Photo: Stephen A. Marshall

Hungerford's Crawling Water Beetle

(Brychius hungerfordi) in Ontario

Ontario Recovery Strategy Series

Recovery strategy prepared under the *Endangered Species Act, 2007*

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Ministry of Natural Resources

Ontario

About the Ontario Recovery Strategy Series

This series presents the collection of recovery strategies that are prepared or adopted as advice to the Province of Ontario on the recommended approach to recover species at risk. The Province ensures the preparation of recovery strategies to meet its commitments to recover species at risk under the Endangered Species Act (ESA) and the Accord for the Protection of Species at Risk in Canada.

What is recovery?

Recovery of species at risk is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of a species' persistence in the wild.

What is a recovery strategy?

Under the ESA a recovery strategy provides the best available scientific knowledge on what is required to achieve recovery of a species. A recovery strategy outlines the habitat needs and the threats to the survival and recovery of the species. It also makes recommendations on the objectives for protection and recovery, the approaches to achieve those objectives, and the area that should be considered in the development of a habitat regulation. Sections 11 to 15 of the ESA outline the required content and timelines for developing recovery strategies published in this series.

Recovery strategies are required to be prepared for endangered and threatened species within one or two years respectively of the species being added to the Species at Risk in Ontario list. There is a transition period of five years (until June 30, 2013) to develop recovery strategies for those species listed as endangered or threatened in the schedules of the ESA. Recovery strategies are required to be prepared for extirpated species only if reintroduction is considered feasible.

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Nine months after the completion of a recovery strategy a government response statement will be published which summarizes the actions that the Government of Ontario intends to take in response to the strategy. The implementation of recovery strategies depends on the continued cooperation and actions of government agencies, individuals, communities, land users, and conservationists.

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Cette publication hautement spécialisée Recovery strategies prepared under the *Endangered Species Act, 2007, n'est disponible qu'en Anglais en vertu du Règlement 411/97 qui en exempte l'application de la Loi sur les services en français. Pour obtenir de l'aide en français, veuillez communiquer avec Cathy Darevic au ministère des Richesses naturelles au 705-755-5580.*

AUTHORS

David Anthony Kirk, Aquila Conservation & Environment Consulting

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DECLARATION

The recovery strategy for the Hungerford's Crawling Water Beetle was developed in accordance with the requirements of the *Endangered Species Act,* 2007 (ESA). This recovery strategy has been prepared as advice to the Government of Ontario, other responsible jurisdictions and the many different constituencies that may be involved in recovering the species.

The recovery strategy does not necessarily represent the views of all of the individuals who provided advice or contributed to its preparation, nor the official positions of the organizations with which the individuals are associated.

The goals, objectives and recovery approaches identified in the strategy are based on the best available knowledge and are subject to revision as new information becomes available. Implementation of this strategy is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy.

RESPONSIBLE JURISDICTIONS

Ontario Ministry of Natural Resources
Environment Canada - Canadian Wildlife Service, Ontario

EXECUTIVE SUMMARY

The Hungerford's Crawling Water Beetle (*Brychius hungerfordi*) is a small beetle (Family Haliplidae) occurring in Canada only in the Great Lakes region of Ontario. Believed to be a postglacial relict, it is listed as endangered under Ontario's *Endangered Species Act, 2007* (ESA). Hungerford's Crawling Water Beetle has also been designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) but is not currently listed under Schedule 1 of the federal *Species at Risk Act* (SARA). In Canada, the Hungerford's Crawling Water Beetle is restricted to three rivers in Bruce County in Ontario (the Rankin, the Saugeen and the North Saugeen). Little is known about the current status of the species at the Rankin or Saugeen sites; the most recent surveys on the Rankin showed that the species was present in 2011 and this is believed to be the most important site in Ontario. Declines have occurred over the last 10 years in the North Saugeen population in Ontario and the population may be extirpated. In the United States, Hungerford's Crawling Water Beetle occurs in eight streams in four counties in northern Michigan; three new populations have been discovered since the United States Fish and Wildlife Service five-year review (2009).

Small to medium-sized streams with moderate to fast flowing water provide habitat for the Hungerford's Crawling Water Beetle. Such streams have good aeration, cool water temperatures, an inorganic substrate and high pH. Hungerford's Crawling Water Beetles seem to concentrate downstream of culverts and human-made impoundments, but they may be more generally distributed throughout streams, albeit at lower density, at least in Michigan and possibly in Ontario. An essential habitat component during breeding is an algae, *Dichotomosiphon tuberosus*, which is eaten by beetle larvae.

The main threats to the Hungerford's Crawling Water Beetle come from stream embankment and channelization, removal or modification of dams, weirs and culverts, and road construction which could influence water quantity and quality. Land use in areas adjacent to streams and within the entire watershed may also impact the species, since this affects hydrology. Farming activities on agricultural land could increase sediment load and/or pollutant run-off (50% of the Saugeen and North Saugeen are in agricultural land), as could urban and industrial development (including aggregate extraction).

The recovery goal is to enhance long-term population viability by maintaining at least three self-sustaining populations of Hungerford's Crawling Water Beetle in Ontario. This should be achieved by actively protecting and managing suitable habitat for this species and its ecosystem in southern Ontario. Protection and recovery objectives are as follows.

- Protect existing populations and habitat where Hungerford's Crawling Water Beetle is found.
- Determine the distribution and abundance of Hungerford's Crawling Water Beetle outside the existing known sites.

- Investigate the habitat requirements of the species and in particular determine the role of human-made impoundments.
- Identify, quantify and seek to mitigate or remove threats to existing populations.
- Promote ongoing measures to protect vegetation adjacent to the extant occurrences of Hungerford's Crawling Water Beetle and watershed vegetation cover.
- Investigate the possibility of translocation from a thriving population to the North Saugeen population, if required.

Some of the above recovery and protection objectives would benefit from promotion of existing voluntary programs that encourage landowners to protect streamside vegetation from erosion and run-off through planting of native trees and shrubs. Liaising with the Ontario Ministry of Natural Resources, conservation authorities, municipalities and water-based conservation organizations (e.g., Trout Unlimited) about channelization projects that could impact streams with Hungerford's Crawling Water Beetle would also be beneficial. It is likely that recovery efforts for the Hungerford's Crawling Water Beetle would benefit other aquatic species and could be addressed as part of an ecosystem recovery plan.

The area described in a habitat regulation should include the locations where Hungerford's Crawling Water Beetles have been surveyed and detected on the Rankin River, the Saugeen River and the North Saugeen River (if the species still occurs there). This should include a distance of 400 metres upstream and downstream of known occurrences including at least a 30 m band extending into riparian areas adjacent to the stream.

Ensuring that best management practices are carried out at the watershed level is also critical; this involves retaining as much permanent native vegetation cover as possible, such as forest cover, riparian areas and permanent grassland. Best management practices should be required for management activities both at the occupied site and immediately upstream.

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1.0 BACKGROUND INFORMATION

1.1 Species Assessment and Classification

COMMON NAME: Hungerford's Crawling Water Beetle SCIENTIFIC NAME: *Brychius hungerfordi* SARO List Classification: Endangered SARO List History: Endangered (2011) COSEWIC Assessment History: Endangered (2011) SARA Schedule 1: No schedule, No status CONSERVATION STATUS RANKINGS: GRANK: G1 NRANK: N1 SRANK: S1

The glossary provides definitions for technical terms, including the abbreviations above.

1.2 Species Description and Biology

<u>Species Description</u>
The Hungerford's Crawling Water Beetle (*Brychius hungerfordi*) is a small aquatic beetle belonging to the family Haliplidae. Beetles from this family (i.e., haliplids) are distinguished from other small beetles by the disproportionately large coxal plates at the base of their hind legs (Roughley 2001). Three genera of haliplids occur in North America (*Brychius*, *Haliplus* and *Peltodytes*). *Brychius* is distinguished from the other genera by its body shape (elongated and torpedo shaped) and the shape of the sides of the dorsal plate between the head and base of its wings (Roughley 2001). At the larval stage, *Brychius* can be identified by the unique elongate and curved appendage (the urogomphus) on the last abdominal segment (Mousseau and Roughley 2007).

There are three species of *Brychius* in North America (five globally): *B. hungerfordi* is the only species found in the Great Lakes region and has three distinctive features: (1) the finely toothed (denticulate) margins of the wing cover (elytra); (2) a thick black band on the basal margin of the dorsal plate between the head and wings (pronotum); and (3) its large size relative to the other *Brychius* species (3.7 to 4.4 mm long). Appendix 1 provides information on generalized beetle anatomy.

