Reintroduction of Mussels into the Upper Duck River, Tennessee

James B. Layzer and Mark E. Gordon

U.S. Fish and Wildlife Service, Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville

Abstract. Populations of indigenous freshwater mussels have declined drastically within the Tennessee River drainage. Two causal factors implicated in this decline are pollution and channel modifications for power, navigation, and recreation. Unexplained catastrophic die-offs in the upper Duck River have resulted in the virtual elimination of mussels from that section of the drainage. In May 1988, we initiated a study to determine the feasibility of reintroducing mussels into the upper Duck River, because natural recolonization from downstream is prevented by mill dams. A total of 1,213 mussels of eight species were collected from the lower river, permanently marked, and distributed uniformly throughout the transplant site. We did not observe any immediate mortality. Five months after transplant, mortality was estimated to be 6 to 8%. Results of annual quantitative sampling indicate that mussel density on the transplant site decreased by 80% over 3.5 years. Because we found few marked shells, mortality on the transplant site apparently has been low. Post-transplant changes in streambed elevations suggest that scouring during flood events was a major factor in the mussel decline. Finding live, marked mussels downstream of the site indicates downstream transport during high discharge.

Introduction

During the past century, mussel populations have declined dramatically throughout much of the Cumberland and Tennessee river systems (Ahlstedt 1986, Gordon and Layzer 1989). Many of these populations have been affected by municipal and industrial discharges, as well as poor land-use practices associated with agriculture, forestry, and surface mining of coal. The construction and operation of dams have directly contributed to the extinction of some species and jeopardized the existence of others (Layzer et al. 1993). The cumulative effect of these factors has been to isolate many populations of mussels. Although conditions in some previously degraded streams may have improved, natural recolonization is not possible because of fragmentation of mussel habitat (Layzer and Anderson 1992). Transplanting adult mussels into these streams may be an effective means of reestablishing populations. Similarly, relocating mussels may insure the survival of many species. In fact, the recovery plans for many endangered mussels include reestablishing populations within their historical range (e.g., U.S. Fish and Wildlife Service 1983). The objective of our study was to evaluate transplanting adult mussels as a means of reestablishing populations in the upper Duck River, Tennessee.

Study Area

The Duck River is a major tributary of the Tennessee River (Figure 1). Ortmann (1924) found an abundant and diverse mussel assemblage made up of both Cumberlandian and Ohioan species, and Starnes and Bogan (1988) list 68 taxa from the Duck River. In 1965, a rich mussel fauna persisted throughout most of the river (Isom and Yokley 1968). By 1972, however, mussels had nearly disappeared from the upper Duck River (van der Schalie 1973). Subse-

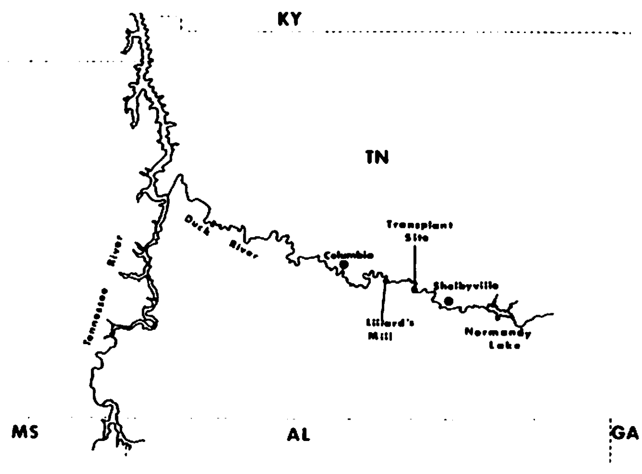

Figure 1. The Duck River, Tennessee.

quent surveys confirmed the scarcity of mussels upstream of Lillard's Mill (Ahlstedt 1981). The loss of mussels from the upper Duck River has been attributed to operation of Normandy Dam and to past discharges from Shelbyville (Ahlstedt 1986). Because water quality has improved in recent years, this river reach may once again be capable of supporting a rich mussel fauna. However, Lillard's Mill Dam is a barrier to fish movement. Thus, recolonization by mussels via glochidia-infected fish from downstream areas is not possible. Nonetheless, Barr et al. (1986) found a diverse fish community, including many known host species, upstream of Lillard's Mill.

Materials and Methods

On five days between 16 May and 1 June 1988, adult mussels were collected by hand from the Duck River downstream of Lillard's Mill and held in 6-mm-mesh dive bags submerged in the river at the collection site. All mussels were marked by filing a groove on the sides of both valves, placed in coolers, covered with ice, and transported to the transplant site. At the transplant site, mussels were inserted in a natural orientation into the substrate. We attempted to distribute the mussels evenly throughout a 432-m^2 area. Most mussels were transplanted the same day they were collected; on one occasion mussels were held overnight in the river.

