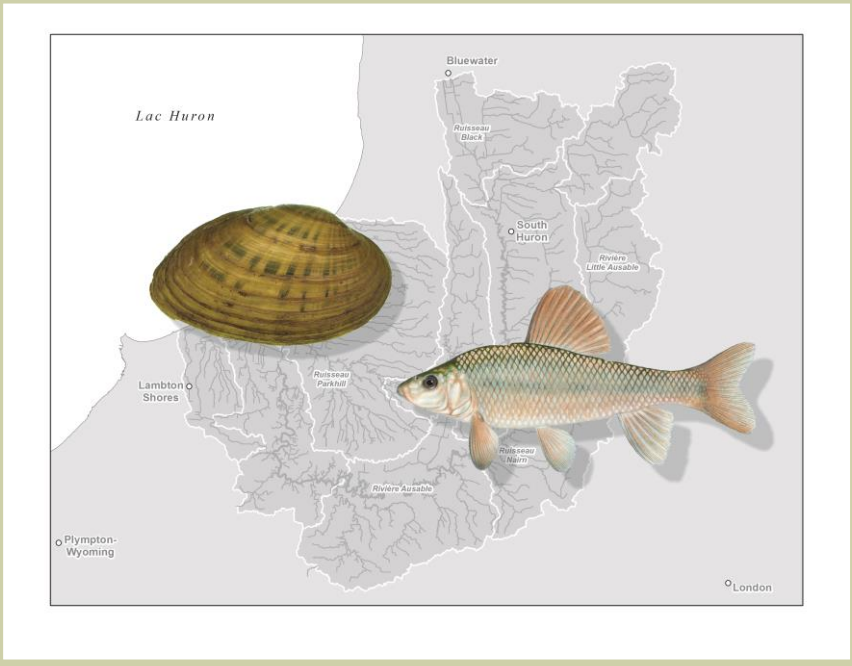
Species at Risk Act
Action Plan Series

Action Plan for the Ausable River in Canada: An Ecosystem Approach

Freshwater Mussels: Northern Riffleshell, Snuffbox, and Kidneyshell

Fishes: Lake Chubsucker, Pugnose Shiner, and Eastern Sand Darter



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For copies of the action plan, or for additional information on species at risk, including COSEWIC Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the SAR Public Registry.

Cover Illustration: Lake Chubsucker © Joseph R. Tomelleri

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Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA) the federal competent ministers are responsible for the preparation of action plans for species listed as Extirpated, Endangered, and Threatened for which recovery has been deemed feasible. They are also required to report on progress five years after publication of the final document on the Species at Risk Public Registry.

The Minister of Fisheries and Oceans Canada is the competent minister under SARA for the three freshwater mussels (Kidneyshell, Northern Riffleshell, and Snuffbox) and three fishes (Eastern Sand Darter, Lake Chubsucker, and Pugnose Shiner) and has prepared this ecosystem-based action plan to implement the applicable recovery strategies, as per section 47 of SARA. In preparing this action plan, the competent minister has considered, as per section 38 of SARA, the commitment of the Government of Canada to conserving biological diversity and to the principle that, if there are threats of serious or irreversible damage to the listed species, cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty. To the extent possible, this action plan has been prepared in cooperation with the Government of Ontario, Ausable Bayfield Conservation Authority and the University of Guelph as per subsection 48(1) of SARA.

As stated in the preamble to SARA, success in the recovery of these species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions and actions set out in this action plan and will not be achieved by Fisheries and Oceans Canada, or any other jurisdiction alone. The cost of conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing this action plan for the Ausable River to benefit the three freshwater mussels and three fishes and Canadian society as a whole.

Under SARA, an action plan provides the detailed recovery planning that supports the strategic direction set out in the recovery strategy for the species. The plan outlines recovery measures to be taken by Fisheries and Oceans Canada and other jurisdictions and/or organizations to help achieve the population and distribution objectives identified in the recovery strategy. Implementation of this action plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Acknowledgments

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Executive summary

The Ausable River, located on the northern edge of the Carolinian Zone in southwestern Ontario, supports one of the most diverse and unique assemblages of aquatic fauna for a watershed of its size in Canada. At least 26 species of freshwater mussels and 85 species of fish have been found here. Many of these species are rare and 12 species, including six mussels and six fishes, have been assessed by the Committee on the Status of Endangered Wildlife in Canada as Endangered, Threatened, or Special Concern. The majority of these species are protected under the federal *Species at Risk Act* (SARA) and/or the Ontario *Endangered Species Act*, 2007. Three freshwater mussels (Kidneyshell, Northern Riffleshell, and Snuffbox) and three fishes (Eastern Sand Darter, Lake Chubsucker, and Pugnose Shiner) are the focus of this action plan. The needs of these at risk fishes and mussels within the Ausable River watershed will be addressed using a multi-species, ecosystem-based approach. The present plan is guided by five SARA recovery strategies for these six species and builds on the draft ecosystem-based Ausable River Recovery Strategy that was developed.

The Ausable River watershed is highly agricultural and dominated by row cropping with less than 15% wetland and forest habitat remaining. The river has three main tributaries: Nairn Creek, Black Creek, and the Little Ausable River. Critical habitat has been previously identified on the main stem of the Ausable River; the lower section of Nairn Creek; and, separate wetland habitats (Old Ausable Channel, L Lake, and Old Mouth Lake) for five of the six species at risk (Eastern Sand Darter has not been reported from the river since 1928). Known or suspected threats to these species in the watershed include: sediments, nutrient enrichment, low dissolved oxygen concentrations (Old Ausable Channel only), altered flow, contaminants, invasive species, thermal effects, habitat modification, and changes in the fish community.

The action plan includes implementation schedules with 35 prioritized measures to support the recovery of the target fish and mussel species at risk. Where possible, multi-species approaches are recommended. The recovery measures include: inventory and monitoring (four actions), research (nine actions), management and coordination (five actions), and stewardship and outreach (17 actions). To maximize the effectiveness of threat mitigation, priority sub-watersheds of the Ausable River watershed have been identified for stewardship activities to benefit critical habitat. Best management practices in these regions will address the following medium to high threats: loadings of suspended solids and nutrients from overland runoff and livestock, altered flow regime, contaminants (for example, chloride), invasive species, and habitat modifications.

An evaluation of the socio-economic costs and benefits of the action plan are included; costs are anticipated to be low with the majority of funds for implementation being provided by various levels of government. Many ‘on the ground’ actions are voluntary and would provide benefits to both agricultural and non-farm land owners. Secondary benefits of implementing the action plan would include improved water quality as well as improved habitats supporting fisheries and wildlife.

Methods for measuring and reporting on progress of implementation are also included.

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1. Introduction

The Ausable River, located on the northern edge of the Carolinian Zone in southwestern Ontario, supports one of the most diverse and unique assemblages of aquatic fauna for a watershed of its size in Canada (figure 1). At least 26 species of freshwater mussels and 85 species of fish have been found here. Many of these species are rare and 12 species, including six mussels and six fishes, have been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Endangered, Threatened, or Special Concern (table 1); in addition, the Ausable River also supports other rare semi-aquatic species at risk (SAR), specifically turtles and the Endangered Queen Snake (*Regina septemvittata*). The majority of these species are protected under the federal *Species at Risk Act* (SARA) and/or the Ontario *Endangered Species Act*, 2007 (ESA).

Previous studies have shown that the Ausable River population of the globally-rare Northern Riffleshell is one of only four known reproducing populations of this species remaining in North America (Baitz et al. 2008; COSEWIC 2010). The Snuffbox is also considered to be quite rare and its numbers have been significantly reduced throughout its range. Its status in the Ausable River was unknown until a 2006 study confirmed a reproducing population. In addition, an Ausable River oxbow known as L Lake is considered to have the healthiest population of Lake Chubsucker remaining in Canada (Fisheries and Oceans Canada [DFO] 2011). Consequently, the Ausable River watershed is of national significance to the survival of these and other species within Canada.

The proposed version of the Action Plan for the Ausable River in Canada: An Ecosystem Approach, published in 2018, included two additional freshwater mussels - Mapleleaf (Great Lakes-St. Lawrence population) and Rainbow, which were then listed under SARA as Threatened and Endangered respectively. In August 2019, both species were reclassified to Special Concern and no longer require action plans under SARA. As this action plan was developed using an ecosystem approach, none of the recovery measures identified in the document are specific to these two species. Both Mapleleaf and Rainbow, along with other Special Concern species found in the area, will benefit from implementation of this action plan.

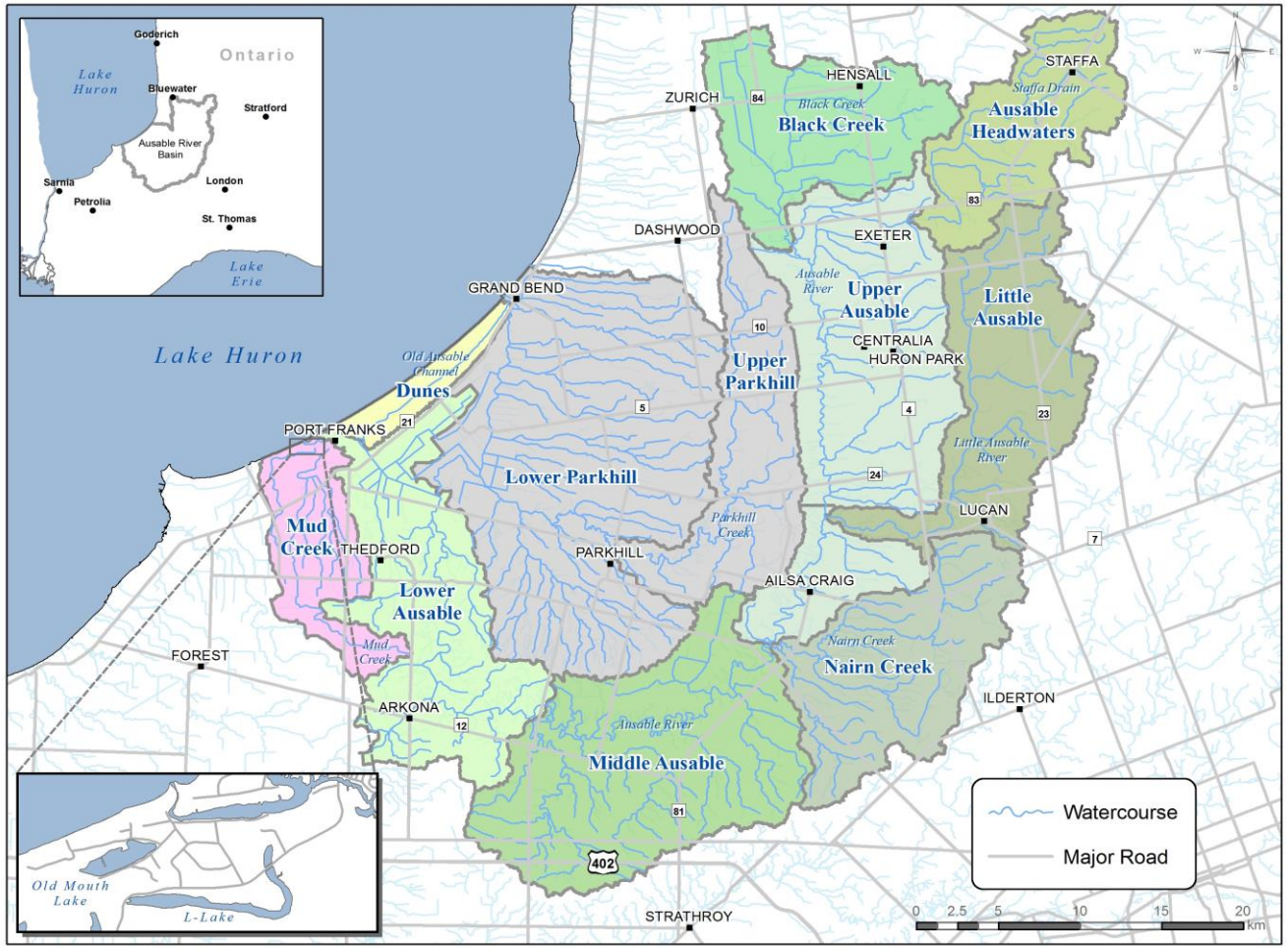

Figure 1. Map of the Ausable River watershed in southwestern Ontario
Eleven sub-watersheds are shown. The Mud Creek sub-watershed features two significant wetland oxbows: L Lake and Old Mouth Lake. Note that the two Parkhill Creek sub-watersheds are not included as part of this action plan as this watercourse has been severed as a tributary from the Ausable River system.

