Long Term Resource Monitoring Program

Program Report

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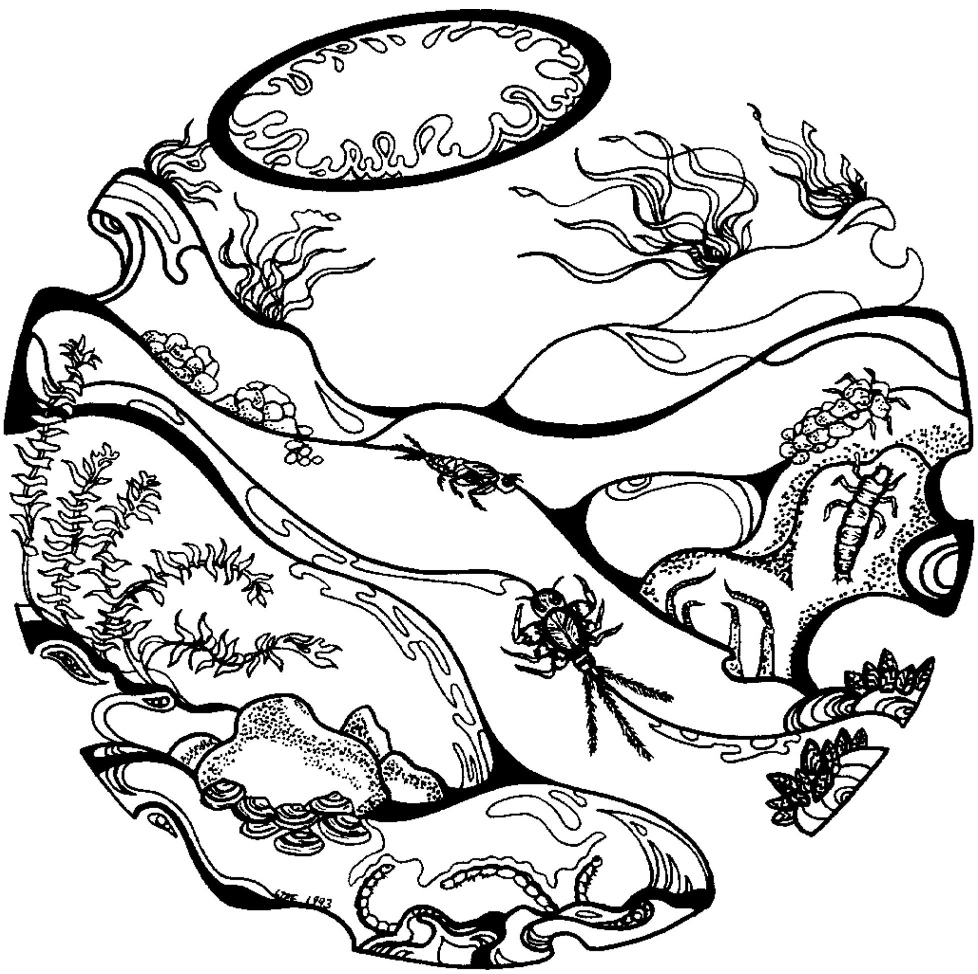
Annual Status Report, 1997: Macroinvertebrate Sampling



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Annual Status Report, 1997: Macroinvertebrate Sampling

by

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March 1998

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Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center, a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This document is an annual summary for 1997, containing a synthesis of target macroinvertebrate populations in the UMRS. This report satisfies, for 1997, Task 2.2.7.4, *Evaluate and Summarize Annual Results* under Goal 2, *Monitor Resource Change*, as specified in the Operating Plan for the Long Term Resource Monitoring Program (U.S. Fish and Wildlife Service 1993). This report was developed with funding provided by the Long Term Resource Monitoring Program.

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by

Jennifer S. Sauer

Abstract

In 1992, macroinvertebrate sampling was initiated in Pools 4, 8, 13, 26, and the Open River reach of the Mississippi River, and La Grange Pool of the Illinois River as part of the Long Term Resource Monitoring Program. This report summarizes the 1997 macroinvertebrate sampling. Long-term monitoring is needed to detect population trends and local changes in aquatic ecosystems. Mayflies (Ephemeroptera), fingernail clams (Sphaeriidae), and the exotic *Corbicula* species were selected for monitoring. Midges (Chironomidae) were added to the sampling design in 1993 and zebra mussels (*Dreissena polymorpha*) were added in 1995. Mayflies, fingernail clams, and midges, members of the soft-substrate community, were chosen because they play an important ecological role in the Upper Mississippi River System. Sampling was based on a stratified random design and was conducted at approximately 125 sites per study area. Mean densities of taxa were weighted by strata for extrapolation purposes. Pool 13 had the highest mean number of mayflies and fingernail clams (165 and 87 m^{-2}, respectively). Pool 4 reported the highest densities of midges (152 m^{-2}). Overall, the impounded areas, including Lake Pepin, and the contiguous backwaters tended to support the highest densities of mayflies, fingernail clams, and midges. Substrates with predominantly a silt clay constituent supported the highest mean densities of mayflies, fingernail clams, and midges.

Introduction

In 1986, Congress designated the Upper Mississippi River System (UMRS), which consists of the Upper Mississippi and Illinois Rivers and several important tributaries, as a nationally significant ecosystem and a nationally significant navigation system. In 1992, macroinvertebrate sampling was initiated in Pools 4, 8, 13, 26, the Open River reach of the Mississippi River, and La Grange Pool of the Illinois River as part of the Long Term Resource Monitoring Program (LTRMP). Mayflies (Ephemeroptera), fingernail clams (Sphaeriidae), and the exotic *Corbicula* species were selected for monitoring. Midges (Chironomidae) were added to the sampling design in 1993 and zebra mussels (*Dreissena polymorpha*) in 1995. These taxa, found in the soft-sediment substrate, were chosen because they play an important ecological role in the UMRS. The exotic *Corbicula* species and zebra mussels were chosen for sampling because of possible detrimental effects they may have on the economy and biology of the UMRS. Further background information can be found in Sauer (1996).

The objective of the LTRMP macroinvertebrate component is to annually monitor and report trends in the status and distribution of select macroinvertebrate populations. The publicly available data and annual status reports are the most basic LTRMP products. These annual status reports provide more detailed summaries of macroinvertebrate data than are included in trend report (Sauer 1998). The ultimate goal of the LTRMP is not simply to report status and trends, but to improve the understanding and management of the UMRS. That goal can best be achieved by the integration of routine monitoring with experimental research directed at identifying the causes of and solutions to specific problems. Future LTRMP studies will integrate more narrowly focused analyses of data from all LTRMP monitoring components (limnology, bathymetry, sediments, aquatic plants, and fisheries) with results of experimental studies to identify causes of problems and opportunities for improved management. The resulting syntheses will be the ultimate products of the LTRMP.

Methods

Sampling Procedures

The sampling of mayflies, fingernail clams, midges, *Corbicula* sp., and zebra mussels was conducted during 1997 in Pools 4, 8, 13, and 26 of the Mississippi River and La Grange Pool of the Illinois River (Figure 1). The Open River reach was not sampled in 1997 because of flooding.

Sampling was conducted at about 125 sites per study reach per year (Table 1; Figures 2–6). Sample allocation was based on several criteria: surface area of the aquatic area in each study reach, field station input on accessibility, and the productivity of the taxa in each aquatic area. All sites were sampled in spring 1997 (Table 2).

