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Changes in the Mussel Community of Ohio Brush Creek

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Abstract - The status of the mussel community of Ohio Brush Creek and its tributaries in southeastern Ohio was evaluated over a 17-year period. Species richness increased from 16 and 20 species found in 1996 and 1987, respectively, to 23 found in 2004. Despite the increase in species richness, the abundance of live and freshly dead shells declined, particularly for common species. Community structure changed from one dominated by a few abundant species to a more evenly distributed community composed of a greater number of species with lower abundances. Further work is needed to determine if changes in abundance are due to mortality, lack of recruitment, or are simply a reflection of variability in population size and sampling.

Introduction

Freshwater mussels (Order Unionoida) are one of North America's most threatened groups of organisms (Bogan 1993, Ricciardi and Rasmussen 1999). In North America, there are an estimated 264 species of freshwater mussels (Turgeon et al. 1998), 70 of which are federally listed as endangered or threatened in the United States (US Fish and Wildlife Service 1999). Of the 62 recognized native species or subspecies in Ohio, 14 are federally endangered, 27 are endangered in Ohio, and 11 are threatened or of special interest in the state (Watters 1995). Fourteen species of mussels known to have lived in Ohio waters are now extinct or extirpated (Watters 1995).

There are numerous threats to mussels, often acting simultaneously (Bogan 1993, Richter et al. 1997), although it is unlikely that factors affect species and life stages similarly (Miller and Payne 1998, Strayer and Fetterman 1999). Alteration of habitat and flow through impoundment and channelization have been shown to negatively impact certain species (Hardison and Layzer 2001, Vaughn and Taylor 1999, Watters 2000). Point and non-point pollution, including siltation and eutrophication from agriculture, are also threats (Richter et al. 1997). Some species may be at risk because of a decrease in the abundance of specific fish that serve as hosts during development. Introduced species, particularly *Dreissena polymorpha* (Pallas) (zebra mussels), pose a risk for some species (Ricciardi et al. 1998).

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In the present study, the mussel community of the Ohio Brush Creek was examined. Because it drains parts of three major geologic regions—the Interior Low Plateau, Appalachian Plateau, and Central Lowland—species richness is expected to be relatively high (Watters 1996). Numerous museum specimens and two previous surveys are available to assess the status