Table 1. Aquatic species at risk found in the Ausable River watershed

Common name	Species	COSEWIC status	SARA status	ESA status
Kidneyshell	*Ptychobranchus fasciolaris*	Endangered	Endangered	Endangered
Mapleleaf (Great Lakes-Upper St. Lawrence population)	*Quadrula quadrula*	Special Concern	Special Concern	Special Concern
Northern Riffleshell	*Epioblasma rangiana*	Endangered	Endangered	Endangered
Rainbow	*Villosa iris*	Special Concern	Special Concern	Special Concern
Snuffbox	*Epioblasma triquetra*	Endangered	Endangered	Endangered
Wavyrayed Lampmussel	*Lampsilis fasciola*	Special Concern	Special Concern	Threatened
Black Redhorse	*Moxostoma duquesnei*	Threatened	Threatened	Threatened
Eastern Sand Darter (Ontario population)	*Ammocrypta pellucida*	Threatened	Threatened	Endangered
Grass Pickerel	*Esox americanus vermiculatus*	Special Concern	Special Concern	Special Concern
Lake Chubsucker	*Erimyzon sucetta*	Endangered	Endangered	Threatened
Pugnose Shiner	*Notropis anogenus*	Threatened	Threatened	Threatened
River Redhorse	*Moxostoma carinatum*	Special Concern	Special Concern	Special Concern

To ensure the continued survival and recovery of these and other aquatic SAR, the Ausable River Recovery Team (ARRT) was formed in 2002 and drafted a federal, ecosystem-based recovery strategy for this globally significant watershed (S. Staton, ARRT, unpubl., 2005). The ecosystem approach recognizes the links between species, communities and the land and water base that support them. The intention is to maintain or enhance the natural aquatic communities in the Ausable River through managing the impacts of human activities on land and waters in the watershed. The ARRT identified the following benefits of an ecosystem approach:

- recovery actions are selected that benefit several target SAR
- implementation is generally more cost-effective than a single-species approach
- addresses issues of scale (from site-specific to watershed level)
- targets mitigation and rehabilitation of impacts, and it restores ecosystem health to
- prevent the decline of other native species
- ensures that actions taken to benefit some species will not negatively impact other
- SAR in the area

The recovery team prepared four background reports and a synthesis report on the Ausable watershed and the associated SAR. The team recognized that planning and implementation of watershed-based activities requires the full involvement and support of landowners and stakeholders in the watershed. The recovery team included landowners in their membership, and held community meetings and information sessions with stakeholders in the watershed. Recovery efforts have included extensive stewardship projects, management actions,

community awareness and outreach activities as well as research and monitoring. Most of the accomplishments of this recovery work have been detailed in the five year reports on two recovery strategies covering eight species of freshwater mussels (DFO 2012a; DFO 2013a). The present initiative will build on this foundation of recovery work and further advance restoration of the Ausable River ecosystem.

2. Scope of the action plan

Action plans are prepared for species that are listed under SARA as Endangered or Threatened and already have published recovery strategies in place. As such, this action plan addresses the needs of six SARA-listed Endangered and Threatened freshwater mussels and fishes found within the Ausable River watershed (table 2); these species have recovery strategies with critical habitat identified to the extent possible within the Ausable River and throughout their Canadian range. This action plan should be considered along with the five applicable recovery strategies (references found in table 2). These recovery strategies provide the strategic direction and approaches for recovery of these mussels and fishes throughout their range and provide background information on the species and their threats. Many of these species co-occur within the same habitats and share similar threats within this watershed, thus supporting an ecosystem or watershed-based approach to recovery implementation. As such, the focus of this action plan will be on targeted habitat improvement and stewardship as well as priority research and monitoring specific to the watershed.

Table 2. Aquatic species at risk addressed by this action plan

Species	SARA status	Recovery strategy
Eastern Sand Darter	Threatened	DFO 2012 (b)
Kidneyshell	Endangered	DFO 2013 (b)
Lake Chubsucker	Endangered	Staton et al. 2010
Pugnose Shiner	Threatened	DFO 2012 (c)
Northern Riffleshell	Endangered	DFO 2019
Snuffbox	Endangered	DFO 2019

This action plan supports the population and distribution objectives for the six species, that is, to return/maintain self-sustaining populations within the Ausable River watershed. These species would be considered to have met their population and distribution objectives within the watershed when they have returned to historically estimated ranges and have demonstrated reproduction and recruitment. Although not specifically addressed by this action plan, the other six at risk mussels and fishes found within the Ausable River (table 1) will benefit from the recovery actions proposed for the six species covered in this plan (table 2) through overall improvement to shared aquatic habitats. Note that Eastern Sand Darter and River Redhorse have not been detected in the Ausable River in the last 85 years and are possibly extirpated from the watershed (ARRT 2005). The action plan will support other recovery document actions and SARA management plans for Special Concern species (that is the Grass Pickerel, Mapleleaf, Rainbow, River Redhorse, and Wavyrayed Lampmussel) and species that recently listed under SARA but do not have a recovery strategy at this time (that is the Black Redhorse). Other semi-aquatic SAR (that is reptiles such as turtles and snakes) are also expected to benefit from this plan but are not specifically addressed.

3. Background

3.1 Ausable River watershed

The following background information has been summarized and updated from the Ausable River Recovery Strategy (ARRT 2005). The Ausable River drains 1,142 km^2 of southwestern Ontario into the lower portion of Lake Huron. The main tributaries of the Ausable River include: Black Creek, Little Ausable River, and Nairn Creek (figure 1). The Ausable River is approximately J-shaped, arising near Staffa and flowing south through Ailsa Craig before curving west through Arkona where the river enters a deep gorge. From here, the Ausable River flows north to enter what is known as the Ausable River Cut, and then outlets to Lake Huron at Port Franks (figure 1).

Diversions in the Ausable River watershed in the late 1800s caused the original river's path to be altered. Downstream of Arkona, the original path of the Ausable River channel flowed northward towards Grand Bend, and then took a sharp turn to the southwest, traveling parallel to the Lake Huron shoreline to its outlet near Port Franks. In 1873, a channelized section (Ausable River Cut) was excavated from a point east of Port Franks where the river was flowing northward, to the river mouth at Port Franks. As a result, the present outlet of the Ausable River empties directly into Lake Huron at Port Franks. Since the completion of the Ausable River Cut in 1875, no water from the Ausable River has flowed into Grand Bend. There is a stretch of dry riverbed that extends northward from the Cut's origin to the point where Parkhill Creek joined the original course of the Ausable River as a tributary. In 1892, the residents of Grand Bend decided to make a second "cut" out to Lake Huron in order to create a harbor for their town. This caused Parkhill Creek to outlet directly to Lake Huron at Grand Bend, as it still does today. Parkhill Creek is no longer a tributary of the Ausable River, but is its own watershed.

The 1892 diversion created a remnant channel between Grand Bend and Port Franks known as the Old Ausable Channel (OAC) (Dunes sub-watershed) that is isolated from the rest of the river and characterized by clear water and dense aquatic vegetation. Similar habitat is found in remnant oxbow wetlands known as L Lake and Old Mouth Lake (OML) (Mud Creek sub-watershed) adjacent to the Lake Huron shoreline at Port Franks (figure 1). Mud Creek was once a tributary of the Ausable River, but over the years has found its own direct outlet through the sand dunes to Lake Huron. The OAC, L Lake and OML provide distinctly different habitat compared to that of the Ausable River and its tributaries. This has resulted in different species occurring in the wetland habitat compared to the riverine habitat.

The Ausable River watershed is located on a relatively flat till plain bounded on both sides by moraines. Sand and gravel deposits in some areas of the watershed discharge groundwater, creating limited areas of cold or cool water stream habitat. However, the majority of the Ausable River supports a warm water fish community. Historical changes in the land use from lowland and upland forest to agriculture occurred primarily between the 1850s and 1940s. By 1983, approximately 75% of the watershed was under row cropping with forest cover reduced to 13% of the watershed. Since this time there has been little change. A 2003 study estimated wetland cover at only 2.5% across all Ausable River sub-watersheds (Nelson et al. 2003). The amount of wetland lost between pre-settlement (c.1800) and 2002 was documented at over 75% in Ausable River watershed counties (Huron County 76%, Middlesex County 89%, Perth County 87%, and Lambton County 97%) (Ducks Unlimited 2010). Wetland loss and extensive agricultural drainage development have contributed to more rapid runoff and lower base flows across the basin. The Ausable River generally has poor water quality due to non-point source

runoff from agricultural lands, septic systems and manure runoff, as well as point-sources such as wastewater treatment plants.

For the purposes of this action plan, the Ausable River watershed has been divided into nine sub-watersheds. Note that two Parkhill Creek sub-watersheds shown in figure 1 are not included as part of the detailed action plan as this water course has been severed as a tributary from the Ausable River system, and no aquatic SAR have been documented in the Parkhill Creek system.

3.2 Species at risk populations

The current population status (poor, fair, good or extirpated) and distribution of the Endangered and Threatened SAR in the Ausable River watershed was most recently summarized by DFO (DFO 2011; DFO 2012a, 2012b, 2012c; DFO 2013a, 2013b; DFO 2019), Jean et al. (2013), and Staton et al. (2010), and is provided in table 3. Species populations have been divided into two groups based on differences in habitat: Ausable River and tributaries, and wetland habitats (Old Ausable Channel (OAC), L Lake, Old Mouth Lake (OML)) (table 3). For freshwater mussels, Baitz et al. (2008), Upsdell et al. (2010a), Upsdell et al. (2012), Jean and Veliz (2014), the Ausable Bayfield Conservation Authority (ABCA) (K. Jean, ABCA, unpubl. data, 2015), and DFO (K. McNichols-O'Rourke, DFO, unpubl. data, 2013) were consulted for the most recent recruitment and density data to assist in determining sub-basin population status. The presence of specimens < 25 mm in shell length is considered to be indicative of recent recruitment (Metcalfe-Smith et al. 2007).

The six Endangered and Threatened aquatic SAR extant within the Ausable River drainage are concentrated in seven sub-watersheds with their population status ranging from poor throughout their current distribution (Northern Riffleshell) to fair in some sub-basins (Kidneyshell, Pugnose Shiner, Snuffbox, and Lake Chubsucker); Kidneyshell and Lake Chubsucker are the only species with a population status of 'good' in one sub-basin each (table 3). L Lake is considered to have the healthiest population of Lake Chubsucker remaining in Canada (DFO 2011). There is a single record of Eastern Sand Darter occurring in the Ausable River near Ailsa Craig (Upper Ausable sub-watershed) from a 1928 survey. Subsequent searches at this site, and elsewhere in the watershed by DFO, the Ontario Ministry of Natural Resources and Forestry (OMNRF), and ABCA, in potentially suitable habitat, failed to recapture the species. This species has been presumed to be extirpated (DFO 2012b). However, additional targeted sampling using appropriate gears to detect Eastern Sand Darter is recommended in reaches with suitable habitat, as it is possible that the species may still persist in lightly sampled regions. A recent habitat modelling and prediction study identifies possible locations for investigation in the Ausable River (Dextrase et al. 2014). If further sampling for Eastern Sand Darter fails to detect the species, overall improvement of aquatic habitats within the Ausable River would benefit the species if repatriated in the future.

