COSEWIC
Assessment and Status Report

on the

Cobblestone Tiger Beetle
Cicindela marginipennis

in Canada

ENDANGERED
2008

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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COSEWIC
Assessment Summary

Assessment Summary – November 2008

Common name
Cobblestone Tiger Beetle

Scientific name
Cicindela marginipennis

Status
Endangered

Reason for designation
This distinctive species of tiger beetle has a fragmented distribution with a very small extent of occurrence and area of occupancy, and is currently only found in two small regions of the St. John River system. There is evidence for decline of habitat and population in one region and the pressures on the habitat from development and recreation appear to be continuing.

Occurrence
New Brunswick

Status history
Designated Endangered in November 2008. Assessment based on a new status report.

COSEWIC
Executive Summary

Cobblestone Tiger Beetle
Cicindela marginipennis

Species information

Cicindela marginipennis Dejean (1831), the Cobblestone Tiger Beetle (Cicindèle des galets) is a member of the Order Coleoptera (beetles), Family Carabidae (ground beetles), and subfamily Cicindelinae (tiger beetles). No subspecies are currently recognized.

Adults are 11-14 mm in length and like all tiger beetles have large mandibles used to capture their prey. Adults have a narrow continuous cream-coloured border along the elytra (hardened front wing that covers the hind flying wing) and a bright red-orange abdomen that is clearly visible during flight.

The immature stages of this species have not been described. However, all tiger beetle larvae are similar in structure. The predatory larvae usually inhabit a vertical burrow in the soil. The pronotum (part of the top of the thorax) combined with the top of the head forms a flattened disk that creates a plug for the burrow they live in, concealing the larvae and burrow entrance from prey walking on the soil surface. The 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 hook into the wall of the tunnel if the prey attempts to drag the larvae from its burrow.

Distribution

The Cobblestone Tiger Beetle occurs in several small disjunct populations associated with major river systems from Mississippi and Alabama northeastward to Ohio, Indiana, Pennsylvania, New York, and New Hampshire in the United States. In Canada, it occurs only in New Brunswick, at eight locations in two isolated areas along the Saint John River and at Grand Lake.

Habitat

In Canada, the Cobblestone Tiger Beetle occurs only on treed islands of the Saint John River with high, infrequently flooded cobblestone beaches and similarly structured habitats on the shores of Grand Lake. The habitat where the Cobblestone Tiger Beetles live is created in part by the effects of flooding during the spring freshet and flow patterns created by the structure of the islands or beaches themselves. All occupied sites have high cobblestone beaches with sparse vegetation that are probably flooded only during the spring freshet and only rarely after very heavy summer rains. Factors (such as water level) that influence the flow patterns during the spring freshet and during the remainder of the season will have a significant impact on the structure of the habitat.

Biology

Like other beetle species, the Cobblestone Tiger Beetle undergoes complete metamorphosis with an egg, larval, pupal and adult stages. No studies have been published on the life history of this species. However, the biology is undoubtedly similar to that of other species of tiger beetles. Larvae of tiger beetles pass through three larval stages or instars. The third instar larva builds a chamber in the soil and then forms a pupa from which the adult later emerges. Most species of *Cicindela* have a two year life cycle, although adults are present each year at any given locality. Tiger beetles are predators (feeding on spiders, smaller insects), both in the larval and adult stages. Adults are active during the day and will readily take flight when approached.

Population sizes and trends

The total Canadian population probably contains about 5,000 adult individuals. Due to the recent discovery of this species, definite information on population trends is not available. A large proportion (up to 74%) of potential island habitats for this species was lost with the construction of the Mactaquac Dam in 1967

Limiting factors and threats

There is evidence for decline of habitat and population in one region and the pressures on the habitat from development and recreation appear to be continuing. Pollutants such as farm waste products and silt may alter the plant community making the habitats unsuitable for a ground-based insect by increasing plant cover and reducing shoreline prey. Because the larvae live in burrows among the cobblestones, beach traffic from ATVs may cause significant larval mortality as well as changes to the structure of the community and habitat itself. A recent observation at one site at Grand Lake suggests that one population may have declined due to habitat degradation by ATVs.

In Canada, the distribution of this species is highly fragmented, occurring in small populations at only a few locations in a very specialized and fragile habitat. This results in a high probability of extirpation of this insect from any given site. It is this limited distribution and small isolated populations that are the most important factors affecting the status of this species and its long-term persistence in Canada. The small population size and popularity of tiger beetles for natural history collectors makes this species susceptible to over-collecting. Reductions in distribution caused by habitat loss or loss of a population due to other factors could have a significant impact on the entire population by reducing genetic variability of the overall Canadian population and negatively influencing the ability of the species to adapt to future environmental changes such as global climate change.

Special significance of the species

The Cobblestone Tiger Beetle occurs in only a few isolated populations throughout its range. The Canadian populations are disjunct by 500 km from the closest populations in the United States. The Canadian populations contain a low proportion of green and cobalt blue individuals not known to occur in any other known populations of this rare species. Loss of these populations may be a significant loss in the genetic diversity for this globally rare species. Tiger Beetles have become important as a group of environmental indicators and they are the only group of beetles for which a current North American Field Guide exists. Factors that result in the loss of the habitat of the Cobblestone Tiger Beetles likely cause a concurrent loss of many other species of plants and insects that occur in this and adjacent habitats.

Existing protection or other status designations

Currently there is no legal protection for this species in Canada at either the national level or at the provincial level. This species is being considered for threatened status in the United States under the U.S. *Endangered Species Act*.

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 (2008)

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.

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SPECIES INFORMATION

Name and classification

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Description

Adults

C. marginipennis adults are 11-14 mm in length and like all tiger beetles have large mandibles used to capture their prey. Adults have a narrow continuous cream-coloured border along the elytra (Figure 1) and a bright red-orange abdomen (dorsal and ventral sides) that is clearly visible during flight (Figure 2).

