COSEWIC
Assessment and Status Report

on the

Half-moon Hairstreak
Satyrium semiluna

in Canada

ENDANGERED
2006

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

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AU CANADA

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Half-moon Hairstreak — Prodvided by the author.

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COSEWIC
Assessment Summary

Assessment Summary – April 2006

Common name
Half-moon Hairstreak

Scientific name
Satyrium semiluna

Status
Endangered

Reason for designation
The butterfly occurs as disjunct populations in two small, restricted areas at the northern extreme of the species' range. The species' population has likely declined in the past as a result of habitat loss. Both populations continue to be threatened by habitat loss and degradation. In British Columbia the species occurs in an area under severe pressure for development. In both Alberta and British Columbia, invasive weeds also pose a serious threat.

Occurrence
British Columbia, Alberta

Status history
Designated Endangered in April 2006. Assessment based on a new status report.

COSEWIC
Executive Summary

Half-moon Hairstreak
Satyrium semiluna

Species information

The Half-moon Hairstreak, named after its type locality at Half-Moon Ranch in Wyoming, is a small drab hairstreak butterfly in the family Lycaenidae. The adult butterflies are brown or blackish brown on the dorsal wing surfaces and grayish brown on the ventral wing surfaces with variable amounts of white and black maculation. There are two distinct populations in Canada, one in British Columbia and the other in Alberta, and these entities may represent different subspecies.

Distribution

The Half-moon Hairstreak is found from extreme southern interior British Columbia south to central California and east to eastern Wyoming and northern Texas. In Canada the species occurs as two disjunct populations, one on either side of the continental divide. The British Columbia population is known from a few locations in the southern Okanagan Valley from the Canada/United States border north to White Lake. On the east side of the Rocky Mountains, Alberta has one known population in Waterton Lakes National Park, which is also disjunct from the nearest known populations in the United States.

Habitat

In British Columbia, populations of the Half-moon Hairstreak have been found at elevations from 600 m to 1,100 m in a number of scattered sites in sagebrush/grassland habitat where lupines are present. The Alberta population is restricted to an alluvial fan, a grassland habitat with abundant lupines, at 1,300 m elevation in Waterton Lakes National Park.

Biology

The larval food plants of the Half-moon Hairstreak have not been confirmed in Canada, but lupines are thought to be used because of the association of the butterfly with lupines at all known sites in Canada and the confirmed use of lupines as the host plant in the United States. The Half-moon Hairstreak is reported to have one annual brood. Adults of the British Columbia population have been found from 20 May to 4 July

and Alberta adults have been found in late June 25 and in the last two weeks of July. The likely association of the immature stages of the butterfly with ants may be a significant factor in the biology (and hence distribution) of both Canadian populations. The presumed lupine larval food plant is an abundant and widespread species in British Columbia and its presence clearly does not determine the species' range in the province.

Population sizes and trends

Although no quantitative surveys were done in 2003, the Alberta population of the Half-moon Hairstreak was thought to be anywhere from several thousand to less than ten thousand adults. In 2004, only 250 adults were observed over several days of intensive searching. The size of the British Columbia population is unknown, but a plausible range is 5,000 to 15,000 adults. Population trends are unknown.

Limiting factors and threats

The Half-moon Hairstreak requires unforested areas with lupines. This butterfly's larvae may depend on a mutualistic relationship with ants. If that is the case, the presence of the appropriate species of ants will also be a limiting factor. Intensive livestock grazing, especially on private land, conversion of native sagebrush grasslands to agriculture and habitat loss to development are considered to be the main threat to British Columbia populations.

The Alberta population may be limited primarily by a combination of habitat flooding and possibly by severe spring frosts. This population is also threatened by knapweed invasion and control.

Special significance of the species

The Half-moon Hairstreak is one of a group of butterflies that reach their northern distribution limit in western Canada. The Alberta population is disjunct from populations in the United States and in British Columbia.

Existing protection

The Waterton Lakes National Park population is protected under the National Parks Act. The British Columbia population is not protected under any statute although some of its habitat is protected in some lands acquired for conservation purposes. The species is considered to be secure in the United States.

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 5th 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 (2006)

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 it 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

Satyrium semiluna Klots, known until recently as *S. fuliginosum* (W.H. Edwards, 1861), is a hairstreak butterfly of the family Lycaenidae. Mattoon and Austin (1998) provide a recent taxonomic review and recognize five subspecies in two phenotypically distinct groups. The '*fuliginosum*' group was considered to consist of subspecies *albolineatum* Mattoon and Austin, 1998; *fuliginosum*, and *tildeni* Mattoon & Austin, 1998. The '*semiluna*' group was considered to consist of subspecies *maculadistinctum* Mattoon & Austin, 1998 and *semiluna* Klots, 1930.

Recent Canadian literature (Bird *et al*. 1995, Layberry *et al*. 1998, Guppy and Shepard 2001) consistently places the Alberta population in the subspecies *semiluna*. This interpretation is also advanced by Kondla (2003a, 2004b), although the adults are noticeably smaller than individuals from Idaho, southern Montana and Wyoming. Taxonomic placement of the British Columbia populations at the subspecies level is variable in the literature. Layberry *et al.* (1998) treat these as subspecies *fuliginosum* while Guppy and Shepard (2001) treat these as subspecies *semiluna*. Pyle (2002) quotes A. Warren as considering them as a "probably undescribed" subspecies. Kondla (2003b) also considers the British Columbia populations to be an undescribed entity.

Recent work by Warren (2005) resulted in the separation of *S. semiluna* from *S. fuliginosa*, with *S. semiluna* being given formal species status. This split is based on the fact that "males from all populations of *S. semiluna* have forewing stigmata, which vary from being vestigial to well-developed, while males of *S. fuliginosa* lack any trace of forewing stigmata" (Warren, 2005). The stigmata are patches of specialized scent scales that have recently been shown to be important in mating (D. Lafontaine, pers. comm.). Consequently, the former *S. fuliginosa* has been divided into two species (Warren, 2005) with true *S. fuliginosa* restricted to California and *S. semiluna* found everywhere else (D. Lafontaine, pers. comm.). Both populations in Canada are now recognized as being *S. semiluna* (A. Warren, pers. comm.). The British Columbia population may be a separate subspecies from typical *S. semiluna* which was described from northern Wyoming, but there is no subspecific name applied to the British Columbia form (D. Lafontaine, pers. comm.).

The English common name, Half-moon Hairstreak, is used in this report as the species is named for the type locality, Half-Moon Ranch in Teton County, Wyoming (A. Warren, pers. comm.). The French common name 'Porte-queue demi-lune' is recommended (J.-F. Landry, pers. comm.).

