

COSEWIC
Assessment and Status Report

on the

Bogbean Buckmoth
Hemileuca sp.

in Canada



ENDANGERED
2009

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 2009

Common name

Bogbean Buckmoth

Scientific name

Hemileuca sp.

Status

Endangered

Reason for designation

This very rare moth is only known from New York and Ontario. In Ontario, it is found in two widely separated fens. It is susceptible to the effects of exotic invasive plants, especially European Common Reed, that are crowding out its preferred foodplant, the Bogbean, and of potential flooding or drying of habitat resulting from manipulation of water levels at the main site.

Occurrence

Ontario

Status history

Designated Endangered in November 2009.



COSEWIC
Executive Summary

Bogbean Buckmoth
Hemileuca sp.

Species information

Buckmoths (*Hemileuca*) are a relatively well-studied and diverse genus of silk moths. Although the taxonomic rank of Bogbean Buckmoth in Canada is unclear, it is the only species of *Hemileuca* in Eastern Canada, it is a highly distinctive day-flying moth and is ecologically distinct from the buckmoth found in the prairies which has a different primary plant host and prefers drier habitats.

Adult Bogbean Buckmoths are medium-sized moths with forewing lengths of 26-32 mm for males and 32-36 mm for females. They have a distinctive black and white colouration with an eyespot on each wing.

Distribution

Bogbean Buckmoth populations are known only from Ontario and New York. All four Canadian sites are in eastern Ontario: two near Richmond south of Ottawa and two other sites approximately 50 km farther west near White Lake. Each pair of sites is considered to represent a different location with different potential threats. The actual area occupied by this species in Canada is less than 3 km².

Habitat

In Canada, Bogbean Buckmoth is found in open, calcareous, graminoid and low shrub fens. Larvae are most abundant in patches of Twig Rush or Wire Sedge with shallow pools with Bogbean, its primary host. Adjacent *Sphagnum* hummocks with shrubs and stunted tamarack or cedar provide suitable pupation sites.

Biology

The Bogbean Buckmoth is a dayflying silk moth with one generation per year. Adult Bogbean Buckmoths emerge in late September and typically oviposit on Sweet Gale, Bog Birch, and other shrubs. Up to several hundred eggs are laid in a spiral ring on the stem. Eggs hatch in late May to early June and first instars communally feed primarily on Bog Cranberry for about 12 days before switching to Bogbean. Later instar larvae also eat Bog Birch, willows, and other shrubs, perhaps switching to the alternate hosts when the Bogbean is exhausted. In Ontario, adult Bogbean Buckmoths typically emerge in the third week of September. Females emerge from the pupa with fully developed eggs, attract males by emitting a pheromone, mate only once, and oviposit all eggs the same day. Adults do not feed.

The Bogbean Buckmoths might be capable of flying up to several kilometres but are not strong fliers and seldom leave fen habitats. Isolation of populations is increased by the short-lived adult stage.

Population sizes and trends

There are no estimates for global abundance, but an annual average total of 2500 to 10,000 individuals are estimated for Ontario and New York combined. The most recent Canadian survey in 2008 observed a total of 169 larvae at the four sites and estimated a total abundance of approximately 6200 larvae in suitable habitat. This represents approximately 3000 adult buckmoths.

Bogbean Buckmoth is thought to have experienced a large (25-90%) historic global decline associated with habitat loss, particularly in the United States. Population sizes vary widely from year to year, which makes determination of long-term trends difficult, particularly at Canadian sites where they have been monitored only intermittently. Since 1979, the number of Bogbean Buckmoth larvae observed at the Richmond site has ranged from as low as one larva to thousands.

Given its habitat specificity, disjunct distribution of fen habitat, and distance from other populations in the United States, it is highly unlikely that localized extirpations in Ontario would be recolonized from New York. Genetic exchange between Canadian and US populations probably does not occur and is even unlikely between the two pairs of Canadian populations.

Limiting factors and threats

All Canadian Bogbean Buckmoth populations may be substantially threatened by a combination of habitat changes, water level fluctuations, land development, and possibly pest control programs. Habitat degradation due to invasive alien plant species is likely the most significant and imminent threat. In particular, European Common Reed and Narrow-leaved Cattail have invaded Canadian sites and may crowd out host plants and change the open aspect of the fens. Water level control at the White Lake location could substantially impact the habitat.

Special significance of the species

Bogbean Buckmoth shares its specialized habitat with a number of other rare species including the globally rare Eastern Prairie Fringed Orchid. Buckmoths are popular with naturalists and entomologists, in part due to their diurnal habits, relatively large size, and striking colouration.

Existing protection

NatureServe lists the Bogbean Buckmoth as critically imperiled globally but of uncertain taxonomy. It is listed as endangered in New York.



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 (2009)

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

Buckmoths (*Hemileuca*) are a relatively well-studied and diverse genus of silk moths (Saturniidae) of the subfamily Hemileucinae.

Buckmoths in the Great Lakes region exhibit an array of morphological, ecological, and behavioural traits and some populations have been variously considered as *H. maia*, *H. nevadensis* or *H. lucina* (Tuskes *et al.* 1996). They are often referred to as the *Hemileuca maia* complex because *maia* is the oldest name associated with the group (Tuskes *et al.* 1996).

The species in this complex are not well delineated, however, and the taxonomic rank of Bogbean Buckmoth in Canada is unclear. Nonetheless, the Bogbean Buckmoth is the only Buckmoth in Eastern Canada (Figure 1). It belongs to the *H. maia* species complex of which only one other species is found in Canada: *H. nevadensis* which is found in Manitoba and Saskatchewan (Henne 2009). The Bogbean Buckmoth differs from the Prairie Province species and others in the *H. maia* species complex in having a different primary larval foodplant, different habitat requirements and morphological differences of larvae and minor morphological differences of adults (NatureServe 2008). It is more differentiated from *H. maia* than are other wetland inhabiting buckmoths in the Great Lakes region (NatureServe 2008).