Sites included locations where benthic samples were collected historically and randomly selected sites distributed among key aquatic areas, which are based on enduring geomorphic features (Wilcox 1993): contiguous backwaters (BWC), areas that have apparent surface water connection with the rest of the river; main channel borders (MCB), the area between the navigational buoys and the riverbank—not including revetments and channel-training structures; impounded areas (IMP), areas that are large, mostly open-water areas located in the downstream portion of the navigational pools; and side channels (SC), channels that carry less flow than the navigational channel. For Pool 4, the "impounded" area is in the form of Lake Pepin, a tributary delta lake (TDL) formed by the Chippewa River. For the present report, only randomly selected sites are discussed.

The LTRMP developed a spatial database of aquatic areas (Owens and Ruhser 1996) on the basis of aerial photography made in 1989; this database is used for randomized selection of sampling sites and the quantification of sampling strata reported herein. Ongoing change detection requires that this database be updated at appropriate intervals. The LTRMP Operating Plan (U.S. Fish and Wildlife Service 1993) prescribes future repetition of aerial photography. Additionally, the LTRMP updates sampling maps, as needed, from direct observations made by the sampling crews.

Macroinvertebrate sampling procedures are described in detail in the LTRMP Procedures Manual (Thiel and Sauer 1995). Benthic samples were collected with a winch-mounted 23- × 23-cm (0.052-m^2) standard Ponar grab sampler (Ponar Grab Dredge, Wildlife Supply Company, Saginaw, Michigan). The sieve size of the Ponar wash frame was U.S. Standard no. 16 (1.18 mm). Thus, inferences in macroinvertebrate numbers made from the data for this report are restricted to the larger taxa of the population whole (i.e., adults). Mayflies, fingernail clams, midges (greater than 1 cm), *Corbicula* sp., and zebra mussels were counted and picked in the field.

Site Information

Substrate composition was noted according to subjective characterization. Six categories of substrate composition were used: hard clay, silt clay, silt clay with sand, sand with silt clay, sand, and gravel rock.

The percentage of submersed and floating-leaved aquatic vegetation in the column of water and sediment that the Ponar dredge fell through was recorded. Also, the type and percentage of vegetation and open water in a 15-m radius from the boat were characterized. Water depth was also measured at each site.

Quality Assurance

After the picking process was complete and only detritus and taxa other than mayflies, fingernail clams, midges, *Corbicula* sp., and zebra mussels were left, it was determined if the sample would be returned to the laboratory for quality assurance procedures (Norris and Georges 1992). Randomly selected samples from 10% of the sites (within each aquatic area) were returned to the laboratory. The results from laboratory-sorted samples were compared with those from samples sorted in the field to determine sorting efficiency.

Statistical Analyses

Total catch is recorded for each target taxa from individual Ponar samples. Whenever a species is not collected in a sample, the catch for that species in that sample is zero.

Analyses of densities in the present report are based on estimates of mean densities obtained by pooling data over all strata selected for macroinvertebrate sampling (Sauer 1998). In this way, the analyses track the broadest possible spatial scale in relative densities. The pooling probably presents a truer image of reachwide trends in densities because it does not rely only on particularly favorable habitats. If the quantity of preferred habitat declines through time while densities in those preferred habitats remains constant, then these pooled mean density statistics should also reflect that decline, whereas mean density statistics from only the preferred habitats would not. The LTRMP monitors both the composition of aquatic areas and macroinvertebrates. Therefore, if the quantity of that aquatic area class preferred by a particular species declines through time while the abundances within each aquatic area remain constant, then the pooled mean density statistics should also reflect the resulting decline in reachwide abundance, whereas mean density statistics from only the preferred aquatic area would not.

The estimates of pooled reachwide mean densities were obtained from the conventional design-based estimator for stratified random samples (Cochran 1977). For an arbitrary random variable denoted *y* (for this report *y* is densities), the pooled mean, denoted $\bar{y}_{st}$ (*st* for stratified) is given by

$$\bar{y}_{st} = \frac{1}{N} \sum_{h=1}^{L} N_h \bar{y}_h \qquad (1)$$

where N_h is the number of sampling sites within stratum *h*, $N = \sum_{h=1}^{L} N_h$, and $\bar{y}_h$ denotes the estimator of the sample mean of *y* for stratum *h*. The estimator of the variance of $\bar{y}_{st}$ is

$$s^2(\bar{y}_{st}) = \frac{1}{N^2} \sum_{h=1}^{L} N_h (N_h - n_h) \left(\frac{s_h^2}{n_h} \right) \qquad (2)$$

where

$$s_h^2 = \frac{\sum_{i=1}^{n_h} (y_{hi} - \bar{y}_h)^2}{n_h - 1}$$

is the usual estimator of the variance of y_h and n_h is the number of samples taken in stratum *h* (Cochran 1977). The standard error of $\bar{y}_{st}$ is therefore $s(\bar{y}_{st})$. For LTRMP macroinvertebrate monitoring, the sampling units are the 50-m^2 sampling grids.

Equation (1) is used to obtain estimates of overall mean densities for stratified random sampling. In random samples, equation (1) yields unbiased estimates of the pooled means regardless of the probability distribution of *y* (Cochran 1977).

Summary

- Measured depths at sampling sites ranged from 0.2 to 11.9 m with a mean of 2.4 m.

- In all study reaches, more than 80% of the Ponar grabs contained no submersed or floating-leaved vegetation (Table 3).

- The majority of samples taken in all reaches were in open water surrounded by little vegetation (Tables 4–7).

- Macroinvertebrate samples (*N* = 534) in 1997 produced a total of 2,088 mayflies, 908 fingernail clams, 1,941 midges, 1 *Corbicula* sp., and 3,723 zebra mussels.

- Mean densities of target taxa were weighted by strata selected for macroinvertebrate sampling (Sauer 1998) to estimate pool or reachwide means (Table 8). Pool 13 had the highest densities of mayflies and fingernail clams. Pool 4 had the highest estimated mean numbers of midges. Low numbers of *Corbicula* species were reported for all study reaches.

- Visual classification of sediments indicated that sample sites in Pools 4, 8, 13, 26, and La Grange Pool were dominated by silt clay (Table 9).

- The BWC aquatic areas in all study areas supported the highest numbers of mayflies (Table 10).

- Mean densities of fingernail clams were greatest in Lake Pepin (Pool 4) and the IMP area of Pool 13. The greatest densities of fingernail clams in La Grange Pool were found in the SC aquatic areas (Table 11).

- The BWC areas had the highest densities of midges in Pools 13, 26, and La Grange Pool. Pools 4 and 8 reported the greatest densities of midges in the IMP aquatic area (Table 12).

- Zebra mussel densities were highest in Pool 13 with one sample containing more than 1,600 individual mussels (Table 13). Zebra mussel densities are probably underestimated because of the sampling method.

- The silt clay substrate supported the highest mean numbers of mayflies in most study reaches, except in La Grange Pool where silt clay with sand supported the highest mean numbers (Table 14). The silt clay substrate also supported the highest mean number of fingernail clams in all study reaches, except Pool 8 (Table 15). The highest densities of midges were found in the silt clay substrates (Table 16). Although the silt clay substrate seems to enable burrowing, it still maintains its shape to allow for water movement and food uptake.

- More than 73% of the samples brought back to the laboratory for quality assurance had zero mayflies, whereas more than 80% of the samples had zero fingernail clams. Mean length for field-picked mayflies was 2.3 cm; fingernail clam mean length was 0.4 cm. Mean length was 1.2 cm in laboratory-picked mayflies and 0.4 cm in fingernail clams.