Morphological description

The Half-moon Hairstreak is a small, drab butterfly that looks predominantly brownish or blackish brown on the dorsal wing surfaces. The colour depends on sex, subspecies, amount of flight wear and age of museum specimens. Unlike many other

species of hairstreaks, there are no tails on the hindwings. Figure 1 illustrates Alberta and British Columbia males. Comparative illustrations showing *S. fuliginosa* and Canadian females are provided in Kondla (2003b).

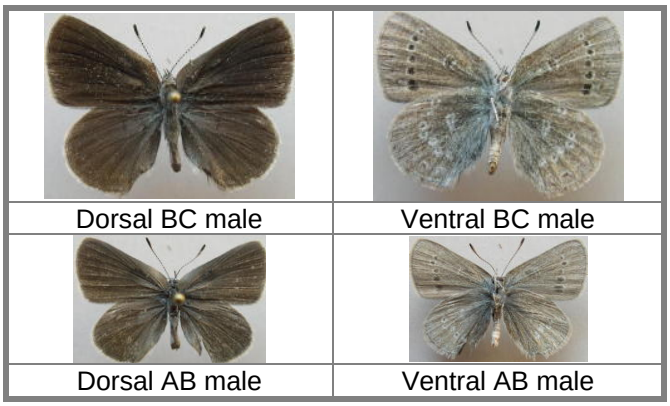

Figure 1. Dorsal and ventral views of the Alberta (Waterton Lakes National Park) and British Columbia (vicinity of White lake) entities in comparison to each other. Scale is lifesize.

Males of the Alberta population are very small, with a wingspan of 25 mm or less. The dorsal wing surface is dark brown which fades to lighter brown with age. Males have a conspicuous dark stigma (patch with androconial scales) on the dorsal surface of the forewing. The undersides of males are medium brown with grey overscaling along the distal wing margins. Large black spots, slightly edged with white scaling, are present in the postmedial area of the ventral surface of the forewing. The black postmedial spotting on the dorsal side of the hindwings is much reduced. The submarginal areas of the undersides of the wings are featureless or have very faint markings. Females are larger and are paler and greyer on the ventral side than males

Males of the British Columbia population of the Half-moon Hairstreak have a wingspan of 30 mm or more and are conspicuously larger than their Alberta counterparts. The dorsal wing colour is a dark grey-brown that appears blackish when fresh. The dorsal colour fades to brown with age. The stigma on the dorsal surface of the forewing of most individuals is inconspicuous and less cleanly defined than in individuals of the Alberta population. Male undersides are more conspicuously spotted than in the Alberta population. This increased maculation includes more distinct marginal spotting and a more conspicuous dark bar at the forewing cell end. Females differ from males in the same manner as their Alberta counterparts.

Adult Half-moon Hairstreaks can be confused with another lycaenid butterfly that flies in the same areas and overlaps in flight period. This butterfly is *Aricia icarioides*, Icarioides Blue or Boisduval's Blue (also placed in the genera *Icaricia* or *Plebejus* by various authors). This identification confusion is limited to ventral views because males of *Aricia icarioides* are blue on the dorsal wing surface and even female *A. icarioides* normally have at least some basal blue on the dorsal surfaces of the wings.

The eggs of *S. fuliginosa*, which may actually refer to *S. semiluna*, are described by Scott (1986a) as greenish white. Scott (1992) provides further details on the appearance of the egg and notes that some eggs are tan coloured, possibly as a consequence of age. Last-instar larvae are described by Ballmer and Pratt (1988). They note that the larva superficially resembles that of *Aricia icarioides*. The larva is reported as having a light green ground colour with whitish lateral chevrons and a dark brown head.

Genetic description

Gene flow between the British Columbia and Waterton Lakes populations is highly unlikely because of substantial geographical separation and ecological barriers. The Guelph Centre for DNA Barcoding has assembled a segment of the mitochondrial DNA sequences of cytochrome C oxidase from ten specimens of *S. semiluna* (four from the White Lake basin in British Columbia, two from Waterton Lakes National Park in Alberta and four from Kittitas County in Washington State). The nucleotide sequence for all ten specimens was identical. This result does not support, but neither does it refute, the hypothesis that differences in the appearance of adults and structural differences in the male androconial patch may be indicative of differences in genetic structure between the Alberta and the British Columbia populations, because the analysis does not resolve recent divergences (F. Sperling, pers. comm.).

Designatable units

There is some evidence that the two Canadian populations may be taxonomically distinct, but there are no subspecies level names for the populations, and more work needs to be done on this aspect. The observed morphological differences may be indicative of two different entities, or they may reflect plasticity of certain characteristics when the species occupies different habitats.

There is a significant geographical disjunction between the two populations in Canada, which also extends well south of the Canadian border. There is no opportunity for exchange of individuals between the Alberta and British Columbia populations. The populations are separated by a linear distance of approximately 400 km, most of which consists of habitats that are not suitable for the species. These populations may not appear to be biogeographically distinct if one considers all of the cordilleran area in southwestern Canada to be homogeneous, but the biogeographic and ecological environments of the south Okanagan area of British Columbia and southwestern Alberta are different. In addition, there are large areas of unsuitable high elevation habitat west and east of the Rocky Mountains both in Canada and in the United States. Although the Alberta and British Columbia populations occur in different ecological situations and are isolated from each other, they occur within the Southern Mountain ecozone.

The Alberta and British Columbia populations are subject to different land use regimes and threats. The Alberta population is located in a national park where anthropogenic threats are limited, although the population is exposed to stochastic

natural processes and is subject to the effects of knapweed invasion and control. The British Columbia population occurs at a number of sites which are subject to a range of land uses that may threaten the persistence of the butterfly at these sites. Its habitat is also subject to invasion by alien plant species.

DISTRIBUTION

Global range

The range of *Satyrium semiluna* occurs from extreme southern interior British Columbia south to the east side of the Sierra Nevadas in central California and thence east to western Montana, eastern Wyoming and northwestern Colorado (Figure 2). The Alberta population belongs to a phenotype that extends to northwestern Colorado and westward through Nevada, Oregon and Idaho (Mattoon and Austin 1998). The taxonomic status and range of the British Columbia entity is unclear, but the southern limit may be in nearby northern Washington as evidenced by the presence of a different phenotype in Kittitas County (N. Kondla unpublished data).

Canadian range

The Canadian range of *S. semiluna* consists of one known population in Waterton Lakes National Park and 11 known sites which may represent six populations of another subspecies in extreme southern interior British Columbia (Figure 3). The British Columbia population is contiguous with populations in Washington State (Guppy and Shepard, 2001). Less than 1% of the global distribution of *S. semiluna* is in Canada.