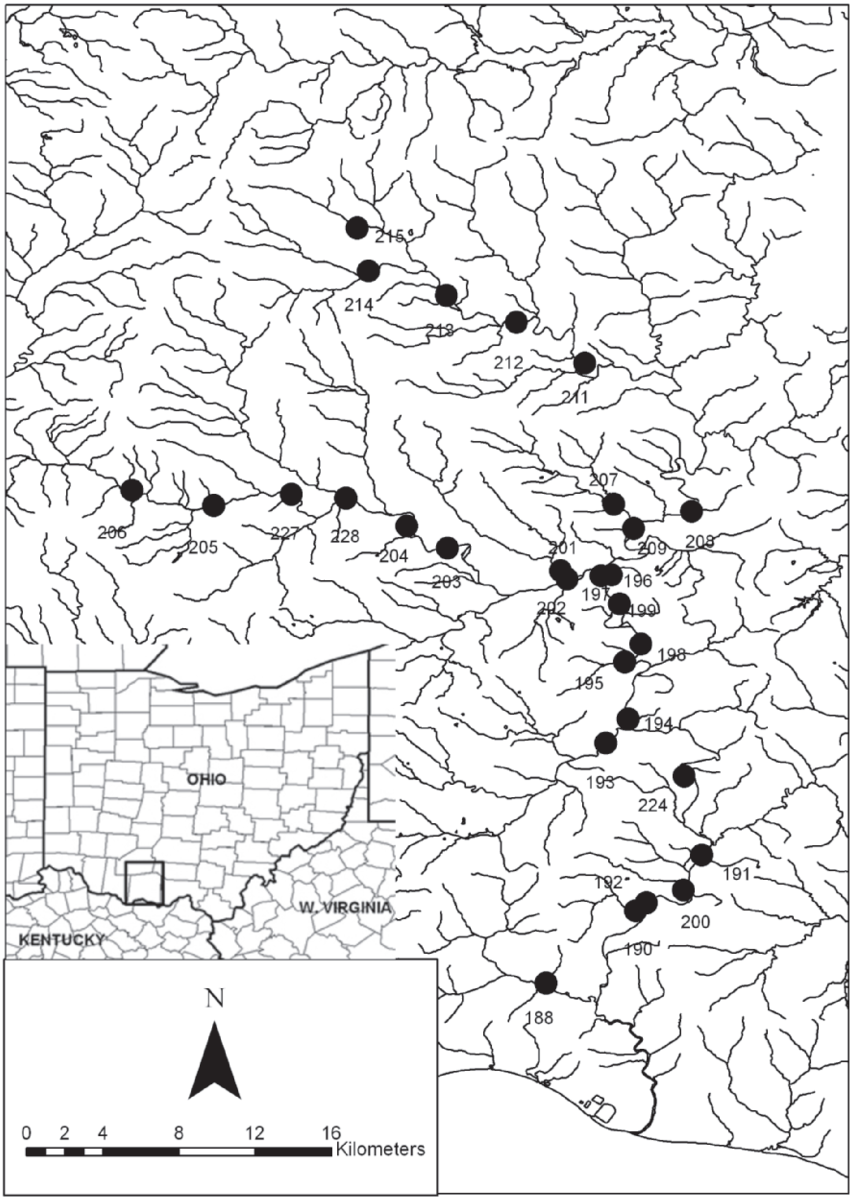

Figure 1. A drainage map showing study sites along the Ohio Brush Creek and its tributaries.

of the mussel community and changes in species composition and abundance over at least a 17-year period. Beyond determining the status of the mussel community, this work will serve as a baseline for future monitoring and provide comparative information for other streams.

Study Site

Ohio Brush Creek is a tributary of the Ohio River draining western Pike, southwestern Ross, south-central Highland, northeastern Brown, and central Adams Counties in Ohio (Fig. 1). Its total catchment area is 1131 km^2 (Watters 1992). The headwaters of the stream largely flow through agricultural land grading to predominantly forested land near the confluence with the Ohio River. A large portion of the watershed in the lower reaches is within the Edge of Appalachia Preserve system administered by The Nature Conservancy (TNC) and Cincinnati Museum Center (CMC). The stream has not been channelized or impounded to a great degree, although there are numerous low water fords and bank modifications for highway bridges.

Materials and Methods

During July of 2004, we surveyed 29 sites along the Ohio Brush Creek and its tributaries (Fig. 1). These sites were previously surveyed for mussels in 1987 and 1996 (Watters 1988, 1996). Because we could not obtain landowner permission, we were not able to census two sites visited in earlier work (sites 189 and 210). These sites and data were excluded from all analyses. To obtain comparable data, we used the same methods used in previous studies (G.T. Watters, Columbus, OH, pers. comm.). The channel and banks, including muskrat middens, were searched, and glass-bottomed buckets were used in deeper areas. At each site, a constant search effort of 1 person-hour was maintained. In general, we searched 50 m up and downstream; however, this distance varied with the nature of each site. Although these methods are not ideal for determining abundances (Strayer and Smith 2003), they should provide a good indication of change, provided observation probability is not more variable than any change.

For each site, we tallied the number of live mussels, fresh dead, and weathered shells of each species. As we often found dead and weathered shells as a lone valve, each single valve, as well as an intact individual, was counted as an "individual" for our analyses. Specimens were identified using the field guides of Cummings and Mayer (1992) and Watters (1995) with nomenclature conforming to Turgeon et al. (1998). We did not include peaclams (Family Sphaeriidae) or *Corbicula fluminea* (Müller) (Asian clam) in our surveys. Voucher specimens of dead shells were deposited at CMC.