Acknowledgments

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References

Cochran, W. G. 1977. Sampling techniques. Third edition. John Wiley & Sons, New York. 428 pp.

Norris, R. H., and A. Georges. 1992. Analysis and interpretation of benthic macroinvertebrate surveys. Pages 234B286 *in* D. M. Rosenberg and V. H. Resh, editors. Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, New York.

Owens, T., and J. J. Ruhser. 1996. Long Term Resource Monitoring Program standard operating procedures: Aquatic areas database production. National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1996. LTRMP 95-P008-6. 4 pp. + Appendix (NTIS # PB96-172267)

Sauer, J. 1996. Annual status report: 1992 macroinvertebrate sampling. National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1996. LTRMP 96-P001. 18 pp. + Appendix A (NTIS # PB96-158860)

Sauer, J. 1998. Temporal analyses of select macroinvertebrates in the Upper Mississippi River System, 1992–1995. U.S. Geological Survey, Environmental Management Technical Center, Onalaska Wisconsin, April 1998. LTRMP 98-T001. 26 pp. + Appendix

Thiel, P. A., and J. S. Sauer. 1995. Long Term Resource Monitoring Program procedures: Macroinvertebrate monitoring. National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin, August 1995. LTRMP 95-P002-2. 9 pp. + Appendixes A–G

U.S. Fish and Wildlife Service. 1993. Operating Plan for the Upper Mississippi River System Long Term Resource Monitoring Program. Environmental Management Technical Center, Onalaska, Wisconsin, Revised September 1993. EMTC 91-P002R. 179 pp. (NTIS #PB94-160199)

Wilcox, D. B. 1993. An aquatic habitat classification system for the Upper Mississippi River System. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, May 1993. EMTC 93-T003. 9 pp. + Appendix A (NTIS # PB93-208981)

Table 1. Macroinvertebrate random sample sites by study reach and aquatic area. Numbers in parentheses are historical (fixed) sites.

Study reach	Contiguous backwater	Impounded	Side channel	Main channel border
Pool 4	55 (3)	44 (1)[a]	10	11
Pool 8	34 (3)	49 (11)	19 (2)	10
Pool 13	43 (2)	46 (1)	14 (4)	15
Pool 26	12	28	30 (3)	15 (4)
La Grange Pool	24 (18)	—	35 (7)	40 (1)

[a]Pool 4 Impounded = Lake Pepin, Tributary Delta Lake.

Table 2. Sampling dates for 1997 macroinvertebrate sampling.

Study reach	Beginning date	Ending date
Pool 4	May 5	May 14
Pool 8	May 27	June 4
Pool 13	May 19	May 30
Pool 26	May 21	May 30
La Grange Pool	April 29	May 8

Table 3. Number of sites, reported as percentages, with submersed and floating-leaved vegetation in the column of water and sediment that the Ponar fell through. *N* = number of samples.

	Vegetation present				
Study reach (*N*)	0%	1%–20%	21%–50%	51%–90%	91%–100%
Pool 4 (120)	93.3	5.8	—	0.8	—
Pool 8 (112)	82.1	16.1	0.9	0.9	—
Pool 13 (118)	80.5	19.5	—	—	—
Pool 26 (85)	100.0	—	—	—	—
La Grange Pool (99)	100.0	—	—	—	—

Table 4. Number of sites, reported as percentages, with submersed vegetation within a 15-m radius from the boat. *N* = number of samples.

	Vegetation present				
Study reach (*N*)	**0%**	**1%–20%**	**21%–50%**	**51%–90%**	**91%–100%**
Pool 4 (120)	98.3	1.7	—	—	—
Pool 8 (112)	83.0	12.5	3.6	0.9	—
Pool 13 (118)	79.7	19.5	0.8	—	—
Pool 26 (85)	100.0	—	—	—	—
La Grange Pool (99)	100.0	—	—	—	—

Table 5. Number of sites, reported as percentages, with floating-leaved vegetation within a 15-m radius from the boat. *N* = number of samples.

	Vegetation present				
Study reach (*N*)	**0%**	**1%–20%**	**21%–50%**	**51%–90%**	**91%–100%**
Pool 4 (120)	100.0	—	—	—	—
Pool 8 (112)	87.5	12.5	—	—	—
Pool 13 (118)	96.6	3.4	—	—	—
Pool 26 (85)	100.0	—	—	—	—
La Grange Pool (99)	100.0	—	—	—	—

Table 6. Number of sites, reported as percentages, with emergent vegetation within a 15-m radius from the boat. *N* = number of samples.

	Vegetation present				
Study reach (*N*)	**0%**	**1%–20%**	**21%–50%**	**51%–90%**	**91%–100%**
Pool 4 (120)	91.7	3.3	4.2	0.8	—
Pool 8 (112)	90.2	9.8	—	—	—
Pool 13 (118)	98.3	1.7	—	—	—
Pool 26 (85)	98.8	1.2	—	—	—
La Grange Pool (99)	100.0	—	—	—	—

Table 7. Number of sites, reported as percentages, with open water within a 15-m radius from the boat. *N* = number of samples.

	Open water present				
Study reach (*N*)	**0%**	**1%–20%**	**21%–50%**	**51%–90%**	**91%–100%**
Pool 4 (120)	—	—	0.8	14.2	85.0
Pool 8 (112)	—	0.9	—	5.4	93.8
Pool 13 (118)	1.7	—	—	—	98.3
Pool 26 (85)	—	—	—	1.2	98.8
La Grange Pool (99)	—	—	—	—	100.0

Table 8. Reachwide estimated mean number of mayflies, fingernail clams, midges, *Corbicula* sp., and zebra mussels per square meter by year and study area, weighted by areas of strata. Numbers in parentheses are ±1 standard error. *N* = number of samples.

