Species at Risk Act
Recovery Strategy Series
Adopted under Section 44 of SARA

Recovery Strategy for the Half-moon Hairstreak (*Satyrium semiluna*) in Canada

Half-moon Hairstreak

2016

Government of Canada
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For copies of the recovery strategy, or for additional information on species at risk, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk (SAR) Public Registry[1].

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[1] http://www.registrelep-sararegistry.gc.ca

RECOVERY STRATEGY FOR THE HALF-MOON HAIRSTREAK (*Satyrium semiluna*) IN CANADA

2016

Under the Accord for the Protection of Species at Risk (1996), the federal, provincial, and territorial governments agreed to work together on legislation, programs, and policies to protect wildlife species at risk throughout Canada.

In the spirit of cooperation of the Accord, the Government of British Columbia has given permission to the Government of Canada to adopt the “Recovery Strategy for the Half-moon Hairstreak (*Satyrium semiluna*) in British Columbia and Alberta” (Part 2) under Section 44 of the *Species at Risk Act* (SARA). Environment and Climate Change Canada has included a federal addition (Part 1) which completes the SARA requirements for this recovery strategy.

The federal recovery strategy for the Half-moon Hairstreak in Canada consists of two parts:

Part 1: Federal Addition to the “Recovery Strategy for the Half-moon Hairstreak (*Satyrium semiluna*) in British Columbia and Alberta”, prepared by Environment and Climate Change Canada.

Part 2: "Recovery Strategy for the Half-moon Hairstreak (*Satyrium semiluna*) in British Columbia and Alberta", prepared by the British Columbia Southern Interior Invertebrates Recovery Team for the British Columbia Ministry of Environment.

TABLE OF CONTENTS

Part 1: Federal Addition to the "Recovery Strategy for Half-moon Hairstreak (*Satyrium semiluna*) in British Columbia and Alberta", prepared by Environment and Climate Change Canada

PREFACE

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years after the publication of the final document on the SAR Public Registry.

The Minister of Environment and Climate Change and Minister responsible for the Parks Canada Agency is the competent minister under SARA for the Half-moon Hairstreak and has prepared the federal component of this recovery strategy (Part 1), as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with the Province of British Columbia (B.C.), the Province of Alberta, and the Southern Interior Invertebrates Recovery Team. SARA section 44 allows the Minister to adopt all or part of an existing plan for the species if it meets the requirements under SARA for content (sub-sections 41(1) or (2)). The Province of British Columbia provided the attached recovery strategy for Half-moon Hairstreak (Part 2) as science advice to the jurisdictions responsible for managing the species in British Columbia. It has been prepared in cooperation with Environment and Climate Change Canada and the Parks Canada Agency.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment and Climate Change Canada and the Parks Canada Agency, or any other jurisdiction, alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Half-moon Hairstreak and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Environment and Climate Change Canada and the Parks Canada Agency and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

The recovery strategy sets the strategic direction to arrest or reverse the decline of the species, including identification of critical habitat to the extent possible. It provides all Canadians with information to help take action on species conservation. When critical habitat is identified, either in a recovery strategy or an action plan, there may be future regulatory implications, depending on where the critical habitat is identified. SARA requires that critical habitat identified within a national park named and described in Schedule 1 to the *Canada National Parks Act*, the Rouge National Urban Park established by the *Rouge National Urban Park Act*, a marine protected area under the

[2] http://registrelep-sararegistry.gc.ca/default.asp?lang=en&n=6B319869-1#2

Oceans Act, a migratory bird sanctuary under the *Migratory Birds Convention Act, 1994* or a national wildlife area under the *Canada Wildlife Act* be described in the *Canada Gazette*, after which prohibitions against its destruction will apply. For critical habitat located on other federal lands, the competent minister must either make a statement on existing legal protection or make an order so that the prohibition against destruction of critical habitat applies. For any part of critical habitat located on non-federal lands, if the competent minister forms the opinion that any portion of critical habitat is not protected by provisions in or measures under SARA or other Acts of Parliament, or the laws of the province or territory, SARA requires that the Minister recommend that the Governor in Council make an order to prohibit destruction of critical habitat. The discretion to protect critical habitat on non-federal lands that is not otherwise protected rests with the Governor in Council.

ACKNOWLEDGEMENTS

Many people are to be acknowledged for their involvement in the preparation of this federal recovery strategy addition. This document was prepared by Kella Sadler (Environment and Climate Change Canada, Canadian Wildlife Service (ECCC CWS) - Pacific and Yukon Region (PYR)) with the input of Dan Shervill (ECCC CWS-PYR) and Laura Parkinson. Substantial input and/or collaborative support was provided by Mark Wayland, Greg Wilson, and Medea Curteanu (ECCC CWS - Prairie and Northern Region), Diane Casimir, Robert Sissons, and Cyndi Smith (Parks Canada Agency), Adrienne Fowlie Larocque and Ron Casorso (National Research Council Canada – White Lake, BC), Leah Westereng, Jennifer Heron, Bryn White, Orville Dyer, Mark Weston, Kirk Safford, Sara Bunge, and Jim Mottishaw (Government of British Columbia, Sue Cotterill (Government of Alberta), Dennis St. John (Private Entomologist), Sylvie Desjardins (UBC Kelowna), Geoff Scudder (UBC), and Dennis Knopp (Private Consultant, Sardis). Richard Post, Amos Chow, Clare O'Brien and Sean Butler provided assistance with mapping and figure preparation.

ADDITIONS AND MODIFICATIONS TO THE ADOPTED DOCUMENT

The following sections have been included to address specific requirements of SARA that are not addressed in the "Recovery Strategy for the Half-moon Hairstreak (*Satyrium semiluna*) in British Columbia and Alberta" (Part 2 of this document, referred to henceforth as "the provincial recovery strategy") and to provide updated or additional information.

Under SARA, there are specific requirements and processes set out regarding the protection of critical habitat. Therefore, statements in the provincial recovery strategy referring to protection of survival/recovery habitat may not directly correspond to federal requirements. Recovery measures dealing with the protection of habitat are adopted; however, whether these measures will result in protection of critical habitat under SARA will be assessed following publication of the final federal recovery strategy.

1. Species Status Information

Legal Status: SARA Schedule 1 (Endangered) (2007)

Table 1. Conservation Status of Half-moon Hairstreak (from NatureServe 2013, BC Conservation Data Center 2013, BC Conservation Framework 2013, and Alberta Conservation Information Management System (ACIMS) 2013).

Global (G) Rank*	National (N) Rank*	Sub-national (S) Rank*	COSEWIC Designation	Provincial Listing	BC Conservation Framework
G4	Canada (N1N2) United States (N4)	Canada: Alberta (S1), British Columbia (S1) ; United States: California (SNR), Colorado (S3), Idaho (SNR), Montana (S4), Nevada (SNR), Oregon (SNR), Utah (SNR), Washington (S4), Wyoming (SNR)	Endangered (2006)	BC: Red List (Extirpated, Endangered, or Threatened); AB: S1 (five or fewer occurrences or especially vulnerable to extirpation)	Highest priority: 1, under Goal 3**

*Rank 1– critically imperiled; 2– imperiled; 3- vulnerable to extirpation or extinction; 4- apparently secure; 5– secure; H– possibly extirpated; NR – status not ranked
**The three goals of the BC Conservation Framework are: 1. Contribute to global efforts for species and ecosystem conservation; 2. Prevent species and ecosystems from becoming at risk; 3. Maintain the diversity of native species and ecosystems

It is estimated that the percent of the global range of this species in Canada is less than 1%.

2. Population and Distribution Objectives

This section replaces the "Population and Distribution Goal" and "Rationale for the Population and Distribution Goal" sections in the provincial recovery strategy.

Environment and Climate Change Canada has determined the Population and Distribution Objective for Half-moon Hairstreak to be:

> *To ensure the persistence of Half-moon Hairstreak at all known extant locations*[3] *(and any new locations) within the species' range in Canada.*

Rationale:

Occurrence information for Half-moon Hairstreak shows it is extant at nine known locations in Canada: eight locations in BC and one location in Alberta. The British Columbia Conservation Data Centre and NatureServe databases define "extant" as all observations made within the last 20 years, provided the habitat has not been substantially altered or degraded. Population numbers, including abundance trends, are unknown. Currently there is insufficient information to complete minimum population viability analysis, dispersal and re-colonization capabilities are unknown, and detailed habitat requirements are unclear. Likewise there is no information to indicate that the species was previously more widespread, therefore an objective to actively increase the number of populations, which may allow for down-listing of the species, is not appropriate at this time. However, if additional naturally occurring populations are discovered, their persistence should also be ensured. Future population and distribution data may indicate that deliberate attempts to increase abundance would be warranted at one or more locations (for example, where either or both of abundance and/or species' range shows a documented decline).

3. Broad Strategies and General Approaches to Meet Objectives: Recovery Planning Table

The recovery planning table included in the provincial recovery strategy (i.e., Table 3 of provincial recovery strategy) details actions to meet recovery objectives. One of the actions listed is to: "Determine quality and quantity of habitat required to ensure persistence of a population in a given location or within a given large habitat patch. Information gathering will include host plant densities, host plant health (e.g. disease), area of extent of host plants at each location, possible ant associations (e.g. which ant species occur on host plants), systematic threat assessments so comparisons between locations can be drawn (e.g. grazing intensity, etc), and other information as necessary." In reference to the "other information as necessary" portion of this action, the points

[3] Locations are based on the biological parameters of the butterfly (e.g. dispersal distance and habitat connectivity between known occurrences, and whether the individuals mix between locations). The definition of location for recovery of the species is defined as a stand-alone population that does not mix with other locations. Sites within a location may mix. Locations are defined to match provincial recovery strategy descriptions as closely as possible.

below amend this table to include additional details on information considered necessary to address knowledge gaps:

- In areas where vegetation surveys have not yet been completed, ground-truth areas delineated as “suitable habitat” to confirm whether or not biophysical attributes necessary to support Half-moon Hairstreak are present, and refine Terrestrial Ecosystem Mapping (TEM) classification type used to indicate “suitable habitat” so that representation of habitat quality for Half-moon Hairstreak is most optimal.
- Determine structural element requirements (i.e. species and/or objects utilized, amount and density of structural elements required) for adult butterflies in both BC and Alberta.
- Identify shelter resources necessary to support Half-moon Hairstreak at all stages in its life-cycle at locations in BC and Alberta.
- Identify movement capabilities and use of corridors for dispersal among locations, as components of sustaining connectivity, and genetic viability of Half-moon Hairstreak in Canada.
- Examine the importance of topographical heterogeneity and sources of soil moisture as components of habitat capable of supporting Half-moon Hairstreak.

4. Critical Habitat

4.1 Identification of the Species’ Critical Habitat

This section replaces the “Description of Survival/Recovery Habitat” section in the provincial recovery strategy.

Section 41 (1)(c) of SARA requires that recovery strategies include an identification of the species’ critical habitat, to the extent possible, as well as examples of activities that are likely to result in its destruction. The 2011 provincial recovery strategy for Half-moon Hairstreak includes a description of the biophysical attributes of survival/recovery habitat. This science advice was used to inform the critical habitat identification in this federal recovery strategy. Critical habitat for Half-moon Hairstreak is identified in this document to the extent possible; more precise boundaries may be mapped, and additional critical habitat may be added in the future if additional research supports the inclusion of areas and/or biophysical attributes beyond those currently identified. Primary considerations in the identification of critical habitat include the amount, quality, and locations of habitat needed to achieve the population and distribution objectives.

Critical habitat for Half-moon Hairstreak is identified at nine locations. Eight locations are in British Columbia[4], and one is in Alberta:

1) White Lake (East and West), BC (Figure A1): corresponds with BC CDC EO #6
2) Keremeos Columns, BC (Figure A2): corresponds with BC CDC EO #7
3) Blind Creek, BC (Figure A2): corresponds with BC CDC EO #3
4) Richter Pass & Mount Kobau & Kilpoola BC (Figure A3): corresponds with BC CDC EO #4
5) Kilpoola Lake, BC (Figure A4): corresponds with BC CDC EO #5
6) Chopaka East, BC (Figure A4): corresponds with BC CDC EO #8
7) Anarchist Mountain, BC (Figure A5): corresponds with BC CDC EO #2
8) East Osoyoos, BC (Figure A5): corresponds with BC CDC EO #1
9) Blakiston Fan, Waterton Lakes National Park (WLNP), AB (Figure A6)

The areas containing critical habitat for Half-moon Hairstreak are identified based on a combination of (1) all documented occurrences[5] (including data sets from the BC CDC, the recovery team and the Canadian Wildlife Service (CWS) collected between 2001 and 2013), (2) an estimate of the seasonal dispersal capabilities of adult Half-moon Hairstreak butterflies, applied as a 600 m radius[6] around each documented occurrence, and (3) selection of all suitable habitat within this occurrence radius. In British Columbia, plant communities containing >10% cover of Big Sagebrush (*Artemisia tridentata*) were selected as suitable habitat for Half-moon Hairstreak (Iverson and Haney 2010, COSEWIC, 2006) using Terrestrial Ecosystem Mapping (TEM). Ecosystem mapping units associated with individual occurrence records were considered inherently indicative of use by Half-moon Hairstreak, and therefore included by default (i.e., regardless of proportion of Big Sagebrush). In Waterton Lakes National Park Alberta, dry grassland (BL1, BL2, BL3) and stream channel (SC) ecosites were selected as suitable habitat for Half-moon Hairstreak using Ecological Land Classification (ELC) mapping (Achuff et al. 2002a; 2002b).

[4] All location names listed here, with the exception of East Osoyoos, match those used in the provincial recovery strategy. BC CDC EO = British Columbia Conservation Data Centre Element Occurrence. The East Osoyoos, BC, location was included in the provincial recovery strategy, as part of the Anarchist Mountain location. The BC Conservation Data Centre recognizes the East Osoyoos location as a unique element occurrence (EO #8) (NatureServe 2002), as such it has been treated as a unique location in this federal recovery strategy.

[5] BC CDC occurrence records, Parks Canada Agency (Alberta) records, Alberta Conservation Information Management System and/or any other additional occurrence records available.

[6] Although there is no direct dispersal measurement data available for Half-moon Hairstreak, results from preliminary mark recapture studies for the related species, Behr's Hairstreak (*Satyrium behrii*), conducted at sites in the south Okanagan valley from 2004-2007 indicated a 100 m average seasonal dispersal (with some variation depending on climatic conditions during the flight season) and a 1200 m maximum dispersal distance (COSEWIC, 2012). The adult lifespan of Half-moon Hairstreak is estimated at a minimum of 6 days. In absence of specific information, a daily movement distance of 100 m was considered to be a realistic precautionary estimate. Therefore the consensus of the British Columbia Southern Interior Invertebrates Recovery Team was to consider 600 m (i.e. 6 days x 100 m/day) as representing the best available information on the seasonal dispersal capabilities of Half-moon Hairstreak, based on a combination of expert opinion, anecdotal observations, and estimated life-span of adult butterflies (Scott, 1973; Knopp et al., 2008; S. Desjardins; J. Heron, pers. comm., 2012).

The biophysical attributes as detailed below summarize known essential elements for Half-moon Hairstreak within the areas identified as containing critical habitat. These biophysical attributes are consistent with the habitat attributes outlined in the provincial recovery strategy, the COSEWIC status report (COSEWIC 2006), and other sources (Knopp et al. 2009; James and Nunnallee 2011). These attributes include: larval host plants, nectar host plants, and other structural attributes essential for life cycle completion. Detailed information about the composition and spatial relationship of individual biophysical attributes required by Half-moon Hairstreak at particular locations, and the relative required amount, condition, and density of individual biophysical attributes within areas identified as containing critical habitat are currently unknown. Each of the biophysical attributes described are identified as critical habitat wherever they occur within the area identified as containing critical habitat.

Larval Host Plants

Half-moon Hairstreak uses one or more species of Lupine (*Lupinus* sp.) year-round, i.e., for completion of all life history stages. Lupines are the only known larval host plant. Adult butterflies lay their eggs in the summer either on Lupine larval host plants, or in the litter (or other inert surfaces) at the base of, or nearby, Lupines, where the eggs overwinter until the following spring. Upon hatching, larvae stay on or near Lupines to feed on the plant, and may also seek cover or shelter in the associated litter. Although the movement capabilities and/or patterns of Half-moon Hairstreak larvae are not known, it is considered reasonable that they would not move farther than 5 m away from larval host plants[7]. As such, all Lupine plants, and the soils/litter occurring within 5 m of these plants are identified as biophysical attributes of critical habitat for Half-moon Hairstreak.

a. In BC: Lupine species that are known larval host plants for Half-moon Hairstreak include Silky Lupine *(L. sericeus*) and Sulphur Lupine *(L. sulphureus*).

b. In Alberta: Lupine species that are known larval host plants for Half-moon Hairstreak include Silky Lupine (*L. sericeus*) and Silvery Lupine (*L. argenteus*).

Nectar Host Plants

During the flight period (typically late May to early July in B.C., and typically throughout July in Alberta), Half-moon Hairstreak uses one or more species as nectar host plants. Half-moon Hairstreak may select nectar host plants opportunistically; therefore any plants flowering during the flight period of Half-moon Hairstreak should be considered potential nectar host plants.

a. In BC: Known nectar host plants include Common Yarrow (*Achillea millefolium*), Parsnip-flowered Buckwheat (*Eriogonum heracleoides*), and Grey Horsebrush (*Tetradymia canescens*).

[7] It is possible that Half-moon Hairstreak in Canada have a mutualistic association with ants, in which ants protect the larvae from predation, and the larvae excrete amino acids that the ants consume. This relationship is commonly observed in Half-moon Hairstreak populations in the United States, including locations in Washington and California, but has not yet been observed in Canadian populations. Should this association exist in Canadian populations of Half-moon Hairstreak, it would occur on or within 5m of host plant Lupines, as this where the larvae would occur.

b. In Alberta: Known nectar host plants include Yellow Buckwheat (*Eriogonum flavum*), and Missouri Goldenrod.

