Freshwater mussel timed-search surveys at historically sampled sites in the Grand River and Thames River watersheds, Ontario, 2021

Margaret N. Goguen, Kelly A. McNichols-O'Rourke, and Todd J. Morris

Fisheries and Oceans Canada
Ontario and Prairie Region
Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road
Burlington, ON
L7S 1A1

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The Grand and Thames rivers of southwestern Ontario are two of Canada's most important freshwater mussel (Bivalvia: Unionidae) rivers. Historically home to 32 and 35 species respectively, they now represent two of the last strongholds for many freshwater mussel species at risk (SAR) in Canada. Although extensive surveys had been completed throughout the Grand River and the Thames River watersheds in the past, these data likely no longer represent the current status of the freshwater mussel communities in these critically important watersheds. In 2021, Fisheries and Oceans Canada (DFO) surveyed 42 sites across the Grand River watershed and 8 sites in Thames River watershed to collect current information on the distribution and abundance of freshwater mussel communities. Each site was surveyed by a three-person crew for 4.5 person-hours using the qualitative timed-search method. In the Grand River watershed, a total of 2,898 live individuals representing 24 species were found including 264 SAR individuals of 6 species. In the Thames River watershed, 2,049 live individuals representing 21 species were found including 173 SAR individuals of 7 species. These data will provide current information for species assessments by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and contribute to meeting short- and long-term recovery objectives for SAR.

RÉSUMÉ

Goguen, M.N., McNichols-O'Rourke, K.A., and Morris, T.J. 2023. Freshwater mussel timed-search surveys at historically sampled sites in the Grand River and Thames River watersheds, Ontario, 2021. Can. Data Rep. Fish. Aquat. Sci. 1352: v + 23 p.

Situées au sud-ouest de l'Ontario, les rivières Grand et Thames sont parmi les plus importantes rivières à moules d'eau douce (*Bivalvia : Unionidae*) du Canada. Ces rivières qui, par le passé, abritaient 32 et 35 espèces respectivement, représentent aujourd'hui deux des derniers bastions de nombreuses espèces de moules d'eau douce en péril (p. ex. *Lampsilis fasciola*, *Quadrula quadrula* et *Truncilla donaciformis*) au Canada. Même si des relevés exhaustifs des moules d'eau douce indigènes ont déjà été effectués dans l'ensemble des bassins versants de la rivière Grand (années 1970 et 1990) et de la rivière Thames (années 1990 et début des années 2000), ceux-ci datent maintenant de 15 à 50 ans. Par conséquent, les données qu'ils contiennent ne représentent probablement plus l'état actuel des communautés de moules d'eau douce dans ces bassins versants d'une importance cruciale. En 2021, Pêches et Océans Canada a effectué un relevé de 42 sites dans le bassin versant de la rivière Grand et de 8 sites dans le bassin versant de la rivière Thames afin de recueillir des données récentes sur la répartition et l'abondance des communautés de moules d'eau douce de ces deux rivières. Les relevés de chaque site ont été effectués par une équipe de trois personnes pendant 4,5 heures-personnes, en utilisant la méthode qualitative de recherche à intervalles réguliers. Dans le bassin versant de la rivière Grand, on a trouvé un total de 2 898 individus vivants représentant 24 espèces, dont 264 individus de 6 espèces en péril. Dans le bassin versant de la rivière Thames, on a trouvé un total de 2 049 individus vivants représentant 21 espèces, dont 173 individus de 7 espèces en péril. Les relevés effectués en 2021 donnent un aperçu à jour de la communauté des unionidés de la rivière Grand dans l'ensemble du bassin versant, et des données récentes ont été recueillies pour certains sites clés du bassin versant de la rivière Thames. Ces données pourront être utilisées pour les évaluations des espèces par le Comité sur la situation des espèces en péril au Canada, et contribueront à l'atteinte des objectifs de rétablissement à court et à long terme des espèces en péril.

INTRODUCTION

Freshwater mussels are critically important components of the aquatic ecosystems in which they occur as they are natural environmental filters, provide habitat for algae and invertebrates, provide physical stability to the substrate, and transfer energy from aquatic to terrestrial environments (Haag 2012). In recent decades, the Bivalvia taxon has experienced global declines and is one of the most imperilled in the world (Lopes-Lima et al. 2018). This trend of drastic declines has also been seen nationally and has resulted in 35% of Canada's 55 native species being considered at-risk (Ricciardi et al. 1998; Government of Canada 2021). Declines have been primarily driven by the invasion of dreissenid mussels (*Dreissena polymorpha*, Zebra Mussel; *Dreissena rostriformis bugensis*, Quagga Mussel), habitat loss and degradation, and decreasing water quality (Ricciardi et al. 1998).

With 42 of the country's native freshwater mussel species, Ontario is the national hotspot for unionids (Metcalfe-Smith et al. 2005; DFO unpublished data). As such, Ontario has been the focus for freshwater mussel surveys since formal surveying began in earnest in the 1990s. By the end of 2010, most of the large inland waterbodies of southwestern Ontario had been systematically surveyed (Sheldon et al. 2020) including the Grand River (Kidd 1973; Mackie 1996; Metcalfe-Smith et al. 1998; Metcalfe-Smith et al. 1999; Metcalfe-Smith et al. 2000a) and Thames River (Morris 1996; Metcalfe-Smith et al. 1998; Metcalfe-Smith et al. 1999; Morris and Edwards 2007). These extensive surveys provided an understanding of the freshwater mussel community at the watershed scale and identified the importance of the Grand River and Thames River watersheds, which historically contained 32 and 35 species, respectively, as well as 12–13 species at risk (SAR; McNichols-O'Rourke et al. 2012). However, depending on the site, these data are now 15–50 years old and likely do not represent the current status of the freshwater mussel communities in either of these watersheds. While more recent surveys have occurred at select sites within these watersheds (Sheldon et al. 2020; DFO unpublished data), largescale watershed-wide surveys have not occurred since the original surveys, as effort has been focused on sites with known SAR (Table 1) populations and on other research objectives.

In 2021, Fisheries and Oceans Canada (DFO) returned to sites in the Grand River and Thames River watersheds that had been previously surveyed to collect current data on the native freshwater mussel communities. Effort was focused primarily on the Grand River watershed with sites selected from the upper to lower reaches of the main channel, as well as numerous tributaries, to provide coverage of the entire watershed. Sites were also surveyed in the Thames River watershed with the primary purpose of collecting data for a separate project that is not summarized in this data report. The data collected in the Thames River watershed will provide current information on the freshwater mussel communities at those sites; however, it does not represent a watershed-wide effort. The collection of these data in the Grand River and Thames River watersheds will provide current information for use by the Committee on the Status of Endangered Wildlife in

Canada (COSEWIC) to assist in the assessment of species and will aid in achieving short- and long-term recovery objectives identified in recovery strategies and management plans for SAR in Canada (DFO 2018a; DFO 2018b; DFO 2018c).

METHODS

SITE SELECTION

The Grand River watershed is the largest watershed in Ontario, located within the Lake Erie drainage in the southwestern region of the province and draining ~6,800 km^2 of land (Metcalfe-Smith et al. 2000a). Freshwater mussel surveys were first conducted on a watershed scale in the Grand River in the 1970s when 115 sites were surveyed (Kidd 1973). Twenty years later, qualitative timed-search surveys were conducted at 70 sites in 1995 (Mackie 1996) and 24 sites in 1997–1998 (Metcalfe-Smith et al. 1998; Metcalfe-Smith et al. 1999) in the Grand River watershed. Between July and September 2021, DFO surveyed 42 sites throughout the Grand River watershed that were selected from the previously surveyed sites from Kidd (1973), Mackie (1996), Metcalfe-Smith et al. (1998; 1999), or the Lower Great Lakes Unionid Database (2021) (Table 2; Figure 1; Figure 2). Sites were selected based on accessibility and to ensure a distribution of sites throughout the watershed.

The Thames River watershed is located within the Lake St. Clair drainage and is the second largest watershed in Ontario, draining 5,285 km^2 of land (Morris and Edwards 2007). Extensive qualitative freshwater mussel surveys were conducted at 30 sites in 1995 (Morris 1996), 16 sites in 1997–1998 (Metcalfe-Smith et al. 1998; Metcalfe-Smith et al. 1999), and 37 sites in 2004–2005 (Morris and Edwards 2007). Between July and August 2021, DFO surveyed eight sites in the Thames River watershed that were selected from sites previously surveyed by Morris (1996), Metcalfe-Smith et al. (1999), or Morris and Edwards (2007) (Table 2; Figure 1; Figure 3). Sites were selected based on suitability for another project that is not detailed in this report.

