UNIVERSITY OF WATERLOO

THESIS PART II

Conserving a species by accessing its host: Potential to expand the range of *Simpsonaias ambigua* into known *Necturus maculosus* habitats and range

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Preface

This document is a part two of a two-part thesis series. Its focus is on the potential to expand the range of the endangered mudpuppy mussel, *Simpsonaias ambigua*, by using artificial dens to monitor its abundant host in Kemptville Creek. The use of artificial den sites is purposed to better track and understand the habitat requirements and movement of the host *Necturus maculosus*, as well as to develop a strategy for the assisted colonization of the target species, *S. ambigua*.

This document should serve as a secondary document to the main thesis, and may provide a base for further research topics.

Comparisons between the current, limited *Simpsonaias* range and the two locations on Kemptville Creek are made in an effort to draw preliminary conclusions regarding the potential of the Creek to host a *Simpsonaias* population.

For information on the intended research, observing the denning behaviour of mudpuppies, *Necturus maculosus*, please see thesis part one. Supplementary research on the rate and process of healing an injured mudpuppy, *Necturus maculosus*, is found in Appendix 1 of part one.

Abstract

Ecological Land Classification (ELC) and other related characteristics were compared for the East Sydenham River – current range of *Simpsonaias ambigua* – and Kemptville Creek, both in Ontario. Factors such as climate, geology, substrates, and surrounding land uses were considered. Most characteristics of the ELC and other factors examined are very similar between the two systems, which are the results of rare and unique combinations of geology, ecology, and human history. Although mussels were found to have corroding shells at Kemptville Creek, it appears overall to be a suitable candidate for expanding the range of *S. ambigua*. Further investigation is needed.

Acknowledgements

I would like to thank Harold Lee and the other instructors of the 2011 ELC course in Huntsville, Ontario, in partnership with the University of Waterloo, for providing us with the basic tools needed to perform an ELC study. Todd Morris of Fisheries and Oceans Canada was an important resource for direction and providing documents for reference. Fred Schueler and Aleta Karstad of the Bishops Mills Natural History Centre were instrumental in assisting with field notes and observations, as well as editing. Finally, I am grateful to Professor Stephen Murphy, thesis advisor, for being present when needed, providing direction, and for the incredible amount of flexibility allowed.

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Research Concept

The research is focused on the conservation of the species *Simpsonaias ambigua*, or mudpuppy mussel, a rarely-seen and little-studied species. It is listed in Canada as endangered under the *Committee on the Status of Endangered Wildlife in Canada* (COSEWIC) and the *Species at Risk Act* (SARA), and is the only mussel known to use a non-fish host – the common mudpuppy, or *Necturus maculosus* (DFO, 2008; Morris and Burridge, 2006: iii). The mussel's current range in Canada (Figures 1-2) is likely reduced to a 50km stretch along the East Sydenham River in Ontario, although research on its distribution has been limited due to the difficulty in surveying the specie (Morris and Burridge, 2006: 23). *S. ambigua* is believed to be at the Northern-most part of its range in Ontario, thus being naturally sparse.

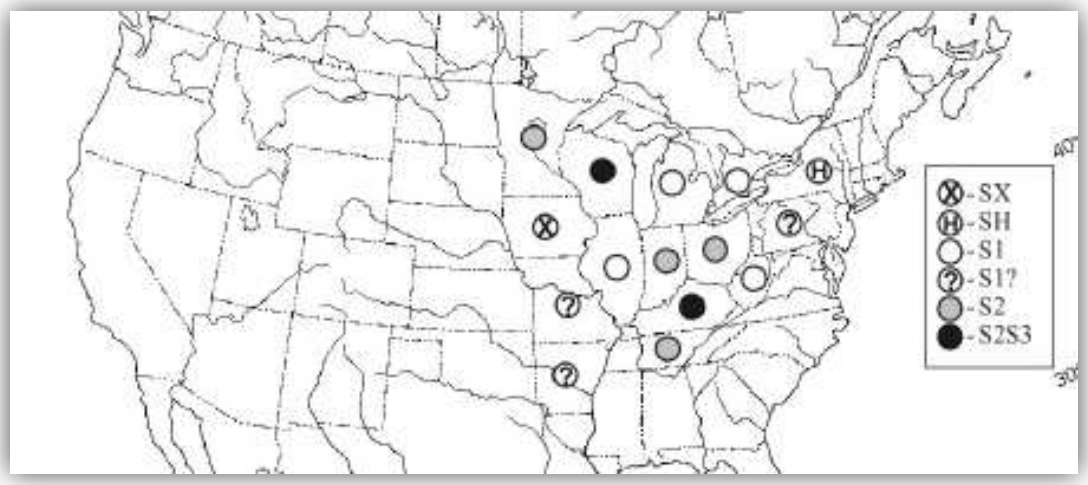

Figure 1: Current range and status of Simpsonaias ambigua in North America (Watson, Metcalfe-Smith and Di Maio, 2001: 11).