Structural Elements

During the flight period, various plants and other features are used by adult Half-moon Hairstreak as structural elements for perching and mating, and potentially also for roosting and/or shelter (from exposure, and also predators – including camouflage). Wherever they exist at individual locations, the following species are considered important biophysical attributes of critical habitat:

a. In BC: Plants known to be used as structural elements by Half-moon Hairstreak include: Big Sagebrush, Three-tip Sagebrush (*Artemisia tripartita*), Arrow-leaved Balsamroot (*Balsamorhiza sagittata),* and Prairie Sagebrush (*Artemisia frigida*).

b. In Alberta: Plants and substrates known to be used as structural elements by Half-moon Hairstreak include: low-lying herbaceous vegetation, including larval and nectar host plants (stated above), Prairie Sagebrush, Aster (*Aster* sp.), Wolf Willow (*Elaeagnus commutata*), Cinquefoil (*Potentilla* sp.), Milk-vetch (*Astragalu*s sp.) rocks and boulders, and patches of bare ground.

The areas containing critical habitat for Half-moon Hairstreak are presented in Appendix 1 (Figures A1-A6). Critical habitat for Half-moon Hairstreak in Canada occurs within the detailed yellow polygons (critical habitat units) shown on each map where the occurrence radius and habitat type criteria (i.e., TEM and ELC habitat mapping) described in this section are met, and where any of the known biophysical attributes exist. Unsuitable habitats such as forested areas, lakes, permanent standing water below the lowest documented water line, and permanent anthropogenic features (including existing infrastructure – buildings, telescopes, and running surfaces of roads) do not possess the attributes required by Half-moon Hairstreak and they are not identified as critical habitat. Detailed methods and decision-making processes relating to critical habitat identification are archived in a supporting document.

Dispersal and/or movement corridor habitat is that which is required by adult butterflies to move among locations, sites or to unoccupied habitat. Connective habitat is important to prevent further fragmentation and isolation of Half-moon Hairstreak locations. Connectivity may likewise facilitate recolonization of some areas after a catastrophic event. It is recognized that the critical habitat identified above is insufficient to achieve the population and distribution objectives for Half-moon Hairstreak because information that would allow for the identification of dispersal and/or movement corridors required by the species is not available at this time.

The schedule of studies (Section 4.2) outlines the activities required to identify additional critical habitat necessary to support these objectives.

4.2 Schedule of Studies to Identify Critical Habitat

This section replaces the “Studies Needed to Describe Survival/Recovery Habitat” section in the provincial recovery strategy.

The following schedule of studies (Table 2) outlines the activity required to complete the identification of critical habitat for Half-moon Hairstreak.

Table 2. Schedule of Studies to Identify Additional Critical Habitat.

Description of Activity	Outcome/Rationale	Timeline
Determine movement activities and capabilities and dispersal requirements for Half-moon Hairstreak	Movement / dispersal corridors will be included as a component of critical habitat identification, to support all extant locations of Half-moon Hairstreak in Canada.	2016 - 2021

4.3 Examples of Activities Likely to Result in Destruction of Critical Habitat

Understanding what constitutes destruction of critical habitat is necessary for the protection and management of critical habitat. Destruction is determined on a case by case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from a single or multiple activities at one point in time or from the cumulative effects of one or more activities over time. Activities described in Table 3 include those likely to cause destruction of critical habitat for Half-moon Hairstreak; destructive activities are not limited to those listed.

Table 3. Examples of activities likely to result in destruction of critical habitat for Half-moon Hairstreak in Canada. Threat numbers are in accordance with the IUCN World Conservation Union–Conservation Measures Partnership unified threats classification system (CMP 2010).

Description of Activity	**Description of effect (biophysical attribute or other)**	**Details and relationship to identified threats**
Conversion of natural landscape (within the areas identified as containing critical habitat) for residential, commercial, and/or industrial development	Results in the direct loss of critical habitat through vegetation removal and replacement, debris deposition, soil disturbance and compaction, and/or related indirect effects which cause damage or destruction to biophysical attributes required by Half-moon Hairstreak	The primary threat to Half-moon Hairstreak in B.C. is direct habitat loss to residential and commercial development (housing, urban, commercial and industrial areas) (IUCN Threat # 1.1, 1.2)
Fire management strategies that result in long-term fire suppression in open grassland and/or Sagebrush ecosystems, and/or human-caused fire resulting in destruction to existing biophysical attributes of critical habitat	Continued active fire suppression results in long-term loss of open grassland and Sagebrush habitat due to tree encroachment, and alteration of plant community composition such that it no longer contains biophysical attributes required by Half-moon Hairstreak. Conversely, where these biophysical attributes do exist, human-caused fire can result in their destruction.	Fire suppression by wildfire protection programs is an ecosystem-level threat to the persistence open grassland and/or Sagebrush habitats in both B.C. and AB. Where biophysical attributes required by Half-moon Hairstreak do occur, local destruction by fire is a potential threat at all locations in Canada. (IUCN Threat # 7.1)
Grazing practices at any time of year that result in the damage or destruction of larval host plants; grazing practices in the non-dormant phase (March-September inclusive) that results in the destruction of nectar host plants and/or other structural elements identified as essential to the Half-moon Hairstreak; grazing practices in the dormant phase (October-February inclusive) that results in compaction or removal of soils associated with larval host plants (within 5 m), permanent net loss of nectar host plants or structural elements, and/or creation of new exposed/disturbed trails or clearings	Livestock use can result in disturbance, removal, and/or compaction of vegetation and ground layer (via grazing or trampling), causing the loss of larval and nectar host plants, essential structural elements (e.g., adult perching plants) and damage to litter required by Half-moon Hairstreak eggs and larvae. New disturbance can facilitate establishment of alien invasive species.	Domestic livestock grazing is known to occur, and is a potential threat, at most locations in B.C. (IUCN Threat # 2.3)

Description of Activity	Description of effect (biophysical attribute or other)	Details and relationship to identified threats
Any motorized recreational activities (e.g., ATVs or other vehicles) occurring outside of existing roads or trails, at any time and in all seasons; non-motorized recreational activities (e.g., foot traffic, mountain biking, and horse-back riding) occurring during the non-dormant phase (March-September inclusive) to the extent that larval host plants are damaged or destroyed, or to the extent that nectar host plants and/or other structural elements identified as essential to Half-moon Hairstreak are destroyed; non-motorized recreational activities during the dormant period (October-February inclusive) that results in the damage or destruction of larval host plants and/or compaction or removal of associated soils (within 5 m); non-motorized recreational activities at any time of year that (individually, and/or cumulatively) results in the permanent net loss of nectar host plants, structural elements, and/or creation of new roads, trails or clearings	Results in disturbance of local biophysical conditions, including direct physical damage to or loss of biophysical attributes required by Half-moon Hairstreak. Activities may cause vegetation removal (impacting the availability of egg, larval and nectar host plants, and other essential structural elements) and cause trampling or removal of soil and litter required by Half-moon Hairstreak eggs and larvae. New disturbance can facilitate establishment of alien invasive species.	Recreational activities (at various levels) threaten Half-moon Hairstreak habitats at all locations in B.C. and AB. Thought to be the primary threat for Half-moon Hairstreak in Alberta (IUCN Threat # 6.1)
Introduction of alien invasive species	Alien invasive species may cause destruction of habitat available to Half-moon Hairstreak by making required biophysical attributes of critical habitat (larval host plants and nectar host plants, and/or required structural elements) functionally unavailable to Half-moon Hairstreak, as a consequence of their physical occupation of space and resources.	Some alien invasive grasses may be deliberately introduced for range purposes (IUCN Threat # 8.1)
Activities related to the control of invertebrate pests and/or invasive plant species (mechanical or chemical) that are not in accordance with provincial best management practices, where available. This may include on-site activities, and/or pesticide/herbicide drift from adjacent agricultural areas.	Efforts to control invertebrate pests or invasive plants through chemical means (pesticides or herbicides) or by physical means can result in destruction of critical habitat by degrading or removing biophysical attributes required for survival (as a consequence of weed-pulling), or microhabitat toxicity resulting from the application of pesticides and/or herbicides.	Impacts are localized and likely being reduced through improved Integrated Pest Management techniques. The locations in B.C. that are within provincial parks or national properties are not adjacent to agricultural spray areas. Pesticide application by spot-spraying of target species does occur within WLNP AB (IUCN Threat # 9.3)

The primary activity likely to result in the destruction of Half-moon Hairstreak critical habitat in BC is considered to be habitat loss by conversion of natural areas for residential, commercial, agricultural and industrial development. The lower elevation grassland ecosystems of the south Okanagan, that include Half-moon Hairstreak critical habitat, are considered one of the four most endangered ecosystems in Canada owing to conversion as a result of agricultural development (particularly vineyards) and/or residential or urban development. Much potentially suitable Half-moon Hairstreak habitat has already been lost to development in the south Okanagan Valley, and development pressure continues to be high. The primary activity likely to result in destruction of critical habitat in Alberta (Waterton Lakes National Park) is recreational use and impacts to areas outside of existing Park roads and trails (i.e., via expansion of existing roads or trails, and/or creation of new roads, trails, or clearings within areas identified as containing critical habitat). Activities associated with the regular functioning, maintenance, and repair of existing roads or trails in these areas are not considered likely to result in the destruction of critical habitat.

In many areas where Half-moon Hairstreak occurs, the land management plan and expectation is to suppress fire, which can contribute to the loss of critical habitat. Slow natural succession of pines and other native trees into open areas is ongoing due to long-term fire suppression. In the absence of regularly occurring fires, the size and extent of ecological communities (and associated biophysical attributes) required by Half-moon Hairstreak has likely been reduced by tree encroachment at some locations, owing to shading and competition. Conversely, human-caused fires in areas where critical habitat for Half-moon Hairstreak is present may result in local destruction of necessary biophysical attributes. Habitat fragmentation and land use have altered natural fire regimes and patterns in Sagebrush and grassland communities of the south interior of BC. It is estimated that at least half of fires in the Okanagan valley are human-caused (e.g. 56% of fires in the Okanagan fire Zone from 2004-2013 were human-caused; at lower elevations in the Okanagan Valley as much as 80% human-caused) (J. Mottishaw pers. comm. 2014). Further, invasive plants may out-compete native nectar plants post-fire and result in long-term reduction in habitat suitability, unless there is successful deliberate seeding of native species. Therefore in this portion of its range, human-caused wildfire may be more likely to result in critical habitat destruction than fire suppression, depending on historical fire regimes, current land use pressures, local vegetation community characteristics, and the intensity of fire (M. Weston, pers. comm. 2013). Prescribed burning to achieve general thinning or fuel removal at sites (e.g., for maintenance of grassland and/or open forest ecosystems) must take into account the potential negative consequences of fire to Half-moon Hairstreak, where semi-isolated populations and/or local biophysical attributes required by the species could be easily and/or irreparably devastated (D. St. John, pers. comm. 2014).

Grazing practices resulting in deterioration of grassland (ecosystem) health (such as loss of composition, structure, site stability, etc.) and related biophysical attributes required by Half-moon Hairstreak (nectar plants and host plants) are identified as an activity likely to impact or destroy critical habitat. It is unknown to what level actual stocking rates (and yearly implementation of rates), timing of use, length of use, will affect or impact habitat

to the extent that critical habitat is lost. However, it is intuitive that inappropriate use of range with intensive grazing over long periods of time will impact the biophysical attributes necessary for Half-moon Hairstreak. It is possible that some level of grazing may not be detrimental to Half-moon Hairstreak at some locations, i.e., where the occurrence, proportion, and abundance of larval and nectar host plants, and required structural elements are demonstrably maintained or increased under existing levels of livestock activity. Additional research is required to determine the grazing practices and/or threshold level(s) of grazing intensity that are consistent with ensuring the long-term persistence of biophysical attributes necessary for Half-moon Hairstreak.

Destruction of critical habitat by the introduction of invasive plants (or their control) is considered to be of most concern at Blakiston Fan in Waterton Lakes National Park, Alberta, in relation to Spotted Knapweed (*Centaurea maculosa*). Spotted Knapweed potentially competes with Half-moon Hairstreak larval and nectar host plants, and may change the composition and structure of the plant and invertebrate communities where it occurs. Parks Canada is currently undertaking activities to mitigate the spread of Spotted Knapweed at Blakiston Fan.

5. Statement on Action Plans

One or more action plans will be posted on the Species at Risk Public Registry by 2021.

6. Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[8]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the Federal Sustainable Development Strategy's[9] (FSDS) goals and targets.

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

The ranges of several other species at risk overlap the range and habitat of Half-moon Hairstreak. In the South Okanagan Valley, the Big Sagebrush-Bluebunch Wheatgrass

[8] http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1
[9] http://www.ec.gc.ca/dd-sd/default.asp?lang=En&n=CD30F295-1

plant community is a rare ecosystem in British Columbia (red-listed) and is globally ranked G2 or imperiled (BC Conservation Data Centre, 2011). This rare plant community provides habitat for many provincially- and federally- listed species at risk. Federally listed species at risk that may overlap with Half-moon Hairstreak habitat in BC include (but are not limited to): Sage Thrasher (*Oreoscoptes montanus*), American Badger (*Taxidea taxus*), Nuttall's Cottontail *nuttallii* subspecies (*Sylvilagus nuttallii nuttallii*), Tiger Salamander (*Ambystoma mavortium*), Great Basin Spadefoot (*Spea intermontana*), Western Rattlesnake (*Crotalus oreganus*), Great Basin Gophersnake (*Pituophis catenifer deserticola*), Lewis's Woodpecker (*Melanerpes lewis*), Western Yellow-bellied Racer (*Coluber constrictor*), Pallid Bat (*Antrozous pallidus*), Wallis' Dark Saltflat Tiger Beetle (*Cicindela parowana wallisi*), Rusty Cord-moss (*Entosthodon rubiginosus*), Showy Phlox (*Phlox speciosa* ssp. *occidentalis*), Grand Coulee Owl-clover (*Orthocarpus barbatus*), Lyall's Mariposa Lily (*Calochortus lyallii*), Scarlet Ammannia (*Ammannia robusta*), and Toothcup (*Rotala ramosior*). Federally listed species at risk found within grassland habitat in AB that may overlap with Half-moon Hairstreak include (but are not limited to): Sprague's Pipit (*Anthus spragueii*), and Long-billed Curlew (*Numenius americanus*).

Implementation of the recovery strategy will indirectly benefit other species at risk in the area; increased public education and awareness may limit harmful recreational activities at these locations, and conservation actions to restore and protect grasslands ecosystems for Half-moon Hairstreak are likely beneficial to all species that rely on these threatened ecosystems. Likewise, conservation actions underway or proposed to protect the other species at risk are likely beneficial to Half-moon Hairstreak – a multi-species approach to conservation planning is recommended. In acknowledgement of the high potential for shared habitat among local species at risk, large-scale management actions, such as invasive species removal or the use of herbicides or pesticides, should be planned and implemented carefully. All on-site activities (surveys, research, and management), to aid recovery may pose a threat to co-occurring species (e.g., via trampling, increased herbivory via incidental creation of trails, or inadvertent dispersal of alien species during disposal), unless care is taken to avoid damage.

7. References

Achuff, P.L., R.L. McNeil, M.L. Coleman, C. Wallis and C. Wershler. 2002a. Ecological land classification of Waterton Lakes National Park, Alberta. Vol. I: integrated resource description. Parks Canada, Waterton Park, Alberta. 226 pp.

Achuff, P.L., R.L. McNeil, M.L. Coleman, C. Wallis, C. Wershler and R. Riddell. 2002b. Ecological land classification maps of Waterton Lakes National Park, Alberta. Prepared by Terrain Resources Ltd., Lethbridge, Alberta, for Parks Canada, Waterton Park, Alberta. 5 maps & legend.

Alberta Conservation Information Management System (ACIMS): List of all Species and Ecological Communities in Alberta, within the ACIMS Database - June, 2013. Available: http://albertaparks.ca/albertaparksca/management-land-use/alberta-conservation-information-management-system-(acims).aspx (accessed December 12, 2013).

BC Conservation Data Centre. 2013. Species Summary: *Satyrium semiluna*. B.C. Minist. of Environment. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed December 12, 2013).

BC Conservation Framework. 2013. Conservation Framework Summary: *Satyrium semiluna*. B.C. Minist. of Environment. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed December 12, 2013).

CMP (Conservation Measures Partnership). 2010. Threats Taxonomy. Available: http://www.conservationmeasures.org/initiatives/threats-actions-taxonomies/threats-taxonomy.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2006. COSEWIC assessment and status report on the Half-moon Hairstreak *Satyrium semiluna* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 26 pp. (http://www.registrelep-sararegistry.gc.ca/sar/assessment/status_e.cfm).

Iverson, K., and A. Haney. 2010. Refined and updated ecosystem mapping for the South Okanagan Valley and Lower Similkameen. Unpub. report prepared for the Regional District of the Okanagan Similkameen and South Okanagan – Similkameen Conservation Program.

James, D. and D. Nunnallee. 2011. Life Histories of Cascadia Butterflies. Oregon State University Press. Corvallis, OR. 448pp.

Knopp, D., L. Larkin, J.Heron and O.Dyer. 2009. 2008 Surveys for Half-moon Hairstreak, *Satyrium semiluna*, in the Southern Okanagan, British Columbia. British Columbia Ministry of Environment, Ecosystem Branch, Vancouver, BC.

NatureServe, 2002. Element Occurrence Data Standard. Available http://www.natureserve.org/prodServices/eodata.jsp (Accessed: November 5 2012)

NatureServe. 2013. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer (accessed December 12, 2013).