Study area and year (*N*)	Mayflies (m^{-2})	Fingernail clams (m^{-2})	Midges (m^{-2})	*Corbicula* sp. (m^{-2})	Zebra mussels (m^{-2})
Pool 4					
1992 (122)	59 (±18.2)	47 (±18.5)	—	0 (±0.03)	—
1993 (121)	128 (±36.2)	74 (±10.8)	317 (±39.0)	0 (±0.0)	—
1994 (126)	203 (±50.0)	88 (±12.2)	184 (±32.5)	0 (±0.1)	—
1995 (120)	178 (±35.9)	61 (±13.3)	81 (±13.9)	0 (±0.0)	27 (±27.2)
1996 (121)	132 (±33.9)	39 (±7.3)	38 (±11.5)	0 (±0.0)	116 (±113.3)
1997 (120)	69 (±20.7)	76 (±8.7)	152 (±35.0)	0 (±0.0)	31 (±27.5)
Pool 8					
1992 (109)	51 (±24.6)	15 (±11.4)	—	0 (±0.0)	—
1993 (109)	118 (±40.9)	22 (±11.0)	50 (±9.4)	0 (±0.0)	—
1994 (110)	86 (±27.6)	11 (±5.0)	27 (±15.8)	0 (±0.0)	—
1995 (109)	55 (±14.2)	6 (±3.0)	11 (±3.9)	0 (±0.0)	0.2 (±0.2)
1996 (109)	38 (±11.2)	2 (±0.9)	15 (±4.1)	0 (±0.0)	1 (±0.4)
1997 (112)	71 (±16.4)	9 (±3.6)	26 (±6.3)	0 (±0.0)	25 (±11.1)
Pool 13					
1992 (118)	120 (±30.5)	84 (±27.6)	—	0 (±0.0)	—
1993 (119)	155 (±39.3)	2,596 (±494.3)	509 (±94.8)	0 (±0.2)	—
1994 (125)	194 (±35.8)	594 (±156.5)	75 (±34.1)	0 (±0.0)	—
1995 (118)	182 (±51.7)	276 (±81.9)	40 (±9.4)	0 (±0.0)	10 (±6.8)
1996 (118)	147 (±38.0)	231 (±58.2)	21 (±7.0)	0 (±0.0)	14 (±8.2)
1997 (118)	165 (±42.5)	87 (±23.1)	79 (±36.0)	0 (±0.0)	562 (±448.3)
Pool 26					
1992 (117)	21 (±9.5)	15 (±9.4)	—	2 (±1.1)	—
1993 (66)	7 (±1.9)	1 (±0.5)	10 (±2.1)	0 (±0.0)	—
1994 (124)	21 (±6.3)	5 (±2.9)	14 (±7.7)	1 (±0.7)	—
1995 (69)[a]	—	—	—	—	—
1996 (112)	13 (±10.4)	0 (±0.1)	18 (±8.5)	0 (±0.0)	0.3 (±0.3)
1997 (85)	16 (±7.9)	1 (±0.7)	13 (±6.1)	0 (±0.0)	1 (±1.2)
Open River					
1992 (92)	22 (±12.0)	5 (±3.4)	—	1 (±0.6)	—
1993[b]	—	—	—	—	—
1994 (84)	19 (±8.6)	1 (±0.5)	8 (±3.6)	2 (±1.2)	—
1995 (112)	12 (±5.5)	0 (±0.0)	14 (±5.0)	2 (±1.1)	2 (±2.0)
1996 (107)	11 (±6.1)	0 (±0.0)	5 (±2.4)	1 (±0.8)	0 (±0.2)
1997[b]	—	—	—	—	—
La Grange Pool					
1992 (102)	13 (±6.3)	4 (±2.4)	—	0 (±0.4)	—
1993 (98)	11 (±4.8)	17 (±9.5)	52 (±14.3)	0 (±0.0)	—
1994 (126)	27 (±8.5)	51 (±12.5)	57 (±9.9)	10 (±2.9)	—
1995 (98)	6 (±3.5)	15 (±8.2)	32 (±12.1)	1 (±0.7)	9.0 (±9.0)
1996 (98)	4 (±1.5)	5 (±2.7)	150 (±49.7)	1 (±0.7)	0.4 (±0.4)
1997 (99)	8 (±3.3)	9 (±4.8)	101 (±33.0)	0 (±0.03)	0 (±0.0)

[a]No reachwide estimate because of low sample size.
[b]Not sampled because of flooding.

Table 9. Percentage of predominant substrate type found in Ponar grab samples by study reach. *N* = number of samples.

Study reach (*N*)	Predominant substrate (%)					
	Hard clay	Silt clay	Silt clay with sand	Sand with silt clay	Sand	Gravel rock
Pool 4 (120)	0.8	60.8	10.8	0.8	21.7	4.2
Pool 8 (112)	0.9	34.8	14.3	31.3	18.8	—
Pool 13 (118)	—	55.9	10.2	15.3	18.6	—
Pool 26 (85)	2.4	48.2	7.1	2.4	37.6	2.4
La Grange Pool (99)	9.1	27.3	24.2	18.2	20.2	1.0

Table 10. Mean number of mayflies per square meter by study reach and aquatic area. *N* = number of samples.

Study reach (*N*)	Aquatic area			
	BWC[a] (±1 SE)	MCB[b] (±1 SE)	IMP[c] (±1 SE)	SC[d] (±1 SE)
Pool 4 (120)	80.1 (±19.3)	3.5 (±2.3)	75.6 (±23.7)[e]	0.0 (±0.0)
Pool 8 (112)	86.5 (±21.6)	5.8 (±5.8)	82.0 (±15.4)	52.6 (±17.1)
Pool 13 (118)	235.2 (±42.7)	88.5 (±42.9)	138.4 (±29.7)	153.8 (±91.6)
Pool 26 (85)	120.2 (±40.0)	0.0 (±0.0)	53.6 (±16.5)	17.3 (±15.4)
La Grange Pool (99)	14.4 (±6.5)	4.3 (±1.9)	—	12.1 (±3.4)

[a]BWC = contiguous backwater.
[b]MCB = main channel border.
[c]IMP = impounded.
[d]SC = side channel.
[e]Pool 4 IMP = Lake Pepin, Tributary Delta Lake.

Table 11. Mean number of fingernail clams per square meter by study reach and aquatic area. *N* = number of samples.

Study reach (*N*)	Aquatic area			
	BWC[a] (±1 SE)	MCB[b] (±1 SE)	IMP[c] (±1 SE)	SC[d] (±1 SE)
Pool 4 (120)	5.2 (±1.5)	5.2 (±5.2)	102.7 (±11.2)[e]	1.9 (±1.9)
Pool 8 (112)	9.9 (±2.4)	13.5 (±9.1)	3.5 (±1.3)	17.2 (±8.4)
Pool 13 (118)	101.5 (±21.2)	23.1 (±10.5)	110.8 (±29.3)	33.0 (±20.2)
Pool 26 (85)	4.8 (±3.5)	0.0 (±0.0)	7.6 (±3.9)	1.3 (±1.3)
La Grange Pool (99)	21.6 (±12.1)	3.4 (±1.5)	—	11.0 (±3.7)

[a]BWC = contiguous backwater.
[b]MCB = main channel border.
[c]IMP = impounded.
[d]SC = side channel.
[e]Pool 4 IMP = Lake Pepin, Tributary Delta Lake.

Table 12. Mean number of midges per square meter by study reach and aquatic area. *N* = number of samples.

	Aquatic area			
Study reach (*N*)	**BWC[a] (±1 SE)**	**MCB[b] (±1 SE)**	**IMP[c] (±1 SE)**	**SC[d] (±1 SE)**
Pool 4 (120)	80.8 (±20.0)	7.0 (±7.0)	189.7 (±43.0)[e]	1.9 (±1.9)
Pool 8 (112)	19.8 (±6.6)	5.8 (±5.8)	39.2 (±6.5)	10.1 (±5.8)
Pool 13 (118)	212.9 (±98.9)	10.3 (±9.0)	18.8 (±5.9)	0.0 (±0.0)
Pool 26 (85)	105.8 (±46.1)	6.4 (±3.6)	39.8 (±11.2)	0.0 (±0.0)
La Grange Pool (99)	187.5 (±57.7)	63.9 (±22.0)	—	54.9 (±27.1)

[a]BWC = contiguous backwater.
[b]MCB = main channel border.
[c]IMP = impounded.
[d]SC = side channel.
[e]Pool 4 IMP = Lake Pepin, Tributary Delta Lake.

Table 13. Mean number of zebra mussels per square meter by study reach and aquatic area. *N* = number of samples.