At the time of the transplant, we established three permanent transects across the study site. We used standard surveying techniques to determine streambed elevations at 60-cm intervals along each transect. In July 1990, we resurveyed these transects to assess changes in channel morphology.

We used a stratified random sampling design to estimate the number of mussels remaining on the transplant site during each of four sampling periods. A random numbers table was used to generate a set of coordinates for each quadrat sample. Measuring tapes were then used to establish the locations of three sampling points within each 36-m^2 stratum. Samples were collected with the aid of scuba equipment. The substrate within each 1-m^2 quadrat was removed by hand to a depth of about 10 cm. After the entire quadrat was searched, the substrate was replaced, and all mussels collected were identified and examined for marks prior to being reinserted into the substrate encompassed by the quadrat frame. Mussels found partially within a quadrat were included in the count only if they occurred under the downstream or left side of the quadrat frame. On two occasions we made a qualitative search downstream of the transplant site.

Results

A total of 1,213 mussels of eight species were transplanted (Table 1). Five months after transplant, we estimated that 92% of the mussels were still living on the site. Because stream discharge remained low during this five-month period (Figure 2), shells of dead mussels would most likely have remained on the site. Thus, we made a second, independent estimate of mortality (6%) based on the number of dead, marked mussels found within each quadrat.

Although the two population estimates made in 1989 are very similar, the June sample may not be as reliable because only one-half of the site was sampled due to a rain event and rising water levels. Our estimates indicate that about 80% of the transplanted mussels remained on the site in October 1989. The population estimates we made in 1991 indicated that only 20% of the transplanted mussels remained on the site. Wide 95% confidence limits (± 50–70% of mean) were associated with all population

Table 1. Numbers of mussels transplanted in May 1988 and estimated number present at each sampling period.

Species	Number transplanted	Estimated number Oct. 1988	June 1989	Oct. 1989	Oct. 1991
Amblema plicata	197	180	227	120	10
Cyclonaias tuberculata	441	492	409	468	154
Fusconaia barnesiana	17			36	
Lexingtonia dolabelloides	102	72	45	48	29
Megalonaias nervosa	183	216	136	168	29
Quadrula cylindrica	20	12			
Quadrula pustulosa	142	84	91	108	29
Truncilla truncata	111	60	45	24	
Total	1,213	1,116	954	972	251

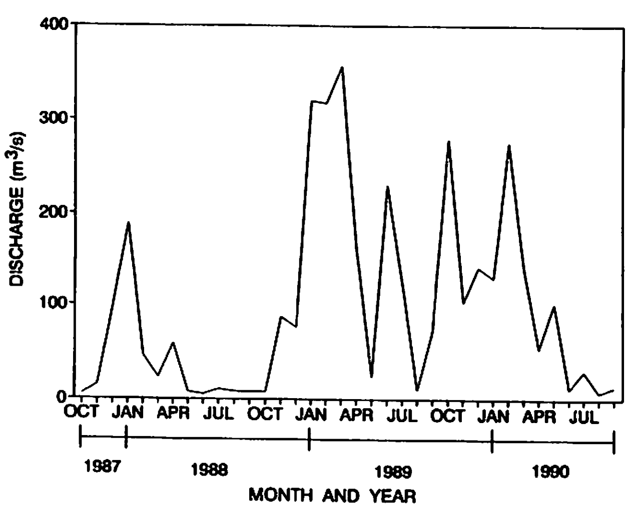

Figure 2. Maximum mean daily discharge of the Duck River near Shelbyville, Tennessee. Records were obtained from Lowery et al. (1989, 1990) and Flohr et al. (1991).

estimates. A Duncan's multiple range test indicated that only the final population estimate differed significantly ($P < 0.05$) from the number of mussels originally transplanted. Between October 1988 and October 1991, we found few dead, marked mussels on the site.

Mussel density estimates changed substantially within and among strata between 1988 and 1989 (Figure 3). Most of the upstream strata were nearly devoid of mussels in 1989. In contrast, mussel densities increased between 1988 and 1989 in all downstream strata.

In October 1989, we noted that substrate composition and water depth on the site had changed dramatically since the previous year. Results of resurveying streambed elevations along the three transects in July 1990 indicated major changes in channel morphology (Figure 4). As much as 85 cm of the gravel-sand substrate had degraded and exposed the underlying bedrock along much of the upper and middle transects. The downstream transect showed evidence of channel widening and aggradation.

