoundments and ponds in the watershed could be responsible for most of the sunfish and catfish seen in recent samples. Spillway escape should produce sufficient stock of largemouth bass, bluegill and perhaps channel catfish to allow a fishery to develop in Cox and Panther creeks if the habitat will support them. Increased depths and improved habitat diversity should result in better sport fish populations but more time may be needed to reach the full potential. Periodic surveying will continue in Panther and Cox creeks to assess fish community and sport fisheries changes that occur over time.

CONCLUSIONS

Streambank stabilization measures employed on Cox Creek in 1997 has led to reduced potential for bank erosion. Aquatic habitat changes were also a result of rock riffle, Lunker structure and dormant willow post installation. Typical low-flow water width increased moderately and water depths were substantially increased by riffle placement. Average water depths in the Cox Creek project area were doubled and maximum depth readings were 2 to 2.5 times greater in post-project assessments, a significant increase in comparison to the Panther Creek control reach according to BACI analyses. The increase in stream width was not significant due to corresponding increases in Panther Creek width measurements, which presumably were a result of beaver dams and/or a 1999 riffle project downstream of the control reach.

Habitat measurements for the Lower Cox Creek segment recorded 13.3% of transects and an estimated 22.4% of station as riffle habitat in 1998, where no riffles were present in the pre-project condition. The Panther Creek control reach was nearly devoid of riffle habitat throughout the study period. Run habitat was largely unchanged in the Lower Cox Creek segment, but in the Upper Cox segment was decreased from an estimated 79.5% of station in 1996 to 13.8% in 1998 as shallow runs were replaced by riffle and pool habitats. Pool habitat increased most in the Upper Cox segment from an estimated 29% in 1996 to 69.5% in 1998. Run habitat was also diminished in Upper Panther Creek in 1998 and replaced with pool habitat, apparently a result of raised water level elevation downstream. Aquatic habitat quality as measured by SHAP was significantly higher in post-project Cox Creek when compared to Panther Creek. Pool quality (depth), substrate (rip rap), instream cover (Lunker

structures, boulders) and riparian (improved stability of bank vegetation) metric scores were increased by the project.

Fish species richness and IBI values generally increased in Cox Creek after project implementation. BACI analyses of simple species richness and IBI were comparable in this study, with species richness achieving significant increases post-project samples. IBI values were not significantly different however. Establishing statistical relationships between habitat and diversity or between habitat and biological integrity remains elusive in these small streams.

An anticipated increase in fish size accompanying increased water depths in the low flow condition was indicated only in the white sucker. No significant size differences were evident between pre- and post-project samples of hornyhead chub, golden redhorse, yellow bullhead, green sunfish or Johnny darter. Perhaps more time is needed for fish size/age structures to respond to habitat changes.

Fish species colonization of the Cox Creek study reach, as indicated by species richness, was not evident until 1.5 years after project implementation. Further increases in richness were seen after 4.5 years but appeared to level out at 6.5 years. A total of 12 new fish species have been documented in the Cox Creek study area since 1997. It appears that many of those species may persist in the sample reach. Riffle inhabiting species that have colonized the reach are freckled madtom, slenderhead darter and mud darter. Pool-inhabiting species that first appeared in post-project samples of Cox Creek include emerald shiner, redbfin shiner, blackstripe topminnow, river carpsucker, highfin carpsucker, channel catfish, and freshwater drum.

While sport fishes such as largemouth bass, bluegill and yellow bullhead have been present in Cox Creek throughout the study period, they are yet to support a substantial sport fishery. Numbers of largemouth bass and bluegill have increased in recent samples, but introductions from nearby stocked impoundments are a likely factor. Still there is the possibility that improvements in the sport fishery are forthcoming as the fish community continues to adjust to the habitat changes.