FRESHWATER MUSSEL SAMPLING

At each site, a semi-quantitative timed-search survey was conducted by a three-person crew for a total of 4.5 person-hours (Metcalfe-Smith et al. 2000b). Crew members used either mussel viewers, mussel scoops, or tactile searching based on the depth and turbidity of a site. All live mussels and shells found during the survey were collected and processed at the end of the search time. Each mussel found alive was identified to species, measured (maximum length in millimetre), and sexed visually (if sexually dimorphic) before being returned to the waterbody. Shells of species not observed live at the site were also identified to species and counted.

ENVIRONMENTAL DATA COLLECTION

Environmental data were also collected at each site. Before the timed-search survey began, air temperature (Kestrel 2000 Pocket Wind Meter), wind speed (Kestrel

2000 Pocket Wind Meter), water velocity (OTT MF Pro flow meter), water clarity (0.60 m turbidity tube), water temperature (EXO2 Multiparameter YSI), and water chemistry (EXO2 Multiparameter YSI) were measured. After the survey was completed, substrate composition was visually estimated across the entire site. Definitions of substrate sizes were taken from Stanfield (2010): boulder (>250 mm in diameter), cobble (65–250 mm), gravel (2–65 mm), sand (<2 mm), and "other" material (mud, muck, silt, and detritus). The length of river searched (Nikon Laser 1200S waterproof laser range finder), minimum, maximum, and average river width within the site (Nikon Laser 1200S waterproof laser range finder), and minimum and maximum depth searched (metre stick) were also measured. The environmental data were collected to provide a general understanding of the site characteristics and were not meant to provide a quantitative measure of habitat conditions.

RESULTS

Across all 50 sites, a total of 4,946 live mussels were observed representing 28 species. In the Grand River watershed, 2,898 live mussels were observed representing 24 species (Table 3). Live species richness ranged from zero species at six sites to 13 species at two sites. There was a general trend of increasing species richness when moving downstream in the watershed. *Eurynia dilatata* (Spike) was the most abundant species found in the Grand River watershed with a relative abundance of 19.53% (566 individuals). *Strophitus undulatus* (Creeper) was the most widespread species being found live at 52.38% (22/42) of the sites surveyed. Of the live individuals found in the Grand River watershed, 9.11% (264 individuals) were SAR representing six species: *Cambarunio iris* (Rainbow), *Lampsilis fasciola* (Wavyrayed Lampmussel), *Obliquaria reflexa* (Threehorn Wartyback), *Pleurobema sintoxia* (Round Pigtoe), *Quadrula quadrula* (Mapleleaf), and *Toxolasma parvum* (Lilliput). One additional SAR, *Truncilla donaciformis* (Fawnsfoot), was found only as valves at two sites in the lower Grand River. *Cambarunio iris* was the most abundant SAR found with an overall relative abundance of 4.49% (130 individuals) and a SAR relative abundance of 49.24%. *Cambarunio iris* and *L. fasciola* were the most widespread SAR, both being found at 16.67% (7/42) of the sites surveyed. Relevant environmental data are summarized for each site in Table 5.

In the Thames River watershed, 2,049 live mussels were observed representing 21 species (Table 4). Three additional common species were found only as shells/valves: *Alasmidonta viridis* (Slippershell), *Amblema plicata* (Threeridge), and *Fusconaia flava* (Wabash Pigtoe). Live species richness ranged from 4 species at one site to 13 species at two sites. Sites in the lower Thames River generally had higher species richness than sites in the upper Thames River and upper tributaries. *Ortmanniana ligamentina* (Mucket) was the most abundant species found across the Thames River sites accounting for 42.29% (866 individuals) of all individuals observed. *Lasmigona costata* (Flutedshell) was the most widespread species being found live at 75.00% (6/8) of the sites surveyed. Of the live mussels found, 8.44% (173 individuals) were SAR representing seven species: *C. iris*, *Cyclonaias tuberculata* (Purple Wartyback), *L. fasciola*, *O. reflexa*, *Paetulunio*

fabalis (Rayed Bean), *Q. quadrula*, and *T. donaciformis*. Three additional SAR were observed as shells/valves only: *Obovaria subrotunda* (Round Hickorynut), *P. sintoxia*, and *Ptychobranchus fasciolaris* (Kidneyshell). *Quadrula quadrula* was the most abundant SAR found with an overall relative abundance of 4.30% (88 individuals) and a SAR relative abundance of 51.16%. *Cyclonaias tuberculata* was the most widespread SAR being found at 50.00% (4/8) of the sites surveyed. Relevant environmental data are summarized for each site in Table 5.

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Table 1. Species at risk in Ontario and their current COSEWIC assessment (Government of Canada 2021), federal SARA listing (Government of Canada 2021), and provincial ESA listing (OMNRF 2021) as of November 2021. UC indicates species that are under consideration for SARA listing. The historical (H) and current (C) occurrence of each SAR is indicated for both the Grand River (GR) and Thames River (TR) as summarized in McNichols-O'Rourke et al. (2012). *Simpsonaias ambigua* shells have been found in the Grand River since the publication of McNichols-O'Rourke et al. (2012) and are included in this table (DFO unpublished data). Species found live in the watershed are indicated by Y and species known only as shells/valves in a watershed as indicated by SH. Nomenclature here and throughout follows MolluscaBase eds. (2021).

Scientific Name	Common Name	COSEWIC	SARA (Federal)	ESA (Provincial)	GR(H)	GR(C)	TR (H)	TR(C)
[1]*Cambarunio iris*	Rainbow	Special Concern	Special Concern	Special Concern	Y	Y	Y	Y
Cyclonaias tuberculata	Purple Wartyback	Threatened	UC	UC	-	-	SH	Y
Epioblasma rangiana	Northern Riffleshell	Endangered	Endangered	Endangered	-	-	SH	-
Epioblasma triquetra	Snuffbox	Endangered	Endangered	Endangered	Y	-	SH	SH
Lampsilis fasciola	Wavyrayed Lampmussel	Special Concern	Special Concern	Threatened	Y	Y	Y	Y
Obliquaria reflexa	Threehorn Wartyback	Threatened	Threatened	Threatened	SH	Y	Y	Y
Obovaria olivaria	Hickorynut	Endangered	Endangered	Endangered	Y	-	SH	-
Obovaria subrotunda	Round Hickorynut	Endangered	Endangered	Endangered	SH	-	SH	SH
[2]*Paetulunio fabalis*	Rayed Bean	Endangered	Endangered	Endangered	-	-	SH	Y
Pleurobema sintoxia	Round Pigtoe	Endangered	Endangered	Endangered	SH	Y	Y	Y
Ptychobranchus fasciolaris	Kidneyshell	Endangered	Endangered	Endangered	SH	SH	SH	Y
Quadrula quadrula	Mapleleaf	[4]Special Concern	[4]Special Concern	Special Concern	Y	Y	Y	Y
[3]*Sagittunio nasutus*	Eastern Pondmussel	Special Concern	Special Concern	Special Concern	SH	-	-	-
Simpsonaias ambigua	Salamander Mussel	Endangered	Endangered	Endangered	-	SH	-	SH
Toxolasma parvum	Lilliput	Endangered	Endangered	Threatened	SH	Y	Y	Y
Truncilla donaciformis	Fawnsfoot	Endangered	Endangered	Endangered	SH	Y	-	Y

Species currently listed under SARA and formerly known as:
[1]*Villosa iris*
[2]*Villosa fabalis*
[3]*Ligumia nasuta*
[4]Great Lakes - Upper St. Lawrence population

Table 2. Site locations and sample dates for sites sampled in the Grand River and Thames River watersheds in 2021. Sites are listed in upstream to downstream order. The separation of upper and lower Thames River sites is indicated by the dotted line. The original survey of each site is summarized in various reports; the original site code and relevant report is indicated.

