COSEWIC
Assessment and Status Report

on the

Cobblestone Tiger Beetle
Cicindela marginipennis

in Canada

SPECIAL CONCERN
2021

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Cobblestone Tiger Beetle — Photograph by John Klymko.

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COSEWIC
Assessment Summary

Assessment Summary – April 2021

Common name
Cobblestone Tiger Beetle

Scientific name
Cicindela marginipennis

Status
Special Concern

Reason for designation
This distinctive tiger beetle has a small and scattered range within New Brunswick spread over three isolated geographic areas: the Saint John River, the Southwest Miramichi River, and the Grand Lake area. This species' habitat, which is sparsely vegetated cobble and sand beaches on lake shores and riverine islands, is highly fragmented and limited. Up to 74% of potential habitat on the Saint John River was lost with the construction of the Mactaquac Dam in the 1960s. The main threats to the habitat include shoreline modifications from cottage development and soil compaction from ongoing all-terrain vehicle (ATV) recreation within the Grand Lake area. Because the larvae live in burrows among cobblestones, beach traffic from ATVs and other vehicles can crush burrows and cause mortality to individual larvae as well as negatively impact the habitat structure. The shoreline in front of cottages is often modified by removal of vegetation and sometimes levelling, including sand deposition which smothers larval burrows. The improved status of the beetle reflects additional sites discovered, including a new watershed, since the last assessment as well as a change in the interpretation of severe fragmentation. However, the species may become Threatened if threats are not managed with demonstrable effectiveness.

Occurrence
New Brunswick

Status history
Designated Endangered in November 2008. Status re-examined and designated Special Concern in May 2021.

COSEWIC
Executive Summary

Cobblestone Tiger Beetle
Cicindela marginipennis

Wildlife Species Description and Significance

Cobblestone Tiger Beetle (*Cicindela marginipennis*) is in the subfamily Cicindelinae, family Carabidae. Adults (11 – 14 mm long) are predatory and have large mandibles, elytra (i.e., the hardened front wings) with a narrow continuous cream-coloured border and a bright red-orange abdomen that is clearly visible during flight. No subspecies are described.

Tiger beetle larvae (e.g., grub-like with a flattened head and pronotum and large sickle-shaped mandible) typically construct and inhabit vertical burrows in the soil. The top of the head and pronotum (i.e. part of thorax adjacent to the head) together form a flattened disk used to create a plug at the top of their burrow, concealing the entrance and resident larva. The larvae are predatory and wait in their concealed burrow for unsuspecting prey to walk by on the soil surface. The dorsal surface of the larva's fifth abdominal segment is equipped with two pairs of large hooks that attach to the wall of the tunnel, securing the beetle larva if the prey attempts to drag it from its burrow.

Distribution

Globally, Cobblestone Tiger Beetle ranges in eastern North America. The species distribution throughout its range is not contiguous; the species occurs in small and widely separated disjunct subpopulations associated with major river systems. In the United States (U.S.), the species ranges from Mississippi and Alabama in the south, to Ohio and Maine in the north. In Canada, it is known from New Brunswick and occurs in seven subpopulations spread over three isolated geographic areas: The Saint John River, the Southwest Miramichi River, and the Grand Lake area. Cobblestone Tiger Beetle occurs in colonies that occupy discrete portions of cobblestone shoreline, termed sites throughout this report.

Habitat

In Canada, Cobblestone Tiger Beetle occurs on sparsely vegetated cobble and sand beaches on lake shores and the upstream end of riverine islands. The primary factor that has a significant impact on the structure of the beetle's habitat is the shoreline water level, which is heavily influenced by flow patterns during the spring freshet and water levels (e.g., including levels of drought) the remainder of the season.

Biology

Cobblestone Tiger Beetle has four life stages (egg, larva, pupa, and adult) and undergoes complete metamorphosis. There have been no studies on its life history; however, the biology is like that of other tiger beetles. *Cicindela* species have a 1-4-year life cycle. Eggs are laid in the summer and larvae hatch and create a burrow in which they remain for up to three years. Tiger beetles typically pass through three larval stages or instars, each of these living in the same burrow. The third instar builds a chamber in the soil and then forms a pupa from which the adult later emerges. These immature stages can withstand flood events, as the beach substrate in which they reside is flooded annually at many sites. Tiger beetles are predators of both larval and adult arthropods. Adults are active during the day and will readily take flight when approached.

Population Sizes and Trends

Cobblestone Tiger Beetle is documented at a minimum of 37 sites in Canada (see **Canadian Range**); the current (as of 2019) Canadian population is estimated at 11,093 - 14,333 adults. Population abundance studies completed in 2007 and 2008 estimated 8,483 - 9,083 adults at the eight sites known at that time. The increase in population is due to additional sites being documented at the Grand Lake Complex and Southwest Miramichi River areas.

No formal population census has been done since 2008 so there are no data available to estimate a population trend. Colonies at all five sites on the Saint John River and all four sites within the Grand Lake Complex recorded between 2003 and 2005 were confirmed in 2014 or later. A large proportion (up to 74%) of potential island habitats for this species on the Saint John River was lost with the construction of the Mactaquac Dam in the 1960s.

Threats and Limiting Factors

In Canada, the distribution of Cobblestone Tiger Beetle is highly fragmented, occurring in small colonies in a specialized and fragile habitat. This results in a high probability of local extirpation at extant sites. The main threats apply to the habitat at the Grand Lake Complex and include cottage development and soil compaction from illegal vehicle use along cobblestone beaches. Because the larvae live in burrows among cobblestones, beach traffic from vehicles may crush burrow sites, cause mortality to individual larvae as well as negatively impact the habitat structure. Observation at one site within the Grand Lake Complex suggests habitat degradation from frequent vehicle use likely caused a decline of beetles within this area. The small size of colonies at some sites and popularity of tiger beetles for natural history collectors makes this species susceptible to over-collecting.

Protection, Status and Ranks

Cobblestone Tiger Beetle was assessed as Endangered by COSEWIC and is listed as such under Schedule 1 of the federal *Species at Risk Act* (SARA) and New Brunswick *Species at Risk Act*. All subpopulations and habitats occur on non-federal land for which the federal SARA does not apply, and to date none of the prohibitions of the New Brunswick *Species at Risk Act* are afforded to the species.

TECHNICAL SUMMARY

Cicindela marginipennis

Cobblestone Tiger Beetle

Cicindèle des galets

Range of occurrence in Canada: New Brunswick

Demographic Information

Generation time	2 – 4 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Yes, inferred < 10% reduction in number of mature individuals over 3 generations (12 years) on Grand Lake Complex based on declining habitat quality.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Yes, suspected < 10% decline in number of mature individuals over 3 generations (12 years) on Grand Lake Complex based on declining habitat quality.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a period including both the past and the future.	Yes, suspected < 10% reduction in total number of mature individuals over 3 generations (12 years) within Grand Lake Complex based on declining habitat quality
Are the causes of the decline a. clearly reversible and b. understood; and c. ceased?	a. No b. Yes, partially c. No Main causes of decline are the slow ingrowth of invasive plants into cobblestone habitat, clearing cobblestone beach habitat for recreational use (e.g., sunbathing), and illegally driving vehicles on cobblestone shorelines thereby resulting in compacted soil and a decline in larval habitat quality and quantity.
Are there extreme fluctuations in number of mature individuals?	Unknown, insufficient data

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	6329 km²
Index of area of occupancy (IAO)	132 km²

Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. Unlikely. The habitat patches appear large enough to support viable subpopulations. b. There is no dispersal between the Grand Lake Complex, Saint John River and Southwest Miramichi River subpopulations; however, there is likely dispersal within these subpopulations.
Number of “locations”*	Not applicable; >21 locations at the Grand Lake Complex if each site has a different applicable threat. There are no significant threats at the Saint John River or Southwest Miramichi River sites.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No. The Saint John River and Southwest Miramichi River subpopulations are inferred to be stable; the Grand Lake Complex habitats have some threats but overall the EOO will likely remain stable.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes. Observed and projected for Grand Lake Complex subpopulations which may be impacted from cottage development. No decline inferred for Saint John River or Southwest Miramichi River subpopulations.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No. The Saint John River and Southwest Miramichi River subpopulations are inferred to be stable; the Grand Lake Complex habitats have some threats and subpopulation abundance may decline (see Threats), but the subpopulation is inferred to remain at these sites.
Is there an [observed, inferred, or projected] decline in number of “locations”*?	Yes, inferred decline in number of locations at the Grand Lake Complex. Main causes of decline differ depending on the site and include the slow ingrowth of invasive plants into cobblestone habitat, clearing cobblestone beach habitat for recreational use (e.g., sunbathing), and illegally driving vehicles on cobblestone shorelines thereby resulting in compacted soil and a decline in larval habitat quality and quantity. Decline not likely at Saint John River or Southwest Miramichi River subpopulations.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, observed, inferred, and projected decline in area, extent, and quality of habitat at the Grand Lake Complex. Main causes of decline differ depending on the site and include the slow ingrowth of invasive plants into cobblestone habitat, clearing cobblestone beach habitat for recreational use (e.g., sunbathing), and illegally driving vehicles on cobblestone shorelines thereby resulting in compacted soil and a decline in larval habitat quality and quantity. Decline not likely at Saint John River or Southwest Miramichi River subpopulations.

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term

Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (plausible ranges)	**N Mature Individuals**
Grand Lake Complex north	487 (2007 census); 986 (2008 census)
Grand Lake Complex south	Estimated 2500-5000 in 2019
Southwest Miramichi River 1	Estimated 10-50 in 2019
Southwest Miramichi River 2	Estimated 100-200 in 2019
Saint John River 1	3991 (2007 census); ~6800 (2008 census)
Saint John River 2	496 (2007 census)
Saint John River 3	estimated to be 100-400 in 2007
Total	11093-14333

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Not applicable, insufficient data

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes. Completed January 30, 2018. Threat impact: Low – Medium

Threats (in order of highest threat).

6.1 Recreational activities – Medium-Low
1.1 Housing and urban areas – Low
7.3 Other ecosystems modifications – Low
9.3 Agricultural & forestry effluents – Unknown
5.1 Hunting & collecting terrestrial animals – Unknown
7.2 Dams and water management/use – Unknown
11.4 Storms & flooding – Unknown

What additional limiting factors are relevant?

- *Habitat specificity:* In Canada, Cobblestone Tiger Beetle lives only on extensive cobblestone beaches, which are limited in area and extent .
- *Specific soil for larval burrow sites*: Larval burrows may be limited by soil substrate and sensitive to ground freezing.
- *Temperature extremes and cover areas*: Surface and ambient temperatures govern tiger beetle activity. Adults are less active at lower temperatures.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Closest population in the United States is 250 km from Canadian sites
Is immigration known or possible?	Not possible
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?[+]	Yes, at habitats within the Grand Lake Complex
Are conditions for the source population deteriorating?[+]	Yes
Is the Canadian population considered to be a sink?[+]	No
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species? Yes. The species is targeted by some beetle collectors.

Status History

COSEWIC: Designated Endangered in November 2008. Status re-examined and designated Special Concern in May 2021.

Status and Reasons for Designation:

Status:	**Alpha-numeric codes:**
Special Concern	Not applicable
Reasons for designation: This distinctive tiger beetle has a small and scattered range within New Brunswick spread over three isolated geographic areas: the Saint John River, the Southwest Miramichi River, and the Grand Lake area. This species' habitat, which is sparsely vegetated cobble and sand beaches on lake shores and riverine islands, is highly fragmented and limited. Up to 74% of potential habitat on the Saint John River was lost with the construction of the Mactaquac Dam in the 1960s. The main threats to the habitat include shoreline modifications from cottage development and soil compaction from ongoing all-terrain vehicle (ATV) recreation within the Grand Lake area. Because the larvae live in burrows among cobblestones, beach traffic from ATVs and other vehicles can crush burrows and cause mortality to individual larvae as well as negatively impact the habitat structure. The shoreline in front of cottages is often modified by removal of vegetation and sometimes levelling, including sand deposition which smothers larval burrows. The improved status of the beetle reflects additional sites discovered, including a new watershed, since the last assessment as well as a change in the interpretation of severe fragmentation. However, the species may become Threatened if threats are not managed with demonstrable effectiveness.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Insufficient data on trends.

[+] See Table 3 in the COSEWIC guidelines for modifying status assessment based on rescue effect

Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Although EOO and IAO are below the threshold for Threatened, and there is a continuing decline projected in quality of habitat, no other sub-criteria are met since it is not severely fragmented, number of locations is >10, and no extreme fluctuations. At some Grand Lake sites there is ongoing shoreline clearing, beach creation (through bulldozing and sand deposition), and sand compaction (due to vehicles driving on habitat). At sites within the Saint John River, fluctuating water levels and excessive erosion are causing changes in the island habitats.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Comes close to meeting Threatened, C1, the Canadian population is 11,093-14,333 adults. The species may decline 10% within 10 years due to cumulative effects of beachfront clearings, ATV use, and natural vegetation succession at some habitats at Grand Lake Complex.
Criterion D (Very Small or Restricted Population): Not applicable. Exceeds thresholds.
Criterion E (Quantitative Analysis): Not applicable. Insufficient data.