Scott, J.A. 1973. Life-span of Butterflies. Journal of Research on the Lepidoptera. 12(4) 225:23

Appendix 1. Maps of Critical Habitat for Half-moon Hairstreak in Canada

Critical habitat for Half-moon Hairstreak has been identified at nine locations in Canada. Eight locations are in British Columbia (Figures A1-A5), and one location is in Alberta (Figure A6):

1) White Lake (East and West) BC (Figure A1): corresponds with B.C. CDC EO #6
2) Keremeos Columns BC (Figure A2): corresponds with B.C. CDC EO #7
3) Blind Creek, BC (Figure A2): corresponds with B.C. CDC EO #3
4) Richter Pass & Mount Kobau & Kilpoola BC (Figure A3): corresponds with B.C. CDC EO #4
5) Kilpoola Lake BC (Figure A4): corresponds with B.C. CDC EO #5
6) Chopaka East BC (Figure A4): corresponds with B.C. CDC EO #8
7) Anarchist Mountain BC (Figure A5): corresponds with B.C. CDC EO #2
8) East Osoyoos BC (Figure A5): corresponds with B.C. CDC EO #1
9) Blakiston Fan, Waterton Lakes National Park, Alberta (Figure A6)

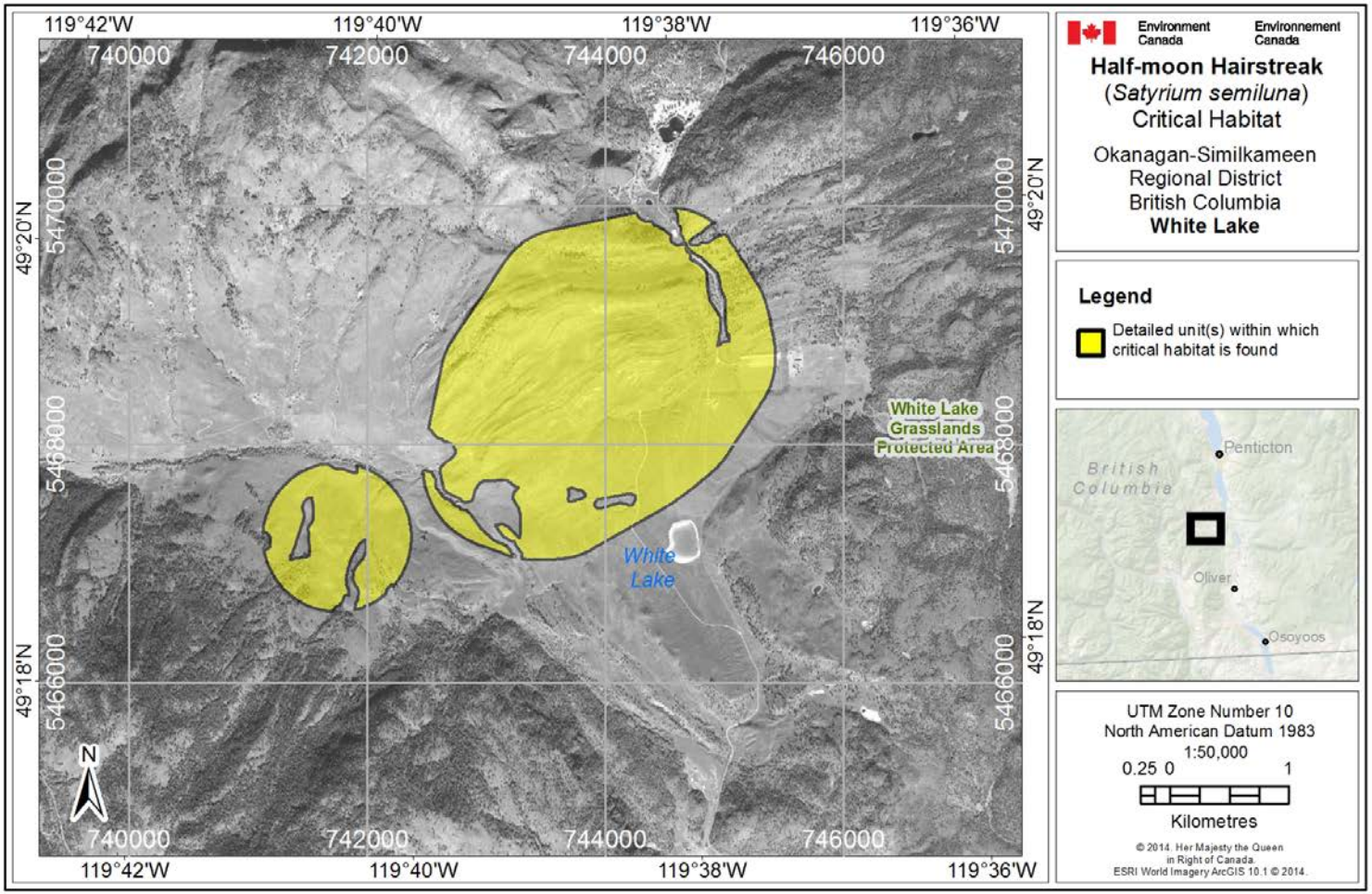

Figure A1. Critical habitat for Half-moon Hairstreak at White Lake (East and West), British Columbia (corresponds with BC CDC EO #6) is represented by the shaded yellow polygons (709.8 ha in total), where the criteria and methodology set out in Section 4.1 are met.

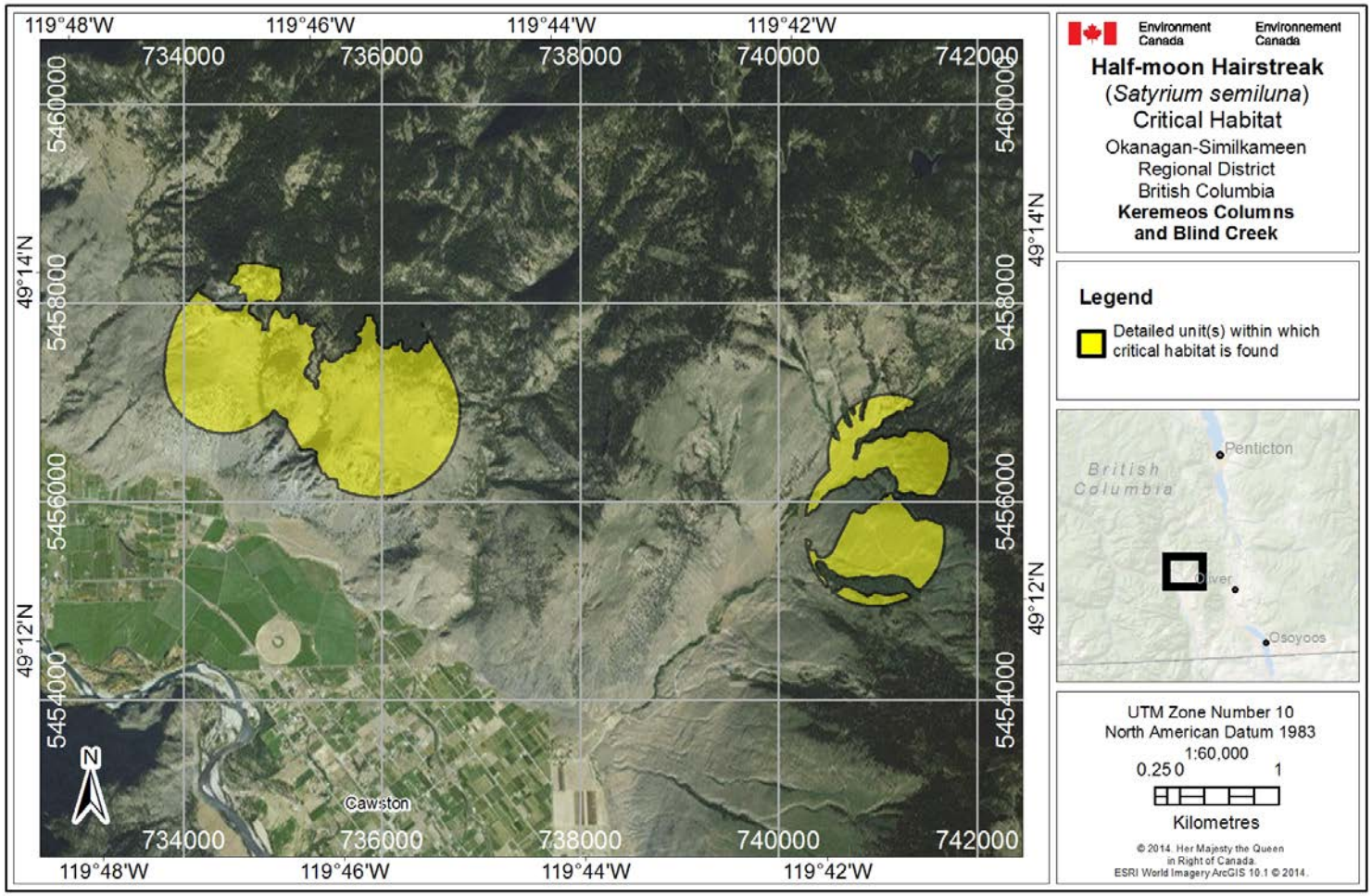

Figure A2. Critical habitat for Half-moon Hairstreak at Keremeos Columns (west polygon) and Blind Creek (east polygon), British Columbia (the Keremeos location corresponds with BC CDC EO #7 and the Blind Creek location corresponds with BC CDC EO #3) is represented by the shaded yellow polygons (552.8 ha in total), where the criteria and methodology set out in Section 4.1 are met.

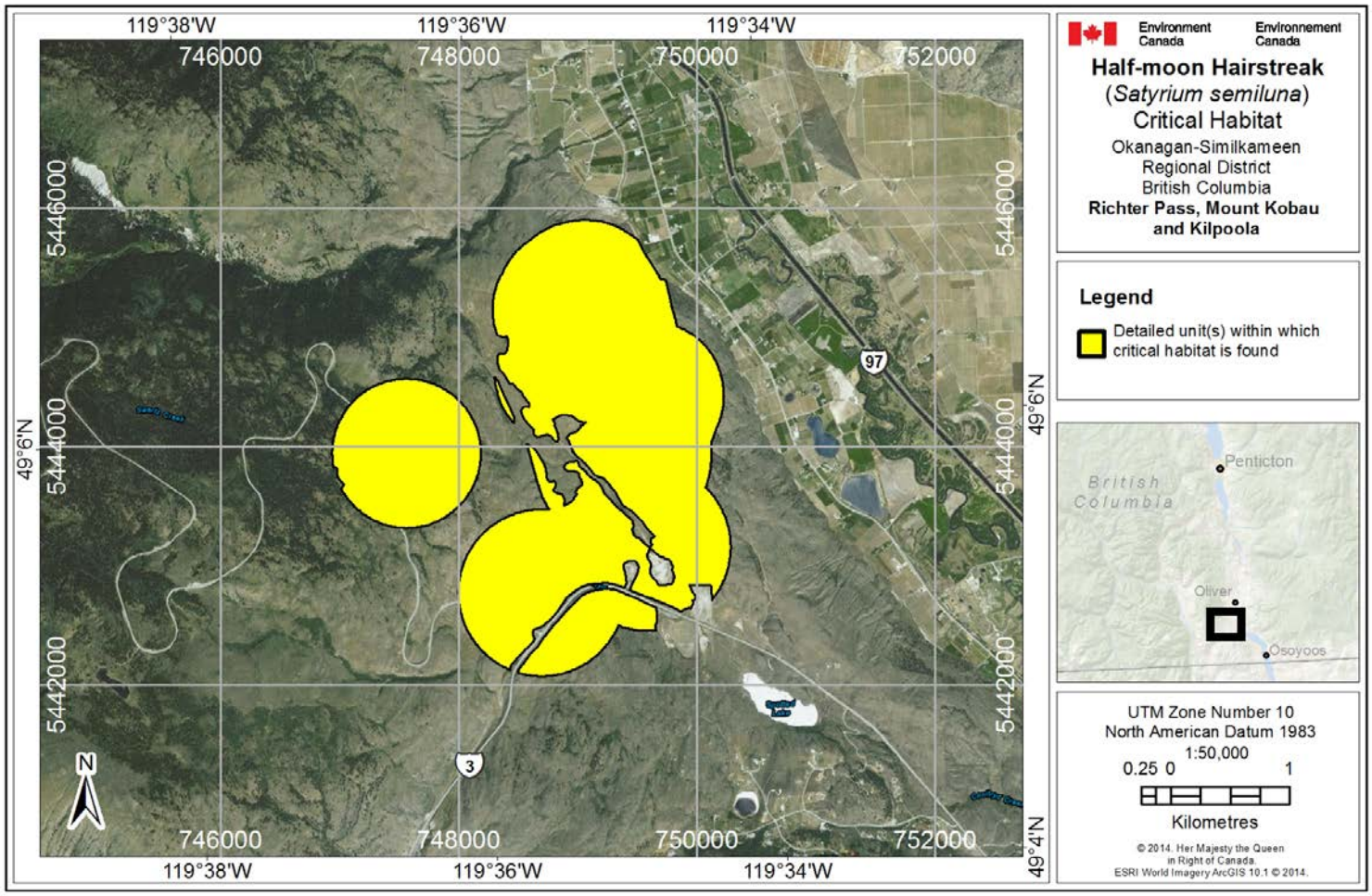

Figure A3. Critical habitat for Half-moon Hairstreak at Richter Pass, Mt. Kobau and Kilpoola, British Columbia (corresponds with BC CDC EO #4) is represented by the yellow shaded polygons (679.2 ha in total), where the criteria and methodology set out in Section 4.1 are met.

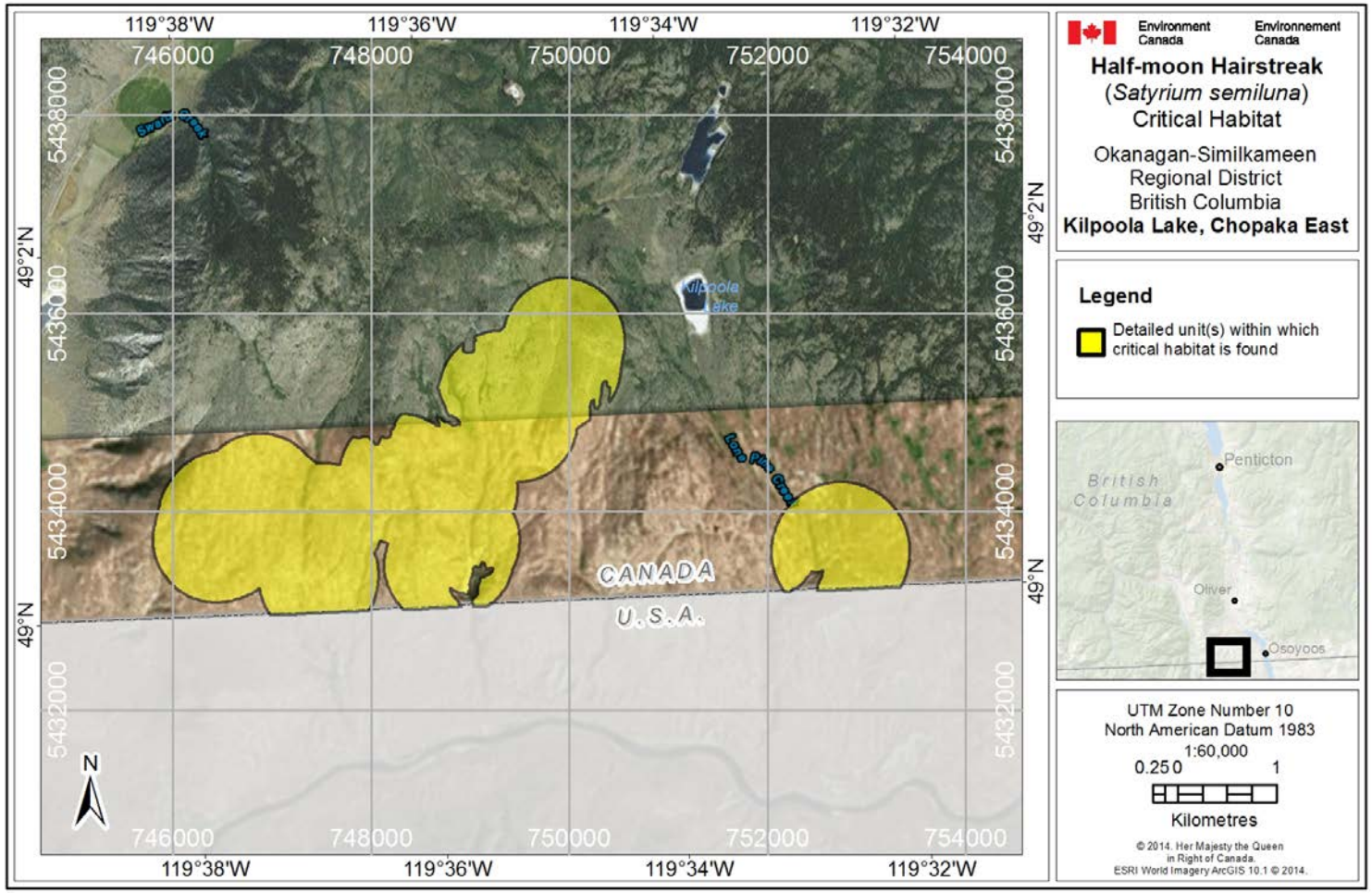

Figure A4. Critical habitat for Half-moon Hairstreak at Chopaka East (west polygon; corresponds with BC CDC EO #8) and Kilpoola Lake (east polygon, corresponds with BC CDC EO #5), British Columbia is represented by the yellow shaded polygons (946.7 ha in total), where the criteria and methodology set out in Section 4.1 are met.

