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Freshwater mussels of the Fox River basin in Illinois

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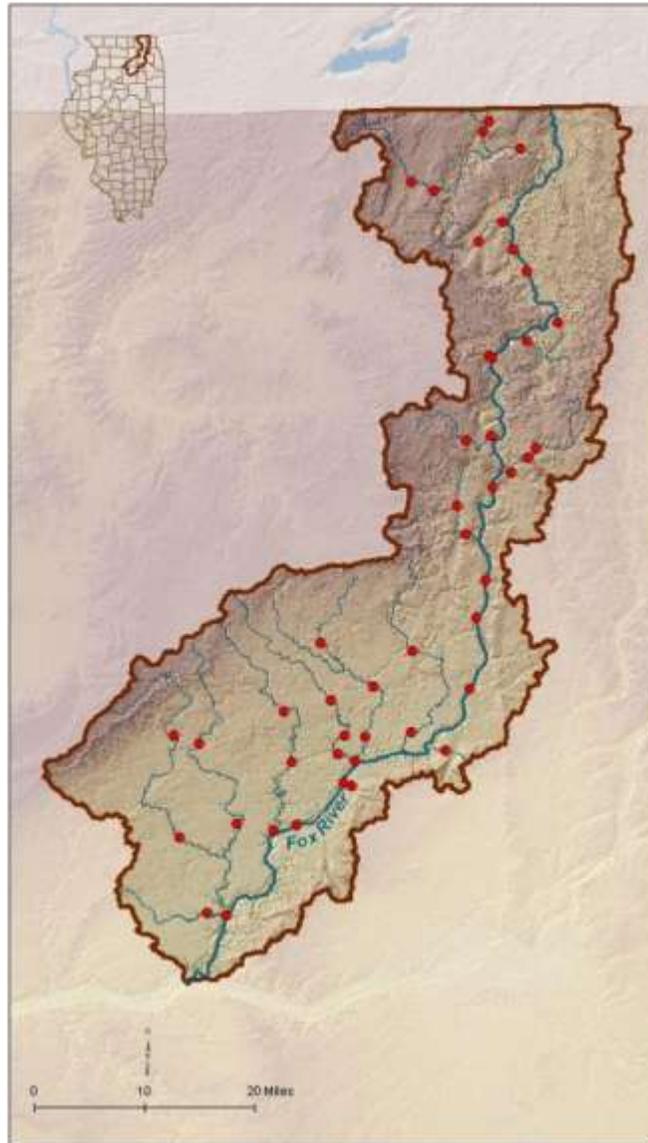
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Preface

While broad geographic information is available on the distribution and abundance of mussels in Illinois, systematically collected mussel-community data sets required to integrate mussels into aquatic community assessments do not exist. In 2009, a project funded by a US Fish and Wildlife Service State Wildlife Grant was undertaken to survey and assess the freshwater mussel populations at wadeable sites from 33 stream basins in conjunction with the Illinois Department of Natural Resources (IDNR)/Illinois Environmental Protection Agency (IEPA) basin surveys. Inclusion of mussels into these basin surveys contributes to the comprehensive basin monitoring programs that include water and sediment chemistry, instream habitat, macroinvertebrate, and fish, which reflect a broad spectrum of abiotic and biotic stream resources. These mussel surveys will provide reliable and repeatable techniques for assessing the freshwater mussel community in sampled streams. These surveys also provide data for future monitoring of freshwater mussel populations on a local, regional, and watershed basis.

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Introduction

Freshwater mussel populations have been declining for decades and are among the most seriously impacted aquatic animals worldwide (Bogan 1993, Williams et al. 1993). It is estimated that nearly 70% of the approximately 300 North American mussel taxa are extinct, federally-listed as endangered or threatened, or in need of conservation status (Williams et al. 1993, Strayer et al. 2004). In Illinois, 25 of the 62 extant species (44%) are listed as threatened or endangered (Illinois Endangered Species Protection Board 2011) and an additional 5 species are species in greatest need of conservation (SGNC; IDNR 2005). While broad geographic information is available on the distribution and abundance of mussels in Illinois, systematically collected mussel community data sets required to integrate mussels into aquatic community assessments do not exist. This report summarizes the mussel surveys conducted in the Fox River basin from 2010 to 2012 in conjunction with IDNR and IEPA basin surveys and other targeted survey sites. This report divides results into two major basins using HUC 8 digit delineation: the Upper and Lower Fox (USGS 2013, Figure 1).

The Fox River originates near Menominee Falls in Waukesha County, Wisconsin, crosses into Illinois near Antioch in Lake County, and flows south and west to its confluence with the Illinois River near Ottawa in LaSalle County (IDNR 2000, Schanzle et al. 2004). Draining an area of approximately 4,455 km² (1,720 mi²) this basin encompasses Kendall, Kane, McHenry, Lake, Cook, DuPage, DeKalb, Will, LaSalle, and Grundy counties in northern Illinois (Page et al. 1992). The basin lies within the Northeastern Morainal natural division, located in the northern half of the basin, and the Grand Prairie natural division located in the southern portion of the basin (Schwegman 1973, Page et al. 1992). Unique features of the Fox River basin are the glacially formed lakes in the northern portion. The largest, Chain O'Lakes in northeastern Lake County, is among 406 lakes which occur along the river (IDNR 2000). Principal tributaries include Boone, Poplar, and Nippersink Creeks (Upper Fox) and Blackberry, Somonauk, Big Rock and Indian Creeks (Lower Fox; IEPA 1996, Figure 2).

Land-use and Instream Habitat

Land cover types in the Fox River basin in Illinois consist of agricultural land (66%), urban (18%), woodlands (9.2%), wetlands (4.5%), and lakes and streams (2.3%; IDNR 1998). The Upper Fox basin contains numerous glacial lakes and wetlands with fewer forests and less land devoted to agriculture than the Lower Fox basin (IDNR 2000). It is also highly urbanized and industrialized, encompassing many large cities including Aurora (pop. 197,899) and Elgin (pop. 108,188; US Census Bureau 2010). Land use in the Lower Fox basin is primarily agricultural (~90%), however population growth and urban sprawl is apparent in this area with communities such as

Sycamore (pop. 17,519) and Yorkville (pop. 16,921) gaining over 10,000 in population in the last ten years (US Census Bureau 2010). Fifteen low head dams, built in the 1830-50s, exist on the Fox River and have altered the fish, macroinvertebrate, and mollusk assemblages of the river (Page et al. 1992, Schanzle et al. 2004, Santucci et al. 2005, Tiemann et al. 2007). Additional threats to water quality in this basin include agriculture runoff, municipal and industrial discharges, and other habitat modifications (IEPA 1996).

Substrates in most streams of this basin are dominated by a mixture of cobble, gravel, sand, and silt. In the upper reaches of the Fox basin, cobble substrate dominates with lesser amounts of sand and gravel interspersed. The lower portion of the basin contains more equal amounts of cobble, gravel, and sand and greater amounts of silt as compared to the upper reaches. Most sites had wadeable water depths; however, sampling sites on the lower portion of the Fox River mainstem were limited due to non-wadeable water depths (e.g., depth >1m).

Methods

During the 2010-2012 surveys, freshwater mussel data were collected at 46 sites: 18 Upper and 28 Lower (Figure 2; Table 1). Locations of sampling sites are listed in Table 1 along with information regarding IDNR/IEPA sampling at the site. In most cases, mussel survey locations were the same as IDNR/IEPA sites. At two sites, mussel data were collected on more than one occasion to fulfill sampling objectives for other analyses (Table 1).

Live mussels and shells were collected at each sample site to assess past and current freshwater mussel occurrences. Live mussels were surveyed by hand grabbing and visual detection (e.g., trails, siphons, exposed shell) when water conditions permitted. Efforts were made to cover all available habitat types present at a site including riffles, pools, slack water, and areas of differing substrates. A four-hour timed search method was implemented at most sites, and an abbreviated survey (1 to 2 hours) was completed at six sites due to ephemeral streams and/or siltation (Table 1). An eight-hour time search method was implemented at Poplar Creek (site 16) to fulfill the objectives of another study. No age or length data was taken at this site. Live mussels were held in the stream until processing.