PREFACE

Cobblestone Tiger Beetle was first assessed by COSEWIC as Endangered in November 2008 and listed in 2011 as Endangered under Schedule 1 of *Canada's Species at Risk Act*. In 2013 it was listed as Endangered under the New Brunswick *Species at Risk Act*. Since the previous assessment, a large amount of survey work has been conducted on Grand Lake and adjacent lakes (termed the Grand Lake Complex), and the Tobique, Southwest Miramichi, Little Southwest Miramichi, and Northwest Miramichi rivers. The species has been confirmed extant at all sites reported in the 2008 assessment; 21 new sites within the Grand Lake Complex and four new sites on the Southwest Miramichi River. Sites are defined as tiger beetle colonies that occupy discrete portion(s) of cobblestone shoreline; multiple sites within a 10km radius of suitable habitat or 5 km of unsuitable habitat are considered part of the same subpopulation. These new sites more than doubled the index of area of occupancy although the species in New Brunswick is always recorded in specific cobblestone shoreline habitat. The new sites and additional information added to a more thorough understanding of the species' habitat requirements on cobblestone lake shorelines.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS (2021)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment and Climate Change Canada
Canadian Wildlife Service
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The Canadian Wildlife Service, Environment and Climate Change Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Class: Insecta - insects
Subclass: Pterygota – winged insects
Order: Coleoptera – beetles
Family: Carabidae – ground beetles
Subfamily: Cicindelinae – tiger beetles
Genus: *Cicindela*
Subgenus: *Cicindelidia*
Species: *Cicindela* (*Cicindelidia*) *marginipennis* Dejean, 1831

French Common Name: Cicindèle des galets

The taxonomic classification of Cobblestone Tiger Beetle (*Cicindela marginipennis*) follows Bousquet *et al.* (2013). Pearson *et al.* (2015) elevate *Cicindelidia* to the genus level and call Cobblestone Tiger Beetle "*Cicindelidia marginipennis* Dejean" [*sic*]. However, Pearson *et al.*'s (2015) classification is based on an unpublished molecular study cited as "Duran, D.P., and R.A. Gwiazdowski. 2015. Systematic revision of Nearctic Cicindelini (Coleoptera: Carabidae: Cicindelinae): Re-evaluating Rivalier's taxonomy," which has been criticized in the literature (see Jackson (2017)) so is not followed here. No subspecies of *Cicindela marginipennis* are recognized.

Morphological Description

Cobblestone Tiger Beetle has four distinct life stages (egg, larva, pupa, adult) and develops through complete metamorphosis. The morphological characters of Cobblestone Tiger Beetle have been described only for the adult life stage.

<u>Adults:</u>

Cobblestone Tiger Beetle adults (Figure 1 and front cover photo) are 11-14 mm in length and like all tiger beetles, have large mandibles used to capture their prey. Colouration of this species varies, and most individuals can be assigned into one of four colour morphs: i) dark brown to reddish brown with a reddish sheen, ii) dull olive green with a greenish sheen, iii) green to dark green (with greenish sheen), and iv) cobalt blue (Webster 2009). However, the elytra in all colour forms have a narrow continuous cream-coloured lateral border, and the abdomen is bright reddish orange (Figure 1) that is clearly visible during flight.

Figure 1. Adult Cobblestone Tiger Beetle (*Cicindela marginipennis*) in copula. Photo by John Klymko.

The immature stages (egg, larvae, pupae) of this species have not been described but are like other tiger beetle species.

Eggs:

Tiger Beetle eggs are 2-4 mm long and are covered in a sticky layer that apparently allows them to be adhered to a suitable location in the substrate (Pearson and Vogler 2001).

Larvae:

Tiger beetle larvae are grub-like, predaceous, and sedentary; they inhabit vertical burrows in the soil. The larvae are ambush predators and the shape of their head conceals the larvae and burrow entrance from potential prey walking on the soil surface. The top of the head and pronotum together form a flattened disk that creates a plug for their burrow. Larvae have large sickle-shaped mandibles that extend beyond the disk. The dorsal surface of the humped fifth abdominal segment is equipped with two pairs of large hooks that attach to the wall of the tunnel, securing the tiger beetle if the prey attempts to drag the larva from its burrow. See Figure 2.19 in Pearson and Vogler (2001) for a diagram of a typical tiger beetle larva.

Pupae:

The larva pupates in a small chamber constructed at the bottom of the larval tunnel. Pupae are crescent shaped, and many adult features, such as long legs, are evident. See Figure 2.29 in Pearson and Vogler (2001) for a photograph of a typical tiger beetle pupa.

Population Spatial Structure and Variability

The population spatial structure and variability of Cobblestone Tiger Beetle has not been studied in Canada or the United States (U.S.). The closest population in the U.S. is approximately 250 km away in Somerset County, Maine. This range disjunction suggests the Canadian population may be genetically isolated.

There is likely no present-day genetic exchange between sites on the Southwest Miramichi River, Saint John River, and sites within the Grand Lake Complex; they are separated by over 100 km of unsuitable habitat. The Mactaquac Dam was constructed in 1967 which altered the flow regime below the dam and flooded potentially suitable habitat now in the head pond. Prior to dam construction, the river and lake subpopulations may have been separated by as little as 35 km and may have had genetic exchange.

In Canada, adult Cobblestone Tiger Beetles have four colour forms (Webster 2009). The frequency of the four colour forms was investigated during two mark-release-recapture studies (Webster 2008, 2009) and results show the relative frequency of the four colour forms was consistent between the two years for sites on the Saint John River and the Grand Lake Complex. Globally, one of the forms has only been reported from the Saint John River, Grand Lake Complex, and Maine. One different form is found at only one of the subpopulations in Canada (Webster 2009, Mays pers. comm. 2017) and may be genetically unique to this region.

Designatable Units

Cobblestone Tiger Beetle is being assessed in Canada as one designatable unit. There are no subspecies described for Cobblestone Tiger Beetle. The absence of the cobalt blue colour forms within some of the subpopulations suggests they may have been genetically isolated. However there has been no further study or genetic analysis, and thus no further evidence to suggest they represent discrete and evolutionarily significant subpopulations. All Canadian subpopulations fall within the Atlantic National Ecological Area (COSEWIC 2017).

Special Significance

Cobblestone Tiger Beetle is a globally rare species and occurs in isolated subpopulations throughout its Canadian range. The unique colour form found only in Canada adds to the significance of the species. Tiger beetles have long been the study of amateur and professional entomologists due to their attractiveness, diurnal habits, and diversity. Consequently, they have been important models for the study of ecology and evolution (Pearson and Vogler 2001). This species is part of Canadian ecosystems that are important to Indigenous people, who recognize the interconnectedness of all species within the ecosystem.

DISTRIBUTION

Global Range

Globally, Cobblestone Tiger Beetle ranges from southeast Mississippi and Alabama, north from Kentucky to Maine and reaches its northernmost extent in New Brunswick (Ward and Mays 2010; Pearson *et al.* 2015; U.S. Fish and Wildlife Service 2018). The global range is not continuous and occurs in isolated and disjunct subpopulations in eastern North America (Pearson *et al.* 2015) (Figure 2). Choate's (2003) state-level distribution map included South Carolina; however, there is no reference to that state record datum in the associated text suggesting the map may be erroneous. This South Carolina record has not been included in subsequent works (e.g. Pearson *et al.* 2015; U.S. Fish and Wildlife Service 2018; Beaton *et al.* in press) and was considered unconfirmed by Bousquet (2012).

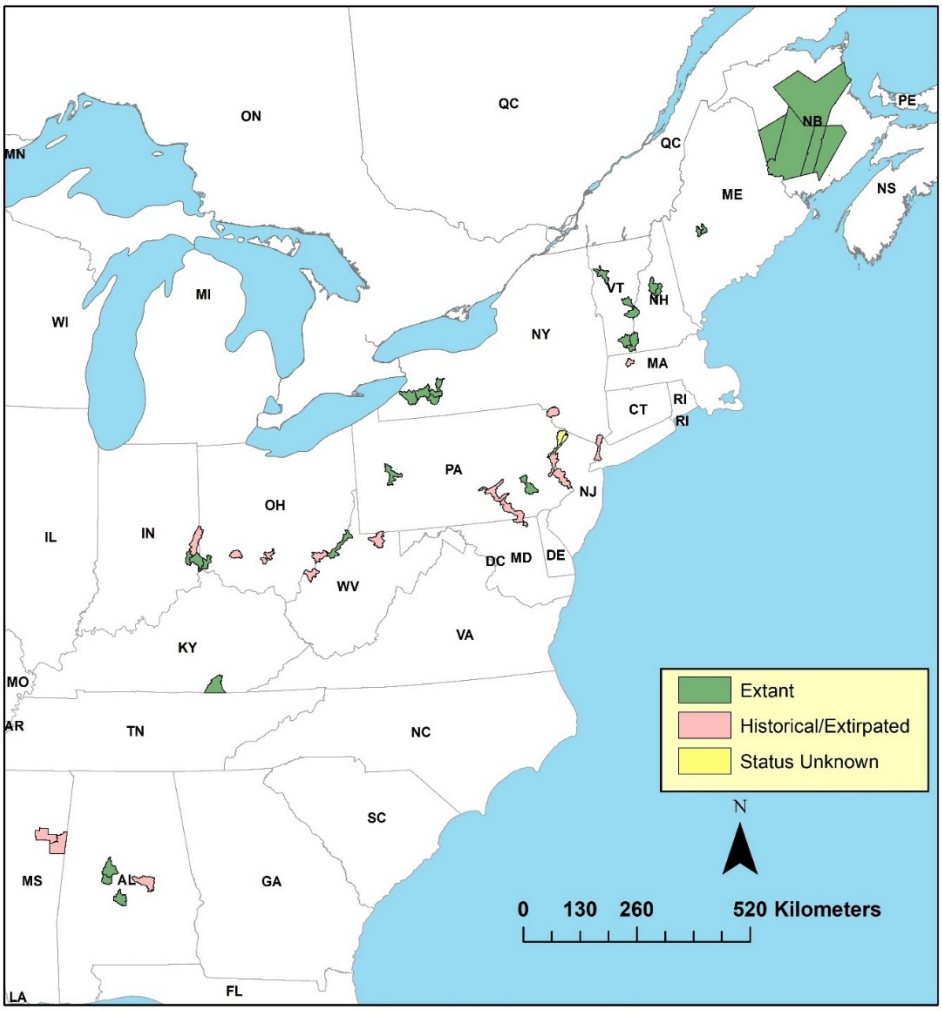

Figure 2. Global distribution of Cobblestone Tiger Beetle (*Cicindela marginipennis*). Displayed by county in New Brunswick (although county sizes are larger in New Brunswick and not reflective of the area occupied by the species), Kentucky, and Mississippi, and USGS 10-digit Hydrologic Unit Code HUC (HUC10) watershed elsewhere. American county data modified from U.S. Fish and Wildlife Service (2018).

Canadian Range

In Canada the Cobblestone Tiger Beetle only occurs in New Brunswick (Sabine 2004; Webster 2006). The species is known from seven subpopulations in three separate geographic areas: Saint John River, Southwest Miramichi River, and Grand Lake Complex. The three subpopulations in the islands of the Saint John River area are composed of five sites, the two subpopulations on the Southwest Miramichi area are composed of four sites, and the two subpopulations within the Grand Lake area are composed of 27 sites (collectively called the Grand Lake Complex) (Figure 3) (Sabine 2004; Webster 2006; ACCDC 2019). A previous report from Quebec is erroneous (Sabine 2004). Less than 5% of the global range is in Canada.

Cobblestone Tiger Beetle occurs in colonies that occupy discrete portions of cobblestone shoreline and in this report are referred to as sites. Subpopulations include sites within a five kilometre radius or less of unsuitable habitat or 10 kilometres or less of suitable habitat. This separation is recommended for the delineation of element occurrences by NatureServe (2017). For non-migratory species, element occurrences are modeled after the International Union for the Conservation of Nature (IUCN) definition of subpopulations, which are geographic areas wherein a species exists, and between which there little gene flow (typically the annual migration of less than one individual or gamete per year) (IUCN 2001; Master *et al.* 2009). COSEWIC's concept of a subpopulation is similarly based on the IUCN model.

Locality data associated with the Canadian range of Cobblestone Tiger Beetle are considered sensitive and are not included in this status report. Site descriptions are left vague, and specific information is provided in a separate data-sensitive appendix (Appendix 1).