Site Code	Original Site Code	Drainage	Waterbody	Latitude	Longitude	Date
HIST-196	71-99[1]	Lake Erie	Grand River	44.139640	-80.359280	25-Aug-21
HIST-195	71-98[1]	Lake Erie	Grand River	44.071120	-80.370350	25-Aug-21
HIST-191	71-94[1]	Lake Erie	Grand River	43.967570	-80.355580	25-Aug-21
HIST-192	71-95[1]	Lake Erie	Black Creek	43.960570	-80.376470	26-Aug-21
HIST-210	70-15[1]	Lake Erie	Grand River	43.923320	-80.321370	26-Aug-21
HIST-189	71-92[1]	Lake Erie	Willow Brook	43.910360	-80.275340	24-Aug-21
HIST-207	70-12[1]	Lake Erie	Grand River	43.881330	-80.277880	24-Aug-21
MAC26	26[2]	Lake Erie	Mallet Creek	43.780582	-80.733037	28-Jul-21
HIST-214	70-22[1]	Lake Erie	Conestogo River	43.757038	-80.669589	28-Jul-21
HIST-186	71-89[1]	Lake Erie	Irvine Creek	43.742030	-80.429080	19-Jul-21
MAC68	68[2]	Lake Erie	Swan Creek	43.656860	-80.401470	19-Jul-21
HIST-183	71-85[1]	Lake Erie	Swan Creek	43.642959	-80.427063	03-Aug-21
MAC38	38[2]	Lake Erie	Speed River	43.668480	-80.288450	05-Jul-21
HIST-187	71-90[1]	Lake Erie	Speed River	43.656460	-80.292730	15-Jul-21
HIST-160	71-83[1]	Lake Erie	Canagagigue Creek	43.640610	-80.578980	20-Jul-21
HIST-161	71-84[1]	Lake Erie	Canagagigue Creek	43.616550	-80.560040	20-Jul-21
MAC20	20[2]	Lake Erie	Eramosa River	43.606600	-80.155240	05-Jul-21
MAC21	21[2]	Lake Erie	Blue Springs Creek	43.571645	-80.148385	03-Aug-21
MAC24	24[2]	Lake Erie	Eramosa River	43.547454	-80.197591	15-Jul-21
MAC64	64[2]	Lake Erie	Boomer Creek	43.549948	-80.647672	29-Jul-21
GR-23	GR-98-23[3]	Lake Erie	Conestogo River	43.541375	-80.554359	04-Aug-21
GR-25	-	Lake Erie	Grand River	43.526966	-80.478583	04-Aug-21
GR-20	GR-97-10[3]	Lake Erie	Grand River	43.473130	-80.426300	06-Jul-21
GR-12	GR-97-12[4]	Lake Erie	Grand River	43.422100	-80.411250	06-Jul-21
GR-02	GR-97-02[4]	Lake Erie	Grand River	43.277290	-80.346780	07-Jul-21
GR-24	GR-98-24[3]	Lake Erie	Nith River	43.242770	-80.522000	07-Jul-21
MAC6	6[2]	Lake Erie	Horner Creek	43.226800	-80.616490	13-Jul-21
HIST-157	71-102[1]	Lake Erie	Fairchild Creek	43.187992	-80.197497	14-Jul-21
MAC13	13[2]	Lake Erie	Fairchild Creek	43.158210	-80.170860	23-Aug-21
HIST-169	71-70[1]	Lake Erie	Grand River	43.135261	-80.268871	27-Jul-21
GR-01	GR-97-01[4]	Lake Erie	Grand River	43.111780	-80.242880	01-Sep-21
GR-22	GR-98-22[3]	Lake Erie	Grand River	43.099291	-80.240755	27-Jul-21
HIST-170	71-68[1]	Lake Erie	Big Creek	43.115849	-80.053344	26-Jul-21
MAC10	10[2]	Lake Erie	McKenzie Creek	43.044121	-79.978236	26-Jul-21

Table 2. continued.

Site Code	Original Site Code	Drainage	Waterbody	Latitude	Longitude	Date
GR-05	GR-97-05[4]	Lake Erie	Grand River	43.042550	-79.904660	21-Sep-21
HIST-181	71-45[1]	Lake Erie	McKenzie Creek	43.023710	-79.913730	01-Sep-21
HIST-118	72-10[1]	Lake Erie	Grand River	43.019880	-79.891220	31-Aug-21
HIST-180	71-49[1]	Lake Erie	Grand River	43.011910	-79.885150	20-Sep-21
HIST-175	71-63[1]	Lake Erie	Grand River	42.946360	-79.861040	31-Aug-21
GR-11	GR-97-11[4]	Lake Erie	Grand River	42.932620	-79.684620	20-Sep-21
GR-07	GR-97-07[4]	Lake Erie	Sulphur Creek	42.901130	-79.635830	30-Aug-21
GR-17	GR-97-17[4]	Lake Erie	Sulphur Creek	42.896280	-79.634740	30-Aug-21
m14	14[5]	Lake St. Clair	South Thames River	43.018680	-80.926640	22-Jul-21
TR-12	TR-98-12[3]	Lake St. Clair	North Thames River	43.149430	-81.191800	21-Jul-21
m11	11[5]	Lake St. Clair	Medway Creek	43.107730	-81.324560	21-Jul-21
m20	20[5]	Lake St. Clair	Dingman Creek	42.926802	-81.336257	22-Jul-21
TR-51	TM05-10[6]	Lake St. Clair	Thames River	42.708210	-81.616230	19-Aug-21
TR-42	TM05-01[6]	Lake St. Clair	Thames River	42.642570	-81.704020	19-Aug-21
TR-50	TM05-09[6]	Lake St. Clair	Thames River	42.563080	-81.929590	18-Aug-21
m24	24[5]	Lake St. Clair	Thames River	42.544220	-81.968420	18-Aug-21

[1] Kidd (1973)
[2] Mackie (1996)
[3] Metcalfe-Smith et al. (1999)
[4] Metcalfe-Smith et al. (1998)
[5] Morris (1996)
[6] Morris and Edwards (2007)

Table 3. Species information for each site surveyed in the Grand River watershed in 2021. Sites are presented in upstream to downstream order. Species at risk are highlighted. S(#) represents species found as complete shells and the number of shells found. V(#) represents species found as valves (one half of a full shell) and the number of valves found. Unknown individuals and individuals identified only to genus are included in the abundance total, but not in the species richness totals. All shells/valves are in weathered condition unless otherwise indicated.

Scientific Name	Common Name	HIST-196	HIST-195	HIST-191	HIST-192	HIST-210	HIST-189	HIST-207	MAC26	HIST-214	HIST-186	MAC68
Alasmidonta marginata	Elktoe						1					
Alasmidonta viridis	Slippershell	1	S(6);V(8)	V(8)	V(2)	V(5)	S(1);V(3)	V(5)	21	S(6);V(1)	31	2
Amblema plicata	Threeridge											
Cambarunio iris	Rainbow								98			
Cyclonaias pustulosa	Pimpleback											
Eurynia dilatata	Spike								65			
Fusconaia flava	Wabash Pigtoe											
Lampsilis cardium	Plain Pocketbook											
Lampsilis fasciola	Wavyrayed Lampmussel											
Lampsilis siliquoidea	Fatmucket								39	V(2)	287	
Lasmigona compressa	Creek Heelsplitter	1	S(1);V(2)	V(7)	S(1);V(6)	V(6)	V(6)	V(8)	1		24	
Lasmigona costata	Flutedshell								14			S(1)
Ligumia recta	Black Sandshell											
Obliquaria reflexa	Threehorn Wartyback											
Ortmanniana ligamentina	Mucket											
Pleurobema sintoxia	Round Pigtoe											
Potamilus alatus	Pink Heelsplitter											
Potamilus fragilis	Fragile Papershell											
Pyganodon grandis	Giant Floater	3	6		5			S(1)	5		26	27
Quadrula quadrula	Mapleleaf											
Strophitus undulatus	Creeper	75	S(5);V(13)	1	9	V(1)	5		59	S(1);V(1)	99	7
Toxolasma parvum	Lilliput											
Truncilla donaciformis	Fawnsfoot											
Truncilla truncata	Deertoe											
Truncilla sp.												
Utterbackia imbecillis	Paper Pondshell											
Unknown												
Total abundance		80	6	1	14	0	6	0	302	0	467	36
Live species richness		4	1	1	2	0	2	0	8	0	5	3
Total species richness		4	4	3	4	3	4	3	8	3	5	4

Table 3. Continued.