Following the timed search, all live mussels and shells were identified to species and recorded (Table 2). For each live individual, shell length (mm), gender, and an estimate of the number of growth rings were recorded. Shell material was classified as recent dead (periostracum present, nacre pearly, and soft tissue may be present) or relict (periostracum eroded, nacre faded, shell chalky) based on condition of the best shell found. A species was considered extant at a site if it was represented by live or recently dead shell material (Szafoni 2001). The nomenclature employed in this report follows Turgeon et al. (1998) except for recent

taxonomic changes to the gender ending of lilliput (*Toxolasma parvum*), which follows Williams et al. (2008; Appendix 1). Voucher specimens were retained and deposited in the Illinois Natural History Survey Mollusk Collection. All non-vouchered live mussels were returned to the stream reach where they were collected.

Parameters recorded included extant and total species richness, presence of rare or listed species, and individuals collected, expressed as catch-per-unit-effort (CPUE; Table 2). A population was considered to indicate recent recruitment if individuals less than 30 mm in length or with 3 or fewer growth rings were recorded. Finally, mussel resources were classified as Unique, Highly Valued, Moderate, Limited, or Restricted (Table 2) based on the above parameters (Table 4) and following criteria outlined in Table 5 (Szafoni 2001).

Results

Species Richness

A total of 24 species of freshwater mussels were observed in the Fox River basin, 22 of which were live (Table 2). Across all sites, the number of live species collected ranged from 0 to 13, the number of extant species collected (live + dead) ranged from 1 to 14, and the total number of species collected (live + dead + relict) ranged from 1 to 17. The Upper Fox species richness ranged from 0 to 10 live species, 1 to 10 extant species, and 3 to 15 total species. The Lower Fox species richness ranged from 0 to 13 live species, 1 to 14 extant species, and 1 to 17 total species.

Across all sites, the white heelsplitter (*Lasmigona complanata*) was the most widespread species, collected at 25 of 46 sites (54%). Other widespread species were the giant floater (*Pyganodon grandis*) and plain pocketbook (*Lampsilis cardium*) collected at 24 and 22 sites, respectively (52% and 48%). These three species were the most widespread species in both the Upper and Lower Fox basins, albeit in different orders (Figure 3a-b). In the Upper Fox, giant floater was the most widespread species (10 of 18 sites, 59%) and white heelsplitter was the most widespread species in the Lower Fox (17 of 28 sites, 59%; Figure 3a-b).

Abundance and Recruitment

A total of 2,060 individuals were collected across 46 sites. The number of live individuals collected at a site ranged from 1 to 241, with an average of 42 mussels per site (Table 2a-b). Live individuals collected ranged from 2 to 125 at Upper Fox sites and from 1 to 241 at Lower Fox sites. A total of 182 collector-hours were spent sampling with an average of approximately 11 mussels collected per hour. The most commonly collected species across all sites was the plain pocketbook, which comprised 21% of all individuals collected (n=439). The giant floater was the most commonly collected species in the Upper Fox (n=87) and the plain pocketbook

was the most commonly collected species in the Lower Fox (n=372; Table 2a-b). Catch per unit effort (CPUE) at individual sites ranged from 0 to 60.25 individuals/collector-hour (Table 2a-b). Extant mussel populations existed at 95% of all sites (88% of sites in the Upper Fox and 100% of sites in the Lower Fox). Only two sites, Boone and Crystal Creek (sites 7 and 12) did not have extant mussel populations (Table a-b).

Recruitment for each species was determined by the presence of individuals less than 30 mm or with 3 or fewer growth rings. Smaller (i.e., younger) mussels are harder to locate by hand grab methods and large sample sizes can be needed to accurately assess population reproduction. However, a small sample size can provide evidence of recruitment if it includes individuals that are small or possess few growth rings. Alternatively, a sample consisting of very large (for the species) individuals with numerous growth rings suggests a senescent population.

Recruitment at individual sites ranged from none observed to very high across the basin. Recruitment levels, referred to in Table 4 as Reproduction Factor, varied from 1 to 5, and 3 sites exhibited high to very high recruitment. We observed recruitment in over 50% of species collected in the Fox River (site 9, Figure 4a). Two sites exhibited high recruitment (>30-50%) including North Branch Nippersink (site4A) and the Fox River (site 37, Figures 4a-b). Seven other sites (8, 11, 18, 24, 31, 38, and 41) exhibited moderate recruitment. Nearly 80% of sites sampled (36 of 46) displayed no recent recruitment (Figures 4a-b). Sampling methods to target juvenile mussels would be necessary to better assess the reproductive status of these populations.

Mussel Community Classification

Based on data collected in the 2010-2012 basin surveys, approximately 60% of the sites in the Fox River basin are classified as Moderate, Highly Valued, or Unique mussel resources under the current MCI classification system (Table 5, Figure 4a-b). Little Indian Creek (site 44) was classified as a Unique mussel resources due to the presence of intolerant species, number of mussels collected, and species richness of the site. Twelve sites were classified as Highly Valued (Upper-4 and Lower-8) and 15 sites (Upper-6 and Lower-9) were ranked as Moderate mussel resources. The 19 remaining sites were considered Limited or Restricted mussel resources.

Noteworthy Finds

Ten species known historically from this basin not collected during this survey include the sheepnose (*Plethobasus cyphus*), monkeyface (*Quadrula metanevra*), wartyback (*Quadrula nodulata*), pistolgrip (*Tritogonia verrucosa*), snuffbox (*Epioblasma triquetra*), wavy-rayed lampmussel (*Lampsilis fasciola*), hickorynut (*Obovaria olivaria*), pink heelsplitter (*Potamilus alatus*), pink papershell (*Potamilus ohioensis*), and fawnsfoot (*Truncilla donaciformis*). Sheepnose and snuffbox are federally-endangered, the wavy-rayed lampmussel is state-

endangered, and monkeyface is a species of greatest need of conservation (Illinois Endangered Species Protection Board 2011, IDNR 2005, USFWS 2012) in Illinois.

Three state threatened species known from this basin, slippershell mussel (*Alasmidonta viridis*; n=8, 5 sites), spike (*Elliptio dilatata*; n=14, 2 sites), and black sandshell (*Ligumia recta*; n=11, 1 site), were collected alive. These species were collected as relict shell at 10, 13, and 3 additional sites, respectively. Species in greatest need of conservation including creek heelsplitter (*Lasmigona compressa*; n=25, 10 sites), flutedshell (*Lasmigona costata*; n=33, 5 sites), and ellipse (*Venustaconcha ellipsiformis*; n=193, 14 sites) were collected alive. Relict shell of these species was also found at additional sites (Table 2). Two species, purple wartyback (*Cyclonaias tuberculata*; state threatened) and rainbow (*Villosa iris*; state endangered), were represented by relict shell only (Table 2a-b).

Discussion

Historically, 34 species were known from the Fox River basin (Tiemann et al. 2007a). This survey documented 22 live species and 24 total species. The Fox River basin has been the subject of several previous surveys and publications including Eldridge (1914, 13 species), Matteson (1957-58 surveys, 20 species), Mathiak (1979, 18 species), Schanzle et al. (2004, 27 species) and Tiemann et al. (2007b, 14 species). Species listings for the basin based on published reports and museum specimens have also been reported in Baker (1906 and 1928), Page et al. (1992), Cummings and Mayer (1997), and Tiemann et al. (2007a). The earlier surveys focused primarily on the Fox River mainstem (Mathiak 1979 and Matteson 1957-58) and the upper reaches of the basin (Mathiak 1979). Tiemann et al. (2007b) studied mussel species assemblages in relationship to low-head dams located on the Fox River near Batavia and Aurora. The most recent mussel community assessment, completed by R.W. Schanzle et al. (2004) between 1997 and 2001, recorded 27 total species with 23 species represented by live specimens collected from 96 mainstem and tributary sites in Wisconsin and Illinois (Table 3). Although nearly twice as many sites were sampled by Schanzle et al. and only approximately 1/3 of the sites were sampled at close proximity during our surveys, results between the two surveys were very similar (Table 3). All species recorded during our surveys were collected by Schanzle et al.; one additional live species, rainbow (*Villosa iris*, n=8), and dead/relict shell of snuffbox, pink heelsplitter, and pink papershell were reported by Schanzle et al. (2004).