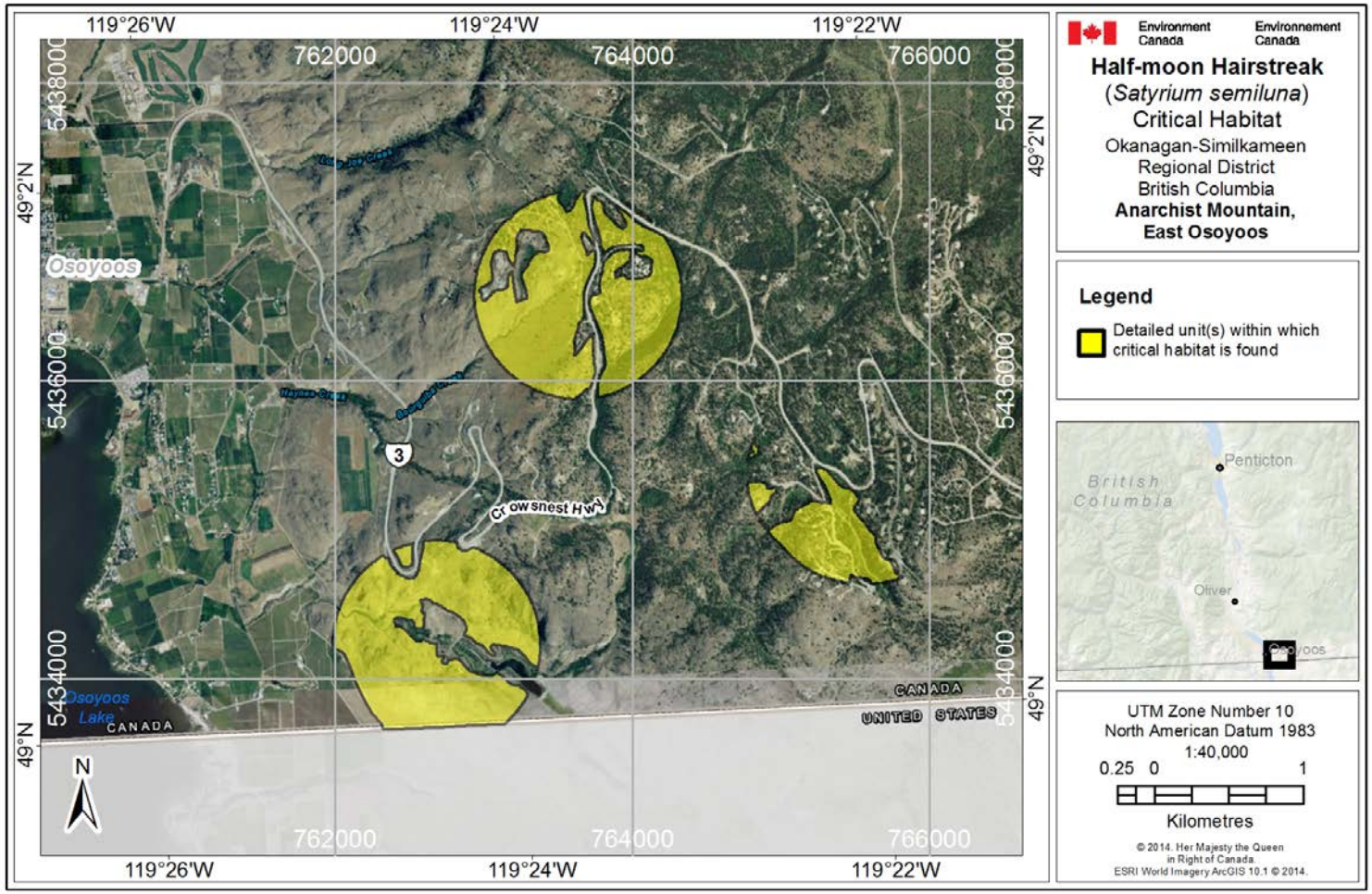

Figure A5. Critical habitat for Half-moon Hairstreak at East Osoyoos (southwest polygon; corresponds with BC CDC EO #1) and Anarchist Mountain (north and east polygons; corresponds with BC CDC EO #2), British Columbia is represented by the yellow shaded polygons (280.5 ha in total), where the criteria and methodology set out in Section 4.1 are met.

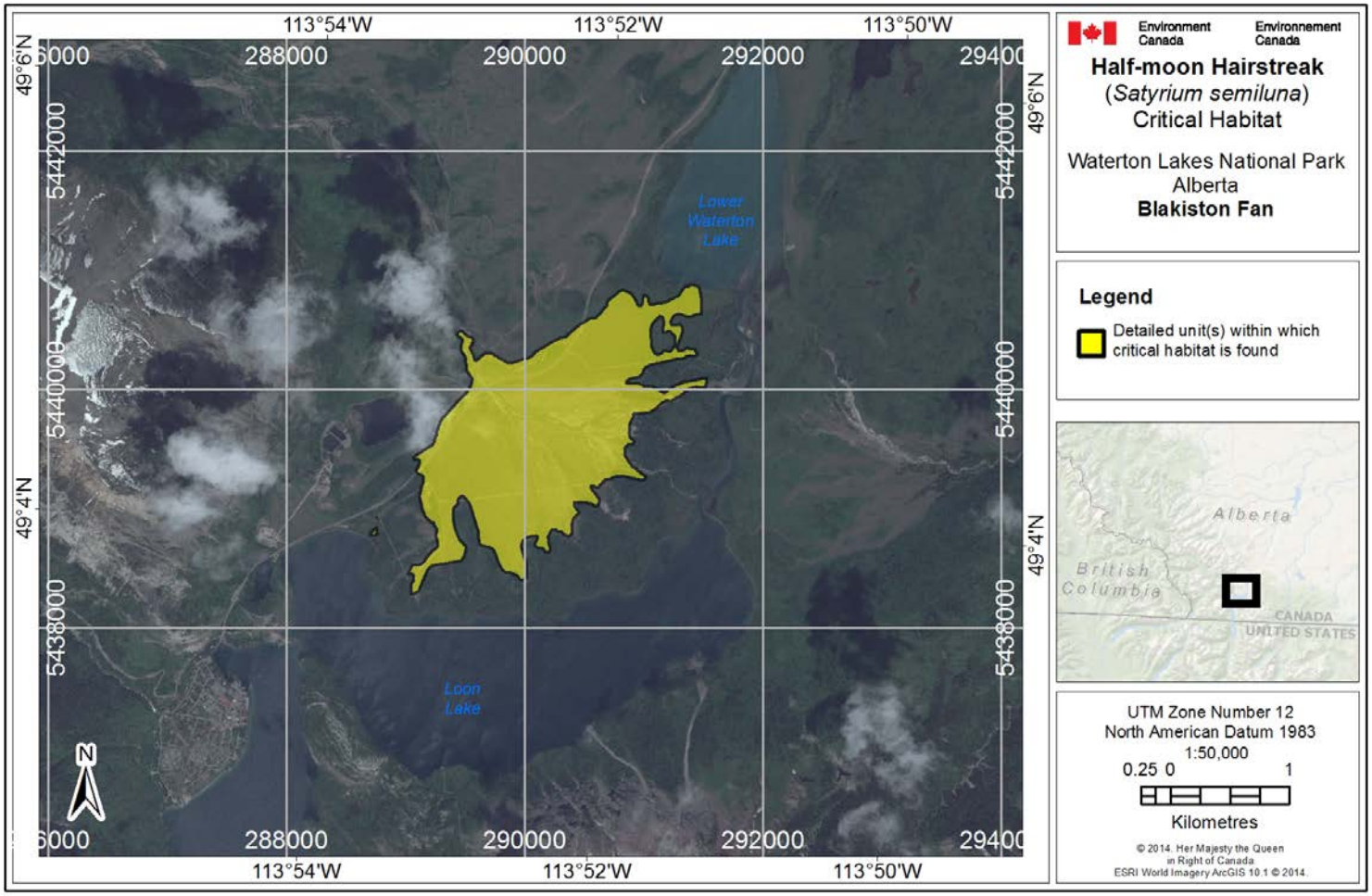

Figure A6. Critical habitat for Half-moon Hairstreak at Blakiston Fan, Waterton Lakes National Park, Alberta is represented by the yellow shaded polygons (295.8 ha in total), where the criteria and methodology set out in Section 4.1 are met.

Part 2: "Recovery Strategy for Half-moon Hairstreak (*Satyrium semiluna*) in British Columbia and Alberta", prepared by the British Columbia Southern Interior Invertebrates Recovery Team for the British Columbia Ministry of Environment

Recovery Strategy for Half-moon Hairstreak (*Satyrium semiluna*) in British Columbia and Alberta

Prepared by the British Columbia Southern Interior Invertebrates Recovery Team

BRITISH COLUMBIA | Ministry of Environment

November 2011

About the British Columbia Recovery Strategy Series

This series presents the recovery strategies or recovery plans that are prepared as advice to the Province of British Columbia on the general strategic approach required to recover species at risk. Recovery strategies are prepared in accordance with the priorities and management actions assigned under the British Columbia Conservation Framework. The Province prepares recovery strategies or recovery plans to ensure coordinated conservation actions and meet its commitments to recover species at risk under the *Accord for the Protection of Species at Risk in Canada*, and the *Canada – British Columbia Agreement on Species at Risk*.

What is recovery?

Species at risk recovery is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of a species' persistence in the wild.

What is a recovery strategy?

A recovery strategy summarizes the best available science-based knowledge of a species or ecosystem to identify goals, objectives, and strategic approaches that provide a coordinated direction for recovery. These documents outline what is and what is not known about a species or ecosystem, identify threats to the species or ecosystem, and explain what should be done to mitigate those threats.

What's next?

In some cases, one or more action plan(s) will be developed to define and guide implementation of the recovery strategy. Action plans include more detailed information about what needs to be done to meet the objectives of the recovery strategy. However, when sufficient information to guide implementation for the species can be included in the recovery strategy, a separate action plan is not required.

For more information

To learn more about species at risk recovery in British Columbia, please visit the Ministry of Environment Recovery Planning webpage at:
<http://www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm>

To learn more about the British Columbia Conservation Framework, please visit the Ministry of Environment Conservation Framework webpage at:
< http://www.env.gov.bc.ca/conservationframework/>

Recovery Strategy for Half-moon Hairstreak (*Satyrium semiluna*) in British Columbia and Alberta

Prepared by the British Columbia Southern Interior Invertebrates Recovery Team

November 2011

Recommended citation

B.C. Southern Interior Invertebrates Recovery Team. 2011. Recovery strategy for Half-moon Hairstreak (*Satyrium semiluna*) in British Columbia and Alberta. Prepared for the B.C. Ministry of Environment, Victoria, BC. 33 pp.

Cover illustration/photograph
Denis Knopp (Photo taken in South Okanagan Grassland Protected Area, BC Parks, June 2007).

Additional copies

Additional copies can be downloaded from the B.C. Ministry of Environment Recovery Planning webpage at:

<http://www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm>

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Disclaimer

This recovery strategy has been prepared by the British Columbia Southern Interior Invertebrates Recovery Team, as advice to the responsible jurisdictions and organizations that may be involved in recovering the species. The British Columbia Ministry of Environment has received this advice as part of fulfilling its commitments under the *Accord for the Protection of Species at Risk in Canada*, and the *Canada - British Columbia Agreement on Species at Risk.*

This document identifies the recovery strategies that are deemed necessary, based on the best available scientific and traditional information, to recover Half-moon Hairstreak populations in British Columbia and Alberta. Recovery actions to achieve the goals and objectives identified herein are subject to the priorities and budgetary constraints of participatory agencies and organizations. These goals, objectives, and recovery approaches may be modified in the future to accommodate new objectives and findings.

The responsible jurisdictions and all members of the recovery team have had an opportunity to review this document. However, this document does not necessarily represent the official positions of the agencies or the personal views of all individuals on the recovery team.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that may be involved in implementing the directions set out in this strategy. B.C. Ministry of Environment encourages all Canadians to participate in the recovery of Half-moon Hairstreak.

RECOVERY TEAM MEMBERS

Sylvie Desjardins, University of British Columbia Okanagan Campus, Kelowna, BC
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Cyndi Smith, Parks Canada Agency, Waterton Lakes National Park, AB
Dennis St. John, Private Entomologist, Willowbrook, BC

RESPONSIBLE JURISDICTIONS

The British Columbia Ministry of Environment is responsible for producing a recovery strategy for Half-moon Hairstreak under the *Accord for the Protection of Species at Risk in Canada*. Parks Canada Agency and Environment Canada also participated in the preparation of this recovery strategy.

ACKNOWLEDGEMENTS

Many individuals contributed information to this strategy. Jennifer Heron (B.C. Ministry of Environment) wrote the draft recovery strategy, which was then edited according to suggestions from members of the Southern Interior Invertebrates Recovery Team. Orville Dyer (B.C. Ministry of Forests, Lands and Natural Resource Operations) contributed significant feedback and editorial suggestions to the recovery strategy. Dennis St. John contributed data and scientific expertise; his collective (over a number of years) and independent research on Half-moon Hairstreak and other butterflies in the southern Okanagan is vital to these species' recovery in British Columbia. Brenda Costanzo provided information about plant communities in the Southern Interior.

Additional reviews were completed by Jeff Brown (B.C. Ministry of Environment), Diane Casimir (Parks Canada Agency), and Norbert Kondla (consultant). B.C. Parks and Protected Areas staff (Sarah Bunge and Andrea Mead, through support of their supervisor Mark Weston) spent time and resources searching for the Half-moon Hairstreak. Norbert Kondla, Jennifer Heron, and Denis Knopp provided photographs. Leah Westereng reformatted this document as per Ministry of Environment's standards (see Ministry of Environment 2010a) and contributed greatly to editorial revisions and overall document completion.

EXECUTIVE SUMMARY

Half-moon Hairstreak (*Satyrium semiluna*) is listed as Endangered in Canada on Schedule 1 of the *Species at Risk Act* (SARA). The butterfly was assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) due to a small, restricted range and decline, likely as a result of habitat loss. In British Columbia (B.C.), the conservation status rank of Half-moon Hairstreak is S1 (imperiled) and is on the provincial Red list. The B.C. Conservation Framework ranks Half-moon Hairstreak as a priority 1 under goal 3 (maintain the diversity of native species and ecosystems). Half-moon Hairstreak is identified as a Species At Risk under the *Forest and Range Practices Act* and is listed as Identified Wildlife under the Identified Wildlife Management Strategy. The Alberta Conservation Information Management System (ACIMS) lists the species provincially as S1 (imperiled; Red-listed). Recovery of Half-moon Hairstreak is considered biologically and technically feasible.

Half-moon Hairstreak (Family Lycaenidae) is a small butterfly with a 2.0 – 3.4 cm wingspan. The dorsal wing surfaces are a uniform brownish-black "sooty" colouration. The flight period is from late May through late June in B.C. and late June through late July in Alberta (AB), with one generation per year in both provinces. The flight period is correlated with the flowering period of nectar host plants, which include yellow buckwheat (*Eriogonum flavum*) in AB and Missouri goldenrod (*Solidago missouriensis*) in both B.C. and AB. The flight period usually declines with the senescence (aging) of the larval host plants, which are lupines (*Lupinus* spp.).

Within Canada, Half-moon Hairstreak is restricted to the dry arid grasslands of southern B.C. and southwestern AB. In total, there are eight locations of the species in Canada: seven locations in the south Okanagan Valley in B.C. and one location within Blakiston Creek fan, Waterton Lakes National Park (WLNP), AB. The combined B.C. and AB area of occurrence is approximately 346 km^2. There may be additional locations for the species within unchecked grassland habitats in both southern B.C. and AB.

In B.C., definitive threats to Half-moon Hairstreak are mainly from urban and agricultural land development. Additional potential threats in B.C. that need clarification include competition from introduced plants and animals and the habitat changes that result from introduced species; and impacts to habitat from domestic livestock overgrazing. Potential threats applicable to both B.C. and AB (and need further clarification) include overgrazing from native ungulates, climate change and natural disasters throughout the butterfly's Canadian range; and range-wide changes in ecological dynamics and ecological processes due to the combination of fire suppression, forest encroachment, changing soil chemistry, and water availability.

The population and distribution goal for Half-moon Hairstreak is to ensure the persistence of populations of Half-moon Hairstreak at all known extant locations (and any new locations) within the species' range in Canada.

The recovery objectives are

1. To establish habitat protection[1] for the eight known extant Half-moon Hairstreak locations.
2. To assess and mitigate the extent of known and potential threats at each Half-moon Hairstreak location.
3. To confirm the distribution of all populations (existing and new locations) of Half-moon Hairstreak in British Columbia and Alberta.
4. To address knowledge gaps such as life history, dispersal and population information, and habitat requirements.

RECOVERY FEASIBILITY SUMMARY

The recovery of Half-moon Hairstreak in Canada is considered feasible based on the criteria outlined by the Government of Canada (2009):

1. Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.

   Yes. Half-moon Hairstreak populations are present at seven known locations within B.C. and one location within AB.

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.

   Yes. Half-moon Hairstreak occurs in sagebrush grassland habitats in the southern Okanagan in B.C. The AB location within Waterton Lakes National Park is in grasslands naturally dominated by oatgrasses, rough fescue, and junegrass (Achuff *et al*. 2002). Habitat mapping in both B.C. and AB suggests a substantial amount of potential habitat is available.

   Visually suitable habitat exists in AB on the Sofa Creek and Stoney Creek alluvial fans within WLNP, and adjacent to WLNP. Portions of Sofa Creek alluvial fan have been checked, although additional surveys are needed. The vegetation appears similar to occupied sites at Blakiston Creek fan. Additional work is required to determine whether the species does exist in these areas.

[1] *Protected habitat* is habitat (see Section 3.3.1, Habitat and Biological Needs) managed to maintain Half-moon Hairstreak over a long time period (i.e., 100 years). Protection can be achieved through various mechanisms including: voluntary stewardship agreements, conservation covenants, sale by willing vendors on private lands, land use designations, and protected areas with appropriate management plans.

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.

   Yes. Significant threats to Half-moon Hairstreak habitat in both B.C. and AB can be mitigated through habitat protection, education, introduced species control, and changes to livestock grazing regimes (when deemed necessary) that consider negative impacts to butterfly host plants. Taking steps to maintain natural grassland environments and connectivity is important to maintain the long-term viability of meta-populations at each location.

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.

   Yes. Effective recovery techniques exist to restore habitat for Half-moon Hairstreak in both B.C. and AB. Techniques focus on protecting habitat (in B.C.), removing and controlling introduced plants (in B.C. and AB), and managing unsuitable livestock grazing regimes (in B.C. and if new locations are found in AB, outside of WLNP).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 COSEWIC* SPECIES ASSESSMENT INFORMATION

Date of Assessment: April 2006
Common Name (population): Half-moon Hairstreak
Scientific Name: *Satyrium semiluna*
COSEWIC 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.
Canadian Occurrence: British Columbia, Alberta
COSEWIC Status History: Designated Endangered in April 2006. Assessment based on a new status report.

* Committee on the Status of Endangered Wildlife in Canada.