	Aquatic area			
Study reach (*N*)	**BWC[a] (±1 SE)**	**MCB[b] (±1 SE)**	**IMP[c] (±1 SE)**	**SC[d] (±1 SE)**
Pool 4 (120)	2.8 (±1.9)	673.1 (±602.7)	0.9 (±0.9)[e]	7.7 (±5.9)
Pool 8 (112)	3.0 (±1.5)	5.8 (±4.1)	36.9 (±14.9)	29.4 (±17.2)
Pool 13 (118)	2.2 (±1.5)	1,761.5 (±1141.4)	754.6 (±684.6)	6.9 (±5.6)
Pool 26 (85)	0.0 (±0.0)	1.3 (±1.3)	0.0 (±0.0)	1.9 (±1.4)
La Grange Pool (99)	0.0 (±0.0)	0.0 (±0.0)	—	0.0 (±0.0)

[a]BWC = contiguous backwater.
[b]MCB = main channel border.
[c]IMP = impounded.
[d]SC = side channel.
[e]Pool 4 IMP = Lake Pepin, Tributary Delta Lake.

Table 14. Mean number of mayflies per square meter by study reach and predominant substrate type. *N* = number of samples.

Study reach (*N*)	Predominant substrate					
	Hard clay (±1 SE)	Silt clay (±1 SE)	Silt clay with sand (±1 SE)	Sand with silt clay (±1 SE)	Sand (±1 SE)	Gravel rock (±1 SE)
Pool 4 (120)	19.2	96.7 (±18.6)	51.8 (±39.7)	0.0	0.0 (±0.0)	3.8 (±3.8)
Pool 8 (112)	0.0	151.4 (±21.1)	68.5 (±20.5)	23.6 (±6.7)	9.2 (±7.3)	—
Pool 13 (118)	—	278.3 (±35.0)	83.3 (±37.5)	32.1 (±17.5)	0.9 (±0.9)	—
Pool 26 (85)	0.0 (±0.0)	83.0 (±19.2)	9.6 (±9.6)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)
La Grange Pool (99)	0.0 (±0.0)	15.0 (±5.8)	16.8 (±4.5)	3.2 (±2.3)	3.8 (±2.6)	0.0

Table 15. Mean number of fingernail clams per square meter by study reach and predominant substrate type. *N* = number of samples.

Study reach (*N*)	Predominant substrate					
	Hard clay (±1 SE)	Silt clay (±1 SE)	Silt clay with sand (±1 SE)	Sand with silt clay (±1 SE)	Sand (±1 SE)	Gravel rock (±1 SE)
Pool 4 (120)	134.6	60.3 (±8.7)	11.8 (±7.4)	19.2	0.7 (±0.7)	0.0 (±0.0)
Pool 8 (112)	0.0	10.8 (±3.4)	16.8 (±5.9)	3.4 (±1.9)	7.3 (±5.5)	—
Pool 13 (118)	—	132.0 (±23.1)	83.3 (±32.7)	29.9 (±12.4)	0.9 (±0.9)	—
Pool 26 (85)	0.0 (±0.0)	6.6 (±2.8)	6.4 (±6.4)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)
La Grange Pool (99)	6.4 (±3.2)	20.7 (±10.8)	13.6 (±5.2)	3.2 (±2.3)	1.9 (±1.3)	0.0

Table 16. Mean number of midges per square meter by study reach and predominant substrate type. *N* = number of samples.

Study reach (*N*)	Predominant substrate					
	Hard clay (±1 SE)	Silt clay (±1 SE)	Silt clay with sand (±1 SE)	Sand with silt clay (±1 SE)	Sand (±1 SE)	Gravel rock (±1 SE)
Pool 4 (120)	76.9	158.9 (±29.7)	63.6 (±17.9)	0.0	8.1 (±5.2)	0.0 (±0.0)
Pool 8 (112)	0.0	42.9 (±8.0)	28.8 (±10.2)	16.4 (±4.8)	5.8 (±4.2)	—
Pool 13 (118)	—	149.2 (±65.1)	6.4 (±4.9)	13.9 (±9.6)	0.0 (±0.0)	—
Pool 26 (85)	0.0 (±0.0)	58.2 (±15.9)	9.6 (±9.6)	0.0 (±0.0)	1.2 (±1.2)	0.0 (±0.0)
La Grange Pool (99)	74.8 (±30.1)	171.7 (±51.9)	68.1 (±40.0)	68.4 (±38.9)	40.4 (±22.7)	0.0 (±0.0)

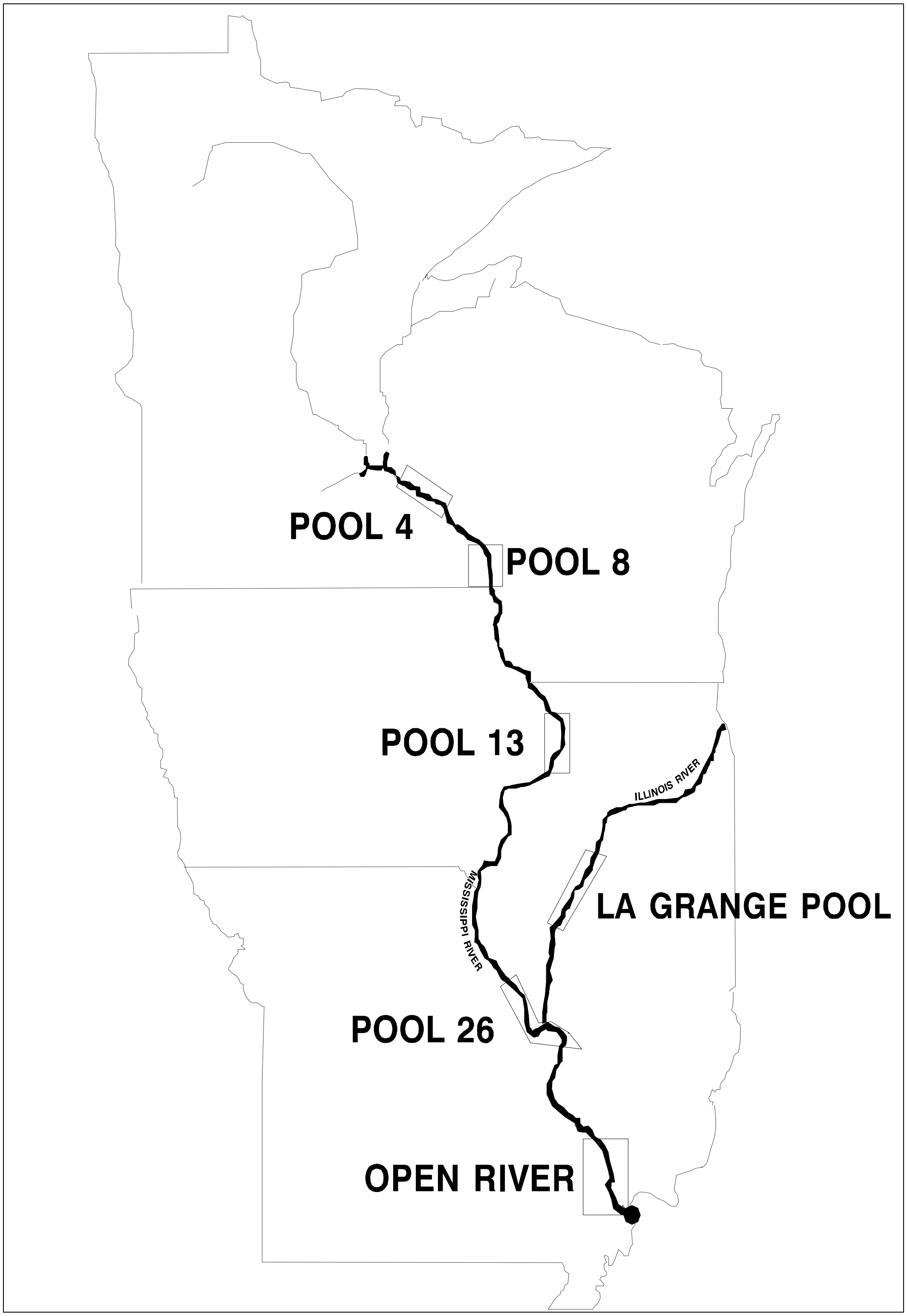

Figure 1. Long Term Resource Monitoring Program study reaches for macroinvertebrate sampling.