Scientific Name	Common Name	HIST-183	MAC38	HIST-187	HIST-160	HIST-161	MAC20	MAC21	MAC24	MAC64	GR-23	GR-25	GR-20
Alasmidonta marginata	Elktoe										3		1
Alasmidonta viridis	Slippershell	V(3)	S(1);V(36)	S(3);V(16)			S(3); V(5)		1	10	V(2)		
Amblema plicata	Threeridge												
Cambarunio iris	Rainbow										9	8	1
Cyclonaias pustulosa	Pimpleback												
Eurynia dilatata	Spike										18	252	27
Fusconaia flava	Wabash Pigtoe												
Lampsilis cardium	Plain Pocketbook												
Lampsilis fasciola	Wavyrayed Lampmussel										5	15	9
Lampsilis siliquoidea	Fatmucket					V(2)				13	3	2	2
Lasmigona compressa	Creek Heelsplitter		S(1);V(2)	V(1)			S(1)						
Lasmigona costata	Flutedshell					S(1)				6	34	16	42
Ligumia recta	Black Sandshell												
Obliquaria reflexa	Threehorn Wartyback												
Ortmanniana ligamentina	Mucket												
Pleurobema sintoxia	Round Pigtoe												
Potamilus alatus	Pink Heelsplitter												
Potamilus fragilis	Fragile Papershell												
Pyganodon grandis	Giant Floater	S(1)*;S(3)	V(1)	V(1)		V(1)	20			51	V(1)		
Quadrula quadrula	Mapleleaf												
Strophitus undulatus	Creeper	1	S(4);V(7)	2		1	S(4)		1	10	2	1	5
Toxolasma parvum	Lilliput												
Truncilla donaciformis	Fawnsfoot												
Truncilla truncata	Deertoe												
Truncilla sp.													
Utterbackia imbecillis	Paper Pondshell												
Unknown													
Total abundance		1	0	2	0	1	20	0	2	90	74	294	87
Live species richness		1	0	1	0	1	1	0	2	5	7	6	7
Total species richness		3	4	4	0	4	4	0	2	5	9	6	7

* Fresh shell with tissue inside.

Table 3. Continued.

Scientific Name	Common Name	GR-12	GR-02	GR-24	MAC6	HIST-157	MAC13	HIST-169	GR-01	GR-22	HIST-170	MAC10	GR-05
Alasmidonta marginata	Elktoe	V(3)	4	6				7	V(1)	V(1)			S(10);V(11)
Alasmidonta viridis	Slippershell		V(1)			V(1)							V(1)
Amblema plicata	Threeridge					11	1		3	7		1	17
Cambarunio iris	Rainbow			8						1			V(1)
Cyclonaias pustulosa	Pimpleback												14
Eurynia dilatata	Spike	V(1)	V(1)	164									V(1)
Fusconaia flava	Wabash Pigtoe					3	S(2);V(1)			V(1)		2	7
Lampsilis cardium	Plain Pocketbook			3			1	10	8	1	3	S(1);V(1)	5
Lampsilis fasciola	Wavyrayed Lampmussel	4	25	4				2					S(1)*
Lampsilis siliquoidea	Fatmucket		3	63		2	V(1)				13	36	
Lasmigona compressa	Creek Heelsplitter			1									
Lasmigona costata	Flutedshell	7	36	105		S(1)	V(1)	23	S(1)	1	5	S(4);V(1)	2
Ligumia recta	Black Sandshell						3	17	5	7		6	6
Obliquaria reflexa	Threehorn Wartyback												V(1)
Ortmanniana ligamentina	Mucket			1			1	115	13	19	2	2	19
Pleurobema sintoxia	Round Pigtoe												3
Potamilus alatus	Pink Heelsplitter									1			3
Potamilus fragilis	Fragile Papershell											5	5
Pyganodon grandis	Giant Floater	5				3	3			3	5	S(1);V(1)	
Quadrula quadrula	Mapleleaf												2
Strophitus undulatus	Creeper	4	1	106	1			5					S(1)
Toxolasma parvum	Lilliput												
Truncilla donaciformis	Fawnsfoot												
Truncilla truncata	Deertoe												13
Truncilla sp.													V(1)
Utterbackia imbecillis	Paper Pondshell												
Unknown													
Total abundance		20	69	461	1	19	9	179	29	40	28	52	96
Live species richness		4	5	10	1	4	5	7	4	8	5	6	12
Total species richness		6	7	10	1	6	8	7	6	10	5	9	19

*Fresh shell with tissue inside.

Table 3. Continued. Total abundance, relative abundance, and frequency of occurrence are presented for each species; these data are calculated across all 42 sites surveyed in the Grand River watershed.

Scientific Name	Common Name	HIST-181	HIST-118	HIST-180	HIST-175	GR-11	GR-07	GR-17	Totals	Relative Abundance (%)	Frequency of Occurrence (%)
Alasmidonta marginata	Elktoe	V(1)	9	1					32	1.10	19.05
Alasmidonta viridis	Slippershell								66	2.28	14.29
Amblema plicata	Threeridge	3	1	6			1	V(1)	51	1.76	23.81
Cambarunio iris	Rainbow	5							130	4.49	16.67
Cyclonaias pustulosa	Pimpleback		2	S(2);V(4)			1	V(2)	17	0.59	7.14
Eurynia dilatata	Spike	40	V(1)						566	19.53	14.29
Fusconaia flava	Wabash Pigtoe			2		5	S(1)		19	0.66	11.90
Lampsilis cardium	Plain Pocketbook		1						32	1.10	19.05
Lampsilis fasciola	Wavyrayed Lampmussel								64	2.21	16.67
Lampsilis siliquoidea	Fatmucket	14	1	2					480	16.56	33.33
Lasmigona compressa	Creek Heelsplitter								27	0.93	9.52
Lasmigona costata	Flutedshell	S(2)	9	4					304	10.49	33.33
Ligumia recta	Black Sandshell	1	6	3					54	1.86	21.43
Obliquaria reflexa	Threehorn Wartyback				V(1)			1	1	0.03	2.38
Ortmanniana ligamentina	Mucket	5	70	76	V(1)				323	11.15	26.19
Pleurobema sintoxia	Round Pigtoe		3	1					7	0.24	7.14
Potamilus alatus	Pink Heelsplitter		V(1)	5				V(1)	9	0.31	7.14
Potamilus fragilis	Fragile Papershell	V(1)	1	5	2			V(1)	18	0.62	11.90
Pyganodon grandis	Giant Floater	S(1);V(3)				2	4	2	170	5.87	38.10
Quadrula quadrula	Mapleleaf	S(1)	1	2	S(1)	30	16	2	53	1.83	14.29
Strophitus undulatus	Creeper	S(2)	1	1					397	13.70	52.38
Toxolasma parvum	Lilliput					8		1	9	0.31	4.76
Truncilla donaciformis	Fawnsfoot		V(1)					V(5)	-	-	-
Truncilla truncata	Deertoe		1	3	V(1)			V(12)	17	0.59	7.14
Truncilla sp.									-	-	-
Utterbackia imbecillis	Paper Pondshell	S(1)				41	3	6	50	1.73	7.14
Unknown juvenile			2						2	0.07	2.38
Total abundance		68	108	111	2	86	25	12	2,898		
Live species richness		6	13	13	1	5	5	5	24		
Total species richness		13	16	14	5	5	6	11	25		

Table 4. Species information for each site surveyed in the Thames River watershed in 2021. Sites are presented in upstream to downstream order. Species at risk are highlighted. S(#) represents species found as complete shells and the number of shells found. V(#) represents species found as valves (one half of a full shell) and the number of valves found. Unknown individuals are included in the abundance total, but not in the species richness totals. All shells/valves were in weathered condition.

Scientific Name	Common Name	m14	TR-12	m11	m20	TR-51	TR-42	TR-50	m24	Totals	Relative Abundance (%)	Frequency of Occurrence (%)
Alasmidonta marginata	Elktoe		3		V(1)		S(1);V(1)	1	V(3)	4	0.20	25.00
Alasmidonta viridis	Slippershell	V(2)		S(3)	V(1)					-	-	-
Amblema plicata	Threeridge					S(1);V(1)	S(1);V(2)		V(2)	-	-	-
Cambarunio iris	Rainbow		1	11	V(1)					12	0.59	25.00
Cyclonaias pustulosa	Pimpleback					160	58	184	6	408	19.91	50.00
Cyclonaias tuberculata	Purple Wartyback		14			13	1	12	V(1)	40	1.95	50.00
Eurynia dilatata	Spike	V(2)	4	261	V(8)				V(9)	265	12.93	25.00
Fusconaia flava	Wabash Pigtoe	V(3)			S(3);V(13)					-	-	-
Lampsilis cardium	Plain Pocketbook	1	6			8	1	2	1	19	0.93	75.00
Lampsilis fasciola	Wavyrayed Lampmussel		19							19	0.93	12.50
Lasmigona complanata	White Heelsplitter	35			2	3	6	V(1)	V(1)	46	2.24	50.00
Lasmigona compressa	Creek Heelsplitter	S(1)			3					3	0.15	12.50
Lasmigona costata	Flutedshell	11	39	3	V(2)	18	1	9		81	3.95	75.00
Ligumia recta	Black Sandshell					5	2	3		10	0.49	37.50
Obliquaria reflexa	Threehorn Wartyback					1		2	V(2)	3	0.15	25.00
Obovaria subrotunda	Round Hickorynut						S(1)			-	-	-
Ortmanniana ligamentina	Mucket	4				364	179	309	10	866	42.26	62.50
Paetulunio fabalis	Rayed Bean		3							3	0.15	12.50
Pleurobema sintoxia	Round Pigtoe	V(1)								-	-	-
Potamilus alatus	Pink Heelsplitter					2		5	1	8	0.39	37.50
Potamilus fragilis	Fragile Papershell					23	4	17	4	48	2.34	50.00
Ptychobranchus fasciolaris	Kidneyshell								V(1)	-	-	-
Pyganodon grandis	Giant Floater	2		35	11					48	2.34	37.50
Quadrula quadrula	Mapleleaf					63	7	18		88	4.29	37.50
Strophitus undulatus	Creeper	1	7	1	8					17	0.83	50.00
Truncilla donaciformis	Fawnsfoot					3	1	4		8	0.39	37.50
Truncilla truncata	Deertoe					15	1	30	1	47	2.29	50.00
Unknown juvenile						6				6	0.29	12.50
Total abundance		54	96	311	24	684	261	596	23	2,049		
Live species richness		6	9	5	4	13	11	13	6	21		
Total species richness		11	9	6	10	14	14	14	13	27		