Literature reports indicate that the Half-moon Hairstreak in Canada has been recorded (under the name Sooty Hairstreak) from only a few areas in British Columbia and from Waterton Lakes National Park in Alberta (Bird *et al.* 1995, Bowman 1951, Guppy and Shepard 2001, Kondla 2003b, Layberry *et al.* 1998). The species is not known to occur in the area surrounding Waterton Lakes National Park (Kondla 2004a). A report of this species from the lower Fraser valley by Llewellyn-Jones (1951) is considered to be an error because the species has never been documented to occupy moist forest habitat anywhere in its range.

Prior to 2003, *S. semiluna* (then known as *S. fuliginosum semiluna*) was known in Canada from a historical collection by J. McDunnough in Waterton Lakes National Park in 1923 (specimen in Canadian National Collection). Kondla visited this area in 2003, noted a specimen in the park insect collection from 1967, and then discovered an extant population on an alluvial fan in the park (Kondla 2003a).

Figure 2. Global and North American range of *Satyrium semiluna*. Source: adapted from Opler (1999), S. Kohler (pers. comm.), N. Kondla (unpublished data), and A. Warren (pers. comm.). Note the disjunct population in SW Alberta.

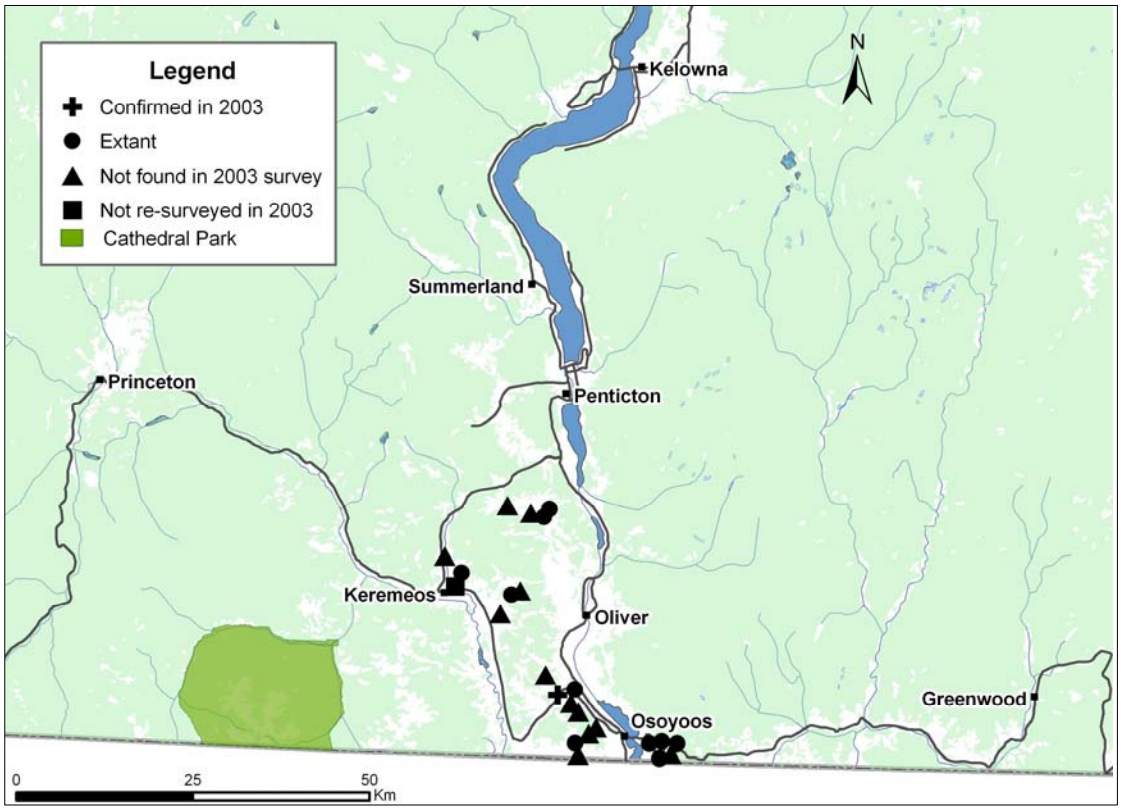

Figure 3. Known distribution of *Satyrium semiluna* in British Columbia: cross = previously known location confirmed in 2003; square = previously known location not resurveyed in 2003; circle = new locations found in 2003; triangle = locations surveyed in 2003 but no Hairstreaks found. Note: due to map scale not all sites examined can be displayed as individual symbols.

In British Columbia, the earliest known record for *S. semiluna* (also originally called S. *fuliginosum*) is from an unknown location in the vicinity of Osoyoos in 1895 (Canadian National Collection). Three specimens in the Royal British Columbia Museum were collected in 1898 and 1901 at an unknown location in British Columbia. Subsequently, there were a few collections from the vicinity of Keremeos in 1923; Anarchist Mountain in 1975, 1976, 1979, 1985 and 1990; and one sight record from Richter Pass in 2002. In 2003, Kondla conducted field surveys to confirm some past records and locate additional sites. This work resulted in the discovery of new sites in the vicinity of Kilpoola Lake, White Lake and Mt. Kobau, as well as the confirmation of the species' presence at Richter Pass and Anarchist Mountain. An additional site near Keremeos Columns Provincial Park was reported by J. Fenneman (pers. comm.) in 2003.

The extent of occurrence and the area of occupancy of the single Alberta population are about 5 km^2.

The extent of occurrence of the known British Columbia population is approximately 480 km^2. The maximum potential area of occupancy of the British Columbia population is

about 250 km^2, based on a rough estimate of the amount of non-forested habitat within the extent of occurrence. Only a small portion of the total area of sagebrush/grassland habitat in British Columbia has been searched for the presence of *S. semiluna*. Field surveys in 2003 did not find the species in all apparently suitable habitat patches and yielded only seven occupied sites out of 33 searched. Existing information and observations suggest the species does not use steep terrain. Information is not available on how much of the non-forested area supports the lupine species presumed to be the larval food plant of the Hairstreak. In addition, the lupine is an abundant and widespread species in British Columbia, and its presence clearly does not determine the butterfly's range in the province. Given these considerations, it is likely that the actual area of occupancy is a small percentage of the unforested area. A very rough preliminary estimate is that the maximum area of occupancy could be as little as 25 km^2.

The extent of occurrence for the entire population of *S. semiluna* in Canada (Alberta and British Columbia populations combined) is 485 km^2, and its area of occupancy is about 30 km^2.