2 SPECIES STATUS INFORMATION

Half-moon Hairstreak[a]	
Legal Designation:	
Identified Wildlife (B.C.):[b] Yes	B.C. *Wildlife Act*:[c] No SARA Schedule: 1 (2007)
Conservation Status[d]	
B.C. List: Red B.C. Rank: S1 (2006)	AB List: Red AB Rank: S1 (2006)
National Rank: N1 (2009)	Global Rank: G4 (2007)
USA Subnational Ranks:[e] California: SNR; Colorado: S3; Idaho: SNR; Montana: S4; Nevada: SNR; Oregon: SNR; Utah: SNR; Washington: S4: Wyoming: SNR	
B.C. Conservation Framework (CF)[f]	
Goal 1: Contribute to global efforts for species and ecosystem conservation.	Priority:[g] 3 (2009)
Goal 2: Prevent species and ecosystems from becoming at risk.	Priority: 6 (2009)
Goal 3: Maintain the diversity of native species and ecosystems.	Priority: 1 (2009)
CF Action Groups:	Compile Status Report; Planning; List under *Wildlife Act*; Send to COSEWIC; Habitat Protection; Habitat Restoration; Private Land Stewardship

a Data source: B.C. Conservation Data Centre (2010) unless otherwise noted.
b Identified Wildlife under the Forest and Range Practices Act, which includes the categories of species at risk, ungulates, and regionally important wildlife (Province of British Columbia 2002).
c Not designated as wildlife under the B.C. Wildlife Act (Province of British Columbia 1982).
d S = subnational; N = national; G = global; B = breeding; X = presumed extirpated; H = possibly extirpated; 1 = critically imperiled; 2 = imperiled; 3 = special concern, vulnerable to extirpation or extinction; 4 = apparently secure; 5 = demonstrably widespread, abundant, and secure; NA = not applicable; NR = unranked; U = unrankable. U.S. data from NatureServe (2009).
e Data source: NatureServe (2009).
f Data source: Ministry of Environment (2010b).
g Six-level scale: Priority 1 (highest priority) through to Priority 6 (lowest priority).

3 SPECIES INFORMATION

3.1 Species Description

Half-moon Hairstreak (*Satyrium semiluna,* family Lycaenidae) was described as a subspecies of *S. fuliginosum* until recently when Warren (2005) provided reasons for designating *semiluna* to species status. It has been suggested populations in British Columbia (B.C.) (Figure 1 and 2) and Alberta (AB) (Figure 3 and 4) may be separate subspecies based on noted multiple visual differences (N. Kondla, pers. comm., 2008). Until further taxonomic and/or genetic studies confirm otherwise, both B.C. and AB populations of Half-moon Hairstreak are considered a single species. There are no subspecies of *S. semiluna* identified in Canada at this time.

Half-moon Hairstreak (Figures 1 - 4) is a small butterfly with a wingspan from 2.0 to 3.4 cm (Guppy and Shepard 2001; N. Kondla, pers. comm., 2008). Adults do not have 'tails', which are evident on most other hairstreak species in B.C. and AB; this morphological feature makes this species distinguishable from other hairstreaks. The dorsal wing surfaces are a uniform brownish-black 'sooty' colouration (Figure 1 for B.C.; Figure 3 for AB) with white fringe scales that vary in colour from grey to tan to white, depending on light conditions. Females tend to have 'paler' fringe scales (N. Kondla, pers. comm., 2009). The ventral wing surfaces (Figure 2 for BC; Figure 4 for AB) are a greyish brown, have a faint white fringe, and have two rows of black spots towards the outer half of the wing. White fuzzy-edged rings surround these black spots, and some spots are solid white. In many specimens, these spots are indistinct. The body is sooty grey on the dorsal surface and lighter whitish grey on the ventral surface. Overall, females tend to be larger and paler than males in a given population (N. Kondla, pers. comm., 2008). For further information on the species' appearance, refer to Bird *et al*. (1995), Layberry *et al.* (1998), Mattoon and Austin (1998), Guppy and Shepard (2001), Warren (2005), and the COSEWIC status report (2006).

When multiple B.C. and AB specimens are compared, B.C. males tend to be measurably larger than AB males (COSEWIC 2006). In addition, the overall colouration of AB specimens is a lighter grey than B.C. specimens and without pronounced dots on the wings. For a further description of Half-moon Hairstreak, see Bird *et al.* (1995), Layberry *et al.* (1998), Guppy and Shepard (2001), and COSEWIC (2006).

Figure 1. Dorsal wing surfaces of B.C. specimen of Half-moon Hairstreak. Specimen from Anarchist Mountain (location #2), near Osoyoos, B.C. (collected June 21, 1975, by J.L. Gordon) and housed at the Beaty Biodiversity Museum Spencer Entomological Collection at the University of B.C. Photo: J. Heron

Figure 2. Ventral wing surfaces of Half-moon Hairstreak. The discal spot on this specimen is not typical, and usually darker in other specimens (see arrow). Specimen from Anarchist Mountain (location #2), near Osoyoos, BC (collected June 21, 1975, by J.L. Gordon) and housed at the Beaty Biodiversity Museum Spencer Entomological Collection at the University of B.C. Photo: J. Heron.

Figure 3. Dorsal wing surfaces of AB male specimen of Half-moon Hairstreak from Blakiston Fan, AB. Note this specimen looks darker than the B.C. male, however this is just due to photographic quality. In order to compare B.C. and AB specimens (e.g. size, colour, etc.) numerous specimens would need to be compared. Photo: N. Kondla.

Figure 4. Ventral wing surfaces of AB male specimen of Half-moon Hairstreak. Specimen from Blakiston Fan, AB. Photo: N. Kondla.

Similar Species: Half-moon Hairstreak adults may be confused with the Lycaenid butterfly, Boisduval's Blue *(Plebejus icarioides*). Half-moon Hairstreak and Boisduval's Blue have overlapping flight periods in both B.C. and AB (Bird *et al*. 1995; Layberry *et al.* 1998; Guppy and Shepard 2001; Kondla 2003a). The ventral wing surfaces of both species are similar in colouration, and neither species has a tail. However, unlike Half-moon Hairstreak, the dorsal wing surfaces of Boisduval's Blue males are blue and females' light blue (not pictured). Boisduval's Blue females that overlap with Half-moon Hairstreak in Canadian locations are typically brown on the dorsal surfaces, with limited blue scaling. Half-moon Hairstreak perches

and nectars with its wings closed, while Boisduval's Blue often opens its wings while at rest or nectaring (N. Kondla, pers. comm., 2008).

Eggs: Half-moon Hairstreak eggs are greenish white and occasionally tan-brown (Scott 1986a, 1986b, 1992); the tan colouration is a factor with egg age (D. Jones, pers. comm., 2008). Egg descriptions are further detailed in Scott (1986a, 1986b, 1992) and have been observed by Jones (pers. comm., 2008). There is one documented observation of an egg from the B.C. location at White Lake (location #3, see map in Figure 66; D. St. John, pers. comm., 2008). There are no documented observations of eggs from AB.

Larvae: Half-moon Hairstreak larvae have a brown head and a light green body with white chevrons on the lateral surface (Scott 1986a, 1986b, 1992; G. Pratt, pers. comm., 2008). Larval descriptions are further detailed in Ballmer and Pratt (1988). There are no documented observations of larvae from B.C. or AB locations.

3.2 Populations and Distribution

The global range of Half-moon Hairstreak is restricted to western North America from south-central B.C., east to Waterton Lakes National Park (WLNP) in AB; south through eastern Washington and Oregon, Idaho, northeastern California, northern Nevada, and east to Montana, Wyoming, and Colorado (Figure 5). Occurrences within B.C. and AB are the northernmost records in the species' global range (COSEWIC 2006; B.C. Conservation Data Centre 2010) and the locations within these two provinces are separated by more than 400 km of apparently unsuitable habitat.

Surveys for Half-moon Hairstreak from 2003 to 2010 (see Section 6.1, Actions Completed or Underway) confirm eight extant locations[2] within Canada: seven within B.C. [3] (COSEWIC 2006; B.C. Conservation Data Centre 2010) and one within AB (COSEWIC 2006; Poll and Poll 2008; Table 1). Populations in B.C. and AB are considered disjunct due to the extensive separation distance (> 400 km) and unsuitable habitat between locations (COSEWIC 2006). The AB location is considered disjunct from the main U.S. populations (Figure 5) and rescue effect is not likely to occur.

[2] Locations are based on the biological parameters of the butterfly (e.g., dispersal distance and habitat connectivity between known occurrences, and whether the individuals mix between locations). The definition of location for recovery of the species is defined as a stand-alone population that does not mix with other locations. Sites within a location may mix.

[3] The COSEWIC status report (2006) for Half-moon Hairstreak states six locations in B.C., however, since the status report was written, one additional location has been recorded in B.C. (B.C. Conservation Data Centre 2008; Knopp *et al*. 2008).

Figure 5. Global range of Half-moon Hairstreak (COSEWIC 2006).

Current quantified population estimates at each Half-moon Hairstreak location in both B.C. and AB are unavailable. Population estimates are difficult to calculate and the population numbers fluctuate from year to year. Half-moon Hairstreak is often detected in low numbers, and may not be detected yearly at some sites. Due to weather fluctuations and the natural fluctuations in butterfly populations, it is difficult to estimate a trend. For example, in 2003 Kondla (COSEWIC 2006) detected a population at the West White Lake (location #3) (Table 1); in 2005, St. John (pers. comm., 2008) did not find one specimen there despite intensive surveys throughout the flight period; in 2006, St. John detected one specimen in late June at the location; and in 2007, St. John detected numerous individuals nearby, although not in the exact same host plant area as 2003 or 2006. Although population estimates have been reported previously (Kondla 2003a, 2004b; COSEWIC 2006), these numbers are not based on any mark-recapture work or scientific data, and the validity of the population estimate is questionable.

Table 1. Known locations[a] of Half-moon Hairstreak in Canada as of 2010.

Location	Location name	Land tenure	Elevation (m)	Most recent year observed
	Alberta			
1	Waterton Lakes National Park [b]	National park	1290	2009 (Kondla 2009)
	British Columbia			
2	Anarchist Mountain [b]	Private land	800	2003 (COSEWIC 2006)
3	3a. East, White Lake [b]	NRC [e]	615	2007 (Scott et al. 2007).
	3b. West, White Lake [c]	NRC	595	2010 (EC-CWS,[g] unpubl. data)
4	4a. Richter Pass [b]	Private (multiple landowners)	700	2003 (COSEWIC 2006)
	4b. Mount Kobau Site [b] and Kilpoola Site [c,d]	South Okanagan Grasslands Protected Area [f]	765	2009 (B.C. Conservation Data Centre 2010)
5	Blind Creek [b]	Private	984	2010 (EC-CWS, unpubl. data)
6	Kilpoola Lake [b,d]	Private	700	2010 (EC-CWS, unpubl. data)
7	Near Keremeos Columns Provincial Park [b]	Private	1140	2003 (COSEWIC 2006)
8	Chopaka East Site [c]	South Okanagan Grasslands Protected Area [f]	unknown	2007 (Knopp *et al.* 2008)

[a] No information is available for population size or area of occupancy at each location.
[b] Location previously reported in COSEWIC (2006) status report on page 9 and/or page 16.
[c] New location (or site within a location) not previously reported in COSEWIC (2006).
[d] Despite similar names, Kilpoola Lake (private land) and Kilpoola Site (South Okanagan Grasslands Protected Area) are two separate locations. The distance between these locations is large and the populations are not likely connected.
[e] NRC = National Research Council
[f] South Okanagan Grasslands Protected Area (provincial park) is a vast expanse of land that has multiple and fragmented areas throughout the south Okanagan (e.g., it is not a contiguous piece of property). The distance between the two locations listed here is extensive and without suitable habitat for Half-moon Hairstreak.
[g] EC-CWS: Environment Canada – Canadian Wildlife Service, Delta, B.C.

There may be additional locations for Half-moon Hairstreak within unsurveyed grassland habitats in southern B.C., including unknown potential habitats between the southern Okanagan Valley and WLNP. Half-moon Hairstreak individuals are likely overlooked by the non-lepidopterist due to the species' small size, non-descript grey colouration and low numbers. Priority B.C. areas for surveys include east of the Okanagan region, the dry grasslands from Rock Creek to Grand Forks, and portions of the southern Rocky Mountain trench.

There may be additional locations for the species within unsurveyed grassland habitats in southern AB. Additional surveys in 2009 in other habitats within WLNP (i.e., Sofa Creek and Stoney Creek alluvial fans[4]) did not reveal new occurrences (Kondla 2009) and additional search effort in suitable habitats surrounding WLNP has yielded no further records for Half-moon Hairstreak (N. Kondla, pers. comm., 2008). Further surveys in the sage slopes in the South Castle River Valley in AB may have suitable habitat for Half-moon Hairstreak (N. Kondla, pers. comm., 2008).

[4] An alluvial fan is a low, outspread, relatively flat to gently sloping mass of alluvium that is shaped like an open fan. Commonly deposited by a stream at the place where it issues from a narrow mountain valley upon a plain or broad valley. (United States Geological Survey, 2011).

The B.C. extent of occurrence for Half-moon Hairstreak is 341 km^2 within the southern Okanagan River Valley (Figure 6; B.C. Conservation Data Centre 2010). The B.C. range extent is calculated and updated based on new information, and is less than previously calculated in the COSEWIC (2006) assessment report. The northernmost location is within the White Lake basin, southwest of Penticton (most recent observation by St. John, 2008) and the southernmost location is along the U.S. border about 6 km west of Osoyoos (Knopp *et al*. 2008).

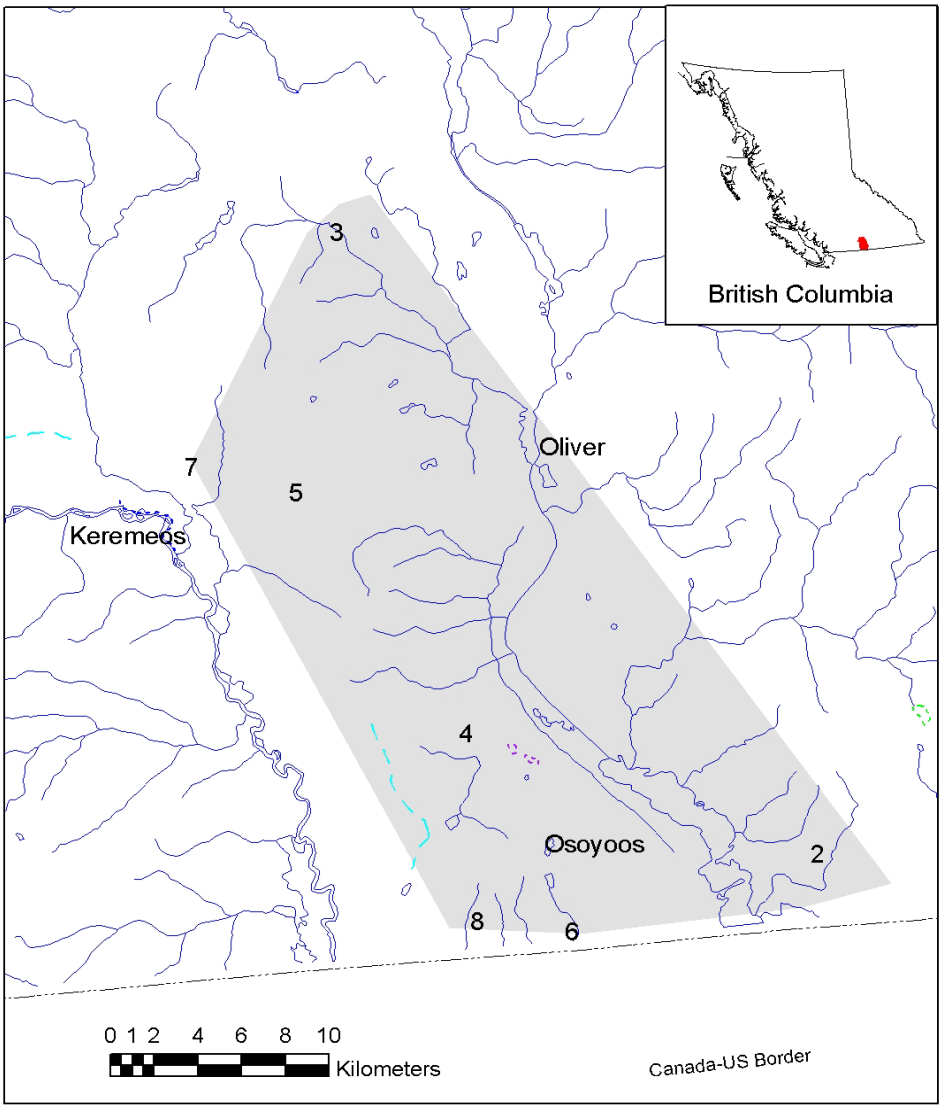

Figure 6. Range (shaded) and distribution (location numbers[5]) of Half-moon Hairstreak in B.C. (B.C. Ministry of Environment 2010).

In AB, both the AB range extent and the AB area of occurrence for Half-moon Hairstreak are the same and calculated at < 5 km^2 (COSEWIC 2006). This single known location within AB is from Blakiston fan, WLNP (Figure 7; COSEWIC 2006).

[5] The numbers on the map correspond to locations of the species and are listed in Table 1. See footnote 2 for the definition of a location.

Figure 7. Range (solid black area) of Half-moon Hairstreak in AB.

3.3 Needs of the Half-moon Hairstreak

Half-moon Hairstreak flight period is different for B.C. and AB, and flight periods can both peak and vary with weather patterns in both provinces. In B.C., Half-moon Hairstreak records are from late May through early July (COSEWIC 2006; D. St. John, pers. comm., 2008; N. Kondla, pers. comm., 2008; B.C. Conservation Data Centre 2010), with one generation per year (Guppy and Shepard 2001; Layberry *et al.* 1998) and a flight period that peaks during the last two weeks of June (B.C. Conservation Data Centre 2010). In B.C., Half-moon Hairstreak adults likely live less than two weeks (D. St. John, pers. comm., 2008). In AB, Half-moon Hairstreak records are from July (COSEWIC 2006) with one generation per year (Layberry *et al.* 1998; Guppy and Shepard 2001) and a peak in the last two weeks of July (COSEWIC 2006).