Table 5. Relevant environmental data collected at each site in the Grand River watershed. Sites are presented in upstream to downstream order.

		HIST-196	HIST-195	HIST-191	HIST-192	HIST-210	HIST-189	HIST-207	MAC26	HIST-214	HIST-186	MAC68	HIST-183	MAC38	HIST-187
Search Area Measurements	Length of Reach Searched (m)	121.0	328.5	596.0	251.0	649.0	227.5	642.0	56.0	193.0	108.0	259.0	163.0	353.5	254.0
	Min Width of Reach (m)	8.0	4.5	11.5	6.0	15.0	4.5	15.5	3.5	14.5	10.0	1.0	1.0	5.0	7.0
	Max Width of Reach (m)	18.5	12.0	23.0	8.0	19.5	11.5	31.5	6.0	35.0	12.0	5.5	7.5	17.5	15.0
	Avg Width (m)	8.0	8.0	20.0	7.0	17.0	7.5	18.0	5.5	17.0	10.0	3.0	4.0	10.0	10.0
	Max Depth Searched (m)	0.55	0.55	0.70	0.60	0.60	0.60	0.55	0.27	1.10	0.80	0.40	0.40	0.65	0.46
	Avg Depth Searched (m)	0.40	0.30	0.40	0.45	0.40	0.25	0.15	0.15	0.35	0.20	0.20	0.15	0.25	0.32
	Water Clarity (m)	>0.60	>0.60	>0.60	>0.60	>0.60	>0.60	>0.60	>0.60	0.27	>0.60	>0.60	>0.60	>0.60	>0.60
	Water Velocity (m/s)	0.025	0.022	0.044	0.108	0.052	0.015	0.178	0.250	0.001	0.031	0.165	0.143	0.210	0.204
YSI Measurements	Water Temperature (°C)	23.34	25.51	25.23	23.81	25.22	19.59	25.43	19.58	24.15	21.12	24.51	15.74	25.25	19.16
	Conductivity (µs/cm)	642.00	549.00	238.30	143.00	291.50	408.80	362.40	473.40	494.40	400.70	610.00	474.50	515.00	482.30
	TDS (mg/L)	439.54	353.58	154.24	95.15	188.41	296.28	233.73	343.19	326.55	281.39	400.84	374.80	332.82	353.30
	ODO (%)	71.70	108.90	126.40	80.30	115.30	73.50	125.00	77.40	104.20	79.50	199.00	84.50	146.10	90.30
	ODO (mg/L)	6.19	8.94	10.42	6.75	9.53	6.70	10.25	7.04	8.71	7.04	16.77	8.32	12.01	8.35
	Turbidity (FNU)	2.73	2.67	2.30	4.15	3.86	3.12	2.23	2.73	18.24	2.46	4.23	1.37	0.88	2.15
Stream Morphology	Riffle (%)	0	10	10	0	5	15	35	10	0	0	0	10	30	30
	Pool (%)	0	0	0	0	0	5	0	0	5	5	0	0	5	5
	Run (%)	100	90	90	100	95	80	65	90	95	95	100	90	65	65
	Flat (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Substrate Composition	Bedrock (%)	0	0	0	0	0	0	40	0	0	0	0	0	5	0
	Boulder (%)	0	5	10	0	5	5	15	0	5	0	0	0	5	5
	Rubble (%)	5	60	50	5	45	80	40	15	60	20	40	50	70	70
	Gravel (%)	45	30	30	5	40	10	5	80	30	60	50	35	15	15
	Sand (%)	45	5	5	15	10	5	0	5	0	5	0	5	5	5
	Silt (%)	5	0	5	70	0	0	0	0	5	15	10	10	0	5
	Clay (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Muck (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Detritus (%)	0	0	0	5	0	0	0	0	0	0	0	0	0	0

Table 5. Continued.

		HIST-160	HIST-161	MAC20	MAC21	MAC24	MAC64	GR-23	GR-25	GR-20	GR-12	GR-02	GR-24	MAC6	HIST-157
Site Measurements	Length of Reach Searched (m)	380.5	75.0	302.0	236.0	341.5	104.0	213.0	213.5	241.0	291.0	476.0	237.5	418.5	88.5
	Min Width of Reach (m)	2.0	9.0	6.8	6.0	13.0	10.0	45.0	52.0	34.5	73.5	101.0	23.0	6.0	8.0
	Max Width of Reach (m)	6.0	15.0	22.0	12.0	32.0	11.0	55.0	52.0	100.0	114.0	105.0	36.0	10.0	10.0
	Avg Width (m)	4.0	9.0	14.5	10.0	22.0	10.0	45.0	52.0	40.0	90.0	105.0	35.0	8.0	9.0
	Max Depth Searched (m)	0.40	0.45	0.78	0.70	0.58	0.80	0.60	0.80	0.60	0.70	0.67	0.71	1.00	1.30
	Avg Depth Searched (m)	0.15	0.25	0.35	0.35	0.30	0.60	0.50	0.65	0.30	0.40	0.50	0.46	0.65	1.20
	Water Clarity (m)	>0.60	0.07	>0.60	>0.60	>0.60	>0.60	>0.60	>0.60	>0.60	>0.60	>0.60	>0.60	>0.60	0.07
	Water Velocity (m/s)	0.098	0.495	0.373	0.269	0.252	0.021	0.709	0.182	0.395	0.092	0.259	0.110	0.076	0.186
YSI Measurements	Water Temperature (°C)	20.68	22.50	23.42	16.06	22.00	20.51	21.33	24.07	26.08	25.06	25.55	26.33	19.20	21.70
	Conductivity (µs/cm)	498.50	435.20	535.00	552.00	589.00	530.00	400.80	467.30	647.00	674.00	909.00	741.00	690.00	716.00
	TDS (mg/L)	353.20	309.40	358.63	432.66	413.00	376.74	280.14	309.20	411.80	437.62	584.76	469.70	103.50	496.50
	ODO (%)	150.90	65.00	91.40	88.50	105.70	46.00	92.60	155.40	116.40	70.10	107.20	119.90	100.70	72.00
	ODO (mg/L)	13.66	5.58	7.77	8.78	9.42	4.07	8.15	13.09	9.42	5.74	8.75	9.66	9.30	6.31
	Turbidity (FNU)	1.50	75.00	2.99	1.39	2.67	4.45	3.71	3.45	3.26	2.60	1.72	2.50	1.74	91.00
Stream Morphology	Riffle (%)	10	10	15	15	30	0	20	0	15	15	60	10	0	0
	Pool (%)	0	0	10	0	0	10	0	0	0	5	0	0	30	0
	Run (%)	90	90	75	85	70	90	80	100	85	80	40	90	70	100
	Flat (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Substrate Composition	Bedrock (%)	0	0	5	0	5	0	0	0	0	0	0	0	0	0
	Boulder (%)	5	5	15	10	5	0	5	5	5	0	0	0	2	5
	Rubble (%)	30	40	25	10	70	30	50	75	55	80	50	35	0	0
	Gravel (%)	40	40	5	0	15	15	30	15	39	15	40	45	0	0
	Sand (%)	20	0	0	0	5	5	5	0	1	0	5	15	55	0
	Silt (%)	5	15	50	75	0	50	10	5	0	5	5	5	43	0
	Clay (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	75
	Muck (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Detritus (%)	0	0	0	5	0	0	0	0	0	0	0	0	0	20

Table 5. Continued.