Figure 1. Adult *Cicindela marginipennis*, dorsal view. Photo by Dwayne Sabine.

Figure 2. Adult *Cicindela marginipennis*, ventral view. Photo by Dwayne Sabine.

Similar species

No other species of tiger beetles in Canada have the combination of a continuous cream-colored border on the elytra and bright red-orange abdomen.

Larva

The immature stages of this species have not been described. However, tiger beetle larvae of different species are similar in structure (See Figure 3.3 in Downie & Arnett 1996 for a diagram of a typical tiger beetle larva). The predatory larvae of tiger beetles inhabit a vertical burrow in the soil. The pronotum combined with the top of the head forms a flattened disk that creates a plug for the burrow they live in, concealing the larvae and burrow entrance from prey walking on the soil surface. The 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 hook into the wall of the tunnel if the prey attempts to drag the larvae from its burrow.

Figure 3. Adult *Cicindela marginipennis* in natural habitat at Grand Lake. Photo by Dwayne Sabine.

Designatable units

Although the two regions of occurrence on the St. John River are now separated by an area of unsuitable habitat due to the Mactaquac Dam, they were likely formerly more continuous and are best regarded at one designatable unit.

DISTRIBUTION

Global range

Globally, this rare tiger beetle exists in only a few disjunct populations (Bousquet & Larochelle 1993, Pearson *et al*. 2006). These populations are associated with major river systems in the United States and Canada (Figure 4). In the United States, populations have been found from Mississippi (Tombigbee River) and Alabama (Coosa River) (Graves & Pearson 1973, Huber, personal communication, December 2006) northeastward to Ohio (Little Miami and Scioto Rivers) (Dunn 1982, Graves & Brzoska 1991, Blatchley 1910), Indiana (Knisley *et al*. 1987), West Virginia (Ohio River) (Acciavatti *et al*. 1992), Pennsylvania, and New York (Susquehanna and Delaware Rivers) (Boyd 1978, Leng 1902, Schauup 1883-4, Stamatov 1970, Wickham 1899), New Jersey (Delaware River) (Boyd 1978), and Vermont and New Hampshire

(Connecticut River) (Dunn 1979, Leonard & Bell 1999). A small population was recently discovered in extreme southwestern New York (Pearson *et al*. 2006) (Figure 4). In Canada, the Cobblestone Tiger Beetle occurs only in New Brunswick and is associated with the Saint John River system (see below) (Sabine 2004, Webster 2006).

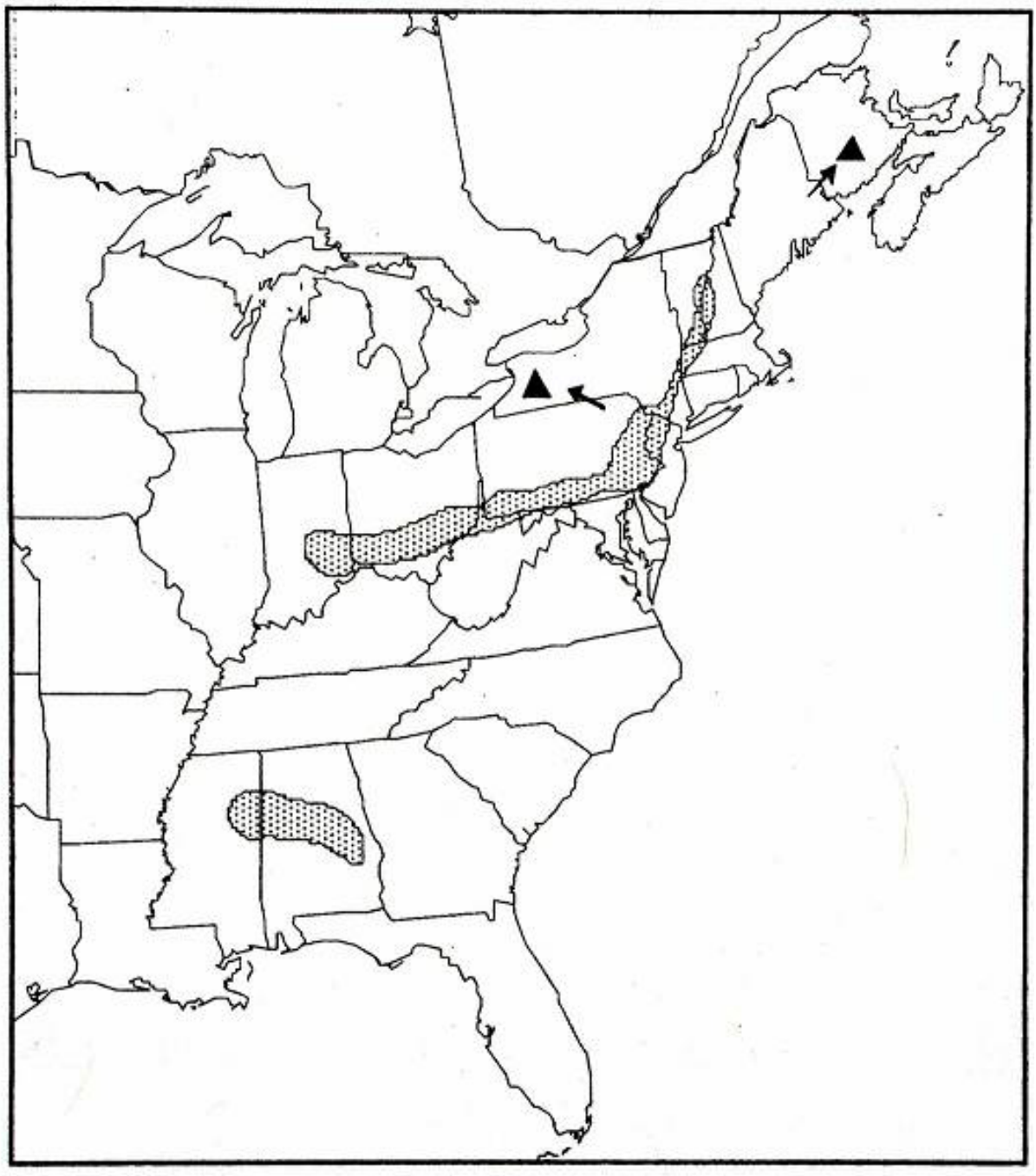

Figure 4. Global distribution of *Cicindela marginipennis* (shaded areas and triangles - after Pearson *et al*. 2006).