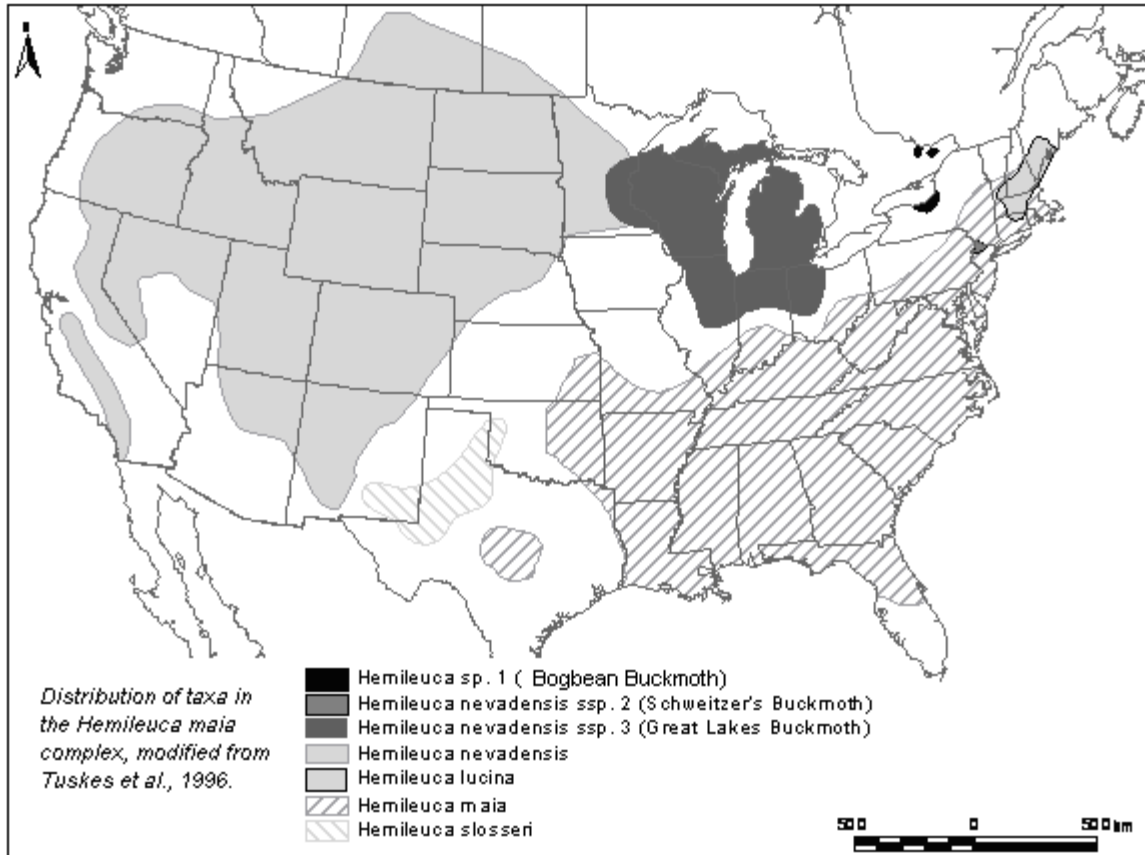


Figure 1. Distribution of the Bogbean Buckmoth and *Hemileuca maia* complex in North America (modified from Tuskes *et al.* 1996).

Morphological description

Adult Bogbean Buckmoths are medium-sized moths with forewing lengths of 26-32 mm for males and 32-36 mm for females. They have a distinctive black and white colouration with an eyespot on each wing (Figure 2). Males have a red tip on the abdomen, but their genitalia are not useful in discriminating species. There is considerable variation within the *H. maia* complex in the degree of opaqueness of the black ground colour and the width of the white wing bands (Tuskes *et al.* 1996). In comparison to other Great Lakes Bogbean Buckmoths, adults from Ontario and New York are generally large (unusually so for their latitude), very translucent (comparable to other buckmoths this far north) and with scalloped forewing bands (NatureServe 2008).



Figure 2. Bogbean Buckmoth adult and larva.

The adult Bogbean Buckmoth is highly distinctive and unlikely to be confused with any other moth in eastern Canada.

Late instar Bogbean Buckmoth larvae are up to 65 mm long and 8 mm in diameter, with rusty-orange, branched spines along the dorsum (Figure 2). The head capsule and prolegs are reddish-brown and the body is predominantly black. Earlier instars have a mainly black body and spines. The last two instars from Ontario and New York buckmoth populations have distinctly reduced yellow markings compared to other Great Lakes *Hemileuca*, including wetland-inhabiting, Bogbean-feeding populations in New Jersey and Wisconsin, termed *H. maia* ssp. 2 (Schweitzer's Buckmoth) and ssp. 3 (Great Lakes Buckmoth) respectively (NatureServe 2008). They lack the yellow spiracular stripe typical of the *H. nevadensis-maia* complex, and the colour of the spines more closely resembles that of *H. lucina* larvae.

Genetic description

Molecular genetic studies using allozymes and/or mitochondrial DNA sequences have indicated that the Bogbean Buckmoth belongs to the *Hemileuca maia* species group, but could not be clearly distinguished from other members of that group using these techniques (Legge *et al.* 1996; Rubinoff and Sperling 2004).

Schweitzer had no difficulty producing and rearing a three-way hybrid stock between New York, New Jersey, and Ohio fen buckmoths but some F1 backcross larvae seemed weak (NatureServe 2008). Some members of the *H. maia-nevadensis* complex are reproductively isolated from *H. maia* and *H. lucina*, but this may or may not be true for Ontario's Bogbean Buckmoths (NatureServe 2008).

Designatable units

Because Bogbean Buckmoth is considered to be a different taxon from *H. nevadensis* found in western Canada, there is no reason to consider it a designatable unit (DU) of the latter. All four Ontario populations are considered to represent one taxon and all are located in the relatively restricted region of the Ottawa Valley making one DU appropriate.

DISTRIBUTION

Global range

The global maximum extent of occurrence of the *H. maia* complex is approximately 895,000 km², but this includes taxa that are well differentiated from the Bogbean Buckmoth.

Disjunct populations of the Bogbean Buckmoth are found in northern New York and Ontario (Figure 1). New York has two sites in Oswego County: one a complex of several discrete fens adjacent to Lake Ontario, and another complex approximately 7 km inland (S. Bonnano, pers. comm.). As the Ontario and New York populations are considered to be a separate taxon from the Great Lakes *H. maia* complex, the global maximum extent of occurrence is 13,000 km² and the area of occupancy is less than 100 km² (NatureServe 2008).

The present distribution of these populations may be a relict of a post-glacial expansion by *Hemileuca* from western North America, and subsequent isolation in isolated fens and bogs as forests subsequently gradually reclaimed post-glacial wetland habitats (Pryor 1998).