		MAC13	HIST-169	GR-01	GR-22	HIST-170	MAC10	GR-05	HIST-181	HIST-118	HIST-180	HIST-175	GR-11	GR-07	GR-17
Site Measurements	Length of Reach Searched (m)	71.0	95.0	200.5	73.0	312.0	30.0	93.0	15.5	24.0	48.5	90.0	98.0	93.5	33.5
	Min Width of Reach (m)	8.0	85.0	43.5	69.0	6.0	13.0	29.5	13.5	125.0	157.0	153.0	185.0	49.5	38.0
	Max Width of Reach (m)	11.0	85.0	59.5	69.0	11.0	13.0	31.5	16.5	125.0	157.0	153.0	185.0	49.5	38.0
	Avg Width (m)	11.0	85.0	55.0	69.0	11.0	13.0	31.0	14.5	125.0	157.0	153.0	185.0	49.5	38.0
	Max Depth Searched (m)	1.10	0.65	0.60	1.15	1.10	0.43	1.10	0.20	0.40	0.54	1.15	1.40	1.20	1.15
	Avg Depth Searched (m)	1.00	0.34	0.30	0.75	0.70	0.43	0.60	0.20	0.35	0.39	1.00	0.73	1.10	1.05
	Water Clarity (m)	0.10	>0.60	>0.60	>0.60	0.35	0.13	0.35	0.20	0.39	0.15	0.43	23.50	0.19	0.18
	Water Velocity (m/s)	0.029	0.365	0.011	0.011	0.041	0.047	0.032	0.508	0.120	0.250	0.001	0.014	0.058	0.024
YSI Measurements	Water Temperature (°C)	23.27	24.08	23.33	24.92	22.60	22.70	20.78	22.58	26.28	20.18	25.45	20.95	28.20	26.71
	Conductivity (µs/cm)	729.00	721.00	632.00	873.00	762.00	679.00	693.00	1264.00	888.00	712.00	846.00	681.00	931.00	713.00
	TDS (mg/L)	490.79	477.36	424.05	568.62	518.68	461.84	490.13	861.95	563.65	509.72	544.80	4817.94	570.72	448.72
	ODO (%)	71.60	99.50	138.50	101.30	56.60	63.60	88.40	69.10	100.90	97.20	67.50	74.70	116.80	75.00
	ODO (mg/L)	6.04	8.36	11.99	8.34	4.83	5.43	7.91	5.92	8.12	8.79	5.42	6.63	9.11	5.97
	Turbidity (FNU)	53.89	3.23	3.37	5.10	12.61	37.16	14.68	17.16	12.49	29.79	4.99	15.16	20.35	15.21
Stream Morphology	Riffle (%)	0	0	0	0	0	0	0	100	0	0	0	0	0	0
	Pool (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Run (%)	100	100	100	100	100	100	100	0	100	100	100	100	100	100
	Flat (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Substrate Composition	Bedrock (%)	0	0	0	0	0	0	0	0	0	5	5	0	0	0
	Boulder (%)	0	5	0	0	5	5	2	5	0	0	0	0	0	0
	Rubble (%)	0	40	0	70	20	50	8	50	50	50	35	0	0	0
	Gravel (%)	20	50	5	20	5	40	30	35	50	35	50	2	0	5
	Sand (%)	0	5	50	0	0	0	45	0	0	0	0	0	0	0
	Silt (%)	0	0	45	10	60	5	10	10	0	5	10	0	30	35
	Clay (%)	65	0	0	0	0	0	0	0	0	5	0	90	70	10
	Muck (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	5
	Detritus (%)	15	0	0	0	10	0	5	0	0	0	0	8	0	45

Table 6. Relevant environmental data collected at each site in the Thames River watershed. Sites are presented in upstream to downstream order.

		m14	TR-12	m11	m20	TR-51	TR-42	TR-50	m24
Site Measurements	Length of Reach Searched (m)	174.5	151.0	77.5	95.5	33.5	50.5	29.5	50.0
	Min Width of Reach (m)	24.0	28.5	5.0	12.5	45.0	43.0	43.0	38.0
	Max Width of Reach (m)	24.0	41.0	9.0	16.5	45.0	60.0	43.0	38.0
	Avg Width (m)	24.0	28.5	7.0	16.5	45.0	56.0	43.0	38.0
	Max Depth Searched (m)	0.65	0.60	0.50	0.40	0.40	0.50	0.70	0.60
	Avg Depth Searched (m)	0.45	0.40	0.35	0.40	0.30	0.40	0.65	0.55
	Water Clarity (m)	>0.60	>0.60	>0.60	0.28	0.09	0.07	0.08	0.10
	Water Velocity (m/s)	0.809	0.255	0.026	0.082	0.350	0.559	0.192	0.143
YSI Measurements	Water Temperature (°C)	20.17	22.24	26.20	19.30	24.61	23.31	23.79	23.05
	Conductivity (µs/cm)	974.00	553.00	542.00	871.00	753.00	671.00	659.00	675.00
	TDS (mg/L)	697.54	379.68	345.00	633.70	493.26	450.20	438.81	457.56
	ODO (%)	115.20	101.00	149.00	68.80	88.80	81.10	89.10	85.00
	ODO (mg/L)	10.51	8.78	12.20	6.28	7.38	6.89	7.51	7.21
	Turbidity (FNU)	5.34	1.23	1.70	14.00	54.76	83.40	88.00	76.50
Stream Morphology	Riffle (%)	10	20	5	0	20	30	20	0
	Pool (%)	5	5	0	5	0	0	0	0
	Run (%)	85	75	95	95	80	70	80	100
	Flat (%)	0	0	0	0	0	0	0	0
Substrate Composition	Bedrock (%)	0	0	0	0	0	0	0	0
	Boulder (%)	0	40	5	5	0	0	0	0
	Rubble (%)	20	40	15	20	0	10	5	40
	Gravel (%)	10	15	30	35	60	60	55	50
	Sand (%)	0	5	40	0	35	30	40	0
	Silt (%)	50	0	10	40	0	0	0	0
	Clay (%)	20	0	0	0	5	0	0	10
	Muck (%)	0	0	0	0	0	0	0	0
	Detritus (%)	0	0	0	0	0	0	0	0