Half-moon Hairstreak flight period is correlated with the onset of the flowering period and senescence of the species larval host plants (see Section 3.3.1, Habitat and Biological Needs) (COSEWIC 2006). Adult females lay eggs on the larval host plants or in the leaf litter at the base

of the larval host plant (Scott 1986b, 1992; G. Pratt, pers. comm., 2008). Oviposition has not been observed in B.C. or AB and thus the exact location of egg placement on the host plant (e.g. top, middle, or bottom of the plant stalk) is unknown. Eggs overwinter until the following spring when larvae hatch. Pratt (pers. comm., 2008) remarks that the larvae (within California) likely begin feeding under the protection of snow cover, and before snow melt, as the shoots of the larval host plant grow. Larvae (elsewhere within the species global range) have been observed to be quite large and well developed before host plant flowering (G. Pratt, pers. comm., 2008). Larvae feed until late April/early May when they enter a short pupation period before emerging as adults in early to mid-June. Larval feeding has not been observed in B.C. or AB.

3.3.1 Habitat and Biological Needs

B.C. habitat and biological needs

In B.C., Half-moon Hairstreak habitat includes dry bunchgrass-sagebrush ecosystems with larval and nectar host plants and shrub vegetation for perching. Ants (species unknown) appear to be associated with hairstreak populations, although the biological role of ants in the species' life cycle is unclear.

Within B.C., Half-moon Hairstreak habitat occurs in the Southern Interior Okanagan River Valley in sagebrush–bluebunch wheatgrass ecosystem type. Locations 2, 4 and 8 are within the Okanagan very dry hot grassland phase variant of the Interior Douglas-fir biogeoclimatic zone (IDFxh1a) and Okanagan very dry hot grassland phase variant of the Ponderosa Pine biogeoclimatic zone (PPxh1a). The vegetation types include big sagebrush (*Artemesia tridentata*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), prairie junegrass (*Koeleria cristata*), and pinegrass (*Calamagrostis rubescens*) as common associates. Location 3 (White Lake location) is in the PPxh1a variant with common plant associates: bluebunch wheatgrass, needle-and-thread grass (*Hesperostipa comata*), and big sagebrush. This ecosystem classification is based on standards set by the B.C. Ministry of Forests, Lands and Natural Resource Operations (2011). The remaining locations (2, 4a, 5, 6, 7) have not had vegetation assessment completed. However, it is likely the vegetation at these locations is similar to the other locations described.

Half-moon Hairstreak flight period is correlated with the flowering period of nectar host plants, which include Missouri goldenrod (*Solidago missouriensis*) and yarrow (*Achillea millefolium*) (COSEWIC 2006), parsnip-flowered buckwheat (*Eriogonum heracleoides*) (Figure 8; COSEWIC 2006; Knopp *et al.* 2008) and grey horsebrush (*Tetradymia canescens*) (Figure 9; Knopp *et al.* 2008; D. St. John, pers. comm., 2008). Nectar plants are likely chosen opportunistically, as opposed to specifically (D. St. John., pers. comm., 2008).

Figure 8. Half-moon Hairstreak nectaring on parsnip-flowered buckwheat at Chopaka East Site (location #8), South Okanagan Grasslands Protected Area location in B.C., 2008. Photo: D. Knopp.

Figure 9. Half-moon Hairstreak nectaring on grey horsebrush at Mount Kobau (location #4b), within the South Okanagan Grasslands Protected area location in B.C., 2008. Photo: D. Knopp.

Half-moon Hairstreak flight period usually declines with the senescence of the larval host plants, which are lupines (*Lupinus* spp.), although the specific lupine species in B.C. are unclear. At the White Lake location (location #3), sulfur lupine (*Lupinus sulphureus*) and silky lupine (*Lupinus sericeus*) may be larval host plants (D. St. John, pers. comm., 2008). Elsewhere within the species' global range, silky lupine and spurred lupine (*Lupinus arbustus*) are known larval host plants. However, spurred lupine is likely not a host plant in B.C. because the plant is provincially Red-listed and thought to be extirpated from the province (B.C. Conservation Data Centre 2010).

Half-moon Hairstreak has been found in B.C. at elevations between 600 and 1100 m.

AB habitat and biological needs

The AB location (Table 1, Figure 7) is within the grasslands of the Foothills Parkland Ecoregion in WLNP. Specifically, the AB location is within the Blakiston Creek alluvial fan (COSEWIC 2006), which is one of the largest in the Canadian Rocky Mountains (Scott and Suffling 2000). The Blakiston Ecosection is dry grassland on soils that were formed on rapidly to moderately well-drained, coarse-textured fluvial landforms (Achuff *et al.* 2002).

The vegetation type at the AB location is naturally dominated by oatgrasses (*Danthonia* spp.), rough fescue (*Festuca scabrella*), and junegrass (*Koeleria macrantha*) (Achuff *et al.* 2002) with dominant component of bunchgrasses. Silky lupine composed up to 15% cover in general vegetation plots in the mid-1990s (Achuff *et al.* 2002) and 14% (range 0–63%) in plots within habitat where hairstreak butterflies were present (Kondla 2004b). Yellow buckwheat (*Eriogonum flavum*) also composed up to 25% (range 0–25%) cover on the same plots (Kondla 2004b).

Half-moon Hairstreak flight period in AB is correlated with the flowering period of nectar host plants, which include yellow buckwheat and Missouri goldenrod. The flight period usually declines with the senescence of the larval host plants, lupines (mostly silky lupine) but possibly also silvery lupine (*Lupinus argenteus*), which intergrades with silky lupine (Kuijt 1982). The

grassland ecosystems of the AB location are not assigned conservation status ranks by the ACIMS (Government of Alberta 2011).

Half-moon Hairstreak has been found at Blakiston Fan in AB at elevations ranging from 1290 to 1300 m.

Biological information applicable to B.C. and AB

Larval and nectar host plants may provide mating sites for Half-moon Hairstreak. Mating pairs in B.C. have been observed on the flowers of yellow buckwheat, Missouri goldenrod (D. St. John, pers. observation, 2008), prairie sagewort (*Artemisia frigida*), and various species of lupines. In addition, big sagebrush may also be important for mating sites in B.C., as observed four times (D. Knopp, pers. comm., 2008). In B.C., big sagebrush shrubs may be important for male perching (COSEWIC 2006). In WLNP, mating pairs have been observed on goldenrod species (*Solidago* spp.), buckwheat species (*Eriogonum* spp.), prairie sagewort, and various species of lupines (N. Kondla, pers. comm., 2008).

Ants may play a role in the presence of Half-moon Hairstreak, as ants were observed in close association with the lupine plants where Half-moon Hairstreak occurs at the White Lake location (location #3) (D. St. John, pers. comm., 2008). Ants and larvae may have a mutualistic relationship, where the ants protect larvae from predators and parasitoids, and the larvae secrete liquid containing amino acids and carbohydrates, which the ants consume (Pierce 1987; Leimar and Axén 1993 in COSEWIC 2006). Alternately, hairstreak larvae may "give" sugar packets to prevent ants from eating the larvae, and thus minimize predation by ants. Pratt (pers. comm., 2008) has reared numerous different populations of Lycaenid butterflies and observed that these butterflies rely heavily on ants, so much so that ants may determine whether the butterfly species is present in some habitats and not in others. Pratt (pers. comm., 2008) found Wood Ants (*Formica* spp.) and Carpenter Ants (*Camponotus* spp.) associated with Half-moon Hairstreak larvae in California.

3.3.2 Ecological Role

Half-moon Hairstreak is not likely an essential pollinator of its larval host plant or adult nectar plants, nor is it known to have other crucial ecological roles such as food-web dynamics. Small mammals, invertebrate predators, and birds likely predate upon Half-moon Hairstreak.

Half-moon Hairstreak may have a mutualistic association with various ant species (e.g., Wood Ants and/or Carpenter Ants), which are an important ecological component of arthropod fauna within grassland environments,.

3.3.3 Limiting Factors

Host plant specificity

Half-moon Hairstreak depends on larval host plants and without these plants the butterfly cannot complete its life cycle (see Section 3.3.1, Habitat and Biological Needs). The butterfly likely chooses nectar (adult) host plants opportunistically and preference may appear limited to the few

plant species flowering during the flight period and not the specific biological preference by the butterfly (D. St. John, pers comm., 2008).

Limited dispersal capability

Half-moon Hairstreak does not likely have high dispersal capabilities although it has not been documented how far the species will travel between host plant patches. Isolation due to dispersal limitations may lead to decreased genetic diversity within a population, greater genetic differences among locations, inbreeding depression, and no rescue effect.

Myrmecophily

Myrmecophily in butterflies is the close association or mutualistic relationship between the butterflies' larval life stage and the adult life stage of ant species (see Section 3.3.1, Habitat and biological needs). It may be that the presence of ants at a host plant may define whether the adult butterfly oviposits at that specific plant (D. St. John, pers. obs., 2008).

Habitat specificity

The presence of sagebrush may be an important habitat requirement for Half-moon Hairstreak in B.C., as it is present at most locations where the species has been found in B.C. (D. St. John, pers. observation, 2008). It may not be the sagebrush plant itself, but the structural function of the plant that is important for perching and mating: this information needs to be clarified with further research. Adults may use this plant for roosting sites and are well camouflaged among sage leaves. Larvae may gain some protection at the base of these perennial plants. Alternatively, it may be restricted habitat availability in Canada that limits Half-moon Hairstreak, and not specific habitat requirements beyond host plant availability and ant relationships. The presence of sagebrush at a location and the butterfly's use of the plant as a resting site may be an opportunistic relationship, and the structural aspects and size of a habitat patch of sagebrush (and not the plant species itself) may be the limiting factor. The males use a combination of perching and patrolling mate locating behaviour, as has been observed in both B.C. and AB (N. Kondla, pers. comm., 2008). Half-moon Hairstreak has been observed using *Chrysothamnus* spp., various lupine species, and pine trees, for perching (Warren 2005). Additional research is needed to clarify potential relationships in both B.C. and AB.

In AB, sagebrush is not present on Blakiston Creek fan in WLNP where Half-moon Hairstreak is known to occur. Half-moon Hairstreak butterflies on Blakiston Creek fan in WLNP don't appear to perch on vegetation; they fly close to the ground and perch on low-lying herbaceous vegetation, mainly the lupines growing within the area (N. Kondla, pers. comm., 2011). In 2009, surveys were conducted at the only known location of sagebrush in the park (nearly 6 km away and 200 m higher in elevation), and no Half-moon Hairstreak were observed (Kondla 2009).

Short adult life cycle

Half-moon Hairstreak has a short flight season, with individual butterflies living approximately two weeks (D. St. John, pers. comm., 2008). Inclement weather and the premature senescence of host plants, combined with the short flight period and declining habitat quality and quantity, may limit growth of the population.

Native Grazers

Native ungulates in both B.C. and AB habitats (in WLNP) range throughout Half-moon Hairstreak habitat and are known to graze on larval and nectar plants. In B.C., native ungulate grazers likely do not have significant impacts. The Blakiston Creen Fan in AB is currently grazed by native species during the winter, including elk (*Cervus canadensis*), mule deer (*Odocoileus hemionus*), and white-tailed deer (*O. virginianus*); 700 to 1,000 elk have been observed gathering on the Fan (C. Smith, pers. comm., 2008). It is unknown how native grazers limit Half-moon Hairstreak. The impacts from other grazers (e.g. herbivorous insects, rodents, etc.) are also unknown.

4 THREATS

Threats are defined as the proximate (human) activities or processes that have caused, are causing, or may cause the destruction, degradation, and/or impairment of biodiversity and natural processes. Threats can be past (historical), ongoing, and/or likely to occur in the future. Threats do not include intrinsic biological features of the species or population such as inbreeding depression, small population size, and genetic isolation, which are considered limiting factors.

4.1 Threat Assessment

The threat classification (Table 2) is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system and is consistent with methods used by the B.C. Conservation Data Centre and the B.C. Conservation Framework. For a detailed description of the threat classification system see the CMP website (CMP 2010). For information on how the values are assigned or overall impact is calculated see Master *et al.* (2009) and table footnotes for details. Threats for the Half-moon Hairstreak were assessed for B.C. and AB (Table 2).

Table 2. Threat classification table for Half-moon Hairstreak in B.C. and AB.

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Locations	Stress[e]
1	Residential & commercial development	Medium	Restricted	Extreme	High - Moderate		
1.1	Housing & urban areas	Medium	Restricted	Extreme	High	Location 2, 4a, 5, 6, 7 (B.C.)	Local extirpation; decreased population viability; decreased host plant resources; dispersal sinks
1.2	Commercial & industrial areas	Medium	Restricted	Extreme	High	Location 2, 4a, 5, 6, 7 (B.C.)	Local extirpation; decreased population viability; decreased host plant resources; dispersal sinks
2	Agriculture & aquaculture	Medium	Pervasive	Moderate	High		
2.3	Livestock farming & ranching	Medium	Pervasive	Moderate	High	7 of the 8 locations are subject to domestic livestock grazing.	Changes in plant species and plant community structure due to selective domestic grazers; increased trampling of host plants and plant communities in B.C. decreased populations at some locations where there is an incompatible grazing regime; dispersal sink where adult Half-moon Hairstreaks may oviposit on plants within the overgrazed habitats; reduced host plant availability (larval and nectar plants); increased egg and larval mortality (trampling).

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Locations	Stress[e]
6	Human intrusions & disturbance	Low	Large	Slight	High		
6.1	Recreational activities	Low	Large	Slight	High	All 8 locations, especially at location #1 in AB.	Decreased host plant resources; direct mortality of host plant resources (e.g. trampling by hiking and horseback riding); direct mortality of eggs and larvae (e.g. trampling by hiking and horseback riding).; decreased population numbers.
7	Natural system modifications	Medium	Pervasive	Moderate	Low		
7.1	Fire & fire suppression	Medium	Pervasive	Moderate	Low	All 8 locations	Increased fuel load thus changing soil structure and nutrient composition, leading to changes in plant community; decreased host plant resources; decreased population numbers; decreased number of locations.
8	Invasive & other problematic species & genes	Low	Pervasive	Slight	High		
8.1	Invasive non-native/alien species	Low	Pervasive	Slight	High	All 8 locations	Increased competition for resources (e.g., to host plants); increased predation pressure to Half-moon Hairstreak individuals (from alien species such as Tachinid flies); increased consumption of host plant(s) by invertebrate herbivores. Leads to reduction in overall host plant resources and direct mortality to individuals. Potential habitat alteration by knapweed in Half-moon Hairstreak habitat in Alberta
9	Pollution	Unknown	Restricted	Unknown	Moderate		
9.3	Agricultural & forestry effluents	Unknown	Restricted	Unknown	Moderate	Possible at 5 locations on private land (B.C.)	Reduced larval and nectar host plant resources; direct mortality of larvae and adults; reduced survival of larvae and adults.
11	Climate change & severe weather	Medium	Pervasive	Moderate	Low		
11.1	Habitat shifting & alteration	Medium	Pervasive	Moderate	Low	All 8 locations	Reduced survival of larvae that reach diapause; decreased population numbers; reduction in host plant resources due to changes to host plant phenology and

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Locations	Stress[e]
							grassland ecosystem structure.
11.4	Storms and flooding	Medium-Low	Restricted	Serious - Moderate	Low	1 location (AB)	Direct loss of host plant; reduced survival of larvae that reach diapause; decreased population numbers; reduction in host plant resources due to changes to host plant phenology and grassland ecosystem structure.

[a] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each stress is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%).
[b] **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%).
[c] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%).
[d] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.
[e] **Stress** – the condition or aspect (key ecological, demographic, or individual attribute) of the conservation target that is impaired or reduced by a threat (e.g., directly or indirectly results from human activities).

4.2 Description of Threats

The primary threat to Half-moon Hairstreak in B.C. is direct habitat loss or conversion to agricultural or urban development[6] (Table 2, Medium Threat Impact). The low elevation grassland ecosystems of the south Okanagan, that include Half-moon Hairstreak habitat, are considered one of the four most endangered ecosystems in Canada (Schluter *et al.* 1995) due to conversion as a result of agricultural or urban development.

In AB, the primary threat to Half-moon Hairstreak in WLNP is from recreational users (e.g., horseback riding, hiking, trail development) immediately within habitat. A secondary threat, but a threat that is not immediate, is potential loss of habitat from catastrophic flooding. Further threats include invasive plant species.

The overall Canadian-wide Threat Impact for Half-moon Hairstreak is High[7]. Details are discussed below under the Threat Level 1 headings.

4.2.1 Existing Threats[8]

IUCN-CMP Threat 1. Residential and commercial development (1.1 Housing and urban areas; 1.2 Commercial and industrial areas)

This threat applies to five locations in B.C. that are on private land and subject to possible landowner development in some form (not possible to differentiate commercial from urban). This is a potential and widespread threat within unchecked potential habitat in AB (outside of WLNP) and in B.C. There is a significant amount of potential Half-moon Hairstreak habitat outside of WLNP that is protected by the Nature Conservancy of Canada through conservation easements on their Waterton Park Front Project (C. Smith, pers. comm., 2011).

In B.C., the predominant threats to Half-moon Hairstreak are habitat loss, fragmentation, and degradation of sagebrush and bunchgrass plant communities and ecosystems both at the known private sites and within potential habitat on private land. Direct and complete irreversible physical destruction of grassland habitat (e.g., construction of housing or commercial developments) is ongoing throughout the Okanagan River Valley. Increased fragmentation of sagebrush communities reduces re-occupancy rates after natural stochastic events. Indirect effects of habitat conversion include fragmentation of species populations and inability to disperse across boundaries established due to development.

[6] Although natural system modifications and climate change also have a Threat Impact value of Medium, these threats are only considered potential threats that may happen in the future.
[7] The overall threat impact was calculated following Master et al. (2009) using the number of Level 1 Threats assigned to this species: 4 Medium, 2 Low, and 1 Unknown (Table 2).
[8] This includes Level 2 Threats where value for Timing is High (Table 2; CMP 2010).