Several species are being restricted from upstream distribution due to the series of low-head dams on the Fox River (Tiemann et al. 2007b). This includes four species known historically from the basin not collected during this survey, pistolgrip, pink heelsplitter, pink papershell and fawnsfoot. Another species, fragile papershell, considered limited by Tiemann et al. was collected alive (n=4) at one location on the Fox River near the Montgomery Dam (Figure 1)

during our surveys. These five species are fairly common and wide-spread across Illinois (Cummings and Mayer 1992) and are known to occur in the Illinois River basin upstream and downstream of the Fox River Basin (INHS Mollusk Collection database). Thus, our surveys would concur with the observations of Tiemann et al. (2007b) that the distribution of these species is being affected by the low-head dams on the Fox River.

Other species that are likely extirpated in the Fox River basin include sheepsnose, monkeyface, wartyback, snuffbox, wavy-rayed lampmussel, and hickorynut. Nearly all records for these species are shell records found pre-1900, with the exceptions of monkeyface and wartyback; these were collected as dead shell in 1991 and 2006, respectively. Monkeyface, sheepsnose, and snuffbox historically occurred statewide but are uncommon or rare throughout their range and wartyback, wavy-rayed lampmussel, and hickorynut, would be outside of their normal ranges (Cummings and Mayer 1992). All of these species, with the exception of monkeyface and wartyback, are state or federally listed (Appendix 1).

Mussel community of the Fox River basin

Previous reports have suggested that low-head dams have adversely affected fish, macroinvertebrate and mollusk communities of the Fox River by degrading habitat and water quality and fragmenting the river into a series of lentic ecosystems (Santucci et al. 2005, Tiemann et al. 2007b). Much of the Fox River mainstem is considered impaired for aquatic life use based on biological, physiochemical, physical habitat, and toxicity data recently collected (IEPA 2012). Causes of impairment include sedimentation, changes in stream depth and velocity patterns and stream side vegetation alteration, along with increased levels of phosphorus, aldrin, hexachlorobenzene, mercury, polychlorinated biphenyls, chloride, cooper, and fecal coliform (IEPA 2012). Many Fox River mainstem sites sampled were considered Restricted, Limited or Moderate mussel resources (6 of 8) and only two sites (sites 8 and 37) were considered Highly Valued. These Highly Valued sites are located above (site 8) and below (site 37) the majority of the low-head dams located on the river (Figures 1 and 2).

Unique and Highly Valued sites exist in the Fox River basin include North Branch Nippersink, Spring and Poplar Creeks in the Upper Fox and Ferson, Big Rock, Little Rock, Somonauk, Indian and Little Indian Creeks in the Lower Fox. However, 40% of the sites in this basin were considered Limited or Restricted mussel resources and 33% of sites contained 4 to 10 relict mussel species possibly indicating that many of the mussel communities in this basin have deteriorated over time. Our surveys documented the existence of 22 live and 24 total species in the Fox River basin; these numbers are less than historical and slightly less than the mussel communities documented by Schanzle et al. (2004).

Although a few threatened, endangered, and rare species have been lost from this basin,

several others are still persisting; slippershell mussel, spike, black sandshell, creek heelsplitter, flutedshell, and ellipse were all collected alive during this survey. While the mainstem Fox River has been negatively affected by low-head dams and urbanization, these recent findings indicate that areas within the Fox River basin are capable of supporting rare, threatened, and endangered species and should be protected from further disturbance.

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Table1a. 2010-2012 Upper Fox River Basin. Types of samples include MU-mussel sampling, F-fish community sampling, FF-fish flesh contaminate, D-discharge, H-habitat, M-macroinvertebrate, S-sediment, and W-water chemistry. Sites sampled on more than one occasion are noted with an asterisk (*), sites with less than a 4-hour sample was completed are noted with a double asterisk (**).

Site number	IEPA Code	Stream	Types of Samples	County	Location	Watershed area (km ²)
Upper Fox						
1	DTK-06	Nippersink Creek	MU	McHenry	5 mi S Hebron; Allendale Road bridge	77.20
2	DTK-09	Nippersink Creek	MU, F, D, H, M, W	McHenry	McHenry Conservation District; Greenwood Road	216.33
3	DTKKA-03	North Creek	MU	McHenry	1 mi E Richmond; Rt. 173 bridge	32.35
4*	DTKA-04	North Branch Nippersink Creek	MU, F, D, H, M, W	McHenry	1 mi SSE Richmond; Hill Road bridge	179.46
5	DTK-04	Nippersink Creek	MU, F, FF, H, M, W	McHenry	0.6 mi W Spring Grove; Spring Grove/Richardson Road	493.66
6	DTZT-02	Boone Creek	MU, F, D, H, M, W	McHenry	2.5 mi SW McHenry; Bull Valley Road bridge	43.03
7**	DTZT-01	Boone Creek	MU	McHenry	Rt 120 & 31 bridge; McHenry	59.13
8	DT-51	Fox River	MU, F	McHenry	McHenry Dam; SE McHenry Shores	3138.22
9	DT-22	Fox River	MU, F, FF, H, M, W	McHenry	0.5 mi SSW Holiday Hills; Rt. 176 bridge	3210.78
10	DTZS-01	Flint Creek	MU, F, D, H, M, W	Lake	Lake Barrington, Kelsey Road bridge, Flint Creek Forest Preserve	95.76
11	DTH-01	Spring Creek	MU	McHenry	Algonquin/Braeburn/Plum Tree Road crossings	67.50
12	DTZR-02	Crystal Creek	MU, F, D, H, M, S, W	McHenry	Algonquin; Towne Park	69.00
13	DT-06	Fox River	MU, F, H, M, W	McHenry	Algonquin; Algonquin Road bridge	3527.42
14	DTZP-04	Tyler Creek	MU	Kane	Elgin; Randall Road bridge	86.17
15	DTZP-02	Tyler Creek	MU, F, D, H, M, W	Kane	2 mi NNW Elgin; Tyler Creek Forest Preserve	103.27
16	DTG-07	Poplar Creek	MU	Cook	1 mi W Rt. 59 Elgin; Rt. 58 bridge	70.64
17	DTG-10	Poplar Creek	MU	Cook	2 mi E Elgin; Rohrsen Road bridge	89.66
18	DTG-03	Poplar Creek	MU	Cook	2 mi NE South Elgin; Hammond Avenue	111.16

Table1b. 2010-2012 Lower Fox River Basin. Types of samples include MU-mussel sampling, F-fish community sampling, FF-fish flesh contaminate, D-discharge, H-habitat, M-macroinvertebrate, S-sediment, and W-water chemistry. Sites sampled on more than one occasion are noted with an asterisk (*), sites with less than a 4-hour sample was completed are noted with a double asterisk (**).