<u>Species Biology</u>
Since little information exists about the biology of Hungerford's Crawling Water Beetles (Grant and Vande Kopple 2009), it has been assumed that their life history traits are similar to those of other haliplid water beetles (COSEWIC 2011). Mating likely occurs in

June based on an anecdotal observation of Hungerford's Crawling Water Beetle mating during this month (Scholtens 2002), and on the fact that the closely related *Brychius hornii* also mates at this time (Mousseau and Roughley 2003). Preliminary information from Michigan suggests that two generations of adults per year are possible (Grant et al. 2000).

There are four stages of complete metamorphosis in the species: egg, larva, pupa and adult. Although the egg or egg-laying stages have not been described in the Hungerford's Crawling Water Beetle or other *Brychius* species (United States Fish and Wildlife Service 2006), in other Haliplidae eggs are laid in spring and early summer and possibly again in the autumn (Roughley 2001). In *Haliplus* and *Peltodytes*, the eggs are laid in cavities chewed in algae or aquatic vascular plants, and on the surface of aquatic plants, respectively (Roughley 2001). Following oviposition, larvae hatch in 8 to 14 days (United States Fish and Wildlife Service 2006) and are herbivorous throughout their three instars. Stable isotope analyses demonstrate that larval *B. hungerfordi* specialize on the alga *Dichotomosiphon tuberosus* (Grant and Vande Kopple 2009). Observations of Hungerford's Crawling Water Beetle (Strand and Spangler 1994) and studies of *Brychius hornii* indicate that mature larvae pupate in the moist soil of river banks (Mousseau 2004). As in other haliplids they are generally thought to overwinter as larvae and pupate in the spring (United States Fish and Wildlife Service 2006). Undoubtedly some adults survive the winter, as adults have been collected in December and February (Grant et al. 2000). Lasting up to two weeks in other haliplids, the length of the pupal stage is probably dependent on the temperature of the substrate (Roughley 2001). Adult Hungerford's Crawling Water Beetles emerge from the moist soil of river banks, re-enter the river and the cycle begins again. Like many water beetles, Hungerford's Crawling Water Beetle swims underwater with an air bubble. This, and the fact that they are weak swimmers and have to swim to the surface often to replenish their air supply, may make them more susceptible to predation by some insectivorous fish species (M. Strand, pers. comm. 2012). Fish are believed to be the most important predators of Hungerford's Crawling Water Beetle and other species of *Brychius* (Hickman 1931); other predators of haliplids generally are waterfowl, amphibians and other aquatic invertebrates (Hickman 1931). Invertebrate predators may be important, especially in the egg, larval or pupal stages (M. Strand, pers. comm. 2012). It has been suggested that both bottom-feeding fish and fish species that feed at the surface and water column may prey on Hungerford's Crawling Water Beetle (White 1986, Strand 1989, Wilsmann and Strand 1990).

It is not known how long adult Hungerford's Crawling Water Beetles live, but captive haliplids survive up to 18 months (Hickman 1931). While flight is believed to be very rare in this species, it has been observed and is one means by which individuals could potentially disperse.

1.3 Distribution, Abundance and Population Trends

Endemic to the Great Lakes region of North America, the Hungerford's Crawling Water Beetle occurs in only three rivers in Bruce County, Ontario and eight streams in four counties (Emmet, Montmorency, Charlevoix and Oscoda) of the northern Lower Peninsula of Michigan (Figure 1). The rivers in Ontario are the Rankin, the Saugeen and the North Saugeen (Figure 2). In surveys for Hungerford's Crawling Water Beetle in the Rankin River in 2008, a total of 10 adults and three larvae were found with only four kicks of a D-net (0.5 hours of sampling effort). Moreover, in 2009, eight adults and one larva were sampled (three hours search effort; COSEWIC 2011); more Hungerford's Crawling Water Beetles were found in 2011, 1.5 km from the site below the Rankin River dam where individuals were originally captured (sampling effort was not recorded; S. Robinson, pers. comm. 2012). The relatively large numbers of adults and larvae found at this site with minimal survey effort suggest that the Rankin River site is an extremely important location for this species in Ontario (C. Jones, pers. comm. 2012). In the Saugeen River in 2008, one adult was found (one hour search effort), and on two other occasions (also in 2008) adults were present but not collected (COSEWIC 2011). It is believed that the North Saugeen population may have been extirpated over the last 10 years since numbers apparently declined from 42 adults in 1986 to one adult in 2001, and none were found in 2002, 2008 and 2009 (COSEWIC 2011). It is possible that the decline of this population is due to warming of the water temperature or other changes brought about by bridge construction at this site in the 1980s (COSEWIC 2011). About 40 percent of the global range was estimated in Canada by COSEWIC (2011) but this is less now that more populations have been discovered in Michigan (Figure 1). Three out of 11 populations (27.2% of the rivers) of Hungerford's Crawling Water Beetle occur in Ontario.

In Michigan, the best studied and largest population of Hungerford's Crawling Water Beetle occurs on the East Branch of the Maple River. Estimated at 200 to 500 individuals prior to listing, the population is believed to have remained stable since then (United States Fish and Wildlife Service 2009). A mark-recapture study carried out in 2001 in another pool of the East Branch estimated the population at 1,052 individuals (Grant et al. 2002). Little is known about the other populations; the four populations mentioned in the recovery plan are believed to be small, as are the three recently discovered ones (B. Vande Kopple, pers. comm. 2012). In the five-year review in the United States, it was stated that two of the six populations were thought to be stable (United States Fish and Wildlife Service 2009).

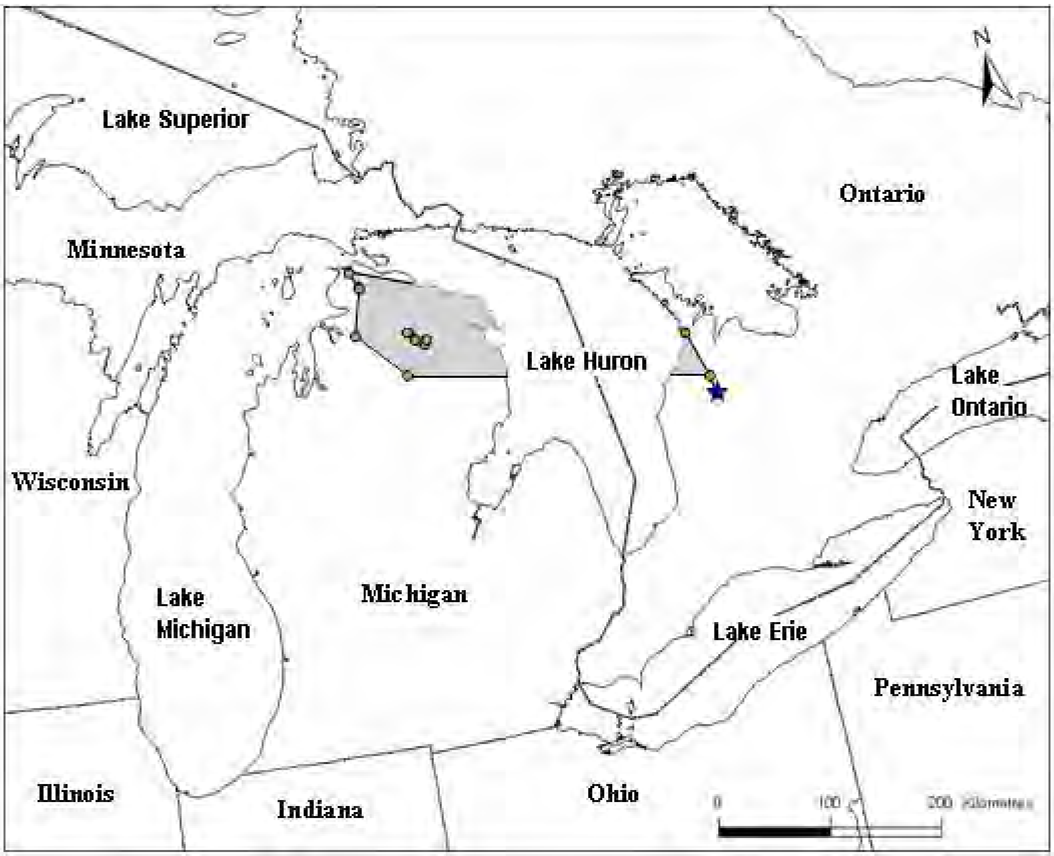

Figure 1. Distribution of Hungerford's Crawling Water Beetle in Ontario (orange dots show current locations - including new locations in Michigan, blue star is probably extirpated location on North Saugeen; polygons show area of occurrence in Michigan and Ontario; Map updated from COSEWIC 2011, used with permission)