Additional surveys are required for some species to confirm these assertions. Although all known data were used in the analysis, some are based on presence or absence. Recent quantitative data were available in most sub-watersheds for freshwater mussels from long-term bio-monitoring stations established between 2006 and 2010 and resampled in 2011, 2013, and 2014.

Table 3. Species population status and distribution by sub-watershed

Species	Upper Ausable	Middle Ausable	Lower Ausable	Nairn Creek	Dunes, OAC	Mud Creek, L Lake	Mud Creek, OML
Kidneyshell*							
Northern Riffleshell*							
Snuffbox*							
Eastern Sand Darter*	EXP						
Lake Chubsucker**							
Pugnose Shiner**							

* Species found in the main Ausable River and tributaries
** Species found in the Old Ausable Channel and Mud Creek Oxbow Wetlands

Population Status

Poor	Reproduction status is poor or unknown; population density is unknown or low; and, only a few individuals/sites (mussels density is <0.25/m^2)
Fair	Evidence of reproduction (as determined by ABCA and DFO data 2006 to 2014 for mussels); and, population density is unknown or low
Good	Reproduction status is good; and, population density is moderate (mussels density is >1/m^2)
EXP	Species possibly extirpated from the watershed
	Species not present in sub-watershed (may indicate unsuitable habitat or no surveys)

3.3 Threats to species at risk

Known or suspected anthropogenic threats to aquatic SAR in the Ausable River were determined through a synthesis of all available background information (Nelson et al. 2003; Upsdell et al. 2010b; Jean and Veliz 2011; Brock and Veliz 2013; Jean et al. 2013). The Ausable River sub-watersheds were divided into two areas, the main Ausable River sub-watersheds and the Dunes/Mud Creek sub-watersheds (figure 1). The Dunes/Mud Creek sub-watersheds are isolated oxbow wetland habitats that provide different habitat for aquatic species compared with the Ausable River and its tributaries. Threats for the different species and their habitat are summarized in two tables according to this division (table 4a and table 4b), with additional information added from recovery strategies for the six mussel and fish SAR (table 2), and include: increased suspended sediment and sediment deposition, elevated concentrations of nutrients, low dissolved oxygen concentrations (Old Ausable Channel (OAC) only), altered flow, contaminants, invasive species, thermal effects, habitat modification, and changes in fish community (predominantly within the OAC). Based on available background information, the general and specific threats to SAR in sub-basins of the Ausable River watershed have been assigned ranks by the recovery team of high, medium, low or unknown to describe the relative severity that a certain cause is affecting, or has the potential to affect, SAR in a sub-basin. The probable success of threat mitigation has also been estimated by the recovery team as high, medium or low, and was informed through the approach used in the Sydenham River Action Plan (DFO 2018d). Note that the overall level of concern for each threat takes into account the extent, frequency, causal certainty and severity. The high or medium threats are:

- sediments (including siltation and suspended solids), within riverine habitats only, impacting SAR mussels
- nutrient enrichment
- low dissolved oxygen (OAC only, impacting SAR fishes)
- altered flow regime
- contaminants (for example, chlorides)
- invasive species
- habitat modifications

An overview of each of the predominant threats has been summarized below from the Ausable River Recovery Strategy (S. Staton, ARRT, unpublished, 2005), unless otherwise noted.

Sediments: the most significant threat for the majority of aquatic SAR in the Ausable River sub-watersheds (excluding the Dunes and Mud Creek sub-basins) is documented to be turbidity and associated siltation caused by sedimentation (generation of sediment and total suspended solids). The majority of rare fish and mussel species are sensitive to siltation (degradation) of their habitat (that is, gravel and sand substrates). High turbidity levels may affect visual behaviour of species including feeding, predator avoidance, and visual display used in reproduction (mussels). The main land use in the Ausable River watershed, agriculture (> 85% of basin area), is considered to be a major contributor of suspended sediments to the system. The loss of riparian cover across the basin increases the susceptibility of the river to agricultural runoff as well as bank erosion. Other potential sources of suspended material include wastewater treatment plants and surface runoff from urban areas. Suspended sediment concentrations available from eight provincial water quality monitoring stations across the watershed collected over the past 40 years indicated no significant trend over time for the watershed as a whole (Veliz 2003). Mean concentrations were highest in the main Ausable channel where the majority of SAR occur. Mean suspended sediment concentrations (±

standard error) from the Middle Ausable station between 1970 and 1993 were 117 ± 6 mg/L (n=289). Concentrations of suspended solids in this region, which is located within the known range of the Northern Riffleshell, were more than twice those found in the adjacent Sydenham River, which has a naturally reproducing population of this species (Dextrase et al. 2003). Recent water quality analysis (Upsdell et al. 2010b) looked at total suspended solids (TSS) concentrations in the main Ausable River for the period of 2000 to 2008 at four locations. This study found TSS concentrations were relatively high (often exceeding 80 mg/L) and show no signs of decreasing during the study period. According to the European Inland Fisheries Advisory Committee (EIFAC 1965, cited by Kerr 1995), concentrations of TSS between 80 and 400 mg/L are unlikely to support good fisheries. It is important to note that samples are typically collected during low flow conditions and therefore, under-represent times when TSS concentrations are elevated such as during rain or rain on snow events.

A recent study in the OAC found average TSS concentrations at four sites (sampled from March to November, 2008 to 2014) were always below 30 mg/L; this is well below the 80 mg/L suggested limit for good fisheries (Jean et al. 2015). As such, suspended solids are considered a low threat to the SAR fishes found here.

Nutrient enrichment: nutrient concentrations (total phosphorus and nitrate) in the Ausable River typically exceed provincial water quality objectives and potentially pose a risk to the health of aquatic fauna. Nutrient sources to the Ausable River watershed include: agricultural runoff, livestock, tile drainage, wastewater treatment plants, and septic system loadings. Recent water quality analysis (Upsdell et al. 2010b) looked at nutrient concentrations in the main Ausable River for the period of 2000 to 2008 at four locations and found that concentrations of nitrate and total phosphorus were high (frequently exceeding guidelines) at locations in the watershed in the vicinity of SAR; however, nitrate did show a slight declining trend during this time period. Recent municipal sewage treatment plant reports for locations in the Ausable River watershed indicate that total phosphorus concentrations are meeting the effluent quality limits (S. Abernethy, Ministry of the Environment and Climate Change [MOECC], pers. comm., 2014). However, total phosphorus concentrations are still exceeding the Provincial Water Quality Objective (0.03 mg/L) in some cases. Furthermore, as noted by Simmons et al. (2013), water samples collected during low flow conditions under-represent the range of total phosphorus conditions; additional sampling during periods of high flow within the Ausable River watershed could help quantify this tendency.

Recent water quality analysis also looked at total phosphorus concentrations in the OAC, L Lake, and Old Mouth Lake (OML) (Jean et al. 2013; Jean et al. 2015). In the OAC, concentrations of total phosphorus were higher (often exceeding the provincial objective) in northern areas during the period of 2008 to 2014. Water samples taken from L Lake and OML during 2012 found that total phosphorus did not exceed provincial objectives.

Low dissolved oxygen concentrations: SAR fishes have been killed in the OAC during recent winters due to suspected low dissolved oxygen levels when the OAC was covered with ice. Increases in aquatic plant growth (related to elevated nutrient concentrations) could exacerbate this problem, as increased bacterial decomposition of plant material would further decrease dissolved oxygen available for fishes during the winter. Concentrations of dissolved oxygen were summarized at six locations in the OAC in 2013 and 2014 (Jean et al. 2015). It is apparent from the summarized data that during the study period, each of the six sites experienced a daily average of 0 mg/L dissolved oxygen for an extended period of time. This period of 0 mg/L dissolved oxygen occurred at all sites during the winter from 69 to 110 days depending on the site location.

Altered flow: the change in land use surrounding the Ausable River from a predominantly forested, unsettled landscape to its current agricultural, settled state over the last 200 years has been associated with severe alterations to the drainage pattern of the basin. The creation of channel diversions, major dams and water impoundments, subsurface and surface drainage, as well as the transformation of open surface drains to closed tiled drains has greatly affected the natural structure and course of the Ausable River and its tributaries. The creation of the Ausable River Cut, ironically, has proved beneficial to some SAR and created one of the most unique areas in the entire watershed. The Ausable River Cut effectively isolated the OAC from the rest of the river system, and in so doing, reduced its susceptibility to the deteriorating water quality issues affecting the rest of the system. Due to the nature of the climate, geology and soils of the Ausable River basin, flow is strongly dependent upon precipitation. It is believed that landscape changes that have occurred during the past 200 years (and associated drainage alterations) have likely intensified the natural flow variability of the Ausable River and may now pose a threat to aquatic species. In comparison with other rivers in the Great Lakes basin, the Ausable River was classified as “event responsive” in terms of flow responsiveness to precipitation events and as one of the most susceptible rivers in southern Ontario to experience repeated low base flow events (Richards 1990). Flow variability may impact species in many ways causing effects such as: substrate instability (which is a particular habitat requirement of many mussel species), scouring during excessive flows, increased erosion, and by reducing riffle habitat availability during droughts, which can result in mussel stress or mortalities when individuals are exposed to desiccation and predation.

Alteration of flow in the OAC is related to level manipulation by both humans and nature. Beavers are quite active in the OAC, often leading to increased water depths through dam building or blocked culverts. In some cases, beaver dams have been removed by humans causing considerable water level drops affecting aquatic SAR.

Contaminants: contaminants affecting aquatic SAR and their habitat are associated with agricultural practices, and are also found in both urban runoff and municipal waste water (Gillis 2012, 2014a, 2014b). Pesticide runoff (for example, herbicides and insecticides) associated with agricultural practices and urban areas could have negative impacts, including oxidative stress (Gillis et al. 2014b), on Ausable River SAR mussels. It is likely that this threat is widespread in the Ausable River watershed as the primary source of pesticides is from agricultural land. However, it is difficult to adequately assess the impact specifically to Ausable River SAR as this type of data has only just begun to be collected in the watershed. The current data set is preliminary and there is presently only one stream site that has been consistently sampled for a very short amount of time (K. Stammler, MOECC, pers. comm., 2014). Other contaminants such as chloride have been investigated in a long-term study at select locations in the Ausable River system. The study found chloride concentrations have increased significantly at two locations (Upper Ausable and Little Ausable sub-watersheds) in the Ausable River watershed between 1975 and 2009 during the warm season (Todd and Kaltenecker 2012). The maximum chloride concentrations noted in this study exceeded the long-term guideline for chloride (Canadian Water Quality Guideline [CCME 2011], 120 mg/L) at the Upper Ausable location, but not at the Little Ausable site. This long-term guideline may not be protective of certain species of endangered and special concern freshwater mussels (CCME 2011). A separate study has shown that high concentrations of chloride can be toxic to juvenile mussels (Gillis 2011). The risks from contaminants to some species may be heightened at juvenile life stages (particularly for mussels) and at times of increased stress.

Invasive species: invasive species may have negative impacts on SAR in the Ausable River. Common Carp (*Cyprinus carpio*) is widespread in the Ausable River watershed and is a threat to SAR due to its destructive feeding behaviour, which tends to uproot aquatic vegetation and cause elevated turbidity levels. This species may be a particular threat to the highly vegetated, clear water habitats that support Pugnose Shiner and Lake Chubsucker (DFO 2012c; Staton et al. 2010). Common Carp also feeds on sediment-associated fauna (which may include juvenile mussels).