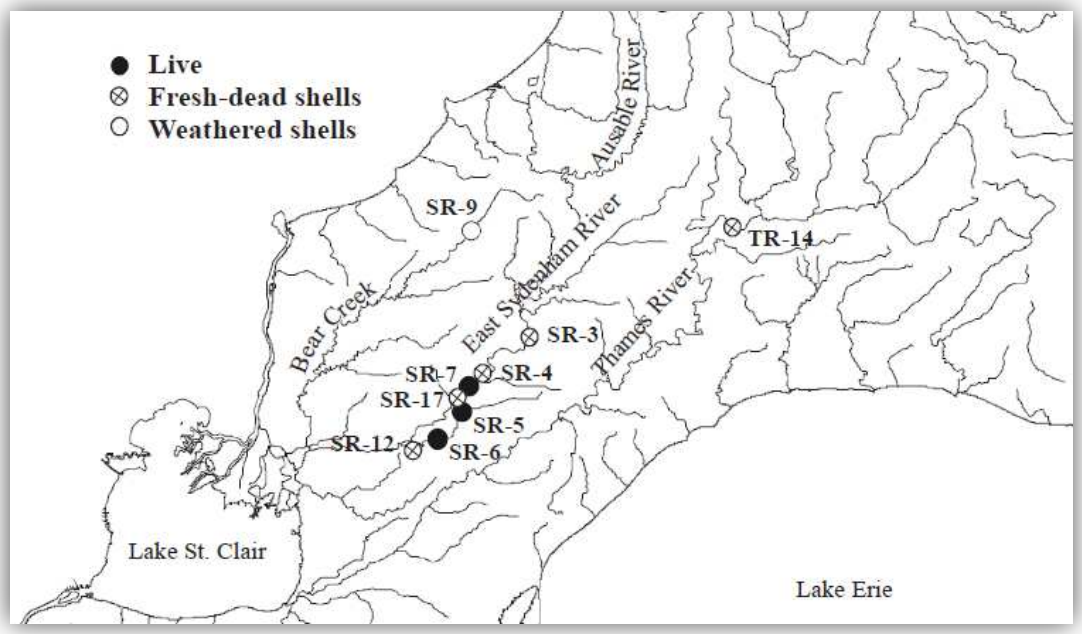

Figure 2: Current Simpsonaias range in Ontario, Canada (Watson, Metcalfe-Smith and Di Maio, 2001: 12).

S. ambigua uses *N. maculosus* as a host to carry around its young, called glochidia (DFO, 2008). The glochidia are carried around on the host's gills until they mature, at which point they fall off and settle into the substrate at or near that location. The mussels are typically found under large stones, but whether this is because *N. maculosus* spend most of their time in a den – either for breeding, hunting, or temporary shelter purposes – during the time the glochidia mature, or because they simply prefer under-stone life, or even because they were shifted around in the current until they were trapped or could settle into crevices and under rocks, is undetermined. One problem with monitoring *S. ambigua* from the glochidia stage, in addition to the species being rare, is that locating the dens of its host is difficult (Morris, 2011; Schueler and Karstad, 2011: Pers Comm). Although the juveniles and adults can be easily found in their 'wintering grounds', they likely move downstream to a deeper, murkier habitat for breeding. I hope to improve our ability to research *S. ambigua* in part by helping to better locate *N. maculosus* dens or temporary sheltering sites.

There is little research available on *S. ambigua* regarding its distribution, health, ecological role, or even its relationship with its host. Therefore, there remains a high possibility to contribute to the many gaps in literature in this area. The purpose of this study is to assess whether we can increase the distribution potential of the mudpuppy mussel, *Simpsonaias ambigua*, via the range of the host mudpuppy, *Necturus maculosus*.

East Sydenham River

The Sydenham River in Lambton County is a major tributary to Lake St. Claire between the Georgian Bay, Lake Huron and Lake Erie in Southwestern Ontario, Canada. Figure 3, below, shows a map of the region which *S. ambigua* is known to inhabit. The watershed is almost level at a relief of only 0.06% (Jacques Whitford Environment Ltd, 2001: ii). The East Sydenham habitat consists of a series of riffles and pools. Riffles are generally made up of tightly packed gravel and clay while pools consist of sand or silt which is normally covered with other material such as the parent clay. It is a turbid, nutrient-rich system with nutrient concentrations often exceeding the Provincial Water Quality Objectives mostly due to runoff from surrounding agricultural lands (Jacques Whitford Environment Ltd, 2001: iii).

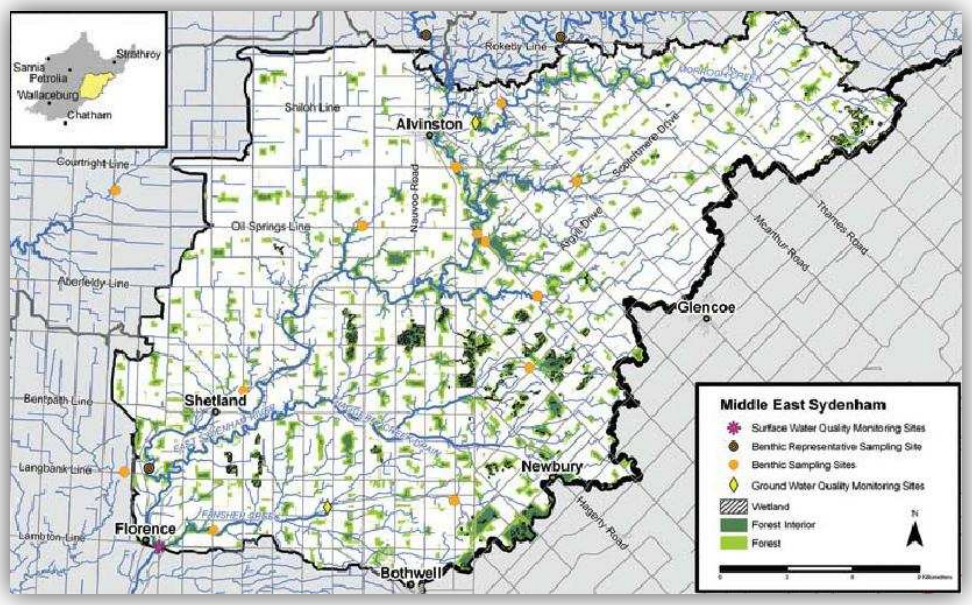

Figure 3: High-density area for rare and endangered mussel species. Simpsonaias ambigua's only range, roughly from Alviston to Florence. Map credit: SCRCA (nd).