Data analysis

Overall similarity in community composition between years was examined using Kendall's τ_b, a nonparametric rank-correlation test that includes ties in rank. For this analysis, we considered the abundance of the 22 species present as live or fresh dead specimens in at least one year. To compare species richness and mussel abundance, we examined the data in two ways, either structuring the data by site or by species. For data structured by sites, we tallied the number of species and the abundance of live and fresh dead individuals occurring at each site in each year. To structure the data by species, we tallied the number of sites in which a species occurred (distribution) and the mean abundance of that species in those occupied sites each year. We analyzed both data sets using generalized linear models with site or species as the subject and number of occurrences or mean abundance in each year as a repeated measure.

Results

We found 23 species of mussels in our survey, an increase from 16 and 20 species found in 1996 and 1987, respectively (Fig. 2). The results are

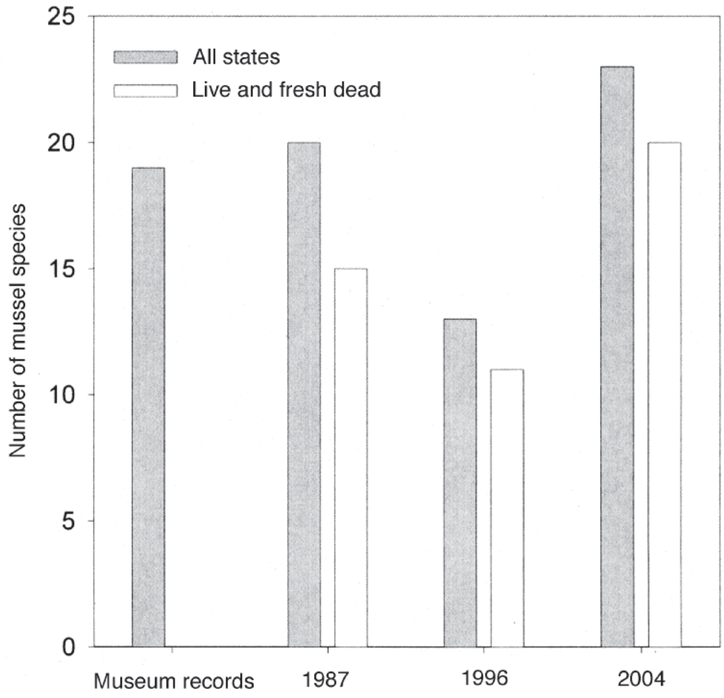

Figure 2. The number of mussel species found in museum records (OSU and CMC) and surveys conducted in 1987, 1996, and 2004. Data are shown separately for all specimens and for the combination of live mussels and fresh dead shells.

similar when restricting the data to live and fresh dead mussels and accounting for sample size. We found 20 species from a total sample of 416 live and fresh dead individuals. In 1996, 11 species were found in a sample of 252 live and fresh dead individuals; 15 species were found in a sample of 839 live and fresh dead individuals in 1987 (Fig. 2). The number of species found in the present survey is greater than the number found in museum records (Ohio State University and CMC), but is less than the 34 species found in any condition during irregular surveys conducted by staff from CMC's Edge of Appalachia Preserve since 2001. A total of 39 species of bivalves, including all sources and two introduced species, has been recorded for Ohio Brush Creek (Table 1).

Community structure varied among the surveys (Fig. 3). In 1996 and 1987, the samples of live and fresh dead mussels had different species richness, but a similar pattern of evenness. The 2004 survey showed a higher species richness than either previous survey, but a greater evenness of species due to a decrease in number of the most dominant species and low abundance of additional species.