HABITAT

Habitat requirements

In 2003, the British Columbia population of *S. semiluna* was found only in sagebrush/bluebunch wheatgrass habitat with silky lupine (*Lupinus sericeus*) present, at an elevation from 600 m to 1,100 m. Extant populations were found in areas that, at the landscape scale, had reduced relief in comparison to surrounding steeper areas (Figure 4). All sites where the butterflies were present also had flowering plants of common yarrow (*Achillea millefolium*) and umbrella-plant (*Eriogonum heracleoides*).

Figure 4. Typical Half-moon Hairstreak habitat in British Columbia – White Lake basin.

Because the British Columbia population has not been found in all visually suitable habitat patches that have been searched, the population appears to be fragmented. Clusters of sites in the White Lake, Richter Pass and Anarchist Mountain areas are each considered to represent one population. Each of the other three sites is

considered to represent a separate population. There is, however, substantial connectivity of sagebrush habitats which could allow movement between occupied sites. It is possible that these sites represent part of one large, fragmented meta-population. The one known exception is the White Lake basin which has a block of known and potential habitat that is disjunct at the landscape scale from other known habitat patches and is therefore not part of that meta-population.

Multiple sites were examined in the White Lake basin in 2003. A robust population of *S. semiluna* was found in lightly grazed sagebrush/grass habitat. In contrast, no Hairstreaks were found just across the road in very heavily grazed sagebrush/grass habitat. Hairstreaks were also not seen in areas where lupine was present but sagebrush was absent. It appears that the presence of sagebrush is an important habitat component in British Columbia. The minimum amount of lupine needed as a habitat component is unknown. No Half-moon Hairstreaks were seen at any British Columbia site with extreme livestock grazing.

The single Alberta population of *S. semiluna* occupies level grassland habitat at an elevation of about 1,300 m on a coarse-textured alluvial fan with abundant *Lupinus sericeus* and flowering low goldenrod (*Solidago missouriensis*) and yellow umbrella-plant (*Eriogonum flavum*). Numerous areas within and near Waterton Lakes National Park at low to high elevations and with *Lupinus* present were searched but no additional Hairstreaks were found except for three individuals on hummocky moraine near the densely populated fan habitat (Kondla 2003a, 2004b). Furthermore, these three individuals outside the breeding habitat on the nearby alluvial fan were seen only in 2003 under very windy conditions. Examination of the same area in 2004 under calm conditions did not reveal any Hairstreaks. It is possible that the three individuals had been blown away from their normal habitat. Habitat in Alberta is not fragmented because there is only a single population of *S. semiluna* in a single habitat patch.

There may be an obligatory association of the larvae in the two Canadian populations of *S. semiluna* with specific species of ants. This potential relationship, if present, may be a key component of the habitat requirements of *S. semiluna*. Ants have specific habitat requirements, which may be different from butterfly habitat requirements, and hence two interacting sets of habitat requirements may determine the suitability of an area for *S. semiluna*.

Habitat trends

Except for periodic flooding and reworking of portions of the alluvial deposits, the Half-moon Hairstreak habitat in Waterton Lakes National Park is stable. The habitat is being invaded, however, by knapweed (*Centaurea maculosa*). Continuation of this process will alter the habitat either directly through plant competition or as a consequence of weed control measures.

Information on site-specific habitat trends is lacking for the British Columbia populations, except to note that one occupied site on Anarchist Mountain was burned by a

wildfire in July of 2003. The condition of sagebrush sites at lower elevations was observed by Kondla to be generally poorer than at higher elevations. The quantities of six types of sagebrush grasslands where the Half-moon Hairstreak may occur in the Okanagan valley as well as the trends for these habitats are presented in Table 1. Many of these habitats have undergone substantial declines, ranging from 40% (for big sagebrush – bluebunch wheatgrass, the habitat type for the Half-moon Hairstreak) to none. However, several of the sites where the Hairstreak occurs are on lands recently acquired for protection purposes. Such protection will partially offset the trend of loss of sagebrush grasslands, only 50% of which remain compared to what occurred historically in the south Okanagan Valley (T. Lea, pers. comm.). The general increase in land use intensity in the south Okanagan-Similkameen area will likely cause further losses and degradation to the condition of the small amounts of these sagebrush grassland habitats that persist outside protected areas at both lower and higher elevations.

Table 1. Habitat trends for sagebrush grassland habitat types that potentially support *S. semiluna*. (Dyer and Lea, unpublished data, 2005)

Habitat type	Total area occurring in 1995 (ha)	Total area occurring in 1800 (ha)	Change from 1800 to 1995 (ha)	% change
Big sagebrush-selaginella; very shallow soil	4546	4536	10	~0%
Big sagebrush-bluebunch wheatgrass; mesic	2000	3321	-1320	-40%
Bluebunch wheatgrass-arrow-leaved balsamroot; deep soil	7671	7776	-105	~0%
Bluebunch wheatgrass-Sandberg's bluegrass; deep soil	4400	4314	86	~0%
Bluebunch wheatgrass-junegrass; mesic	1829	2454	-625	-25%
Bluebunch wheatgrass-selaginella; shallow soil	12563	12456	107	~0%

Habitat protection/ownership

The Waterton Lakes National Park population of *S. semiluna* is protected by virtue of its location, and the significance of this population is now known to park officials, but the habitat is susceptible to the effects of knapweed invasion.

Most of the known British Columbia populations of the butterfly are located on private land where they do not receive any legal protection; however, some sagebrush grasslands that potentially support the butterfly are within conservation lands (Table 2). Some confirmed sites for *S. semiluna* occur within recently acquired sites, including White Lake and Mount Kobau (D. Fraser, pers. comm.). Some of the White Lake population is on federal land belonging to the National Research Council and leased to a private ranching family that is cooperating with the Biodiversity Ranch Program of The Nature Trust. Management of the land does not presently include specific consideration

of *S. semiluna* habitat requirements, but the Ranch takes an integrated approach to managing ranching and other land uses to balance the habitat requirements of the many species at risk that exist there. Some of these may be complementary to the needs of the Half-moon Hairstreak (CWS, Pacific and Northern Region, pers. comm., 2006).

Table 2. Current ownership and conservation status of sagebrush grassland habitat types that potentially support *S. semiluna* (Dyer and Lea, unpublished data, 2005).

Habitat type	Total (ha)	Lands in conservation (ha)	Provincial crown land (ha)	Indian reserve (ha)	Private land (ha)
Big sagebrush-selaginella; very shallow soil	4546	1163	1112	944	1327
Big sagebrush-bluebunch wheatgrass; mesic	2000	457	273	329	941
Bluebunch wheatgrass-arrow-leaved balsamroot; deep soil	7671	966	1589	2628	2488
Bluebunch wheatgrass-Sandberg's bluegrass; deep soil	4400	471	780	851	2298
Bluebunch wheatgrass-junegrass; mesic	1829	374	238	368	849
Bluebunch wheatgrass-selaginella; shallow soil	12519	2547	3794	2532	3646

BIOLOGY

Life cycle and reproduction

Eggs are laid on host lupines or in the leaf litter at the base of plants (Scott 1986b, 1992). The eggs overwinter and the larval and pupal stages occur in spring. Adults emerge in the late spring or early summer and complete the life cycle. The species is reported as having one generation per year.