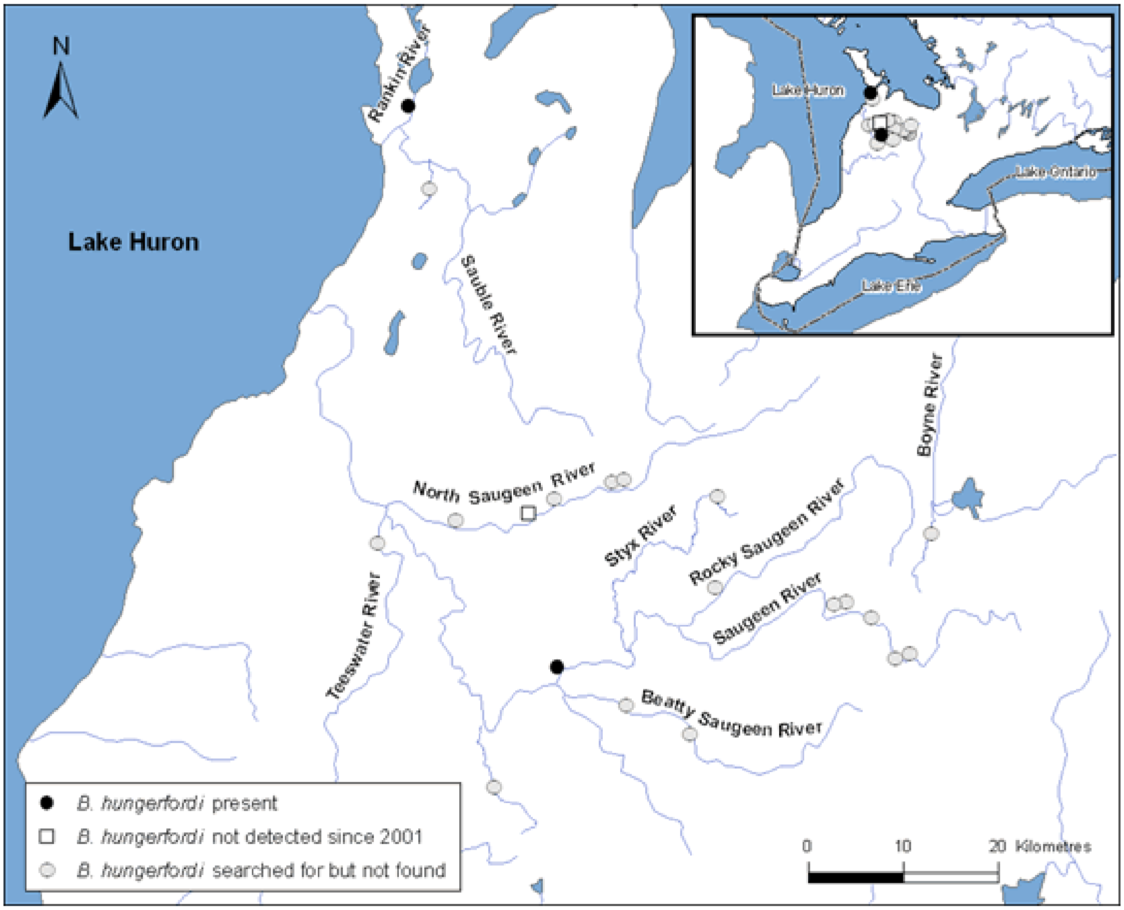

Figure 2. Distribution of Hungerford's Crawling Water Beetle in Canada. Map shows two extant populations (black dots), a probably extirpated population (open square) and locations where beetles were surveyed for but not observed (grey dots); map from COSEWIC 2011, used with permission.

1.4 Habitat Needs

Local habitat at specific Ontario locations

At all Ontario locations, Hungerford's Crawling Water Beetles have been found within 1.5 km downstream of human-made structures (e.g., weirs or dams). Despite sampling at varying distances downstream from these locations, no more Hungerford's Crawling Water Beetles have been found (Appendix 2). However, this could be because of detectability biases; because Hungerford's Crawling Water Beetles are very small and occur at very low density it is possible that sampling has not been sufficiently intensive to detect them away from dam sites.

Possibly the functioning of the human-made structures creates suitable ecological conditions and is important for the continued existence of the Hungerford's Crawling Water Beetle populations. However, the specifics of the effects of drawdown and other dam operations are unknown at this time.

The three Ontario locations differ in their habitat features suggesting that the habitat requirements of the species are poorly understood. The specific sites are discussed below.

The Rankin River location is downstream of a dam with an epilimnion outlet. During surveys for Hungerford's Water Beetle, individuals were collected in both open cobble and gravel patches and areas with more abundant vegetation and silt/sand substrate (COSEWIC 2011). More than half of the 20 kicks used for sampling were done downstream of the original capture location; no beetles were captured up to 75 m downstream of the original site where individuals were recorded. In 2011, beetles were also captured 1.5 km downstream (direct distance) of the original capture location below the Rankin Dam during ongoing inventory and monitoring for this species on the Rankin River (S. Robinson, pers. comm. 2012).

This dam was built in 1961, originally to allow the development of agricultural land in the subwatershed (Grey Sauble Conservation Authority 2007). Usually stop logs are installed in the spring after Rainbow Trout (*Onchorhynchus mykiss)* have spawned. Because of the large capacity of the lakes downstream, there is a lengthy draw down period every fall, the timing of which depends on summer and fall water levels (Grey Sauble Conservation Authority 2007, J. Bittorf, pers. comm. 2012).

At the location below the Rankin dam where Hungerford's Crawling Water Beetles were found the presence of riffles depends on water levels; on some occasions no riffles are present but they have been observed at other times (C. Jones, pers. comm. 2012). Moreover, riffles are present elsewhere on the Rankin River, (S. Robinson, pers. comm. 2012). One location where Hungerford's Crawling Water Beetles were detected in 2011, 1.5 km downstream of the Rankin dam site, has pools and riffles as well as limestone outcropping, sandy substrates and submerged aquatic vegetation (S. Robinson, pers. comm. 2012).

The Rankin River has only moderate flow and ranged in depth from 15 to 60 cm in August of 2008 and 2009. The stream substrate is mixed, coarse gravel and cobble stones and there are substantial areas of silt and sand. Moderate to heavy patches of aquatic vegetation (including abundant algae) occur in the river. The river is highly alkaline with a pH of 8.09 measured on 5 October, 2005 and 7.91 measured on 4 October, 2008 (S. Robinson in pers. comm. to C. Jones 2009).

On the Saugeen River near Hanover, Hungerford's Crawling Water Beetles are found a few hundred metres downstream from a weir (COSEWIC 2011). Built in the early 1900s to service the settlers in the area, this dam was rehabilitated in 1985 to provide a barrier to migratory fish species (D. Pybus, pers. comm. 2012).

Historically this weir was a mill race but has been filled in for several years. It is a large concrete weir and there is a high flow channel to the north of the dam. Rehabilitation work was completed on this dam in 1990. The Town of Hanover owns the dam, and the

Saugeen Valley Conservation Authority provides an annual inspection report (J. Harbinson, pers. comm. 2012).

Water flow at this site is moderate [the lowest mean flow for seven consecutive days with a 10 year recurrence interval or 20 year recurrence interval is 4.36 cubic metres per second or 3.92 cubic metres per second, respectively (Saugeen Valley Conservation Authority 2008a)], there are no riffles and depth ranges from 30 to 90 cm (in August 2008, 2009). Gravel and fine sediments line the stream bed and there are few macrophytes, except at the water's edge where the current is slower. Substrates are covered in filamentous algae.

The Hungerford's Crawling Water Beetle population at Scone on the North Saugeen River may have been extirpated as no individuals have been found since 2001. The water at this location has warm temperatures because of the surface outlet from the dam with the epilimnion outlet upstream; this may mean that it provides suboptimal habitat since Hungerford's Crawling Water Beetles prefer cool water temperatures (United States Fish and Wildlife Service, 2006). The Scone dam is privately owned and generates 70 kilowatts per hour. This dam is one of the oldest hydro-electric dams in Canada (built in 1850) and is in need of repairs (Saugeen Times 2008, Owen Sound Sun Times 2008).