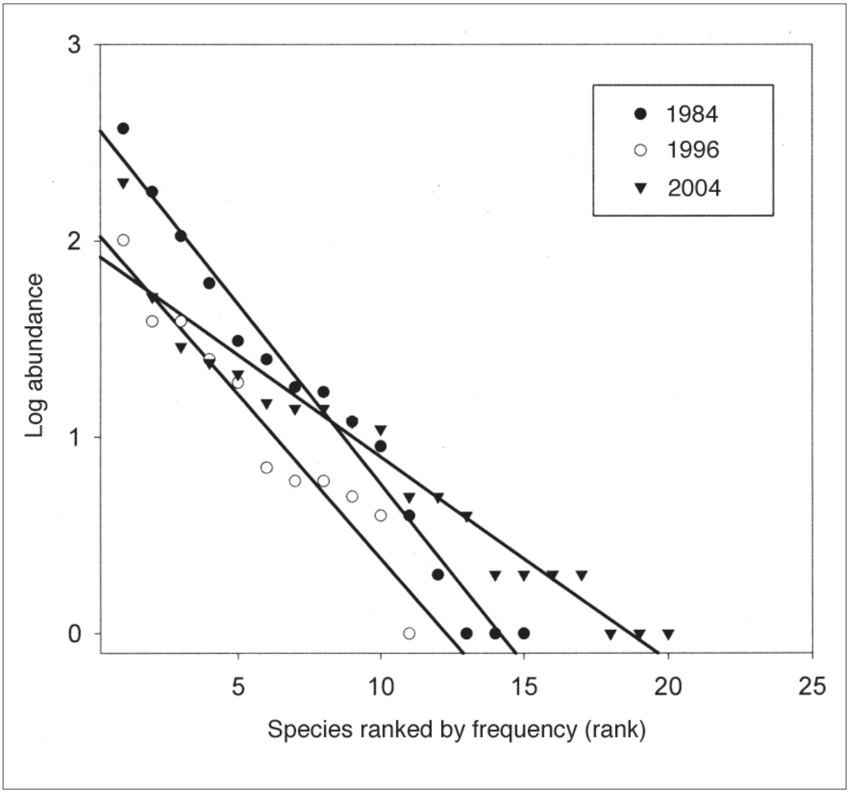

Figure 3. Log abundance plotted versus the rank of species abundance for 1987, 1996, and 2004. The most abundant species is rank one. Best fit lines for each year are shown for qualitative comparison.

Species composition was similar among all years. Similar to the plot of diversity, correlations were stronger between 1987 and 1996 ($\tau_b = 0.84$, N =

Table 1. Species of freshwater bivalves found in Ohio Brush Creek and its tributaries. Data shown are the number of sites in which a species was found and the mean abundance calculated for sites where the species was found. Data consist only of live individuals and fresh dead shells.

	Number of sites			Mean abundance		
Species	1987	1996	2004	1987	1996	2004
Family Unionidae						
Actinonaias ligamentina (Lamarck)	0	0	2			7.5
Amblema plicata (Say)	2	1	4	1.0	1.0	1.5
Anodontoides ferussacianus (Lea)	2	2	1	6.0	2.5	1.0
Cyclonaias tuberculata (Raf.)	0	0	2			1.0
Fusconaia flava (Raf.)	0	0	2			1.0
Lampsilis cardium Raf.	13	10	10	8.2	2.5	2.4
Lampsilis siliquoidea (Barnes)	21	16	19	17.8	6.3	10.5
Lampsilis teres (Raf.)	1	0	0	1.0		
Lasmigona complanata (Barnes)	5	2	6	5.0	3.5	1.8
Lasmigona costata (Raf.)	10	5	5	1.7	1.2	1.0
Leptodea fragilis (Raf.)	13	10	11	4.7	1.9	2.6
Ligumia recta (Lamarck)	0	0	1			1.0
Obliquaria reflexa (Raf.)	1	0	1	1.0		2.0
Potamilus alatus (Say)	13	8	13	13.7	4.9	4.0
Potamilus ohiensis (Raf.)	1	0	0	1.0		
Ptychobranchus fasciolaris (Raf.)	0	0	1			1.0
Pyganodon grandis (Say)	8	7	11	2.0	5.6	1.9
Quadrula quadrula (Raf.)	3	1	3	1.3	4.0	1.3
Strophitus undulatus (Say)	14	5	7	2.2	1.2	1.7
Tritogonia verrucosa (Raf.)	4	0	5	2.3		2.8
Truncilla donaciformis (Lea)	0	0	1			2.0
Truncilla truncata Raf.	0	0	6			2.3
Family Corbiculidae:						
Corbicula fluminea (Müller)	*Present but not quantified					