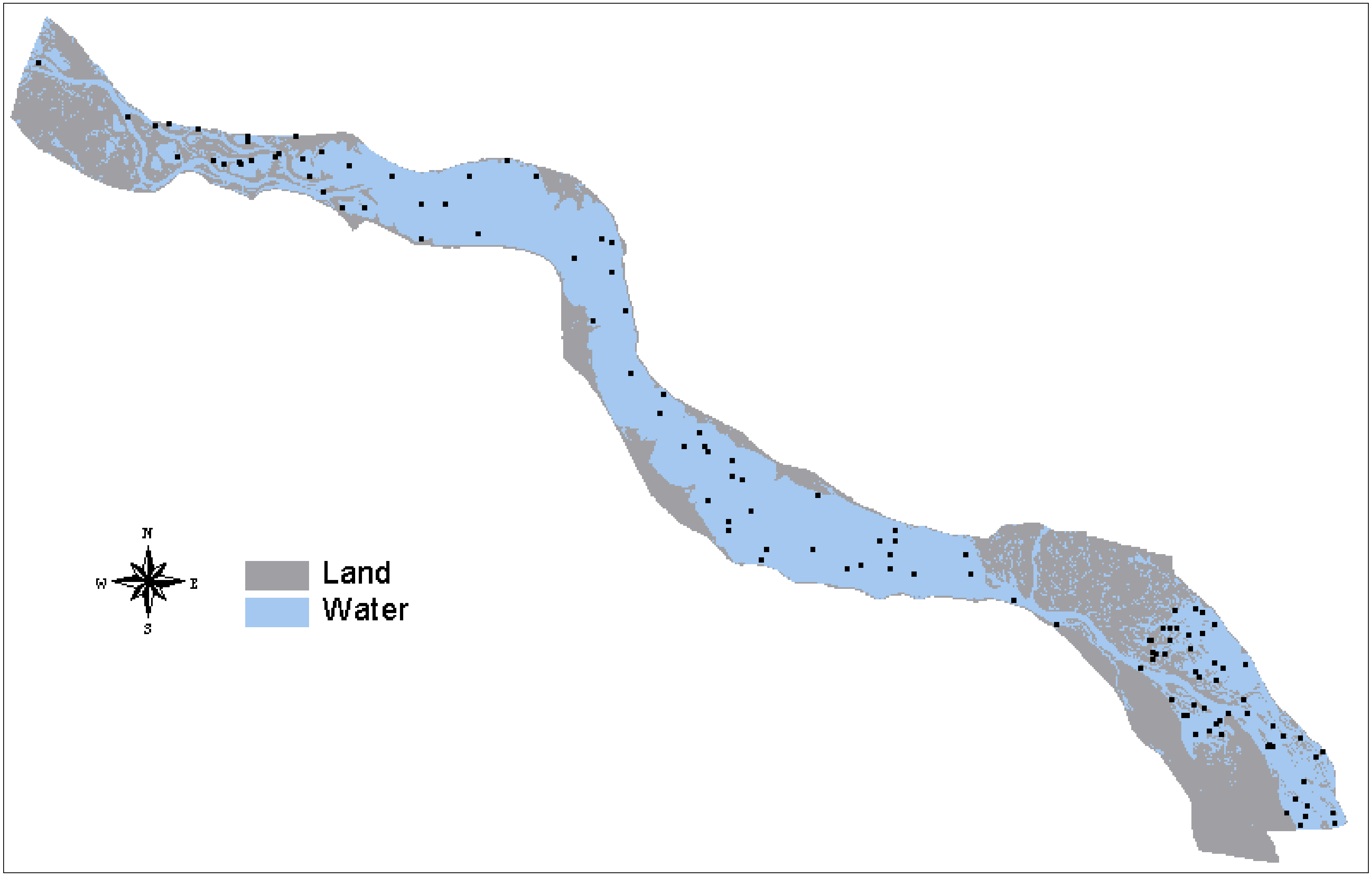

Figure 2. Pool 4 (river miles 753–797)—1997 Long Term Resource Monitoring Program macroinvertebrate random sample points.