On the North Saugeen River, the lowest mean flow for seven consecutive days within a 10 year recurrence interval was 0.82 cubic metres per second (Saugeen Valley Conservation Authority 2008a). The river bed is described as having substantial deposits of a marl-like substance on rocks and stones (COSEWIC 2011). Marl is a calcium or lime deposit and it is not clear what the origin of these deposits is, and whether they have any effect on Hungerford's Crawling Water Beetle populations. Presumably they are indicative of alkaline conditions. While the North Saugeen River provided apparently suitable habitat for the Hungerford's Crawling Water Beetle in 1986 (and as recently as 2001), it may no longer do so (COSEWIC 2011). It is also possible that the population was very small and was extirpated due to stochastic events.

As well as local site conditions, land cover and land use adjacent to the sites and within the watershed influence water flow and water quality. Forest cover is particularly important since trees moderate infiltration rates and reduce run-off. All three watersheds where Hungerford's Crawling Water Beetle occurs in Ontario have greater than 30 percent forest cover; the Rankin River watershed (221.8 km^2) occurs within a region that has greater than 35 percent forest cover (Grey Sauble Conservation Authority 2011, 2012) the Upper Main Saugeen watershed (782 km^2) has 35 percent forest cover (Saugeen Valley Conservation Authority 2008 a,b) and the North Saugeen (269 km^2) has 41 percent forest cover. The type of forest is also important. Riparian forest (linear buffers of trees growing along streams and around water bodies) is particularly critical, and there is evidence that the more complex riparian forests are, the more effective they are in their ecological benefits. Well-established riparian vegetation reduces water flow velocity and the fine root systems associated with trees bind soil, prevent erosion and stabilize stream banks (McKergow et al. 2003, Boothroyd et al.

2004). Moreover, the organic matter associated with trees improves the physical and chemical properties of soil, as well as infiltration and thus reduces run-off. Among the non-point source pollutants intercepted by trees are pesticides (Muscutt et al. 1993, Borin et al. 2004, Sweeney et al. 2004), phosphates and nitrates from fertilizers (Mayer et al. 2007) and heavy metals (Schnoor 1997). Riparian vegetation also provides shade and thus moderates water temperatures; cool temperatures are a key feature of Hungerford's Crawling Water Beetle habitat. According to the watershed report cards, both the North Saugeen and Upper Main Saugeen have only 43 percent of forested habitat in riparian buffer strips of 30 m width (75% is recommended by Environment Canada), while riparian cover in the Rankin River subwatershed is described as good to fair (25-50%; Grey Sauble Conservation Authority 2011,2012).

Wetlands are also important for the ecological integrity of watersheds and could be important to the existence of Hungerford's Crawling Water Beetle; 10 percent is the minimum recommended by Environment Canada for a healthy watershed. While the Rankin River subwatershed is above this threshold at 13.1 percent (29.08 km^2 - Grey Sauble Conservation Authority 2011, 2012), both the North Saugeen River watershed (5.9%) and the Upper Main Saugeen (5.7%) are well below the threshold (Saugeen Valley Conservation Authority 2008 a,b).

Local habitat in Michigan

In Michigan, Hungerford's Crawling Water Beetles are found downstream of dams, culverts or weirs. They have been found to concentrate at culverts, where they scrape algae from clean gravel (M. Strand, pers. comm. 2012). Where culverts are 'hanging' they may present a barrier to Hungerford's Crawling Water Beetles moving upstream. However, in most cases Hungerford's Crawling Water Beetles appear to be adept at crawling upstream of culverts (M. Strand, pers. comm., 2012). They have been found to be more widely dispersed along extensive stretches of stream (B. Vande Kopple, pers. comm. 2012). For example, on the East Branch of the Maple River in Michigan they are found throughout the stream (along several kilometres). During egg-laying, 10 to 20 Hungerford's Crawling Water Beetles can occur in one very small area within a stream (B. Vande Kopple, pers. comm. 2012).

According to M. Strand (pers. comm. 2012), it is also possible that populations of Hungerford's Crawling Water Beetle have typically always been small and scattered, as is the case in the Maple River. However, under specific ecological conditions, numbers may build to larger levels. If the historical distribution and abundance of Hungerford's Crawling Water Beetle was dependent on the presence of dams built by American Beavers (*Castor canadensis*), then this life history strategy could pre-adapt the species to colonizing ephemeral habitat created by beavers (M. Strand, pers. comm. 2012).

All of the streams known to be occupied by Hungerford's Crawling Water Beetles are small to medium-sized with moderate to fast-flowing water. Water volume usually ranges from 0.14 to 0.71 cubic metres per second in summer (B. Vande Kopple, pers. comm. 2012). However, this varies from river to river, and in the smallest stream

(Stewart Creek) may be only 0.06 to 0.14 cubic metres per second. During peak run-off in the spring, water volume may be much higher, up to 2.83 cubic metres per second. These streams are typically well oxygenated with cool (but not too cold) water temperatures (15-25^{o} C), a high pH (alkaline) and an inorganic substrate (cobble gravel or sand; Wilsmann and Strand 1990). Water supply in the streams is a mix of surface lake run-off and groundwater (hard water). Hungerford's Crawling Water Beetles are almost never found in pure groundwater streams (e.g., in the north branch of the Boyne River in Charlevoix County, Michigan, only one larva and no adults were found; B. Vande Kopple, pers. comm. 2012). The streams are also characterized by seasonally fluctuating water levels, with spring and early summer highs and late summer and autumn lows. During low water levels, exposed damp sand along the shoreline is thought to provide pupation sites for the Hungerford's Crawling Water Beetle (Strand and Spangler 1994).

It is possible that various algae play a critical role in determining the distribution and abundance of Hungerford's Crawling Water Beetle both in Michigan and Ontario (M. Strand, pers. comm. 2012). Larvae depend on the algae *Dichotomosiphon tuberosus* for their development. *Dichotomosiphon* has a restricted distribution in streams and appears to be more typical of lakes (for example, it was discovered in Lake Simcoe, Ontario in 1983 – Neil and Robinson 1985). It is possible that human-made structures or beaver dams create suitable habitat conditions (pools below dams or weirs) for *Dichotomosiphon*. This may explain why Hungerford's Crawling Water Beetles congregate at specific locations in streams to breed and lay their eggs.

Adult beetles are less restrictive (polyphagous) in their choices of algae and thus are able to disperse more widely throughout streams. For example, Hungerford's Crawling Water Beetles have been captured clinging to *Chara* spp. (a genus of green algae) holdfasts below the waterline (M. Strand, pers. comm. 2012).

1.5 Limiting Factors

Believed to be a post-glacial relict isolated by the formation of the Great Lakes, the Hungerford's Crawling Water Beetle may have once been much more widespread (USFWS 2006). An alternative explanation is that populations of this species have always been small. Their disjunct distribution, small populations and limited dispersal potential via flight makes them inherently vulnerable to stochastic events including local and watershed-level changes in habitat quality.

1.6 Threats to Survival and Recovery

A wide range of potential threats could impact the stream habitat of the Hungerford's Crawling Water Beetle, which requires relatively pristine conditions. This is because many activities in watersheds can influence chemical and physical stream characteristics such as water quality and flow volume.

The main threats (categorized by activity) to the species in Ontario include the following:

Changes in water flow or quality due to local (instream) habitat alteration or degradation
Stream embankment and channelization
One of the main potential threats to Hungerford's Crawling Water Beetle in Ontario and Michigan is physical alteration to stream beds, adjacent banks and edge vegetation through channellization, dredging, bank stabilization, erosion control and some kinds of impoundment (Wilsmann and Strand 1990, USFWS 1994, Hyde and Smar 2000). Logging of trees in the riparian zone could cause changes in stream-bank characteristics, as well as run-off from non-point source (NPS) pollutants and changes in hydrology and ground water quality (Strand 1989). At the North Saugeen site at Scone, Ontario, at least 50 trees were felled along the shoreline within 30 m of the Hungerford's Crawling Water Beetle site (Saugeen Times 2007). The above activities could potentially impact the riffle and pool habitat preferred by Hungerford's Crawling Water Beetle as well as remove or affect the suitability of bank-side pupation sites. Some management activities could also be beneficial, such as bank stabilization. However, although perhaps temporary depending on the type of material, artificial impervious covers used for stabilization could destroy potential pupation habitat. It is also important to consider that some erosion control measures may have temporary adverse effects, but in the long-term may provide overall benefit.