Round Goby (*Neogobius melanostomus*) has been found in the lower reaches of the Ausable River and is a threat to native species (Poesch et al. 2010). It may utilize native mussels as a food source (a direct threat to juvenile mussels) and compete with benthic fishes such as sculpins and darters if it was to move upstream. Many species of darters act as hosts for mussel SAR[1] and mussel populations could therefore be indirectly threatened by an invasion of Round Goby (Poesch et al. 2010); further, Tremblay et al. (2016) suggest that Round Goby may directly limit recruitment success of freshwater mussels as it serves more as a sink for glochidia than as a host.

Zebra Mussel (*Dreissena polymorpha*) has been found in the mouth region of the Ausable River Cut (K. Jean, pers. comm., 2016); its impacts on native freshwater mussels are well documented and its colonization could be a future threat, although much of the river is not navigable by motorized boats and no immediate impoundments are present that could support a permanent colony.

Common Reed (*Phragmites australis*) may have impacts on wetland habitats and the lower Ausable River where it is currently present. Additional introductions of invasive species could occur through the movement of boats from infested areas, the illegal act of dumping live baitfishes (which may include incidentally caught illegal species), or the natural invasion of species already introduced into the Great Lakes basin.

Thermal effects: aquatic species may be impacted by thermal changes, particularly increasing water temperatures, in the Ausable River watershed. The loss of riparian areas can increase the amount of solar radiation reaching the surface of the watercourse, leading to warming of the river's water. Field observations have noted limited riparian vegetation along the Ausable River and its tributaries, particularly in headwater areas. Two major dams (Morrison and Exeter dams) are present in the Ausable River watershed. Both are located in the Ausable River headwater's sub-watershed. Small scale property owners' dams, low level crossings and beaver dams can be found throughout the watershed. Their associated reservoirs and impoundments increase surface area and hold water causing warming. While the Ausable River generally supports a warm water aquatic community with species tolerant of warm water, an increase in water temperatures may be an additional stress. Nairn and Black creeks support cold water species that would be affected by increases in water temperatures. In addition to dams and riparian zone loss, climate change is expected to cause increases in surface water temperatures in southern Ontario (Dove-Thompson et al. 2011).

Thermal conditions in OAC, L Lake, and OML are considered more stable as these areas have more forest cover, are more vegetated, are groundwater-fed, and are not subjected to the same threats as the Ausable River.

[1] For more information on known and suspected host fishes for individual mussel SAR, please refer to the applicable recovery strategy referenced in table 2.

Habitat modifications: preferred habitat of Pugnose Shiner and Lake Chubsucker has become fragmented as a result of habitat loss or degradation across their range. In the OAC, a decline in water quality (due to increased nutrients) may be contributing to an increased rate of natural succession that, over the long term, will alter the aquatic habitat to more of a terrestrial one (Jean et al. 2013); this is most apparent in the northern portion of the OAC where high nutrient levels have resulted in vegetation and algal overgrowth causing increased sedimentation and habitat loss. The situation is exacerbated by the historical channel alterations of the past century that resulted in the OAC being isolated from the flow of the Ausable River. Alterations to the aquatic vegetation community as a result of degradation (due to increased nutrient inputs) pose a threat to these species as they depend on dense aquatic vegetation as part of their critical habitat (Staton et al. 2010; DFO 2012c; Jean et al. 2013).

Changes in fish community: within the OAC, a shift in fish communities from a cyprinid (minnow) dominated community to one dominated by centrarchids (sunfishes) is suggested to have negative impacts on Pugnose Shiner and Lake Chubsucker (Edwards et al. 2005). These effects could be a result of an increase in predators and/or an increase in competition for resources. Also of concern is the illegal dumping of bait buckets by fishermen that can result in the introduction of undesirable species to habitat occupied by SAR.

Table 4a. List of general and specific threats to SAR in sub-watersheds of the main Ausable River (modified from Nelson et al. 2003)
Level of threat severity to SAR is classified as low, medium, or high, as is the expected mitigation success rate. Information used to inform classifications are numbered to a corresponding document or expert (see below table 4a).

General threat	Specific threat	General cause	Specific cause	Ausable Headwaters	Black Creek	Upper Ausable	Little Ausable	Nairn Creek	Middle Ausable	Lower Ausable	Expected mitigation success rate (high, medium, low)
Sediments 1, 2	Generation of sediment	Agriculture Erosion	Non-point source pollution Storm water/runoff								High
1, 2	Total suspended solids	Agriculture Erosion	Non-point source pollution Storm water/runoff (overland, tile drains, livestock)	UKN	UKN	UKN					High
12, 13	Siltation deposition	Agriculture Erosion Roads	Non-point source pollution Storm water/runoff								Medium
Nutrient enrichment 2, 3, 4	Phosphorus, nitrogen	Agriculture	Overland runoff								High
2, 3, 4	Phosphorus, nitrogen	Agriculture	Drainage								Low
2, 3, 4	Phosphorus, nitrogen	Agriculture	Livestock								High
5, 6	Phosphorus, nitrogen, suspended solids	Urban	Wastewater treatment plants	N/A	UKN			N/A			High
Altered flow regime 3, 7	Increase in peak flow	Agriculture(tile/ open drainage)	Storm water/runoff								Medium
3, 7	Increase in peak flow	Land use	Loss of natural areas (including wetlands, forest)								Medium
3, 7	Increase in peak flow	Climate change	Increased frequency of winter melt events and summer flooding	UKN	UKN	UKN	UKN	UKN	UKN	UKN	Low
3, 7	Reduced base flow	Water taking									Low
3, 7	Reduced base flow	Climate change	Increased possibility of drought conditions	UKN	UKN	UKN	UKN	UKN	UKN	UKN	Low
3, 7	Reduced base flow	Impoundments Dams									Low
Contaminants 8, 9, 10	Chlorides	Roads	De-icing		UKN			UKN			Low
8, 9, 10	Herbicides, pesticides	Agriculture	Drainage/non-point source pollution	UKN	UKN	UKN	UKN	UKN	UKN	UKN	Medium
Invasive species 11, 12	Dreissenids[2],Round Goby, Common Carp	Impoundments and upstream migration	Competition for food, habitat, or host fish								Low
Thermal 3, 12	Increase in water temperature	Reservoirs	Increased pond surface area								Medium
3, 12	Increase in water temperature	Loss of riparian area	Reduction in shading								High

[2] Zebra Mussel and Quagga Mussel (*D. bugensis*)

Level of threat severity to SAR

Low	The threat is unlikely to jeopardize the survival or recovery of SAR
Medium	The threat would likely jeopardize the survival or recovery of SAR
High	The threat is expected to jeopardize the survival or recovery of SAR
Unknown (UKN)	Effect of threat is unknown due to lack of data
Not Applicable (N/A)	Threat is not applicable

References or Expert Opinions used to inform threat classifications (low, medium, high)

1. Veliz et al. (2011)
2. Upsdell et al. (2010b)
3. Brock and Veliz (2013)
4. Expert Opinion: Mari Veliz, ABCA
5. Expert Opinion: Scott Abernethy, MOECC
6. Scott Abernethy, MOECC, pers. comm. 2014
7. Expert Opinion: Davin Heinbuck, ABCA
8. Todd and Kaltenecker (2012)
9. Expert Opinion: Katie Stammler, MOECC
10. Expert Opinion: Georgina Kaltenecker, MOECC
11. Poesch et al. (2010)
12. Expert Opinion: Kari Jean, ABCA
13. Killins et al. (2007)

Table 4b. List of general and specific threats to SAR in the Dunes and Mud Creek sub-watersheds (modified from Nelson et al. 2003)
Level of threat severity to SAR is classified as low, medium or high, as is the expected mitigation success rate. Information used to inform classifications are numbered to a corresponding document or expert (see below table 4b).

General threat	Specific threat	General cause	Specific cause	Dunes, OAC	Mud Creek, L Lake and OML	Expected mitigation success rate (high, medium, low)
Sediments 1, 2	Siltation and turbidity	Urban residences				High
Nutrient enrichment 1, 2	Phosphorus, nitrogen loading	Urban residences	Septic systems, lawn fertilizer			High
1, 2	Increased rate of natural succession from aquatic to terrestrial ecosystem	Nutrients, aquatic vegetation	Septic systems, lawn fertilizer			Medium
Low dissolved oxygen concentrations 1	Winter kills	Low dissolved oxygen concentrations	Prolonged ice cover, vegetation decomposition			Low
Altered flow regime 1, 3	Manipulation of water levels	Dams	Beavers, humans		N/A	Medium
Contaminants 3	Herbicides, pesticides, fertilizers	Urban residences		UKN	UKN	High
Invasive species 4, 5	Common Carp, Round Goby	Migration, Anglers				Low
4, 5	*Phragmites australis*	Invasion				High
Habitat modification 2, 3, 7, 8	Loss of quality wetland habitat	Urban residences,natural succession	Water quality			High
Changes in fish community 3, 4 , 5, 6, 7, 8, 9	Recreational fishing (live bait)	Baitfish introductions				Medium
3, 4, 5 , 6, 7, 8, 9	Changes in trophic levels	Predators			UKN	Low

Level of threat severity to SAR

Low	The threat is unlikely to jeopardize the survival or recovery of SAR
Medium	The threat would likely jeopardize the survival or recovery of SAR
High	The threat is expected to jeopardize the survival or recovery of SAR
Unknown (UKN)	Effect of threat is unknown due to lack of data
Not Applicable (N/A)	Threat is not applicable

References or Expert Opinions used to inform threat classifications (low, medium, high)

1. Jean et al. (2015)
2. Jean et al. (2013)
3. Expert Opinion: Kari Jean, ABCA
4. ABCA monitoring program
5. DFO monitoring program
6. ARRT (2005)
7. Staton et al. (2010)
8. DFO (2012a)
9. Edwards et al. (2005)

4. Recovery actions

4.1 Critical habitat

4.1.1 Identification of the species' critical habitat

Critical habitat for the three freshwater mussels and three fishes has been identified to the extent possible within the respective recovery strategies for these species using the best available information (that is, DFO 2012b, section 2.7; DFO 2012c, section 2.7; DFO 2013b, section 7; DFO 2019, section 2.6; and, Staton et al. 2010 section 2.7). These recovery strategies also contain species-specific details about the identified critical habitat, including geospatial extent and biophysical functions, features and attributes.

The geographic extent of critical habitat within the Ausable River watershed for the fish and mussel species is summarized below to provide context for recovery actions only; for greater detail please refer to the relevant sections of the applicable recovery strategies.

For all three of the freshwater mussels, the extent of critical habitat is found on the main stem of the Ausable River from the upstream boundary at Crediton Road to the downstream boundary, which is approximately 1 km upstream of Parkhill Drive (County Road 18). Also included are short sections of the mouths of one tributary: the extent of critical habitat for Kidneyshell includes the lower reaches of Nairn Creek.

Critical habitat overlaps in the Old Ausable Channel (OAC) for Lake Chubsucker and Pugnose Shiner. It has been identified as the entire OAC from the mouth of the channel at the Ausable River Cut, upstream to its isolated origin near Grand Bend for both fishes. Critical habitat was also identified for Lake Chubsucker in L Lake as all contiguous waters and wetlands of L Lake, including the northern and western tips of L Lake bisected by Outer Drive, and the wetlands to the north of the lake (seasonally wetted). Additionally, critical habitat was identified for Pugnose Shiner in Old Mouth Lake (OML) as the entire lake and includes the contiguous waters and wetlands, extending up to the high-water mark. For Eastern Sand Darter, critical habitat has not been identified within the Ausable River watershed because only one historical record (1928) exists for this species within the Upper Ausable sub-watershed (DFO 2012b).

Areas within which critical habitat may be found in the Ausable River watershed for the three freshwater mussels and two fishes are illustrated in figure 2.