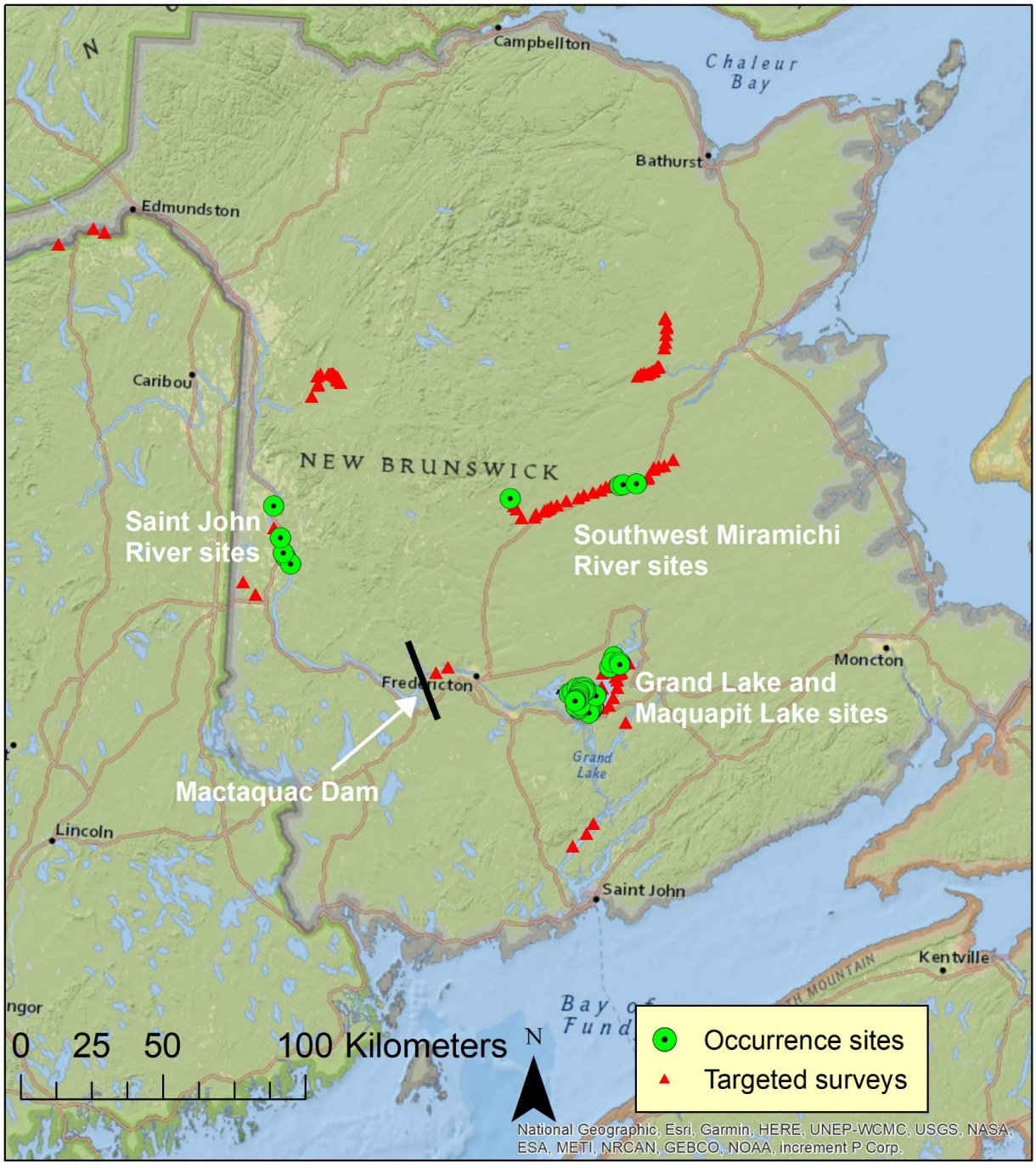

Figure 3. Distribution of Cobblestone Tiger Beetle (*Cicindela marginipennis*) in New Brunswick, Canada.

Extent of Occurrence and Index of Area of Occupancy

Cobblestone Tiger Beetle extent of occurrence (EOO) in Canada is 6329 km^2 measured using a minimum convex polygon encompassing the extant sites. The index of area of occupancy (IAO) is 132 km^2 (33 grid squares), based on a 2 km x 2 km grid over these same sites.

The biological area of occupancy was calculated by estimating the spatial extent of habitat use by the species (based on observational data from Sabine 2004; Webster 2006; ACCDC 2019) at each site and aerial photographs. This area is estimated at 0.85 km^2 (Saint John River = 0.75 km^2, Grand Lake Complex = 0.12 km^2, Southwest Miramichi River = 0.024 km^2).

Search Effort

Cobblestone Tiger Beetle was first recorded in Canada in 2003 from New Brunswick (Sabine 2004; Webster 2006; ACCDC 2019). This first record prompted intensive surveys during 2004, 2005, and 2006. Over these three field seasons, 62 sites were surveyed (42 in the Grand Lake Complex, 14 on islands and shoreline habitats on the Saint John River, two on the Meduxnekeag River, and four on the Southwest Miramichi River) (Webster 2006). During these surveys, colonies were found on three beaches of the Grand Lake Complex and five islands on the Saint John River. The species was first recorded on the Southwest Miramichi River in 2019. Specific survey sites and detailed habitat information are considered sensitive data and included in Appendix 1. Below is a summary of search effort since the first Cobblestone Tiger Beetle COSEWIC (2008) status report and summarized in Table 1.

Table 1. Summary of information for Cobblestone Tiger Beetle (*Cicindela marginipennis*), at each subpopulation and site. Grand Lake and Maquapit Lake sites are collectively called the Grand Lake Complex throughout the status report; however, in this summary table they are separated. (n/a = no data)

Sub-pop'n	Site Name	Number of adult beetles recorded during surveys	Habitat, threats information (when available) and length of occupied habitat during surveys	2007 pop'n est.	2008 pop'n est.
Grand Lake south/ Maquapit Lake	Grand Lake Site 1	2005: 5 on 28 July on a 100m transect (Webster 2006). 2007: 2 on 23 July in a 100m transect (Webster 2008). 2013, 2015 and 2016: none over 11 visits on eight dates, totalling 593 surveyor minutes (Klymko 2014; Klymko *et al.* 2016; Klymko and Robinson 2016). 2017: 1 on July 16 and 120 minutes, one surveyor (Bell pers. comm. 2017). It is unclear if a population has existed here since 2005 (year first recorded) (Webster 2006) or if the individual found in 2017 was an immigrant. 2018: none on 1 August over 90 minutes, one surveyor (Klymko pers. comm. 2018).	High cobble and gravel beach, some areas with exposed bedrock and sparsely vegetated with Hemp Dogbane (*Apocynum cannabinum* L.), Meadow-Sweet (Spiraea alba Du Roi), and willow (*Salix* sp.) backed by undisturbed forest with Red Maple (*Acer rubrum* L.), American Elm (*Ulmus americana* L.), Trembling Aspen (*Populus tremuloides* Michx.), Eastern White Cedar (*Thuja occidentalis* L.), and White Pine (*Pinus strobus* L.). Some stretches with Sweet-Fern (*Comptonia peregrina* (L.) Coult.) in upper beach. Section of beach where beetles observed approximately 460m.	n/a	n/a
Grand Lake north	Grand Lake Site 2	2004: 26 on a 100m transect on 17 and 26 August (Webster 2006). 2005: 31 on a 100m transect 26 July (Webster 2006). 2007: 8 on 24 July, 3 on 7 August, both dates entire site surveyed (Webster 2008) 2008: 7 on 30 July, entire site surveyed (Webster 2009). 2013: None with search effort of 4 visits and 154 surveyor minutes (Klymko 2014). 2015: 2 in copula after four visits and 373 surveyor minutes (Klymko *et al.* 2016). 2016: 15 on 20 July (100 surveyor minutes); none on 4 August with 80 surveyor minutes (Klymko and Robinson 2018). 2018: 10 on 26 July within 10 survey minutes with two people looking under flat pieces of cobble in rainy weather (ACCDC 2018).	Small island narrowly connected to land by a peninsula at normal summer water levels, high cobble beach around small vegetated area with mature Red Oak (*Quercus rubra* Michx) , mature but dying spruce (*Picea* sp.), small White Ash (*Fraxinus americana* L.), and Speckled Alder (*Alnus incana* (L.) Moench). Cobble sparsely vegetated with Prairie Cord Grass (*Sporobolus michauxianus* (Hitchcock) P.M. Peterson & Saarela [=*Spartina pectinata* Bosc ex Link)]), Blue Flag, and willow. Section of beach where beetles observed at normal summer water levels more than 200m of suitable cobble beach available on the northeast facing side of the peninsula, and more than 100m of beach on the south facing side of the peninsula (Klymko 2014). Threat information: ATV tracks noted in 2005, 2007 (both visits), 2008, 2013, 2015, 2016 and 2018	14	n/a

Sub-pop'n	Site Name	Number of adult beetles recorded during surveys	Habitat, threats information (when available) and length of occupied habitat during surveys	2007 pop'n est.	2008 pop'n est.
Grand Lake north	Grand Lake Site 3	2004: 35 in a 100m transect (Webster 2006) 2005: 109 in a 100m transect (Webster 2006) 2013: 9 on 22 July with two surveyors looking for 20 minutes (40 surveyor minutes); 0 on 23 July with two surveyors looking for 25 minutes (50 surveyor minutes); "several" on 25 July with 3 surveyors looking for 10 minutes (30 surveyor minutes); 3 on 7 August with one surveyor looking for 20 minutes; 3 on 13 August with one surveyor looking for 45 minutes (Klymko 2014) 2015: 6 on 16 July with one surveyor looking for 44 minutes; 12 on 23 July with three surveyors looking for 12 minutes (36 surveyor minutes); 3 on 27 July with three surveyors looking for 10 minutes (30 surveyor minutes); 16 on 5 August with five surveyors looking for 22 minutes (110 surveyor minutes); 3 on 11 August with two surveyors looking for 22 minutes along a 311m transect (44 surveyor minutes); 0 on 13 August with one surveyor looking for 50 minutes; 3 on 14 August with two surveyors looking for 7 minutes (14 surveyor minutes) (Klymko *et al.* 2016). 2016: 51 on 20 July with two surveyors looking for 20 minutes along a 311m transect (40 surveyor minutes); 23 on 3 August with two surveyors looking for 19 minutes along a 311m transect (38 surveyor minutes) (Klymko and Robinson 2018). 2018: "common" on 31 July (ACCDC 2018)	High cobble beach with boulders and bedrock, sparsely vegetated with Meadow-Sweet, Hemp Dogbane, Blue Flag, Sage Wormwood (*Artemisia campestris* L.), and Canada Tick-Trefoil (*Desmodium canadensis* (L.) D.C.). Sweet-Fern common on upper beach. Beach backed by undisturbed White Pine, Jack Pine, Red Oak, Red Maple, and Trembling Aspen forest. (Klymko 2014). Section of beach where beetles observed is approximately 340m.	473	986

Sub-pop'n	Site Name	Number of adult beetles recorded during surveys	Habitat, threats information (when available) and length of occupied habitat during surveys	2007 pop'n est.	2008 pop'n est.
Grand Lake north	Grand Lake Site 4	2003: site first recorded in Canada, 8 found by one surveyor on 9 August, 13 found by four surveyors on 20 August (Sabine 2004) 2004: seven site visits failed to detect beetles (Webster 2006) 2013: 2-6 on 22 July with two surveyors looking for 30 minutes (60 surveyor minutes). Five subsequent visits, with 170 surveyor minutes, failed to produce additional records (Klymko 2014) 2014: 3 on 18 July with 5 surveyors looking for 71 minutes (355 surveyor minutes); 0 on 24 July with 4 surveyors looking for 66 minutes (264 surveyor minutes); 3 on 31 July with 3 surveyors looking for 36 minutes (108 surveyor minutes); 4 on 12 August with 4 surveyors looking for 33 minutes (132 surveyor minutes); 1 on 20 August with 3 surveyors looking for 30 minutes (90 surveyor minutes); 12 on 21 August with 2 surveyors looking for 120 minutes (240 surveyor minutes) (O'Malley pers. comm. 2018) 2015: 1 on 16 July with one person surveying for 30 minutes; 2 on 5 August with one person surveying for 44 minutes, 0 on 11 August with one person surveying for 20 minutes (Klymko *et al.* 2016) 2018) 2016: 3 on 20 July with one person surveying for 20 minutes; 0 on two other surveys with 64 surveyor minutes (Klymko and Robinson 2018) 2018: 40 with three people surveying for 6 minutes (18 surveyor minutes) (ACCDC 2018).	Low cobble and sand substrate backed by willow thicket and high sand and gravel beach. Sparsely vegetated with Prairie Cord Grass, New York Aster, Sagewort Wormwood, and willow (Klymko 2014). Section of beach where beetles observed approximately 100 m.	n/a	n/a
Grand Lake north	Grand Lake Site 5	2016: 8 within 70 minutes with 3 observers (Klymko and Robinson 2018) 2018: 40 beetles within 120 survey minutes (ACCDC 2018)	Cobble beach with scattered vegetation including flatsedges (*Cyperus* spp.) and Swamp Candle. The beach is backed by a lagoon and Red Maple forest. Section of beach where beetles observed is approximately 105m. No development near this beach, vehicle tracks and small dirt road that terminates at the site (Klymko and Robinson 2018).	n/a	n/a
Grand Lake north	Grand Lake Site 6	2018: 5 on 12 July by 45 survey minutes (ACCDC 2018)	High cobble beach sparsely vegetated with Swamp Candle, American Water Horehound (*Lycopus americanus* Muhl. ex W. Bart.), Prairie Cord Grass, and Blue Flag. Beach backed by Red Oak forest with Silver Maple (*Acer saccharinum* L.) along the shore. Section of beach where beetles observed approximately 40m	n/a	n/a