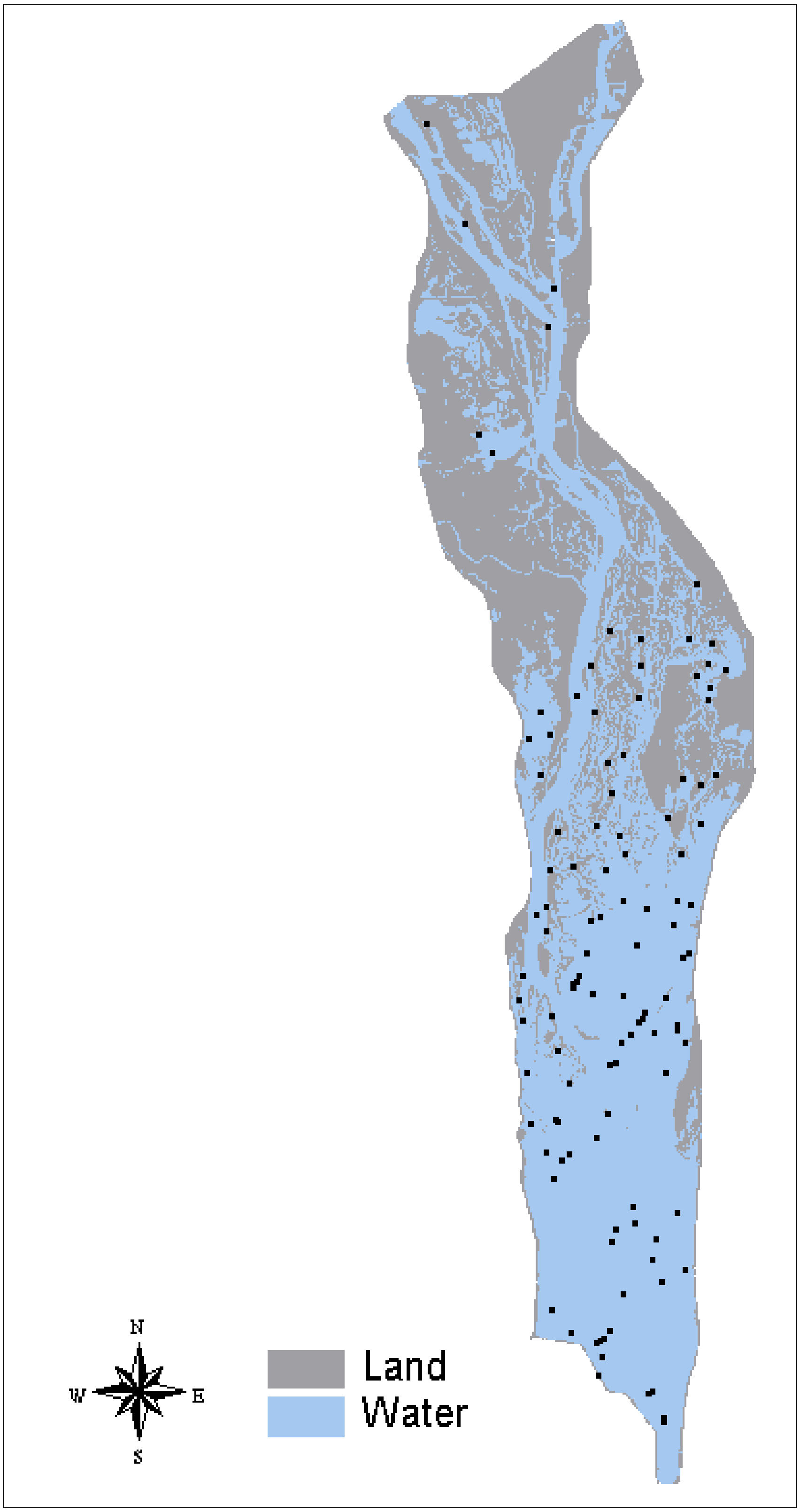

Figure 3. Pool 8 (river miles 679–703)—1997 Long Term Resource Monitoring Program macroinvertebrate random sample points.

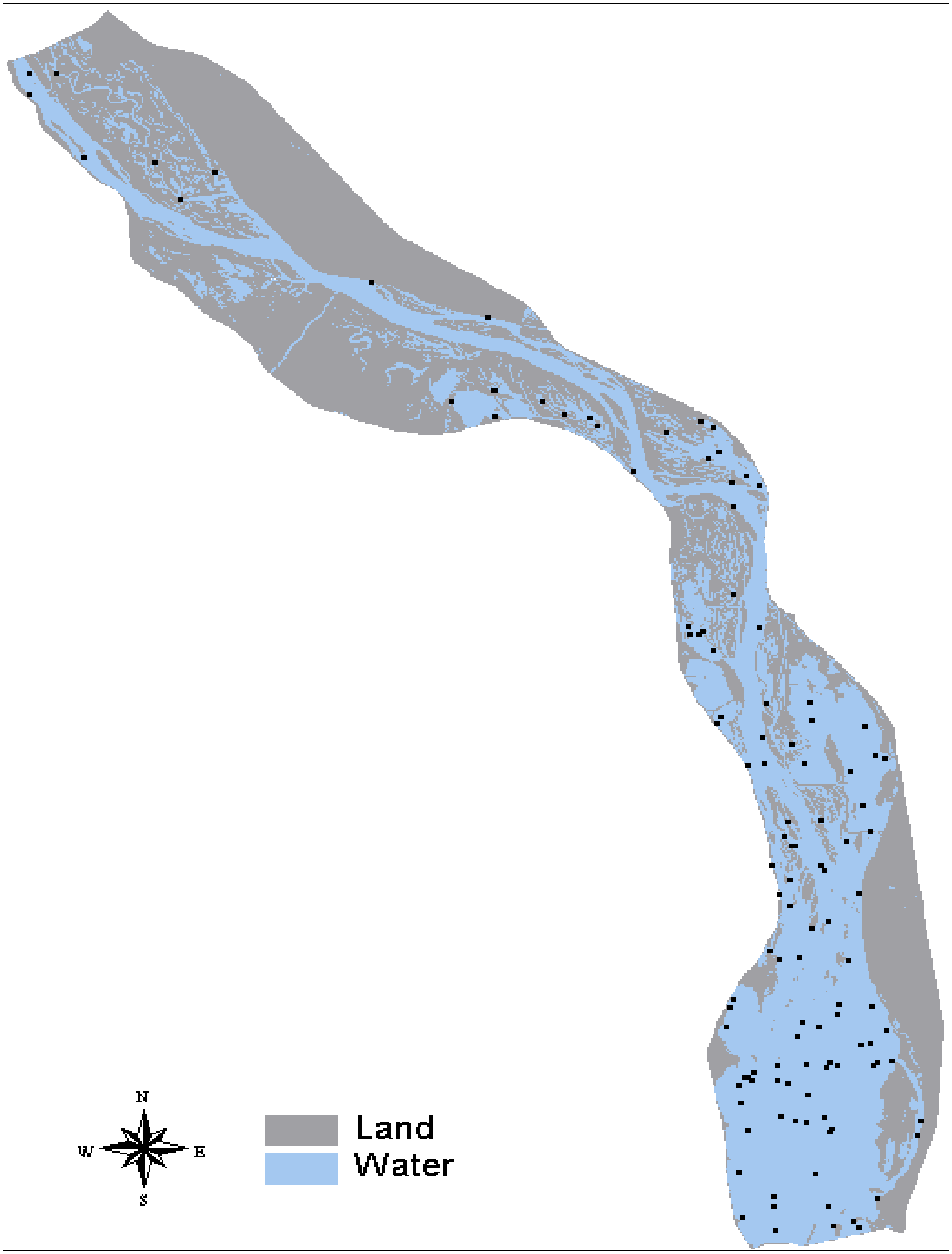

Figure 4. Pool 13 (river miles 522.5–557)—1997 Long Term Resource Monitoring Program macroinvertebrate random sample points.