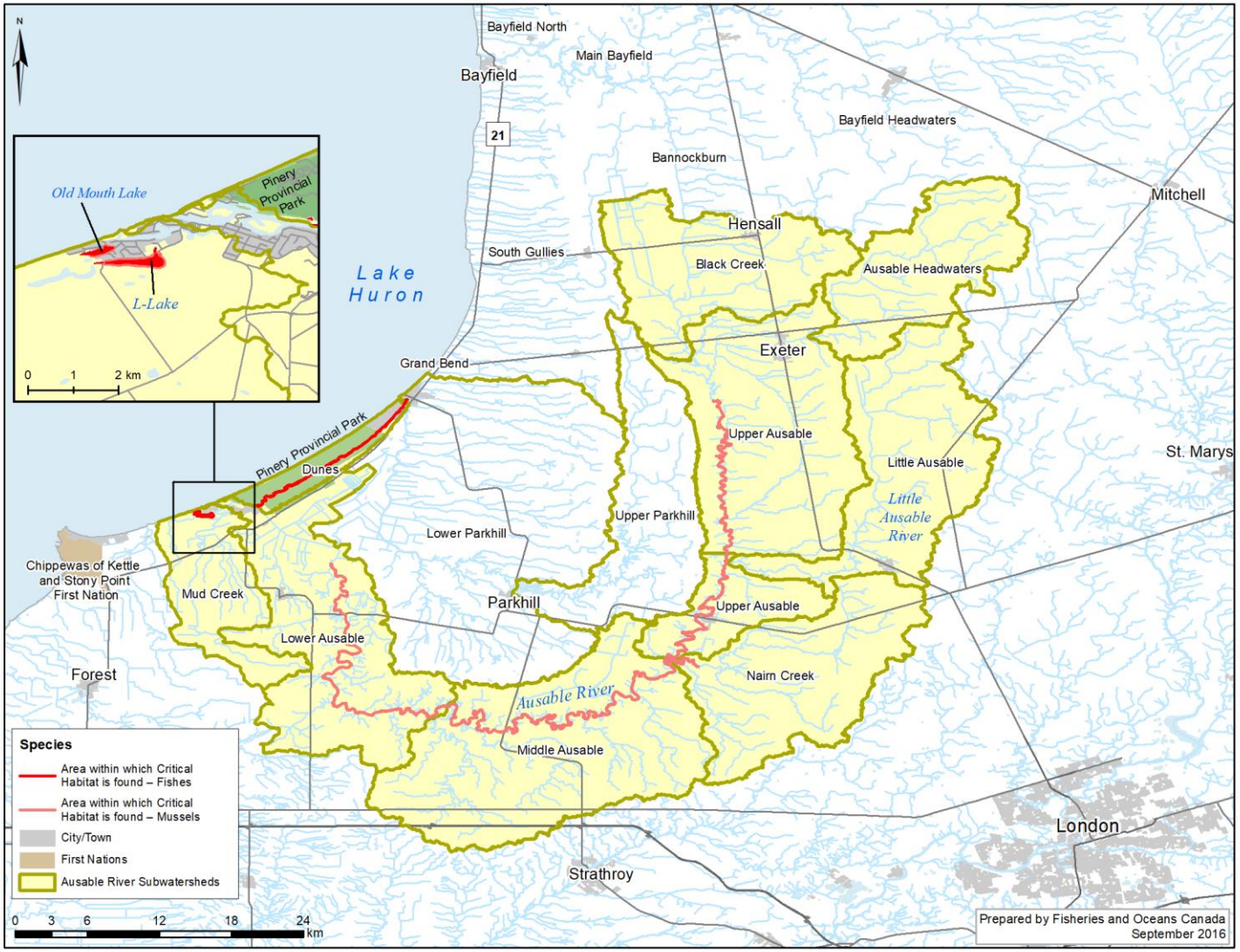

Figure 2. Areas within which critical habitat for fishes and freshwater mussels may be found in the Ausable River watershed (all species covered by the action plan are included).
(to be used for illustrative purposes only, for more detail refer to relevant recovery strategies)

4.1.2 Examples of activities likely to result in destruction of critical habitat

The following is a summary of examples of human activities likely to result in the destruction of critical habitat for SAR fishes and/or mussels in the Ausable River watershed:

- work in or around water with improper sediment and erosion control
- unfettered livestock access to waterbodies
- intensive land use such as urbanization and continuous cultivation
- removal of riparian vegetation
- removal or alteration of aquatic vegetation
- over-application of fertilizer and improper nutrient management
- introduction of high levels of chloride through excessive salting of roads in winter
- water-level management or water extraction activities that causes dewatering of habitat or excessive flow rates
- direct or indirect removal large numbers of host fishes (for example, through harvest)
- introduction of invasive species
- over application or misuse of herbicides and pesticides
- grading, dredging or excavation
- placement of material or structures in water
- construction of dams and/or barriers
- use of motor vehicles in the river (for example, ATVs) and crossing watercourses without proper culverts or bridges

More detailed information regarding activities likely to result in the destruction of critical habitat for the three freshwater mussels and two fishes known to be extant in the Ausable River watershed may be found in their respective recovery strategies (that is, DFO 2012c section 2.7.6; DFO 2013a section 7.6; DFO 2019 section 2.6.6; and, Staton et al. 2010 section 2.7.2).

4.2 Measures to protect critical habitat

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a final recovery strategy or action plan and included in the Species at Risk Public Registry. For the three freshwater mussels and two fishes, this is accomplished through SARA Critical Habitat Orders made under subsections 58(4) and (5), which invokes the prohibition in subsection 58(1) against the destruction[3] of the identified critical habitat. It should also be noted that the Ontario ESA provides provincial protection to all six fishes and mussels and their habitat found within the Ausable River watershed.

[3] Destruction is determined on a case by case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from a single or multiple activities at one point in time or from the cumulative effects of one or more activities over time.

4.3 Focusing stewardship prioritization

To increase the probability of successful mitigation of threats within the 1,142 km^2 watershed, stewardship activities should be concentrated where they most benefit populations of the Endangered and Threatened fish and mussel SAR listed under SARA; this may include tributaries and headwaters that may not be inhabited by SAR, but influence critical habitat downstream. Extant populations of the three freshwater mussels are known within the main stem of the Ausable River (Upper Ausable to Lower Ausable sub-watersheds) as well as two tributaries (Little Ausable River and Nairn Creek). Extant populations of the two fishes are known in the Old Ausable Channel (OAC), L Lake and Old Mouth Lake (OML). These sections of the watershed include the critical habitat identified for these species (with the exception of Little Ausable River) and are considered priority zones by the recovery team (figure 3).

The sub-watersheds that contain and/or support critical habitat are important areas for targeted mitigation activities. Sub-watersheds were assigned a ranking of high, medium, and low conservation priority for on-the-ground SAR recovery actions in figure 3, based on ABCA analysis (Upsdell et al. 2010b; Jean and Veliz 2011; Jean et al. 2015). Priority sub-watersheds for SAR recovery actions were categorized based on areas of known aquatic SAR occurrence as well as areas of potential sediment loss and loading to the Ausable River, and habitat conditions in the OAC, L Lake, and OML. The high conservation priority sub-watersheds included: lower part of Upper Ausable (split into high and medium based on SAR occurrence), Nairn Creek, Middle Ausable, Lower Ausable, and Dunes. The Ausable Headwaters was found to have a high potential amongst the sub-watersheds for both potential soil loss and sediment loading to the Ausable system. However, it is likely that this sediment settles out as the river flows downstream to the Morrison Dam reservoir, Exeter Dam reservoir, and subsequently the Hay Swamp wetland area near the town of Exeter before flowing south through the Upper Ausable sub-watershed to Ailsa Craig.

Stewardship efforts should be prioritized with a two-pronged approach, which includes: targeting priority sub-watersheds and addressing the greatest threats (high and medium level of concern, tables 4a and 4b: sediments [including siltation and suspended solids], nutrient enrichment, altered flow regime, contaminants, invasive species, and habitat modifications). Supporting recovery actions throughout the watershed including headwater areas and tributaries is also very important. Stewardship actions, including best management practices (BMPs), should be encouraged through outreach and education, and stewardship grants. Further details are included within the implementation schedule (tables 5, 6, and 7).

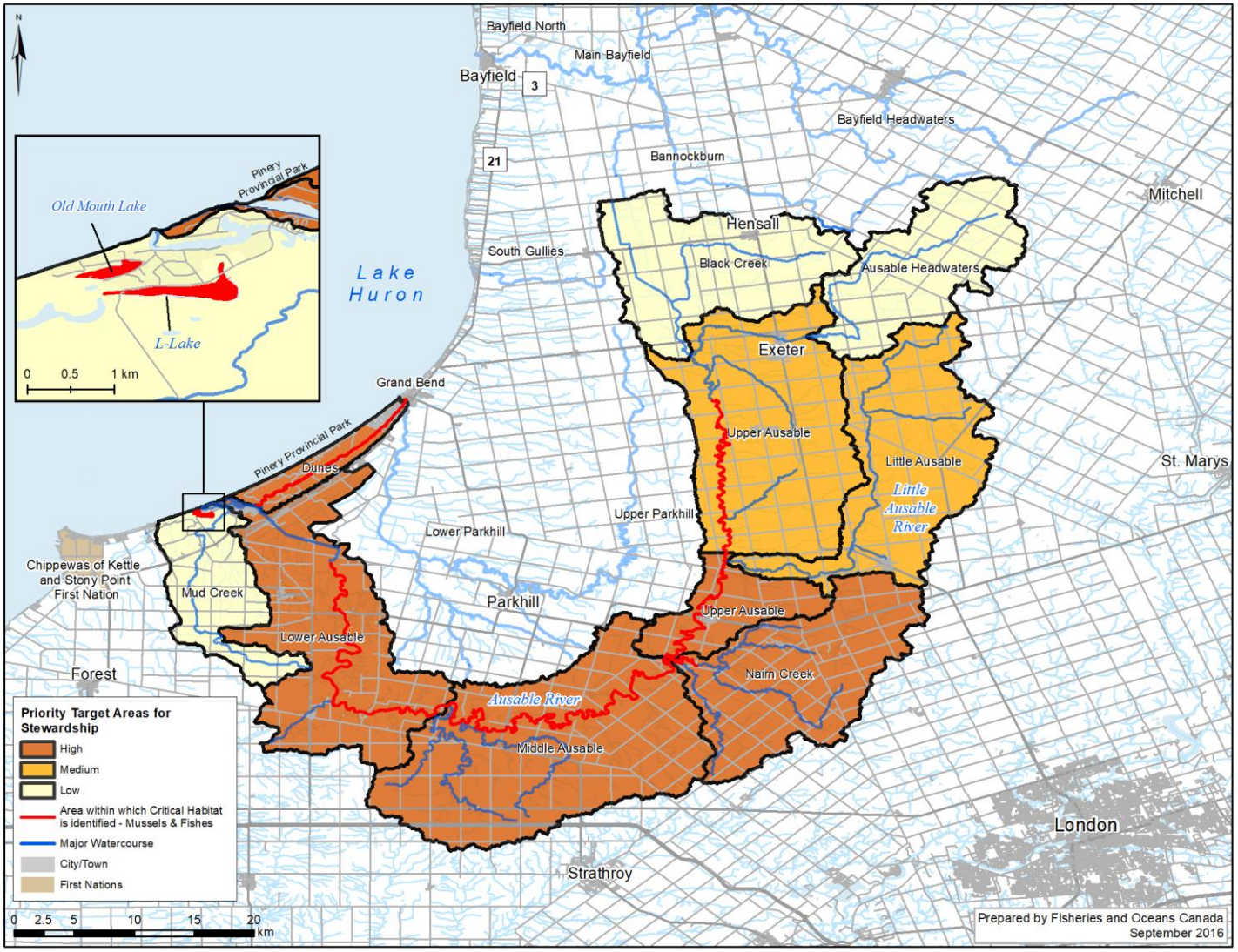

Figure 3. Priority sub-watersheds for stewardship activities to benefit critical habitat.