Canadian range

In Canada, Bogbean Buckmoth is only known from four sites in eastern Ontario (Table 1, Figure 3) where it was first discovered in 1977: two near Richmond south of Ottawa (herein referred to as location A, fens 1 and 2) and two other sites approximately 50 km farther west near White Lake (herein referred to as location B, fens 1 and 2) (Figure 3). The two Richmond sites are fen communities within a larger wetland.

Table 1. Summary of label data from *Hemileuca* sp. at the Canadian National Collection, Ottawa.

Location	Township	Collector	Date Collected	# Specimens
Location A fen 1		D.M. Wood	13.IX.1978	2
Location A fen 1		D.M. Wood	19.IX.1978	34
Location A fen 1		J.D. Lafontaine	14.IX..1978	16
Location A fen 2	Marlborough	R.A. Layberry	15.IX.1979	11
Location B fen 1	McNab	R.A. Layberry	9.IX.1979	8
Location B fen 1		R.A. Layberry	IX.1979	8
Location B fen 1	McNab	R.A. Layberry	16.IX.1979	5
Location B fen 1 ?		J. & A. Reddoch	16.IX.1978	1
Location B fen 1 ?		Mark A. Saunders	9.X.1982	3
Location B fen 2	Pakenham	P. Catling	1.X.2000	2

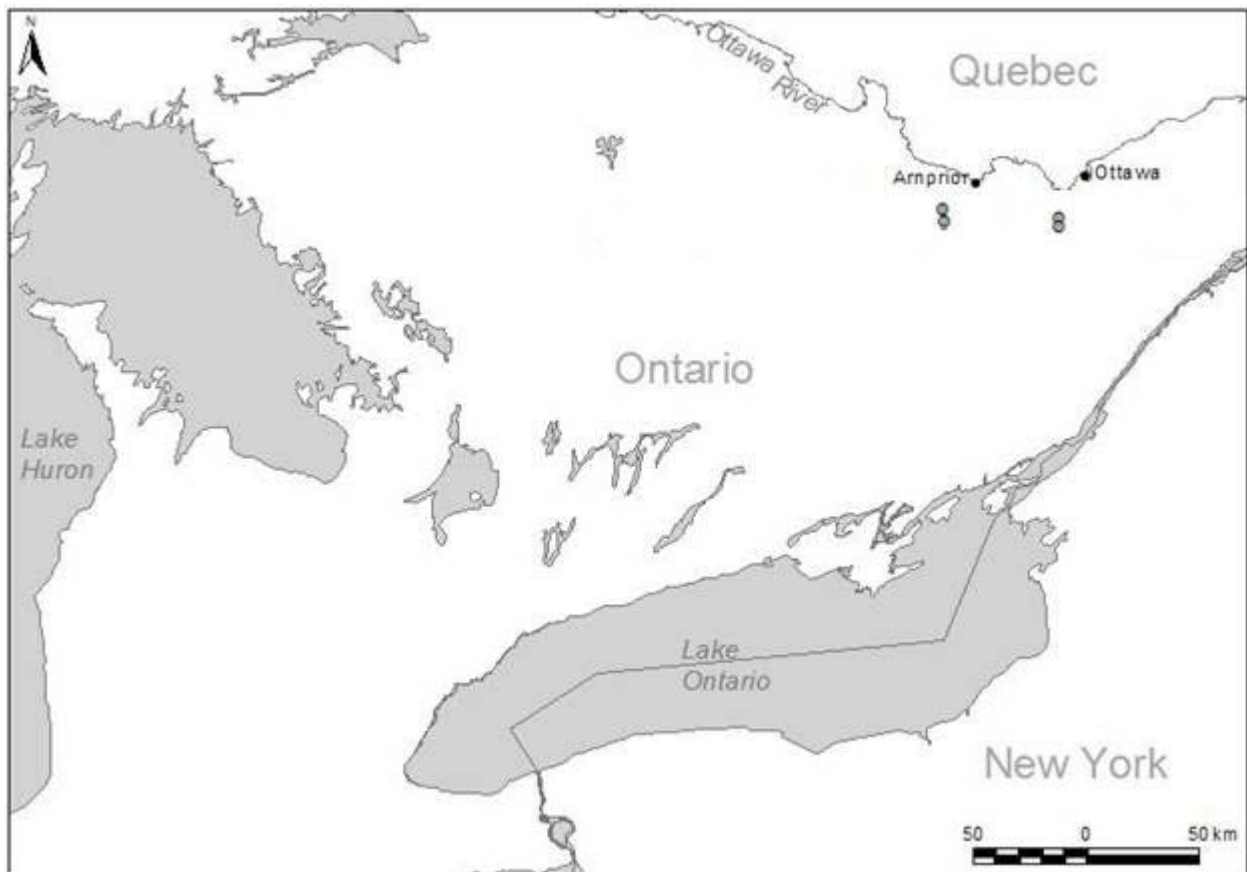


Figure 3. Distribution of Bogbean Buckmoth in Canada.

The four Canadian sites are considered four separate populations based on criteria provided by Dale Schweitzer for mapping *Hemileuca* occurrences (NatureServe 2008). Schweitzer considers a separation distance of 2 km for populations with unsuitable intervening habitat, and 10 km between populations with suitable intervening habitat. The fens at location A are separated by 2.2 km of unsuitable forest habitat. The 2008 buckmoth observations at these two sites were separated by 3.4 km. The fens at location B are 3.2 km apart with no suitable intervening habitat. Although they qualify as separate populations, these four Canadian sites may function as two separate metapopulations and are considered to represent two locations according to COSEWIC definitions. These two locations are sufficiently separated for the species to be considered severely fragmented in Canada as 50 km is far too great a distance for this species to be able to recolonize one pair of fens from the other.

All known Ontario sites are within the Mixedwood Plains Ecozone (LaFontaine 1999). These sites fall within the former bed of the Champlain Sea (Woulfe, pers. comm.) and their distribution may reflect post-glacial dispersal from the south and west (Pryor 1998; Tuskes *et al.* 1996). The maximum extent of occurrence (EO) in Canada encompasses 195 km². The maximum index of area of occupancy (IAO) is 20 km² based on a 2x2 km grid with all fens occurring in separate squares and Phragmites fen occurring in two separate squares because it is longer than 2 km. The actual area occupied is less than 3 km².