Canadian range

C. marginipennis was first discovered in Canada in 2003 (Sabine 2004). The only known localities in Canada are in New Brunswick (Sabine 2004, Webster 2006). This species is known from nine locations (a location is where adults were observed in appropriate habitat at least a km from another such observation): six on islands in the lower Saint John River and three on the shores of Grand Lake (Webster 2006) (Figure 5, although the site of the initial discovery may not be a permanent population). Previous reports of this species from Quebec are erroneous (Sabine 2004) based on a website report for which there is no satisfactory documentation. The distribution of these habitats is fragmented and the species occurs in very small limited areas, but some populations are within a km of each other. The extent of occurrence is around 2036 km^2. However, using observations of the habitat areas used by the species at each site and aerial photographs, the area where the beetles occur in Canada is only about 0.79 km^2 (0.75 km^2 on islands in the Saint John River, and 0.04 km^2 on the shores of Grand Lake). Using the 1X1 km^2 grid, the nine sites, some of which are only a km apart are included in an area of occupancy of 12 km^2. Using a 2X2 km^2 grid, the area of occupancy is 44 km^2.

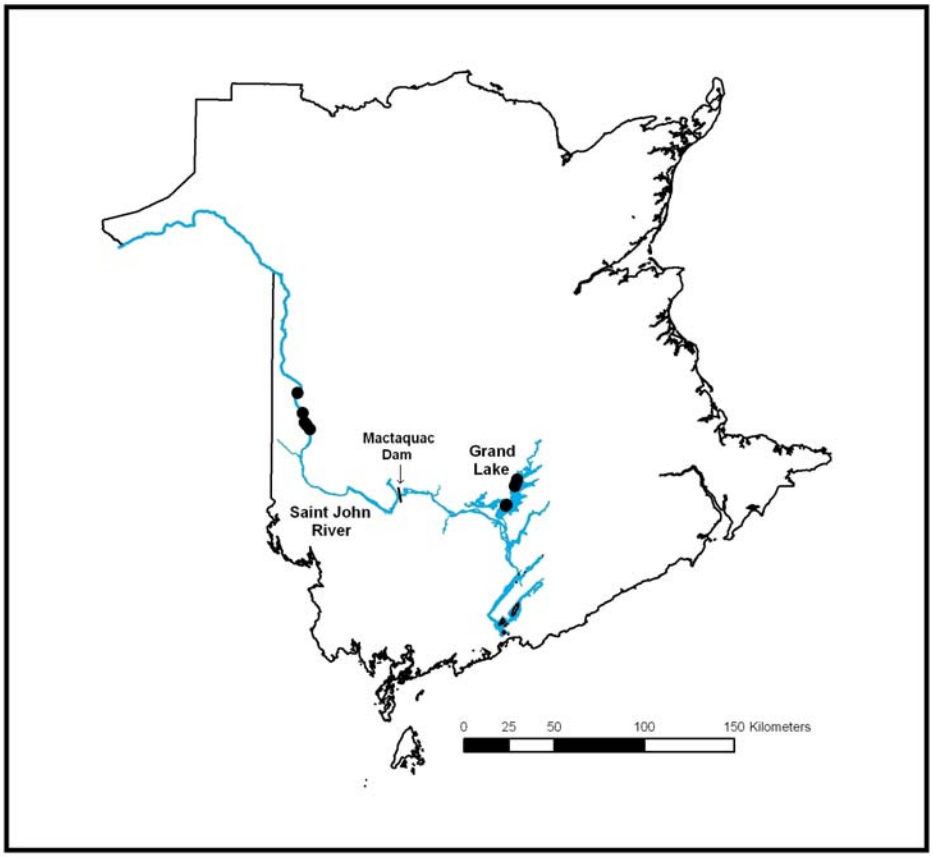

Figure 5. Distribution of *Cicindela marginipennis* in New Brunswick and Canada**.** Dots indicate location of populations.

Search Effort

Only a small number of suitable sites exist in Canada and none occur in adjacent jurisdictions (Maine or Quebec). A number of coleopterists have searched for this species in Quebec and Ontario since its discovery in New Hampshire by Dunn (1979), but no populations have been found (Bousquet, personal communication, November 2007). The discovery of the Cobblestone Tiger Beetle for the first time from Canada in August, 2003, on a small cobblestone beach at Grand Lake, New Brunswick by Dwayne Sabine (Sabine 2004) represented a northeastward range extension of approximately 500 km from the closest known populations along the Connecticut River in Vermont and New Hampshire (Dunn and Wilson 1979). The discovery of this species in New Brunswick prompted an intensive survey for this species during 2004, 2005 and 2006.

During this three year survey (Webster 2006), 62 sites were surveyed for *C. marginipennis* along the shores of Grand Lake, and on islands and shoreline habitats on the Saint John and Miramichi River Systems. A few sites were also visited on the Meduxnekeag River (a tributary of the Saint John River). *C. marginipennis* was discovered at three new sites at Grand Lake and five new sites on islands on the Saint John River. This tiger beetle species was not found along the Miramichi River or at any other sites in New Brunswick, including additional sites surveyed in 2007 and 2008. Although the searches have been aimed at appropriate extensive cobblestone habitat, many less exposed rivershores were examined in the process and the lack of discovery in these situations reinforced the conclusion that this species has a very restricted distribution and habitat.