Adult activity period

In British Columbia, adults have been found as early as 20 May and as late as 4 July. Based on observations in 2003 and most museum specimens, the last two weeks of June appear to be the peak flight period in British Columbia. Capture dates for five museum specimens from the period 1895 to 1901 are notably earlier and range from May 20 to June 2. Lack of precise geographic locations for these specimens makes it impossible to determine if these early dates were the result of unusual climatic conditions at that time or if the specimens originated from low elevation habitat which no longer exists.

An early specimen from the Alberta population was collected on 25 June (Bird *et al*., 1995). In Kondla's 2003-2004 surveys, the Alberta population flew in the last two weeks of July. The flight period in both provinces appears to be correlated with seasonal senescence of *Lupinus sericeus*.

In both British Columbia and Alberta, adults were active during much of the daylight period. In 2003, adults were active between 0830 and 1800 hours in British Columbia and between 0830 and 1930 hours in Alberta (Kondla, personal observation). British Columbia individuals may engage in some communal roosting overnight at the tops of sagebrush plants. Three individuals were noted within a few centimetres of each other at the top of a sagebrush plant at 1800 h on one occasion. In 1975, Guppy (unpublished data) noted many adults resting individually, with their wings closed, on the upper surface of large arrowleaf balsamroot (*Balsamorhiza sagittata*) leaves at midday in hot weather with the sun mostly obscured by high thin cloud.

Adult food resources

Alberta adults primarily use *Eriogonum flavum* as a nectar source, probably because of the abundance of this plant in its habitat. Flowers of *Solidago missouriensis* are also used as a nectar source, but this plant is much less abundant in the habitat (Kondla 2003a, 2004b). British Columbia adults have been found taking nectar at *Achillea millefolium*, *Eriogonum heracleoides*, and rabbitbrush (*Chrysothamnus viscidiflorus*) (Kondla 2003b and unpublished data).

Reproductive behaviour

Perching appears to be the primary form of mate-locating behaviour exhibited by males in both Alberta and British Columbia.

In Alberta, several mating pairs of *S. semiluna* were found on flowers of both *Eriogonum flavum* and *Solidago missouriensis*. It is possible that nectar sites also serve as mate-locating sites. Mating pairs have also been noted on *Lupinus,* pasture sagewort (*Artemisia frigida*) and other vegetation. Under conditions with little or no wind, Alberta males engage in low (less than 60 cm high) patrolling flights which include circling of *Lupinus* plants. Both males and females have also been seen on a variety of substrates, including bare soil, grass culm, rocks, dry knapweed stalk, aster (*Aster* sp.), silverberry (*Eleaegnus commutate*), *Lupinus sericeus*, cinquefoil (*Potentilla* sp.) and milk-vetch (*Astragalus* sp.) (N. Kondla 2003a, 2004b).

In British Columbia, male *S. semiluna* were commonly found perching on big sagebrush (*Artemisia tridentate*) shrubs. They were also observed making short flights at heights of 1 to 2 metres between shrub perches. These flights sometimes included circling a given sagebrush plant two or three times before the male moved on to another plant and settling into a perch (N. Kondla, unpublished data).

Larval resources

Larvae in the United States have been reported to feed on various species of *Lupinus* (Ballmer and Pratt 1988, Scott 1986b, 1992). Several species of *Lupinus* are known to occur in Alberta and British Columbia, but only the widespread and common *Lupinus sericeus* has been consistently noted where *S. semiluna* populations have been found (Kondla, unpublished data).

Interspecific interactions – Myrmecophily

Myrmecophily in butterflies is a mutualistic relationship between the larva and one or several ant species. The larvae of lycaenid butterflies secrete a nutritious liquid containing carbohydrates and free amino acids from a dorsal gland (Pierce 1987, Leimar and Axtén 1993). These secretions are eagerly consumed by the attendant ants. In return, the ants guard the larvae from attacks by predators and parasitoids.

Among Lepidopterans, myrmecophily is most prevalent among Lycaenid butterflies. More than 50% of the butterfly species within the family have a relationship with ants during larval development (Seufert and Fiedler 1996). Some Lycaenid species are obligates (they cannot survive without ant attendants, usually of a specific ant species). Others are facultative (the caterpillar can interact with different ant species, but can survive without them). However, even among facultative species, the larvae usually gain an advantage from myrmecophily.

Myrmecophily in North American Lycaenid species has been noted by a number of researchers, including Ballmer and Pratt (1988) and Scott (1992). Many species in the family Lycaenidae form obligatory associations with certain ant species. In California, the larvae of *S. fuliginosa* (and presumably *S. semiluna*) are frequently tended by at least three species of ants (Warren, 2005). It is not known if myrmecophily is a factor in Canadian populations of *S. semiluna*, but if these populations are strongly myrmecophilous, then this ant association might help explain the apparently patchy distribution of the butterfly within larger areas of otherwise seemingly suitable habitat.

Adaptability

The presence of a British Columbia population of *S. semiluna* in an area that is fairly heavily grazed by livestock suggests that the butterfly is at least somewhat tolerant of that land use. The lack of a consistent association of the butterfly with any lupine other than *Lupinus sericeus*, combined with the patchy distribution within apparently suitable habitat, suggests that *S. semiluna* may be quite specialized and not very adaptable. Alternately, it may be that the attendant ants have a patchy distribution that limits the butterfly.

POPULATION SIZES AND TRENDS

Search effort

The plausible distribution of the British Columbia populations has been the subject of considerable historical field time by many people over more than 100 years (Guppy and Shepard 2001). Thirty-three apparently suitable sites were searched over 11 days by Kondla in 2003 (detailed site and search effort information not available) as part of presence/absence surveys conducted specifically for this species. Some areas were searched more than once before Hairstreak presence was noted. These searches

resulted in Hairstreak presence being detected at only seven sites. Because a cumulative historical total for *S. semiluna* of only 11 sites is known, it appears that the British Columbia populations are highly localized and that the dearth of known locations is not a result of the species being persistently overlooked.

The area of occupancy of S. *semiluna* in Alberta is also within an area that has received a substantial amount of historical field time (Bird *et al.* 1995). In 2003 and 2004, Kondla examined more than 40 Alberta sites (detailed site and search effort information not available) and detected only one population in Waterton Lakes National Park.