Search effort relating to distribution

Fairly extensive but unsuccessful searches for Bogbean Buckmoth have been conducted at other potentially suitable wetland habitat in Ontario, particularly at sites associated with the former Champlain Sea bed, because the known buckmoth populations are found on this landform (M. Woulfe, pers. comm.). Three fens on Lowney Lake adjacent to White Lake have been checked in the past (Oct 2000; July 2001) for larvae and/or adults, as well as in July 2008 (Foster and Harris 2008). Stoco Fen (Hastings Co.), Long Swamp Fen (Leeds Co., Grenville Co.), Mer Bleue (Ottawa-Carleton Co.), and Alfred Bog (Prescott and Russell Co.) have been surveyed for buckmoths by entomologists (R. Layberry, pers. comm.; M. Woulfe, pers. comm.). Like other known Canadian buckmoth sites, Minesing Swamp (Simcoe Co.) has open fen habitats with Eastern Prairie Fringed Orchid (*Platanthera leucophaea*), but no buckmoths were observed there during a 1-day survey in the early 1990s (K. Schneider, pers. comm.) or during a survey on July 12, 2008 for this report (Foster and Harris 2008).

Other potentially suitable Ontario fens with habitat that at least formerly supported Eastern Prairie Fringed Orchids, which might serve as an indicator species for the presence of Bogbean Buckmoth, include: 1) a relict fen at the mouth of the Holland River (Simcoe Co.), 2) the Menzel Centennial Nature Preserve (Hastings Co.), 3) the Murray Marsh (Northumberland Co.), and 4) Mac Johnson Wildlife Area (a portion of the Long Swamp Fen). The degree of targeted survey (if any) at these sites is unknown, and it is possible that Bogbean Buckmoths may be present. However, no new buckmoth sites have found in Ontario since discovery of the four sites in the late 1970s. Given the degree of interest by naturalists in these natural areas and the diurnal habits of this large distinctive species, the probability of undiscovered Ontario buckmoth populations is low.

HABITAT

Habitat requirements

In Canada, Bogbean Buckmoth is found in calcareous fens with its primary host plant, Bogbean (*Menyanthes trifoliata*). The fens at location A are palustrine fens on a limestone plain and organic (peat) landform (Chapman and Putnam 1984 in White 1992; NHIC 2008a). Those at location B overlay lime-rich marble, which has permitted the development of fen communities (NHIC 2008b). The New York Bogbean Buckmoth sites are: (i) a complex of several discrete, rich, shrub-dominated fen openings behind barrier dunes on Lake Ontario at one site, and (ii) an inland complex of sedge-dominated floating peat mats on lake edges (Pryor 1998; Reschke 1990; Stanton 2003).

The main site at location A is predominantly a low shrub fen dominated by Sweet Gale, Bog Birch (*Betula pumila*), Bog Willow (*Salix pedicellaris*) and other willows, but with patches of open fen dominated by sedges and Water Horsetail (*Equisetum fluviatile*) (Reddoch 1979). The secondary site at location A is a mainly open fen dominated by sedges such as Wire Sedge (*Carex lasiocarpa*), Twig Rush (*Cladium mariscoides*) and American Common Reed (*Phragmites australis* ssp. *americanus*) surrounded by conifer swamp. Both fens at location B have similar dominants (Foster and Harris 2008). At all sites, Bogbean Buckmoths are most abundant in patches of graminoid fen dominated by Twig Rush and/or Wire Sedge with shallow pools and *Sphagnum* hummocks with Stunted Tamarack (*Larix laricina*) and Eastern White Cedar (*Thuja occidentalis*) nearby (Foster and Harris 2008) (Figure 4, Figure 5). Bogbean, a perennial, is most abundant in the hollows where surface water is present most of the year. Parts of the main site at location A that lack *Sphagnum* hummocks in proximity also appear to lack Bogbean Buckmoth, possibly due to the scarcity of suitable pupation and oviposition sites (D. Cuddy, pers. comm. 1996; Foster and Harris 2008).



Figure 4. Typical Bogbean Buckmoth habitat, July 2008. (Photo by R. Foster.)



Figure 5. Fen pool with numerous Bogbean Buckmoth larvae, July 2008. (Photo by R. Foster.)

Habitat trends

Habitat loss does not appear to have significantly impacted Canadian populations of Bogbean Buckmoth, as all four known sites are relatively intact. However, fens in many parts of southern Ontario have deteriorated over the past few decades (P. Catling, pers. comm., 2008). Other, smaller fens that may have formerly held undocumented buckmoth populations may have been drained and developed in the past. Most of the original habitat in New York has been lost but the remainder seems to be stabilized (NatureServe 2008). There are only about 236 hectares of known Bogbean Buckmoth habitat in Canada, with the majority at location A fen 1 (144 ha) and fen 2 (61 ha) and relatively little at location B fen 1 (19 ha) and fen 2 (12 ha) (Foster and Harris 2008).

There has been some habitat degradation at Canadian sites. A railway cuts through location A, fen 1, resulting in minor loss (<2 ha) of fen habitat and disruption of water movements. A snowmobile trail running through location A fen 2 has caused localized changes in fen vegetation. Otherwise there is little direct human disturbance to any of the four sites. Non-native species, primarily Narrow-leaved Cattail (*Typha angustifolia*) and European Common Reed (*Phragmites australis* ssp. *australis*), have invaded all sites to some degree, and it is anticipated that the latter may lead to the substantial deterioration of the fen habitat at all Ontario locations in the near future (P.M. Catling, pers. comm., 2008). Although native American Common Reed was noted as a significant component of location A fen 1 in 1990 (Scholtens and Wagner 1994) this subspecies does not aggressively modify fen habitats. Narrow-leaved Cattail is not noted as a dominant in any past description of the habitats at any of the sites, although Reddoch (1979) mentioned that marsh species including cattails were “surprisingly common” in location A fen 1. Narrow-leaved Cattail is now locally dominant in patches and/or along the periphery at location A fen 1, location B fens 1 and 2 (Foster and Harris 2008), possibly as a result of changes in natural water flows at all of these sites. The fen plant communities may be gradually changing at all Ontario sites due to changes in hydrology. Control of water levels at the second location has likely flooded previous fen habitat and disruption of surface and ground water flow by the railway and surrounding agricultural lands at location A may be leading to gradual changes there as well.