Site number	IEPA Code	Stream	Types of Samples	County	Location	Watershed area (km ²)
Lower Fox						
19	DT-09	Fox River	MU, F, FF, H, M, W	Kane	South Elgin; State Street bridge	3926.12
20*	DTFA-01	Otter Creek	MU, F, D, H, M, W	Kane	3 mi SW South Elgin; Silver Glen Road	77.75
21	DTF-02	Ferson Creek	MU, F, D, H, M, W	Kane	1.5 mi NNW St. Charles; Leroy Oakes Forest Preserve	135.47
22	DT-69	Fox River	MU, F, H, M, W	Kane	Geneva; Fabyan Park, Geneva Batavia pool	4289.51
23	DTZL-01	Mill Creek	MU	Kane	4.3 mi N Aurora; Rt. 31, Les Arends County Forest Preserve	79.20
24	DT-38	Fox River	MU, H, M, W	Kane	Montgomery; Mill Street Bridge	4386.64
25**	DTZJ-02	Morgan Creek	MU	Kendall	3.4 mi E Yorkville; Minkler Road	46.13
26	DTD-03	Blackberry Creek	MU, F, D, H, M, W	Kane	5.6 mi SE Kaneville; Bliss Wood Forest Preserve	79.69
27	DTD-02	Blackberry Creek	MU, F, D, H, M, W	Kendall	1.3 mi NNW Yorkville; Hwy. 34 bridge	188.87
28	DTCD-03	East Branch Big Rock Creek	MU	Kane	2.6 mi NE Hinckley; County Line Road	71.72
29	DTC-07	Big Rock Creek	MU, F, D, H, M, W	Kane	4.5 mi N Plano; Jericho Road, Big Rock Creek Forest	279.77
30	DTC-05	Big Rock Creek	MU, F, FF, H, M, W	Kendall	Plano; Main Street bridge, Klatt Park	304.71
31	DTCA-08	Little Rock Creek	MU, F, D, H, M, W	Kendall	4.5 mi NNW Plano; Galena Road	150.15
32	DTCA-04	Little Rock Creek	MU	Kendall	1.5 mi WNW Plano; Creek Road bridge	175.00*
33**	DTCA-02	Little Rock Creek	MU	Kendall	2.5 mi E Sandwich; Griswold Springs Road	191.57
34**	DTCA-01	Little Rock Creek	MU, F, D, W	Kendall	1.9 mi S Plano; at mouth	192.42
35**	DTZG-01	Hollenbeck Creek	MU	Kendall	0.25 mi N Millbrook; Fox River Road	24.78
36	DT-32	Fox River	MU, F, H, M	Kendall	4 mi SE Sandwich, Shu Shu Gah canoe launch	5357.45
37	DT-27	Fox River	MU	LaSalle	2.4 mi NE Sheridan; Rolling Woods Campground	5732.22
38	DTB-04	Somonauk Creek	MU, F, D, H, M, W	DeKalb	4.5 mi NNW Sandwich; Creek Road	100.09
39	DTB-02	Somonauk Creek	MU, F, D, H, M, W	DeKalb	1 mi E Somonauk; Suannak Forest Preserve campground loop	146.15
40	DTB-01	Somonauk Creek	MU, F, D, H, M, W	LaSalle	1 mi N Sheridan; 42nd Road bridge	213.41
41	DTA-09	Indian Creek	MU, F, D, H, M, W	DeKalb	5 mi NW Leland; Suydam Road bridge	94.26
42	DTA-08	Indian Creek	MU, F, D, H, M, W	LaSalle	5 mi SE Earlville; Hwy. 22 bridge	320.39
43	DTAB-01	Little Indian Creek	MU, F	DeKalb	3.4 mi NNW Leland; Suydam Road bridge	81.81
44	DTAB-02	Little Indian Creek	MU, F, D, H, M, W	LaSalle	4 mi NW Sheridan; County Road 4275N bridge	219.67
45	DT-36	Fox River	MU, F, FF, M, W	LaSalle	0.5 mi NE Wedron; Ayers Landing	6543.40
46	DTZB-02	Buck Creek	MU, F, H, M, W	LaSalle	1.5 mi W Wedron; 19th Road bridge	113.39

Table 2. Mussel data for sites sampled during 2010-2012 surveys (Tables 1) in the Upper Fox (a), and Lower Fox (b). Numbers in columns are live individuals collected; "D" and "R" indicates that only dead or relict shells were collected. Shaded boxes indicate historic collections at the specific site location obtained from the INHS Mollusk Collection records. Species in bold are federally or state-listed species or species in Greatest Need of Conservation by IL DNR. Proportion of total is number of individuals of a species divided by total number of individuals at all sites. Extant species is live + dead shell and total species is live + dead + relict shell. NDA represents no historical data available. MCI scores and Resource Classification are based on values in Tables 3 and 4 (R= Restricted, L= Limited, M= Moderate, HV= Highly Valued, and U= Unique). Sites with one or more samples denoted by A and B, **denotes less than 4-hour sample.

a. Upper Fox

Species	Site Number																		Proportion of total
	1	2	3	4A	4B	5	6	8	9	10	11	13	14	15	16	17	18		
Subfamily Anodontinae																			
<i>Alasmidonta marginata</i>				13	13												1	5.4%	
<i>Alasmidonta viridis</i>	1				R		R			R	1		R	R	R			0.4%	
<i>Anodontoides ferussacianus</i>	3	1				R	1				2		R	D	2	D	2	2.2%	
<i>Lasmigona complanata</i>	9	8	R	R	R	1				11	1	2	D	D	1		1	6.8%	
<i>Lasmigona compressa</i>			R		D	R	5						R		R		1	1.2%	
<i>Lasmigona costata</i>				8	1				R									1.8%	
<i>Pyganodon grandis</i>	1	1	R	2		D		35	3	1	1	1			33	D	9	17.4%	
<i>Strophitus undulatus</i>				7	3	3					2		R	R	2			3.4%	
<i>Utterbackia imbecillis</i>								1										0.2%	
Subfamily Ambleminae																			
<i>Amblema plicata</i>			2	3	R	R		1	R			R						1.2%	
<i>Cyclonaias tuberculata</i>												R						0.0%	
<i>Elliptio dilatata</i>		R		R		R		R	R			R						0.0%	
<i>Fusconaia flava</i>					D	1			1		1					R		0.6%	
<i>Pleurobema sintoxia</i>				11	4	1		R			1	R						3.4%	
<i>Quadrula pustulosa</i>				1		5		57	19			R						16.4%	
Subfamily Lampsilinae																			
<i>Actinonaias ligamentina</i>				17	10	22		1	R									10.0%	
<i>Epioblasma triquetra</i>																		0.0%	
<i>Lampsilis cardium</i>			R	5	R	9		24			2	D	R	D		1	26	13.4%	
<i>Lampsilis siliquoidea</i>						R		R	R	R								0.0%	
<i>Leptodea fragilis</i>																		0.0%	
<i>Ligumia recta</i>						11			R									2.2%	
<i>Toxolasma parvum</i>			R			R		6	D	D	1				D			1.4%	
<i>Venustaconcha ellipsiformis</i>	2			R				R	R	R	10	R	D	D	29	9	13	12.6%	
<i>Villosa iris</i>																		0.0%	
																		Totals	
Individuals collected	16	10	2	67	31	53	6	125	23	12	22	3	0	0	67	10	53	500	
Live species collected	5	3	1	9	5	8	2	7	3	2	10	2	0	0	5	2	7	18	
Extant species	5	3	1	9	7	9	2	7	4	3	10	3	2	4	6	4	7	18	
Total species collected	5	4	6	12	11	15	3	11	11	6	10	9	7	6	8	5	7	21	
Historical species richness	NDA	6	NDA	12	12	14	3	17	2	3	NDA	8	1	NDA	9	NDA	NDA		
Catch per unit effort (CPUE)	4.00	2.50	0.50	16.75	7.75	13.25	1.54	31.25	5.75	3.08	5.50	1.50	0.00	0.00	8.32	1.24	13.59		
Mussel Community Index (MCI)	11	6	4	14	10	11	6	12	11	6	15	6	0	0	9	9	13		
Resource Classification	M	L	R	HV	M	M	L	HV	M	L	HV	L	R	R	M	M	HV		