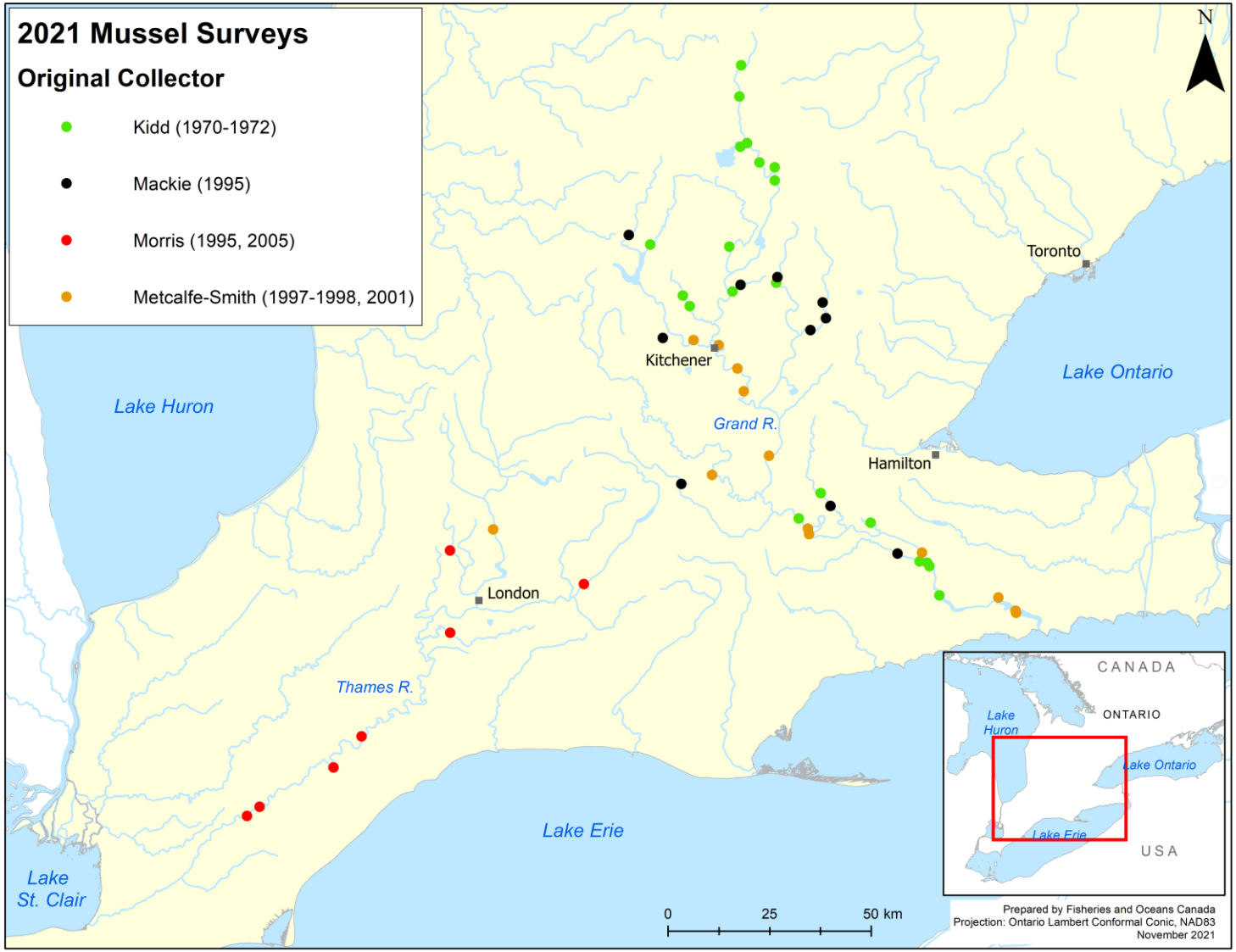

Figure 1. Sites surveyed in the Grand River and Thames River watersheds in 2021.

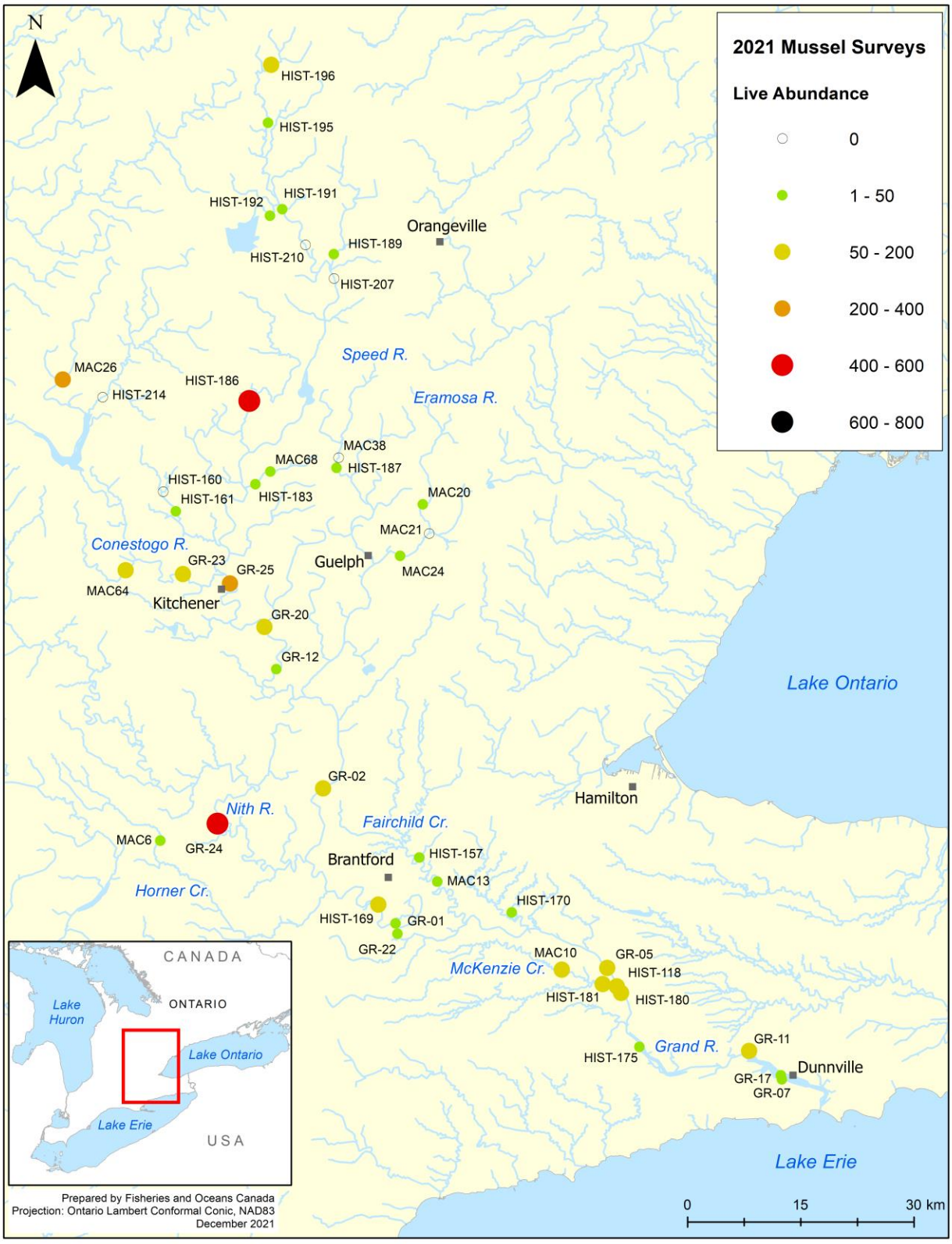

Figure 2. Live abundance of freshwater mussels found during timed-search surveys in the Grand River watershed in 2021.

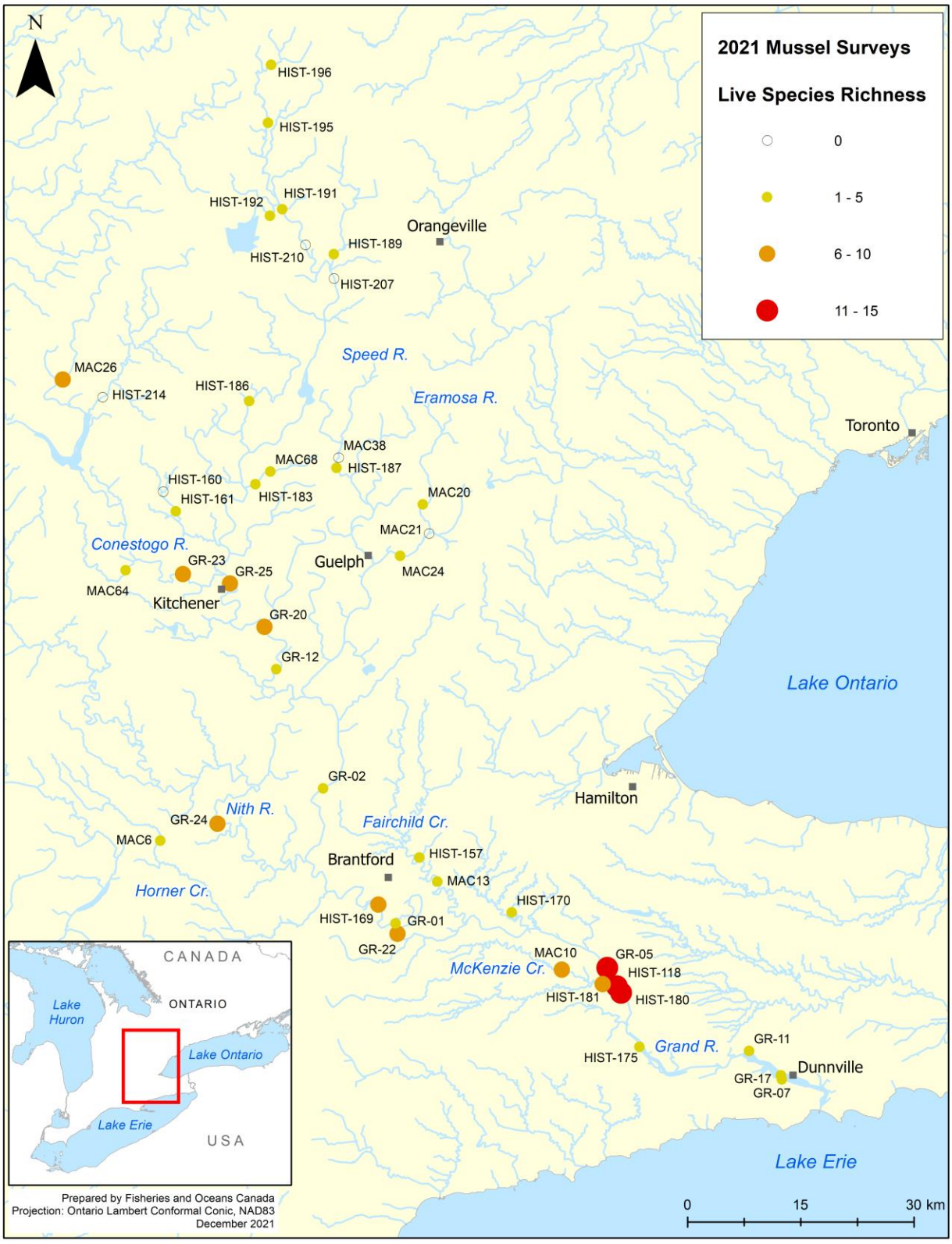

Figure 3. Live species richness of freshwater mussels found during timed-search surveys in the Grand River watershed in 2021.

