# COSEWIC
# Assessment and Status Report

on the

# Dusky Dune Moth
## *Copablepharon longipenne*

**in Canada**

**THREATENED**
**2022**

**COSEWIC**
Committee on the Status
of Endangered Wildlife
in Canada

**COSEPAC**
Comité sur la situation
des espèces en péril
au Canada

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# COSEWIC
# Assessment Summary

**Assessment Summary – May 2022**

**Common name**
Dusky Dune Moth

**Scientific name**
*Copablepharon longipenne*

**Status**
Threatened

**Reason for designation**
This moth is restricted to a handful of open, active sand dunes and blowouts on the Prairies. Beginning in the 1940s, these dunes are slowly becoming stabilized and vegetated, and the area of open sand of many dunes has declined by an estimated 10-40% per decade. The decline in dune area has reduced the moth's habitat and has resulted in a more fragmented landscape. Although the moth can be common where it is found, it occurs in only a small proportion of the apparently suitable sites and has disappeared from a few historical localities. Dispersal between most dune systems is extremely unlikely and the moth is likely not viable at several sites, and viability is uncertain at others but there are continuing declines in quality and quantity of habitat.

**Occurrence**
Alberta, Saskatchewan, Manitoba

**Status history**
Designated Endangered in November 2007. Status re-examined and designated Threatened in May 2022.

# COSEWIC
# Executive Summary

## Dusky Dune Moth
*Copablepharon longipenne*

### Wildlife Species Description and Significance

Dusky Dune Moth (*Copablepharon longipenne*) is a medium-sized (11–20 mm) light brown noctuid (cutworm or owlet) moth with a distinctive line of black dots on the forewing. Adults are sexually dimorphic in size, with males slightly smaller than females. Males have narrowly bipectinate antennae (about 2.5 times as long as wide), whereas female antennae are filiform. Dusky Dune Moth is a member of a highly specialized dune-dwelling community of plants and animals that are restricted to the isolated active sand dunes across the prairie landscape that were left by the retreat of the continental glaciers, thousands of years ago.

### Distribution

Dusky Dune Moth is restricted to the Great Plains of North America, with a global range that extends from near Saskatoon, in the Canadian prairies, south to Texas. The Canadian range of Dusky Dune Moth extends from Spruce Woods Provincial Park in southwestern Manitoba, through southern Saskatchewan to southeastern Alberta. The global and Canadian distribution is not continuous, and subpopulations are confined to small, highly fragmented, discrete areas of suitable habitat.

In Canada, Dusky Dune Moth is known from 15 subpopulations: 13 extant and two historical. This includes three new subpopulations recorded since the first COSEWIC status report. Within the sand hill habitats where the 13 subpopulations occur, Dusky Dune Moth is present at 35 sites (i.e., discrete sand dunes or blowouts separated by vegetated habitat). There are likely additional unrecorded Canadian subpopulations of Dusky Dune Moth; given that only about 60 % of the potentially suitable habitat for this species has been surveyed. The species does not appear to be abundant.

### Habitat

Dusky Dune Moth primarily occurs in active sand dunes, or sand blowout habitats associated with sand hills or dune fields. Less frequently, it uses open sandy areas that have been the result of human activity (e.g., sandy roads and fire breaks). The species appears to be more abundant in naturally occurring sand dunes.

## Biology

Little is known about the biology of Dusky Dune Moth; it is nocturnal, and difficult to survey. In Canada, the species has one generation per year and a flight period from mid-June to late August. Dusky Dune Moth does not appear to be host plant specific. Mating occurs on low vegetation or on the ground, with oviposition (egg laying) in shallow sand. The eggs hatch into larvae approximately three weeks later and feed below-ground on dune vegetation, likely burrowing into the soil for the winter, although the microsite and sand depth are unknown. Larvae emerge in the spring or early summer and continue feeding prior to pupation, which occurs in the soil. The adult dispersal ability of Dusky Dune Moth is unknown. Given that dune habitats are often patchily distributed, it is likely that short-distance dispersal occurs to adjacent habitats. However, dispersal between regionally isolated sand dune systems (>10 km) is unlikely.

## Population Sizes and Trends

Over the past decade, the number of sites occupied by Dusky Dune Moth in Canada appears to be stable but has declined from historical levels due to sand dune habitat loss. Over the last 100 years, the active dune habitats on which the moth depends have substantially declined in area, a trend that is expected to continue. At least two subpopulations (Lethbridge and Sunnydale) have been extirpated in the last century. It is likely that a third, the occurrence at the Dominion Sand Hills, is also lost since there is very little open sand habitat remaining. Too few data are available on which to base subpopulation estimates or a Canada-wide population estimate. However, the abundance of Dusky Dune Moth at extant sites is presumed to have declined, as inferred from a decrease in active bare sand habitat due to dune stabilization.

## Threats and Limiting Factors

The primary threat to the long-term survival of Dusky Dune Moth appears to be the loss of habitat resulting from the stabilization of active sand by both native and introduced vegetation. This natural process is largely driven by regional climate trends, but has accelerated over the last 150 years, in part due to decreasing aridity, reduced wildfire, and the decline in abundance of Plains Bison (*Bison bison bison*), which would have been part of the natural habitat disturbance patterns.

## Protection, Status and Ranks

Most of the known Dusky Dune Moth sites have secure tenure on leased provincial Crown land, within provincial or regional parks, or the federal Department of National Defence lands. A few sites are on Indigenous lands, private land or where the land tenure is unknown (particularly for historical occurrences).

Dusky Dune Moth is listed as Endangered under federal *Species at Risk Act* and Endangered under the Manitoba *Endangered Species and Ecosystems Act*. It is ranked as G4 (Apparently Secure) globally, N2 (Imperilled) nationally in Canada, S1 (Critically Imperilled). In the provinces, it is ranked S1S2 (Critically Imperilled) in Manitoba, S1S2 in Alberta, and S2 (Imperilled) in Saskatchewan.