Sub-pop'n	Site Name	Number of adult beetles recorded during surveys	Habitat, threats information (when available) and length of occupied habitat during surveys	2007 pop'n est.	2008 pop'n est.
Grand Lake south/ Maquapit Lake	Grand Lake Site 7	2005: None on 4 August (Webster 2006) 2018: 15 over 80 survey minutes (ACCDC 2018)	High cobble beach, portions with bedrock, a fair bit of gravel and sand and sparsely vegetated with Prairie Cord Grass, Swamp Candle, New York Aster, and Meadow-Sweet. Backed by White Pine, Eastern Hemlock (*Tsuga canadensis* (L.) Carr.), and Red Oak forest. Section of beach where beetles observed is approximately 550m. Threat information: Several cottages and RV trailers behind beach; beach appears undisturbed.	n/a	n/a
Grand Lake south/ Maquapit Lake	Grand Lake Site 8	2018: minimum of 30 on 24 July by two observers on a 200m transect (ACCDC 2018)	High cobble beach with gravel and sand, sparsely vegetated with New York Aster, Prairie Cord Grass, Canadian Mint (*Mentha canadensis* L.), and Swamp Candles, backed by sparse Silver Maple and American Elm. The beach habitat exhibits little sign of disturbance, but the habitat above the beach is sparsely treed, with clearings for recreational vehicle camping.	n/a	n/a
Grand Lake south/ Maquapit Lake	Grand Lake Site 9	2018: 10 on 18 July in 45 survey minutes (ACCDC 2018)	High cobble beach with abundant sand, scattered willow, Sand Cherry (*Prunus pumila* L.), Blue Flag, Indian Hemp, New York Aster, Prairie Cord Grass, and Canada Tick-Trefoil. Backed by cottage with manicured lawn and Sugar Maple (*Acer saccharum* Marsh.). Section of beach where beetles observed is approximately 30m. Threat information: ATV tracks on the beach, adjacent beach is disturbed, particularly to the south where the beach is cleared of vegetation and there is heavy ATV damage.	n/a	n/a
Grand Lake south/ Maquapit Lake	Grand Lake Site 10	2005: None on 28 July (Webster 2006) 2018: 100s on 16 July within 60 survey minutes (ACCDC 2018)	Beach with small cobble and sand at the tip of Indian Point, a 700m gravel bar which is sparsely vegetated with New York Aster, willow, Sage Wormwood, and Prairie Cord Grass. Beach backed by open gravel with Sage Wormwood, Common St. John's-wort (*Hypericum perforatum* L.), and Sand Cherry. Section of beach where beetles observed is approximately 100m. Habitat with beetles showed no signs of disturbance, but area behind beach an open gravel area with heavy ATV compaction.	n/a	n/a

Sub-pop'n	Site Name	Number of adult beetles recorded during surveys	Habitat, threats information (when available) and length of occupied habitat during surveys	2007 pop'n est.	2008 pop'n est.
Grand Lake south/ Maquapit Lake	Grand Lake Site 11	2005: none on by 28 July by 2 observers (Webster 2006) 2018: 10 on 16 July within 30 survey minutes (ACCDC 2018).	Narrow sand and gravel beach with scattered *Salix* and small graminoids and backed by Prairie Cord Grass and *Salix* thicket. Section of beach where beetles observed is approximately 130m. Threat information: light foot traffic	n/a	n/a
Grand Lake south/ Maquapit Lake	Grand Lake Site 12	2004: no beetles observed 1 July and 18 August (Webster 2006). 2018: "dozens" on 16 July within 60 survey minutes (ACCDC 2018)	Disturbed gravel and sand beach with no cobble and patches of Prairie Cord Grass, Meadow-Sweet, sedges (*Carex* spp.), and Sand Cherry backed by low Red Oak, Red Ash (*Fraxinus pennsylvanica* Marsh.), Grey Bird (*Betula populifolia* Marsh.), and Red Maple forest. Section of beach where beetles observed is approximately 170m. Habitat had been created by clearing vegetation (adjacent habitat of similar slope, substrate, and elevation is forested). Ongoing disturbance from vehicles at this site is at least partly responsible for it not becoming revegetated.	n/a	n/a
Grand Lake south/ Maquapit Lake	Grand Lake Site 13	2005: 1 on 28 July (Webster 2006) 2013: 2 on 25 July with three surveyors looking for 50 minutes (150 surveyor minutes); 0 beetles on two other site visits with 140 surveyor minutes (Klymko 2014) 2015: 0 beetles over three site visits with 111 surveyor minutes (Klymko *et al.* 2016) 2016: 2 on 20 July with four surveyors looking for 40 minutes (160 surveyor minutes); 0 on 4 August with four surveyors looking for 30 minutes (120 surveyor minutes) (Klymko and Robinson 2018) 2018: 2 on 27 July with three surveyors looking for 15 minutes (45 surveyor minutes) (ACCDC 2018)	High cobble beach with exposed bedrock and sparsely vegetated with Sagewort Wormwood, New York Aster, Canadian Mint Blue Flag, and the upper section with Sweet-Fern. Site backed by undisturbed Red Pine (*Pinus resinosa* Ait.), White Pine, Jack Pine (*P. banksiana* Lamb), Red Maple, and birch (*Betula* sp.) woods. Section of beach where beetles observed is approximately 140m.	n/a	n/a
Grand Lake south/ Maquapit Lake	Maquapit Lake Site 1	2018: "hundreds" of beetles on 20 July 140 survey minutes (ACCDC 2018)	High cobble and sand beach with scattered Prairie Cord Grass, American Water Horehound, and New York Aster; backed by Trembling Aspen and Red Oak forest. Section of beach where beetles observed is approximately 420m. Threat information: beach backed by two cottages, each with a boat launch that crosses the beach, otherwise beach is undisturbed.	n/a	n/a

Sub-pop'n	Site Name	Number of adult beetles recorded during surveys	Habitat, threats information (when available) and length of occupied habitat during surveys	2007 pop'n est.	2008 pop'n est.
Grand Lake south/ Maquapit Lake	Maquapit Lake Site 2	2018: 12 on 20 July in 30 survey minutes (ACCDC 2018).	High cobble beach, with bedrock, sand, and boulders; sparsely vegetated with Grass-leaved Goldenrod (*Euthamia graminifolia* (L.) Greene), Prairie Cord Grass, Canadian Mint, and Swamp Candle sp. Backed by Red Oak and Grey Birch woods. Section of beach where beetles observed is approximately 140m. Threat information: habitat is adjacent to groomed beach, backed by cottages and vehicular damage to the substrate is extensive in some areas.	n/a	n/a
Grand Lake south/ Maquapit Lake	Maquapit Lake Site 3	2018: 20 on 20 July within 100 survey minutes (ACCDC 2018).	Very wide cobble beach with lots of sand and gravel; sparsely vegetated with Spartina, Indian hemp, Swamp Candles, and Sage Wormwood; backed by White Pine and Red Oak forest. Section of beach where beetles observed is approximately 360m. Threat information: habitat backed by many cottages, one ATV track across the entire site.	n/a	n/a
Grand Lake south/ Maquapit Lake	Maquapit Lake Site 4	2018: 10 on 16 July in 60 survey minutes (ACCDC 2018). 2018: 'dozens' on 25 July in 60 survey minutes	Sand and gravel barrier and high cobble beach approximately 900m, with scattered Swamp Candles, Indian Hemp, and New York Aster. Backed by mixed forest. Threat information: several cottages at the eastern end of beach. Most of this site is backed by the Pickerel Pond Nature Reserve, which is owned by the Nature Trust of New Brunswick, only disturbance observed on the beach was from foot traffic.	n/a	n/a
Grand Lake south/ Maquapit Lake	Maquapit Lake Site 5	2018 (ACCDC 2018) Four beetles in 20 survey minutes 25 July 2018.	Medium height cobble and sand beach with scattered Swamp Candles, Prairie Cord Grass. Backed by *Quercus rubra*, Silver Maple, and *Tsuga canadensis* forest. Section of beach where beetles observed is approximately 45m and no damage evident.	n/a	n/a
Grand Lake south/ Maquapit Lake	Maquapit Lake Site 6	2018: 'hundreds' on 25 July by four observers (ACCDC 2018).	High cobble beach with sand and boulders, sparsely vegetated with Prairie Cord Grass, Swamp Candles, Toothed Flatsedge (*Cyperus dentatus* Torr.) and Meadow-Sweet. Backed by Red Oak forest. Section of beach where beetles observed is approximately 250m. Threat information: No damage to the beach habitat was evident.	n/a	n/a

Sub-pop'n	Site Name	Number of adult beetles recorded during surveys	Habitat, threats information (when available) and length of occupied habitat during surveys	2007 pop'n est.	2008 pop'n est.
Grand Lake south/ Maquapit Lake	Maquapit Lake Site 7	2018: 'dozens of beetles' on 25 July by four observers (ACCDC 2018)	High cobble beach with sand and gravel, sparsely vegetated with Prairie Cord Grass, Swamp Candles, Toothed Flatsedge, and Meadow-Sweet. Backed by Red Oak forest. Section of beach where beetles observed is approximately 110m. Threat information: No damage to the beach habitat was evident.	n/a	n/a
Grand Lake south/ Maquapit Lake	Maquapit Lake Site 8	2018: 8 on 20 July in 60 survey minutes. (ACCDC 2018)	Cobble beach sparsely vegetated with Prairie Cord Grass, New York Aster, Common St. John's-wort, and American Water Horehound; in front of trailer campsite with Silver Maple, Red Oak, and birch forest. Section of beach where beetles observed is approximately 60 m, most beetles observed in southern half of site. Threat information: Beach heavily disturbed by ATV use in the same section where beetles observed.	n/a	n/a
Saint John River 1	Saint John River Site 1	2005: 148 on a 250m transect on 23 August 2005 (Webster 2016) 2014: 12 on 21 August with 2 surveyors looking for 120 minutes (240 surveyor minutes) (O'Malley pers. comm. 2017) 2015: 23 July (65 beetles), 30 (34), August 7 (56), 13 (7), and August 20 none observed. All surveys done on 250m transect (O'Malley pers. comm. 2017) 2018: Common on 2 July 2018 (ACCDC 2018)	High cobble beach on up-river end of island; patches of Indian Hemp and scattered Balsam Poplar (*Populus balsamifera* L.) (Webster 2006). Situated on Middle Becaguimec Island and owned by the Nature Trust of New Brunswick. Threat information: In the summer of 2017, lower water levels made the island accessible by ATV; two ATVs were observed on the island's shoreline. They left after being asked to do so by a Nature Trust of New Brunswick steward who happened to be canoeing nearby (Dowding, pers. comm. to J. Klymko 2018).	2740	n/a
Saint John River 1	Saint John River Site 2	2005: 7 on a 50m transect (Webster 2006) 2015: 5 on 31 July on a 310m transect (O'Malley pers. comm. 2017)	Small high cobble beach on up-river end of island; patches of Indian Hemp and scattered Balsam Poplar (Webster 2006). Situated on Lower Becaguimec Island and owned by New Brunswick Power. Threat information: On August 23, 2005 discharge from a poultry farm was noted from a site near Hartland (Webster 2006). Cobblestones along shoreline and gravel under water coated with a 0.5 cm layer of organic material, air smelled of poultry manure. Dead mussels observed on the river bottom. It was not clear if this was the result of a large one-time discharge or a chronic problem.	400* (estimate made on a cool, cloudy day; may not be accurate)	3182

Sub-pop'n	Site Name	Number of adult beetles recorded during surveys	Habitat, threats information (when available) and length of occupied habitat during surveys	2007 pop'n est.	2008 pop'n est.
Saint John River 1	Saint John River Site 3	2005: 48 on a 200m transect (Webster 2006) 2015: 29 and 8 were seen on 30 July and 13 August, respectively, both times on a 210m transect (O'Malley pers. comm. 2017)	Extensive high cobble beach on up-river end of island; patches of Indian Hemp and scattered Balsam Poplar (Webster 2006). Situated on Becaguimec Island, owned by New Brunswick Power and habitat under a stewardship agreement with the Nature Trust of New Brunswick.	851	933
Saint John River 2	Saint John River Site 4	2005: 189 (Webster 2006) 2018: Approximately 10 in 90 survey minutes (ACCDC 2018)	Extensive high cobble beach on up-river end of island; patches of Indian Hemp, and scattered Balsam Poplar (Webster 2006). Situated on Lower Presque Isle Island and owned by the Nature Trust of New Brunswick.	496	n/a
Saint John River 3	Saint John River Site 5	2005: 14 (Webster 2006) 2014: 3 on 23 August with 2 surveyors looking for 60 minutes (120 surveyor minutes) (O'Malley pers. comm. 2017)	Extensive high cobble beach on up-river end of island; patches of Indian Hemp, and scattered Balsam Poplar (Webster 2006). Situated on Green Island, owned by the Nature Trust of New Brunswick. In 2014, Green Island Nature Preserve received designation as a Class II Protected Natural Area (PNA) under the province of New Brunswick's PNA Act.	n/a	n/a

Grand Lake Complex search effort:

In 2013, 2015, and 2016, surveys were conducted to delimit the boundaries for the three known sites in the Grand Lake Complex for the purposes of describing critical habitat in the federal recovery strategy (Klymko 2014; Klymko *et al.* 2016; Klymko and Robinson 2018). These surveys consisted of walking in a meandering pattern through habitats to confirm presence and walking within a 1 km radius of known occurrences to detect dispersing adults.

- Surveys failed to detect beetles at one of these sites (11 visits, eight dates, totalling 9.9 surveyor hours). However, on 16 July 2017, one beetle was recorded after two hours of surveying (Bell pers. comm. 2017). It is unknown if beetles have persisted at this site since it was first recorded in 2005.
- Beetles were recorded at the second of the three sites in 2015 and 2016, but not 2013.
- Beetles were recorded at the third site in 2013, 2015 and 2016.
- A fourth site had been surveyed approximately 1 km north of the most southerly site in 2005 and one beetle had been recorded during this survey. However, it was assumed the beetle was from a nearby site where numerous beetles were detected, so it was not considered a site (e.g. COSEWIC 2008). Beetles were recorded at this site in 2013 (2 beetles) and 2016 (2 beetles), but not 2015. This site is now considered extant.