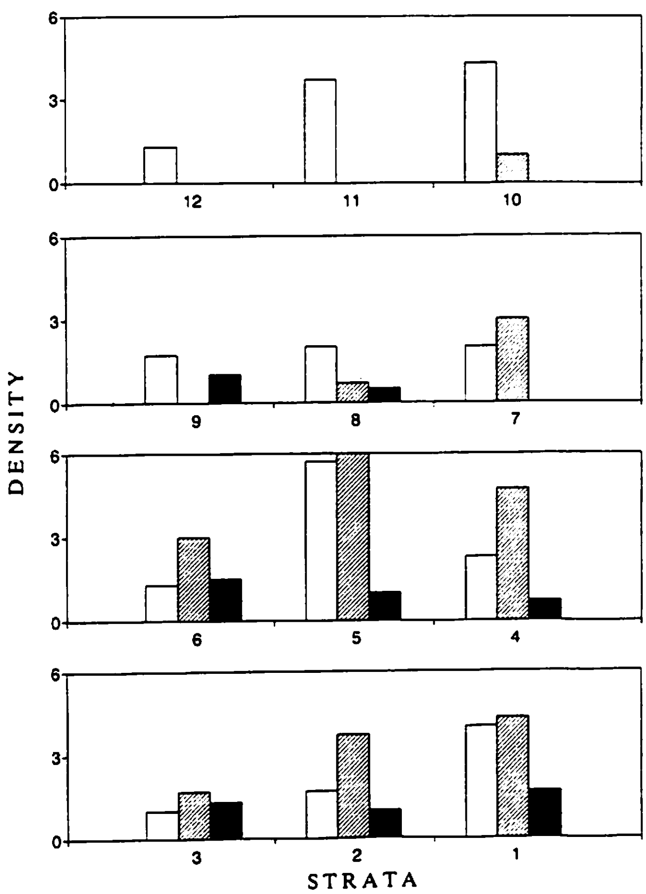

Figure 3. Estimated mussel densities (#/m²) in various strata. The most downstream strata are numbers 1 through 3. All estimates were made in October each year (open bars = 1988; hatched bars = 1989; solid bars = 1991).

From October 1988 through July 1992, we collected several live, unmarked mussels of eight species, including five species that we did not transplant (*Elliptio dilatata, Lampsilis cardium, L. fasciola, Villosa taeniata, V. vanuxemensis*). Most of the unmarked mussels appeared to be relatively young (< 10 years old). In fact, several individuals were less than five years old. During our qualitative searches downstream of the transplant site, we collected 14 live, marked mussels, including two 12-cm-long *M. nervosa* found about 600 m downstream of the site.

Discussion

Initial mortality of transplanted mussels was low. Five months after translocation, total mortality was estimated to be only 6 to 8%. Following this period of low mortality, the mussel population continued to decline at a similar rate; however, between October 1989 and October 1991, transplanted mussels declined precipitously. The scarcity of dead mussels on the site indicated that either mortality was low or empty valves were washed downstream. Prior to our first estimate of the size of the transplanted population, all of Tennessee had been under drought conditions, and flows in the Duck River were relatively low. Beginning in January 1989 and continuing for the remainder of our study, periodic high discharge events were common in the Duck River. Degradation of the stream channel was obvious at the transplant site. The initial discharges apparently dislodged mussels from the upstream sampling strata and transported them only as far as the downstream strata as evidenced by the increased densities in the lower strata in October 1989. Pre-

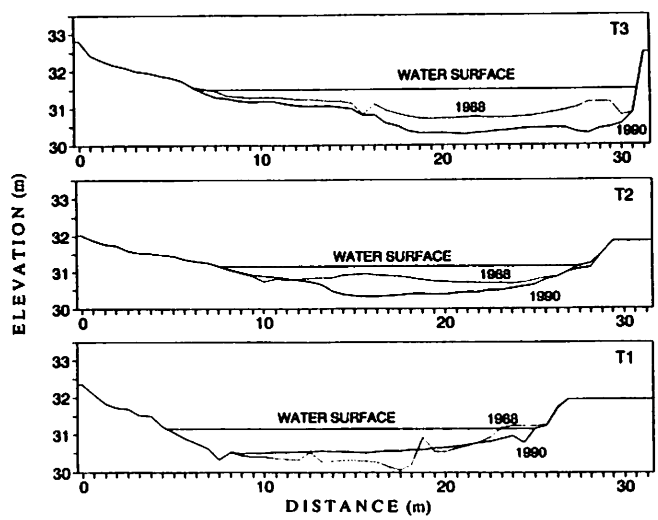

Figure 4. Stream channel cross-sections showing changes in streambed elevations between 1988 and 1990 at three transects on the transplant site. The most downstream transect is T1.

sumably, subsequent periods of high discharge washed the mussels further downstream and were responsible for the rapid reduction in the number of mussels on the transplant site. The fate of most of the dislodged mussels is unknown, but we found marked mussels living downstream of the transplant site. The occurrence of two large, marked *M. nervosa* 600 m downstream of the transplant site suggests that many of the smaller individuals were probably carried downstream considerably farther. Undoubtedly, some mortality of dislodged mussels occurred, but we believe that a substantial number survived.