b. Lower Fox

Species	Site Number																										Proportion of total					
	19	20A	20B	21	22	23	24	25*	26	27	28	29	30	31	32	33*	34*	35*	36	37	38	39	40	41	42	43		44	45	46		
Subfamily Anodontinae																																
<i>Alasmidonta marginata</i>	R	1	4	3		R			1	5		8	R		D				D	4			R		R	7	2		2.2%			
<i>Alasmidonta viridis</i>		R							R		2	R		1	R						D	D			3				0.4%			
<i>Anodontoides ferussacianus</i>		2	4	R							2	1	R	5	3	D	1	D			3	D		8		32	6		D	4.3%		
<i>Lasmigona complanata</i>		1	2	1		D	48	2				14	1	26	D	R	R		4	10	92	D	3	5	62	3	48	20		21.9%		
<i>Lasmigona compressa</i>		2	5	2					D		R	D	D	1							5	R		2		1	1			1.2%		
<i>Lasmigona costata</i>					R					9									R			D			1		14			1.5%		
<i>Pyganodon grandis</i>	D	3	23	1	D	10	31	8	3	6		1							D	R		1	1	4	7		4			6.6%		
<i>Strophitus undulatus</i>			D						R	R		D			R					R	D	R		D	2		8		R	0.6%		
<i>Utterbackia imbecillis</i>				1		2	1																								0.3%	
Subfamily Ambleminae																																
<i>Amblema plicata</i>					R												R		28	19			3					4		3.5%		
<i>Cyclonaias tuberculata</i>																			R												0.0%	
<i>Elliptio dilatata</i>				6	R				R			8	R						R	R		R	R				D			0.9%		
<i>Fusconaia flava</i>		2	4	R			R		7	R									R	R	40						22	R		4.8%		
<i>Pleurobema sintoxia</i>	R								1	6									R	R	2	R					10			1.2%		
<i>Quadrula pustulosa</i>	D																		21	45			D			1	6			4.7%		
<i>Quadrula quadrula</i>						1	11												26	35		1	D		2			18			6.0%	
Subfamily Lampsilinae																																
<i>Actinonaias ligamentina</i>					R		R												R	R									R		0.0%	
<i>Lampsilis cardium</i>	R	6	18	18	D	31	105			D		52	D	4	R				35	7	2	2	14	5	10		47	16	R	23.8%		
<i>Lampsilis siliquoidea</i>									4					4	D		R				15	5	D	8	5	24	36	R	4		6.7%	
<i>Leptodea fragilis</i>							4																								0.3%	
<i>Ligumia recta</i>					R														R												0.0%	
<i>Toxolasma parvum</i>		R			R	1	R							R					R		9	R					R		D	0.6%		
<i>Venustaconcha ellipsiformis</i>	R	2	5	18	R	R			R	6		1		15	R		R		R	R	37	D	R	9	R	D	37	R		8.3%		
<i>Villosa iris</i>									R										R									R			0.0%	
																																Totals
Individuals collected	0	19	65	50	0	45	200	10	16	32	4	85	1	56	3	0	1	0	114	120	205	9	21	41	89	63	241	66	4	1560		
Live species collected	0	8	8	8	0	5	6	2	5	5	2	7	1	7	1	0	1	0	5	6	9	4	4	7	7	5	13	6	1	20		
Extant species	2	8	9	8	2	6	6	2	6	6	2	9	3	7	4	1	1	1	7	6	11	9	7	8	7	6	14	6	3	20		
Total species collected	6	10	9	10	9	8	9	2	11	8	3	10	6	8	8	2	5	1	17	13	11	14	10	8	9	6	16	10	5	24		
Historical species richness	4	7	7	10	11	NDA	NDA	NDA	NDA	2	5	13	8	5	3	NDA	7	NDA	NDA	NDA	NDA	NDA	6	NDA	4	NDA	11	1	2			
Catch per unit effort (CPUE)	0.00	16.25	4.75	12.49	0.00	11.25	49.98	10.00	4.00	8.00	1.00	21.25	0.25	14.00	0.75	0.00	0.25	0.00	28.49	30.00	51.25	2.27	5.25	10.25	22.25	15.75	60.25	16.50	1.00			
Mussel Community Index (MCI)	0	11	10	13	0	8	11	7	7	11	8	13	4	15	5	0	4	0	8	12	15	12	8	13	11	12	16	8	7			
Resource Classification	R	M	M	HV	R	M	M	L	L	M	M	HV	R	HV	L	R	R	R	M	HV	HV	HV	M	HV	M	HV	U	M	L			

Table 3. Summary of sites sampled during 2010-2012 (46 sites, 182 total hours) and summary of species collected by Schanzle et al. (2004); (96 sites, 384 total hours). ** *Plethobasus cyphus*, *Quadrula metanevra*, *Quadrula nodulata*, *Tritogonia verrucosa*, *Lampsilis fasciola*, *Obovaria olivaria*, and *Truncilla donaciformis* are included in historical total but not represented in the table.

Species	Total individuals	# of sites live	# of sites extant	# of sites L/D/Relict	Proportion of total live	Schanzle et al. 1997-2001	
						Total individuals	Proportion of total live
Subfamily Anodontinae							
<i>Alasmidonta marginata</i>	62	12	14	19	4.1%	116	3.2%
<i>Alasmidonta viridis</i>	8	5	7	17	0.5%	31	0.9%
<i>Anodontoides ferussacianus</i>	78	17	23	27	5.1%	305	8.5%
<i>Lasmigona complanata</i>	376	25	30	35	24.7%	483	13.5%
<i>Lasmigona compressa</i>	25	10	14	20	1.6%	61	1.7%
<i>Lasmigona costata</i>	33	5	6	9	2.2%	71	2.0%
<i>Pyganodon grandis</i>	190	24	29	31	12.5%	486	13.6%
<i>Strophitus undulatus</i>	27	7	11	19	1.8%	104	2.9%
<i>Utterbackia imbecillis</i>	5	4	4	4	0.3%	14	0.4%
Subfamily Ambleminae							
<i>Amblema plicata</i>	60	7	7	13	3.9%	104	2.9%
<i>Cyclonaias tuberculata</i>	0	0	0	2	0.0%	R	0.0%
<i>Elliptio dilatata</i>	14	2	3	16	0.9%	60	1.7%
<i>Fusconaia flava</i>	78	8	9	16	5.1%	189	5.3%
<i>Pleurobema sintoxia</i>	36	8	8	14	2.4%	167	4.7%
<i>Quadrula pustulosa</i>	155	8	10	11	10.2%	487	13.6%
<i>Quadrula quadrula</i>	94	7	8	8	6.2%	31	0.9%
Subfamily Lampsilinae							
<i>Actinonaias ligamentina</i>	50	4	4	10	3.3%	156	4.4%
<i>Epioblasma triquetra</i>	0	0	0	0	0.0%	R	0.0%
<i>Lampsilis cardium</i>	439	22	27	33	28.8%	397	11.1%
<i>Lampsilis siliquoidea</i>	105	9	11	17	6.9%	62	1.7%
<i>Leptodea fragilis</i>	4	1	1	1	0.3%	2	0.1%
<i>Ligumia recta</i>	11	1	1	4	0.7%	4	0.1%
<i>Potamilus alatus</i>	0	0	0	0	0.0%	R	0.0%
<i>Potamilus ohioensis</i>	0	0	0	0	0.0%	D	0.0%
<i>Toxolasma parvum</i>	17	4	8	17	1.1%	73	2.0%
<i>Venustaconcha ellipsiformis</i>	193	14	18	34	12.7%	174	4.9%
<i>Villosa iris</i>	0	0	0	3	0.0%	8	0.2%
					Totals		
					Individuals collected	2060	3585
					Live species collected	22	23
					Extant species	22	24
					Total species collected	24	27
					Historical species	34	

Table 4. Mussel Community Index (MCI) parameters and scores.