4.4 Measures underway

Measures underway to address threats include stewardship actions by landowners involving BMPs for agricultural properties (Agriculture Canada and OMAFRA 1992 to 2011) and residential properties (School of Environmental Design and Rural Development 2007) within the catchment area where the six species of fishes and freshwater mussels are found.

Voluntary stewardship activities have already been undertaken toward reducing sediment and nutrient inputs throughout the Ausable River watershed; this has occurred since 2005 with the implementation of the Ausable River Recovery Strategy (ARRT 2005). Riparian vegetation has been planted at many sites to reduce streamside erosion and sediment inputs. In some cases, stream banks have been stabilized to reduce erosion, riparian zones have been preserved or improved, shorelines have been fenced to restrict livestock from watercourses, and manure storage facilities and septic system have been upgraded to reduce nutrient runoff, thus protecting nearby watercourses. The protection of key areas in watersheds that generate and deliver water, sediment and nutrients during rain events in addition to the riparian zone is also very important. Practices to “avoid, control, trap and treat” sediment and nutrients with conservation tillage, residue management, cover crops and berms should continue to be employed and in some instances targeted to appropriate locations to reduce threats. Ongoing understanding of the role of improved soil conditions in improving water quality conditions is critical. Recent work completed by ABCA has highlighted the importance of healthy soils for water quality improvements.

To encourage further stewardship efforts, an active outreach program exists providing:

- direct landowner contact
- a dedicated website (Ausable Bayfield Conservation – Species at Risk) (en anglais seulement)
- displays at community events
- riverbank signage posted in areas identified as critical habitat (at access points)
- presentations at public meetings and to non-governmental interest groups of farmers, naturalists or community groups
- demonstration projects that profile several pasturing options designed to keep cattle out of streams (for example, solar-powered water pumps for pasture cattle, rotational grazing, low level stream crossings)
- an education program for school-aged children
- presentations and displays on the Ausable River Recovery Strategy at watershed community events
- an annual notice of funding distributed through all watershed newspapers

4.5 Measures to be taken and implementation schedule

Success in the recovery of freshwater mussels and fishes at risk in the Ausable River is dependent on the actions of many different jurisdictions; it requires the commitment and cooperation of the constituencies that will be involved in implementing the directions and measures set out in this action plan.

This action plan provides a description of the measures that provide the best chance of achieving the population and distribution objectives for the six Endangered or Threatened aquatic SAR within the Ausable River watershed. Such measures include those to be taken to address threats to these species and monitor their recovery and guide not only activities to be undertaken by DFO, but those for which other jurisdictions, organizations and individuals have a role to play. As new information becomes available, these measures and the priority of these measures may change.

DFO strongly encourages Canadians to participate in the conservation of aquatic SAR within the Ausable River watershed through undertaking recovery measures outlined in this action plan. DFO recognizes the important role of the ARRT and its member organizations and agencies in the ongoing implementation of recovery measures.

Table 5 identifies the recovery measures to be undertaken by DFO to support the recovery of the six species of freshwater mussels and fishes in the Ausable River watershed.

Table 6 identifies the measures to be undertaken collaboratively between DFO and its partners, other agencies, organizations and individuals (for example, members of the ARRT). Implementation of these measures will be dependent on a collaborative approach, in which DFO is a partner in recovery efforts, but cannot implement the measures alone.

As all interested citizens are invited to join in supporting and implementing this action plan, table 7 identifies the remaining measures that represent opportunities for other interested jurisdictions, groups or individuals to lead the recovery of these species. If your organization is not already involved with the ARRT and is interested in participating in one of these measures, please contact the Species at Risk-Central and Arctic office.

Implementation of this action plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations. Note that further details relating to individual recovery measures in the following implementation tables may be found within the relevant fish and mussel recovery strategies (refer to table 2).

Table 5. Measures to be undertaken by DFO

- **Broad strategy 1:** inventory and monitoring (measures 1 and 2)
- **Broad strategy 2:** research (measures 3 to 5)
- **Broad strategy 3:** management and coordination (measures 6 to 8)
- **Broad strategy 4:** stewardship and outreach (measures 8 to 10)

#	Recovery measures	Priority[4]	Threats or objective addressed	Timeline
1	**Targeted sampling for fish SAR:** background surveys, Eastern Sand Darter.** Conduct targeted sampling in areas of appropriate habitat that have been lightly surveyed. Use sampling techniques proven to detect Eastern Sand Darter. Predictions from a habitat modelling study will be used to assist in choosing locations to sample (Dextrase et al. 2014).	Medium	Will confirm if this species is extirpated and determine presence/absence of Eastern Sand Darter within the Ausable River. If an extant population is confirmed, will determine health, range, abundance and population demographics and contribute to the identification of critical habitat.	2020 to 2021
2	**Long-term monitoring program for fish SAR and their habitat:** monitoring, Lake Chubsucker and Pugnose Shiner populations and habitat:** a) Establish a network of permanent monitoring stations throughout historical and present ranges (OAC, L Lake, and OML) to permit tracking of populations, analysis of trend patterns, and permit the evaluation of recovery actions to be revisited every five years. b) Establish and implement a standardized index population and habitat monitoring program (water levels, dissolved oxygen concentrations, water quality, and aquatic vegetation). The monitoring	High	Will provide a measure of species' security. Will provide insight into threat factors and inform management actions. Will enable assessments of changes in range, abundance, key demographic characters and changes in habitat features, extent and health.	2020 to 2022

[4] "Priority" reflects the degree to which the measure contributes directly to the recovery of the species or is an essential precursor to a measure that contributes to the recovery of the species:

- "high" priority measures are considered likely to have an immediate and/or direct influence on the recovery of the species
- "medium" priority measures are important but considered to have an indirect or less immediate influence on the recovery of the species
- "low" priority measures are considered important contributions to the knowledge base about the species and mitigation of threats

	program will provide insight into the significance of threat factors.			
3	**Investigate feasibility of population augmentations and/or repatriations, a):***** science-based guidelines on the feasibility of translocations and repatriations to determine if small populations can be augmented or if the species can be repatriated in their historical range were recommended as part of the Sydenham River Action Plan (SRAP). These guidelines would be used to guide the following work for Northern Riffleshell and Eastern Sand Darter in the Ausable River watershed: investigate population augmentation or other possible mitigation strategies for Northern Riffleshell (globally rare) as populations are exceedingly sparse and may be susceptible to local extirpation.	High	Will prevent species extirpation from the Ausable River watershed.	2021 to 2022 (timing dependent on the completion of background work through the SRAP)
4	**Investigate feasibility of population augmentations and/or repatriations, b):***** investigate the feasibility of Eastern Sand Darter repatriation if required (once other needed presence/absence surveys are completed).	Low	As above.	2021 to 2022
5	**Advances in monitoring techniques**: investigate the possibility of using eDNA techniques as a detection method for Eastern Sand Darter and Northern Riffleshell.	Medium	Will assist in the possible detection of very low density populations.	2020 to 2021
6	**Encourage/coordinate actions to reduce harmful impacts upon mussels, fish and habitat among government and non-government entities, a):** integration of recovery actions across relevant recovery teams. Work with existing recovery teams to implement recovery actions as needed.	Medium (all SAR)	Ensure efficient and effective implementation of all recovery actions across jurisdictions.	Ongoing
7	**Encourage/coordinate actions to reduce harmful impacts upon mussels, fish and habitat among government and non-government entities, b):** habitat management awareness: ensure planning and	High	Will result in the awareness of the need to protect important habitat from development activities, and help ensure the flow requirements of SAR are met.	Ongoing

	management agencies recognize the importance of wetland habitats (for Lake Chubsucker and Pugnose Shiner) as well as riverine habitats for SAR mussels.			
8	**Evaluation of watershed scale stressors:** evaluate the cumulative impacts and relative importance of watershed-scale stressors to SAR populations and their habitats (for example, invasive species, cumulative impacts of municipal wastewater, and urban runoff such as road salt).	High	Will help evaluate the cumulative impact of multiple stressors affecting SAR populations.	2022 to 2023
9	**Increase awareness about the distribution, threats and recovery of all SAR, a):** awareness of critical habitat: hold one-day workshops with municipal staff and planning and review agencies, and work with municipal planning authorities so that they consider the protection of critical habitat for SAR within official plans.	High	Will provide further protection for SAR and promote future development that does not degrade important habitat.	Ongoing
10	**Increase awareness about the distribution, threats and recovery of all SAR, b):** increase awareness of the presence of and need to protect critical habitat among landowners and those accessing the river corridor for recreation. This will help voluntarily reduce disruptive activities such as driving motor vehicles or ATV's in the river.	High	Will promote protection and/or mitigation of habitat from various threats (including impacts from vehicles and ATVs driving in the river).	Ongoing

** Measures that relate to the sampling of fish populations; where possible, these activities should be conducted in a coordinated fashion using sampling methodologies that help fill the survey needs of multiple species (including those covered by management plans: Beauchamp et al. 2012).

*** As part of the feasibility of any potential translocations or repatriations, analysis would need to be conducted to confirm that adequate water quality and available habitat exists for the species under consideration. Note that if feasibility analysis recommends population augmentations or repatriations for a species, final implementation steps would be considered separately in partnership with OMNRF (and is outside the scope of the present action plan). The OMNRF Fish Culture Section has been working with experts across North America to develop the husbandry skills and propagation techniques required to raise at risk mussels.

Table 6. Measures to be undertaken collaboratively between DFO and its partners

- **Broad strategy 1:** inventory and monitoring (measures 1 to 3)
- **Broad strategy 2:** research (measures 4 to 8)
- **Broad strategy 4:** stewardship and outreach (measure 9)

#	Recovery measures	Priority[5]	Threats or objective addressed	Timeline (short, medium or long term)	Partner(s)
1	**Long-term monitoring program for SAR mussels and their habitat, a):** monitoring mussel and host fish populations and their habitat: resample permanent monitoring stations (Baitz et al. 2008 and Upsdell et al. 2012) throughout historical and present ranges of SAR mussels to permit tracking of populations, analysis of trend patterns, and permit the evaluation of recovery actions. Maintain a standardized index population and habitat monitoring program to be revisited every five years.	High (all mussels)	Will provide a measure of species' security. Will help ensure that the most effective recovery actions are given priority over less effective actions.	Medium	ABCA
2	**Long-term monitoring program for SAR mussels and their habitat, b):** establish permanent monitoring program for tracking changes in habitat. Incorporate current water quality and quantity monitoring as well as invertebrate sampling.	Medium	Provides trend data for key habitat parameters and will help evaluate the relative threat of habitat loss.	Ongoing	ABCA
3	**Long-term monitoring program for SAR mussels and their habitat, c):** conduct long-term monitoring to survey host fish distribution in the Ausable River watershed (every five years) at established index stations in collaboration with long-term mussel monitoring.	Medium	Will help determine if host abundance is limiting factor for the three mussel species. If required, background data will be available to develop additional	Long	ABCA

[5] "Priority" reflects the degree to which the measure contributes directly to the recovery of the species or is an essential precursor to a measure that contributes to the recovery of the species:

- "high" priority measures are considered likely to have an immediate and/or direct influence on the recovery of the species
- "medium" priority measures are important but considered to have an indirect or less immediate influence on the recovery of the species
- "low" priority measures are considered important contributions to the knowledge base about the species and mitigation of threats

			actions for the management of host species.		
4	**Confirm/identify threats, evaluate their relative importance and implement remedial actions to minimize their impacts, a):** evaluate changes in habitat conditions for SAR mussels in riverine habitats. This research will be informed through the habitat monitoring program (measure #2) as well all other sources of data (including geomorphologic studies).	Medium	Will help evaluate the severity of specific threats to individual SAR mussel populations and inform actions to alleviate their impacts.	Long	ABCA
5	**Confirm/identify threats, evaluate their relative importance and implement remedial actions to minimize their impacts, b):** evaluate changes in habitat conditions for SAR fishes in OAC, L Lake, and OML, with a focus on water levels and factors exacerbating natural succession and fish kills (that is, nutrient inputs, low dissolved oxygen concentrations, aquatic vegetation species diversity and density).	High	Will help evaluate the severity of specific threats to individual SAR fish populations and inform actions to alleviate their impacts.	Short	ABCA, OMNRF
6	**Confirm/identify threats, evaluate their relative importance and implement remedial actions to minimize their impacts, c):** organize a technical team and work with various researchers to identify opportunities to address fish habitat issues (for example, winter refugia locations) and answer further questions about the OAC's habitat, such as a better understanding of the relationship between nutrient concentrations and aquatic plant growth.	High	Will provide a better understanding of threat factors within the OAC and how best to address them.	Medium	ABCA, OMNRF
7	**Determine/confirm functional host fishes and their distributions and abundances (for all mussels),a):** research host fishes: build on recommendation from the SRAP to continue host fish testing for all at-risk freshwater mussels in the laboratory and confirm functional host species used in the Ausable River and its tributaries	High	Together with measure #3, will help determine if host abundance is limiting factor for the three mussel species. If required, background data will be available to develop additional actions for the management of host species.	Medium	University of Guelph

8	**Determine/confirm functional host fishes and their distributions and abundances (for all mussels), b):** build on recommendation from the SRAP to continue juvenile propagation for all at-risk freshwater mussels in the laboratory.	Medium	Will provide for the possibility of population augmentations in the future.	Long	OMNRF[6]
9	**Increase awareness of critical habitat (all SAR):** encourage public support and participation in SAR recovery by developing awareness materials and programs. Will encourage participation in local stewardship programs to improve and protect habitat.	Medium	Will promote protection of critical habitat and/or mitigate multiple threats through stewardship actions.	Ongoing	ABCA

[6] The OMNRF Fish Culture Station is currently working on several SAR mussels (for example, Kidneyshell, Northern Riffleshell, and Snuffbox), developing husbandry and propagation techniques. This work includes care and treatment guidelines for host fishes.

Table 7. Measures that represent opportunities for other jurisdictions, organizations or individuals to lead

- **Broad strategy 3:** management and coordination (measures 1 and 2)
- **Broad strategy 4:** stewardship and outreach (measures 3 to 16)

#	Recovery measures	Priority[7]	Threats or concerns addressed	Suggested other jurisdictions or organizations †
1	**Encourage/coordinate actions to reduce harmful impacts upon SAR and SAR habitat among government and non-government entities, a):** wastewater treatment plants and stormwater management facilities: i. Evaluate whether existing wastewater treatment plants (for example, Hensall, Exeter, Ailsa Craig) are functioning to specifications and encourage upgrading where appropriate. Where possible, quantify overflows. ii. Review stormwater management facilities for quantity and quality control in new developments, and retro-fit existing development where possible. iii. Evaluate levels of chloride and consider how to mitigate.	Medium (all mussels)	Will improve water quality by reducing nutrient and suspended solid inputs from urban centres.	MOECC
2	**Encourage/coordinate actions to reduce harmful impacts upon SAR and SAR habitat among government and non-government entities, b):** ensure that flow requirements of all SAR (fishes, mussels and their hosts) are considered in the management of water supply and flow regimes.	High	Will ensure the flow requirements/water levels of SAR are met. Would support the removal of obsolete dams or insertion of water control structures to maintain habitat (for example, OAC).	Ontario Parks, OMNRF

[7] "Priority" reflects the degree to which the measure contributes directly to the recovery of the species or is an essential precursor to a measure that contributes to the recovery of the species:

- "high" priority measures are considered likely to have an immediate and/or direct influence on the recovery of the species
- "medium" priority measures are important but considered to have an indirect or less immediate influence on the recovery of the species
- "low" priority measures are considered important contributions to the knowledge base about the species and mitigation of threats

3	**Encouraging best management practices (BMPs) to help reduce the impacts of terrestrial activities on aquatic ecosystems through increasing awareness of these activities as well as through the provision of financial assistance to local landowners (all SAR). The following BMPs and stewardship activities will be directed to stewardship priority sub-watersheds (refer to figure 3), a):** riparian buffers: establish riparian buffer zones (ideally 30 m in width or greater) in areas of high erosion potential by encouraging naturalization or planting of native species. Care must be taken not to impact important nesting beaches for the Eastern Spiny Softshell (*Apalone spinifera*) (SARA status: Threatened) when working in the riparian zone.	High	Will improve water and habitat quality by reducing siltation and turbidity (bank erosion, sedimentation and overland run-off), nutrient loads, toxic compounds, and thermal effects (shade).	ABCA
4	**Encouraging best management practices (BMPs) to help reduce the impacts of terrestrial activities on aquatic ecosystems through increasing awareness of these activities as well as through the provision of financial assistance to local landowners (all SAR). The following BMPs and stewardship activities will be directed to stewardship priority sub-watersheds (refer to figure 3), b):** non-riparian erosion control: encourage erosion control practices (conservation tillage, residue management, cover crops, berms) to reduce sedimentation and nutrient inputs.	High	Will improve water and habitat quality by reducing sedimentation and nutrient inputs.	ABCA, OSCIA
5	**Encouraging best management practices (BMPs) to help reduce the impacts of terrestrial activities on aquatic ecosystems through increasing awareness of these activities as well as through the provision of financial assistance to local landowners (all SAR). The following BMPs and stewardship activities will be directed to stewardship priority sub-watersheds (refer to figure 3), c):** tile drainage and open drains: work with landowners to mitigate the effects of tile drainage and agricultural drains to reduce nutrient and sediment inputs. Pilot and demonstration projects may be a necessary first step.	High	Will improve water quality by reducing nutrient and sediment inputs.	ABCA
6	**Encouraging best management practices (BMPs) to help reduce the impacts of terrestrial activities on aquatic ecosystems through increasing awareness of**	High	Will improve water quality by reducing nutrient and sediment inputs.	ABCA

	these activities as well as through the provision of financial assistance to local landowners (all SAR). The following BMPs and stewardship activities will be directed to stewardship priority sub-watersheds (refer to figure 3), d): herd management: encourage the active exclusion of livestock from the watercourse (for example, by fencing) to reduce bank erosion and nutrient and sediment inputs.			
7	**Encouraging best management practices (BMPs) to help reduce the impacts of terrestrial activities on aquatic ecosystems through increasing awareness of these activities as well as through the provision of financial assistance to local landowners (all SAR). The following BMPs and stewardship activities will be directed to stewardship priority sub-watersheds (refer to figure 3), e):** protection and enhancement of natural areas (wetlands and forests): i. prioritize locations for enhancing or re-establishing forests or wetlands in appropriate locations ii. assist with protection of existing wetlands and forests through various means (including acquisition if warranted) iii. assist with enhancement or restoration of wetlands and forests iv. work with landowners to decrease sediment and nutrient loading to wetland habitats (for example, OAC, L Lake, OML)	High	Will improve water quantity and quality by contributing to low flow augmentation, groundwater recharge and sediment/nutrient control.	ABCA
8	**Encouraging best management practices (BMPs) to help reduce the impacts of terrestrial activities on aquatic ecosystems through increasing awareness of these activities as well as through the provision of financial assistance to local landowners (all SAR). The following BMPs and stewardship activities will be directed to stewardship priority sub-watersheds (refer to figure 3), f):** livestock waste management: assist with establishing adequate manure collection and storage systems to avoid accidental spills and winter-spreading of manure to reduce nutrient inputs (for consistency with the policies of the Canada-Ontario Farm Stewardship Program).	Medium	Will improve water quality by reducing nutrient loads.	ABCA

9	**Encouraging best management practices (BMPs) to help reduce the impacts of terrestrial activities on aquatic ecosystems through increasing awareness of these activities as well as through the provision of financial assistance to local landowners (all SAR). The following BMPs and stewardship activities will be directed to stewardship priority sub-watersheds (refer to figure 3), g):** invasive Species (for example, *Phragmites australis*): assist stakeholders in controlling invasive species to prevent establishment in wetland habitats and upstream areas (OAC, L Lake, OML).	Medium	Will reduce the threat of an invasive species to wetland habitats.	Ontario Invasive Plant Council, and/or OMNRF
10	**Encouraging best management practices (BMPs) to help reduce the impacts of terrestrial activities on aquatic ecosystems through increasing awareness of these activities as well as through the provision of financial assistance to local landowners (all SAR). The following BMPs and stewardship activities will be directed to stewardship priority sub-watersheds (refer to figure 3), h):** farm planning: encourage the development and implementation of environmental farm plans and nutrient management plans to minimize nutrient and sediment inputs. In some cases, such plans are required for landowner eligibility for stewardship funds.	High	Will improve water quality by reducing nutrient and sediment inputs.	ABCA, OSCIA
11	**Encouraging best management practices (BMPs) to help reduce the impacts of terrestrial activities on aquatic ecosystems through increasing awareness of these activities as well as through the provision of financial assistance to local landowners (all SAR). The following BMPs and stewardship activities will be directed to stewardship priority sub-watersheds (refer to figure 3), i):** sewage treatment: a) assist landowners to participate in programs to improve faulty septic systems to reduce nutrient inputs (particularly in the OAC) b) work with residents toward replacing septic systems with sewers in the OAC watershed	High	Will improve water quality by reducing nutrient inputs.	Municipality of Lambton Shores
12	**Encouraging best management practices (BMPs) to help reduce the impacts of terrestrial activities on**	Medium	Will improve the implementation of stewardship activities.	ABCA (other partners)

	aquatic ecosystems through increasing awareness of these activities as well as through the provision of financial assistance to local landowners (all SAR). The following BMPs and stewardship activities will be directed to stewardship priority sub-watersheds (refer to figure 3), j): cooperating and coordinating efforts with stewardship councils and ABCA to improve the implementation of stewardship activities and leverage additional funding.			
13	**Encouraging best management practices (BMPs) to help reduce the impacts of terrestrial activities on aquatic ecosystems through increasing awareness of these activities as well as through the provision of financial assistance to local landowners (all SAR). The following BMPs and stewardship activities will be directed to stewardship priority sub-watersheds (refer to figure 3), k):** work with OAC residents (and other stakeholders): i. identify management options to alleviate nutrient concentrations and resultant vegetative growth in the northern OAC through: landowner stewardship actions; lessening watershed nutrient sources; and investigating aquatic vegetation control options ii. implement management recommendations identified for the OAC in the Old Ausable Channel Management Plan and the Ausable River Action Plan	High	Will improve habitat conditions in the OAC by reducing nutrient loading and improving dissolved oxygen concentrations over winter.	ABCA
14	**Increase awareness about the distribution, threats and recovery of these species (all SAR), a):** increase public knowledge of critical habitat, stewardship options and financial assistance available to participate in activities (for example, watershed news release distributed annually by ABCA).	High	Will increase public participation in recovery actions and a reduction in all threats.	ABCA
15	**Increase awareness about the distribution, threats and recovery of these species (all SAR), b):** invasive species: increase public awareness of the potential impacts of transporting/releasing invasive species as well as the importance of identifying and reporting them. Encourage	Low	Will reduce the risk of invasive species becoming established in new locations (for example, dreissenid mussels, Round Goby, *Phragmites australis*).	OMNRF, OFAH, Pinery Provincial Park, Ontario Invasive Plant Council

	use of the Ontario Federation of Anglers and Hunters (OFAH) invading species hotline and DFO's Baitfish Primer.			
16	**Increase awareness about the distribution, threats and recovery of these species (all SAR), c):** outreach: i. encourage public support and participation by developing awareness materials such as an annual newsletter, posters, website, riverbank signage and displays and programs for schools, public interest groups, agencies, and other interested stakeholders regarding SAR mussels and fishes of the Ausable River ii. work with local communities to develop and implement sub-watershed management plans that would address threats and provide stewardship actions for the community iii. involve the community in observing changes to the OAC habitat through a citizen science watch program iv. recognize and address specific threats to SAR fishes, such as low dissolved oxygen concentrations, through the OAC Management Plan (Killins 2008) committee made up of the community, researchers, and affected agencies v. strengthen relationships and hold regular meetings for the OAC committee (community, researchers, and affected agencies) to direct and target recovery actions and stewardship efforts for these species	Medium Medium Medium High High	Will increase public awareness of the importance of SAR and a reduction in all threats. Will increase public participation in recovery actions, uptake of stewardship and reduce threats.	ABCA, OMNRF, Pinery Provincial Park, community groups