The 50km stretch where most *S. ambigua* have recently been found occurs between three built-up areas: Strathroy to the North of where the mussels have been found, Alvinston at the population's most dense area, and Dresden to the South. The surrounding topography varies from approximately 180-210m above sea level (Centre for Topographic Information, 2000b; Canada Centre Mapping, 1994; Centre for Topographic Information, 2001b). There are some wooded areas and small towns along this stretch with agriculture being the main land use in the area.

ELC characteristics

The East Sydenham River is located in Ecoregion 7E, Lake Erie-Lake Ontario (Crins et al, 2009). As the only river system which is entirely held within Canada's Carolinian Life Zone (SCRCA, 2001), the climate is relatively mild (Crins et al, 2009). The mean average annual temperature range is 6.3°-9.4°C and the average annual precipitation is 776-1016mm. A third of the system – 33% – lies in clay plains with poor drainage which, coupled with a low gradient and shallow valleys, results in occasional flooding (Chapman and Putnam, 1984: 92-93; SCRCA, nd). Almost half the area, 43%, is on sand plains and another 24% consists of bevelled till plains (SCRCA, nd). The river has not been able to carve very deep into the clay because of the presence of bedrock near the surface (Chapman and Putnam, 1984: 88). The soils surrounding the Middle-East Sydenham consist of 54% silt and clay, 35% sand loams, 5% bottom land and beach, 3% loam and 3% silt and clay loams (SCRCA, nd).

In some areas of the Sydenham, sand and gravel are superimposed on top of the parent material (Chapman and Putnam, 1984: 147), resulting in good mussel habitat. Roughly 22% of the banks within 15m of each side of the river are vegetated (SCRCA, nd). Tree species in the area are highly varied since it is located in the Carolinian zone, which has the most diverse flora

and fauna in Canada. Bird species include the Green Heron, Virginia Rail, Cooper's Hawk, Eastern Kingbird, and various warblers. Typical mammals include White-tailed Deer, Raccoon, Skunk, and Virginia Opossum. Many common and rare species of Herpetofauna are also found in this region, some of which are critically endangered and/or are found nowhere else in Canada. In general, a good portion of all Ontario's species at risk are found in this ecoregion (SCRCA, nd).

About 78% of the land in Ecoregion 7E is currently used as cropland and pasture with some urban areas making up another 7% of the ecoregion (Crins et al, 2009). However, despite this breakdown of area land use, this ecoregion is the most heavily populated in Ontario (Crins et al, 2009).

Mussels and ecology of the East Sydenham River

There are 34 species of Unionidae within the Sydenham River system, of which nine are listed as rare under COSEWIC and five are endangered (Jacques Whitford Environment Ltd, 2001: 23). The endangered species are the Northern riffleshell (*Epioblasma torulosa rangiana*), the wavyrayed lampmussel (*Lampsilis fasciola*), the rayed bean (*Villosa fabalis*), the snuffbox (*Epioblasma triquetra*), and the mudpuppy mussel (*Simpsonaias ambigua*). Interestingly, all five endangered species are known to inhabit the Middle East Sydenham between the towns of Alviston and Dawn Mills. While most Unionidae habitat appears in-tact some species, like the Northern riffleshell, have been observed to have reduced numbers in recent years (Jacques Whitford Environment Ltd, 2001). Most concerning of these species is the wavy-rayed lampmussel, which is now suspected to be extirpated from the area. Causes of decreasing numbers and possible extirpation are not known (Jacques Whitford Environment Ltd, 2001: 26). *S. ambigua* is of similar concern, as few live specimens have been found in recent years and, according to the 2001 Assessment and Status Report by COSEWIC, the entire known population could be eliminated by a single upstream event (Watson, Metcalfe-Smith and Di Maio, 2001: iii).

Siltation and shifting patterns of mussel hosts seem to be factors of major concern (Jacques Whitford Environment Ltd, 2001: 26). As mudpuppies (*Necturus maculosus*) are sensitive to siltation, it is possible that this combined with increased runoff and sewage deposition could feasibly cause the relocation of *N. maculosus*, thus resulting in a further decrease of *S. ambigua*. However, there has not been an effort to accurately record information about *N. maculosus* populations or movement, so no specific conclusions can be made with regards to changes in activity or presence (Jacques Whitford Environment Ltd, 2001: 26). That the only population of *S. ambigua* in Canada could become extirpated is not an unrealistic possibility.

Simpsonaias ambigua requirements

The majority of mussels in the Middle East Sydenham, where *S. ambigua* is found, inhabit areas with the swiftest currents and shallow waters about 10-20cm in depth (Metcalfe-Smith et al, 2007:11). They were found in substrates with as little clay, much, or detritus as possible, but with 10-20% of the substrate consisting of silt. Bedrock is rarely inhabited by mussel populations, with a density of $0.6/m^2$ (Metcalfe-Smith et al, 2007:11). However, in the

study by Metcalfe-Smith et al (2007:2), no *S. ambigua* were actually sampled and the researchers concluded the species may need a different sampling method due to its specialized habitat.