Extant species in sample	Species Richness	Catch per Unit Effort (CPUE)	Abundance (AB) Factor
0	1	0	0
1-3	2	1-10	2
4-6	3	>10-30	3
7-9	4	>30-60	4
10+	5	>60	5
% live species with recent recruitment	Reproduction Factor	# of Intolerant species	Intolerant species Factor
0	1	0	1
1-30	3	1	3
>30-50	4	2+	5
>50	5		

Table 5. Freshwater mussel resource categories based on species richness, abundance, and population structure. MCI = Mussel Community Index Score

Unique Resource MCI ≥ 16	Very high species richness (10 + species) &/or abundance (CPUE > 80); intolerant species typically present; recruitment noted for most species
Highly Valued Resource MCI = 12 - 15	High species richness (7-9 species) &/or abundance (CPUE 51-80); intolerant species likely present; recruitment noted for several species
Moderate Resource MCI = 8 - 11	Moderate species richness (4-6 species) &/or abundance (CPUE 11-50) typical for stream of given location and order; intolerant species likely not present; recruitment noted for a few species
Limited Resource MCI = 5 - 7	Low species richness (1-3 species) &/or abundance (CPUE 1-10); lack of intolerant species; no evidence of recent recruitment (all individuals old or large for the species)
Restricted Resource MCI = 0 - 4	No live mussels present; only weathered dead, sub-fossil, or no shell material found



Figure 1. Divisions of the Upper and Lower Fox basins and locations of dams in the basin. Adapted from Santucci et al. 2005.

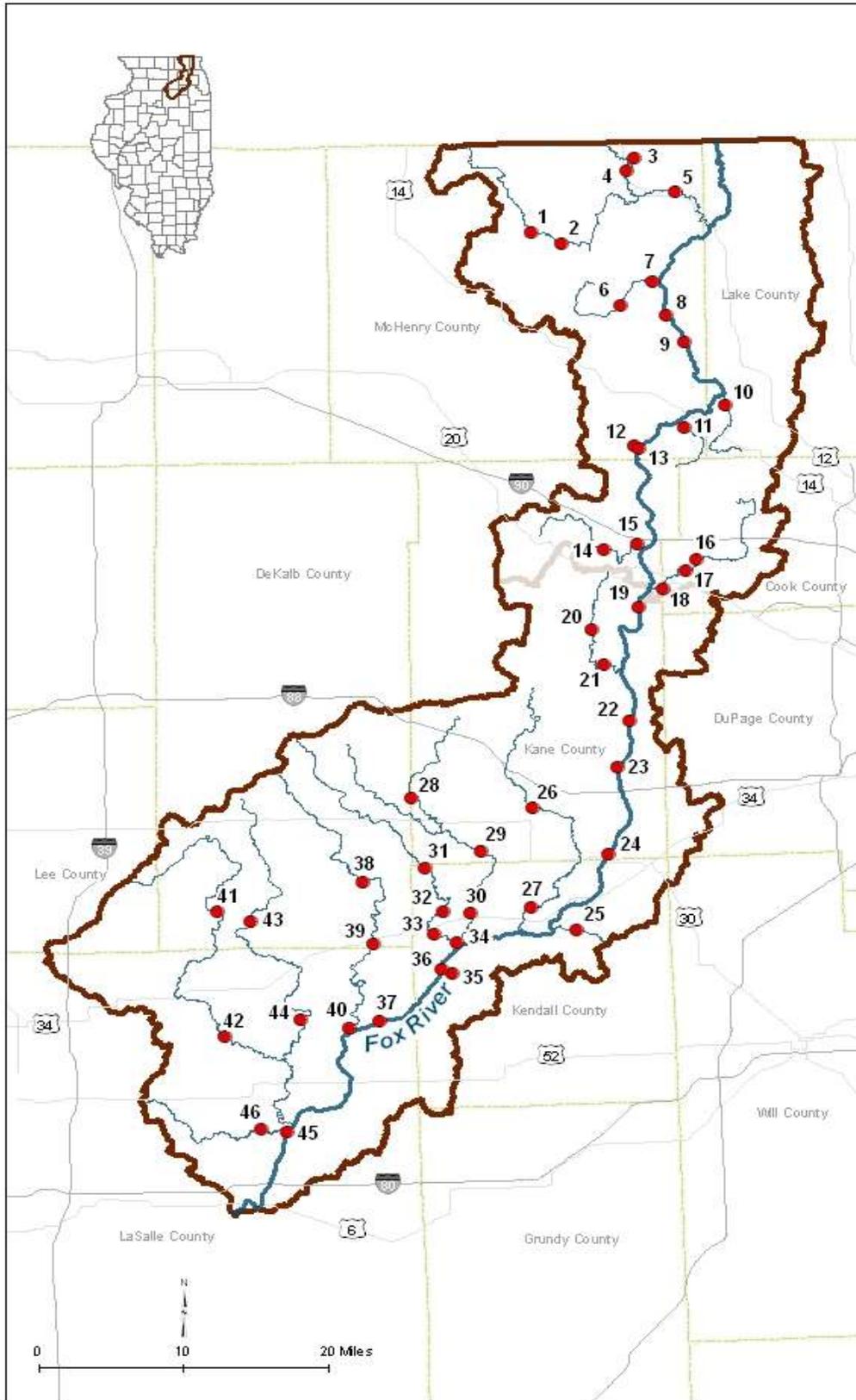


Figure 2. Sites sampled in the Fox River basin during 2010-2012. Site codes referenced in Table 1.