Abundance

A preliminary estimate of the Alberta population of *S. semiluna*, based on counting butterflies and professional opinion, suggests a population in the range of 3,000 to 10,000 adults in 2003 (Kondla 2003a). In 2004, only about 250 adults were counted in the same population (Kondla 2004b).

The sizes of the seven British Columbia populations are unknown. The limited available information suggests that populations vary in size and that the total adult population could plausibly be in the order of 5,000 to 15,000, but this is a very crude estimate. The numbers of adults seen in British Columbia populations in 2003 are: Anarchist Mountain – 5, Blind Creek – 9, Kilpoola – 5, Richter Pass – 47, White Lake – 56. Dennis St. John repeatedly surveyed the White Lake site in 2005, but found only two adults (O. Dyer, pers. comm.). Museum specimens are also of few individuals from each site. The examination of collection data from 37 Canadian collections and one USA collection revealed a total of 40 specimens, of which 19 are located in one collection. Thirty-three of the museum specimens are from Anarchist Mountain. Five of the remaining seven specimens may also have been collected on Anarchist Mountain, but the exact collection site of these specimens is unknown.

Fluctuations and trends

There is insufficient data to identify fluctuations and trends for the British Columbia population. The only suggestive information comes from historical and recent collections on Anarchist Mountain where the species has been found on a number of occasions. The number of specimens collected from this location over the years suggests that the species may have been more abundant there in the past. In 1975, a search by Guppy for a few hours on one day yielded nine adults. Although Guppy returned in 1976 and 1988, he did not find any adults in a few hours of searching each time. In 2003, intensive searching by Kondla on four days yielded only five adults.

For the British Columbia population as a whole, it is reasonable to suggest that infrastructure development, reduction in host plant abundance by livestock grazing, weed invasion and forest ingress into open areas subsequent to wildfire control has resulted in a smaller population of *S. semiluna* compared to pre-settlement times.

The Alberta population was examined by the same observers in 2003 and in 2004. In 2003, there were so many individuals that they could not be counted in any practical manner. A conservative population estimate is several thousands of individuals. In contrast, only about 250 adults were located in four days of field time in 2004. This massive reduction may have been caused by an unusually late killing frost in the area in the spring of 2004 (Kondla 2004b) (Appendix 1). Stochastic weather events may cause order of magnitude population size fluctuations in the Alberta population.

Rescue effect

Dispersal abilities for *Satyrium* butterflies are thought to be quite small, a few kilometres and generally less. There are populations of *S. semiluna* in Washington State that are apparently secure (S4) and contiguous with the British Columbia population (Guppy and Shepard, 2001) so that rescue of the latter could be considered possible. However, if the extirpation of population from a site is caused by habitat loss/degradation, then that site will not be recolonized until suitable habitat becomes once again available, and even then it may not happen if the source population is more than a few kilometres away.

Rescue is very unlikely for the Alberta population because there are no known nearby locations. There is a record of the species in Montana on the other side of the continental divide. However, this record is questionable because the area of the record is not typical habitat for *S. semiluna* (S. Kohler, pers. comm.). In any case, movement of *S. semiluna* across the continental divide is not plausible. The nearest known population of the butterfly along the east front of the Rocky Mountains in Montana is some 300 kilometres distant, and it would not likely be a natural rescue source for the Alberta population of *S. semiluna*.

LIMITING FACTORS AND THREATS

The presence of the larval food plants is thought to be one of the primary limiting factors of the butterfly at the landscape scale. The species is associated with warm, dry habitats and is at the northern extent of its range in Canada, thus suggesting regional climate as a limiting factor. The presence of the appropriate species of ants may also be a limiting factor. Wildfire is potentially a local factor in habitat suitability and population size over time.

The Alberta population of *S. semiluna* is restricted to an alluvial fan where there is a strong likelihood of mortality of individuals from natural flooding. Some limitation to the population may also result from the mechanical effects of trampling by elk (*Cervus canadensis*) wintering in its habitat. The massive population reduction witnessed in 2004 suggests that extirpation through natural stochastic process, for example, unseasonable frost, is possible. The extirpation of a subalpine population of the Silvery Blue (*Glaucopsyche lygdamus*) and the severe reduction of populations of several other butterflies by an unseasonably late frost occurred in Colorado; the populations had not

recovered several years later (Ehrlich *et al*. 1972). The only apparent and substantive human-induced threat to *S. semiluna* in Alberta is habitat change resulting from the expanding spotted knapweed (*Centaurea maculosa*) population and subsequent knapweed control activities. Knapweed is known to cause significant ecological damage by changing the structure and diversity of plant communities through competition for resources and release of allelopathic compounds (e.g., Tyser and Key, 1988; Kelsey and Locken, 1987). Knapweed has also been linked to increases in surface water runoff and soil sedimentation (Lacey *et al*. 1989). Control measures for knapweed, such as herbicide use, may also affect non-target plants in the area. The specific consequences for the Half-moon Hairstreak have not been researched, but such fundamental changes in the ecosystem are likely to have negative consequences for the butterflies, and so this weed is considered to be a significant threat to the Alberta population. Knapweed control is underway by Parks Canada. This is being done with due diligence and with regard for the undesirable effects of the control measures themselves, but even a combination of spot herbicide application and hand pulling results in some unavoidable damage.

The British Columbia population is subject to a wide variety of human activities that could depress or extirpate local populations. Livestock grazing is the most pervasive economic land use and is a likely factor in population dynamics on lands subjected to extremely intense and persistent grazing. Populations of Half-moon Hairstreaks occur on grazed lands, and the Richter Pass population co-exists with fairly heavy livestock grazing. However, in the White Lake basin, the butterflies were found in an area of light grazing, but none were seen just across the road where the same habitat had been very heavily grazed. Excessive livestock grazing represents a clear, existing threat, especially given that most known populations occur on private land where there are no legal requirements to prevent excessive livestock grazing. The amount of habitat at one of the Richter Pass locations may be reduced in the future through the expansion of an aggregate pit. Mining activity is also a potential source of habitat reduction. The human population is growing at a rapid rate in the area and this is expected to continue. Associated with increases in the human population, residential housing and road construction continues to consume habitat on Anarchist Mountain (Kondla, pers. obs. 2003), and housing expansion is very much an ongoing threat in the south Okanagan area. Native habitat is also being converted to intensive agricultural uses, including vineyards which are undergoing rapid expansion in the area. Knapweed was not observed in the occupied Half-moon Hairstreak sites in 2003. Lack of historical information precludes proof that any populations of the Half-moon Hairstreak have been affected by knapweed in the past, but knapweed and other weeds, are likely potential threats to extant populations of the Half-moon Hairstreak in its British Columbia range.