Non-native species are a major concern in fen habitats. Glossy Buckthorn (*Rhamnus frangula*) has been observed at location A fen 2 (D. Cuddy, pers. comm.) and Purple Loosestrife has been seen at all sites (Foster and Harris 2008). The much more devastating European Common Reed is spreading rapidly and increasing in abundance in the Ottawa valley (Catling and Carbyn 2006).

Habitat protection/ownership

All known Bogbean Buckmoth populations in Ontario are within officially evaluated provincially significant wetlands (PSW) (Hueston and Gallway 1995; Brownell 1999). No development or site alteration is allowed in a PSW south of the Canadian Shield in Ontario under the *Ontario Planning Act* unless the developer can demonstrate no adverse impact. Development or site alteration within 120 m of provincially significant wetlands must have no negative impacts on ecological functions or natural features. Richmond Fen and White Lake Fen are also designated as Areas of Natural or Scientific Interest (ANSI) (Brunton 1990; White 1992), which affords similar protection under the *Planning Act* as well. Location A is recognized as greenspace with respect to planning.

White Lake Wetlands Conservation Reserve (C46) was established in 1999 on Crown Land adjacent to the privately owned location B where the buckmoth are found. According to OMNR's (1999) land use strategy, OMNR is to work cooperatively with private landowners and municipalities regarding the protection of the private land portion of this site.

BIOLOGY

Bogbean Buckmoth is a univoltine, diurnal silk moth. Adults do not feed.

Life cycle and reproduction

Adult Bogbean Buckmoths emerge in late September and typically oviposit on Sweet Gale, Bog Birch and other shrubs 10 to 40 cm above the water level (Pryor 1998), and less commonly on Common Reed, Marsh Muhly (*Muhlenbergia glomerata*), goldenrods (*Solidago* spp.), asters (*Aster* spp.), and rushes (*Scirpus* spp.) (Kamstra 1982; R. Layberry, pers. comm.). Bogbean has usually died back when oviposition occurs. Up to several hundred eggs are laid in a spiral ring on the stem (Pryor 1998; Foster and Harris 2008). In New York, eggs hatch in late May to early June, and first instars feed primarily on bog cranberry (*Vaccinium macrocarpon*) for about 12 days until Bogbean leafs out (Pryor 1998). Bogbean does not appear to be the first host plant in Canadian populations either (Layberry 1981). Early instars are very gregarious but they become progressively less so as the summer progresses (Pryor 1998), and sixth instar larvae are often found alone or in loose groups (Foster and Harris 2008).

In Canadian populations, Bogbean Buckmoth larvae have been observed feeding primarily on Bogbean until late July (Foster and Harris 2008). Bogbean Buckmoth larvae from Oswego County, New York also feed primarily on Bogbean (Pryor 1998). Bogbean (Menyanthaceae) is unrelated to any other *Hemileuca* host plant. Large numbers of last instar larva were observed feeding almost exclusively on Bog Birch in location A fen 1 on July 25, 1996, and last instar larvae have been reared on Bog Birch until pupation (D. Cuddy, pers. comm.). Layberry (1985) observed thousands of 5th or 6th instar larvae feeding on narrow-leaved Meadow-sweet, Bog Birch, Slender Willow (*Salix petiolaris*), and Bebb's Willow (*S. bebbiana*) on July 15, 1984 at location A fen 1 *Hemileuca* larvae collected as 3rd to 5th instars from Bogbean at both locations have been reared successfully on Bogbean, narrow-leaved Meadow-sweet, Slender Willow, and Bebb's Willow (Layberry pers. comm.). Layberry (1985) suggests that larvae may switch to alternate hosts when the Bogbean is exhausted. Cuddy (pers. comm.), observed that most of the Bogbean Buckmoth observed on Bog Birch in 1996 at location A fen 1 were adjacent to heavily or completely defoliated Bogbean.

Most other Great Lakes populations of *Hemileuca* (different species or subspecies than the one under consideration here) feed primarily on small willows (Tuskes *et al.* 1996), but populations in two Wisconsin counties have been found eating Bogbean and Bog Birch (Kruse 1998). Some New Jersey populations also eat Bog Birch (D.

Schweitzer, pers. comm.) and they have also been reported from cottonwood (*Populus deltoides*), Bog Birch, and narrow-leaved Meadow-sweet in some Michigan populations (Scholtens and Wagner 1994). *Hemileuca* larvae will often feed on plants other than the preferred host species of early instars. Last instars from at least some populations in Indiana and New Jersey could not be induced to eat Bogbean (D. Schweitzer, pers. comm.). Larvae in southern Wisconsin (Jefferson County) have also been observed to extensively defoliate Purple Loosestrife (*Lythrum salicaria*), but have much lower survivorship to pupation (24%) compared to those feeding on willow (90%) (Gratton 2006). Western populations of *H. nevadensis* generally feed on willows and cottonwoods, whereas *H. maia* prefers oaks (*Quercus* spp.) (Tuskes *et al.* 1996).

Sixth instar larvae burrow into the peat on *Sphagnum* hummocks to pupate (D. Cuddy, pers. comm.; Stanton 2003) beginning in late July. In Ontario, adult Bogbean Buckmoths typically emerge in the third week of September, but teneral adults have been reported from September 9 (R. Layberry, pers. comm.) to as late as October 12 (Kamstra 1982). Females emerge from the pupa with fully-developed eggs, attract males by emitting a pheromone, mate only once, and oviposit all eggs the same day (Tuskes *et al.* 1996). Adult males fly repeatedly around the fen searching for receptive females which typically perch on vegetation near the ground (Pryor 1998). Peak flying times for New York males are 11:00 to 14:00 (Pryor 1998). Females fly slightly later in the day and have shorter, more direct flights while searching for oviposition sites. Adult males live several days and can mate multiple times. Females usually emerge from the pupa, mate, lay their eggs and die all within 24 hours. On windy or cold days (<12°C), adults are typically inactive and do not fly (S. Bonnanno, pers. comm.; J. Kamstra, pers. comm.).