Simpsonaias ambigua, below (Fig. 4), is found in areas where the host *Necturus maculosus* takes refuge. These regions can include bedrock, gravel, sand, or mud in areas with a moderate current (Gendron, 1999: 86). Although live *S. ambigua* have been found in multiple habitats in North America – from mud at medium depths to silt and sand in shallow waters – they have most often been locally found under large, flat rocks in substrate consisting of gravel, cobble, and boulders in shallow water and in swift currents (Watson, Metcalfe-Smith, and Di Maio, 2001:19).

Figure 4: *Simpsonaias ambigua* found in the Sydenham, 2006. Photo credit S. Staton (St. Clair Conservation, 2012).

Kemptville Creek

Kemptville Creek is a much less-studied water system than the Sydenham River. The Creek is a tributary to the Rideau River and is located within the boundaries of the United Counties of Leeds and Grenville, in Eastern Ontario (RVCA, 2005). Kemptville Creek, being about 63km in length, crosses several communities including the towns of Kemptville, Oxford Mills, and Bishops Mills. It is important to note that *Necturus* are only found below the Southern-most dam in Oxford Mills, a stretch of creek that is approximately 20km in length.

Most of the area immediately surrounding stretch of river near the study sites consists primarily of agricultural areas and settlements, although there are vast swampland and other wetlands up river. The immediate topography is relatively flat terrain, keeping within 100 and 106m above sea level throughout the stretch (Centre for Topographic Information, 2000a and 2001a). Although this gradient, approximately 14cm/km, is true for most of the 63km of the river, a higher gradient – estimated to be similar to the Sydenham – can be found below the dam in and around the study site (Fred Schueler, Pers Comm, 31 August 2011). Prior research

and observations, including Unionid species and precise locations, are provided by Fred Schueler and Aleta Karstad of the Bishops Mills Natural History Centre. This information infiltrates the text in the next few sections.

ELC characteristics

Kemptville Creek is generally located in Ecoregion 6E, Lake Simcoe-Rideau. The climate is generally mild and moist, with a mean temperature range from 4.9°-7.8°C and with an average annual precipitation of 759 to 1087 mm (Crins et al, 2009). Although the temperature in the winter months is cooler than that of the Sydenham due to Kemptville's more Northerly location, its limestone bedrock absorbs large amounts of sun, resulting in a warm-water stream in the summer. Whether this kind of temperature fluctuation would be acceptable to *S. ambigua* is unclear. Here the geology consists largely of fragmentary and sandy glacial deposits which have been reworked by wave action of the Champlain Sea (Chapman and Putnam, 1984: 14). Bedrock and boulder clay are covered in level or slightly undulating, glaciofluvial sand (Chapman and Putnam, 1984: 200; Crins et al, 2009) for much of the area. The soils are largely acidic with a generally low nutrient content, with sand and sandy loam making up the greater soil profile, particularly in lower lying areas (Chapman and Putnam, 1984: 200) such as where the Creek is located. Only 3% of the Creek's banks show signs of erosion, and 80% of the Creek showed no signs of in-stream pollution (RVCA, 2005). Moisture-loving trees are characteristic of this region, such as maple and white cedar in the plains, and tamarack and black spruce in the bogs(Chapman and Putnam, 1984: 200).

Wildlife that have been recorded in the area include Great Blue Heron, Song Sparrow, Deer, Chipmunk, Muskrat, Beaver, Green Frog, Bullfrog, Monarch Butterflies and various Minnows, Shiners, Pike, Dragonflies, Damselflies, Mussels, Crayfish, Mayflies, Stoneflies, Caddisflies and Leech (RVCA, 2005). Although the system is healthy with a balanced amount of vegetation, 85% of the region has invasive species including European frogbit, which at times chokes up the banks of upstream regions (RVCA, 2005). Species more recently observed include the American Bittern, Whitethroat Sparrow, Otter, Mink Frog, Pike, Muskellunge, *Orconectes virilis* Crayfish, Water Snakes, Painted turtle, Snapping turtles, Blanding's turtles, SAR Stinkpots and the only Rideau Drainage population of the Minnow *Rhinichthys cataractae* below the dam in Oxford Mills (Fred Schueler, Pers Comm, 31 August 2011).

Case study

Two locations (Figure 5, below) along Kemptville Creek were observed on 22nd July 2011 as case studies in order to assess the potential of the system to successfully host a healthy and growing *Simpsonaias* population. These locations were selected by local scientists as sites where locating *Necturus* nests were likely. See Appendix 1 for field notes and examples of observations.