Other species recorded from Ohio Brush Creek in either museum records (OSU & CMC) or irregular surveys by CMC staff but not found live or fresh dead during this survey:

Family Unionidae
Alasmidonta viridis (Raf.)
Elliptio crassidens (Lamarck)
Epiobasma triquetra (Raf.)
Lampsilis ovata (Say)
Megalonaias nervosa (Raf.)
Obovaria subrotunda (Raf.)
Pleurobema clava (Lamarck)
Pleurobema cordatum (Raf.)
Pleurobema sintoxia (Raf.)
Quadrula cylindrica (Say)
Quadrula nodulata (Raf.)
Quadrula metanerva (Raf.)
Quadrula pustulosa (Lea)
Simpsonaias ambigua (Say)
Toxolasma parvus (Say)
Family Dreissenidae
Dreissena polymorpha (Pallas)

22, $P_{\text{two-tailed}} < 0.01$) than between 2004 and 1987 ($\tau_b = 0.54$, N = 22, $P_{\text{two-tailed}} < 0.01$) and between 2004 and 1996 ($\tau_b = 0.58$, N = 22, $P_{\text{two-tailed}} < 0.01$) . This change is due to both changes in abundance and changes in species composition. We found two species not present in previous published works or museum records for Ohio Brush Creek: *Ligumia recta* (black sandshell) and *Pleurobema cordatum* (Ohio pigtoe). The black sandshell was found as one fresh dead valve, while the three pigtoe specimens were found as weathered valves at three different sites. Live *L. recta* have been found in Ohio Brush Creek in sites not sampled here (F.J. Borrero and S.F. Matter, pers. observ.). We failed to find five species which were present in previous surveys or museum records: *Lampsilis teres* (yellow sandshell), *Megalonaias nervosa* (washboard), *Pleurobema clava* (Lamarck) (clubshell), *Potamilus ohiensis* (pink papershell), and *Quadrula cylindrica* (rabbitsfoot). We also failed to find *Alasmidonta viridis* (slippershell). This species was previously found only at one site which we could not resample in our survey. By far the most common species was *Lampsilis siliquoidea* (fatmucket). We found 199 specimens (either live or fresh dead), and this species was present at 19 of the 29 sites (Table 1). The next most numerous species was *Potamilus alatus* (pink heelsplitter) represented by 52 specimens. We found no zebra mussels in our survey; however, they are present in the lower reaches of Ohio Brush Creek (CMC C11940), and are established in the Ohio River (Ricciardi et al. 1998).

Examination of the data at the site level showed differences in the mean number of species among sites and years (Fig. 4). The number of species found per site varied by year ($F_{1.6,\ 43.8} = 7.69$, $P < 0.01$, n.b. degrees of freedom are modified by Greenhouse-Geisser epsilon, $\varepsilon = 0.73$), with significantly fewer species per site in 1996 than in 1987 ($P < 0.01$, Bonferroni adjusted multiple comparison) and in 2004 ($P = 0.03$). The mean number of species per site was the same in 1987 and 2004 ($P = 1.00$). Sites also differed in the mean number of species found ($F_{1,28} = 46.25$, $P < 0.01$).

The mean number of live and fresh dead mussels also varied by year ($F_{1.4,38.3} = 9.47$, $P < 0.01$, $\varepsilon = 0.68$) and site ($F_{1,28} = 28.84$, $P < 0.01$). Mussel abundance was significantly lower in 1996 than in 1987 ($P < 0.01$). No other comparisons between years showed a significant difference ($P > 0.05$), although numbers found in 2004 were almost half that found in 1987 ($P = 0.06$).