Cobblestone Tiger Beetle was found during surveys in 2013, 2015 and 2016 at the site where it was first recorded in Canada in 2003 (Sabine 2004). Extensive surveying in 2004 had failed to detect beetles there, and it was assumed those present in 2003 had emigrated from a nearby site. For this reason, the site where the beetle had been initially recorded in Canada was not considered to support a subpopulation in the previous COSEWIC assessment (COSEWIC 2008) or in the species' recovery strategy (Environment Canada 2013).

During the 2013, 2015, and 2016 surveys (126 surveyor hours) were spent searching for Cobblestone Tiger Beetle within the 1 km of known sites on Grand Lake. Approximately 10.6 km of cobble shoreline was surveyed. These surveys produced no additional observations other than those listed above (Klymko unpubl. data).

During the 2015 and 2016 surveys, three sites away from the designated survey area (approx. 1.9km of shoreline) were surveyed over two visits and 11 hours 30 minutes (Klymko unpubl. data). Eight adults were recorded at one site on the second visit (Klymko and Robinson 2018). This specific portion of beach did not appear to be high quality habitat and had not been surveyed in 2016 (Klymko unpubl. data) or on 17 August 2004 (Sabine pers. comm. 2016).

In 2018 surveys took place over 14 days and 65 km of shoreline, which is most of the habitat available on these lakes. Surveys were conducted by one to four observers and totaled 137 surveyor hours. During this inventory work, 15 additional Cobblestone Tiger Beetle sites were recorded, each with at least four adults observed in a single survey event or at least one beetle seen on multiple dates. Three of these sites had been previously surveyed in 2004 and 2005 with null results. One of the sites surveyed on two dates in 2004 (with null results) had more than 50 beetles recorded in 2018.

In 2019, surveys took place over 10 days and covered 33 km of shoreline, including 12 km not surveyed in 2018. Surveys were conducted by two to four observers and totaled 101 surveyor hours. Cobblestone Tiger Beetle was found at all but one site recorded in 2018, and at four sites that had not been surveyed before. Two additional sites were confirmed in 2019: a single beetle was also found at a Grand Lake site where two beetles were found in 2018, and 13 were found at a site on Maquapit Lake where two beetles were found in 2018. Survey work is detailed in ACCDC (2019)

Given the level of coverage in 2018 and 2019, it is assumed that most sites in the Grand Lake Complex have been documented.

Saint John River search effort:

In 2014 and 2015 four of the five islands on the Saint John River were resurveyed and beetles confirmed (O'Malley pers. comm. 2017); the fifth island was confirmed in 2018 (ACCDC 2019). In 2015, an additional two sites on the Saint John River were surveyed but no beetles were recorded (O'Malley pers. comm. 2017). These had previously been surveyed in 2003 with null results (ACCDC 2019). One of the five islands (SJR #3) was

surveyed and confirmed in 2019; approximately 10 adult beetles were observed on August 13, 2019 over two hours of wandering transects by three surveyors (Heron pers. obs. 2019; M. Sabine pers. obs. 2019). A second of the five islands (SJR #2) was surveyed on September 19, 2019 by multiple observers; at least a dozen beetles were observed on this date (Klymko pers. comm. 2021).

Southwest Miramichi River search effort:

In 2019, New Brunswick's Southwest Miramichi River was surveyed for Cobblestone Tiger Beetle (Klymko and Earle 2019). Surveys were done by two observers over seven days between July 11 and July 26. Thirty-five (35) islands were visited for total of 14.8 hours (29.6 surveyor hours). Cobblestone Tiger Beetles were recorded at 4/35 islands (Island 1: 1 – 2 detected; 4 – 37 recorded at the other three islands).

Other search effort:

In 2019, the Wapske, Tobique, Northwest Miramichi, and Little Southwest Miramichi rivers (in New Brunswick) were surveyed for Cobblestone Tiger Beetle. Two surveyors spent one day on each river between 9 and 25 July, and in total 47 islands were surveyed for a total of 10.75 hours (21.5 surveyor hours). Though some seemingly suitable habitat was observed, particularly on the Northwest Miramichi, and Little Southwest Miramichi rivers, no Cobblestone Tiger Beetles were recorded.

The specific habitat requirements of Cobblestone Tiger Beetle appear to limit the species' potential habitat in Canada. Search effort, specific habitat requirements and limited habitat availability, popularity amongst entomologists (e.g., people like to survey for tiger beetles) suggest Cobblestone Tiger Beetle is not likely to be recorded outside of New Brunswick. The beetle occurs in northern New Hampshire (Dunn and Wilson 1979) and numerous Coleopterists have searched for the beetle in southern Quebec and Ontario with the possibility of it being in these provinces. However, no beetles have been recorded (Bousquet 2012; Bousquet *et al.* 2013).

HABITAT

Habitat Requirements

Cobblestone Tiger Beetle occurs on cobblestone beaches on vegetated islands of the Saint John River (Webster 2006) and Southwest Miramichi River (Klymko and Earle 2019), and similar habitats on lakeshores and river margins in the Grand Lake Complex (Sabine 2004; Webster 2006; COSEWIC 2008; ACCDC 2019). All Cobblestone Tiger Beetle habitats are subject to a natural regime of spring floods that appears integral to maintaining the species' open habitat. These conditions exist on large rivers and lakes that have water levels that fluctuate with large rivers. Extensive open cobble of round stones exists only on those large rivers within a landscape of glacial overburden. Although these conditions are not confined to New Brunswick, they are not widespread in eastern Canada.

Grand Lake Complex habitats:

Cobblestone Tiger Beetle habitat includes ice-scoured beaches of cobble and sand with sparse vegetation. The amount of bedrock ledge, large boulders, and sand varies between sites (Figures 4 and 5). Gravel and sand patches occur amongst the cobble and some sites have some sandy beach areas (variable sizes) that appear to not regularly flood. Sites recorded in 2018 (ACCDC 2019) are adjacent to developed lots with permanent cottages or trailers. One new site recorded in 2018 (ACCDC 2019) is a gravel beach created when vegetation had been cleared and adjacent habitat of similar slope, substrate, and elevation is forested. Ongoing vehicular disturbance likely limits vegetation regrowth.

Figure 4. Cobblestone beach on Grand Lake where there is a Cobblestone Tiger Beetle (*Cicindela marginipennis*) colony. Note the bedrock and boulders. Photo by John Klymko, August 7, 2013.

Figure 5. Cobblestone beach on Grand Lake where there is a Cobblestone Tiger Beetle (*Cicindela marginipennis*) colony. Note the absence of boulders and bedrock, and large amount of sand. Photo by John Klymko, August 6, 2013.

Areas where tiger beetles are most abundant tend to be adjacent to undeveloped shoreline (e.g., no homes or cabins in the adjacent habitat), typically mixed forest with varying amounts of Red Maple (*Acer rubrum* L.), Red Oak (*Quercus rubra* Michx.), Trembling Aspen (*Populus tremuloides* Michx.), Red Pine (*Pinus resinosa* Ait.), Jack Pine (*Pinus banksiana* Lamb), and White Pine (*Pinus strobus* L.), or willow (*Salix* spp.). Other vegetation includes Swamp Candle (*Lysimachia terrestris* (L.) B.S.P.), Prairie Cord Grass (*Sporobolus michauxianus* (Hitchcock) P.M. Peterson & Saarela [=*Spartina pectinata* Bosc ex Link]), New York Aster (*Symphyotrichum novi-belgii* L.), Field Wormwood (*Artemisia campestris* L.), and Hemp Dogbane (*Apocynum cannabinum* L.).

The extent of suitable habitat at occupied habitats varies from 50 m - 950 m length of beach front and 5-30 m wide (width being the distance from the water's edge to the forest or thicket behind the beach) during summer months. Seasonal water levels, ice and wind scour create and maintain the open habitat necessary for Cobblestone Tiger Beetle (Sabine 2004). This habitat is considered unique; there are no other examples (other than these habitats) where the beetle occurs away from riverine habitat.

Saint John River habitats:

Sites for Cobblestone Tiger Beetle on the Saint John River (Figure 6) are on larger treed islands within the river with high cobblestone beach on the upstream end of the islands (Webster 2006) (Figure 6). Fine sand and gravel occur between cobblestones and vegetation covers less than 50% of the beach. Habitats flood during the spring and rarely after heavy summer rains. Beetles are most numerous along the upstream end of the islands, but occasionally occur in other areas on the islands with suitable habitat.

Figure 6. Cobblestone beach on an island on the Saint John River where there is a Cobblestone Tiger Beetle (*Cicindela marginipennis*) colony. Photo by John Klymko, August 10, 2016

Vegetation within these cobblestone habitats includes Hemp Dogbane (*Apocynum cannabinum* L.), widely scattered Balsam Poplar shoots (*Populus balsamifera* L.), and Sandbar Willows (*Salix interior* Rowlee). All occupied islands have a mix of hardwoods including Balsam Poplar (*Populus balsamifera* L.), Silver Maple (*Acer saccharinum* L.), Sugar Maple (*Acer saccharum* Marsh), Butternut (*Juglans cinerea* L.), Basswood (*Tilia americana* L.) and softwoods including White Spruce (*Picea glauca* (Moench.) Voss). The beetles mainly occur within the open cobblestone habitats though this vegetation is on the fringes of these habitats (e.g., main vegetated non-flooded parts of the island).

Southwest Miramichi River habitats:

Sites on the Southwest Miramichi River (Figure 7) are like those on the Saint John River (Klymko and Earle 2019). Beetles occur on large islands with sparsely vegetated cobblestone beach on the upstream end or side of the island. The cobblestone habitat is elevated above mean summer water levels so that it would only rarely flood after heavy summer rains. All inhabited islands have densely vegetated habitat above the cobblestone beach, consisting of meadow and, on one island, floodplain forest.

Figure 7. Cobblestone beach on an island on the Southwest Miramichi River where there is a Cobblestone Tiger Beetle (*Cicindela marginipennis*) colony. Photo by John Klymko, July 18, 2019.

Vegetation includes Hemp Dogbane, Sand Cherry (*Prunus pumila* L.), willow, Meadow-Sweet (*Spiraea alba* Du Roi), and rose (*Rosa* sp.). The more densely vegetated upland habitats contain meadows and thickets of Canada Bluejoint (*Calamagrostis canadensis* (Michx.) P. Beauv.), willow, and Reed Canary Grass (*Phalaris arundinacea* L.), with low mixed forest on one island, and Silver Maple floodplain forest on another.

In the U.S., Cobblestone Tiger Beetle occurs on cobblestones and coarse gravel with small patches of sand on banks and upstream ends of treed islands in small-to large-sized river systems (Boyd 1978; Dunn and Wilson 1979; Dunn 1982; Pearson *et al.* 2015). On the Genesee River in New York State, Hudgins *et al.* (2011) studied 40 cobble bars and found that “occupied cobble bars had about twice the area and difference between minimum and maximum elevation, and higher shrub cover, than unoccupied cobble bars”. A now extirpated subpopulation of Cobblestone Tiger Beetle was found at a “runoff stream” at a gravel quarry in Indiana in 1976 and 1977 (Kritsky *et al.* 2009).

Habitat Trends

In Canada, Cobblestone Tiger Beetle was probably more widespread prior to the completion of the Mactaquac Dam in 1967. Aerial photos taken in 1962 and 1963 show 19 treed islands above the dam and with appropriate habitat. These islands are now submerged (COSEWIC 2008) and approximately 96 km of the Saint John River was submerged and is now the dam head pond (Keilty 2015). Four additional islands are downstream from the Mactaquac Dam and likely had suitable habitat for the beetle. However, daily changes in water levels (>1 m) render this habitat unsuitable (COSEWIC 2008). In total, 23 islands with appropriate habitat (representing up to 73% of potential island sites along the Saint John River) were lost with the construction and operation of the Mactaquac Dam. Filling of the reservoir likely had an extensive impact on the species and its habitat.

Housing and recreational property (e.g., cabin) development along the shorelines of the Grand Lake Complex has impacted Cobblestone Tiger Beetle habitat and will likely continue. Conversion of shoreline forest to cottage lots is ongoing and cottage beachfronts are often cleared of cobble to make the area more pleasurable to human swimmers (e.g., smooth sandy beaches). Some tiger beetle habitats within 1 km of extant sites have been cleared within the past decade (Klymko pers. obs.). It is unknown what quantity of occupied larval habitat has been lost due to clearing although the overall incremental habitat declines are inferred at <10% over a ten-year period.

There has been no damming of the Southwest Miramichi River, and no significant development, so the amount of habitat available along this watercourse is assumed to have remained relatively constant.

In the U.S., Cobblestone Tiger Beetle is considered extirpated from several locales (U.S. Fish and Wildlife Service 2018). On the Monongahela River in West Virginia (Acciavatti *et al.* 1992) and the Tombigbee River in Mississippi (NatureServe 2017) (the presumed collection location of a 1970 specimen from Columbus, Mississippi, see Graves and Pearson [1973]) flooding from the construction of locks and dams eliminated habitat. Populations on the Connecticut River in Massachusetts and the Winooski River in Vermont are presumed extirpated on river reaches below dams because of changes in flow regime (U.S. Fish and Wildlife Service 2018). On the Delaware River in New York, the overgrowth of invasive non-native plants has eliminated habitat from cobble bars (Schlesinger and Novak 2011). It is unclear what has enabled these plants to grow so dense; it could be that flow regime management prevents major flooding events, like spring freshets, necessary to eliminate plant growth from cobble (Schlesinger pers. comm. 2017). The species is also considered extirpated or known only from historical records from areas of Indiana, Ohio, New York, New Jersey, Alabama, and Pennsylvania (U.S. Fish and Wildlife Service 2018).