Removal or modification of human-made structures
Waterpower development and associated water management regimes have the potential to impact Hungerford's Crawling Water Beetles, since individuals typically concentrate or only occur downstream of dams, weirs or culverts. Physical alteration, removal or changes to the operation of these human-made structures could pose a threat to the continued existence of Hungerford's Crawling Water Beetles.

Nothing is known of the effects of dam operations on Hungerford's Crawling Water Beetles at the Rankin River Dam. Without further information it must be assumed that the normal operation of the dam does not interfere with Hungerford's Crawling Water Beetle populations, if they continue to exist at this site. Changes in ownership of the dam on the North Saugeen (if the dam is sold) or repairs, could have implications for Hungerford's Crawling Water Beetle, should the species be found to still occur at this location. In 2011, a mass wash-out occurred at this dam because of an extreme stormwater event, and adjacent terrain (a driveway) was washed away because the stop logs in front of the dam could not be removed in time (N. Garland, pers. comm. 2012). It is not known what impacts this may have on water quality and the habitat of Hungerford's Crawling Water Beetle. No operations occur at the Saugeen River dam at Hanover: there is no control structure, no hydro-electric equipment, no boards taken in or out and no gate (J. Harbinson, pers. comm. 2012).

Removal of old dams could have negative impacts on Hungerford's Crawling Water Beetles. This is because water quality in streams below old dams may have reached a steady state and demolishing a dam could alter this by releasing sediments or other materials. Installment of new, small hydroelectric dams could also be a potential threat

(Imhof 2007). It is possible that a relatively new micro-hydroelectric facility operating immediately upstream of the Hungerford's Crawling Water Beetle site on the North Saugeen River changed water flow or quality in some way. The fact that an environmentally-sensitive mayfly genus (*Baetisca* spp.) occurred previously at this site but has not been recorded in recent years (S. Marshall pers. comm. to C. Jones, COSEWIC 2011) may indicate that stream conditions have changed for other invertebrates as well, including the Hungerford's Crawling Water Beetle. Despite this, the Family Biotic Index (FBI), based on sampling of benthic macroinvertebrates for the North Saugeen, scored an A (3.76 on a scale of 1 (healthy) to 10 (degraded); Saugeen Valley Conservation Authority 2008a)). The Upper Main Saugeen also scored an A for the FBI (4.09; Saugeen Valley Conservation Authority 2008b).

Natural dams built by beavers may play a role in maintaining habitat for the Hungerford's Crawling Water Beetle. Because beaver impoundments could maintain habitat for Hungerford's Crawling Water Beetles downstream (Wilsmann and Strand 1990), removal of either dams or individual beavers by humans could pose a threat. Conversely, new beaver activity could flood Hungerford's Crawling Water Beetle habitat and render it unsuitable (B. Vande Kopple, pers. comm. to USFWS 2004; B. Ebbers, pers. comm. to USFWS 2004). It is thought by some that beavers created Hungerford's Crawling Water Beetle habitat and perhaps had a greater role in the past when beavers were more common in some areas (M. Strand, pers. comm., 2012).

Road construction operations
In Michigan, many Hungerford's Crawling Water Beetle populations are located downstream of road crossings or culverts (USFWS 2006). While culverts seem to contribute to provision of suitable habitat, they also have negative effects in that they present barriers to upstream dispersal (Vaughan 2002), and they serve as a conduit for pollutant run-off from roads and roadside ditches.

Road construction can contribute to increased surface run-off, allowing gasoline or other chemicals and sediments to enter stream systems, thereby affecting habitat conditions for the species. Moreover, road crossings that are poorly designed or deteriorating can cause erosion and release of sediments into streams. A bridge constructed in the 1980s upstream of the Hungerford's Crawling Water Beetle site on the North Saugeen River may have caused changes in habitat quality (R. Roughley, pers. comm. to L. A. Wilsmann, COSEWIC 2011). Clearance of ditches can impact water quality and stream attributes if not carried out using best management practices (Hyde and Smar 2000).

Removal of water
Removal of surface water (e.g., for bottled water) or removal of groundwater that feeds surface streams could potentially threaten the survival of Hungerford's Crawling Water Beetle. This is because continuous stream water flow is an essential habitat attribute for the species.

Changes in water flow or quality due to landscape (watershed) habitat alteration or climate change

Agricultural and logging activities

Non-point source (NPS) pollution from run-off of nutrients, pesticides and sediment from land within the watershed has the potential to threaten the survival of Hungerford's Crawling Water Beetle, but the specific direct or indirect effects (e.g., on beetles or their algal food supply) are unknown. The extent to which NPS pollution impacts aquatic ecosystems depends on land cover and land use within the watershed.

Agricultural activities associated with cropping, such as tillage, pesticide and fertilizer use, cause run-off of NPS pollutants which enter streams and other water bodies. The percentage of cropped agricultural land influences run-off of NPS pollutants and ground water contamination. Of the three watersheds, the Upper Main Saugeen River has the highest percentage of agricultural land (58%), followed by the North Saugeen (51% - Saugeen Valley Conservation Authority 2008 a,b). Most land use in the Rankin River subwatershed is 'rural' or 'other' and not agricultural, although there is a large area of agricultural land to the east of the subwatershed (Grey Sauble Conservation Authority 2011, 2012).

In terms of water quality, the North Saugeen scored B for phosphorus (0.03 mg/L, which is the provincial standard) and A for nitrate and nitrites (0.16 mg/L – the standard for drinking water is 10 mg/L). By comparison, the Upper Main Saugeen had lower phosphorus levels (0.02 mg/L) but higher nitrates/nitrite levels (0.26 mg/L – Saugeen Valley Conservation Authority 2008 a,b). Water quality conditions in the Sauble River watershed, which includes the Rankin River, have scored poorly: approximately 76 percent of the samples being fair to very poor (Grey Sauble Conservation Authority 2011, 2012).

Increased water temperatures or reduced basal water flow produced by off-channel ponds created by landowners for fish-rearing or ornamental purposes (Imhof 2007) may have a negative effect on water beetles. These ponds intercept run-off reducing basal flow rates in coldwater streams; when water is added back into the system it is at much higher temperatures. According to Imhof (2007), pond development is apparently increasing in the Saugeen watershed.

Urban and Industrial activities

Changes in hydrology and groundwater quality and quantity as a result of urban and industrial development can negatively impact benthic invertebrate and algal communities (Dewson et al. 2007, Hancock 2002, Stevenson et al. 1996) and thus potentially the Hungerford's Crawling Water Beetle. While the total land area covered by urban or industrial use may be low, it is important to consider that the influences of this human footprint may extend over a much larger area. For example, the percentage of urban land in the Upper Main Saugeen and North Saugeen watersheds is low (1.4% in each) but may influence a wider area. Similarly, pits and quarries for aggregate extraction cover a small area (17.7 km^2 on the Main Saugeen, and 3.25 km^2 on the North Saugeen, or 1.04% and 1.21% of these watersheds, respectively). However, their specific locations and spatial distribution within a watershed are important. Once reserves in the Greater Toronto Area are depleted and transportation methods improved, aggregate extraction is predicted to increase in some watersheds such as the Saugeen (Imhof 2007), which could affect groundwater discharge, storage and movement as well as elevated sedimentation levels in the rivers. Sedimentation is a significant threat for Hungerford's Crawling Water Beetle because it limits the availability of silt-free gravel.

At the Saugeen River site, expansion of an adjacent landfill (Pryde Schropp McComb Ltd and Stantec Consulting Ltd. 2010) could have a negative impact on Hungerford's Crawling Water Beetle through leaching of chemicals and waste products which could affect groundwater quality and thus alter algal communities and benthic invertebrates (Hancock 2002, Dewson et al. 2007, S. Robinson, pers. comm. to COSEWIC 2009).

Predation by introduced or other species
The distribution and abundance of many aquatic invertebrates is strongly influenced by predation and Hungerford's Crawling Water Beetles are no exception (Arnott et al. 2006). Predation by introduced Brown Trout (*Salmo trutta*) was suggested by Strand (1989) as a threat to Michigan populations of Hungerford's Crawling Water Beetle. Because Hungerford's Crawling Water Beetles swim underwater with an air bubble, they are highly visible and are presumably easily detected by predatory Brown Trout. It may not be fortuitous that the largest known population of Hungerford's Crawling Water Beetle occurs at the Maple River site in Michigan, where no Brown Trout are present. In Ontario, Brown Trout are established in the Saugeen River (OMNR 2002) and thus could be a potential threat there. More generally, other species of insectivorous fish may prey on Hungerford's Crawling Water Beetle; in the state of Michigan these species are not stocked in waters where Hungerford's Crawling Water Beetles are known to occur (USFWS 2009).