Examination of the data at the species level (Table 1) shows differences in the distribution and mean abundance of species. The distribution of species varied by year ($F_{2,42} = 10.44$, $P < 0.01$; data met the assumption of sphericity, $P = 0.14$). Species were more broadly distributed in 1987 (5.1 ± 6.2 [std. dev.] sites) and 2004 (5.1 ± 5.0) than in 1996 (3.1 ± 4.5; $P < 0.01$ for both comparisons). The mean distribution of species was the same in 1987 and 2004 ($P = 1.00$). There were also significant differences among species in their distributions ($F_{1,21} = 16.20$, $P < 0.01$). The mean abundance of species at sites where they were present declined from 4.6 ± 5.1 in 1987, to

2.9 ± 1.8 in 1996, to 2.6 ± 2.5 in 2004. Note that these data were ill-conditioned for repeated measures ANOVA. A comparison restricted to the 11 species present in all years shows significant differences in abundance among years ($F_{1.2, 51.0} = 5.05$, $P = 0.04$, $\varepsilon = 0.62$) and among species ($F_{1, 10} = 17.16$, $P < 0.01$). The mean abundance was significantly lower in 2004 than in 1987 ($P = 0.04$); however, no other between-year comparisons were significant ($P < 0.05$).

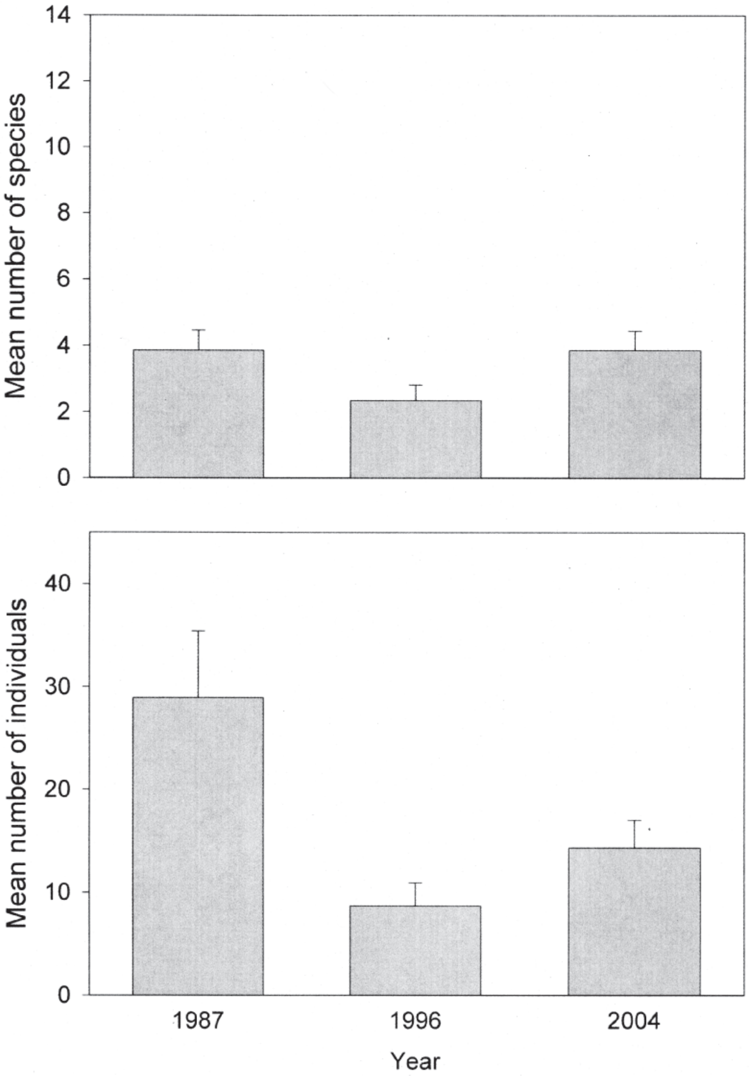

Figure 4. The mean number of species (top) and mussel abundance (bottom) per site. Data includes only live and fresh dead specimens. Means are shown ± standard error.