Although we did not design our study to document reproduction of transplanted mussels, we did find evidence (individuals as small as 20 mm long) of recent recruitment for species not transplanted. Moreover, the recent recruitment of at least three Cumberlandian species is noteworthy because Cumberlandian species appear to be more sensitive than others to environmental perturbations.

The results of our study indicate that the Duck River from Lillard's Mill to the transplant site (25 km upstream) and preferably farther should be intensively studied. Emphasis should be placed on locating suitable mussel habitat that includes highly stable gravel substrates. Based on our experience, the presence of numerous relic shells should not be used as a reliable indicator of stable substrates. We believe that a massive infusion (10,000 to 20,000 individuals) of translocated mussels at one or more suitable sites would be successful in reestablishing mussels in this river reach.

Acknowledgments

We thank the many students and staff of the Tennessee Cooperative Fishery Research Unit for their assistance with various aspects of this project. We also thank Steven A. Ahlstedt and John J. Jenkinson and the field crew they supervised for providing many of the mussels transplanted. Funding for this study was provided by the U.S. Fish and Wildlife Service, Endangered Species Office, Asheville, North Carolina.

Literature Cited

Ahlstedt, S.A. 1981. The molluscan fauna of the Duck River between Normandy and Columbia dams in central Tennessee. Bulletin of the American Malacological Union for 1980:60–62.

Ahlstedt, S.A. 1986. Cumberlandian mollusk conservation program. Activity 1: Mussel distribution surveys. Tennessee Valley Authority, Office of Natural Resources and Economic Development. TVA/ONRED/AWR-86/15. 125 pp.

Barr, W.C., S.A. Ahlstedt, G.D. Hickman, and D.M. Hill. 1986. Cumberlandian mollusk conservation program. Activity 8: Analysis of macrofauna factors. Tennessee Valley Authority, Office of Natural Resources and Economic Development. TVA/ONRED/AWR-86/22. 96 pp.

Flohr, D.F., P.H. Counts, F.D. Edwards, and J.W. Garrett. 1991. Water resources data Tennessee, water year 1990. U.S. Geological Survey, USGA-WRD-TN 90-1. 259 pp.

Gordon, M.E., and J.B. Layzer. 1989. Mussels (Bivalvia: Unionoidea) of the Cumberland River: review of life histories and ecological relationships. U.S. Fish and Wildlife Service, Biological Report 89(15):1–99.

Isom, B.G., and P. Yokley, Jr. 1968. The mussel fauna of the Duck River in Tennessee, 1965. American Midland Naturalist 80(1):34–42.

Layzer, J.B., and R.M. Anderson. 1992. Impacts of the coal industry on rare and endangered aquatic organisms of the upper Cumberland River Basin. Final report to Kentucky Department of Fish and Wildlife Resources, and Tennessee Wildlife Resources Agency. 118 pp.

Layzer, J.B., M.E. Gordon, and R.M. Anderson. 1993. Mussels: The forgotten fauna of regulated rivers. A case study of the Caney Fork River. Regulated Rivers: Research & Management 8(1–2):63–71.

Lowery, J.F., P.H. Counts, F.D. Edwards, and J.W. Garrett. 1989. Water resources data Tennessee, water year 1988. U.S. Geological Survey, USGS-WRD-TN-88-1. 382 pp.

Lowery, J.F., P.H. Counts, F.D. Edwards, and J.W. Garrett. 1990. Water resources data Tennessee, water year 1989. U.S. Geological Survey, USGS-WRD-TN-89-1. 282 pp.

Ortmann, A.E. 1924. The naiad-fauna of Duck River in Tennessee. American Midland Naturalist 9(1):18–62.

Starnes, L.B., and A.E. Bogan. 1988. The mussels (Mollusca: Bivalvia: Unionidae) of Tennessee. American Malacological Bulletin 6(1):19–37.

U.S. Fish and Wildlife Service. 1983. Birdwing pearly mussel recovery plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 56 pp.

van der Schalie, H. 1973. The mollusks of the Duck River drainage in central Tennessee. Sterkiana 52:45–55.