# TECHNICAL SUMMARY

*Copablepharon longipenne*

Dusky Dune Moth

Noctuelle sombre des dunes

Range of occurrence in Canada: Alberta, Saskatchewan, Manitoba

**Demographic Information**

| | |
|---|---|
| Generation time | 1 year |
| Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? | Inferred and projected decline in number of mature individuals from ecosystem modifications as a result of the gradual succession of vegetation into the open sand habitats |
| Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations] | Unknown |
| [Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]. | Unknown |
| [Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations]. | Unknown |
| [Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future. | Unknown |
| Are the causes of the decline a.) clearly reversible and b.) understood and c). ceased? | a.) No (vegetation succession is not clearly reversible)<br>b.) Partially (threats are variable across subpopulations)<br>c.) No (vegetation succession and other threats continue). |
| Are there extreme fluctuations in number of mature individuals? | Unknown; not likely. |

**Extent and Occupancy Information**

| | |
|---|---|
| Estimated extent of occurrence | 149,197 km² |
| Index of area of occupancy (IAO) | 124 km² (extant sites only) |
| Is the population “severely fragmented” i.e., is > 50% of its total area of occupancy is in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse? | a. Yes<br>b. Yes |

| | |
|---|---|
| Number of “locations”* | 13-15; each sand dune complex represents one location; local land management practices can influence the rate of dune succession at each sand dune; range reflects uncertain status of historical subpopulations. |
| Is there an [observed, inferred, or projected] decline in extent of occurrence? | Yes, inferred, and projected decline in extent of occurrence based on ecosystem modifications that result from the gradual succession of vegetation into the open dune habitats, including those at the periphery of its range (#1, 2). |
| Is there an [observed, inferred, or projected] decline in index of area of occupancy? | Yes, inferred, and projected decline in index of area of occupancy based on ecosystem modifications that result from the gradual succession of vegetation into the open dune habitats. |
| Is there an [observed, inferred, or projected] decline in number of subpopulations? | Yes, inferred, and projected decline in number of subpopulations based on ecosystem modifications that result from the gradual succession of vegetation into the open dune habitats. |
| Is there an [observed, inferred, or projected] decline in number of “locations”*? | Yes, inferred, and projected decline in number of locations based on ecosystem modifications that result from the gradual succession of vegetation into the open dune habitats. |
| Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat? | Yes, inferred, and projected decline in area, extent and quality of habitat based on ecosystem modifications that result from the gradual succession of vegetation into the open dune habitats. |
| Are there extreme fluctuations in number of subpopulations? | No |
| Are there extreme fluctuations in number of “locations”*? | No |
| Are there extreme fluctuations in extent of occurrence? | No |
| Are there extreme fluctuations in index of area of occupancy? | No |

**Number of Mature Individuals (in each subpopulation)**

| **Subpopulations (give plausible ranges)** | **N Mature Individuals** |
|---|---|
| Total | Unknown |

**Quantitative Analysis**

| | |
|---|---|
| Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]. | Insufficient data to complete analysis. |

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

**Threats (actual or imminent, to populations or habitats, from highest impact to least)**

| |
|---|
| Was a threats calculator completed for this species? Yes, threat impact Medium – Low.<br>7.3 Other ecosystem modifications (Medium – Low impact)<br>3.1 Oil and gas drilling (Unknown impact)<br>3.2 Mining and quarrying (Unknown impact)<br>6.2 War, civil unrest and military exercises (Unknown impact)<br>7.1 Fire and fire suppression (Unknown impact)<br>8.1 Invasive non-native/alien species (Unknown impact)<br>11.1 Habitat shifting and alteration (Unknown impact)<br>11.3 Temperature extremes (Unknown impact) |

**Rescue Effect (immigration from outside Canada)**

| | |
|---|---|
| Status of outside population(s) most likely to provide immigrants to Canada. | Unknown |
| Is immigration known or possible? | Not possible; nearest known subpopulation in the United States is in Fork Peck, Montana, approximately 280 km from nearest known Canadian subpopulation |
| Would immigrants be adapted to survive in Canada? | Yes, likely. |
| Is there sufficient habitat for immigrants in Canada? | Possibly; habitat is declining but there appears to be sufficient habitat to sustain some subpopulations |
| Are conditions deteriorating in Canada?[+] | Yes. Habitat quantity and quality is declining based on ecosystem modifications that result from the gradual succession of vegetation into the open dune habitats. |
| Are conditions for the source population deteriorating?[+] | Unknown. |
| Is the Canadian population considered to be a sink?[+] | No. |
| Is rescue from outside populations likely? | No. |

**Data Sensitive Species**

| |
|---|
| Is this a data sensitive species? No. |

**Status History**

| |
|---|
| COSEWIC: Designated Endangered in November 2007. Status re-examined and designated Threatened in May 2022. |

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect).

**Status and Reasons for Designation**

| **Status:** | **Alpha-numeric codes:** |
|---|---|
| Threatened | Plausible range of status is Endangered, B2ab(iii), to Special Concern (b), depending on uncertainty of meeting criteria for severe fragmentation. Therefore, the designated status is Threatened, B2ab(iii), given the two non-consecutive status categories. |

**Reasons for designation:**
This moth is restricted to a handful of open, active sand dunes and blowouts on the Prairies. Beginning in the 1940s, these dunes are slowly becoming stabilized and vegetated, and the area of open sand of many dunes has declined by an estimated 10-40% per decade. The decline in dune area has reduced the moth's habitat and has resulted in a more fragmented landscape. Although the moth can be common where it is found, it occurs in only a small proportion of the apparently suitable sites and has disappeared from a few historical localities. Dispersal between most dune systems is extremely unlikely and the moth is likely not viable at several sites, and viability is uncertain at others but there are continuing declines in quality and quantity of habitat.

**Applicability of Criteria**

| |
|---|
| Criterion A (Decline in Total Number of Mature Individuals):<br>Not applicable. Number of mature individuals unknown. |
| Criterion B (Small Distribution Range and Decline or Fluctuation):<br>May meet Endangered B2, with an IAO of 124 km² and (b) an inferred and projected continuing decline of (iii) quality of habitat. Although the species exceeds thresholds for locations, (a) severe fragmentation is possible but uncertain. Species is assessed as Threatened because there is a plausible range of non-consecutive designations of Endangered and Special Concern, depending on whether or not there is (a) severe fragmentation. |
| Criterion C (Small and Declining Number of Mature Individuals):<br>Not applicable; insufficient data. |
| Criterion D (Very Small or Restricted Population):<br>Not applicable. Number of mature individuals unknown. |
| Criterion E (Quantitative Analysis):<br>Not calculated; no data is available for analysis. |

## PREFACE

Since the initial COSEWIC (2007) status report, three additional Dusky Dune Moth subpopulations have been confirmed, and the total number of known subpopulations in Canada is now 15 (13 extant and 2 historical). The extent of the occurrence in 2007 (164,480 $km^2$) included historical sites and the 2021 calculation (149,197 $km^2$) includes extant sites only. The index of area of occupancy (IAO) was 48 $km^2$ in the 2007 status report and is a minimum of 124 $km^2$ in 2021. The change in EOO and IAO includes the new subpopulations; however, these new subpopulations are because of targeted search effort and are not considered a range expansion. No documented Dusky Dune Moth subpopulations have been extirpated over the last ten years, but the Canada-wide population has likely declined from historical levels due to ongoing ecosystems modifications from natural vegetation succession in the open sand habitats. The moth needs open sparsely vegetated and sandy areas, and this spatial area is projected to decline.