BIOLOGY

Life Cycle and Reproduction

Cobblestone Tiger Beetle undergoes complete metamorphosis through four distinct life stages: egg, larva, pupa, and adult. No studies have been completed on the life history of this species; however, the biology is undoubtedly like that of other *Cicindela* species (see Pearson and Vogler 2001).

Cobblestone Tiger Beetle adults are active only during summer months and overwinter as partially grown larvae (one or two successive years) (Pearson *et al.* 2006) and in New Brunswick adults are present from late June to September (Webster 2006; Klymko 2014).

Little is known about courtship behaviour of Cobblestone Tiger Beetle. Other summer-active *Cicindela* begin reproductive activity shortly after emergence (Pearson and Vogler 2001). In 2007, mating pairs of Cobblestone Tiger Beetle were observed from 10:00 to 18:00 hours on warm sunny days (COSEWIC 2008). Dunn and Wilson (1979) observed mating pairs during the afternoon at subpopulations in the U.S. It is not known if female Cobblestone Tiger beetles mate more than once.

There is no information on the fecundity and oviposition behaviour of Cobblestone Tiger Beetle. Other *Cicindela* species deposit eggs singly and up to one centimetre below the soil surface (Pearson and Vogler 2001). In captivity, *Cicindela* can lay 10 – 20 eggs per day, but little data are available on daily egg production in the field or over a lifetime. Once the egg hatches, larvae construct a vertical burrow at the oviposition site, the burrow length varying between species, age of the larva, and substrate. The larvae generally live within the same burrow throughout the development and growth of three instars (Pearson and Vogler 2001); however, at least some species can move their burrows up to a few metres in response to disturbance (COSEWIC 2012).

Tiger beetle larvae are ambush predators. Their flattened heads fill their tunnel openings, and when prey items pass the tunnel entrance, the larvae rear their heads back and grasp it with their large mandibles. Prey is dragged into the burrow; edible portions are consumed, and inedible portions are ejected from the tunnel (Pearson *et al.* 2006). Larvae take 1-4 years to complete development, the length varying between species, and at least in some species, on food availability.

Cobblestone Tiger Beetle burrows are found in wet sand among cobblestones (Pearson *et al.* 2015). In New Brunswick, adults are most abundant on the upper margin of Cobblestone beaches on islands and lake shores. In these areas, patches of dry sand/clay (dry at least on the surface) occur between Cobblestones. Presumably these are the areas where eggs are laid, and larval tunnels occur. During spring and late fall when water levels are higher, these areas will be relatively close to the river or lake margin.

Cobblestone Tiger Beetle adults are active and fast diurnal predators that pursue and capture their prey. There are no published data on prey items consumed by adults or larvae; however, *Cicindela* generally take a wide variety of arthropod prey items, and some species will opportunistically scavenge dead insects (Pearson *et al.* 2006), fallen fruit (Hill and Knisley 1992) and crumbs of canned fish (Robinson pers. comm. 2017).

Physiology and Adaptability

Cobblestone Tiger Beetle adult foraging and larval burrow habitat is frequently flooded. There are no studies on the species' larval physiology or ability to survive flooding either in Canada or elsewhere in its global range. However, both the Saint John River islands and Grand Lake Complex areas were severely flooded in 2018, and in 2019 numerous larval tunnels were observed at both these subpopulations (M. Sabine pers. comm. 2021), suggesting the species is likely able to survive flood events. The larvae of other *Cicindela* species are known to survive flood events. Larvae of the shoreline species *C. dorsalis* and *C. togata* can survive submersion for 6 – 12 days, and the upland species *C. purpurea* can survive submersion for up to three weeks (Pearson and Vogler 2001). Amazonian tiger beetle larvae in the genus *Phaeoxantha* inhabit sandy river bars and beaches and can survive up to three months of water inundation (Zerm and Adis 2000). Under laboratory conditions submersed *Phaeoxantha klugii* larvae develop a tolerance to anoxia. Larvae conditioned with submersion showed a 50% mortality rate after 26 days of anoxia exposure, whereas unconditioned larvae showed 50% mortality rate in less than 6 days (Zerm and Adis 2003).

Dispersal and Migration

Adult Cobblestone Tiger Beetles are active flyers and will take flight when disturbed. Despite their flight capabilities they are rarely recorded outside their preferred habitat (Webster 2006; Klymko 2014; Klymko *et al.* 2016; Klymko and Robinson 2018) although it is assumed that adults may disperse to new sites.

The long-distance dispersal abilities of Cobblestone Tiger Beetle are unknown, and it is unclear how often beetles move between sites. Hudgins *et al.* (2011) documented the movement of Cobblestone Tiger Beetle adults between cobble bars on the Genesee River in New York. In two years, 259 adults were captured, marked, and released. Twenty-one beetles were recaptured, five of which were found to have moved between cobble bars. The average distance moved between captures was 113.9 m and the greatest travel distance was a female that moved 481 m between captures.

During summer floods, some sites within the Grand Lake Complex would become mostly or entirely flooded, and adults would presumably disperse to areas of higher ground. During 2013, water completely submerged one site for several days (Klymko pers. obs). Presumably larvae at such sites could survive a short-term summer flooding.

Gene flow between the subpopulations at the Grand Lake Complex, Southwest Miramichi River, and Saint John River is unlikely; all intervening habitat appears unsuitable.

Interspecific Interactions

Little is known about interspecific interactions in Cobblestone Tiger Beetle. Bronzed Tiger Beetle (*C. repanda* Dejean) and Appalachian Tiger Beetle (*C. ancocisconensis* T. W. Harris) often occur at the same localities as Cobblestone Tiger Beetle. However, these two species usually do not occur within the same microhabitat as Cobblestone Tiger Beetle (Webster unpub. data) and no interspecific interactions have been observed at sites in New Brunswick (Klymko unpub. data; Webster unpub. data). There are no reports of specific prey items of Cobblestone Tiger Beetle adults or larvae.

Parasites and parasitoids may cause significant mortality in Cobblestone Tiger Beetle. Wasps in the genus *Methocha* (Hymenoptera: Thynnidae) are ectoparasitoids of larval tiger beetles (Agnoli 2005). There are no published reports of *Methocha* preying on Cobblestone Tiger Beetle; however, the widespread *M. stygia* (Say) occurs in the Maritimes (Sheffield pers. comm. 2018). Some bee flies in the genus *Anthrax* (Diptera: Bombylidae) are also tiger beetle parasitoids (Yeates and Greathead 1997), including *A. georgicus* Macquart, which occurs in eastern Canada (Kits *et al.* 2008), including New Brunswick (ACCDC 2019).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Studies to estimate the Canadian population were completed in 2007 and 2008 (Webster 2008, 2009). One-day or two-day estimates using a mark-release-recapture (MRR) method were made within the estimated period of maximal adult activity and abundance (early July to mid-August). The Lincoln Index (see Seber 1973) was used to estimate the number of individuals at each known site. In 2007, studies were done at four of five Saint John River sites and two of the three then known Grand Lake Complex sites. One Saint John River site was omitted for logistical reasons, and one Grand Lake Complex site was omitted because the abundance was too small to be effectively indexed. Note, these estimates were completed before many additional sites were recorded at the Grand Lake Complex in 2018 and 2019, and on the Southwest Miramichi River in 2019.

Abundance

A population census was completed in 2007 and 2008, and the estimated population at the sites known at the time was 5,200 – 8,800 adults (Webster 2008, 2009) (see discussion below). Since then, additional sites have been found on the Grand Lake Complex and on the Southwest Miramichi, and the total population estimate is a combination of the formal census results and more recent population estimates. The Canadian population at present (2019) is estimated to be 11,093 and 14,333 adults.

In 2007, the estimated abundance for the Saint John River subpopulations was 4,487 individuals (abundance estimates at individual sites estimated at 851; 2,740; 400 and 496). The Grand Lake Complex abundance was 487 individuals (abundance estimates at individual sites estimated at 473 and 14). Two additional sites that were known at the time, one on the Saint John River and one in the Grand Lake Complex, were each estimated to have a population of 100 – 400 individuals (COSEWIC 2008). The total abundance of the surveyed sites was estimated as 4,974 adults. When estimated abundance at the then known unsurveyed sites is added, the total estimated abundance in 2007 was 5,174 – 5,774 adults.

In 2008, abundance estimates at two sites on the Saint John River and one site within the Grand Lake Complex were completed. The Saint John River sites abundance was estimated at 933 and 3,128 individuals, higher than the 2007 estimates of 851 and 400 for the same two sites. The Saint John River site that had an abundance increase from 400 to 3,128 may not have been accurately assessed in 2007 (poor weather during the 2007 recapture period may have decreased beetle activity and rendered that year's population estimate inaccurate). At the Grand Lake Complex, the abundance was estimated at 986 individuals, higher than the 473 at the same site in 2007 (Webster 2008, 2009).

The two Saint John River Islands that in 2007 contained 2,740 and 496 individuals were not resurveyed in 2008, nor was the island with an estimated 100-400 individuals. If those islands had a similar abundance in 2008, then total abundance on the Saint John River in 2008 would have been 7,397 – 7,697 individuals. In 2008, the total Grand Lake Complex abundance was 986 at the surveyed site plus the unsurveyed sites (approximately 100-400 at the site also not surveyed in 2007, plus perhaps fewer than 10 at the other site, where heavy all-terrain vehicle damage had caused serious decline [Webster 2009]). Therefore, the total known Grand Lake subpopulation in 2008 was approximately 1,086-1,386, and the total known Canadian population was approximately 8,483 – 9,083 adults. The mark-release-recapture studies used to derive the estimates in 2007 and 2008 have not been repeated.

Twenty-five additional sites are now known from the Grand Lake Complex, most of which were found in 2018. In 2018 and 2019, the number of adults observed at these sites was 1 – 84 individuals although in 2018 it was estimated that hundreds of adults were seen at three sites (ACCDC 2019). Adult abundance at all 25 of these sites is estimated at 2500-5000 individuals.

In 2019, Cobblestone Tiger Beetle was also found at four sites on the Southwest Miramichi River. The number observed at these sites was between one and 27, and the total population is estimated to be 110-250.

If the abundance at the sites censused in 2007 and 2008 have remained relatively static, then the approximate total population was between 11,093 (8,483+2,500+110) and 14,333 (9,083+5,000+250) individuals.

Fluctuations and Trends

There are insufficient data with which to estimate population fluctuations and trends for Cobblestone Tiger Beetle in Canada. Population fluctuation in the Saint John River sites, which contain Canada's largest populations, has not been studied. Nonetheless, there is some data that supports fluctuation in abundance and occupancy at the four Grand Lake Complex sites discovered between 2003 and 2005. All these sites show a general pattern of relatively high subpopulations when they were first discovered, relatively low populations in 2013, 2015, and 2016, and relatively high populations in 2018 and 2019. See Table 2 for site abundance data across survey years.

Table 2. Number of Cobblestone Tiger Beetles (*Cicindela marginipennis*) observed at each site over time. Note, surveys completed after 2007 and 2008 (years that had mark-capture-recapture studies) are done by sight, and studies are not comparable. Surveyors are not permitted to capture and/or handle beetles, and this is why some numbers are vague (i.e., 'dozens' or 'hundreds'). MRR = mark-capture-recapture. Commas separate surveys completed on different survey dates (e.g., a zero [0] = days surveyed over the season with no detections), a dash (-) = not surveyed that year, N/A = survey data not available.