Climate change
According to Monk et al. (2010), there was a significant decrease in the maximum river flow in natural rivers in watersheds sampled across southern Ontario between 1970 and 2005 (including those where Hungerford's Crawling Water Beetle occurs). Maximum annual flow (spring freshet) occurs in late spring/early summer and is important for those species whose life cycles are synchronized with this event. For example, it provides rich foods from the flood plains. There has also been a non-significant decrease in the minimum annual flow over the period 1970-2005, which occurs in late summer and late winter. A number of factors are dependent on minimum annual flow, including the availability of aquatic features for species, water temperatures and dissolved oxygen levels (Federal, Provincial and Territorial Governments of Canada 2010). These decreases in maximum and minimum annual flow could negatively influence water conditions for Hungerford's Crawling Water Beetle and the availability of food and pupation sites.

1.7 Knowledge Gaps

There are numerous knowledge gaps that should be filled to effectively achieve recovery objectives for the Hungerford's Crawling Water Beetle:

1) distribution, abundance and population sizes beyond known populations on the Rankin and Saugeen Rivers, and in particular whether the North Saugeen population has been extirpated;
2) knowledge of habitat features required by the species including microhabitat requirements for each life stage (e.g., especially the distribution and role of *Dichotomosiphon* as well as microhabitat for pupation and overwintering stages), in particular water quality (including water chemistry) and physical parameters;
3) knowledge of landcover in the immediate vicinity of populations and in the watershed surrounding populations to predict potential future threats;
4) environmental tolerances and threshold levels for pollutants and sediment loads;
5) knowledge of the life history traits of Hungerford's Crawling Water Beetle (population dynamics, breeding biology);
6) the ecology of algal food or epiphyton food supply;
7) knowledge of the aquatic macroinvertebrate communities at the sites where Hungerford's Crawling Water Beetle occurs, and at similar sites within the watersheds where it occurs;
8) Hungerford's Crawling Water Beetle demographic information to determine its viability and parameters/threats associated with each life stage;
9) relatedness of Ontario and Michigan populations; and
10) dispersal modes and distances.

1.8 Recovery Actions Completed or Underway

No recovery actions have been undertaken specifically for the Hungerford's Crawling Water Beetle. However, some relevant actions have been undertaken which are pertinent to this recovery strategy. Extensive sampling of benthic macroinvertebrates in the Saugeen River has been undertaken by the Ministry of Environment in cooperation with the Saugeen Valley Conservation Authority (SVCA, Jones et al. 2008, Jones and Nicol 2011). About 95 sites have been surveyed over the last five years mainly in the tributaries of the Saugeen (Jones and Nicol 2011, Chris Jones, pers. comm., 2012). The sampling was done using a stratified random sampling design and test sites have been compared with reference sites, using protocols developed by the Ontario Benthos Biomonitoring Network (OBBN) and deploying a reference condition approach (RCA) (Jones et al. 2007).

In terms of outreach and education, a series of public information sessions have been hosted by the OMNR, as well as by the Grey County Stewardship Network, the Saugeen Valley Conservation Authority and the Bait Association of Ontario about species at risk in the Saugeen River watershed. These events provided an opportunity for landowners, agencies and contractors to become involved in land stewardship incentives to improve environment health and quality of life on the Saugeen River.

Moreover, funding was provided to carry out stream-related conservation projects that could benefit aquatic species at risk, such as the Hungerford's Crawling Water Beetle (SVCA 2012).

Recent searches were conducted for the Hungerford's Crawling Water Beetle in many streams within the Saugeen, Grey-Sauble and Owen Sound watersheds in preparation for the COSEWIC status report (44 locations, 16 streams) on the following dates: 25 to 26 August, 2008, 24 to 26 August, 2009 and 5 to 7 October, 2009, as well as in 2011. Only streams that were considered suitable habitat were surveyed. Surveys were done using kick-sampling within the stream current using an aquatic D-net (COSEWIC 2011). In this technique the substrate is disturbed by the feet of the human observer, thereby dislodging invertebrates which are then transported into the waiting net by the current. Further sampling should be done with extreme care, especially for the most susceptible life stages (eggs, larvae and pupae).

2.0 RECOVERY

2.1 Recovery Goal

The recovery goal is to enhance long-term population viability by maintaining at least three self- sustaining populations of Hungerford’s Crawling Water Beetle in Ontario. The species was probably never widespread and is possibly a glacial relict and so this is considered a reasonable recovery goal.

2.2 Protection and Recovery Objectives

Table 1. Protection and recovery objectives

No.	Protection or Recovery Objective
1	Protect existing populations and habitat where Hungerford’s Crawling Water Beetle is found
2	Determine the distribution and abundance of Hungerford’s Crawling Water Beetle outside the existing known sites
3	Investigate the habitat requirements of the species and in particular determine the role of human-made impoundments.
4	Identify, quantify and seek to mitigate or remove threats to existing populations.
5	Promote ongoing measures to protect vegetation adjacent to the extant occurrences of Hungerford’s Crawling Water Beetle and watershed vegetation cover.
6	Investigate the possibility of translocation from a thriving population to the North Saugeen population, if required.

2.3 Approaches to Recovery

Table 2. Approaches to recovery of the Hungerford's Crawling Water Beetle in Ontario

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
1. Protect existing populations and habitat where Hungerford's Crawling Water Beetle is found.				
Critical	Long-term	Protection, Management	**1.1** Use surveys of population distribution and abundance and habitat use to: - delineate stream water habitat - identify adjacent substrate and vegetation on stream banks that provides pupation sites - map adjacent substrate and vegetation cover to identify areas for protection	• Distribution and abundance • Habitat loss or degradation
Critical	Long-term	Protection, Management	**1.2** Encourage landowners to protect streamside vegetation through planting native trees and shrubs to minimize erosion and run-off	• Habitat loss or degradation
Critical	Long-term	Protection, Management	**1.3** Develop a habitat regulation to protect Hungerford's Crawling Water Beetle habitat in Ontario	• Habitat loss or degradation
2. Determine the distribution and abundance of Hungerford's Crawling Water Beetle outside the existing known sites.				

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Necessary	Long-term	Monitoring and Assessment	**2.1** Conduct standardized surveys of adults using sweep sampling away from main locations to refine distribution and determine whether the pattern observed is due to habitat specialization or detectability biases - determine the population status (i.e., extant or extirpated) at North Saugeen River - map spatial distribution - increase effort on surveys downstream (or upstream if habitat appropriate) of the known sites	• Distribution and abundance
Necessary	Long-term	Monitoring and Assessment	**2.2** Conduct wider systematic surveys of suitable riverine sites - use specialized sampling for rare species to determine whether any other populations exist	• Distribution and abundance
3. Investigate the habitat requirements of the species and in particular determine the role of human impoundments.				

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Beneficial	Short-term	Research	**3.1** Quantify abiotic features of streams at local and landscape levels - collect water quality parameters (chemistry and biophysical) at sites where adults are found	• Quantify habitat features required by the species and in particular water quality parameters (including water chemistry).
Beneficial	Short-term	Research	**3.2** Use reference condition approach (RCA[1]) to compare sites that are relatively pristine to test sites which are already being exposed to human stressors - compare sites occupied by Hungerford's Crawling Water Beetles with other sites (including reference)	• Quantify habitat features required by the species and in particular water quality parameters (including water chemistry).
4. Identify, quantify and seek to mitigate or remove threats to existing populations.				
Critical	Ongoing	Protection, Management, Monitoring and Assessment	**4.1** Identify threats to existing populations - prioritize threats - map watershed features and cover in GIS to determine adjacent land use and potential non-point source pollution from agricultural fields - relate water chemistry and biophysical parameters to stressors	• All threats
Beneficial	Ongoing	Research	**4.2** Develop models to evaluate significance of threats	• All threats