Predation

Bogbean Buckmoth eggs are preyed upon by velvet mites (Trombididae) and may be accidentally ingested by White-tailed Deer that consume most plant stems (Pryor 1998). Parasitism of Bogbean Buckmoth eggs by the wasp, *Anastatus furnissi* (Eupelmidae) has been reported for New York populations (Pryor 1998; Stanton 2003) and may partially account for fluctuations in populations. The native hymenopteran *Hyposter fugitivus* (Say) (Ichneumonidae), native tachinid *Leschenaultia fulvipes* (Bigot), and the introduced *Compsilura concinnata* (Tachinidae) are parasitoids of *H. maia* in Massachusetts, but do not appear to cause significant mortality (Selfridge *et al.* 2007). However, Gratton (2006) reported intense parasitism rates (up to 93%) of wetland-inhabiting *Hemileuca* in Wisconsin by the tachinid *L. flavipes* (Bigot). *Compsilura concinnata* (Meigen) has had severe impacts on some saturniids in eastern North America (Boettner *et al.* 2000), but mainly in forested rather than open habitats like fens (G. Boettner, pers. comm.). No parasitism of *Hemileuca* has been reported at Canadian sites, although *C. concinnata* is likely present (M. Wood, pers. comm.).

Many vertebrate predators that typically consume caterpillars may avoid Bogbean Buckmoth due to the poisonous spines. Predation on a Bogbean Buckmoth larva by *Dolichoderus* ants (Formicidae) has been observed (Foster and Harris 2008) and by true bugs (Hemiptera) in New York (Pryor 1998). Buckmoth pupae in New York appear to have been heavily preyed upon by beetles (Coleoptera) (Pryor 1998).

Adult buckmoths are preyed upon by spiders (Aranaeidae) (R. Layberry, pers. comm.), paper wasps (*Polistes*, Vespidae), Blue-headed Vireos, and possibly other birds occurring in fens (Pryor 1998). Dragonfly larvae (Aeshnidae) are found in the fen pools in Ontario populations (R. Foster, pers. obs.), and adults are potential aerial predators of adult buckmoths (Scholtens and Wagner 1994).

Nuclear polyhedrosis virus (NPV) has been reported as a mortality factor for some *Hemileuca maia* (Mitchell *et al.* 1985).

Physiology

Bogbean Buckmoth adults prefer open sunny habitats. Adults typically fly on warm, sunny days from late morning to early afternoon, but may also fly on sufficiently warm cloudy days. They apparently will not enter forested habitat and avoid shaded areas. This may be due to thermoregulation or mating behaviour. Larvae actively feed during the day, often in bright sun during cooler morning temperatures, but in late afternoon on hot sunny days, may seek shade under Bogbean leaves (Foster and Harris 2008). Late instar larvae will also feed on warm, cloudy days and probably at night as well.

Dispersal

Bogbean Buckmoth might be capable of flying several kilometres but seldom leave fen habitats (NatureServe 2008) and they are not strong fliers like noctuid or sphingid moths. *Hemileuca lucina* and *H. nevadensis* readily fly over highly unsuitable environments for short distances. Movements of up to at least 4 km have been documented for *H. lucina* (NatureServe 2008). It is assumed that Bogbean Buckmoth are capable of such flights. However, dispersal has not been seen in New York populations, where most Bogbean Buckmoth flew within 1 m of the ground (Pryor 1998). Layberry (1985) reports that, at high densities at least, adult Bogbean Buckmoths spread out over the entirety of location A fen 1 (approx. 144 ha), even though the larvae are concentrated in an area about one-quarter the size. Mark-recapture studies of adult Bogbean Buckmoths in New York (Stanton 2003) showed no dispersal between adjacent fens through forested habitat, but movements of up to 500 m within the same fen were documented.

Two kilometers of unsuitable (i.e., non-fen) habitat and 10 km of suitable habitat are considered sufficient to preclude regular dispersal among occupied sites (NatureServe 2008). The short adult lifespan of buckmoths, 2-3 days for males, one day for females, limits their potential for medium to long-range dispersal.

Interspecific interactions

Bush katydids, a number of sawfly species, and four other species of Lepidoptera (Foster and Harris 2008) have been observed feeding on Bogbean at Canadian buckmoth sites, and could potentially compete for the food plant if it was limiting.

Adaptability

Hemileuca is a widespread and diverse taxon, and has adapted to a wide range of habitats across North America. Since the retreat of the Wisconsin glaciers, Great Lakes populations of *Hemileuca* have shown the ability to colonize novel habitats such as wetlands and adapt to new host plants including Bogbean and recently introduced Purple Loosestrife. However, Bogbean Buckmoths are restricted in their distribution to relatively rare open fen habitats and are likely sensitive to habitat perturbations and hence prone to local extirpation.

POPULATION SIZES AND TRENDS

Search effort

Canadian populations of Bogbean Buckmoth have been surveyed intermittently at known sites, often in association with botanical surveys for Eastern Prairie Fringed Orchid. The only attempts to estimate the population are those that were part of the field verification for this report at which time all known populations were visited.

Potentially suitable sites not known to house populations of the Bogbean Buckmoth were noted above (search effort relating to distribution).

Abundance

There are probably at least 20-30 known sites of Bogbean Buckmoth globally but there are likely more because suitable habitat is moderately widespread in the midwest (NatureServe 2008). There are no estimates for global abundance, but an annual total of 2500 to 10,000 individuals are estimated for the Ontario and New York populations (NatureServe 2008).

The most recent Canadian survey in 2008 (Foster and Harris 2008) observed a total of 169 larvae along transects at the four sites and estimated a total abundance of approximately 6200 individuals in open graminoid fen habitat (Table 2; see Foster and Harris 2008 for details). Location A fen 1 was the largest *Hemileuca* population in 2008 and historically, and has the most suitable habitat. Bogbean Buckmoth populations are potentially 3 or 4 times greater if they inhabit the entire fens at similar densities, which could occur, at least in some years. For example, Layberry (pers. comm.) has found larvae or adults throughout location A fen 2, although in 2008 it was more or less restricted to the middle third. Layberry found many *Hemileuca* adults to within 90 m of a

Lake at location B in 1984, whereas the larvae were only found more than 300 m from the lake in 2008 (Foster and Harris 2008). The main concentration of larvae in location A fen 1 in 2008 closely corresponded with the area where Cuddy observed most of the larvae in 1996 (D. Cuddy, pers. comm.), although a lone larva was found 700 m north of the main concentration in 2008. Field experiments in Massachusetts with closely related *H. maia* found approximately 40% mortality of pupae, presumably from vertebrate or large insect predators (Selfridge *et al.* 2007). If similar rates of pupal mortality occur in Canadian populations of Bogbean Buckmoth, and assuming some additional predation or parasitism of late instar larvae, then the estimated 6200 Bogbean Buckmoth larvae observed in 2008 might represent approximately 3000 adult moths.