IUCN-CMP Threat 2. Agriculture and aquaculture (2.3 Livestock farming and ranching)

Domestic livestock grazing is known to occur at all seven locations in B.C. It has occurred throughout most of the southern Okanagan River Valley for over 100 years. COSEWIC (2006) identified livestock grazing as a potential threat to Half-moon Hairstreak in B.C. Grazing leads to changes in plant species and plant community structure due to selective domestic grazers, choosing to forage on some plants and not others. Livestock grazing may alter vegetation through trampling and feeding, and alter leaf litter through trampling. Grazing may impact host plants for egg laying and larval feeding, leaf litter for larval development, and nectar and perching plants for adults.

Known occupied habitat within WLNP, AB had domestic grazing by cattle and horses under permit until the 1960s. However, livestock grazing is not considered a potential threat to Half-moon Hairstreak in AB. This is because unlike the western inter-montane bunchgrass ecosystems of B.C., short-steppe grasslands of the Canadian prairies evolved with bovid grazers, *Caespitose* grasses (Milchunas *et al*. 1988), and the influences of overgrazing. As such, the Canadian prairies do not change dramatically as a result of grazing (Milchunas *et al.* 1988).

Grazing, whether by livestock or native ungulates involves defecation and urination, may increase bare soil through repeated trampling or disturbance to vegetation, alters the microbiotic crust, and has the potential to destroy larval and nectar host plants for Half-moon Hairstreak. Grazing regimes alter natural vegetation, potentially increasing the establishment of non-native introduced plants and competition from non-native species (see above). Impacts vary dramatically with grazing intensity, livestock numbers, and season of use.

The overall impact of grazing within Half-moon Hairstreak habitat has not been studied. The cumulative impacts from defecation and trampling are likely to affect the Half-moon Hairstreak habitat by trampling and grazing of host plants, thus reducing host plant availability. It is possible that light grazing may benefit Half-moon Hairstreak at some sites (D. St. John, pers. comm., 2008) since, for example, lupines and yarrow increase in abundance with cattle grazing (Aleksoff 1999). Conversely, impacts may be negative through the loss of eggs and larvae by trampling host plants and leaf litter at times of the year when these life stages are most active and vulnerable to mortality.

IUCN-CMP Threat 6. Human intrusions and disturbance (6.1 Recreational activities)

Recreational activities (at various levels) threaten Half-moon Hairstreak habitats at all locations in B.C. and AB. The provincial park locations have recreational hiking but no all-terrain vehicle use (although illegal use could occur, but at present is not a high concern). The five private land locations could experience all terrain vehicle use, as well as other recreational use, although the specifics of this threat are not known.

In B.C., the South Okanagan Grasslands Protected Area locations and the White Lake basin location are both high use hiking areas. Although minimal, there is some all terrain vehicle use at the South Okanagan Grasslands Protected Area, Chopaka East Site (location #8), which has the potential to adversely impact host plant resources by driving over them.

In AB, recreational activities are thought to be the primary threat to Half-moon Hairstreak and the species habitat. WLNP is a popular park known for hiking and recreational opportunities including horseback riding throughout Blakiston Creek fan. Two roads cross the fan. Recreational activities potentially increase erosion along trails and increase movement of introduced plants along trails and roads. The erosion along and adjacent to recreational trails and roads may not impact Half-moon Hairstreak habitat as long as additional roads and trails are not created, and recreational users stay to these roads and trails. The dust created from recreational use may threaten developing larvae on host plants immediately next to the road/trail.

4.2.1 Potential Threats[9]

The threats listed below have been identified as potential threats based on existing research and threat information from other species at risk within B.C. and AB and inhabiting similar habitats.

IUCN-CMP Threat 7. Natural system modifications (7.1 Fire and fire suppression)

Fire suppression by wildfire protection programs within both B.C. and AB are a potential threat at all eight Half-moon Hairstreak locations in Canada. Fire suppression appears to have increased potential fire intensity, which would result in large intense fires, rather than small less intense fires that leave part of the plant community intact.

In B.C., tree encroachment, in the absence of regularly occurring fires, may have reduced the size and extent of sagebrush plant communities at some sites due to shading and competition (e.g., Kilpoola Site (location #4b) of the South Okanagan Grasslands Protected Area). Fire suppression has been ongoing for > 100 years within the region. Slow natural succession of pines (*Pinus* spp.) and other native trees into open areas is ongoing due to long-term fire suppression. A controlled burn that includes part of Blakiston Fan in WLNP is on the park's 10-year burn plan (C. Smith, pers. comm., 2009). Additional research is needed to determine if prescribed fire is a possibility for habitat restoration, or if surrogates such as mowing and vegetation removal can be applied.

IUCN-CMP Threat 8. Invasive and other problematic species and genes (8.1 Invasive non-native/alien species)

Introduced species potentially threaten Half-moon Hairstreak habitat and associated ecosystems at all locations in B.C. and AB.

In B.C., the dominant invasive plants that occur in Half-moon Hairstreak habitats and known locations include cheatgrass (*Bromus tectorum*), sulphur cinquefoil (*Potentilla recta*), Dalmatian toadflax (*Linaria vulgaris*), and diffuse knapweed (*Centaurea diffusa*). In AB, spotted knapweed (*Centaurea maculosa*) is the predominant introduced plant. Although unstudied within the ecosystems where Half-moon Hairstreak occurs in B.C. and AB, elsewhere the structure and diversity of plant communities is known to change through competition for resources and release of allelopathic compounds by Knapweed (e.g., Kelsey and Locken 1987; Tyser and Key 1988). Other studies suggest increases in soil sedimentation and surface water runoff are linked to

[9] This includes Level 2 Threats where value for Timing is Medium, Low, or Unknown; or the Impact is Unknown (Table 2; CMP 2010).

Knapweed (Lacey et al. 1989). Overall, these introduced weeds likely compete with larval and nectar host plants for resources, and change the soil chemistry and invertebrate ground fauna. This potential threat is widespread and ongoing throughout both B.C. and AB.

Introduced tachinid flies (family Tachinidae) used as a biological control agents for European Gypsy Moth (*Lymantria dispar*) and other agricultural pests are potential threats to Half-moon Hairstreak. Beginning in 1906 and over a span of the next fifty years, greater than 45 species of tachninid flies were introduced to North America (Elkinton 2004; Mahr 1999). Tachinid flies such as *Compsilura concinnata* are known to parasitize more than 200 host species of lepidoptera in the United States (Elkinton 2004; Mahr 1999) including non-pest species. The distribution of this species, and other non-native tachinid flies is unknown in western North America. The potential threats from this biological control mechanism are unknown.

The impacts from invasive plant species on Half-moon Hairstreak habitat leads to increased resource competition (e.g. to host plants) or predation (e.g. consuming eggs, larvae or adults) from invasive insects. More studies are needed to determine the severity of this threat; however invasive species are expected to have some impact.

IUCN-CMP Threat 9. Pollution (9.3 Agriculture and forestry effluents)

Herbicide application is possible at locations on private land in B.C.

Herbicide drift from adjacent agricultural areas may detrimentally affect Half-moon Hairstreak through direct mortality at localized sites, but impacts are unknown and have not been documented. Herbicide treatments for introduced plants (if applied broad scale) may impact non-target larval and nectar host plants by killing both the plant and/or the potential Half-moon Hairstreak larvae that are present on the plant. Impacts are localized and likely being reduced through improved Integrated Pest Management techniques. The locations in B.C. that are within provincial parks or national properties are not adjacent to agricultural spray areas.

Pesticide application by spot-spraying of target species does occur on Blakiston Fan within WLNP. Herbicides may be used within B.C. parks and protected areas to manage invasive plants (and if the specific park management plan allows for the application of herbicides). Application would be done with consideration of the protection of the ecosystem, and would involve provisions to protect any Half-moon Hairstreak occurrences nearby. The threat of broad pesticide application may be applicable if locations of Half-moon Hairstreak are found outside of WLNP

IUCN-CMP Threat 11. Climate change and severe weather (11.1 Habitat shifting and alteration)

Climate change is considered a potential, but poorly understood, threat to Half-moon Hairstreak habitat at all locations in both B.C. and AB.

In B.C., the south Okanagan Valley is considered one of the warmest climates in the province, and with climate change these areas may experience further drought and a shift in host plant phenology. Leaf and bloom growth on host plants may also be shortened due to increased temperature extremes within the region. This is speculative but possible over the long term.

A shift in timing of host plant growth in spring (larval host plant) could result in premature senescence of host plant prior to larvae reaching a biomass that allows for enough energy for overwintering survival or reduced survival of larvae that reach diapauses.

IUCN-CMP Threat 11. Climate change and severe weather (11.4 Storms and Flooding)

The threat of increased frequency, severity or timing of storms and flooding applies to the one Half-moon Hairstreak location in the WLNP (AB). A large increase in precipitation is projected for both winter and spring seasons in WLNP, which will likely result in increasing peak flows in the park, in turn increasing the frequency and severity of spring floods (Scott and Suffling 2000). Floods would be expected to cause increased erosion damage, and larger sediment transport to the alluvial fans of Blakiston Creek which hosts populations of Half-moon Hairstreak. In potential habitat (with no confirmed occurrences of Half-moon Hairstreak) at Sofa Fan and Stoney Creek fan (Scott and Suffling 2000) this threat also applies. The annual flooding that does occur in Blakiston Fan generally does not produce sheets of water across the entire habitat. In general, flooding breaks through in separate channels. Catastrophic flooding may bring sediment deposits across the fans, which could bury host plants and cause further soil erosion. Further research is needed to determine if flooding is a threat and/or benefit to Half-moon Hairstreak habitat.

Potential threats to unsurveyed Half-moon Hairstreak habitat outside of WLNP, AB.

Intensive land uses, conversion of native grasslands to agriculture, and development for recreation or oil and gas development are likely the most significant threat to potential butterfly habitats outside of WLNP.

5 RECOVERY GOAL AND OBJECTIVES

5.1 Population and Distribution Goal

The population and distribution goal for Half-moon Hairstreak is to ensure the persistence of populations of Half-moon Hairstreak at all known extant locations (and any new locations) within the species' range in Canada.

5.2 Rationale for the Population and Distribution Goal

There are few locations of Half-moon Hairstreak in Canada, and overall the population and distribution goal aims ensure no populations become extirpated in Canada. Historical abundance and distribution information for this species show only a few confirmed extant populations and historic museum records. There is no information to indicate that the species was previously more widespread, therefore an objective to actively increase the number of populations, which may allow for downlisting of the species, is not appropriate.

The population and distribution goal for Half-moon Hairstreak cannot be quantified due to knowledge gaps: population numbers are unknown, insufficient information is available to complete minimum population viability analysis, dispersal and re-colonization capabilities are unknown, and habitat requirements are unclear.

5.3 Recovery Objectives

1. To establish habitat protection[10] for the eight known extant Half-moon Hairstreak locations.
2. To assess and mitigate the extent of known and potential threats at each Half-moon Hairstreak location.
3. To confirm the distribution of all populations (existing and new locations) of Half-moon Hairstreak in British Columbia and Alberta.
4. To address knowledge gaps such as life history, dispersal and population information, and habitat requirements.

6 APPROACHES TO MEET OBJECTIVES

6.1 Actions Already Completed or Underway

Compile Status Report (complete)

- COSEWIC report completed (COSEWIC 2006).

Send to COSEWIC (complete)

- Half-moon Hairstreak assessed as Endangered (COSEWIC 2006). Re-assessment due 2016.

Planning (in progress)

- BC Recovery Strategy completed (this document, 2011).

Habitat Protection and Private Land Stewardship (in progress)

British Columbia

- Two locations of Half-moon Hairstreak are found in the South Okanagan Grasslands Protected Area which is afforded protection through the legal provisions of the *BC Parks Act*.
- Half-moon Hairstreak is identified as a Species At Risk under the *Forest and Range Practices Act* and is listed as Identified Wildlife under the Identified Wildlife Management Strategy. Nine Wildlife Habitat Areas, with associated General Wildlife Measures, have been proposed (not yet approved) to protect habitat from range use impacts.
- Surveys in the range of Half-moon Hairstreak in B.C. (Kondla 2003b; Knopp *et al.* 2008; B.C. Ministry of Environment, 2009; S. Hureau, pers. comm., 2010).
- Surveys at White Lake (location #3) federal lands (National Research Council) (D. St. John, pers. comm., 2004–2008; S. Hureau, pers. comm., 2010).

[10] *Protected habitat* is habitat (see Section 3.3.1, Habitat and Biological Needs) managed to maintain Half-moon Hairstreak over a long time period (i.e., 100 years). Protection can be achieved through various mechanisms including: voluntary stewardship agreements, conservation covenants, sale by willing vendors on private lands, land use designations, and protected areas with appropriate management plans.

- Surveys throughout south Okanagan and confirming population at Kilpoola site (location #4b) of the South Okanagan Grasslands Protected Area and other areas in the South Okanagan (B.C. Ministry of Environment 2007, 2009).

Alberta

- Half-moon Hairstreak is found on federal land in Waterton Lakes National Park, AB. This habitat is afforded protection through the legal provisions of the *Canada National Parks Act*.
- Surveys for Sooty [Half-moon] Hairstreak in WLNP (Kondla 2003ab; 2004b; N. Kondla, unpubl. data, pers. comm., 2008).
- Half-moon Hairstreak monitoring transects in Waterton Lakes National Park (Poll and Poll 2008, Kondla 2009).
- Conservation overview of butterflies in the southern headwaters at risk project (SHARP) area report (Kondla 2004a).
- Introduced plant species surveys in WLNP, mapping of Half-moon Hairstreak host plants (C. Smith, pers. comm., 2008).
- Surveyed 3 potential sites outside of WLNP – no Half-moon Hairstreak were observed (Kondla 2009).

6.2 Recovery Planning Table

Table 3. Recovery planning table for Half-moon Hairstreak.

Obj. no.	Actions to meet objectives	Threat[a] or concern addressed	Priority[b]
CF Action Group: Habitat Protection; Land Stewardship			
3 1 1, 2 2 1,2	Habitat Protection: • Confirm species distribution at known locations • In B.C., develop a habitat protection plan, including work with South Okanagan-Similkameen Conservation Program to identify priority locations for habitat protection (giving consideration to habitat needs of other species at risk) on private land, and working with lands managers with parks and protected areas (and other government owned federal/provincial properties). • In B.C., identify appropriate protection measures and threat mitigation for all locations through legislative protection (e.g., Protected Areas, Wildlife Habitat Areas, landscape management plans) and non-legislative protective means (e.g., best management practices, stewardship agreements). • In B.C. develop specific Half-moon Hairstreak guidelines for land managers, developers, owners, and residents; include options for managing grassland habitat for invertebrates under different land-use practices, including grazing and recreational use. • In B.C. establish tenure appropriate protection measures and threat mitigation for all locations.	Knowledge gap; 1.1, 1.2, 2.3, 6.1, 8.1, 9.3	Essential
2, 3, 4	• Clarify broad-scale comparisons of distribution patterns of the species among urban developments (in B.C.), agricultural edges (in B.C.), recreational areas (in B.C. and AB), and undisturbed (control) grassland habitats (in B.C. and AB). The outcome will allow for clarification of threats and amount of disturbance tolerable by the species within sites that potentially could be survival/recovery habitat.	Knowledge gap; 1.1, 1.2, 2.3, 6.1, 9.3	Necessary
4	• Determine the effects of grazing on Half-moon Hairstreak habitat, both from domestic livestock and native ungulates (to both native and non-native plant species). • Define various types of grazing regimes (using existing definitions, if possible) and monitor grazing use using the *Grassland Monitoring Manual for B.C.* (Grasslands Conservation Council of BC 2009), which provides one method for determining alteration from a reference condition (based on loss of plant layers, biological crusts, etc). Determine if this monitoring regime is useful as a risk management tool for protecting Half-moon Hairstreak locations and/or habitat.	Knowledge gap; 2.3	Necessary
2	Increase awareness of species • In B.C. Work with South Okanagan-Similkameen Conservation Program and other conservation agencies to include this species in landowner contact programs to increase landowners' awareness of the species and its needs, as well as threats to the species depending on the landowner (e.g. agricultural pesticide use).	1.1, 1.2, 2.3, 6.1, 8.1, 9.3	Beneficial
3	Map and survey potential habitat:	1.1, 1.2, 2.3,	Beneficial

Obj. no.	Actions to meet objectives	Threat[a] or concern addressed	Priority[b]
CF Action Group: Habitat Protection; Land Stewardship			
	• Map polygons (using GIS applications, terrestrial ecosystem mapping, and photo-interpretation) with potential habitat outside of known locations of Half-moon Hairstreak (e.g., the southern Okanagan, lower Similkameen, Thompson, and lower Kootenay Valleys, outside WLNP). • Use existing habitat information from known localities to prioritize polygons for surveys. For example, complete vegetation assessments at existing locations and where there are similar habitat attributes in both unchecked habitat and known locations, prioritize those habitats for future surveys, compare host plant density between habitats, etc. • Determine land ownership of prioritized sites and work with stewardship groups (e.g. South Okanagan-Similkameen Conservation Program, Nature Conservancy Canada, MULTISAR) to complete landowner contact to request permission to survey on private lands. • Conduct surveys to determine presence of Half-moon Hairstreak in potential habitat.	6.1, 7.1, 8.1	
2, 4	• Establish a monitoring program and standardized methodology for collecting location information (including habitat characterization) and quantifying/identifying the highest threats at known locations.	1.1, 1.2, 2.3, 6.1, 7.1, 8.1	Necessary
4	• Determine quality and quantity of habitat required to ensure persistence of a population in a given location or within a given large habitat patch. Information gathering will include host plant densities, host plant health (e.g. disease), area of extent of host plants at each location, possible ant associations (e.g. which ant species occur on host plants), systematic threat assessments so comparisons between sites can be drawn (e.g. grazing intensity, etc), and other information as necessary.	Knowledge gap; 1.1, 1.2, 2.3, 6.1, 7.1, 8.1	Essential
CF Action Group: Compile Status Report			
4	• Encourage research about the species by academic institutions in priority areas	Knowledge gaps	Beneficial

[a] Threat numbers according to the IUCN-CMP classification (see Table 2 for details).
[b] Essential (urgent and important, needs to start immediately); Necessary (important but not urgent, action can start in 2–5 years); or Beneficial (action is beneficial and could start at any time that was feasible)

6.3 Description of the Recovery Planning Table

Recommended actions have been categorized by the action groups of the B.C. Conservation Framework.