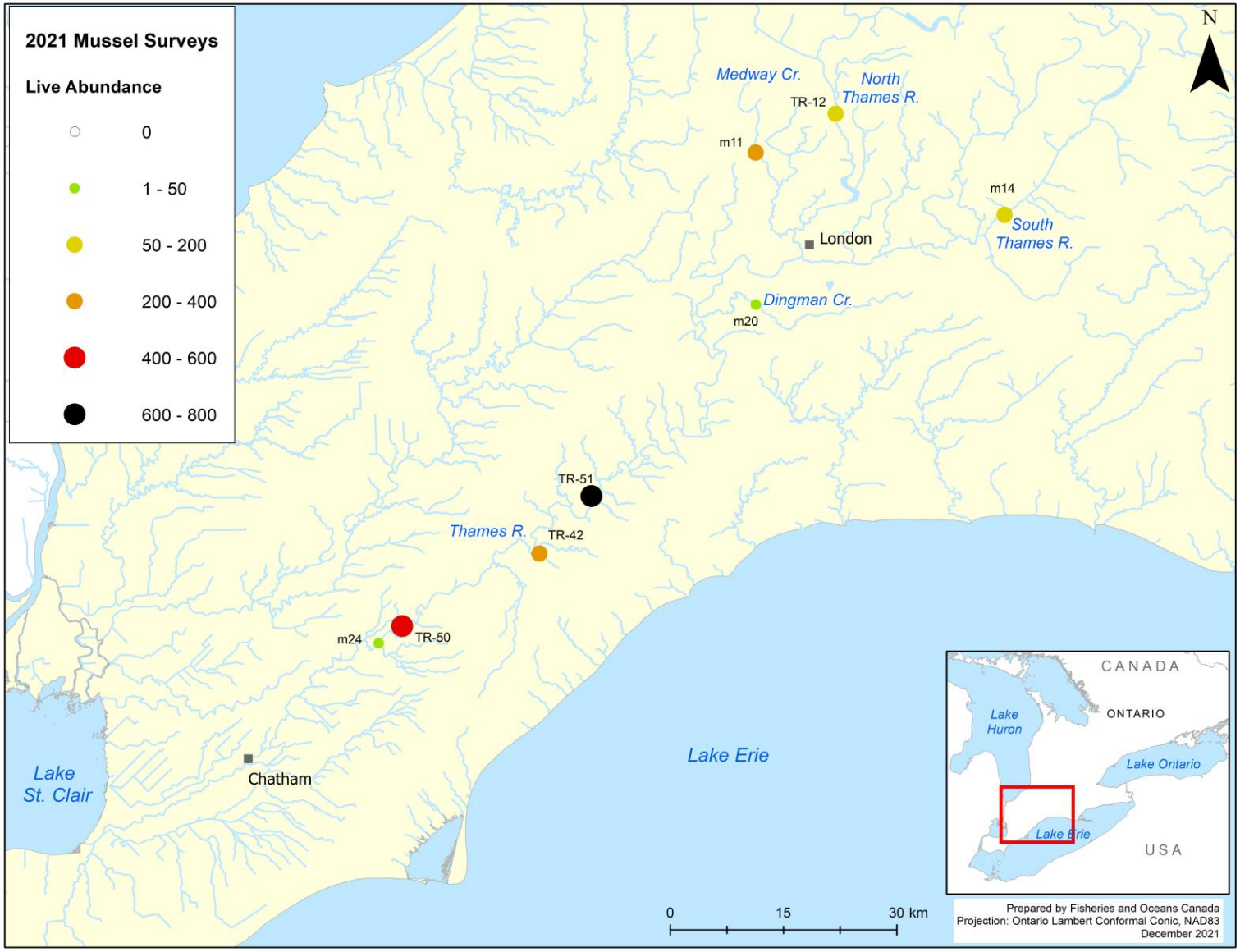

Figure 4. Live abundance of freshwater mussels found during timed-search surveys in the Thames River watershed in 2021.

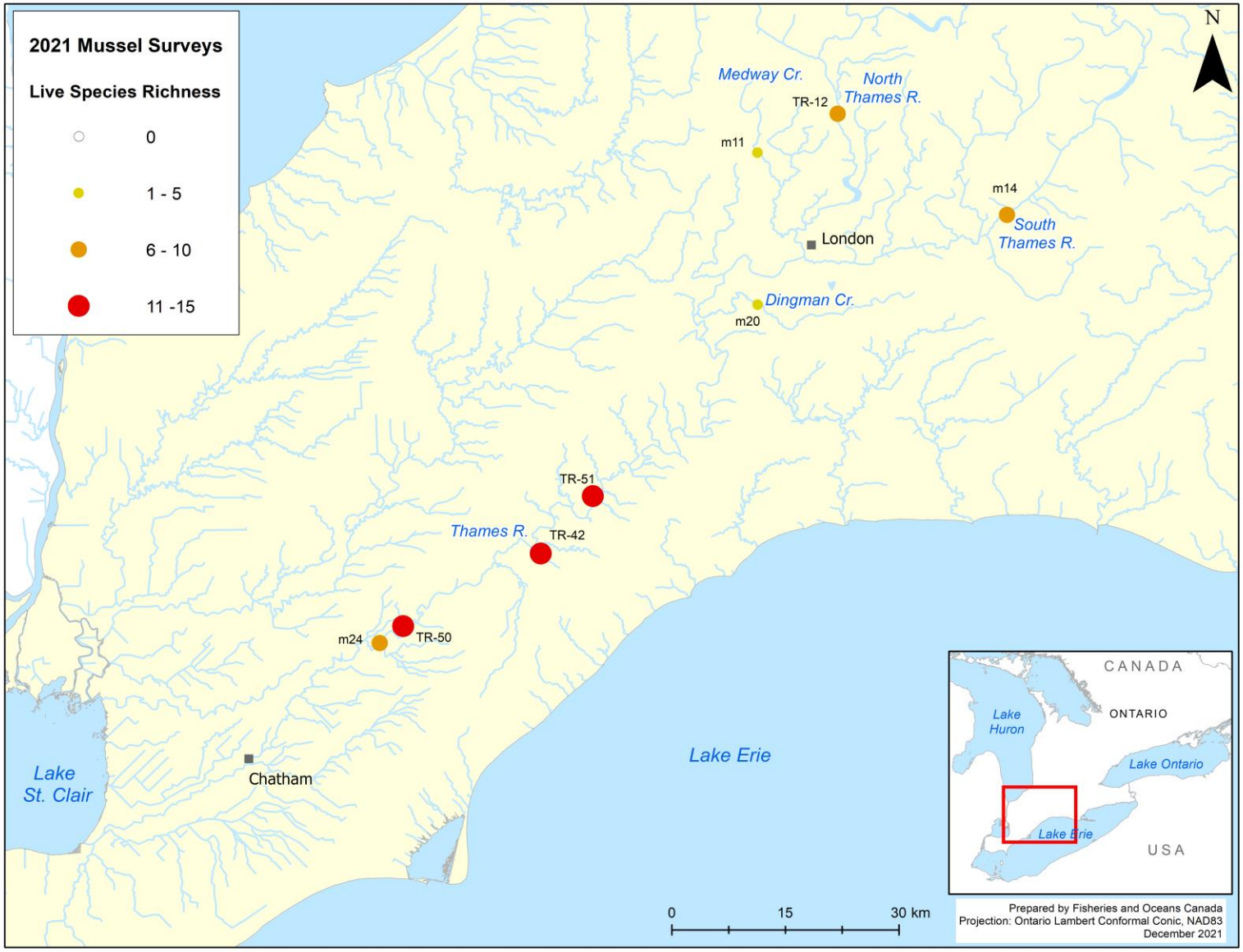

Figure 5. Live species richness of freshwater mussels found during timed-search surveys in the Thames River watershed in 2021.