Based on the survey effort, the limited habitat, and the general knowledge of tiger beetles, which are a popular group with entomologists, it is believed that the Cobblestone Tiger Beetle is unlikely to be found outside of New Brunswick in Canada, and unlikely to occur in many more locations in New Brunswick, if any.

HABITAT

In the United States, *C. marginipennis* occurs almost exclusively among cobblestones and coarse gravel with small patches of sand on upstream ends of treed islands in small-to large-sized river systems (Boyd 1978, Dunn & Wilson 1979, Dunn 1982, Pearson *et al*. 2006).

In New Brunswick this species occurs in similar microhabitats on treed islands of the Saint John River (Webster 2006), although a small number of adults were recently found on a cobblestone beach on a river margin area opposite an occupied island site (Webster 2007). Populations also occur on cobblestone beaches along the shoreline of Grand Lake (Sabine 2004, Webster 2006). These habitats are described in detail below.

A natural regime of spring floods of varying magnitude is apparently necessary to preserve the habitat of this species. These conditions exist on large rivers, and 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 localities

The sites occupied by *C. marginipennis* on Grand Lake consist of high, infrequently flooded cobblestone beaches, with ledge areas (Sabine 2004, Webster 2006). The cobblestones and ledges have a reddish brown cast (Figure 6). Jack Pine (*Pinus banksiana* Lamb.) usually occurs in a narrow band above the beach at each site. Small patches of fine sand/gravel occur between the cobblestones on the upper beach areas where adults are present. Vegetation on the beach is sparse with over 80% of the area vegetation-free. Typically there are widely scattered patches of Indian Hemp (*Apocynum cannabinum* L.), Sweet-Fern (*Comptonia peregrina* (L.) Coult.), and stunted willows (*Salix* sp.) within areas of bare cobblestones, sand and gravel. Adults occur on the highest areas of the beach among cobblestones, gravel and sand, and in areas with ledges, but are most abundant in areas with cobblestones. These areas are probably flooded only during the spring floods and rarely flood after heavy summer rains. It appears that this feature may be critical for the long-term survival of this species. However, this will remain unclear until detailed studies are done on the life history of this species in New Brunswick, and elsewhere. Wave action during spring flooding has probably shaped these habitats making them suitable for the existence of this species along the shores of Grand Lake (Sabine 2004). Although cobble beaches are present at many other sites along the shores of Grand Lake, most are either very small in size or lack the higher areas of cobblestone beach that are rarely flooded during the spring flood and occasional summer floods.

Figure 6. Cobblestone beach on the shores of Grand Lake. Photo by Dwayne Sabine.

Saint John River localities

Most known sites for *C. marginipennis* on the Saint John River are on larger treed islands within the river (Webster 2006). The habitat where adults occur typically consists of a high cobblestone beach with clean light tan cobblestones, best developed on the upstream end of the islands (Figure 7). Fine sand/gravel occurs between the cobblestones on the upper beach areas where adults occur. Vegetation on the beach is sparse with over 50% of the area vegetation free. Typically there were widely scattered patches of Indian Hemp (*Apocynum cannabinum* L.), widely scattered Balsam Poplar shoots (*Populus balsamifera* L.), and Sandbar Willows (*Salix exigua* Nutt.). All the islands occupied by the beetle are treed with a mix of hardwoods [Balsam Poplar, Silver Maple (*Acer saccharinum* L.), Sugar Maple (*Acer saccharum* Marsh), Butternut (*Juglans cinerea* L.), Basswood (*Tilia americana* L.] and softwoods [White Spruce (*Picea glauca* (Moench) Voss) and White Pine (*Pinus strobus* L.)]. Areas occupied by the adults are probably flooded only during the spring floods and are likely rarely flooded after heavy summer rains. Beetles are most numerous along the upstream end of the islands, but occasionally adults occur in other areas on the islands with suitable habitat. The habitat where adults occur is structurally similar to that at the Grand Lake localities, but with different coloured cobblestones.

Figure 7. Cobblestone beach on an island on the Saint John River. Photo by Pascal Giasson.

Adults were generally not found on river margin habitats in New Brunswick (but see below). Most river margin habitats are covered by relatively dense vegetation during the summer and appear to be unsuitable for *C. marginipennis* in being without extensive open cobble. It appears that the flow patterns created by the islands during flooding may be required to create the micro-habitat conditions required for the long-term survival of this rare species. However, in 2007, several individuals of *C. marginipennis* were observed on a small section of cobblestone beach river margin opposite an island occupied by this species (Webster, unpublished). At this previously known site, the adults occurred adjacent to the river on a relatively small access road to the river constructed within the past three years. Apparently construction of the road created the relatively vegetation-free conditions required by the beetle.

Trends

C. marginipennis was apparently more widespread in the United States in the past with historical records from the Monongahela River in West Virginia (Acciavatti *et al*. 1992), Indiana (Blatchley 1910), the Susquehanna River in Pennsylvania (Wickham 1899), and the Ohio river watershed in Ohio (Dunn 1982). These populations appear to have been lost due to dam construction, river channelization, and water pollution (Acciavatti *et al*. 1992, Pearson *et al*. 2006, Tanner 1988).

In Canada, *C. marginipennis* was probably more widespread prior to 1967, when its habitat was likely more widespread. The Mactaquac Dam was built in the 1960s and completed in 1967. The resultant head pond submerged approximately 99 km of the Saint John River to an area close to the first extant site of *C. marginipennis* near Hartland, NB (Sabine personal communication May 2007). Examination of aerial photos taken between 1962 and 1963, show that there were 19 treed islands above the dam that appeared to offer appropriate habitat (extensive cobblestone/gravel margins similar to aerial photos of extant sites) for *C. marginipennis*. This habitat is now perpetually flooded. Downstream from the Mactaquac Dam are another four islands that were likely suitable for *C. marginipennis.* However, daily variations in water flow levels, often by one metre or more within one or two hours (Webster, personal observation), created for electricity generation cause these cobblestone habitats to be inundated repeatedly on a daily basis, rendering the habitats unsuitable for the beetle (and many other insect species). This analysis suggests that 23 islands with appropriate habitat (representing up to 73% of potential island sites) were lost with the construction and operation of the dam. Though it is not possible to determine if *C. marginipennis* had been present at any or all these sites, these islands fall within the range of the species in New Brunswick; indeed, within the same river system and ecoregion. It is therefore possible that the filling of the reservoir had an extensive impact on the species and its habitat.