1 Bailey 2004, Bailey et al. 2007

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Critical	Ongoing	Protection, Management	**4.3** Mitigate or remove threats - work with landowners to educate and assist in maintaining healthy aquatic ecosystems - work with farmers to reduce agricultural non-point source pollution - evaluate and address potential sources of habitat destruction	• All threats
5. Promote ongoing measures to protect vegetation adjacent to the extant occurrences of Hungerford's Crawling Water Beetle and watershed vegetation cover.				
Critical	Ongoing	Communications, or Stewardship	**5.1** Inform landowners, municipalities and other stakeholders about the presence of the species in the river adjacent to their land and the critical importance of stewardship and best management practices for conservation. - use Hungerford's Crawling Water Beetle as a flagship species for river ecosystem protection - encourage landowners to liaise with MNR, Grey Sauble Conservation Authority, Saugeen Valley Conservation Authority, municipalities - develop partnerships with First Nations (Saugeen First Nation, Chippewas of Nawash) - coordinate recovery actions with interested landowners, and the public - educate and assist private landowners with maintaining healthy aquatic ecosystems	• Run-off of NPS pollutants and sediment into river • Habitat loss or degradation

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Critical	Ongoing	Management	**5.2** Identify and implement best management practices in watersheds that will benefit Hungerford’s Crawling Water Beetle - increase permanent semi-natural cover in watershed - implement strategic riparian buffer strips (native species) to reduce non-point source pollution	• Run-off of non-point source pollutants and sediment into river • Habitat loss or degradation
6. Investigate the possibility of translocation from a thriving population to the North Saugeen population, if required				
Beneficial	Ongoing	Management	**6.1** Determine the need and feasibility of translocation	• Distribution and abundance
Beneficial	Ongoing	Management	**6.2** Translocate Hungerford's Crawling Water Beetle where feasible - investigate need to re-establish (if found to be extirpated) or improve (if still present) the population on the North Saugeen.	• Distribution and abundance

Narrative to Support Approaches to Recovery

The critical first step in implementing a recovery strategy for the Hungerford's Crawling Water Beetle is to update information on the species' distribution and abundance. This includes estimating population size (possibly using mark-recapture) on the Rankin River and Saugeen River (outside existing dam sites), and confirming whether or not the population still exists in the North Saugeen River. It is extremely important that the existing known locations not be disturbed by invasive sampling as this may pose a threat to the Hungerford's Crawling Water Beetle. However, this threat can be mitigated firstly, by focusing search effort on other reaches of the Rankin and Saugeen Rivers, where Hungerford's Crawling Water Beetles may also occur. Secondly, surveys should be modified to avoid disturbance to the most critical life stages – namely pupae and larvae (M. Strand, pers. comm. 2012). The greatest potential threat may be from accidental trampling of pupation sites when surveyors enter or exit streams, so great care needs to be exercised when entering streams. Because of their low motility, larvae may also be vulnerable when they are displaced and not able to relocate potential suitable habitat. Avoiding surveys at existing locations where larvae and pupae are known to occur is recommended. On other reaches of the Rankin and Saugeen River, surveys could be timed to mitigate any detrimental effects on these vulnerable life stages. Because they are highly mobile air breathers with tough exoskeletons, adult Hungerford's Crawling Water Beetles are less sensitive to disturbance than pupae and larvae. For example, kick sampling has been used regularly to catch and release adult beetles at a site close to the University of Michigan Biological station with no apparent detrimental effect (M. Strand, pers. comm., 2012).

If survey protocols are used to carefully target adult Hungerford's Crawling Water Beetles and avoid contact with sensitive microhabitats occupied by pupae and larvae then the threat to the species should be minimized. Sweep surveys should be used to sample adults as much as possible rather than kick sampling. Also surveys should only be carried out by personnel already familiar with the species and locations and limited in size (perhaps to three persons), as in Michigan (B. Vande Kopple, pers. comm. 2012). Detectability bias must also be accounted for since when small numbers of beetles are present they can be easily missed (V. Kopple in pers. comm. to C. Jones 2009, COSEWIC 2011).

Monitoring of water chemistry (e.g., dissolved oxygen, phosphorus etc.) and physical parameters (flow rates, water temperature, and depth) and adjacent land use at sites where the species occurs is necessary to inform the development of a habitat regulation. This is important for monitoring site conditions, particularly in relation to changes in water quality or stream flow characteristics that could impact Hungerford's Crawling Water Beetles. This monitoring needs to be done carefully by experienced personnel who are familiar with the sites and the sensitivities of the Hungerford's Crawling Water Beetle.

Widespread declines have occurred in environmentally sensitive mayflies on trout streams throughout south-central Ontario (H. Frania, pers. comm. 2012). For example, the Green Drake Mayfly (*Ephemera guttulata)* was once widespread and abundant on the Saugeen river system as far downstream as Hanover (H. Frania, pers. comm., 2012). Today it is restricted to the upper parts of some of the branches of the Saugeen river such as the Rocky Saugeen (upstream of Markdale), and possibly the Beatty Saugeen (reputed to be a large population though not verified there), and isolated populations on some feeder streams (e.g., Camp Creek). Other mayflies such as *Epeorus vitreus* have also declined in these river systems (H. Frania, pers. comm., 2012).

Better understanding of the aquatic communities in which Hungerford's Crawling Water Beetle lives could be gained by incorporating sites adjacent to where the species is found into a reference condition approach (Bailey et al. 2004, 2007; see also Yates and Bailey 2006, 2010, Yates et al. 2007). Although a reference condition approach is a multi-species, ecosystem approach, it could be very beneficial for Hungerford's Crawling Water Beetle recovery since it would put the species in the context of the broader aquatic invertebrate community (its ecological niche), and quantitatively identify the influence of habitat, stressors, and changes in the biotic condition of sites over time. Sampling to support an RCA has already been done at many sites in the Saugeen River watershed (Jones and Nicol 2011) and sites adjacent to the main populations where Hungerford Crawling Water Beetle is found could easily be sampled in the future for other macroinvertebrates to see how they compare with these other sites within the watersheds (Chris Jones, pers. comm., 2012).

Determining whether the population on the North Saugeen is extirpated is an important objective. If it is extirpated then the possibility of translocation from a thriving population could be considered, providing that this does not in any way compromise populations at extant sites.

It is likely that recovery efforts for the Hungerford's Crawling Water Beetle would benefit other species and could be addressed as part of a multi-species recovery strategy (ecosystem recovery plan). Recovery of many riverine aquatic species at risk has been integrated in ecosystem plans (e.g., Ausable River – Ausable River Recovery Team 2005, Grand River – Portt et al. 2007, Sydenham River - Dextrase et al. 2003, Thames River - Thames River Recovery Team 2005), which have many efficiencies (Kirk and Pearce in review). The spatial distribution of fish and mussel species at risk have already been mapped within the Grey Sauble and Saugeen Watersheds by the Department of Fisheries and Oceans (Conservation Ontario 2012). Some species that could benefit include rare mayflies (*Baetisca* spp.) which have disappeared from the North Saugeen.

Once this strategy is completed it should be integrated into a watershed or ecosystem plan that includes other species at risk. Finally it is important to collaborate and support efforts for Hungerford's Crawling Water Beetle recovery with partners in the United States since many threats and recovery actions may be similar (USFWS 2006).

2.4 Performance Measures

Potential performance measures for Hungerford's Crawling Water Beetle include the following.

- No population declines, populations stable or increasing at the Rankin River and Saugeen sites.
- Potential threats to the Rankin River and Saugeen populations have been identified and mitigated.
- Threats to the North Saugeen population have been identified and mitigated; possibility of reestablishment/restoration of population evaluated.
- Improvements in water quality over time demonstrated and populations of sensitive aquatic macroinvertebrates increased.
- Habitat restoration initiated where feasible.
- Best management practices developed and being employed by landowners and municipalities.

2.5 Area for Consideration in Developing a Habitat Regulation

Under the ESA, a recovery strategy must include a recommendation to the Minister of Natural Resources on the area that should be considered in developing a habitat regulation. A habitat regulation is a legal instrument that prescribes an area that will be protected as the habitat of the species. The recommendation provided below by the author will be one of many sources considered by the Minister when developing the habitat regulation for this species.

In Ontario, the Hungerford's Crawling Water Beetle occurs at three locations (one possibly extirpated though this needs to be confirmed); the total extent of occurrence is 36 km^2 and the area of occupancy is only 12 km^2 based on a 2 x 2 km grid (COSEWIC 2011). Although the areas in which the species has been found are limited to a few hundred metres below a dam or weir, it is important to also consider the influence of adjacent land cover in the vicinity of the site since this can affect water quality and quantity. This includes stream banks, adjacent vegetation such as trees, or structures such as bridges, dams, culverts, roads as well as agricultural fields or other land uses. Desired characteristics of adjacent landcover would be to retain or restore as much permanent natural or semi-natural vegetation cover as possible, especially riparian forest, wetlands and grassland. Riparian buffer strips act as biofilters of sediments and non-point pollutants (see above).