## COSEWIC HISTORY

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

## COSEWIC MANDATE

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

## COSEWIC MEMBERSHIP

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

## DEFINITIONS (2022)

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

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

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

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

Environment and Climate Change Canada
Canadian Wildlife Service
Environnement et Changement climatique Canada
Service canadien de la faune
Canada

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

# COSEWIC Status Report

on the

# Dusky Dune Moth

*Copablepharon longipenne*

**in Canada**

2022

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## WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

### Name and Classification

Phylum Arthropoda - Arthropods
Class Insecta – Insects
Subclass Pterygota – Winged Insects
Order Lepidoptera – Butterflies and Moths
Superfamily Noctuoidea – Owlet Moths and kin
Family Noctuidae – Owlet Moths
Subfamily Noctuinae – Cutworm or Dart Moths
Tribe Noctuini
Subtribe Agrotina
Genus *Copablepharon*
Species *C. longipenne* Grote, 1882

Subspecies: *Copablepharon longipenne longipenne* Grote
*Copablepharon longipenne serraticornis* A. Blanchard

Synonyms: *Copablepharon longipennis* (Hampson, 1903)
*Copablepharon serraticornis* A. Blanchard 1976
*Copablepharon serratacorne*[1] Franclemont and Todd, 1983

French Common Name: Noctuelle sombre des dunes.

English Common Name: Dusky Dune Moth
Brown Copablepharon (Hooper 1994)

Type locality: Montana, holotype housed at Smithsonian National Museum of Natural History (USNM), Washington, D.C.

The 23 described species of *Copablepharon*, all from North America, have been divided in eight species-groups based on adult morphological characters (Lafontaine *et al.* 2004; Pohl *et al.* 2016, 2018). Dusky Dune Moth is one of 11 species within the *longipenne* group. Six of these largely allopatric, dune-dwelling species (*C. columbia, C. longipenne, C. michiganensis, C. mutans, C. nevada,* and *C. pictum*) may eventually prove to be distinctive geographical isolates of *C. longipenne* rather than genetically distinct species. *Copablepharon longipenne* is the only species that occurs in Canada. There are two recognized subspecies of Dusky Dune Moth based on adult morphological characters: *C. l. longipenne* found in Canada and the northern United States (subspecies assessed in this status report), whereas *C. l. serraticornis* is found further south in the United States only. See Lafontaine *et al.* (2004) for further information.

[1] The name *serraticornis* was emended to *serraticorne* by Franclemont and Todd (1983) (Lafontaine 2004).

## Morphological Description

Dusky Dune Moth has four distinct life stages: egg, larva (with an unknown number of instars), pupa and adult, and develops through complete metamorphosis (see **Biology**).

Adults:

Dusky Dune Moth is a medium-sized, light brown moth with a distinctive line of black dots on the forewing (Figure 1). Adults are sexually dimorphic in size: forewing length in the Canadian subspecies of Dusky Dune Moth averages 15.4 mm (range 11–18 mm) in males and 18.6 mm (range 17–20 mm) in females (Lafontaine *et al.* 2004). A pale streak is often present along the edge of the forewing or between the cubital and anal veins (Lafontaine *et al.* 2004). A series of uniformly sized black dots mark each wing vein at the postmedial line. The hindwing is entirely dark fuscous. The fringe is dark brown basally and white outwardly. The head, thorax, and abdomen are light brown. Males have narrowly bipectinate antennae (about 2.5 times as long as wide), whereas female antennae are filiform (Lafontaine *et al.* 2004).


Figure 1. Adult male Dusky Dune Moth (*Copablepharon longipenne*) from the E.H. Strickland Entomological Museum (2020) (photo by G.G. Anweiler) left, and egg mass excavated from open sand in the Seward Sand Hills, right (August 5, 2004, photo by N.A. Page).

Eggs:

The eggs of Dusky Dune Moth are translucent white spheres, approximately 0.3 mm in diameter. They are deposited in groups of 15 to 35 in open sand (Figure 1).

Larvae:

The larvae of Dusky Dune Moth have a grey base colour overlain with brownish-red stripes (Seamans 1925). The ventral surface is distinctly bluish. The head and thoracic shield are light brown with grey mottling.

Pupae:

The pupae of Dusky Dune Moth are approximately 2 cm long and like those of other species of *Copablepharon,* they have a distinctive external sheath (haustellum) enclosing the tongue (proboscis). The haustellum extends to the posterior margin of the sixth abdominal segment. The apex of the last abdominal segment (cremaster) is short and smooth with a pair of straight hairs.

Similar species:

Adult Dusky Dune Moths can be confused with several other *Copablepharon* species within the same habitats and range, particularly old or worn individuals. Antennae, genitalia, and genetic barcodes may need to be examined to identify some *Copablepharon* individuals (Lafontaine pers. comm. 2017). In Canada, Dusky Dune Moth is most likely confused with Pale Yellow Dune Moth (*C. grandis*) and *C. viridisparsa* (no English common name). See Lafontaine *et al.* (2004) for more information on how to distinguish *Copablepharon* species.

## Population Spatial Structure and Variability

The population structure and variability of Dusky Dune Moth is poorly understood. Dusky Dune Moth is found in sparsely vegetated, active sand dunes or blowouts that are patchily distributed within a matrix of more densely vegetated grasslands and unsuitable habitat. This distribution suggests that subpopulations may be connected through dispersal at a local scale (e.g., 200-1000 m) but are isolated at a regional scale (e.g., dune blowouts are widely separated and disjunct across the prairie landscape) (COSEWIC 2007). A total of 11 specimens from the Burstall and Great sand hills (SH) as well as sites in Colorado, New Mexico, Utah, and Wyoming have had their mitochondrial deoxyribonucleic acid (DNA) CO1-5P gene bar-coded (BOLDSYTEMS 2020). DNA barcoding has proved effective at discriminating Noctuoidea species (Zahiri *et al.* 2014), and all 11 specimens from across the continental range of Dusky Dune Moth belonged to one Barcode Index Number (BIN) supporting its status as a single species.

## Designatable Units

Dusky Dune Moth is assessed in Canada as one designatable unit. All Canadian subpopulations fall within the Prairie National Ecological Area (COSEWIC 2017) and belong to the same subspecies. Although there is likely genetic differentiation among widely separated subpopulations, there is no evidence to suggest they represent discrete and evolutionarily significant populations.

## Special Significance

Dusky Dune Moth is a member of a highly specialized dune-dwelling community of plants and animals that are restricted to the widely separated and isolated active sand dunes throughout the prairies that were left thousands of years ago by the retreat of the continental glaciers. Dusky Dune Moth and other *Copablepharon* species are of particular interest to entomologists and other scientists because of their association with isolated dune habitats, a relatively rare and disappearing habitat in Canada. Dusky Dune Moth is part of Canadian ecosystems that are important to Indigenous people, who recognize the interconnectedness of all species within the ecosystem.