SPECIAL SIGNIFICANCE OF THE SPECIES

Satyrium semiluna is one of a number of species that reach their distribution limit in southwestern Canada and are restricted to a very small percentage of the Canadian landscape. The Alberta population of the butterfly is disjunct from populations to the south in the United States and from the other Canadian populations in British Columbia.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The Alberta population of *S semiluna* is protected under the National Parks Act, but is subject to activities within the Park and habitat changes from knapweed invasion. Most known British Columbia populations of the butterfly are not protected under any federal or provincial statute and are mostly on private land. However, several new protected areas in the Okanagan Valley are located within the range of the Half-moon Hairstreak (D. Fraser, pers. comm.) and provide protection for the butterfly's habitat.

The Nature Conservancy has assigned *S. fuliginosa* a global status rank of G4 and a Canadian national status rank of N1N2 (NatureServe, 2005). Because most of the locations are actually records for *S. semiluna*, the ranks are probably valid for this species. The species is ranked SH in Alberta (this rank is outdated; based on 2003 information, S1 is more appropriate), S1 in British Columbia, S4 in Washington and Montana, and SNR in Idaho.

TECHNICAL SUMMARY

Satyrium semiluna
Half-moon Hairstreak — Porte-queue demi-lune
Range of occurrence in Canada: British Columbia and Alberta

Extent and Area information	
• *extent of occurrence*	485 km^2
• *specify trend*	Unknown, probably declining
• *are there extreme fluctuations in EO*	No
• *area of occupancy*	<250 km^2, could be as little as 30 km^2
• *specify trend*	Uknown
• *are there extreme fluctuations in AO*	Unknown, but unlikely
• *number of extant locations*	12 sites, likely representing 7 populations
• *specify trend in # locations*	Unknown, new locations have recently been found, probably as a result of increased search effort
• *are there extreme fluctuations in # locations*	No
• *habitat trend:*	Declining
Population information	
• *generation time*	1 year
• *number of mature individuals in the Canadian population*	Unknown, plausibly as many as 8,000 to 25,000, but lower limit could be considerably lower
• *total population trend*	Unknown, likely declining
• *if decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)*	Not applicable
• *are there extreme fluctuations in number of mature individuals*	Yes in AB population; unlikely in BC population
• *is the total population severely fragmented*	yes
• *list each population and the number of mature individuals in each*	Waterton Lakes –plausibly <1,000 to 10,000 Anarchist Mtn. – unknown Keremeos Columns – unknown Kilpoola grasslands – unknown Mt. Kobau – unknown Richter Pass – unknown White Lake - unknown
• *specify trend in number of populations*	Unknown, may be declining
• *are there extreme fluctuations in number of populations*	Unknown, but probably not
Threats	
- intensive livestock grazing - loss of habitat to agriculture, infrastructure development and other uses - one location could be affected by expansion of an aggregate pit - habitat change by invading knapweed - habitat change and direct mortality from knapweed control activity	

Rescue Effect	Moderate
• *does species exist elsewhere*	Yes
• *status of the outside population(s)?*	US: Apparently secure (S4)
• *is immigration known or possible?*	Possible in BC population, but generally this genus is thought to be a poor disperser; highly unlikely in AB population
• *would immigrants be adapted to survive here?*	Probably
• *is there sufficient habitat for immigrants here?*	Probably, although key habitat requirements remain unknown
Quantitative Analysis	Not applicable

Current Status

COSEWIC: Endangered (2006)
NatureServe: G4, N1N2 in Canada, S1 in BC, SH (should be updated to S1?) in AB, S4 in Washington and Montana, and SNR in Idaho.
General Status: may be at risk

Status and Reasons for Designation

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

Reasons for Designation:

The butterfly occurs as disjunct populations in two small, restricted areas at the northern extreme of the species' range. The species' population has likely declined in the past as a result of habitat loss. Both populations continue to be threatened by habitat loss and degradation. In British Columbia the species occurs in an area under severe pressure for development. In both Alberta and British Columbia, invasive weeds also pose a serious threat.

Applicability of Criteria

Criterion A: (Declining Total Population): no data

Criterion B: (Small Distribution, and Decline or Fluctuation):

- the extent of occurrence is smaller than 5,000 km^2 (485 km^2) – 1
- the area of occupancy is smaller than 500 km^2 (smaller than 250 km^2) – 2
- the population is severely fragmented – a
- and there are continuing declines in the quality of the habitat – b(iii)
- resulting in inferred declines in the number of mature individuals – b(v)

Criterion C: (Small Total Population Size and Decline):Likely meets Threatened C2a(i):

- the number of mature individuals is fewer than 10,000
- there are no data on decline rates
- but continuing decline in population size are inferred on the basis of habitat loss and degradation – 2
- with a population structure – a
- where it is likely that in low population years, the situation exists where no population contains more than 1,000 mature individuals – i
- and although the Alberta population undergoes extreme fluctuations in number of mature individuals, there is no evidence to support extreme fluctuations in the overall population.

Criterion D: (Very Small Population or Restricted Distribution): not applicable

Criterion E: (Quantitative Analysis): no data

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Norbert Kondla is a graduate of the University of Calgary. He has been actively researching butterflies in western Canada for 33 years. He has authored and co-authored numerous papers and reports on the butterflies of this area. These include status assessments for all butterflies in British Columbia, Yukon, Northwest Territories and Nunavut as well as a report on butterflies of conservation interest in Alberta. He has also co-authored one book on butterflies and contributed to several others. Norbert has personal field experience with *Satyrium semiluna* in British Columbia, Alberta, Montana, Wyoming and Idaho.

Crispin Guppy is a graduate (B.Sc., M.Sc.) of the University of British Columbia. He has been actively researching butterflies in British Columbia for 33 years and has authored and co-authored numerous papers and reports on the butterflies of this area. These include status assessments for all butterflies in British Columbia, Yukon, Northwest Territories and Nunavut. He has conducted many inventory projects in British Columbia for butterflies of conservation concern and their habitats. He has co-authored the book *Butterflies of British Columbia* (2001), and edited two books on Russian butterflies. He has personal field experience with *Satyrium semiluna* in British Columbia.