† Acronyms: MOECC: Ministry of the Environment and Climate Change; OMNRF: Ontario Ministry of Natural Resources and Forestry; OFAH: Ontario Federation of Anglers and Hunters; ABCA: Ausable Bayfield Conservation Authority; OSCIA: Ontario Soil and Crop Improvement Association

5. Evaluation of socio-economic costs and benefits

SARA requires that an action plan include an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation (SARA subsection 49(1)(e) 2003). This evaluation addresses only the incremental socio-economic costs of implementing this action plan from a national perspective as well as the social and environmental benefits that would occur if the action plan were implemented in its entirety, recognizing that not all aspects of its implementation are under the jurisdiction of the federal government. It does not address cumulative costs of species recovery in general nor does it attempt a cost-benefit analysis. Its intent is to inform the public and to guide decision making on implementation of the action plan by partners.

The protection and recovery of SAR can result in both benefits and costs. The Act recognizes that "wildlife, in all its forms, has value in and of itself and is valued by Canadians for aesthetic, cultural, spiritual, recreational, educational, historical, economic, medical, ecological and scientific reasons" (SARA, 2003). Self-sustaining and healthy ecosystems with their various elements in place, including SAR, contribute positively to the livelihoods and the quality of life of all Canadians. A review of the literature confirms that Canadians value the preservation and conservation of species in and of themselves. Actions taken to preserve a species, such as habitat protection and restoration, are also valued. In addition, the more an action contributes to the recovery of a species, the higher the value the public places on such actions (Loomis and White 1996; DFO 2008). Furthermore, the conservation of SAR is an important component of the Government of Canada's commitment to conserving biological diversity under the International Convention on Biological Diversity. The Government of Canada has also made a commitment to protect and recover SAR through the Accord for the Protection of Species at Risk. The specific costs and benefits associated with this action plan are described below. The evaluation describes, to the extent possible, the benefits that may accrue, as well as the costs that governments, industry and/or Canadians may incur due to activities identified in this action plan.

This evaluation does not address the socio-economic impacts of protecting critical habitat for all of the species (three mussels, three fishes) represented in this action plan. Under SARA, DFO must ensure that critical habitat identified in a recovery strategy or action plan is legally protected within 180 days of the final posting of the recovery strategy or action plan. Where a Critical Habitat Order will be used for critical habitat protection, the development of the Order will follow a regulatory process in compliance with the Cabinet Directive on Regulatory Management, including an analysis of any potential incremental impacts of the SARA Critical Habitat Order that will be included in the Regulatory Impact Analysis Statement. As a consequence, no additional analysis of the critical habitat protection has been undertaken for the assessment of costs and benefits of the action plan.

Policy baseline

The policy baseline consists of the protection under SARA for these species, along with continued protection under Ontario's ESA. Other legislation that may provide direct or indirect habitat protection for these species include the federal *Fisheries Act* and existing provincial

legislation[8]. The policy baseline also includes the recovery actions that were implemented prior[9] to and after the species were listed under SARA.

These recovery actions included various projects[10] funded by the Government of Canada's Habitat Stewardship Program for Species at Risk, partnering with the province of Ontario, universities, stewardship groups, the ABCA, and with landowners within the watershed. In addition, several research and monitoring projects to support the recovery of SARA-listed fishes and freshwater mussels in the Ausable River have been funded directly by DFO in support of the Ausable River Recovery Strategy (ARRT 2005).

Socio-economic profile
The Ausable River watershed is highly agricultural and dominated by row cropping with about 15% forest and wetland habitat remaining.

Socio-economic benefits of implementing this action plan
Some of the benefits of recovery actions required to return/maintain self-sustaining populations of the six species outlined in this action plan are difficult to quantify but would generally be positive. Beyond some of the unquantifiable non-market benefits mentioned in the second paragraph of this evaluation, the recovery actions are also likely to provide broader benefits for Canadians (for example, enhanced water quality).

Additionally, six other at risk mussels and fishes (not specifically addressed by this action plan: Mapleleaf, Rainbow, Wavyrayed Lampmussel, Black Redhorse, Grass Pickerel, and River Redhorse) will benefit from the recovery actions proposed for the six priority species through the overall improvement to shared aquatic habitats. Where SARA management plans exist for Special Concern species such as Grass Pickerel, Wavyrayed Lampmussel, and River Redhorse, this action plan will help to support many of the management actions required for these species. Semi-aquatic SAR (that is, reptiles such as turtles and snakes) are also expected to benefit from this plan but are not specifically addressed. Many of the stewardship actions proposed (such as the establishment of riparian buffers and improved livestock management) will also result in improved terrestrial habitat for upland wildlife; in some cases, improved hunting opportunities may result.

Recovery actions that help to enhance water quality, through BMPs[11], will contribute to improved downstream drinking water quality. Improved water quality will lead to healthier ecosystems, which in turn, support healthier fisheries. This is expected to result in improved recreational fishing opportunities in the Ausable River as well as healthier fisheries downstream in the waters of the Great Lakes (the Ausable River is a major contributor of sediment and nutrients to lower Lake Huron).

[8] Examples of other provincial legislation that provide habitat protection include considerations under section 3 of Ontario's *Planning Act*, which prohibits development and site alteration in the significant habitat of endangered species and protection under the *Lakes and Rivers Improvement Act* in Ontario.
[9] Recovery actions implemented under the Recovery Strategy for Species at Risk in the Ausable River (ARRT 2005) have been ongoing since 2004.
[10] Projects include stewardship and management actions, community awareness and outreach activities, as well as research and monitoring.
[11] BMPs consist of actions to reduce the amount of nutrient and sediment inputs that are in the water. Examples of such actions include improving sewage treatment, environmentally friendly farming practices, and establishing riparian buffers.

Recovery actions to improve aquatic habitats, in the form of voluntary BMPs[12], are developed and promoted by agricultural groups as cost-effective ways to conserve a farm's soil and water resources (OMAFRA 2012)[13]. There is a positive impact to agricultural producers' sustainability as soil and water quality can be improved through the use of BMPs.

The benefits of implementing the recovery actions contained in the action plan cannot be quantified but would occur over the long term.

Socio-economic costs of implementing this action plan

The majority of the recovery activities identified in this action plan are short term (2020 to 2024), medium term or ongoing. It should be noted that an ecosystem-based action plan that addresses multiple species is a more cost-effective approach than multiple or single-species implementation approaches. An ecosystem or watershed approach also addresses issues of scale, recognizing that threats often originate across the landscape in upstream areas of the watershed and prescribes appropriate and more strategic solutions than could be accomplished with a single-species focus.

Most of these activities focus on research, inventory and monitoring, stewardship and outreach as well as management and coordination to reduce threats and to inform and promote species recovery. Some of the actions are one-time projects (for example, research and inventory), likely funded from existing federal government resources.

Implementation of local stewardship actions would be supported by programs such as the Habitat Stewardship Program. In addition, most funding programs require a level of direct or in-kind support costs from applicants as matching funds[14]. The costs (direct and in-kind) associated with these short-term actions are estimated to be low[15] and spread over the next five years[16].

Costs would be incurred by the federal government and its partners to implement the activities listed in the action plan. In-kind costs such as volunteer time, providing expertise and equipment would be incurred as a result of implementing activities listed in the action plan. Costs (including in-kind support) for voluntary actions could be incurred by the province of Ontario and conservation authorities. Some agricultural and non-farm land owners within the Ausable River watershed may incur some costs for BMPs. However, as many of the activities and actions are implemented on a collaborative and voluntary nature, agricultural and non-farm land owners are likely to only incur costs on a voluntary[17] basis.

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[12] Examples of BMPs for agricultural producers include the establishment of riparian buffers (to reduce the amount of nutrient and sediment inputs into the water), livestock waste management, and wetland restoration and enhancement.

[13] Ministry of Agriculture Food and Rural Affairs Best Management Practices

[14] For example, matching funds for the Habitat Stewardship Program can come from landowners and/or provincial funding programs. This helps leverage additional support for recovery actions.

[15] Low costs are defined as less than $1 million annually, as per the socio-economic cost categories in the SARA Implementation Guide for Action Plans for Fisheries and Oceans Canada May 2015.

[16] Future expenditures cannot be determined in great detail as it is expected these activities would continue to be funded through existing government funding, including the Habitat Stewardship Program, where support is determined on a priority basis and based on availability of resources.

[17] Costs to be compliant with listing or Critical Habitat Order prohibitions and requirements are assessed elsewhere.

Long-term recovery activities will be implemented through a cooperative approach following discussions between other agencies, levels of government, stewardship groups and stakeholders allowing for consideration of costs and benefits during the process.

Distributional impacts
Governments and the ABCA will incur the majority of costs of implementing the action plan.

The Canadian public will benefit from the implementation of the action plan through expected non-market benefits associated with recovery and protection of the species and their habitats. The benefits of implementing the action plan to the Canadian public would additionally include improved water quality as well as improved habitats supporting fisheries and wildlife. The implementation of BMPs by agricultural land owners should help to improve the sustainability of their operations.

6. Measuring progress

The performance indicators presented in the associated recovery strategies provide a way to define and measure progress toward achieving the population and distribution objectives relevant to the Ausable River watershed.

Monitoring measures are also included in the action plan to monitor the recovery of the species, their long-term viability as well as habitat and identified threats; this will be done through long-term monitoring programs, which will help evaluate implementation efforts over time (refer to implementation schedule, table 5, action 2 and table 6, actions 1, 2 and 7). Reporting on implementation of the action plan, under section 55 of SARA, will be done by assessing progress towards achieving the broad strategies/recovery objectives as they relate to recovery measures taken within the Ausable River watershed.

Reporting on the ecological and socio-economic impacts of the action plan (under section 55 of SARA) will be done by assessing the results of monitoring the recovery of the species and their long-term viability, and by assessing the implementation of the action plan.

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Appendix A: effects on the environment and other species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery plan could affect any component of the environment or achievement of any of the Federal Sustainable Development Strategy's (FSDS) goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that implementation of action plans may inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the action plan itself, but are also summarized below in this statement.

The Ausable River Action Plan takes an ecosystem approach in addressing predominant threats in the watershed in an effort to restore and improve aquatic habitat for species at risk mussels and fishes (targeting SARA-listed species, but providing benefits to non-listed SAR as well). By improving water and habitat quality in the system for some of the most sensitive aquatic organisms, habitat improvements will benefit biodiversity in general and help restore balance to the natural community. Work in the riparian areas will be conducted in such a way that it does not interfere with habitats and management of semi-aquatic and terrestrial species at risk. In most cases, riparian restoration will benefit terrestrial wildlife and plant species. Where possible, efforts through the Ausable River Action Plan will be combined with terrestrial efforts by stewardship practitioners as has been done in the past with the Ausable River Recovery Team.