# DISTRIBUTION

## Global Range

Dusky Dune Moth is restricted to the Great Plains of North America (Lafontaine *et al.* 2004; COSEWIC 2007), with a global range that extends from near Saskatoon, in the Canadian prairies south to Texas (Figure 2). Confirmed specimens are documented globally from 30 localities in three Canadian provinces and seven states. Additional specimens from 10 localities in four additional states have been reported since the initial COSEWIC (2007) status report. Some of these specimens (e.g., Arizona) have been confirmed by knowledgeable lepidopterists (e.g., R. Leuschner) (Lee pers. comm. 2020), although others are likely misidentifications (e.g., Michigan; Adams pers. comm. 2020).

Additional surveys are required to confirm the species' global distribution (COSEWIC 2007), as numerous dune systems in the western United States have not been surveyed for *Copablepharon* moths (Lafontaine pers. comm. 2017). The estimated global range was 1,258,285 $km^2$ in the first COSEWIC (2007) status report.

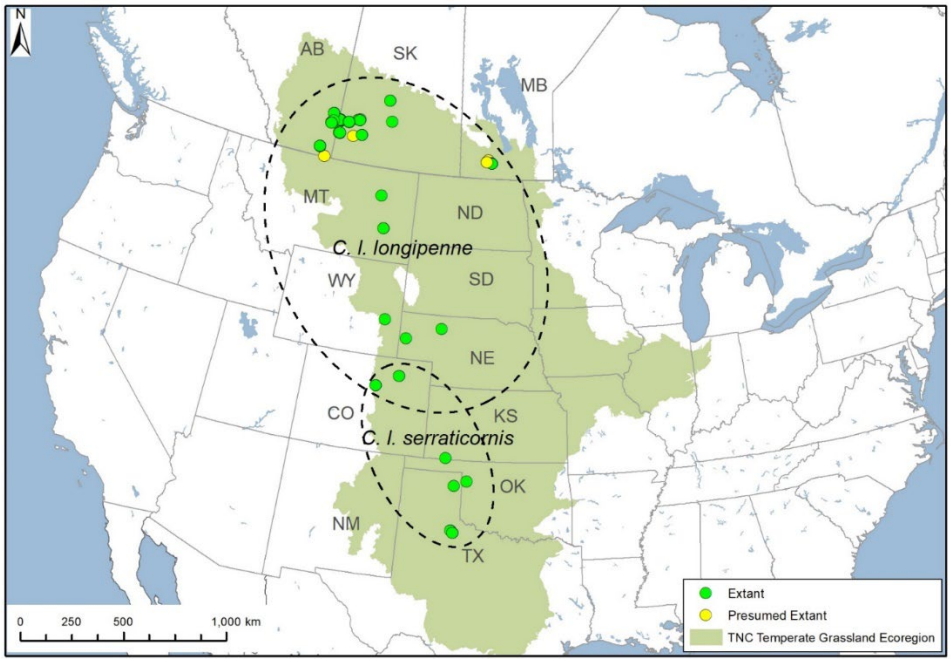


Figure 2. Known global records of Dusky Dune Moth (*Copablepharon longipenne*) and the approximate boundaries of the two described Dusky Dune Moth subspecies (dashed ellipses around *C. l. longipenne* and *C. l. serraticornis*) based on specimens examined by Lafontaine *et al*. (2004). Only one subspecies, *C. l. longipenne*, occurs in Canada. Map by R. Foster, August 1, 2021.

## Canadian Range

The Canadian range of Dusky Dune Moth extends from Spruce Woods Provincial Park (PP) in southwestern Manitoba (MB), through southern Saskatchewan (SK) to southeastern Alberta (AB) (Figure 3). Canadian subpopulations[2] are within the Prairie Ecozone, and all but the Brandon SH subpopulation are within the Central Grassland Ecoprovince (Agriculture and Agri-food Canada 2020), which largely coincides with the Palliser's Triangle, a region of dry, shortgrass prairie with sand dunes (Wolfe *et al.* 2013). The distribution is not continuous and is contained within small, highly fragmented, discrete areas of suitable habitat (see **Habitat**).

[2] Subpopulations are defined as geographically or otherwise distinct groups in the Canadian population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less). Subpopulation size is measured as numbers of mature individuals only (IUCN 2001). The separation distance between subpopulations, as recommended by NatureServe (2020), is 2km for unsuitable habitat and 10 km for suitable habitat (see **Habitat** for what is considered suitable habitat). "Most noctuids are strong fliers and except for a few bog and other wetland species (not included here) almost all can be collected occasionally one to several kilometres out of habitat, although some average sized species are long distance migrants. Nevertheless, most adults probably stay in habitat most or all of their lives. Two kilometres should generally provide some degree of separation but not create a complete lack of gene flow. If the intervening habitat is mostly suitable there is almost no chance (or even known mechanism by which) two collections a few kilometres apart would represent separate populations, but some arbitrary figure is needed. Marginal habitat, for example where the foodplant is relatively scarce (but not absent) should generally be treated as suitable habitat in terms of separation distances" (NatureServe 2020).

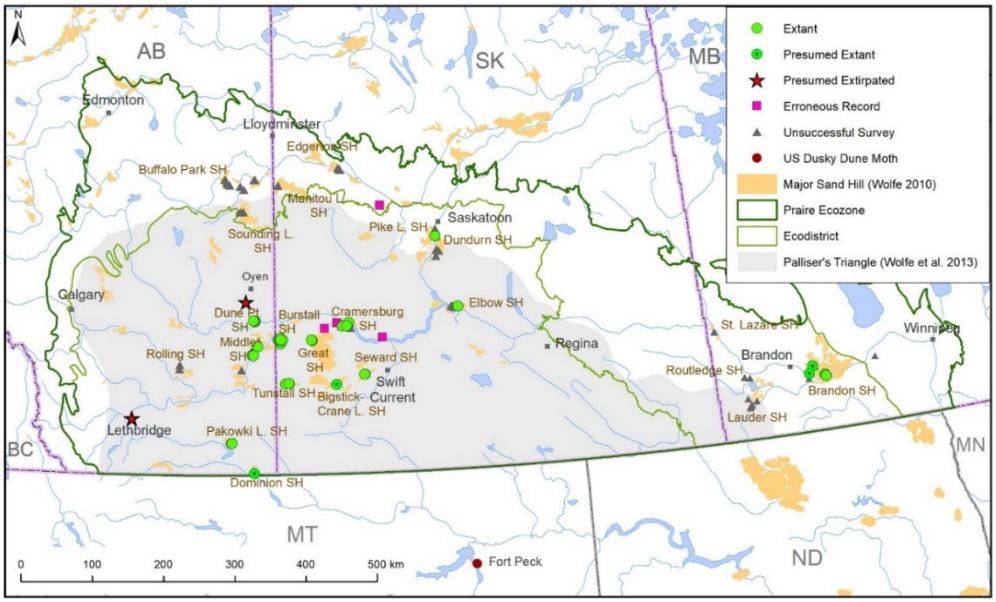


Figure 3. Known Canadian records for Dusky Dune Moth (*Copablepharon longipenne*). See Appendix 1 for site details. Map by R. Foster, August 1, 2021.