COLLECTIONS EXAMINED

The following collections were found to contain specimens of the Half-moon Hairstreak:

Canadian National Collection
Crispin Guppy
Gerald Hilchie
Norbert Kondla
Oregon State University
Royal British Columbia Museum

Appendix I. Minimum daily temperatures (°C) for the months of May and June at the Park Gate weather station in Waterton Lakes National Park (Data extracted from Environment Canada website
http://www.climate.weatheroffice.ec.gc.ca/climateData/canada_e.html)

MAY

Day	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
01	-0.1	-2.5	-1.9	2.0	4.0	1.4	-3.3	-0.6	-1.6	-4.8
02	-3.9	0.3	0.8	2.2	1.7	0.9	2.2	3.2	10.5	-7.6
03	-1.9	-0.7	6.7	2.3	6.3	2.7	-7.2	-0.4	5.7	-0.4
04	-0.3	4.7	-2.5	-0.3	4.8	7.3	-4.0	-1.2	3.2	1.7
05	0.8	5.4	1.0	-0.3	1.7	0.6	0.6	-1.4	-1.6	4.8
06	-1.1	3.3	-4.0	2.8	0.1	1.2	-4.8	-1.4	-1.8	9.0
07	-4.2	1.3	-2.0	-1.5	-1.9	3.7	-4.9	-1.9	-1.1	6.6
08	-5.2	0.8	3.7	-2.2	-8.3	5.3	-5.3	0.2	-0.5	5.0
09	-5.5	7.1	-2.4	-2.8	3.0	1.0	-1.8	-0.3	-1.0	-0.1
10	-3.2	1.6	1.8	-3.8	0.9	2.8	-4.5	0.7	-2.2	1.1
11	-1.8	-4.1	0.3	-7.1	0.4	3.9	2.8	0.2	-3.0	-3.0
12	1.4	7.2	-0.2	4.0	-0.2	0.5	-1.6	1.4	-5.6	-2.8
13	8.4	0.8	-4.2	2.7	1.0	10.9	3.9	7.2	-8.5	5.2
14	8.3	-0.8	5.5	0.8	-2.6	5.1	4.3	9.6	-5.3	2.9
15	2.6	12.9	4.9	1.2	5.4	5.5	0.8	4.7	0.5	11.1
16	7.2	9.1	2.5	1.9	-1.0	2.2	-3.0	-0.1	-1.6	9.1
17	7.6	0.2	2.8	0.9	1.7	5.1	-5.0	0.5	0.2	7.4
18	7.0	-0.5	4.3	5.6	7.7	7.1	0.6	-3.1	-0.9	5.7
19	6.4	5.2	5.1	3.4	8.2	-1.1	2.0	-1.4	3.6	5.3
20	5.6	1.2	1.3	-0.4	9.6	-2.0	7.9	3.4	0.8	7.2
21	4.3	0.3	6.0	1.9	10.1	-1.9	0.5	6.6	2.2	4.8
22	2.6	0.4	8.1	-0.9	11.9	1.8	-2.6	8.0	0.4	3.7
23	0.5	3.6	7.4	9.5	4.1	11.4	-4.8	10.4	0.2	4.5
24	-0.2	3.3	6.9	6.8	-5.2	12.0	2.9	9.5	-0.8	-3.3
25	-0.7	3.6	3.5	10.9	1.4	10.5	1.4	12.2	3.7	1.8
26	3.7	3.8	7.5	2.9	8.6	3.7	6.2	10.9	8.7	0.9
27	2.4	1.8	6.4	11.4E	7.8	2.0	9.9	9.4	8.3	-1.1
28	6.5	3.5	5.4	8.7E	5.7	8.0	9.6	8.5	8.0	-0.9
29	3.3	8.1	1.0	0.9E	-0.1	2.5	12.3	10.0	5.9	-1.6
30	5.0	12.4	6.7	2.8	3.6	5.5	11.7	1.3	7.2	-1.8
31	4.1	10.3	6.7	8.4	0.5	9.9	9.3	8.8	6.6	-0.1

JUNE

Day	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
01	4.6	10.6	1.3E	7.1	-0.3	2.1	4.6	11.8	4.5	6.0
02	6.5	6.8	-1.0	5.1	1.9	5.7	6.4	9.5	-0.1	5.1
03	10.0	1.1	-3.3	8.0	2.4	4.7	5.9	1.2	3.4	6.4
04	8.9	9.5	-0.9	10.1	1.1	6.8	8.1	1.2	11.0	8.7
05	8.4	10.7	1.5	9.9	7.3	6.5	12.1	1.4	9.4	2.7
06	2.6	11.0	2.8	4.5	6.2	5.5	6.4	2.8	7.3	5.0
07	12.5	9.6E	3.9	-1.1	2.1	4.5	3.4	0.6	5.1	2.2
08	15.4	7.2	4.0	0.8	3.8	4.3	0.1	9.4	0.2	5.1
09	12.0	6.3	6.5	4.1	9.0	7.2	0.1	8.5	0.1	6.2
10	4.5	5.1	11.6	3.5	6.3	7.5	0.3	6.3	6.0	7.6
11	7.2	10.1	11.0	4.0	3.5	2.9	2.0	7.8	7.7	9.5
12	2.5	7.3	10.7	-0.6	7.1	3.3	5.5	5.0	6.8	7.5
13	6.9	7.4	5.8	-0.4	7.7	1.1	5.5E	5.0	9.0	7.6
14	7.4	8.8	4.7	9.4	8.1	6.9	2.0	6.6	4.6	4.8
15	4.3	4.8	6.5	3.0	4.5	6.7	4.2	6.9	3.1	2.6
16	8.7	11.5	4.8	1.8	4.9	1.3	7.8	5.7	1.4	-0.1
17	7.3	12.0	3.4	11.9	1.6	0.3	6.1	3.3	1.0	9.5
18	3.3	10.9	9.3	9.4	9.4	2.1	6.1	7.0	-4.3	8.3
19	6.0	8.5	7.3	8.0	7.3	3.9	5.1	11.9	0.0	7.5
20	7.4	8.2	7.3	10.0	4.4E	7.6	8.2	8.3	6.4	4.8
21	4.3	7.1	6.8	10.4	11.0	10.8	6.6	7.4	8.8	4.9
22	2.3	6.3	8.2	9.3	5.0	8.1	8.6	6.2	8.3	15.1
23	4.4	8.3	11.7	9.0	3.7	10.2	13.2	5.2	5.5	6.9
24	7.3	6.2	12.9	5.9	3.6	8.2	10.6	2.1	5.3	2.3
25	4.2	7.5	11.0	3.8	2.8	6.0E	10.7	7.0	8.8	5.4
26	5.8	8.6	7.3	3.1	4.0	5.8	12.5	12.0	8.2	7.3
27	10.5	3.5	6.6	5.8	2.2	8.4	16.0	10.4	6.2	5.0
28	11.8	0.2	10.0	9.7	6.2	12.6	10.2	8.6	6.8	7.8
29	10.8	4.4	6.3	9.0	12.6	6.9	13.0	9.4	9.9	6.7
30	9.8	5.4	10.8	8.3	8.1	10.2	9.3	11.7	11.7	13.0