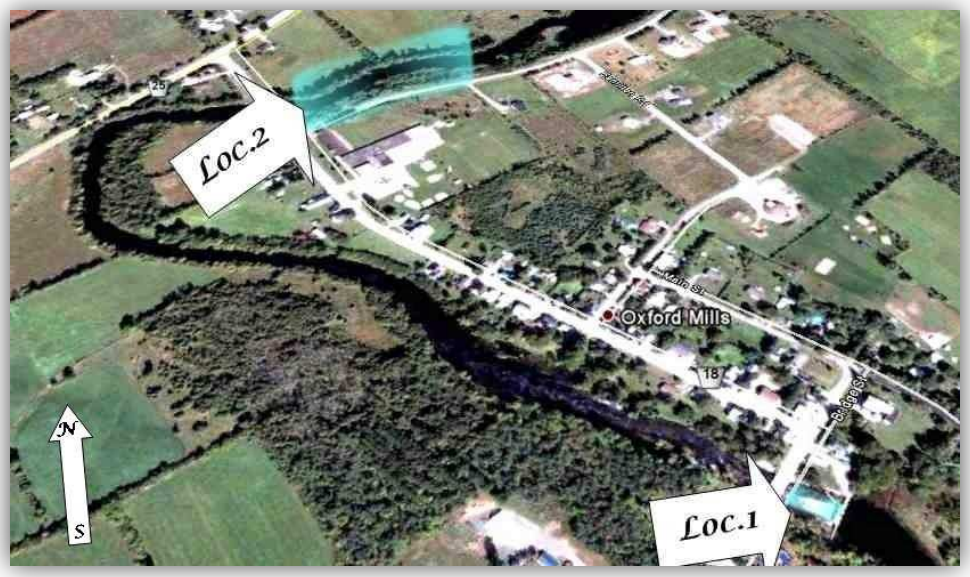

Figure 5: Locations of study sites at Kemptville Creek in Oxford Mills, Ontario. Map courtesy of Google Maps.

The first location, Loc1, is at 44.964737N and 75.67854W. It spans a small area from the foot of the Oxford Mills dam to the Bridge Street/CR18 Bridge. The substrate is primarily flat bedrock which transitions into a mix of bedrock, gravel substrate and mid to large sized rocks. This transition is smooth in most areas except in one spot near the lower SW bank – dubbed 'the drop-off' – where the bedrock breaks off and there is a sudden drop of about 20 inches into rocky and gravel substrate over a lower layer of bedrock. The water temperature was 29°C at approximately 2:30pm.

The second location, Loc2, was further downstream within 500m of the Hanlan Bridge at Water Street/CR18 at 44.96984N and 75.68362W. The substrate consisted of medium to large-sized rocks, mostly rounded but some were shelf-like, surrounded by coarse pea gravel.

Mussels of Kemptville Creek

Four different mussel species were found at both locations during the field observations – none alive at Loc1 – with the vast majority of mussels found at Loc2, likely due to the dominance of bedrock at Loc1. These mussels, including *Elliptio complanata*, *cf Pyganodon*, *Lampsilis sp,* and *Lasmigona costata*, were mostly found scattered in the pea gravel, often between small to medium rocks. Other species which have been found in the past include *Lampsilis sp*, *Strophitus undulatus*, *Lasmigona compressa* and *Anodontoides ferussacianus* (Schueler and Karstad, 2011: pers comm and personal records).

Summary comparison table

The following Table 1 summarizes the ELC and other characteristics of the East Sydenham River and Kemptville Creek, as described in the previous sections. This table will be discussed along with other observations in the following section.

Table 1: Comparison of ELC and other physical characteristics of the East Sydenham River and Kemptville Creek. See above section for more detailed information and its sources.

	Sydenham	Kemptville Loc1	Kemptville Loc2
Climate, temperature, and precipitation	• Climate: relatively mild • Average temperature range: 6.3°-9.4°C • Average annual precipitation: 776-1016mm	• Climate: generally mild and moist • Average temperature range: 4.9°-7.8°C • Average annual precipitation: 759-1087mm	
Geology and habitat	• Bedrock near surface Habitat: locally found under large, flat rocks in substrate consisting of gravel, cobble, and boulders in shallow water and in swift currents	• Bedrock and boulder clay are covered in level or slightly undulating, glaciofluvial sand • Fragmentary and sandy glacial deposits	
Substrates	• Some clay some sand, mostly silty clay with sand loams, loam and silty clay loams. • Sand and gravel are superimposed on top of the parent material	• Acidic soils with low nutrients; sand and sandy loam • Flat bedrock which transitions into a mix of bedrock, gravel substrate and mid to large sized rocks ○ Water temperature was 29°C at 2:30pm	• Medium to large-sized rocks, mostly rounded but some were shelf-like, surrounded by coarse pea gravel.
Surrounding land use and bank conditions	• 15% banks vegetated • Mostly cropland, some pasture and urban areas • Siltation – i.e. From erosion – is an issue	• 97% banks show stability (no erosion or siltation) • 80% stream unpolluted • Cropland and mostly small urban/community developments	

Discussion

Both the East Sydenham River and Kemptville Creek have dams operating upstream – and in the case of the East Sydenham, downstream – of the study areas. Although an issue for some mussel species, dams on the East Sydenham were not found to be problematic for *S. ambigua* since dams were well upstream of the mussel's historic and current range (Watson,

Metcalfe-Smith, and Di Maio, 2001:27). Despite these developments the host and parasite still had regular access to each other, and so the lifecycle was not disrupted in this sense.

All three mussel species found at Kemptville Creek during field observations showed signs of erosion on parts of the shell that were nestled into the substrate. This is perhaps a sign of wear and tear from coarse or corrosive materials in the substrate. The case may be that sediment has been trapped behind the dam and is leeching substances downstream, or simply that mussels found here had lived long lives and had become corroded over the decades. It is possible both the coarser fragments and other materials have an effect on the mussels, with damage further encouraged by the creek's swift water currents. Alternately, another less likely issue may be a lowering of the creek's PH, potentially caused by a combination of soil types, dam processes and/or even hydrolysis from all the metal components littering the creek, which could in turn affect not only the mussels but also the creek's snails, crayfish, and other crustaceans. Nearby peat lands draining into the limestone-based creek may also have an effect.