During 2007, one of the two largest sites at Grand Lake was severely impacted by ATV use (See Threats for details), and only a few individuals were observed where the species was common in 2004 and 2005 (Webster, unpublished). Future surveys will be required to determine if this habitat will be able to continue to support this species. The impact of ATVs at this site was found to be less in the 2008 survey.

Severe flooding on the St. John River during the spring of 2008 appears to have had a beneficial effect, with one population evidently larger in the summer of 2008 (R. Webster, pers. obs.). Vegetation encroaching on the open habitat was eliminated by the flooding.

Protection/ownership

C. marginipennis currently has no legal protection in Canada or New Brunswick. In the United States this species is under federal review for threatened or endangered listing (Leonard and Bell 1999) and is listed as endangered in Vermont.

All known sites for this species at Grand Lake are privately owned and not protected. Three of the five localities on the Saint John River are owned by the Nature Trust, a non-profit conservation organization.

BIOLOGY

General

Like other beetle species, *C. marginipennis* undergoes complete metamorphosis with an egg, larval, pupal and adult stages. No studies have been published on the life history of *C. marginipennis*. However, the biology is undoubtedly similar to that of other species of *Cicindela* (See Pearson & Vogler 2001 for details). Larvae of *Cicindela* pass through three larval stages or instars. The third instar larva builds a chamber in the soil and then forms a pupa from which the adult later emerges. Most species of *Cicindela* have a two year life cycle, although adults are present each year at any given locality. Species of *Cicindela* are predators on small insects and spiders, both in the larval and adult stages.

Adult activity period

Species of *Cicindela* display one of two distinct life cycle patterns; species with adults active only during summer that over winter as partially grown larvae (one or two successive years), and species with spring and fall adult activity patterns with the adults over wintering (those with two year cycle also probably over-wintering one year as a larvae). *Cicindela marginipennis* exhibits the summer adult activity pattern (Pearson *et al*. 2006). In New Brunswick, adults are present from late June to late August (Webster 2006). A clear peak in this period may depend on factors that change from year to year (weather, water levels, etc.), but appears to be between 23 July and 21 August.

Biology and life history

Little is known about courtship behaviour of *C. marginipennis*. Other summer-active *Cicindela* begin reproductive activity shortly after emergence (Pearson & Vogler 2001). Mating takes place throughout the warmer portions of the day (Webster, unpublished). Mating pairs of *C. marginipennis* were observed almost continuously from 10:00 to 18:00 h during warm sunny days during the course of a mark-release-recapture (MRR) studies in 2007 (Webster 2008). Dunn & Wilson (1979) observed mating pairs during the afternoon in the USA. It is not known if females of *C. marginipennis* mate more than once.

Nothing has been published on fecundity and oviposition behaviour of *C. marginipennis.* Other *Cicindela* species deposit eggs singly up to one centimetre below the surface of the soil (Pearson & Vogler 2001). In captivity, *Cicindela* can lay 10-20 eggs per day, but little data is available on daily egg production in the field or total lifetime fecundity for any species. Once the egg hatches, larvae construct a vertical burrow at the site selected by the female for oviposition. The larvae apparently live within the same burrow throughout the three instars, enlarging it as necessary (Pearson & Vogler 2001).

No data are currently available for the sites selected for oviposition by *C. marginipennis* in Canada. Pearson *et al*. (2006) reported that the burrows of *C. marginipennis* are found in wet sand among cobblestones in the U.S.A. In New Brunswick, adults are most abundant on the upper margin of the cobblestone beaches on islands and lake shores. In these areas, patches of dry sand/clay (dry at least on the surface) occur between the cobblestones. Presumably these are the areas where the eggs are laid and the larval tunnels occur. During the spring and later in the fall when water levels are higher, these areas will be relatively close to the river or lake margin.

The larvae of *Cicindela* are predators on other insects and arthropods (Pearson & Vogler 2001, Pearson *et al.* 2006). The larvae remain in their burrows and await prey that walk over the burrow. The modified head and prothorax form a flattened disk that plugs the burrow forming a living trap door. When prey walks over or close to the burrow it is captured and pulled down into the burrow and consumed. No data are available on the prey items used by *C. marginipennis* larvae, but many species of insects are active on the soil surface. Interestingly, the highest numbers of other Carabidae (also predators) occur on the upstream ends of the islands where *C. marginipennis* is most abundant (Webster, unpublished).

Adults of *C. marginipennis* are active diurnal predators that run down and capture their prey. There are no published data on prey items consumed by adult *C. marginipennis*. However, they are probably similar to those consumed by the larvae.

Natural mortality factors

Little is known about the natural mortality factors of *C. marginipennis*. Important predators of other *Cicindela* include robber flies and birds (Pearson & Vogler 2001, Pearson *et al*. 2006). Parasitoid wasps and flies are important enemies of larval tiger beetles, particularly members of the Families Tiphiidae (tiphiid wasps) and Bombyliidae (bee-flies) (Pearson & Vogler 2001, Pearson *et al*. 2006).

The restriction of this species to treed islands and lakeshore habitats with high beaches (infrequently flooded) suggests that flooding may pose a significant natural threat to this species. The forested areas on the islands inhabited by this species show little signs of flooding (Webster, unpublished). Adults (and presumably larvae) occur in areas on the cobblestone beach that are rarely flooded. These high ground areas may provide an import refuge for adults during summer floods and, more importantly, reduce the amount of time that the larval tunnels are subject to flooding. It is not known how the larvae survive flooding of their habitat which frequently occurs during the spring freshet.