Site Name	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19
Grand Lake Site 1	-	-	5	-	2	-	-	-	-	-	0, 0, 0	-	0,0,0	0,0	1	0	N/A
Grand Lake Site 2	-	26,26	31	-	8,3	7	-	-	-	-	0, 0, 0, 0	-	0,0,0,2	15,0	-	10	N/A
Grand Lake Site 3	-	35	109	-	473 (MRR)	986 (MRR)	-	-	-	-	9, 0, several, 3, 3	-	6, 12, 3, 16, 3, 0, 3	51,23,	-	common	N/A
Grand Lake Site 4	8,13	0 (7 visits)	-	-	-	-	-	-	-	-	2-6, 0, 0, 0, 0, 0	3, 0, 3, 4, 1, 12	1, 2, 0	3, 0	-	40	N/A
Grand Lake Site 5	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	40	N/A
Grand Lake Site 6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	N/A
Grand Lake Site 7	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	15	N/A
Grand Lake Site 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Min. 30	N/A
Grand Lake Site 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	N/A
Grand Lake Site 10	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	100's	N/A
Grand Lake Site 11	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	10	N/A
Grand Lake Site 12	-	0,0		-	-	-	-	-	-	-	-	-	-	-	-	doze-	N/A
Grand Lake Site 13	-	-	1	-	-	-	-	-	-	-	2,0,0	-	0,0,0	2,0	-	2	N/A
Maquapit Lake Site 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100's	N/A
Maquapit Lake Site 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	N/A
Maquapit Lake Site 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	N/A
Maquapit Lake Site 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10 – 'doze-	N/A
Maquapit Lake Site 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	N/A
Maquapit Lake Site 6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100's	N/A

Site Name	‘03	‘04	‘05	‘06	‘07	‘08	‘09	‘10	‘11	‘12	‘13	‘14	‘15	‘16	‘17	‘18	‘19
Maquapit Lake Site 7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	‘doze-’	N/A
Maquapit Lake Site 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	N/A
Saint John River Site 1	-	-	148	-	2740 (MRR)	-	-	-	-	-	-	12	65,34, 56,7,0	-	-	‘com-mon’	N/A
Saint John River Site 2	-	-	7	-	400 (MRR)	3182 (MRR)	-	-	-	-	-	-	5	-	-	-	N/A
Saint John River Site 3	-	-	48	-	851 (MRR)	933 (MRR)	-	-	-	-	-	-	29,8	-	-	-	Approx 10
Saint John River Site 4	-	-	189	-	496 (MRR)	-	-	-	-	-	-	-	-	-	-	Approx. 10	
Saint John River Site 5	-	-	14	-	-	-	-	-	-	-	-	3	-	-	-	-	N/A
Southwest Miramichi River Site 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1
Southwest Miramichi River Site 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15
Southwest Miramichi River Site 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27
Southwest Miramichi River Site 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4

At the most southern Grand Lake Complex site, five adults were recorded along a 100 m transect on 28 July 2005, the date the subpopulation was first observed (Webster 2006). Two adults were found in one hour of surveying on 23 July 2007 (Webster 2008). None were found in 2013, 2015, and 2016, despite 11 site surveys over eight dates and almost 10 hours of search effort (Klymko unpubl. data). On 16 July 2017, one beetle was found after two hours of one person searching (Bell pers. comm. 2017) and on 29 July 2019, five or six were found by three surveyors in 33 minutes of searching (ACCDC 2019). It is unclear if the beetle population disappeared entirely from this site between 2007 and 2017 (Table 2), but given that at least five were seen in 2019, there is now a breeding population there (Klymko pers. comm. 2021).

At the second most southern Grand Lake Complex site, 26 individuals were observed over two dates (17 and 26 August) in 2004, and 31 observed 26 July 2005 (Webster 2006). On 24 July 2007, during MRR surveys, 8 adults were recorded, and there were ATV tracks through the habitat. A second survey on 7 August 2007 recorded three adults, and the ATV damage was more extensive at the site. On 30 July 2008 seven adults were recorded as well as extensive ATV damage (Webster 2009). In 2013, no beetles were recorded over four dates and 154 surveyor minutes (Klymko 2014; Klymko unpublished. data). In 2015 the site was surveyed on four dates (373 surveyor minutes) and two adults were observed in copula (Klymko *et al.* 2016; Klymko unpublished data). In 2016, 15 beetles were recorded 20 July (100 surveyor minutes) (Klymko and Robinson 2018; Klymko unpubl. data). During the 2013, 2015, and 2016 visits ATV tracks were observed, but damage to substrate appeared minimal. These data suggest the site abundance may have declined after 2004 and may be recovering and/or may experience natural abundance fluctuations. It is notable that a follow up visit on 4 August 2016 with 80 surveyor minutes failed to detect

adults (Klymko and Robinson 2018). In 2018, this site was visited on a rainy day. One beetle was observed walking on the cobble and flipping flat pieces or cobbles revealed 10 beetles in 10 minutes. In 2019, approximately 90 beetles were found on July 30 by four observers in about 40 minutes of surveying (ACCDC 2019).

At the second most northern Grand Lake Complex site, eight individuals were found by one surveyor on 9 August 2003, and 13 found by four surveyors on 20 August 2003 (Sabine 2004). None were found in 2004, despite searches on seven dates (Webster 2006). Beetles were detected annually at the site from 2013-2016, as well as in 2018 and 2019, with the number observed on visits varying from zero to 40.

At the most northern Grand Lake Complex site, 35 and 109 were seen on a 100m transect in 2004 and 2005, respectively (Webster 2006). A standardized count has been done in three different recent years (2015, 2016, and 2019). This count consists of two surveyors walking in tandem along a 311 stretch of shoreline between two fixed waypoints. One surveyor counts beetles on the upper beach, the other counts beetles on the lower beach. The survey takes approximately 20 minutes. Results of the survey are presented in Table 3. The low abundance observed in the standardized count at the sites in 2015 was consistent with non-standard counts done there in 2013 and 2015. The site was visited on five dates in 2013, and the most productive visit (in terms of beetles per surveyor minute) had 9 beetles found by two surveyors in 20 minutes of survey. It was visited four times on six dates in 2015 (not counting the day of the standardized count), and the most productive visit had 12 beetles found by three surveyors looking for 12 minutes (ACCDC 2019). The high abundance observed in 2016 and 2019 is similar to the numbers seen in 2004 and 2005. MRR surveys at this site in 2007 and 2008 estimated the total population to be 473 and 986, respectively.

Table 3. Results of standardized count conducted at a Grand Lake Complex (ACCDC 2019).

Date	Start/end time	Temp.(˚C)	Windspeed (Beaufort Scale)	% cloud cover	# beetles recorded
11-Aug-2015	13:04 - 13:26	25	B4/B5	40	3
20-Jul-2016	10:30 - 10:50	20	B3	0	51
03-Aug-2016	14:09 - 14:28	28	B1	0	23
30-Jul-2019	13:47 - 14:02	30	B2	0	61
06-Aug-2019	13:43 - 14:01	26	B4/B5	20	125

Population fluctuation has been documented in other rare tiger beetle species. The global population of the Coral Pink Sand Dunes Tiger Beetle (*Cicindela albissima* Rumpp), a species restricted to a small dune area in Utah, was estimated annually from 1999 to 2013. The population averaged 1338 adults, with a low 558 in 2005 and a high of 2944 in 2002 (Knisley 2014a). The Puritan Tiger Beetle (*Cicindela puritana* Horn), a species of the eastern U.S., has similar fluctuations at its four extant metapopulations (Knisley 2014b).

It is possible that the number of sites in the Grand Lake Complex also fluctuates. Three sites first recorded in 2018 had been visited once or twice in the 2000s with null results. This includes a site where beetles were common in 2018 that was visited twice in 2004. Given the year-to-year abundance fluctuation documented at other sites within the Grand Lake Complex, it is impossible to know if colonies were previously absent from these three newfound sites, or if their populations were at such low levels when they were previously surveyed that they went undetected.

Rescue Effect

Cobblestone Tiger Beetle subpopulations on the shores of the Grand Lake Complex, Miramichi River and the Saint John River are approximately 250 km away from the closest subpopulations in Somerset County, Maine. There are large stretches of unsuitable habitat between Maine and New Brunswick subpopulations and rescue is unlikely. See **Dispersal and Migration**.

THREATS AND LIMITING FACTORS

Threats

The International Union for the Conservation of Nature-Conservation Measures Partnership (IUCN- CMP) threats calculator (Salafsky *et al.* 2008; Master *et al.* 2009) was used to classify and list threats to Cobblestone Tiger Beetle. The overall threat impact was calculated at Medium – Low (Table 4) and threats below are discussed from highest to lowest impact.

Table 4. Threat classification table for Cobblestone Tiger Beetle (*Cicindela marginipennis*) across its geographic range in Canada based on the IUCN-CMP (International Union for the Conservation of Nature–Conservation Measures Partnership) unified threats classification system. For a detailed description of the threat classification system, see the Conservation Measures Partnership website (CMP 2006). For information on how the values are assigned, see Master *et al.* (2009).

Scientific Name	Cobblestone Tiger Beetle (*Cicindela marginipennis*)			
Date:	2018-01-30; updated by J. Klymko, J. Heron and M. Sabine in Jan 2020 to include new sites at Southwest Miramichi River.			
Assessor(s):	Jennifer Heron (co-chair and moderator), Paul Grant (co-chair), John Klymko (report writer and SSC member), Rob Longair (SSC member), Mary Sabine (COSEWIC member for NB), Ruben Boles (COSEWIC member for ECCC), Sean Lemoine (ECCC)			
References:	draft status report and draft threats calculator			
		Overall Threat Impact:	**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	0	0
	C	Medium	1	0
	D	Low	2	3
	Calculated Overall Threat Impact:		Medium	Low

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments[1]
1	Residential & commercial development	D	Low	Small (1-10%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	See text in **Threats**.
1.2	Commercial & industrial areas						Not applicable. It is unlikely new marinas will be built on shorelines where tiger beetles occur.
1.3	Tourism & recreation areas						Not applicable.
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						Not applicable.
2.2	Wood & pulp plantations						Not applicable.
2.3	Livestock farming & ranching						Not applicable.
2.4	Marine & freshwater aquaculture						Not applicable.
3	Energy production & mining						
3.1	Oil & gas drilling						Not applicable.
3.2	Mining & quarrying						Not applicable. One site on the Grand Lake Complex is adjacent to a gravel quarry that is now closed and unlikely to re-open. If the site was to re-open, no activity is allowed within the 30m of the shoreline or within tiger beetle critical habitat
3.3	Renewable energy						Not applicable.
4	Transportation & service corridors						
4.1	Roads & railroads						Not applicable.
4.2	Utility & service lines						Not applicable.
4.3	Shipping lanes						Not applicable.
4.4	Flight paths						Not applicable.
5	Biological resource use		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
5.1	Hunting & collecting terrestrial animals		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	See text in **Threats**.

[1] Detailed comments available upon request from the COSEWIC Secretariat.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments[1]
5.2	Gathering Terrestrial Plants						Not applicable.
5.3	Logging & wood harvesting						Not applicable. Three sites on Grand Lake are adjacent to forest that could be harvested. Private landowners adjacent to one site have been approached by a logging company, but they were not interested in selling. Beetles are not in the forest; however, changes to the forest would likely impact sunlight levels and siltation in the waterways. Tree removal is not considered a direct threat (see 7.3).
6	Human intrusions & disturbance	CD	Medium - Low	Restricted - Small (1-30%)	Serious - Moderate (11-70%)	High (Continuing)	
6.1	Recreational activities	CD	Medium - Low	Restricted – Small (1-30%)	Serious - Moderate (11-70%)	High (Continuing)	See text in **Threats**.
6.2	War, civil unrest, and military exercise						Not applicable.
6.3	Work & other activities						Not applicable. Three of the Saint John islands are owned by the Nature Trust (as reserves). There may be research at these sites although permits are required.
7	Natural system modifications	D	Low	Small (1-10%)	Extreme (71-100%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
7.1	Fire and fire suppression						Not applicable.
7.2	Dams & water management/ use		Unknown	Pervasive-Large (31-100%)	Unknown	High (Continuing)	See text in **Threats**.
7.3	Other ecosystem modifications	D	Low	Small (1-10%)	Extreme (71-100%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	See text in **Threats**.
8	Invasive & other problematic species & genes		Unknown	Large (31-70%)	Unknown	High (Continuing)	
8.1	Invasive non-native/ alien species/ diseases		Unknown	Large (31-70%)	Unknown	High (Continuing)	See text in **Threats**.
8.2	Problematic native species/diseases						Not applicable.
8.3	Introduced genetic material						Not applicable.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments[1]
8.4	Problematic species/ diseases of unknown origin						Not applicable.
8.5	Viral/prion-induced diseases						Not applicable.
9	Pollution		Unknown	Pervasive - Large (31-100%)	Unknown	High (Continuing)	
9.1	Domestic & urban wastewater						Not applicable.
9.2	Industrial & military effluents						Not applicable.
9.3	Agricultural & forestry effluents		Unknown	Pervasive Large (31-100%)	Unknown	High (Continuing)	See text in **Threats**.
9.4	Garbage & solid waste						Not applicable. Garbage, such as beer cans and other objects are carried by waves, wash up on Grand Lake and presumably Saint John River islands. This is considered negligible.
9.5	Air-borne pollutants						Not applicable.
9.6	Excess energy						Not applicable.
10	Geological events						
10.1	Volcanoes						Not applicable.
10.2	Earthquakes/ tsunamis						Not applicable.
10.3	Avalanches/ landslides						Not applicable.
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
11.1	Habitat shifting & alteration						Not applicable.
11.2	Droughts						Not applicable.
11.3	Temperature extremes						Not applicable.
11.4	Storms & flooding		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	See text in **Threats**.
11.5	Other impacts						Not applicable.

Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).

Threat 6. Human intrusions and disturbance (Medium-Low impact)

6.1 Recreational activities (Medium-Low impact).

The use of vehicles along the beachfront cobblestone habitats causes significant degradation to habitats occupied by Cobblestone Tiger Beetle. Frequent vehicle use compacts the soil and damages the ecological community. This threat is applicable to most sites within the Grand Lake Complex, although negligible at the Saint John River and Southwest Miramichi River sites because they are on islands and access is limited by water levels.

Cobblestone Tiger Beetle larvae construct and maintain burrows, presumably among cobblestones and intervening sand areas. Soil compaction from vehicles and excessive trampling/walking causes direct mortality of larvae when the larval tunnels collapse and may cause mortality of adults that are unable to move away in sufficient time (adults of Cobblestone Tiger Beetle often do not take flight until closely approached) or are taking refuge under cobblestones.