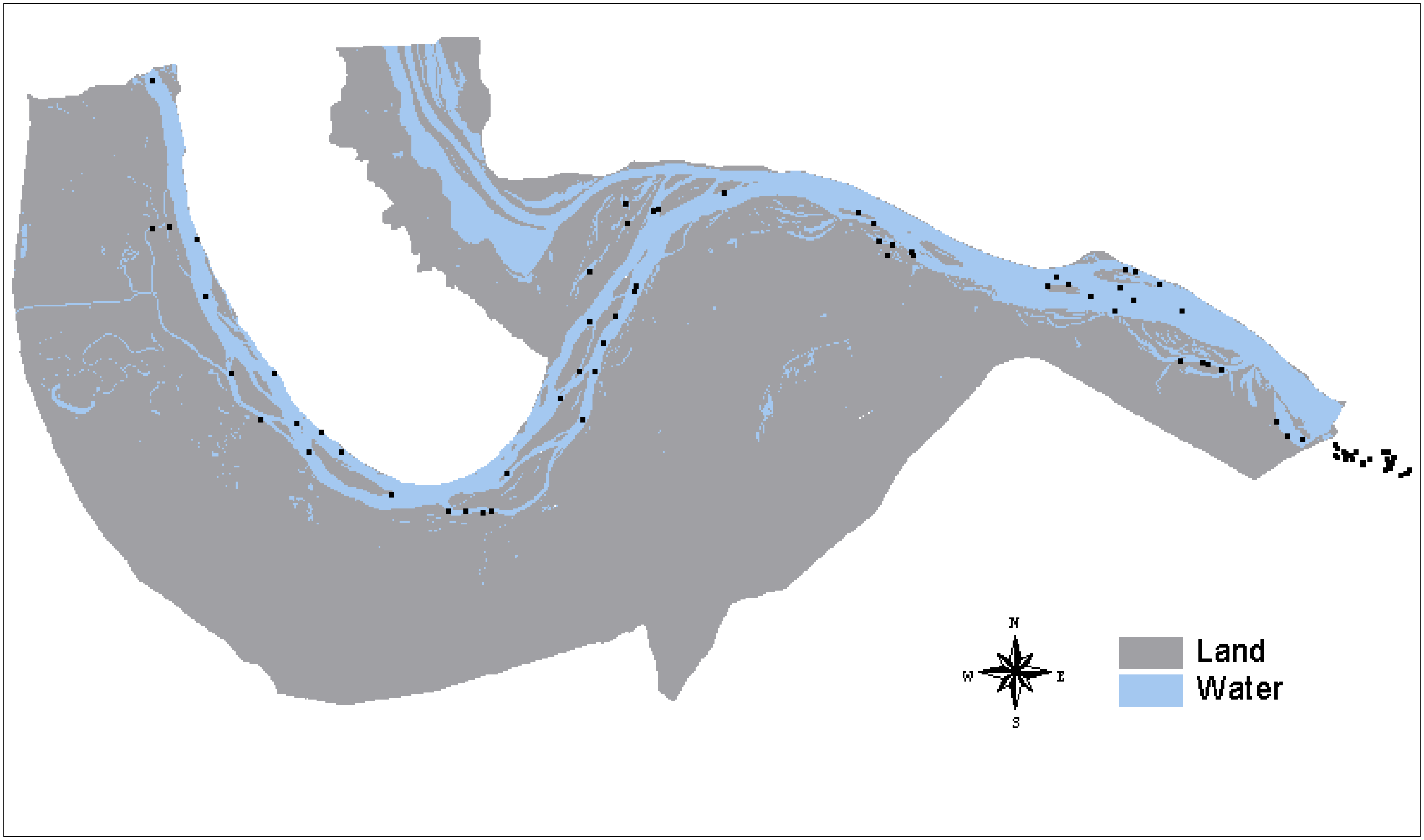

Figure 5. Pool 26 (river miles 203–241.5)—1997 Long Term Resource Monitoring Program macroinvertebrate random sample points.

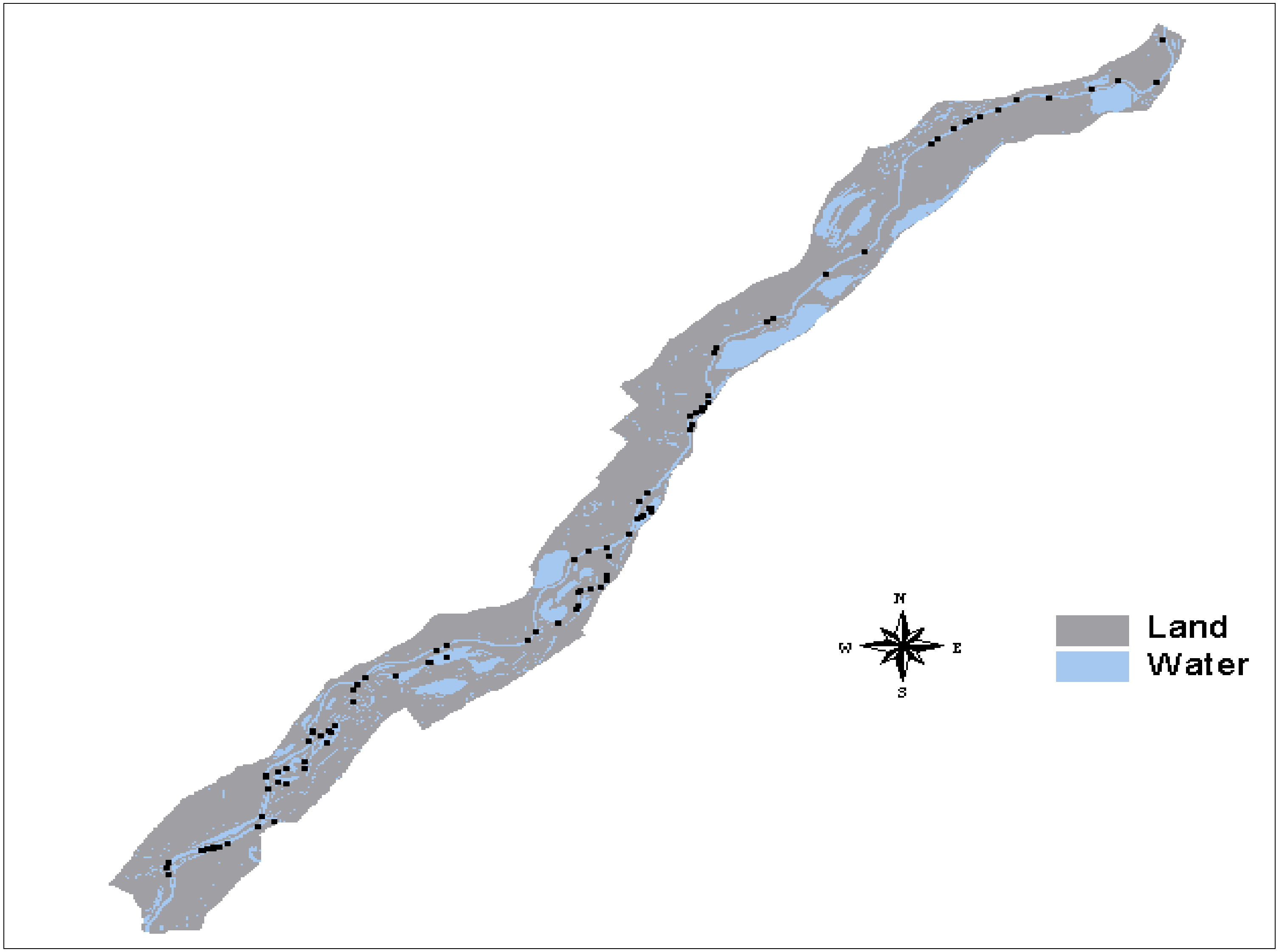

Figure 6. La Grange Pool (Illinois river miles 80–158)—1997 Long Term Resource Monitoring Program macroinvertebrate random sample points.

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13. ABSTRACT (Maximum 200 words)

In 1992, macroinvertebrate sampling was initiated in Pools 4, 8, 13, 26, and the Open River reach of the Mississippi River, and La Grange Pool of the Illinois River as part of the Long Term Resource Monitoring Program. This report summarizes the 1997 macroinvertebrate sampling. Long-term monitoring is needed to detect population trends and local changes in aquatic ecosystems. Mayflies (Ephemeroptera), fingernail clams (Sphaeriidae), and the exotic *Corbicula* species were selected for monitoring. Midges (Chironomidae) were added to the sampling design in 1993 and zebra mussels (*Dreissena polymorpha*) were added in 1995. Mayflies, fingernail clams, and midges, members of the soft-substrate community, were chosen because they play an important ecological role in the Upper Mississippi River System. Sampling was based on a stratified random design and was conducted at approximately 125 sites per study area. Mean densities of taxa were weighted by strata for extrapolation purposes. Pool 13 had the highest mean number of mayflies and fingernail clams (146.6 and 231.4 m^{-2}, respectively). La Grange Pool reported the highest densities of midges (149.9 m^{-2}). Overall, the impounded areas, including Lake Pepin, and the contiguous backwaters tended to support the highest densities of mayflies, fingernail clams, and midges. Substrates with predominantly a silt clay constituent supported the highest mean densities of mayflies, fingernail clams, and midges.

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The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System was authorized under the Water Resources Development Act of 1986 as an element of the Environmental Management Program. The mission of the LTRMP is to provide river managers with information for maintaining the Upper Mississippi River System as a sustainable large river ecosystem given its multiple-use character. The LTRMP is a cooperative effort by the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.