Population dynamics

Due to the recent discovery of this species in Canada, little is currently known about its population dynamics in this country.

Movements/dispersal

Although adults of *C. marginipennis* are active flyers and will readily take flight when approached, they have rarely been found outside their preferred habitat (Webster 2006), suggesting that their propensity to disperse may be very limited. However, under some circumstances adults may disperse to new sites. For example, *C. marginipennis* was not found during the subsequent two years (Webster 2006) at the site of the initial discovery during 2003 at Grand Lake (Sabine 2004). A much larger population was found about 1.0 km away during 2004. Water levels were very high during the summer of 2003, and it is possible that the *C. marginipennis* observed at the discovery site had dispersed (flown) from the main population centre as a result of the previous higher water levels.

During the mark-release-recapture (MRR) study in 2007, adults of *C. marginipennis* became much more common in cobblestone areas near the river (Saint John) margin and water from late morning to mid-afternoon on warm (32^{o} C) sunny days (observed at two sites). Later in the day (after 17:00 h) few adults were observed near the water (Webster, unpublished). This behaviour was not observed at two other sites during the MRR study that were surveyed on cooler days. It is not known if this behaviour occurs only on warm days or is a normal diurnal pattern. This restricted movement is of interest but is not clearly related to risk.

Interspecific interactions

Little is known about interspecific interactions in *C. marginipennis*. Other species of tiger beetles such as *Cicindela repanda* Dejean and *C. ancocisconensis* T. W. Harris often occur at the same localities as *C. marginipennis*, but these two species usually do not occur within the same microhabitat as *C. marginipennis* (Webster, unpublished). No interspecific interactions with the above species have been observed to date at any New Brunswick localities.

Adaptability

C. marginipennis requires a very specialized habitat (large treed islands on large rivers with extensive cobblestone habitats and similarly structured habitats on a lakeshore) for its survival, making this species extremely vulnerable to habitat loss or alteration. The apparent low propensity of *C. marginipennis* to disperse to other sites will compound the effects of habitat loss and degradation.

POPULATION SIZES AND TRENDS

Abundance

Population estimates based on mark, release, recapture (MRR) were completed in 2007 on sunny, warm days during the peak activity period at most known sites for *C. marginipennis* (Webster 2008). The lack of a complete survey at one site is thought not to change the total by more than 20 since there were few individuals present at this site during the first visit. The total adult population number for all Canadian populations is estimated at 4,975 individuals including 488 (14+473 at the two of three Grand Lake localities), and 4,487 (400+2740+851+496) at the four Saint John River localities. These estimates were based on two or three day (individuals marked one day and recapture sample obtained next day) MRR (Mark, Release, Recapture) studies using the Lincoln Index (see below). This method relies on capturing and marking a fraction of the total population and then using this fraction to estimate the actual population size [most assumptions appear to have been met [closed populations (sites are isolated from each other)]. Due to the recent discovery of this species, long-term population trends are unknown, although the population at one site at Grand Lake appears to have declined since 2005, when it was common (ca. 30 adults observed in 100 metre transect). In 2007, the population was estimated at 14 individuals on July 24 and only 3 individuals were observed on August 7 during a 30 minute survey of the entire habitat occupied by the species. In 2008, only 4 adults were observed during a 30 minute survey on July 30.

Lincoln Index Population Estimate (N) = n1 x n2/m2

Where n1 = number first marked, n2 = number captured on second day, M2 = number marked on second day.

This method is also frequently referred to as the Petersen Method (since it was developed by fisheries biologist C.G.J. Petersen in 1896 rather than Lincoln in 1930 (Krebs 1999). The confidence limits based on binomial 95% for m2/n2 ratio, used since the m2/n2 ratio is > 0.10 in some cases (Seber 1982) are as follows: 3 - 200, and 191 - 1466 for the two Grand Lake sites, 83 - 191, 461 - 2075, 2078 - 4157, 176 -1250, and 396 -1516 for 5 St. John River localities. This leads to a population estimate of 3388 - 10855 for the MRR data based on totals for lower confidence limits and totals for upper confidence limits. However, two sites were not included in the MRR study. At one of these 14 individuals were seen in 2005 and at the other 2 were seen in 2007. These numbers and the characteristics of the sites suggest populations of 100 - 400 individuals each. Thus the total population size is approximately 3588 – 11655.

The term “approximately” is appropriate despite confidence limits because the assumption of the Petersen method that the population size is constant is not clearly met. Furthermore the recapture was affected by weather conditions as described in the report (Webster 2008). Finally insect populations tend to fluctuate and it is not clear how such fluctuations would affect the estimate.

Fluctuations and trends

Although information is insufficient to reveal fluctuations or trends, there is some evidence for a population decline at one of the sites on Grand Lake (see under Threats – recreational vehicles). Here it was common in 2005 (30 adults in a 100 m transect). In 2007 the population was estimated at 14 individuals on 24 July and only 3 individuals were observed on 7 Aug. during a 30 minute survey of the entire habitat of the species.

Rescue effect

With a species that appears to be rather strongly confined by a very limited habitat and with the nearest locality in the United States being approximately 500 km away on the Connecticut River in New Hampshire, there seems to be little possibility of rescue effect.

LIMITING FACTORS AND THREATS

Limiting factors

In Canada, *C. marginipennis* lives only on large treed islands on the Saint John River with extensive cobblestone beaches and a few similarly structured habitats on the shores of Grand Lake. All occupied sites have high cobblestone beaches with sparse vegetation that are probably flooded only during the spring freshet and only rarely after very heavy summer rains (Webster 2006). This exceptionally unusual habitat is likely a major limiting factor, prey availability, predation, and microclimate may also play a role.