Table 2. Summary of 2008 larval abundance estimates for Canadian populations of Bogbean Buckmoth.

Location	Total Area of Fen (ha)	Total Area of Suitable ¹ Habitat (ha)	# Larvae Observed in Suitable Habitat	Estimated Total # of Larvae in Suitable Habitat	Estimated Total # of Larvae in Fen ²
Location A fen 1	144	34.9	75	5314	21,940
Location A fen 2	61	19.6	12	282	876
Location B fen 1	19	6.5	65	483	1,415
Location B fen 2	12	3.4	16	112	390
Total	236		168	6191	24,621

¹ open graminoid fen where the main concentration of Bogbean Buckmoth larvae were observed

² including habitat that could be suitable in other years, but which was not surveyed or did not have *Hemileuca* in 2008.

Fluctuations and trends

Bogbean Buckmoth is thought to have experienced a large to moderate (25-90%), long-term global decline associated with habitat loss (NatureServe 2008). Original populations in New York, New Jersey, and the midwest have been fragmented due to historic habitat loss (NatureServe 2008). Bogbean Buckmoth has wide annual variation in population sizes, which makes determination of long-term trends difficult, particularly at Canadian sites where they have been monitored only intermittently. New York populations that have been surveyed annually using a standardized protocol since 1998 show wide variation in the number of adults observed in part due to weather (S. Bonnanno, pers. comm.) and possibly snow pack depth that may influence mortality of overwintering eggs (Serra 2003). Since 1979, the number of Bogbean Buckmoth larvae observed at the location A fen 1 site has ranged from as low as one in some years to thousands (in 1984). Tens or hundreds of thousands of adults were observed flying there on Sept. 23, 1984 when caged virgin females were used to attract males (R. Layberry, pers. comm.) (Foster and Harris 2008). The number of larvae observed for the other sites has been lower, with a maximum of 40 reported for location A fen 1 in 1979 and 65 for location B fen 1 in 2008.

Rescue effect

Given its habitat specificity, disjunct distribution of fen habitat, and distance from other populations in the United States, it is highly unlikely that localized extirpations in Ontario will be recolonized from New York populations: the shortest distance between the two groups of populations is approximately 50 times the dispersal distance of the species. Genetic exchange between Canadian and US populations probably does not currently occur and is probably impossible even between the two pairs of Canadian populations.

LIMITING FACTORS AND THREATS

Bogbean Buckmoth populations are considered to be imminently and substantially threatened by invasion of fen habitat by exotic plants which eliminate native flora, land development, hydrological changes, and pest control programs (NatureServe 2008).

Because all of the Canadian populations of Bogbean Buckmoth are within provincially significant wetlands and/or ANSIs that experience some degree of protection, habitat loss may seem to be not a severe threat. Habitat degradation is likely the most significant threat to Canadian populations. Invasive alien plant species, particularly European Common Reed, Glossy Buckthorn and Narrow-leaved Cattail, are in or adjacent to all Canadian sites and may invade and crowd out Bogbean Buckmoth host plants and change the open aspect of the fens. The European Common Reed in particular is a threat because it forms “dense monospecific stands... and exclude[s] native biodiversity. This has occurred in a number of fens in New York State and in shoreline fens, prairies and wetlands along the Lake Erie and Hudson shores of Ontario as well as in many parts of the St. Lawrence River Valley. At the present rate of spread, all habitats of the Bog-bean Buckmoth may be affected within a decade” (Catling, 2005).

Water level manipulation at the second location and large fluctuations, as observed by Layberry (1982), could potentially cause mortality in a given year. Water levels there are manipulated in accordance to the wishes of cottagers on the lake. Much of location A fen 1 was flooded for a short time over 100 years ago when a river was dammed but it has recovered (Reddoch 1979). Degradation of the wetlands due to climate change is a potential long-term threat as well.

Lafontaine speculated that spray programs by cottagers to control gypsy moths (*Lymantria dispar*) may have negatively impacted Bogbean Buckmoth populations at location B in the past (Woulfe pers comm.). Gypsy moths are uncommon in the Richmond area so spraying is unlikely there (M. Wood, pers. comm.).

SPECIAL SIGNIFICANCE OF THE SPECIES

Bogbean Buckmoths add to the biodiversity of the three provincially significant wetlands in which they are found in Ontario. Fens in general, and open graminoid fens in particular, are rare wetland types in southern Ontario (Brownell 2001), and all four Bogbean Buckmoth sites in Ontario have fen community types that are considered provincially rare: Twig-rush graminoid fen (G3Q S3) and Bog Buckbean graminoid fen (G3G4 S3S4)(NHIC 2008c).

These fens provide habitat for other rare species. Globally rare (G2S2), nationally Endangered, and provincially Endangered Eastern Prairie Fringed-orchid is found in three of the four fens (Reddoch and Reddoch 1997; Brownell 2001) and numerous other species of rare plants are present (Reddoch 1979). Location A fen 1 is well-known for Yellow Rail (*Coturnicops noveboracensis*) (Reilly 2005), which is of Special Concern provincially and nationally. An extremely rare horse fly (Tabanidae: *Atylotus woodi*), is known from location B fen 1 (M. Wood, pers. comm.), two extremely rare spiders *Clubina angulaa* (Clubionidae) and *Goneatara nasuta* (Erigonidae) are known from location A fen 1, and several rare tachinids are known from location A fen 2 (Reddoch 1979).

Buckmoths have long been the study of amateur and professional entomologists, in part due to their diurnal habits and striking colouration. Bogbean Buckmoths belong to a diverse and poorly understood genus and are a useful model for the study of biogeography, gene flow, and evolution (Kruse 1998; Rubinoff and Sperling 2002).

EXISTING PROTECTION OR OTHER CONSERVATION RANKS

The Bogbean Buckmoth is ranked G1Q – critically endangered globally but of uncertain taxonomy. It is listed as Endangered in New York State (NYDEC 2008). Status designations for related *Hemileuca* are given in Table 3.

Table 3. State / Provincial ranks for Bogbean Buckmoth, *Hemileuca* sp. (NatureServe 2008).