Soil compaction and adverse impacts from vehicle traffic on cobblestone habitats was noted in 2008 surveys within the Grand Lake Complex (see Webster 2009). Surveys in 2004 and 2005 did not record evidence of vehicle use (Webster 2006). In 2007, extensive damage from vehicle use was noted through optimal cobblestone beach habitat at one site (e.g., tire tracks, ruts, and damaged plants), and in 2008, similar damage was noted (Webster 2009). Decline in site adult abundance is correlated with off-road vehicle use and mortality of adults and larvae is inferred. Abundance at other sites in the Grand Lake Complex in 2007 and 2008 were like those observed during 2004 and 2005 (Webster 2008, 2009) suggesting that decline was restricted to the vehicle-impacted site.

Threat 1. Residential and commercial development (Low impact)

1.1 Housing and urban areas (Low impact).

Beach front development along the shores of the Grand Lake Complex is ongoing. Shorelines in front of cottages are usually cleared of vegetation and sometimes leveled thus destroying the microhabitat conditions necessary for adult and larval Cobblestone Tiger Beetles. Where beetles are known to occur, there is little or no beach modification from development and such development is not likely to occur with the next 10 years. Waterfront development is not applicable to the Saint John River or Southwest Miramichi River subpopulations; all these sites occur within areas unsuitable for development.

Threat 7. Natural system modifications (Low impact)

7.2 Dams & water management/use (Unknown impact).

This threat is applicable to the Saint John River subpopulation. Beechwood Dam, located upstream of the Saint John River subpopulation, was built in 1955. Discharge can cause the water levels to fluctuate daily up to 1.5 m (Culp *et al.* 2007) and potentially impact both adult tiger beetle activity and larval survival. Periodic large floods may be important to the maintenance of open cobble shorelines. There is no correlation between the frequency of large floods (larger than a one in ten-year event) and the construction of the Mactaquac and Beechwood dams (Kidd *et al.* 2011). Overall, the impact of these water fluctuations is unknown, as adults and larvae are adapted to withstand some water inundation. It is unlikely that additional dams will be constructed in future on the Saint John River or the Southwest Miramichi River.

7.3 Other ecosystem modifications (Low impact).

Non-native plant growth can modify larval habitat by growing into the open sandy areas and ultimately shading open beach habitat and changing the open soil structure for larval tunnels. On the Delaware River in New York, the overgrowth of invasive non-native plants has eliminated habitat from cobble bars, and Cobblestone Tiger Beetle no longer occurs at this site (Schlesinger and Novak 2011). The increase in invasive plant growth may partially be due changes in the water flow management; these changes prevent major flooding events (e.g., spring freshets), which otherwise limit plant growth within the cobble areas (Schlesinger pers. comm. 2017).

The large spring freshet at all sites prevents the growth of many non-native plant species. However, sweet clovers (*Melilotus* spp.) can colonize shoreline despite the freshet. Cobblestone Tiger Beetle requires open beach habitat; non-native plant growth and infilling of the open sand habitats would decrease available habitat and likely decrease beetle site abundance. This threat is applicable to all Cobblestone Tiger Beetle subpopulations, although the severity and timing is variable across the 37 known Canadian sites.

Threat 5. Biological resource use (Unknown impact)

5.1. Hunting & collecting terrestrial animals (Unknown impact).

Tiger beetles are popular with private beetle collectors. Although most beetle collectors are conservation-minded, there are a few tiger beetle collectors in North America that routinely collect large series of individuals (COSEWIC 2008). The collection of large series of adults (at least 12 individuals of each sex) from small colonies, such as those at most sites within the Grand Lake Complex, could have a significant impact on abundance and genetic variability. This threat is unknown although entirely plausible based on online chatter and second-hand conversations with beetle collectors.

Threat 9. Pollution (Unknown impact)

9.3. Agricultural and forestry effluents (Unknown impact).

This threat applies mainly to the Saint John River subpopulation, and overall the threat is difficult to understand, and scored unknown. In general, agriculture can increase the sediment load entering the river, and those sediments carry pesticides and nutrients (Kidd *et al.* 2011). Pesticide run-off could threaten beetle habitats and impact prey abundance (e.g., beetles feed on shoreline insects which may be sensitive to pollution). Also, the increased nutrient and silt from effluent can lead to increased plant cover reducing the habitat of an open ground-based insect.

Western New Brunswick is one of Canada's most important potato growing areas and all Cobblestone Tiger Beetle habitats along the river are adjacent to or near agricultural areas. One example of a pollution event was on 23 August 2005; there was evidence of a significant discharge of what appeared to be waste from a poultry farm at a site near Hartland (Webster 2006). Cobblestone habitat along the entire shoreline of the island and adjacent riverbank, as well as cobblestone and gravel under water, were coated with a 0.5 cm layer of organic material. The air smelled strongly of poultry manure. Numerous dead mussels were observed on the river bottom. It was not clear if this was the result of a large one-time discharge or a chronic problem. Discharges of farm waste could influence the entire ecology of Cobblestone habitat.

The Saint John River sites are below the Beechwood Dam. The dam can significantly lower river water levels, which can decrease how much river water is available to dilute pollutants entering the river from sources below the dam (Kidd *et al.* 2011).

Saint John River water quality has improved since the 1950s and 1960s when concerns were raised about pollution levels (Kidd *et al.* 2011). Dunn and Wilson (1979) remark that Cobblestone Tiger Beetle survives in polluted rivers, stating that "the Connecticut and Delaware are extremely filthy where the beetles occur" and Kritsky *et al.* (1996) note that occupied habitats on the Great Miami River are littered by trash and abandoned automobiles.

Threat 11. Climate change and severe weather (Unknown impact)

11.4 Storms and flooding (Unknown impact).

Increase in frequency or severity of rainfall events would likely increase the frequency of major flooding on the Saint John River system. Flooding during the flight season may be detrimental to Cobblestone Tiger Beetle colonies not adjacent to high beach areas that could act as a refuge during most flood events. However, an increase in such floods might also enlarge areas of sparsely vegetated cobble, and these events could benefit the species through increases to the spatial area of available habitat. The scope is applicable to the whole Canadian population, although the severity and timing at each of the 37 sites is unknown.

Limiting Factors

Limiting factors are not human-induced and include characteristics that make the species less likely to respond to recovery/conservation efforts. Limiting factors for Cobblestone Tiger Beetle are not well documented. Limiting factors for tiger beetles, in general, are summarized from Pearson and Vogler (2001); Pearson *et al.* (2006); COSEWIC (2008) and outlined below.

Habitat specificity:

In Canada, Cobblestone Tiger Beetle lives only on extensive cobblestone beaches of the Saint John and Miramichi rivers and similarly structured habitats on the shores of the Grand Lake Complex. Most sites have high cobblestone beaches with sparse vegetation that appear to flood during the spring freshet and only rarely after very heavy summer rains (Webster 2006; Klymko 2014; Klymko and Robinson 2018). These habitat attributes limit the species' distribution.

Larval burrow sites:

Larval burrows may be limited by soil substrate (specific composition unknown) and may limit larval tunnel depth. Larvae may be sensitive to ground freezing and may burrow deeper into the soil to avoid freezing and mortality.

Temperature extremes and cover areas:

Surface and ambient temperatures govern tiger beetle activity (Pearson and Vogler 2001). Adults are less active at lower temperatures.

Number of Locations

The Grand Lake Complex subpopulation is threatened by shoreline development; the ingrowth of vegetation to potential larval sites/areas, and habitat degradation and/or mortality from off-road vehicle use within the larval sites. Threats are variable in scope and severity across these sites and if each was considered separate (according to landowner), there more than 21 locations in the Grand Lake Complex. The Saint John River or Southwest Miramichi River subpopulations have negligible threats. The collecting of specimens is the most likely threat at Canadian subpopulations, but this threat is unlikely to affect all individuals of the species present. Substantial threats (see Table 4) to Cobblestone Tiger Beetle appear to impact less than 50% of the spatial area and Canadian population. Overall, there are more than 21 locations based on the 21 known sites at the Grand Lake Complex.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Cobblestone Tiger Beetle was assessed as Endangered by COSEWIC in 2008 (COSEWIC 2008) and listed as such under Schedule 1 of the federal *Species at Risk Act* in 2011. A federal recovery strategy was completed in 2013, and critical habitat was identified at the five Saint John River sites and three Grand Lake Complex sites known at the time (Environment Canada 2013).

Cobblestone Tiger Beetle is listed as Endangered under the New Brunswick *Species at Risk Act*. However, there has been no protection assessment completed for the species (see section 24 of the New Brunswick *Species at Risk Act*) and the species currently has no prohibitions or habitat designation afforded to Endangered species, as defined under this act. Invertebrates are not protected under the New Brunswick *Fish and Wildlife Act*.

Non-Legal Status and Ranks

The conservation status ranks for Cobblestone Tiger Beetle are:

- Global Status: G2-Imperiled (last reviewed 2011) (NatureServe 2017).
- Canada National status: N1-Critically Imperiled (last reviewed 2015) (Canadian Endangered Species Conservation Council. 2016).
- New Brunswick status:S1- (Critically Imperiled) (last reviewed 2015) (Canadian Endangered Species Conservation Council. 2016).
- U.S. statuses: Alabama (S1), Indiana (S2), Kentucky (S1), Maine (S1), Massachusetts (SNR), Mississippi (SX), New Hampshire (S1), New Jersey (S1), New York (S1), Ohio (S2), Pennsylvania (S1), South Carolina (SNR), Vermont (S1), West Virginia (S1) (NatureServe 2017).
- Cobblestone Tiger Beetle is listed as Endangered under Massachusetts' *Endangered Species Act*, Endangered under Maine's *Endangered Species Act*, Threatened under Vermont's *Endangered Species Law*, Endangered under New Hampshire's *Endangered Species Conservation Act*, and Threatened by the Ohio Division of Wildlife.
- Cobblestone Tiger Beetle is not listed under the federal U.S. *Endangered Species Act*.

Habitat Protection and Ownership

Cobblestone Tiger Beetle is a species that occurs within the cobblestone habitat that is considered part of the zone of annual water level fluctuation, an area adjacent to water bodies and to the height of the highest water level, and is provincial crown land. Most of the Cobblestone Tiger Beetle habitats are within this annual water level fluctuation zone, and adjacent to private land.

Grand Lake Complex:

Protection for sites in the Grand Lake Complex varies.

- One site is adjacent to provincial crown land that is part of a Class II Protected Natural Area (PNA). Under New Brunswick's *Protected Natural Areas Act*, industrial, commercial, agricultural uses and development are not permitted in a Class II PNA, and the collection of any insects requires a permit.

- A portion of one site is backed by a nature preserve owned by the Nature Trust of New Brunswick and habitat at a second site is managed with a voluntary habitat stewardship agreement between a private landowner and the Nature Trust of New Brunswick.

- Protection of habitat under the New Brunswick *Trespass Act* states that "No person shall trespass by means of a motor vehicle (d) in a lake shore area", wherein "lake shore area" is "land lying within 25 m above and 25 m below the normal high water mark of any lake, and includes any bed, bank, beach, shore, bar, flat, mudflat or sand dune associated with the lake whether or not it lies within that portion of land." This law is applicable to all sites. During the summer months at the Grand Lake Complex, this law is not adhered to and there is ongoing off-road use of vehicles along the cobblestone beachfronts (Klymko pers. obs.).

- Protection of habitat under the New Brunswick *Clean Water Act* includes the prohibition of the deposit of fill or any other material within 30 m of a watercourse, the removal of vegetation from the bank of a watercourse, and the removal of trees within 30m of a watercourse. Regardless of the prohibitions under this act, these prohibited activities occur regularly along shorelines of these lakes, including areas directly adjacent to Cobblestone Tiger Beetle sites (Klymko pers. obs.). It is unknown whether these activities are carried out with appropriate permits.

Saint John River:

Three of five islands on the Saint John River are owned by the Nature Trust of New Brunswick, and one of those islands is a Class II Protected Natural Area (PNA). New Brunswick Power owns the other two Saint John River islands, and the Cobblestone Tiger Beetle habitat at one of these islands is under a habitat stewardship agreement with the Nature Trust of New Brunswick.

Miramichi River:

Sites along and adjacent to the Southwest Miramichi River are owned by multiple private landowners.

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John Klymko is the zoologist at the Atlantic Canada Conservation Data Centre in Sackville, New Brunswick. He conducted extensive fieldwork on Cobblestone Tiger Beetle in New Brunswick. He has also surveyed for Syrphidae, Vespidae, Apoidea, Odonata, Lepidoptera, birds, reptiles, and plants throughout the Maritimes, and has documented close to a hundred new provincial insect records. John is a member of COSEWIC's Arthropods Specialist Subcommittee and an editor of the Journal of the Acadian Entomological Society. He received his B.Sc. in Biology and M.Sc. in Insect Systematics, both from the University of Guelph.

COLLECTIONS EXAMINED

Canadian National Collection of Insects, Ottawa, Ontario, November 2007.

Dwayne Sabine and Reginald Webster collected specimens during inventory work where new occurrences were recorded. Most have been deposited into the Canadian National Collection of Insects, Ottawa, Ontario, and the New Brunswick Museum, Saint John, New Brunswick. Neither the Canadian National Collection nor the New Brunswick Museum collection has Canadian specimens other than those from New Brunswick sites (Lonsdale pers. comm. 2017; McAlpine pers. comm. 2017).

Appendix 1. Sensitive data for Cobblestone Tiger Beetle.

[Editorial note: This appendix has been removed to protect precise location information. Please contact the COSEWIC Secretariat if you require this information.]