The cobblestone habitats on islands within the Saint John River are created in part by the effects of flooding during the spring freshet and flow patterns (volume and speed of water) created by the structure of the island itself. On Grand Lake, wave action during spring flooding has probably shaped these habitats making them suitable for *C. marginipennis*. Factors related to water level that influence the flow patterns during the spring freshet and during the remainder of the season will have an impact on the structure of the habitat. Pollutants such as farm waste products or silt may alter the plant community making the habitats unsuitable (increasing area of cobblestone habitat covered by plants) for this tiger beetle. Pollution may occur in the form of short-term localized events or continuously.

Globally, *C. marginipennis* occurs at only a few localities and the distribution is highly fragmented (Figure 4). In Canada, *C. marginipennis* occurs in only two small population centres in a very specialized and fragile habitat. This results in a high inherent probability of extirpation from any given site. This limited distribution is one of the most important factors affecting the status of this species and its probability of long-term persistence. Reductions in distribution caused by habitat loss or loss of a population due to other factors could have a significant impact on the entire population through the usual negative impacts of small effective population size, such as reduced genetic variability of the overall Canadian population and reduced ability of the species to adapt to future environmental changes like global climate change.

Threats

Waterfront development

Beach front development along the shores of Grand Lake is increasing rapidly. Although development is not allowed below high water mark, higher beach areas are often cleared of vegetation and levelled creating microhabitat conditions unsuitable for *C. marginipennis* and eliminating adjacent natural cover for prey species. Fortunately, most sites where the beetles occur have ledges making it difficult to alter these sites. Waterfront development is not a factor for sites in the Saint John River as all sites occur on islands that are unsuitable for development.

Agricultural effluent

All known sites for *C. marginipennis* along the Saint John River are near agricultural areas and are potentially subject to pollution from farm waste and silt washing in from recently plaighed fields after heavy rain. This could be a significant threat to the species because the beetles feed on shoreline insects and these insects are very likely 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. On August 23, 2005, there was evidence of a significant discharge of pollutant at a site near Hartland (Webster 2006). Cobblestones along the entire shoreline of the island and adjacent river bank, 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 of this nature will undoubtedly influence the entire ecology of the cobblestone habitat. In 2006 and 2007 there was less evidence of serious pollution at this site.

Habitat fragmentation and dams

The distribution of *C. marginipennis* in Canada is fragmented, occurring in two disjunct small population centres. This is in part the result of the naturally isolated distribution of the river and lakeshore habitat occupied by the species. Fragmentation was likely further accentuated by loss of habitat due to the construction of the Mactaquac Dam in 1967. This resulted in the flooding of as many as 23 island habitats that may have supported populations of *C. marginipennis*. It is unlikely that additional dams will be constructed in the future on the Saint John River, and thus this threat is not considered urgent. In addition, some of the island sites on the Saint John River area are also isolated from each other possibly limiting gene flow between these sites.

The long-distance dispersal abilities of *C. marginipennis* are not known. However, it is unlikely that gene flow between the populations at Grand Lake and the Saint John River is possible, as nearly all intervening suitable habitat along the system has been eliminated. Gene flow between the closest populations in Vermont and New Hampshire (several hundred miles to the southwest) is not possible. Loss of populations in New Brunswick will result in the permanent extirpation of the species from Canada.

Specimen collection

Tiger beetles are very popular with beetle collectors. Although the vast majority of beetle collectors are extremely conservation-minded, there are a few tiger beetle collectors in North America that routinely collect large series of individuals (Huber pers. com. 2006). Population sizes at most of the known sites in Canada are small (less than 200 individuals). The collection of long series of adults from these sites could have a significant impact of the population by reducing population size and genetic variability.

Recreational vehicles

Recreational vehicles (ATVs) may cause significant degradation to habitats occupied by *C. marginipennis* by compaction of soil and damage of the plant community by the tires. Habitat on islands in the St. John River is not accessible to ATV traffic, but habitats on Grand Lake are accessible. The larvae of *C. marginipennis* live in tunnels, presumably among the cobblestones. Soil compaction will cause direct mortality of larvae when the larval tunnels are collapsed and may cause mortality of adults that are unable to move away in sufficient time (adults of *C. marginipennis* often do not take flight until closely approached). Beach traffic from walking may also damage larval tunnels. Beachfront development along Grand Lake is increasing rapidly. Although development is not allowed below high water mark, beach traffic from ATVs and walking will likely increase as development (cottage construction) on lakefront properties at Grand Lake continues, causing these habitats to become unsuitable for this insect. All the known sites at Grand Lake are small with only a few hundred individuals present at the best sites. It will not take a significant amount of disturbance to eliminate a given population.

Possible evidence of the negative effects of ATV use on the habitat and population levels of this species was observed during 2007 at one site at Grand Lake (Webster, unpublished). Surveys for this species were conducted at Grand Lake during 2004 and 2005 (Webster, 2006). During 2004 and 2005, 26 and 31 individuals were encountered, respectively, along a 100 metre transect along the point within the best habitat for the species at one site. There was no evidence of ATV use at this site during those two years. During 2007, this site was revisited on July 24 to conduct a mark-release-recapture population estimate. Only 9 individuals were observed during an intensive survey of the site. On this date there was evidence (tire tracks) of ATV use through much of the upper cobblestone beach thought to be prime habitat for *C. marginipennis*. The site was visited again on August 7. Only three individuals were observed during a survey of the entire cobblestone habitat. On this date almost the entire cobblestone habitat on the point showed evidence of tire tracks, ruts, soil (sand, cobblestone) compaction, and damaged plants. Although there is no direct evidence that ATV use actually killed larvae and adults, the significant decline in population levels was concurrent with severe habitat disturbance, which is strongly suggestive that ATV use was the direct causative agent. Interestingly, population numbers at the two other sites were similar to those observed during 2004 and 2005, suggesting that this decline was restricted to this site.