ACKNOWLEDGMENTS

Don Roseboom, John Beardsley and Luong Duong (Illinois State Water Survey) are credited with project design and construction management. The IDNR Heavy Equipment Crew led by Dan Troemper installed the structures. Dave Day and Randy Sauer (IDNR Streams Biologists) prepared early conceptual plans for this project. Don Roseboom and Jim Mick (IDNR Fisheries), were instrumental in taking the project from conceptual stages to completion. Dan Riggs and Kelly Dodsworth (IDNR Land Management) provided support and logistical assistance during the construction phase. IDNR Fisheries Division staff that assisted with Lunker construction, willow post harvesting, and project construction were: Bill Ernst, Dwight Eddington, Larry Muench, Rich Walters, Rob Bartlett, Ronnie Brown, Scott Schleuter and Shawn Hirst. Sampling assistance was provided by

Bob Dunn, Brandon Fletcher, Dale Patterson, Dan Stephenson, Dave Day, Gary Lutterbie, Jana Hirst, Jim Hefley, Jim Walker, Kenny Hills, Ken Russell, Mike Cochran, Randy Sauer, Rich Walters, Ronnie Brown, Scott Schleuter, Shany Atterberry, Shawn Hirst, Steve Pallo, Steve Sobaski and Trent Thomas. Jim Hefley and Matt Short (IEPA) assisted with habitat transect methods instruction and provided transect measurement data for the 2003 sample.

LITERATURE CITED

Bailey, P.R., R.W. Larimore and D.C. Dowling. 1989. Electric Seine as a Fish-Sampling Gear in Streams. *Transactions of the American Fisheries Society*. 118:447-453.

Day, D.M., A.M. Holtrip, H. Dodd, R. Smogor, R. Fischer, and M. Short. 2003. A Guide to Assembly and Operation of an Electric Seine. Illinois Department of Natural Resources, Technical Support Section Report. 37p.

Fuchs, U. and B. Statzner. 1990. Time Scales for the Recovery Potential of River Communities after Restoration: Lessons to be Learned from Smaller Streams. *Regulated Rivers: Research & Management* 5:77-87.

Illinois Environmental Protection Agency. 1994. "Appendix 1, Quality Assurance and Field Sampling Procedures", in Quality Assurance Project Plan: Integrated Water Monitoring Program Document. Bureau of Water, Springfield, Illinois.

Karr, J.R. 1991. Biological Integrity: A Long-Neglected Aspect of Water Resource Management. *Ecological Applications* 1(1):66-84.

Newbury, R.W. and M.N. Gaboury. 1993. Stream analysis and fish habitat design, a field manual. Newbury Hydraulics Ltd., Gibsons, British Columbia, Canada. 256p.

Page, L.M. and B.M. Burr. 1991. A Field Guide to Freshwater Fishes of North America North of Mexico. Houghton Mifflin Company, Boston New York. 432p.

Roseboom, D.P., T.E. Hill, J.D. Beardsley, J.A. Rodsater, L.T. Duong, R.B. Hilsabeck, R.P. Stowe, R.W. Sauer, D.M. Day, and J.A. Lesnak. 1992. Value of Instream Habitat Structures to Smallmouth Bass. Illinois State Water Survey Miscellaneous Publication 139, Champaign, IL. 72p.

Smogor, R. 2000. Draft Manual for Calculating Index of Biotic Integrity Scores for Streams in Illinois. Illinois Environmental Protection Agency, Springfield, Illinois. 23 p. + Appendices.

Schlosser, I.J. 1982. Fish Community Structure and Function Along Two Habitat Gradients in a Headwater Stream. *Ecological Monographs* 52(4):395-414.

Stewart-Oaten, A., W.W. Murdoch and K.R. Parker. 1986. Environmental Impact Assessment: "Pseudoreplication" in Time? *Ecology* 67:929-940.

Vetrano, D.M. 1988. Unit Construction for Trout Habitat Improvement Structures for Wisconsin Coulee Streams. Administrative Report No. 27, Wisconsin Department of Natural Resources, Madison, WI. 35p.

Wang, L, J. Lyons and P. Kanehl. 2002. Effects of Watershed Best Management Practices on Habitat and Fish in Wisconsin Streams. *J. Am. Water Res. Assoc.* 38:663-680.