Siltation is often problematic for *N. maculosus* and *S. ambigua* alike. Fine silts are often found to smother mussels in various ways and to fill in the gaps between and under larger stones and rocks, thus depleting the availability of suitable habitat for *N. maculosus* and *S. ambigua* alike (Watson, Metcalfe-Smith, and Di Maio, 2001:26 and 33). As erosion is a major contributing factor to siltation, Kemptville banks are stable and are less likely to create this issue.

The climate, mean temperature, and mean precipitation per year at both the Sydenham and at Kemptville were very similar. Bedrock is present at the surface level in both systems, and the slope is relatively consistent with both systems being fairly level with swift currents. Large boulders and flat rocks are present in both systems with the majority of the surrounding substrate consisting of sands, gravels, and combinations of sand, silt, and loam. Some clay is also present in the Sydenham and so drainage is poorer at this location. Kemptville soils tend to be more acidic and lower in nutrients than those found in the Sydenham area, although the stability of the banks means much less erosion than what is occurring in the Sydenham. Land use in both areas is mostly rural/agricultural, with some small-medium community and urban developments along the length of both systems.

Overall both systems are ecologically similar considering they are found in two different Ecozone types, and there is potential to further explore the expansion of *S. ambigua* into Kemptville Creek. Research regarding the importance of subtle differences in the ecology of each system may be of importance for further assessments. A primary point of concern is likely the corroding of mussel shells at Kemptville Creek.

Recommendations for future research

There are many gaps in literature related to *Simpsonaias ambigua* and *Necturus maculosus*. In performing the research I have on artificial dens and ELC comparative studies, there are several options for follow-up or complementary studies. First, there should be a test

as to whether mudpuppies will use artificial dens in a natural context where natural options are available. Also, the design of such shelters would need to be adapted to the environment such that weather cycles, currents, and moving objects and sediment do not damage, remove, block, or otherwise alter the shelter in a way which would prevent the target species from using them.

Although artificial dens would likely be used, they may not be more popular choices than natural den sites. If this is true, there is little point in constructing artificial dens unless they provide easier access to any specimens that may be inside. Rather, resources may be better spent tagging or otherwise marking existing dens at various sites at both the East Sydenham and Kemptville Creek. A comparative study between the two river systems would give a more accurate perspective as to whether Kemptville Creek would be an appropriate area in which to augment populations of *S. ambigua*. If it is found to be appropriate, a test as to whether *S. ambigua* can sustainably survive in the general Kemptville Creek habitat as a whole – i.e. its biology and ecology – should be carried out. This could take the form of creek-side studies, including the creation of a small diversion of the creek so that the ability of *S. ambigua* to succeed can be assessed. Alternatively, a survey of populations in the Northern edge of the range – for example, New York and Pennsylvania (Roe, 2003: 8) – may provide data that describes common requirements to and limitations on the species' persistence. Also, controlled methods of using creek water, substrate and organisms including samples of other mussels could be helpful in a lab setting. Interest to set up a breeding facility has been expressed by the Bishops Mills Natural History Centre, although funding opportunities for this type of project remain as elusive as *Simpsonaias* itself.

Some other considerations regarding the assisted colonization of *Simpsonaias* include the need to assess genetic variation and to establish suitable survival conditions for the species at the new site (Roe, 2003: 8). Furthermore, the wellbeing of both the mussels and the host amphibians need to be considered. For example, some concerns have been raised regarding whether the glochidia would attach to and properly develop on a previously non-parasitized population of *Necturus*. Similarly, whether this parasite relationship would have negative effects on the health of the host population is also unknown (Fred Schueler, Pers Comm, 21 February 2012).

Conclusion

Although mussels were found to have corroding shells at the study sites of Kemptville Creek, there are limited records of Unionids without such signs of erosion at the preferred Simpsonaias site near Dennison Road. Also, further observations have begun to show that those specimens living in gravel tend to show more signs of corrosion than those living in mud (Fred Schueler, Pers Comm, 31 August 2011). Further studies on this topic would likely better assess not only the viability for the assisted colonization of *Simpsonaias*, but may also reveal new data about the health and preferred habitats of various mussel species.

The comparison of ELC and similar data results in the conclusion that the Creek may be a suitable candidate for expanding the range of *Simpsonaias ambigua* through a combined

conservation and long-term monitoring program. A healthy *Necturus maculosus* population and ample habitat exist, although relationships with other species of mussel or local wildlife were not considered. As primary data was limited and field studies occurred only at one of the two watersheds, further field observations and meticulous testing should be pursued to confirm the results of this study and to better understand the effects of introducing *S. ambigua* into the established ecology of Kemptville Creek.

Even so, the rare combination of geology, ecology and human history at Kemptville Creek, being similar to that of the East Sydenham River, may mean the system is a suitable site for a focus on recovering the species of endangered mussel, *S. ambigua*.