Figure 3a. Upper Fox

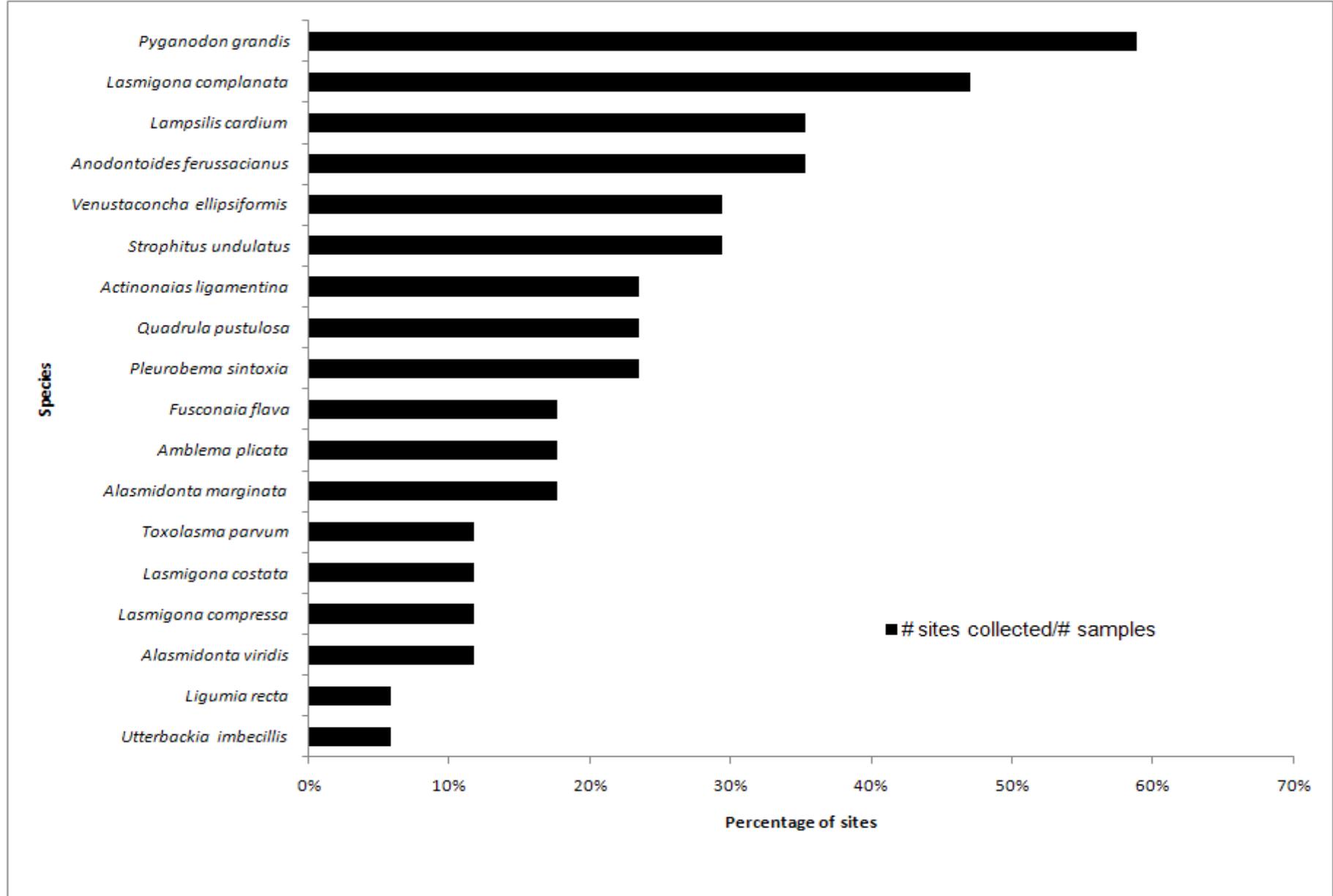


Figure 3b. Lower Fox

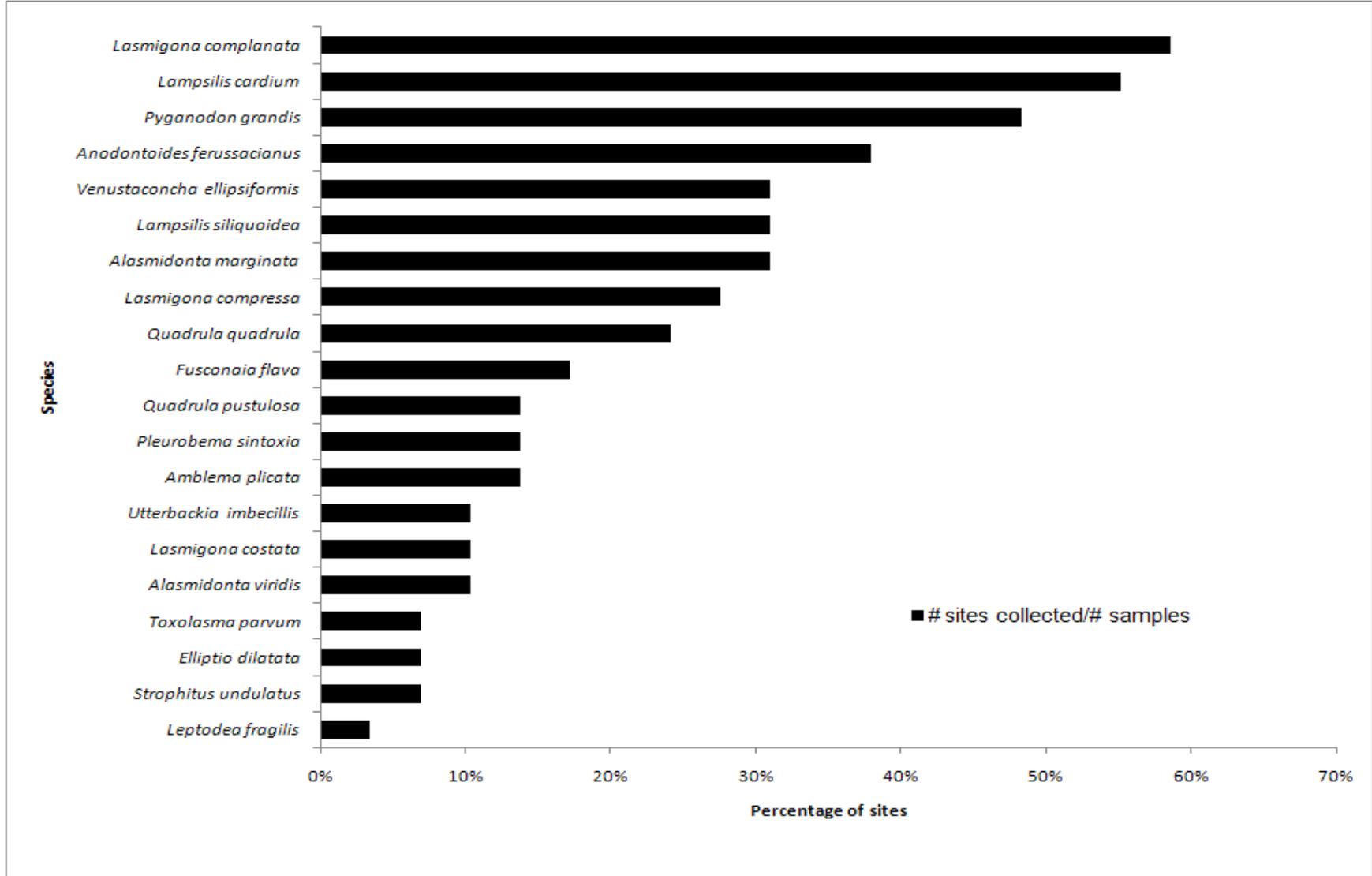


Figure 3. Number of sites where a species was collected live compared to the number of sites sampled in the Upper Fox (a. 16 sites; 17 samples) and Lower Fox (b. 28 sites; 29 samples).