State / Province	Rank	Scientific Name	Common Name*
Ontario	S1	<i>Hemileuca</i> sp. 1	Cryan's or Bog Buckmoth
New York	S1	<i>Hemileuca</i> sp. 1	Cryan's or Bog Buckmoth
New Jersey	S1	<i>H. nevadensis</i> ssp.2	Schweitzer's Buckmoth)
Pennsylvania	S1	<i>H. nevadensis</i> ssp.3	Great Lakes Buckmoth
Indiana	S1?	<i>H. nevadensis</i> ssp.3	Great Lakes Buckmoth
Michigan	S2S3	<i>H. nevadensis</i> ssp.3	Great Lakes Buckmoth
Wisconsin	S3	<i>H. nevadensis</i> ssp.3	Great Lakes Buckmoth
Illinois	SNR	<i>H. nevadensis</i> ssp.3	Great Lakes Buckmoth
Iowa	SNR	<i>H. nevadensis</i> ssp.3	Great Lakes Buckmoth
Minnesota	SNR	<i>H. nevadensis</i> ssp.3	Great Lakes Buckmoth
Ohio	SNR	<i>H. nevadensis</i> ssp.3	Great Lakes Buckmoth

* These are alternative common names for true Bogbean Buckmoth.

TECHNICAL SUMMARY

Hemileuca sp.

Bogbean Buckmoth

Range of Occurrence in Canada: Ontario

Hémileucin du ményanthe

Demographic Information

Generation time (average age of parents in the population)	12 months
[Observed] percent [increase] in total number of mature individuals over the last [10 years].	Not estimated with sufficient accuracy
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [2 generations].	Small decline likely due to invasion of habitat by invasive plants, especially European Common Reed
[Observed] percent [reduction AND increase] in total number of mature individuals over any [10 years] period, over a time period including both the past and the future.	Surveys have been insufficiently detailed to permit detailed analysis
Are the causes of the decline clearly reversible?	Invasive plants rarely have reversible effects
Are the causes of the decline understood?	Somewhat
Have the causes of the decline ceased?	No.
[Observed] trend in number of populations	Stable.
Are there extreme fluctuations in number of mature individuals?	The limited data suggest fluctuations but probably of less than an order of magnitude. Similar levels of fluctuation have been well documented in the New York populations. The data from the surveys of larvae are not readily comparable due to unknown survey effort.
Are there extreme fluctuations in number of populations?	No.

Extent and Area Information

Estimated extent of occurrence	195km ²
[Observed] trend in extent of occurrence	Presumed stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	20km ² based upon a 2X2km grid but suitable habitat is less than 3km ²
[Observed] trend in area of occupancy	Likely stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	Yes – two pairs of sites with dispersal from one pair to the other impossible.
Number of current locations.	2
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Overall, slight decline due to invasive European Common Reed.

Population

N Mature Individuals

Location B	595 larvae = <300 adults
Location A	5596 larvae = < 3000 adults
Number of locations	2

Quantitative Analysis

	Not performed
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Threats (actual or imminent, to populations or habitats)

<ul style="list-style-type: none"> Invasion by Glossy Buckthorn, Narrow-leaved Cattail and European Common Reed, especially the latter. Water level control at the location B.
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Rescue Effect (immigration from an outside source)

Status of outside populations? The species is considered Endangered in New York	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (November 2009) Global G1Q USA N1 Canada N1 New York S1 Ontario S1

Status and Reasons for Designation

Status: Endangered	Alpha-numeric code: B1ab(iii) + 2ab(iii)
Reasons for Designation: This very rare moth is only known from New York and Ontario. In Ontario, it is found in two widely separated fens. It is susceptible to the effects of exotic invasive plants, especially European Common Reed, that are crowding out its preferred foodplant, the Bogbean, and of potential flooding or drying of habitat resulting from manipulation of water levels at the main site.	

Applicability of Criteria

Criterion A (Declining Total Population): Not applicable
Criterion B (Small Distribution, and Decline or Fluctuation): Meets Endangered B1ab(iii)+2ab(iii). The species has a very small EO of 195 km ² and a very small IAO of, at most, 20 km ² , both well below thresholds. It is highly fragmented occurring at 2 locations that are separated by more than 10 times the insect's dispersal distance. All habitat is threatened by the invasive European Common Reed and the main site is threatened by modification of water levels.
Criterion C (Small Total Population Size and Decline): Not applicable. While the total population size is likely a few thousand adult individuals, there is no clear evidence of decline.
Criterion D (Very Small Population or Restricted Distribution): May meet Threatened D2 because IAO is at most 20 km ² and the number of locations is 2.
Criterion E (Quantitative Analysis): Not done.

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Authorities consulted

The following authorities were contacted during the preparation of the COSEWIC status report:

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Robert Foster is co-founder and principal of Northern Bioscience, an ecological consulting firm offering professional consulting services supporting ecosystem management, planning, and research. Dr. Foster has a B.Sc. in Biology from Lakehead University and a D. Phil in Zoology from the University of Oxford. Rob has worked as an ecologist in Ontario for over 15 years, and has authored or coauthored COSEWIC status reports on the Rapids Clubtail, Laura's Clubtail, Northern Barrens Tiger Beetle, and Drooping Trillium, as well as recovery plans for rare plants, lichens, and odonates.

Allan Harris is a biologist with over 20 years' experience in northern Ontario. He has a B.Sc. in Wildlife Biology from the University of Guelph and an M.Sc. in Biology from Lakehead University. After spending seven years as a biologist with Ontario Ministry of Natural Resources, he co-founded Northern Bioscience, an ecological consulting company based in Thunder Bay, Ontario. Al has authored or coauthored dozens of scientific papers, technical reports, and popular articles, including COSEWIC status reports for Rapids Clubtail, Laura's Clubtail, Patterned Green Tiger Beetle, Small-flowered Lipocarpha, and Drooping Trillium. Al also authored the Ontario provincial status report for woodland caribou, and has authored or coauthored national and provincial recovery strategies for vascular plants and birds.

COLLECTIONS EXAMINED

Kristina Verhufen (Biodiversity Technician, CNC) checked all Canadian specimens of *Hemileuca* sp. held at the Canadian National Collection, Ottawa and transcribed label data. Ninety adult specimens were collected in the field (Table 1) and an additional seven were reared from larvae collected June 1979 from location A fen 1 by Ross Layberry.