For the habitat regulation it is important to consider the immediate locations where Hungerford's Crawling Water Beetle are found on the Rankin and Saugeen Rivers, as well as adjacent riparian areas (which include potential pupation sites), and areas of algae within the water channel. In addition, protecting headwater areas upstream (both aquatic and terrestrial) is critical to ensure habitat suitability of the stream. Thus, it is recommended that an area 400 metres downstream of the area of occupancy as well as an area 400 metres upstream (the stream corridor) of Hungerford's Crawling Water Beetles occurrences be protected as habitat such that all hydrologically-connected stream segments are included. This minimum distance was chosen because it would allow for silt to settle out from disturbances upstream. It would also allow for downstream dispersal if Hungerford's Crawling Water Beetle uses drift for dispersal.

The habitat regulation should also include at least 30 metres of riparian or terrestrial vegetation that may be required to protect suitability within the stream. The distance should be measured from the high water mark of the stream and composed of native vegetation (Kiffney et al. 2003, Lee et al. 2004).

In the United States recovery plan it was recommended that 0.25 miles (about 400 m) of habitat upstream of the site where the Hungerford's Crawling Water Beetle is found be protected (this would include habitat upstream of the weir, dam or culvert). This distance was probably chosen because of government right-of-way designation for habitat upstream and downstream from roads.

Because Hungerford's Crawling Water Beetle may be more widely dispersed throughout streams in Ontario, as has been found in Michigan, it is important not to base the entire habitat regulation on a specific distance around known populations. The most critical factors are that the streams should remain in as natural and undisturbed state as possible, and that they have some groundwater input (i.e., they never completely dry up, B. Vande Kopple, pers. comm. 2012). Seasonal dynamics also need to be considered as it is important that lower summer water levels expose substrate for pupation sites. Additional hydrological studies are recommended to monitor seasonal changes in water levels.

It is recommended that sites with historical or potential habitat be included in the regulation where dispersal or translocation is deemed feasible. One such site is the North Saugeen River at Scone, provided that the factors which may have led to the potential extirpation of the species there are mitigated. Although Hungerford's Crawling Water Beetle has rarely been observed in flight, it is possible that individuals disperse in this way. Translocations have been carried out successfully in Michigan on several occasions; from culvert/bridge project areas to other locations on the same stream (B. Vande Kopple, pers. comm. 2012). No information is available on survival of these individuals but it is believed to be successful. The fact that beetles survive in closed test tubes for 48 hours suggests that they are fairly robust to translocation.

It is important to emphasize that these suggestions provide interim guidance and future recommendations should consider any new information that becomes available on the biology, population dynamics or habitat needs of the Hungerford's Crawling Water Beetle.

GLOSSARY

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): The committee responsible for assessing and classifying species at risk in Canada.

Committee on the Status of Species at Risk in Ontario (COSSARO): The committee established under section 3 of the *Endangered Species Act, 2007* that is responsible for assessing and classifying species at risk in Ontario.

Conservation status rank: A rank assigned to a species or ecological community that primarily conveys the degree of rarity of the species or community at the global (G), national (N) or subnational (S) level. These ranks, termed G-rank, N-rank and S-rank, are not legal designations. The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by the letter G, N or S reflecting the appropriate geographic scale of the assessment. The numbers mean the following:

1 = critically imperilled
2 = imperilled
3 = vulnerable
4 = apparently secure
5 = secure

Coxa (pl. coxae): The basal or first leg segment, connected to the body wall.

Coxal plate: The hardened plate to which the coxa is attached.

Endangered Species Act, 2007 (ESA): The provincial legislation that provides protection to species at risk in Ontario.

Endemic: Unique to a defined geographic location.

Elytron (plural = elytra): The hard wing covers on the back of beetles.

Instar: The stage between moults.

Macrophytes: Aquatic plant that grows in or near water and is either emergent, submergent, or floating.

Oviposition: The process of laying eggs by oviparous animals.

Penultimate abdominal segments: segments at rear end of body before tail.

Pronotum: A dorsal plate between the head and base of wings.

Pupa: Life stage of some insects undergoing transformation.

Pupate: To become a pupa

Pupation: The non-feeding life cycle stage during which the insect transforms from larva to adult.

Species at Risk Act (SARA): The federal legislation that provides protection to species at risk in Canada. This act establishes Schedule 1 as the legal list of wildlife species at risk to which the SARA provisions apply. Schedules 2 and 3 contain lists of species that at the time the Act came into force needed to be reassessed. After species on Schedule 2 and 3 are reassessed and found to be at risk, they undergo the SARA listing process to be included in Schedule 1.

Species at Risk in Ontario (SARO) List: The regulation made under section 7 of the *Endangered Species Act, 2007* that provides the official status classification of species at risk in Ontario. This list was first published in 2004 as a policy and became a regulation in 2008.

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APPENDIX 1

Generalized water beetle anatomy.

Spikes/hairs on the first 2 pairs of legs (on some of the tarsi) of the males easily distinguish them from the females.

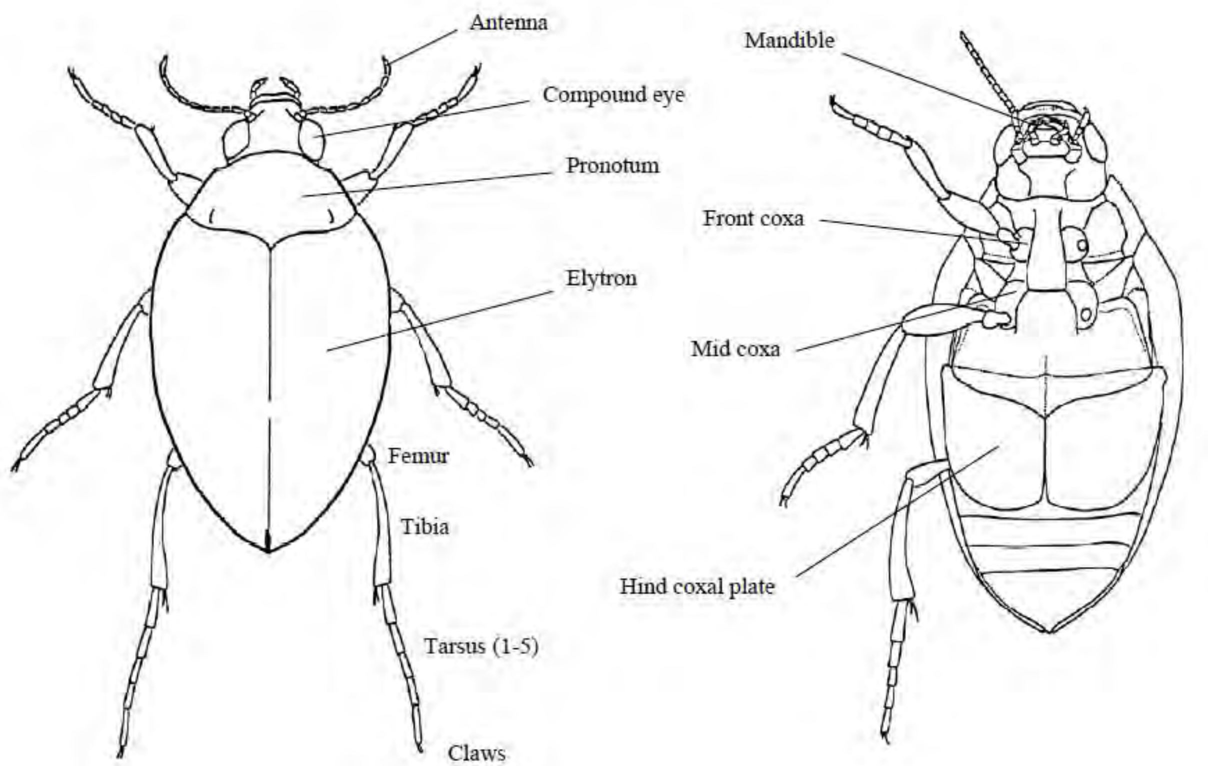

Figure credits: Left - *Haliplus ruficollis* (De Geer), dorsal view. Right - *Haliplus flavicollis* (Sturm), ventral view. Figures adapted from Holmen 1987; (permission from USFWS 2006 pending).