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APPENDICES

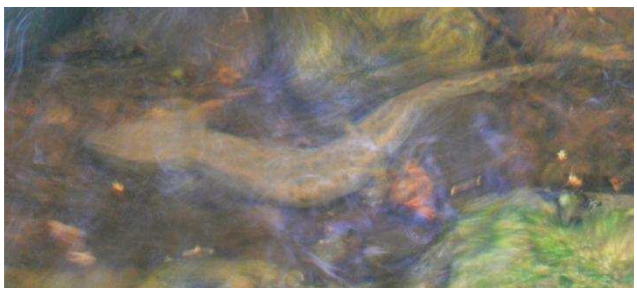
APPENDIX 1 – Examples and Field Notes from Kemptville Creek

Observations occurred at Kemptville Creek with Fred Schueler and Aleta Karstad of the Bishops Mills Natural History Centre on Friday 22nd July 2011 from approximately 2-6pm.

Field notes and initial thoughts:

- Kemptville Creek may not be a suitable habitat for mudpuppy mussels for a few reasons
    - coarser substrate
    - dominance of larger rocks
    - corrosive nature of the creek (likely its substrate but this is unconfirmed)
        - Simpsonaias has a very thin and fragile shell
            - HOWEVER: Simpsonaias lives in similar areas under larger rocks where mudpuppies nest; perhaps they would succeed with less concern about corroding due to their preferred habitats?
- The water is also very hard; different from the Sydenham?
- Simpsonaias didn't always completely overlap with the mudpuppies where it is found on the Sydenham, so perhaps there's a region further downstream where the mussels could live and where the mudpuppies would temporarily frequent at the mussel's breeding time?

Examples of a very young and a juvenile mudpuppy



Examples of substrates and habitats in Kemptvile Creek:

Potential habitat for mudpuppy. Good size rock with relatively flat bottom very close to substrate (small opening).

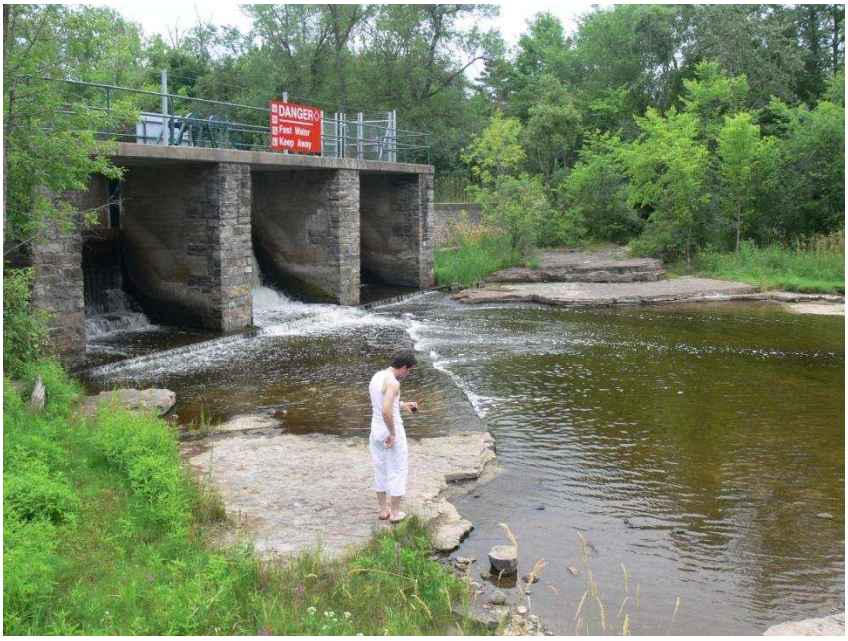
Coarse substrate, found under and between rocks at Kemptville Creek.

Larger substrate found near banks and around the Creek

Location 1 (between Oxford Mills dam and Bridge street/CR18 bridge)

- Bedrock below dam, some rocks and gravel by Bridge street/CR18 bridge (some gradual transition plus 'the drop off')
- Plenty of fish, insects and bedrock overhangs
- Fast-moving water
- Water temperature changes quickly (was 29°C when mudpuppies were released at around 2pm, was ~25 when we left at around 6pm)

Upper (SE) boundary of Loc1; Oxford Mills dam, bedrock, some larger substrate, fast-moving water, very shallow



Main part of Loc1 from NE bank; bedrock along sides, transition into large substrate, drop-off in lower SW side, shallow water through most

NE bank from lower SW bank; bedrock, substrate, shallow water

Lower NE bank from upper NE bank; bedrock ledges with crevices for hiding, some substrate but mostly shelving, drop-off towards Bridge street/CR18 bridge

Mudpuppies often found along this stretch in winter Mudpuppy Nights

Mid-NE bank; rocky ledges and ‘substrate’ over bedrock where mudpuppies hide and are often found in winter

Lower (NW) boundary of Loc1 from mid-SW bank; some bedrock transitioning to rocky substrate mixed with some smaller gravel, depth mostly consistent

Location 2 (downstream from Hanlan Bridge on Water Street)