SPECIAL SIGNIFICANCE OF THE SPECIES

The Canadian populations are disjunct by several hundred km from the closest populations in the United States, where the species is also rare and disjunct. The Canadian population is also the only known population of this species that possess green and cobalt blue individuals. Loss of these populations may be a significant loss in the genetic diversity for this globally rare species.

Tiger beetles have become important as a group of environmental indicators, and they are the only group of beetles for which a current North American Field Guide exists. Although no other rare species were observed within the cobblestone habitat of this species, a number of rare species of plants occur in adjacent habitats, such as the seasonally flooded forests and wetlands along the lower Saint John River. Many species of beetles, such as the other Carabidae (ground beetles) and Staphylinidae (rove beetles) occur along the river margin habitats as well as in the adjacent seasonally flooded forest and wetland habitats. It is probable that some of these species will prove to be rare and even new to science. Factors that result in the loss of *C. marginipennis* may cause a concurrent loss of other species.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Currently there is no legal protection for this species in Canada at either the national level or at the provincial level. This species is being considered for threatened status in the United States under the U.S. *Endangered Species Act*. It is considered globally imperiled (G2) by NatureServe and has been accorded national ranks of N2 for the US and N1 for Canada. In all 13 US states where it occurs, it is S1, S2, SNR or SX. It is threatened in Vermont.

TECHNICAL SUMMARY

Genus species *Cicindela marginipennis*

English common name
Cobblestone Tiger Beetle

Nom français
Cicindèle des galets

Range of Occurrence in Canada: New Brunswick

Demographic Information

Generation time (average age of parents in the population)	Probably two years
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 or 5 years, or 3 or 2 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	Not applicable
Are the causes of the decline understood?	Not applicable
Have the causes of the decline ceased?	Not applicable
[Observed, inferred, or projected] trend in number of populations	Probably stable
Are there extreme fluctuations in number of mature individuals?	Unknown
Are there extreme fluctuations in number of populations?	Unknown

Extent and Area Information

Estimated extent of occurrence	2036 km^2
[Inferred] trend in extent of occurrence	Possible decline at Grand Lake. No recent decline, but probable past decline due to dam construction in 1967
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IOA)	using 2X2 km^2 grid = 44 km^2 using 1X1 km^2 grid = 12 km^2
[Inferred] trend in area of occupancy	Probable decline
Are there extreme fluctuations in area of occupancy?	Unknown
Is the total population severely fragmented?	YES
Number of current locations	9 locations in 2 population centres (Saint John River, Grand Lake) in NB
Trend in number of locations	Probably relatively stable since 1970
Are there extreme fluctuations in number of locations?	Probably relatively stable since 1970

Trend in [area and quality] of habitat	Decline at one site at Grand Lake. May have declined due to dam construction in 1967 on Saint John River

Number of mature individuals in each population

Population Based on mark-recapture	N Mature Individuals
Grand Lake 1	3 - 200
Grand Lake 2	191 - 1466
St. John River 1	83-191
St. John River 2	461-2075
St. John River 3	2078-4157
St. John River 4	176-1250
St. John River 5	396-1516
St. John River 6 - subjective estimate	100-400
St. John River 7 - subjective estimate	100-400
Total	3588-10555
Number of populations (locations)	11

Quantitative Analysis

	None available

Threats (actual or imminent, to populations or habitats)

Recreational vehicles compacting soil and damaging plant community. Agricultural effluent polluting the river and coating the shorelines with organic material. Habitat fragmentation due to waterfront development. Specimen Collection by beetle collectors may have an impact since most populations are small.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: at risk	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Unlikely

Current Status

COSEWIC: Endangered, November 2008

Status and Reasons for Designation

Status:	Alpha-numeric code:
Endangered	B1ab(iii,v)+2ab(iii,v)

Reasons for designation: This distinctive species of tiger beetle has a fragmented distribution with a very small extent of occurrence and area of occupancy, and is currently only found in two small regions of the St. John River system. There is evidence for decline of habitat and population in one region and the pressures on the habitat from development and recreation appear to be continuing.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Population information and information on decline is inadequate.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B1ab(iii,v)+2ab(iii,v) since the known extent of occurrence (2036 km²) is less than 20,000 km² and the area of occupancy (12 km²) is less than 2,000 km² and declines in habitat and population have occurred at one of two small regions of occurrence.
Criterion C (Small and Declining Number of Mature Individuals): Information on decline is not adequate (cannot be placed at more than 10% over three generations) and continuing decline cannot be inferred and fluctuations are not documented and some populations contain more than 1,000 individuals.
Criterion D (Very Small Population or Restricted Distribution): Meets Threatened D2 since the area of occupancy (12 km²) is less than 20 km² and the habitats in one of two regions of occurrence are prone to effects of human activities within a short time period.
Criterion E (Quantitative Analysis): Not applicable

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Reginald P. Webster is currently working as a private consultant. He holds a PhD degree in Entomology from the Department of Entomology, Michigan State University and has authored or co-authored over 25 scientific publications including recent papers on the life history of the endangered Maritime Ringlet butterfly and descriptions of a new species of moth and beetle. He has also authored numerous reports on the biology, ecology and population structure of the Maritime Ringlet and taught courses in Population Biology and Ethology at the University of New Brunswick. Since 1999, Dr. Webster has been doing surveys of rare and endangered butterflies for the Maine Department of Inland Fisheries & Wildlife, and conducting inventories of butterflies, moths and beetles in New Brunswick. He is a former member of the Arthropod Species Specialist Committee of COSEWIC.

COLLECTIONS EXAMINED

Canadian National Collection of Insects, Ottawa, ON, November 2007. All known Canadian specimens were collected by Dwayne Sabine and Reginald Webster and most have been deposited into the Canadian National Collection of Insects, Ottawa, ON, and the New Brunswick Museum, Saint John, NB.

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