6.3.1 Habitat Protection and Private Land Stewardship

Habitat protection and management of known locations are considered essential, particularly in B.C. where five of the locations are on private land and additional unchecked potential habitat

exists. In B.C., working with the South Okanagan-Similkameen Conservation Program to identify priority sites for habitat protection and combining the information with the habitat needs for other species at risk will assist with determining priority sites for stewardship and protection opportunities. In AB, working with conservation agencies to bring awareness of potential unknown locations for Half-moon Hairstreak both in B.C. and outside of WLNP, AB will be important for confirming distribution.

In B.C., it is important to identify and establish tenure appropriate protection measures and threat mitigation for all locations (e.g., Wildlife Habitat Areas, landscape management plans, best management practices). Further review of existing federal, provincial, regional, and municipal legislation is important to identify gaps in protection that can be addressed through non-legislative protective means such as stewardship agreements and best management practises guidelines.

Most of the threats to Half-moon Hairstreak habitat are unclear and require further clarification. Research is needed to examine the extent to which these butterflies can coexist with urban development and whether they can use agricultural edges.

Introduced plants and animals are widespread within the range of Half-moon Hairstreak and may pose problems to this species through habitat modification and/or predation. Knowing whether habitat quality is compromised by introduced species is important. For example, efforts to secure a property that contains suitable habitat may be in vain if introduced species that are harmful to Half-moon Hairstreak are prevalent.

A long-term monitoring program could be implemented because Half-moon Hairstreak is often detected in low numbers, and may not be detected yearly at some sites. Surveys of localities at the periphery of the species' Canadian range are also required to determine if Half-moon Hairstreak occurs in these habitats, to establish null data for range limits, and measure possible range expansion due to climate change over time.

6.3.2 Compile Status Report

Further research into the threats, biology and symbiotic relationship with ant species, host plant requirements, and structural habitat requirements are needed to confirm the habitat needed to maintain a population of Half-moon Hairstreak at a known location. This information will help to mitigate threats at other locations. Research into habitat use, life history, and demography of the species is also necessary and will help fill in gaps in our knowledge about these butterflies, their ecological role, and their habitat requirements.

7 INFORMATION ON HABITAT NEEDED TO MEET RECOVERY GOAL

Threats to Half-moon Hairstreak habitat have been identified for this species. To meet the population and distribution goal of ensuring the persistence of populations of Half-moon Hairstreak within the species' range in Canada, it is recommended that specific habitat attributes

be identified for Half-moon Hairstreak and known locations of habitat are geospatially described on the landscape to facilitate management to mitigate habitat threats.

7.1 Description of Survival/Recovery Habitat

A geospatial description of habitat for survival and recovery of Half-moon Hairstreak in Canada is not being proposed in this recovery strategy.

Currently only general habitat requirements are known for Half-moon Hairstreak (see Section 3.3.1). However, biophysical attributes of survival/recovery habitat for Half-moon Hairstreak should include a minimum density of larval and nectar host plants (*Lupinus* spp.), sagebrush shrub cover used as perching and roosting sites (sagebrush in B.C. only), and habitat components that ensure the presence of potential obligate ant species (note the specifics of the latter habitat components are unknown and unclear). It is recommended that outstanding work required to quantify specific habitat requirements for the species be completed and that the survival/recovery habitat be geospatially described at each known location to facilitate the actions for meeting the population and distribution goal. Currently habitat mapping is underway for the WLNP location (C. Smith, pers. comm., 2011).

7.2 Studies Needed to Describe Survival/Recovery Habitat

Table 4. Studies needed to describe survival/recovery habitat to meet the population and distribution goal for Half-moon Hairstreak for both B.C. and AB.

Description of activity	Outcome/rationale	Start Date
1. Create an inventory strategy for Half-moon Hairstreak to: • document current range and describe habitat use at each location (including potential mutual relationships with other species. e.g. ants and host plants); and • guide mapping potential habitat and potential range	• Standardized habitat information gathered and the comparison of location and location attributes across the range of the species. • A prioritized list of habitat polygons to inventory in unsurveyed habitat.	2012
2. Implement the inventory strategy to describe the current and potential range (e.g., collect data, create maps, etc.).	• Searching known and potential habitat will enable comparisons of occupied versus unoccupied habitats, and help to clarify survival/recovery habitat attributes.	2014
3. Map Half-moon Hairstreak habitat using information gained through surveys (e.g. using standard protocol for gathering habitat information).	• Maps of survival/recovery habitat.	2014

4. Define habitat use by life history stage	• Clarify and quantify components of habitat that are used at different life stages, and thus survival/recovery habitat for different life stages.	2012

8 MEASURING PROGRESS

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution goal and recovery objectives. Performance measures are listed for each objective.

Objective 1 – Habitat Protection

- A detailed habitat protection plan is developed for all known (and any new) Half-moon Hairstreak locations by 2016.
- Stewardship agreements and/or covenants are developed for known (and any new) Half-moon Hairstreak locations on private lands by 2016.
- Where appropriate, protection measures and threat mitigation has been initiated for all locations through existing legislative protection (e.g., Protected Areas, Wildlife Habitat Areas, landscape management plans) and local government bylaws and planning (e.g. official community plans, development permit areas, etc.) by 2016.

Objective 2 - Threats

- Best management practices guidelines for Half-moon Hairstreak are drafted for each landowner or land manager, specific to the threats of the location (e.g. ranching and grazing; horseback riding, etc) by 2016.
- Impact of the main threats (direct habitat loss or conversion to agricultural or urban development in B.C., recreation activities in AB) to the populations has been mitigated by 2016.

Objective 3 – Distribution

- An inventory schedule for unsurveyed potential Half-moon Hairstreak habitat in B.C. and AB is drafted by 2012.
- A standardized inventory protocol for population monitoring and habitat assessment of Half-moon Hairstreak is developed by 2012.
- Potential habitat for Half-moon Hairstreak in B.C. and AB is inventoried by 2016.

Objective 4 – Knowledge Gaps

- Studies addressing knowledge gaps (e.g. life history, habitat requirements, threat mitigation and other information) are initiated by 2012.

9 EFFECTS ON OTHER SPECIES

The ranges of several other species of endangered or threatened animals and plants overlap the range and habitat of Half-moon Hairstreak. The conservation actions to restore and protect grasslands ecosystems for Half-moon Hairstreak are likely beneficial to all species that rely on these threatened ecosystems. Likewise, conservation actions underway or proposed to protect the other species at risk are likely beneficial to Half-moon Hairstreak – a multi-species approach to conservation planning is recommended.

Federally listed species at risk that may overlap with Half-moon Hairstreak habitat in B.C. include Sage Thrasher (*Oreoscoptes montanus*); American Badger (*Taxidea taxus*); Blotched Tiger Salamander (*Ambystoma mavortium*); Great Basin Spadefoot (*Spea intermontana*); Western Rattlesnake (*Crotalus oreganus*); Gopher Snake *deserticola* subspecies (*Pituophis catenifer deserticola*); Lewis's Woodpecker (*Melanerpes lewis*); and Racer (*Coluber constrictor*).

Federally listed species at risk found within grassland habitat in AB that may overlap with Half-moon Hairstreak include Sprague's Pipit (*Anthus spragueii*), Long-billed Curlew *(Numenius americanus)*, and Northern Leopard Frog Western Boreal/Prairie Population *(Lithobates pipiens).*

10 REFERENCES

Achuff, P.L., R.L. McNeil, M.L. Coleman, C. Wallis, and C. Wershler. 2002. Ecological land classification of Waterton Lakes National Park, Alberta. Vol. I: integrated resource description. Parks Canada, Waterton Park, AB. 226 pp.

Aleksoff, K.C. 1999. *Achillea millefolium*. In: Fire Effects Information System [online]. U.S. Dep. Agric. For. Serv., Rocky Mountain Res. Stn., Fire Sci. Laboratory. <http://www.fs.fed.us/database/feis/> [Accessed Jan. 23, 2008]

Ballmer, G.R. and G.F. Pratt. 1988. A survey of the last instar larvae of the Lycaenidae (Lepidoptera) of California. J. Res. Lepidoptera 27:1–81.

B.C. Conservation Data Centre. 2011. BC Species and Ecosystems Explorer. B.C. Min. Environ., Victoria, BC. <http://a100.gov.bc.ca/pub/eswp/> [Accessed Nov. 14, 2011]

B.C. Ministry of Environment. 2007. Half-moon Hairstreak (*Satyrium semiluna*) inventory South Okanagan BCCC invertebrate crew. Internal working report prepared by B.C. Conservation Corp., Penticton, BC. 12 pp.

B.C. Ministry of Environment, 2009. Half-moon Hairstreak (*Satyrium semiluna*) inventory in the Southern Okanagan Valley, British Columbia, 2009. Internal working report prepared by B.C. Conservation Corp., Penticton, BC. 20 pp.

B.C. Ministry of Forests, Lands and Natural Resource Operations. 2011. Biogeoclimatic Classification System/Plant Ecology. <http://www.for.gov.bc.ca/hre/ecoearth/Bioge.htm> [Accessed April 8, 2011]

Bird, C.D., G.J. Hilchie, N.G. Kondla, E.M. Pike, and F.A.H. Sperling. 1995. Alberta butterflies. Prov. Museum of Alberta, Edmonton, AB. 349 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2006. COSEWIC assessment and status report of Half-moon Hairstreak *Satyrium semiluna* in Canada. Ottawa, ON. vi + 26 pp. <www.sararegistry.gc.ca/status_e.cfm>

Conservation Measures Partnership. 2010. Threats taxonomy. <http://www.conservationmeasures.org/initiatives/threats-actions-taxonomies/threats-taxonomy> [Accessed Feb. 8, 2011]

Elkinton, J.S., and G.H. Boettner. 2004. The effects of *Compsilura concinnata*, an introduced generalist tachinid, on non-target species in North America: a cautionary tale. Pp. 4–14. In: Van Driesche, R.G. and Reardon, R., eds., Assessing host ranges for parasitoids and predators used for classical biological control: a guide to best practice. United States Deptartment of Agriculture Forest Health Technology Enterprise Team, Morgantown, West Virginia. Fhtet-2004-03.

Folgarait, P.J. 1998. Ant biodiversity and its relationship to ecosystem functioning: a review. Biodivers. Conserv. 7:1221–1244.

Government of Alberta. 2011. Alberta Conservation Information Management System (ACIMS). <http://www.tpr.alberta.ca/parks/heritageinfocentre/default.aspx> [Accessed November 3, 2011]

Government of Canada. 2009. Species at Risk Act policies, overarching policy framework – draft. Min. Environ., Ottawa, ON. 38 pp. <http://dsp-psd.pwgsc.gc.ca/collection_2009/ec/En4-113-2009-eng.pdf> [Accessed May 3, 2010]

Grasslands Conservation Council of British Columbia. 2009. Grasslands Monitoring Manual for British Columbia: A Tool for Ranchers. written by Delesalle, B.P., B.J. Coupe, B.M. Wikeem, S.J. Wikeem. Available at <http://www.bcgrasslands.org/docs/grassland_monitoring_manual_chapter1.pdf>. Accessed August 18, 2011.

Guppy, C.S. and J.H. Shepard. 2001. Butterflies of British Columbia. Univ. British Columbia Press, Vancouver, BC. 414 pp.

Hölldobler, B. and E.O. Wilson. 1990. The ants. Belknap Press of Harvard Univ. Press, Cambridge, MA.

Kelsey, R.G. and L.J. Locken. 1987. Phytotoxic properties of cnicin, a sesqiterpene lactone from *Centaurea maculosa* (spotted knapweed). Journal of Chemical Ecology 13: 19-33.

Knopp, D., L. Larkin, O. Dyer, and J. Heron. 2008. Half-moon hairstreak *Satyrium semiluna*, South Okanagan inventory. Reported prepared for Min. Environ., Ecosystem Branch, Vancouver, BC. 45 pp.

Kondla, N.G. 2003a. Preliminary field survey for the Sooty Hairstreak (*Satyrium fuliginosum*) in Waterton Lakes National Park. Report prepared for Parks Canada Agency. 17 pp.

Kondla, N.G. 2003b. The Sooty Hairstreak in British Columbia. Boreus 23(2):10–12. <http://esB.C..harbour.com/boreus23_2.pdf>

Kondla, N.G. 2004a. Conservation overview of butterflies in the southern headwaters at risk (SHARP) area. Alberta Fish and Wildlife, Alberta Species at Risk Report No. 80. 40 pp. <http://www3.gov.ab.ca/srd/fw/speciesatrisk/pdf/SAR_80.pdf>

Kondla, N.G. 2004b. Waterton Lakes National Park Sooty Hairstreak survey, 2004. Report prepared for Parks Canada Agency. 24 pp.

Kondla, N.G. 2009. Waterton Lakes National Park – 2009 Half-moon Hairstreak Project Report. Report prepared for Parks Canada Agency. 17 pp.

Kuijt, J. 1982. A flora of Waterton Lakes National Park. Univ. Alberta Press, Edmonton, AB. 684 pp.

Lacey, J.R., C.B. Marlow, and J.R. Lane. 1989. Influence of spotted knapweed (*Centaurea maculosa*) on surface runoff and sediment yield. Weed Technology 3: 627-631.

Layberry, R.A., P.W. Hall, and J.D. Lafontaine. 1998. The butterflies of Canada. Univ. Toronto Press, Toronto, ON. 354 pp. + 32 pls.

Leimar, O. and A.H. Axén. 1993. Strategic behaviour in an interspecific mutualism: interactions between Lycaenid larvae and ants. Anim. Behav. 46:1177–1182.

Mahr, S. 1999. Know your friends, *Compsilura concinnata*, parasitoid of gypsy moth. Midwest Biological Control News Online September 1999. Volume VI, Number 9. <http://www.entomology.wisc.edu/mbcn/kyf609.html> [Accessed Aug. 5, 2011]

Master, L., D. Faber-Langendoen, R. Bittman, G.A. Hammerson, B. Heidel, J. Nichols, L. Ramsay, and A. Tomaino. 2009. NatureServe conservation status assessments: factors for assessing extinction risk. NatureServe, Arlington, VA. <http://www.natureserve.org/publications/ConsStatusAssess_StatusFactors.pdf> [Accessed Feb. 8, 2011]

Mattoon, S.O. and G.T. Austin. 1998. Review of *Satyrium fuliginosum* (W.H. Edwards) with the description of three new subspecies (Lepidoptera: Lycaenidae). Pages 681–690 *in* T.C. Emmel, ed. Systematics of western North American butterflies. Mariposa Press, Gainesville, FL. xxviii + 878 pp.

Meidinger, D. and J. Pojar. 1991. Ecosystems of British Columbia. B.C. Min. For., Victoria, BC.

Milchunas, D.G., W.K. Lauenroth, P.L. Chapman, and M.K. Kazempour. 1989. Effects of grazing, topography, and precipitation on the structure of a semiarid grassland. Vegetation 80:11–23.

Milchunas, D.E., O.E. Sala, and W.K. Lauenroth. 1988. A generalized model of the effect of grazing by large herbivores in grassland community structure. Am. Nat. 132:87–106.

Ministry of Environment. 2010a. British Columbia guide to recovery planning for species and ecosystems. B.C. Min. Environ., Victoria, BC. 32 pp. <http://www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm> [Accessed Feb. 2011]

Ministry of Environment. 2010b. Conservation framework. B.C. Min. Environ., Victoria, BC. <http://www.env.gov.bc.ca/conservationframework/index.html> [Accessed Nov. 23, 2010]

NatureServe. 2009. NatureServe explorer: an online encyclopedia of life [web application]. Version 7.1. Arlington, VA. <http://www.natureserve.org/explorer> [Accessed Nov. 23, 2010]

Pierce, N.E. 1987. The evolution and biogeography of associations between lycaenid butterflies and ants. Oxford Surv. Evol. Biol. 4:89–116.

Province of British Columbia. 1982. Wildlife Act. [RSBC 1996]: Chapter 488. Queen's Printer, Victoria, BC. <http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_96488_01>

Province of British Columbia. 2002. Forest and Range Practices Act. RSBC2002, c.69. Queen's Printer, Victoria, BC. <http://www.for.gov.bc.ca/tasb/legsregs/>

Schluter, A., T. Lea, S. Cannings, and P. Krannitz. 1995. Antelope-brush ecosystems. Min. Environ., Lands and Parks, Victoria, BC. Ecosystems at risk in British Columbia Series.

Scott, D. and R. Suffling. 2000. Climate change and Canada's national park system: a screening level assessment. Environment Canada, Cat. No. En56-155/2000E, ISBN 0-662-28976-5. 183 pp.

Scott, J.A. 1986a. The butterflies of North America. A natural history and field guide. Stanford Univ. Press, Stanford, CA. 583 pp.

Scott, J.A. 1986b. Larval hostplant records for butterflies and skippers (mainly from western U.S.), with notes on their natural history. Papilio (New Series) 4:1–37.

Scott, J.A. 1992. Hostplant records for butterflies and skippers (mostly from Colorado) 1951–1991, with new life histories and notes on oviposition, immatures, and ecology. Papilio (New Series) 6:1–171.

Scott, L., D. St. John, D. Lalonde, and H. Baumbrough. 2007. Assessment report on Showy Phlox *Phlox speciosa* and Half-moon Hairstreak *Satyrium semiluna* in the White Lake Basin. Unpublished report prepared for Andrew Gray, National Research Council Canada, Dominion Radio Astrophysical Observatory, Penticton, BC. 20 pp.

Tyser, R.W. and C.H. Key. 1988. Spotted knapweed in natural area fescue grasslands: an ecological assessment. Northwest Science 62: 151-160.

United States Geological Survey. 2011. <http://earthquake.usgs.gov/hazards/qfaults/glossary.php> Accessed August 10, 2011

Warren, A.D. 2005. Lepidoptera of North America 6. Butterflies of Oregon: their taxonomy, distribution, and biology. Contributions of the C.P. Gillette Museum of Arthropod Diversity, Colorado State Univ., Fort Collins, Colo. 408 pp.

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