In Canada, Dusky Dune Moth is known from 15 subpopulations: 13 of which are confirmed (n=11) or presumed (n=2) extant[3]. An additional two Alberta subpopulations are historical[4] (Lethbridge and Sunnydale) (Table 1, Figure 3). Since the first COSEWIC (2007) status report, Dusky Dune Moth has been confirmed at three new subpopulations: Middle SH (AB), Elbow SH (SK), and Tunstall SH (SK). The increase in known Canadian subpopulations since 2007 is due to additional survey effort after the initial COSEWIC (2007) assessment. Within these 13 sand hills[5], Dusky Dune Moth is present at 35 sites[6] (Table 1). This is an increase from 21 sites reported from the recovery strategy (Environment Canada 2015) and reflects a more detailed compilation and analysis of moth records, rather than an actual increase in number of sites.

[3] Extant: The species is known or thought very likely to occur currently in the area, which encompasses habitats with current or recent (last 20 years) records or where suitable habitat at appropriate altitudes remains. Extant ranges should be considered in the calculation of EOO (IUCN 2018).

[4] Historical: Recent field information verifying the continued existence of the subpopulation is lacking, based on historical collection data, but without recent field survey work. The subpopulation may be extirpated due to general habitat loss or degradation of the environment in the area. Historical status is typically applied to an occurrence that has not been reconfirmed for 20 years or more; may also indicate occurrences with imprecise site collection information such that it may be difficult or impossible to determine whether subsequent observations are of the same occurrence (modified from NatureServe 2022).

[5] Subpopulations are confined to a named *sand hill*, which refers to a well-defined geographic region where several sand dunes exist (David 1977). Within a sand hill there could be numerous *sand dunes* and *blowouts* (sand dunes and blowouts are also sometimes referred to generically as *sites* in this status report, because in past search effort, surveyors have not always differentiated what type of sand hill habitat was searched). A *sand dune* is a "mound, hill or ridge of windblown sand, either bare or variously covered by vegetation, capable of movement from place to place through the development of a slip face, but always retaining its own characteristic shape for an extended period of time" (David 1977). Also within a sand hill are blowouts (which could also be referred to as a site). A *blowout* is "a small, typically less than one hectare in size, area of windblown sand, which is commonly bowl shaped and somewhat elongated in the direction of transporting winds. Thus, road tracks, all-terrain vehicle trails, cattle trails, oil/gas well pads, dugouts, cattle-disturbed areas around water wells sites and ranches, and sand pits are not considered to be natural wind-blown blowouts" (Wolfe 2010).

[6] A site refers to discrete sand dunes or blowouts separated by vegetated habitat. Sand dunes and blowouts are also sometimes referred to generically as *sites* in this status report, because in past search effort, surveyors have not always differentiated what type of sand hill habitat was searched.

**Table 1. Known Canadian subpopulations of Dusky Dune Moth (*Copablepharon longipenne*), the years of first and most recent observation, the number of individuals observed at the subpopulation, number of sites within the subpopulation and the subpopulation status.**

| Sand Hill[1] (SH) | First Observation | Most Recent Observation | Total # of Individuals[2] | Total # Known Sites[3] | Subpopulation Status |
|---|---|---|---|---|---|
| **ALBERTA** | | | | | |
| 0. Lethbridge | 1922 | 1922 | 5 | 0 | Extirpated |
| 0. Sunnydale | 1942 | 1942 | 1 | 0 | Extirpated |
| 1. Dominion SH | 1951 | 1951 | 2 | 1 | Extant |
| 2. Dune Point SH | 2004 | 2015 | 37 | 3 | Extant |
| 3. Middle SH[4] | 2008 | 2010 | 13 | 3 | Extant |
| 4. Pakowki Lake SH | 1925 | 2010 | 23 | 3 | Extant |
| **SASKATCHEWAN** | | | | | |
| 5. Big Stick SH - Crane Lake SH | 1969 | 1969 | 1 | 1 | Extant |
| 6. Burstall SH | 1977 | 2015 | 299 | 9 | Extant |
| 7. Cramersburg SH | 2005 | 2011 | 50 | 4 | Extant |
| 8. Dundurn SH | 2004 | 2004 | 78 | 1 | Extant |
| 9. Elbow SH[4] | 2011 | 2011 | 2 | 1 | Extant |
| 10. Great SH | 1999 | 2005 | 33 | 3 | Extant |
| 11. Seward SH | 2004 | 2004 | 286 | 2 | Extant |
| 12. Tunstall SH[4] | 2010 | 2010 | 80 | 3 | Extant |
| **MANITOBA** | | | | | |
| 13. Brandon SH | 1910 | 2018 | 102 | 1 | Extant |
| **GRAND TOTAL** | | | **1012** | **35** | **13 extant; 2 historical** |

[1] Sand Hill names from Wolfe (2010); Subpopulation numbers from Environment Canada (2015). Lethbridge and Sunnydale subpopulations are considered extirpated.

[2] total number of specimens observed/collected over the years surveyed; this number does not represent a subpopulation size.

[3] sites refer to active open sand dunes or blowouts, typically separated by vegetated habitat.

[4] subpopulations not listed in the COSEWIC (2007) status report.

The exact collection site of the historical Lethbridge and Sunnydale records are unknown, as precise information is not provided on the museum specimen labels. However, there does not appear to be any potentially suitable habitat (i.e., active sand dunes) near either Lethbridge or Sunnydale, so these subpopulations are presumed extirpated (COSEWIC 2007; Anweiler 2015). The exact collection site of the historical Aweme (1910-1911), Onah (1919), and Bald Head Hills (1958) museum specimens are also unknown. Potentially suitable habitat is widely distributed in the Brandon SH, and more recent records from the Spirit Dunes (2003-2004) may overlap with these historical records. The Dusky Dune Moth record from central Manitoba (MPG 2020) (Figure 2) is erroneous[7], as are records from Matador and Sonningdale, SK (Gollop pers. comm. 2020). There are two Royal Saskatchewan Museum[8] specimens that are labelled erroneously as "Portreeve" but are likely from the Great SH south of Scepter (Page pers. comm. 2020).

## Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) of Dusky Dune Moth in Canada is approximately 149,197 $km^2$ using a minimum convex polygon encompassing all 13 extant subpopulations. This value is slightly less than the EOO of 164,480 $km^2$ from the first COSEWIC (2007) assessment, which included all known Canadian records including the two subpopulations that are considered extirpated (i.e., Lethbridge and Sunnydale).

The index of area of occupancy (IAO) of Dusky Dune Moth in Canada is 124 $km^2$ (31 grid squares), based on a fixed 2 x 2 km grid over all extant subpopulations (some subpopulations are composed of numerous sites). The previous IAO estimate was less than 50 $km^2$ (COSEWIC 2007). The increase in IAO is due to search effort that has detected additional occupied habitat and is not indicative of range expansion since the last COSEWIC (2007) assessment. Approximately 60% of sand hills have been surveyed for the moth, suggesting the maximum IAO could be slightly larger, but less than 500 $km^2$.

## Search Effort

Dusky Dune Moth records in Canada date from 1910-2018 and approximately 1000 specimens have been caught or observed to date (Table 1). From 1910 to 2018, Dusky Dune Moths were captured on approximately 55 dates at 35 sites in 13 Canadian sand hills (Figure 3; Table 2; Appendix 1). Until recently, search effort for the Dusky Dune Moth went largely undocumented, with museum specimens representing the only available evidence of successful surveys.

[7] This record may represent a provincial centroid.

[8] Royal Saskatchewan Museum (RSM): ascribing an accurate collection site is a common challenge with older specimens or those lacking GPS coordinates.

**Table 2. Known subpopulations of Dusky Dune Moth (*Copablepharon longipenne*) (DDM) and potential habitat in other sand hills not surveyed (n/s) within the moth's approximate Canadian range[1].**

| Prov. | Sand Hill (SH) | Last Survey Year[2] | Total # DDM | Known Dusky Dune Moth Sites | | Blowouts (Wolfe 2010) | | Dunes (Wolfe 2010) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Total # of Sites | Total Area (ha) [3] | Total # Blowouts | Total Area (ha) | Total # of Dunes | Total Area (ha) |
| AB | 1. Dominion SH | 1951 | 2 | 1 | unknown | 0 | 0 | 0 | 0 |
| AB | 2. Dune Point SH | 2015 | 37 | 3 | 5.3 | 4 | 5.3 | 0 | 0 |
| AB | 3. Middle SH | 2010 | 7 | 3 | 1.2 | 17 | 3.0 | 1 | 0.4 |
| AB | 4. Pakowki Lake SH | 2010 | 23 | 3 | 8.4 | 56 | 23.6 | 0 | 0 |
| SK | 5. Big Stick SH - Crane Lake SH | 1969 | 1 | 1 | unknown | 15 | 8.1 | 4 | 10.1 |
| SK | 6. Burstall SH | 2015 | 299 | 9 | 20.0 | 15 | 23.6 | 0 | 0 |
| SK | 7. Cramersburg SH | 2011 | 50 | 3 | 1.9 | 19 | 11.7 | 0 | 0 |
| SK | 8. Dundurn SH | 2011 | 78 | 1 | 0.5 | 23 | 15.3 | 0 | 0 |
| SK | 9. Elbow SH | 2011 | 2 | 1 | 0.3 | 59 | 22.6 | 1 | 40.0 |
| SK | 10. Great SH | 2009 | 33 | 3 | 9.1 | 142 | 61.9 | 59 | 241.4 |
| SK | 11. Seward SH | 2004 | 286 | 2 | 7.6 | 10 | 8.6 | 3 | 14.9 |
| SK | 12. Tunstall SH | 2010 | 80 | 3 | 10.3 | 15 | 5.0 | 2 | 28.6 |
| MB | 13. Brandon SH | 2018 | 102 | 1 | 25.0 | 0 | 0 | 6 | 78.0 |
| SK | Antelope SH | n/s | - | - | - | 1 | 0.6 | 0 | 0 |
| SK | Birsay SH | n/s | - | - | - | 5 | 2.2 | 0 | 0 |
| AB | Bowmanton SH | n/s | - | - | - | 2 | 0.1 | 0 | 0 |
| SK | Carmichael | n/s | - | - | - | 0 | 0 | 0 | 0 |
| AB/SK | Empress SH | n/s | - | - | - | 1 | 0.6 | 2 | 7.1 |
| MB | Lauder SH | 2014 | 0 | - | - | 11 | 2.2 | 0 | 0 |
| MB | Oak Lake SH | n/s | - | - | - | 0 | 0.0 | 0 | 0 |
| SK | Pelican Lake SH | n/s | - | - | - | 4 | 0.6 | 0 | 0 |
| SK | Piapot SH | n/s | - | - | - | 2 | 3.1 | 0 | 0 |
| SK | Pike Lake SH | n/s | - | - | - | 0 | 0 | 0 | 0 |
| MB | Portage SH | n/s | - | - | - | 0 | 0 | 0 | 0 |
| MB | Routledge SH | 2009 | 0 | - | - | 0 | 0 | 0 | 0 |
| MB | Souris SH | n/s | - | - | - | 0 | 0 | 0 | 0 |
| MB | St. Lazare SH | 2013 | 0 | - | - | 0 | 0 | 0 | 0 |
| SK | Westerham SH | n/s | - | - | - | 2 | 1.7 | 0 | 0 |
| | **TOTAL** | | 1006 | 35 | 89.6 | 403 | 199.7 | 78 | 420.6 |

[1] The term *sand hill* refers to a well-defined geographic region where several sand dune occurrences exist (David 1977).

A *sand dune* is a "mound, hill or ridge of windblown sand, either bare or variously covered by vegetation, capable of movement from place to place through the development of a slip face, but always retaining its own characteristic shape for an extended period of time" (David 1977).

A *blowout* "refers to a small, typically less than 1 hectare in size, area of windblown sand, which is commonly bowl shaped and somewhat elongated in the direction of transporting winds. Thus, road tracks, all-terrain vehicle trails, cattle trails, oil/gas well pads, dugouts, cattle-disturbed areas around water wells sites and ranches, and sand pits" are not considered to be natural wind-blown blowouts (Wolfe 2010).

[2] n/s = habitat not surveyed for Dusky Dune Moth.

[3] There is insufficient data to estimate the total area occupied by Dusky Dune Moth; the ha reported is a maximum spatial area. This same area is declining due to vegetation succession (see **Threats and Limiting Factors**).