Figure 4a. Upper Fox

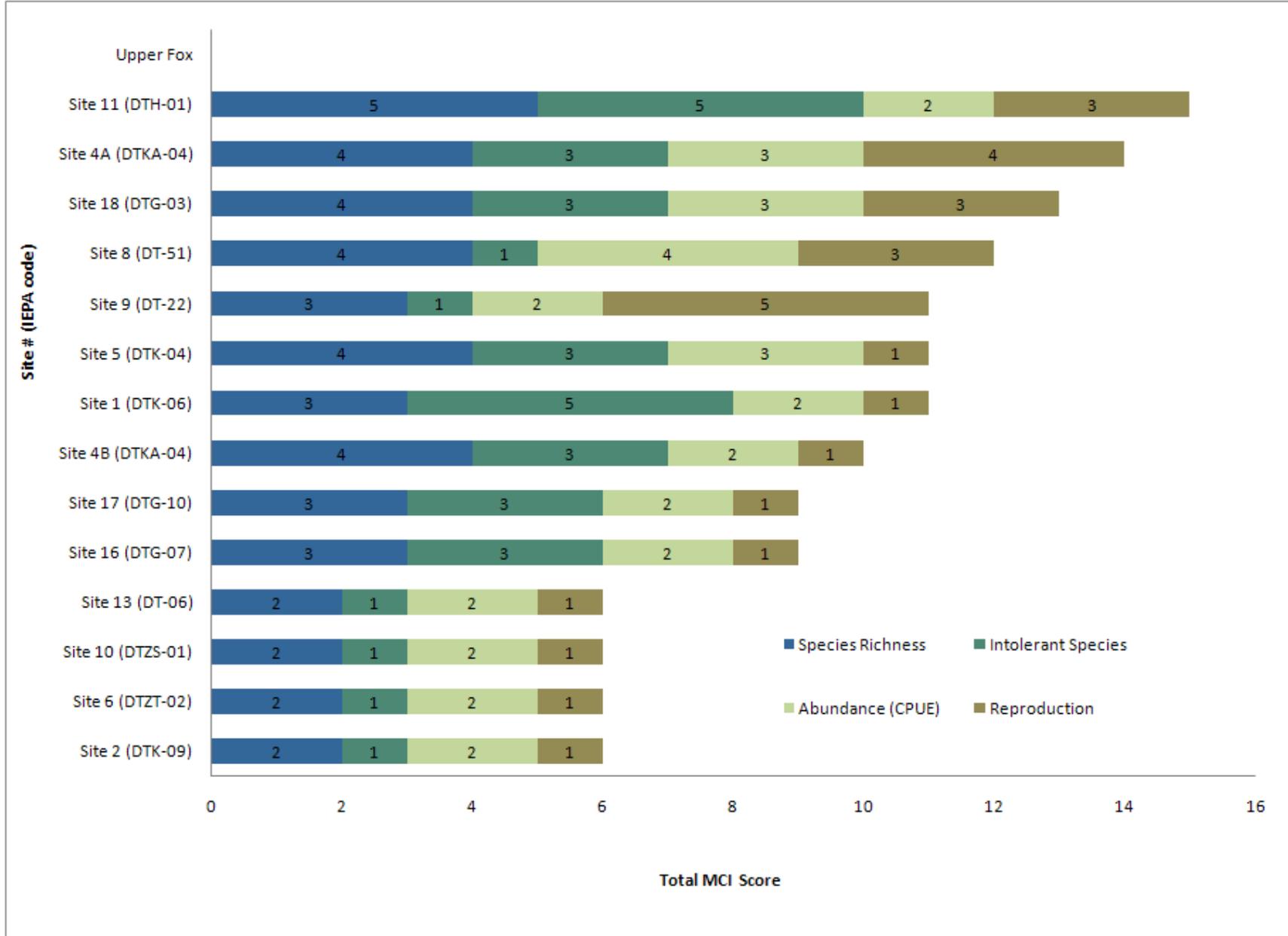


Figure 4b. Lower Fox

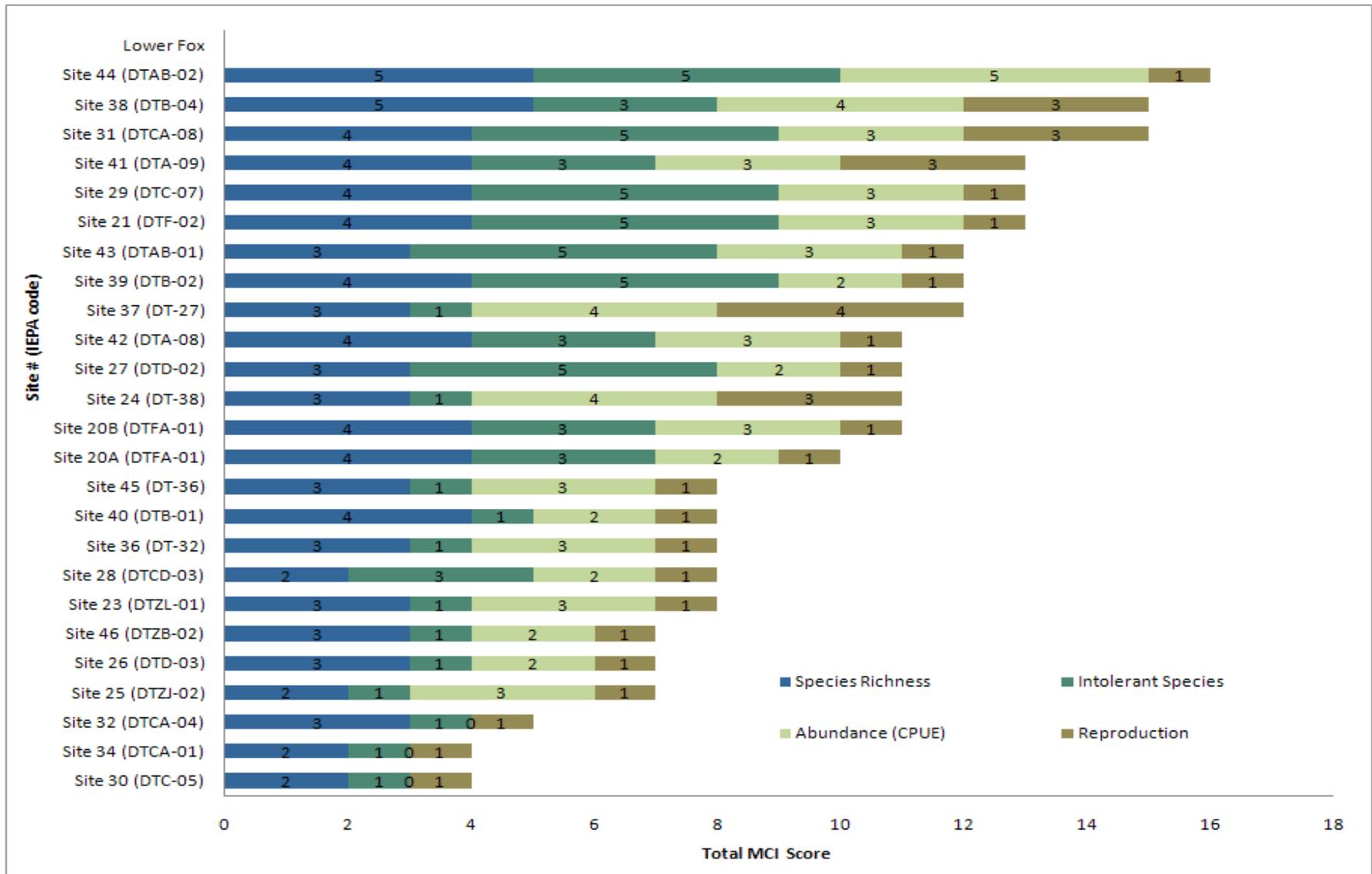


Figure 4. Comparison of Mussel Community Index (MCI) and MCI component scores for Fox River basin sites based on factor values from Table 3. Upper (a) and Lower (b).

Appendix 1. Scientific and common names of species, status refers to conservation status in Illinois at time of printing (February 2013); X = Extirpated, FE = Federally endangered, SE = State endangered, ST = State threatened, SGNC = State greatest need of conservation

Scientific Name	Common Name	Status
Subfamily Anodontinae		
<i>Alasmidonta marginata</i>	elktoe	
<i>Alasmidonta viridis</i>	slippershell mussel	ST
<i>Anodontoides ferussacianus</i>	cylindrical papershell	
<i>Lasmigona complanata</i>	white heelsplitter	
<i>Lasmigona compressa</i>	creek heelsplitter	SGNC
<i>Lasmigona costata</i>	flutedshell	SGNC
<i>Pyganodon grandis</i>	giant floater	
<i>Strophitus undulatus</i>	creeper	
<i>Utterbackia imbecillis</i>	paper pondshell	
Subfamily Ambleminae		
<i>Amblema plicata</i>	threeridge	
<i>Cyclonaias tuberculata</i>	purple wartyback	ST
<i>Elliptio dilatata</i>	spike	ST
<i>Fusconaia flava</i>	Wabash pigtoe	
<i>Plethobasus cyphus</i>	sheepnose	FE
<i>Pluerobema sintoxia</i>	round pigtoe	
<i>Quadrula metanevra</i>	monkeyface	SGNC
<i>Quadrula nodulata</i>	wartyback	
<i>Quadrula pustulosa</i>	pimpleback	
<i>Quadrula quadrula</i>	mapleleaf	
<i>Tritogonia verrucosa</i>	pistolgrip	
Subfamily Lampsilinae		
<i>Actinonaias ligamentina</i>	mucket	
<i>Epioblasma triquetra</i>	snuffbox mussel	FE
<i>Lampsilis cardium</i>	plain pocketbook	
<i>Lampsilis fasciola</i>	wavy-rayed lampmussel	SE
<i>Lampsilis siliquoidea</i>	fatmucket	
<i>Leptodea fragilis</i>	fragile papershell	
<i>Ligumia recta</i>	black sandshell	ST
<i>Obovaria olivaria</i>	hickorynut	
<i>Potamilus alatus</i>	pink heelsplitter	
<i>Potamilus ohioensis</i>	pink papershell	
<i>Toxolasma parvum</i>	lilliput	
<i>Truncilla donaciformis</i>	fawnsfoot	
<i>Venustaconcha ellipsiformis</i>	ellipse	SGNC
<i>Villosa iris</i>	rainbow	SE