Discussion

Differences among the surveys affect the interpretation of the results. Although similar techniques and effort were used in all surveys, sampling dates and stream conditions varied among years. Surveys in 1987 were conducted in September and October during low-flow conditions. Finding mussels is relatively easy when stream flow is low. Surveys in 1996 were conducted in April, August, and September. During April and September of 1996 flow was high, reducing the probability of finding a mussel (Watters 1996). The survey in 2004 was conducted in July during relatively normal conditions for that time of year. Undoubtedly some of the year-to-year variation in the data is due to differences in stream conditions. Due to these sampling conditions, the data from 1987 is biased to show a greater abundance of individual species and higher species richness relative to 2004, while the 1996 data is biased to show lower numbers relative to 2004. This variation is in addition to the normal variation in finding specimens, which likely varies among species, sites, and years (Strayer and Smith 2003).

Interpreting the results in light of the biases in the data presents a mixed message on the status of mussels in Ohio Brush Creek. On the one hand, species richness for the stream appears to be stable, if not increasing. On the other hand, the abundance of several species, particularly species that were previously relatively widespread and abundant, appears to be decreasing. Mechanisms responsible for these changes in the mussel community are difficult to determine and are likely diverse. It is unlikely that the apparent increase in species richness is due to the colonization of the stream during the time between censuses, although this cannot be ruled out (Watters 1992). It is more probable that differences in the number of species result from changes in the relative abundance of species and sampling probability. Species that showed decreases in abundance did so across most sites, suggesting a mechanism or mechanisms acting at stream-wide scales. We did notice factors that may impact local sites, such as disturbance from bridge construction, gravel mining, and acute siltation. We also cannot rule out that changes in abundance simply reflect variability in populations or sampling probability.

The present mussel diversity of Ohio Brush Creek, 20 species (23 total bivalves), is less then the diversity of two other nearby, well-studied streams. Watters examined the mussel fauna of the Big Darby (1998a) and Fish Creek systems (1998b) in 1996 and compared them to previous surveys. He found 35 species (in any condition) in the Darby Creek system (Watters 1998a) and 25 species in the Fish Creek system (Watters 1998b). The Darby Creek system has perhaps the highest mussel diversity in the world for a stream of its size (Watters 1998a). Both streams showed a decrease of three species relative to previous surveys. Interestingly, Fish Creek showed a pattern of decrease in previously abundant species that is similar to that we note for Ohio Brush Creek (Watters 1998b). In broad comparison, the diversity of Ohio Brush Creek is high. Ohio Brush Creek has much higher diversity than the five species found in the highly degraded Cuyahoga River in Northeastern Ohio (Smith et al. 2002) and the 11 species found in the Upper Susquehanna River basin (Strayer and Fetterman 1999).

That we failed to find any *Pleurobema clava* in Ohio Brush Creek is of particular note, as this species is federally and state listed as endangered. It was last reported in the stream in 1987 as a weathered specimen (Watters 1988, 1996). While live individuals of this species are difficult to find (Badra 2001), the lack of any dead or weathered shells is suggestive of its decline or absence. We also did not find three species listed as endangered in Ohio which have previously been found in the stream: *Megalonaias nervosa*, *Quadrula cylindrica*, and *Lampsilis teres*. On a more positive note, we did find four Ohio threatened species: *Truncilla donaciformis* (fawnsfoot) and *Obliquaria reflexa* (threehorn wartyback) and two new species reported for Brush Creek in this survey—*Pleurobema cordatum* and *Ligumia recta*.

Overall, the mussel community of Ohio Brush Creek appears to be changing, progressing from a community dominated by a fewer species to a more evenly distributed community. Changes in the evenness (or dominance) of community structure have not been studied in as much detail as changes in species richness. Increases in community evenness are usually associated with a decrease in inter-specific competition or an increase in habitat complexity (Retana and Cerdá 2000). It is possible that such processes are occurring in Ohio Brush Creek; however, any process that decreases the abundance of dominant species and increases the abundance of rare species would increase evenness. More detailed study of the mussel community of Ohio Brush Creek is warranted. Mark-recapture work combined with size class structure would provide information to assess whether changes in abundance are due to adult survivorship, recruitment, or are simply a reflection of variability in population size and sampling.

Acknowlegdments

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