**Table 3. Land tenure, threats (see Table 5), and identified federal critical habitat (Environment Canada 2015) for known Canadian subpopulations of Dusky Dune Moth (*Copablepharon longipenne*). CFB = Canadian Forces Base; CFD = Canadian Forces Detachment.**

| Prov. | Sand Hill (SH) | Land Tenure | Main IUCN Threat (see Table 5) | Critical Habitat Identified (Environment Canada 2015) |
|---|---|---|---|---|
| AB | 1. Dominion SH | federal agricultural research station | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | No |
| AB | 2. Dune Point SH | Province of Alberta | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | Yes |
| AB | 3. Middle SH | CFB[1] Suffield National Wildlife Area | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | Yes |
| AB | 4. Pakowki Lake SH | Province of Alberta | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | Yes |
| SK | 5. Big Stick SH – Crane Lake SH | Province of Saskatchewan / Big Stick Community Pasture | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | No |
| SK | 6. Burstall SH | Province of Alberta | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | Yes |
| SK | 7. Cramersburg SH | Carry the Kettle Nakoda Nation I.R. 76 | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | Yes |
| SK | 8. Dundurn SH | CFD Dundurn | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | No |
| SK | 9. Elbow SH | Elbow Community Pasture | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | Yes |
| SK | 10. Great SH | Province of Alberta | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | Yes |
| SK | 11. Seward SH | Province of Alberta | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | Yes |
| SK | 12. Tunstall SH | Bitter Lake Community Pasture | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | Yes |
| MB | 13. Brandon SH | Spruce Woods Provincial Park; CFB Shilo | 7.3 other ecosystem modifications as a result of vegetation succession from native and non-native plants into the sand dune habitats. | Yes |

Sampling for Dusky Dune Moths typically involves use of moth traps with an ultraviolet (UV) or mercury vapour (MV) light set on (or suspended over) a collecting bucket and powered by a closed cell 12 volt battery. Vanes may or may not be used to direct moths through a funnel into the holding bucket, which usually holds some carton or other shelter, possibly with a killing agent. MV lights have also been less frequently used in conjunction

with a white sheet suspended from a frame (e.g., at Shilo in 2017 [Johnson 2018]). Traps are used from dusk to dawn, often with a photovoltaic timer to preserve battery life, thus facilitating logistics.

In support of the 2007 COSEWIC status report, a total of 28 trap-nights of survey effort were conducted in 2004-2005 at ten sites with potentially suitable habitat in southern Saskatchewan and Alberta (Appendix 2). Dusky Dune Moths were recorded at three new sand hills (i.e., Seward SH, Cramersburg SH, and Dundurn SH) as well as being reconfirmed in the Great SH. Although the large Edgerton SH have been extensively trapped over several years, no Dusky Dune Moths were recorded, perhaps due to the coarser sand, fewer blowouts, and vegetation that is more parkland than prairie (Schmidt pers. comm. 2017). No fieldwork associated with the preparation of this 2020 COSEWIC update status report was undertaken; other surveys conducted after the 2007 COSEWIC assessment are described below.

Targeted searches for Dusky Dune Moths were conducted in potentially suitable habitat in the Brandon (including Treesbank), Lauder, Portage, St. Lazare, Routledge, and Treesbank sand hills (Friesen and Murray 2011, 2012; Murray 2013, 2014, pers. comm. 2020; Murray and Church 2015). Dusky Dune Moth was confirmed in the Spirit Sands of Spruce Woods PP within the Brandon SH, but at no other sites.

Targeted surveys for Dusky Dune Moth and other moth taxa were conducted in 2008-2011 (Curteanu *et al*. 2011). A total of 84 active open sand dunes and blowouts were surveyed within 16 sites in 13 sand hills. At least 20 trap-nights of effort were done in nine sand hills. Additional surveys (29 trap-nights) were subsequently conducted in 2015 at the Dune Point SH and Burstall SH (Curteanu pers. comm. 2017, 2020; Environment Canada 2015; Snabel pers. comm. 2015). The Spirit Sands area of Spruce Woods PP has had the most intensive sampling effort, with a combined total of 25+ trap-nights of effort in 2003-2004 and 2012-2013 (MB CDC unpublished data; Appendix 2). Burstall Dunes has also had substantial documented trapping effort (Appendix 2). Multiple traps have often been used at a site to sample both open sand and semi-stabilized habitats.

Sixteen trap-nights of effort were conducted from August 20-23, 2016, during targeted dune lepidoptera surveys at CFB Wainwright, but no Dusky Dune Moths were caught (Stantec Consulting Ltd. 2016). Targeted surveys with light-traps at Wainwright Dunes Ecological Reserve and nearby Dilberry Lake PP in Alberta have recently (2015-2016) been conducted, but no Dusky Dune Moths were recorded (Macaulay 2017, 2020).

An existing physiographic inventory of dunes and blowouts in the sand hills of the Canadian Prairie provinces (see Wolfe 2010) were assessed for potential Dusky Dune Moth habitat. The 27 sand hills within the Canadian range of Dusky Dune Moth encompass 78 mapped dunes and 403 blowouts that together represent approximately 620 ha of bare sand area (Table 2). It is estimated that approximately 60% of the potentially suitable habitat that is available has been surveyed. Ten sand hills have had no targeted surveys for Dusky Dune Moth, and another two have not had surveys for more than 50 years. Additional subpopulations in the Canadian prairies likely occur in unsurveyed sandy

grasslands with appropriate habitat, particularly the Great SH, and further investigation is warranted in areas such as Pelican Lake, Westerham[9], Carmichael, and Piapot SH (Environment Canada 2015). COSEWIC (2007) suspected the Westerham, Bigstick, Tunstall, Elbow, and Middle SH as potentially having Dusky Dune Moth subpopulations; subsequent surveys by the Canadian Wildlife Service confirmed their presence at the latter three sand hills. Bigstick-Crane Lake SH has a 1969 record and the Westerham SH remain unsurveyed. Although approximately 60% of the 620 ha of bare sand area (Table 2) has been surveyed, the overall area of habitat is still extremely small and it's not likely moths are within all these habitat parcels. When the species is recorded, it does not appear to be abundant.

No additional records for Dusky Dune Moth are on the Butterflies and Moths of North America (BAMONA) website (Opler *et al.* 2020), NatureServe (2020), BugGuide (2020), or iNaturalist (2020).