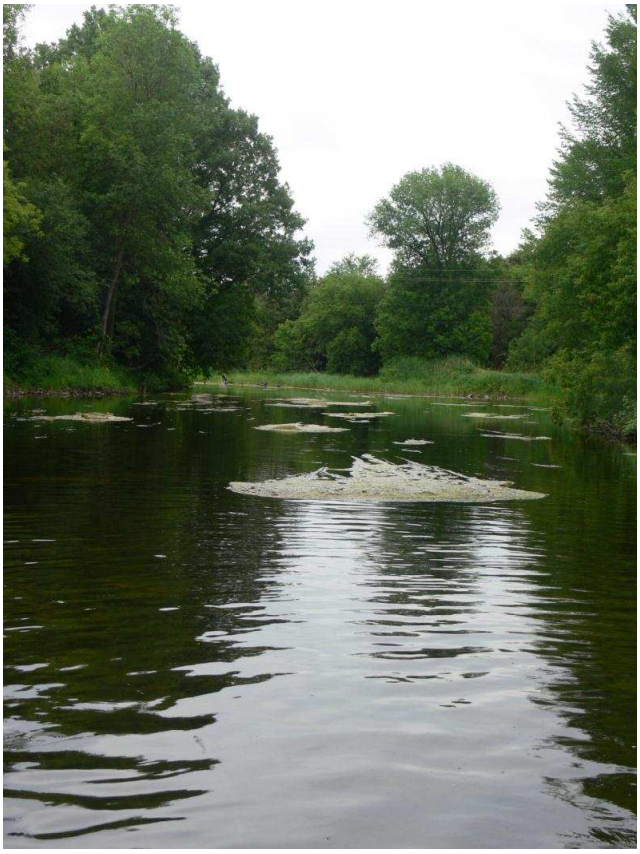
- Mostly rocky substrate with coarse gravel and stone fragments under and littered around
    - Larger rocks were mostly rounded, some shelf-like
- Some higher banks on South side just after Hanlan Bridge, with trees shading parts of creek, North bank mostly flat and further back from shoreline due to bedrock
- Depth varied from a few inches to thigh-depth closer to the middle of the creek
- Good mix of larger rocks and gravel further down

Upper (SE) boundary to Loc2; steep hill on South bank and relatively level North bank (leading into rolling terrain a few feet further in), flat water, mostly rocky terrain with gravel underneath

Mid-North bank from mid-creek; mussels littered all around substrate of Loc2

Mussels found: several Elliptio sp., Lasmigona costata, and cf. Pyganodon

Lower (NE) boundary of Loc2; we did not travel this far down but the substrate and banks were similar to where we were, transitioning into a third location of the creek which we didn't explore



Mussels found

Elliptio complanata

cf Pyganodon

Lasmigona costata

APPENDIX 2 –Field Notes from Kemptville Creek

EOBase Narrative beginning 22 July 2011.

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22 July 2011

Canada: Ontario: Grenville County: Oxford-on-Rideau: **Oxford Mills Dam, Kemptville Creek**. (100m ard dam), 31B/13, 44.96486N 75.67863W TIME: 1428-1510. AIR TEMP: 33, sunny, breezy. HABITAT: brown-water creek at limestone flats below old milldam, water 29 C. OBSERVER: Frederick W. Schueler, Sophie Finlayson-Schueler, Elaine Ho, Armando Ngjeliu. 2011/180/e, **visit** () (event). natural history, wade, photo. visit to release experimental Necturus. Lots of flow over and through the logs of all 3 spillways, Vantage Point Ledge ca 25 cm above current water level. Elaine & Armando measured water temperature of 25 C at 18h00.

Released the experimental Necturus taken 4 March 2011, 2011/022/a, and coaxed them under cover

Lythrum salicaria (Purple Loosestrife) sparse but unperforated and not twisted - maybe there was too much water here during the spring growing season for the Beetles ot get a grip on the plants

Lepomis macrochirus (Bluegill) 22 counted below the dropoff 1 Micropterus dolomieui (Smallmouth Bass) all 10-15 cm, lots of little fish only 1 Rana cf catesbeiana (Bull Frog) tadpole seen, Gyrinidae in a single dense swarm at the Helisoma Ledge -

Orconectes virilis (Northern Crayfish) lots of parts below the spillway ledge (and one found dead) - no idea what the parts represent.

moved 0.68 km NW.
Kemptville Creek below Hanlan Bridge. (400m alg creek), 44.96984N 75.68363W TIME: 1524-1647. AIR TEMP: 33-28, light overcast, breezy. HABITAT: clearwater stoney/gravel-bed creek in wooded valley. OBSERVER: Frederick W. Schueler, Aleta Karstad Schueler, Elaine Ho, Armando Ngjeliu, Sophie Finlayson-Schueler. 2011/181/a, **visit** () (event). natural history, wade, dipnetted, under cover. WAYPT/009, searching for Necturus for ca 400 m downstream. 1 small Rana clamitans (Green Frog) noted generally very few frogs - Elliptio complanata (Eastern Elliptio) abundant as usual Lampsilis radiata (Eastern Lamp-Mussel) noted Lasmigona costata (Fluted Shell) sev noted inc 1 ca 75 mm with ca 6 mm growth lines conspicuous - clumps of najas swathed in Cladophora (both collected by SF-S) - one being oviposited on by 10 chalk-blue Damselflies - Orconectes virilis (Northern Crayfish) 1 crushed by turning rock, generally abundant 33, LOC, CLM at beginning, 28, LOC, CLM at 16h24 Pyganodon grandis (Common floater) small, with W-shaped beak sculpture collected and preserved in ethanol, after freezing, for the DNA - beer bottle with little snails and limpets on it - Necturus maculosus (Mudpuppy) - no nests found but the biggest rocks unturnable 2 ads, 1 10 cm juv under turned rocks in downstream portion of area.

Source: Schueler, F. (2011). EOBase Narrative beginning 22 July 2011. Retrieved on 12 August 2012 from file:///C:/Users/Anthie/AppData/Local/Temp/wza749/JOUROUT.HTM.