# HABITAT

## Habitat Requirements

Dusky Dune Moth is a habitat specialist that occurs primarily in sand hills comprised of glaciofluvial or glaciodeltaic sand deposits that have been reworked into dunes by wind at varying times throughout the Holocene (Wolfe 1997, 2002, 2010) and sparsely vegetated grasslands with patches of open sand (COSEWIC 2007) (Figure 4). Within the Canadian range of this moth, active sand dunes and blowouts now primarily occur as isolated patches, often on the crests of stabilized or semi-stabilized sand hills (Wolfe 2010; Environment Canada 2015). In Canada, adult moths have most frequently been captured in or near sandy blowouts and dune ridges, in blowouts as small as 0.08 ha, but more frequently and in greater abundance in larger sand dunes (Environment Canada 2015). Occasionally, Dusky Dune Moths have been found in stable or semi-stable dunes or dune ridges, often where road cuts, fire guards, and other disturbed areas are a source of open sand in otherwise stabilized dune environment (COSEWIC 2007; Johnson pers. comm. 2017). Anthropogenic features are more often used when they occur adjacent to an active sand dune (i.e., <100 m), and tend to have lower numbers of Dusky Dune Moths. Such linear artificially created features may be less optimal habitat, or a population sink but could potentially link otherwise fragmented active dune habitat (COSEWIC 2007; Environment Canada 2015). All but one Canadian subpopulation is from natural sand dunes or blowouts, with the one exception from a sandy fireguard in the Dundurn SH.

[9] Referred to as "Westham" in Environment Canada (2015)

Figure 4. Sand dune habitat characteristics: a) human-made fireguard with open sand in which Dusky Dune Moth (*Copablepharon longipenne*) was abundant (Dundurn SH); b) semi-stabilized dune blowout in which Dusky Dune Moth was not captured (Dundurn SH); c) dune margin with high abundance of Dusky Dune Moth (Seward SH); d) dry grassland near open dune in which Dusky Dune Moth was not captured (Great SH); e) active dune complex with Lance-Leaved Scurf-pea and Canada Wildrye on the slip face (Cramersburg SH; Dusky Dune Moth was captured); and f) sparsely vegetated margin of active dune in Burstall SH with Lance-leaved Scurf-pea and Sand Dock colonization (not sampled in 2004–2005 but Dusky Dune Moth found several times previously). All photos by N.A. Page (a, b: August 2004; c–f: July 2005) (COSEWIC 2007).

Dusky Dune Moths do not appear dependent on a unique host-plant for larval feeding, oviposition, or adult nectaring (see **Biology**). Plants such as Canada Wildrye (*Elymus canadensis*), Common Skeletonweed (*Lygodesmia juncea*), Lance-leaved Scurf-pea (*Ladeania lanceolata*)[10], Prairie Junegrass (*Koeleria macrantha*), Prairie Sunflower (*Helianthus petiolaris*), Prickly Rose (*Rosa acicularis*), Sand Dock (*Rumex venosus*), Sand Dropseed Grass (*Sporobolus cryptandrus*), and Wolf-willow (*Elaeagnus commutata*) are typically present within the active sand dunes and blowouts that are occupied by the Dusky Dune Moth (COSEWIC 2007; Environment Canada 2015). Plant communities described from active and semi-stable dunes include a Sand Dock herbaceous association from Pakowki Lake (Coenen and Bentz 2003). Fauske (1992) stated that Dusky Dune Moth was often associated with grama needlegrass-wheatgrass steppe and recorded from aeolian drift areas.

Dusky Dune Moths do not appear to use habitats with dense vegetation or grass thatch and may require open sand for oviposition and larval development, including winter diapause (COSEWIC 2007; Environment Canada 2015). The sand substrate may offer a humid and stable microclimate during the vulnerable pupal stage and may facilitate oviposition and the burrowing activity of larvae while feeding on plant roots (COSEWIC 2007).

## Habitat Trends

Sandy soils are widespread in the southern Canadian prairies and are composed of glaciofluvial, glaciolacustrine, and deltaic sediments from the last glaciation that have been reworked by wind action (David 1977). Trends in Dusky Dune Moth habitat in Canada are driven by the patterns of dune activity and stabilization in the southern Prairies. These dune systems are derived from sandy deposits left behind by the receding Laurentide Ice Sheet and reworked by aeolian and other processes (Hugenholtz *et al.* 2010). Dune activity depends on climatic and biological or anthropogenic factors that control sediment availability and/or transport capacity (Muhs and Wolfe 1999; Hugenholtz and Wolfe 2005b), with dune activity typically increased during periods of greater aridity. Stratigraphic and chronological studies (e.g., Dean *et al.* 1996; Wolfe *et al.* 2002, 2004, 2006) document a history of alternating periods of dune activity and stability across the Prairies during the last 10,000 years. Following an active period of approximately 80 years during the 1800s, archival aerial photographs and satellite imagery document widespread dune stabilization across the southern Canadian prairies through the early 1900s, despite periodic drought intervals (Hugenholtz and Wolfe 2005a; Wolfe *et al.* 2001, 2007).

The gradual growth of vegetation into these open areas has reduced the size of most dune systems in the Canadian prairies in the last 200 years. Most sandy habitats are now vegetated, and lack open sand patches except in isolated blowouts, drier dune ridges, road cuts, and other disturbed sites. Vegetation development on dunes often leads to the development of a heavily vegetated sandy grassland that excludes Dusky Dune Moths. For example, exposed sand in the blowout shown in Figure 4b will likely be lost as Creeping Juniper (*Juniperus horizontalis*) and bryophytes spread and replace the bare sand.

[10] Formerly Lance-leaved Psoralea (*Psoralea lanceolata*)

Many active dunes have been stabilized by vegetation at a rate of 10-40% per decade, and less than 1% of the sand hill area in the Canadian prairies currently has active bare sand (Wolfe 2010). Between 1928 and 2006, the open sand area within the 1350 $km^2$ Brandon SH decreased by 95% (Hugenholtz *et al.* 2010; Wolfe *et al.* 2000), and only about 80 ha of open sand dune remains (Wolfe 2010). Much of this open area is within Spirit Sands (Spruce Woods PP), where Dusky Dune Moth was most recently observed in 2018 (Table 1). Despite not being detected with limited trapping (Appendix 2), the species may also persist elsewhere in the Brandon SH at Canadian Forces Base (CFB) Shilo (Table 1), where military activities maintain some open sand areas (e.g., roads) in a matrix of more stabilized dune habitat (Johnson pers. comm. 2017). Many smaller sand hills with minor levels of dune activity in the mid-1900s are now reduced to small pockets of active sand (Hugenholtz *et al.* 2010). For example, a comparison of satellite imagery for Open Dune #749 (Wolfe 2010) in the Seward SH where Dusky Dune Moth was abundant in 2004 (COSEWIC 2007) shows a reduction in open sand area from approximately 6.6 ha in 2007 to approximately 4.4 ha in 2015, more than 30% loss of active sand habitat in less than a decade (Figure 5). In contrast, only 75 km to the north in Cramersburg SH, open sand areas in Blowout #339 have increased from approximately 834 $m^2$ in 2012 to 1441 $m^2$ in 2019 (Figure 6). New landowners began to livestock graze the area circa 2015 after a wetter than average period from 2010-2015 when vegetation cover increased (Cobler 2015); increased grazing may have facilitated expansion of open sand areas observed in the 2019 imagery.

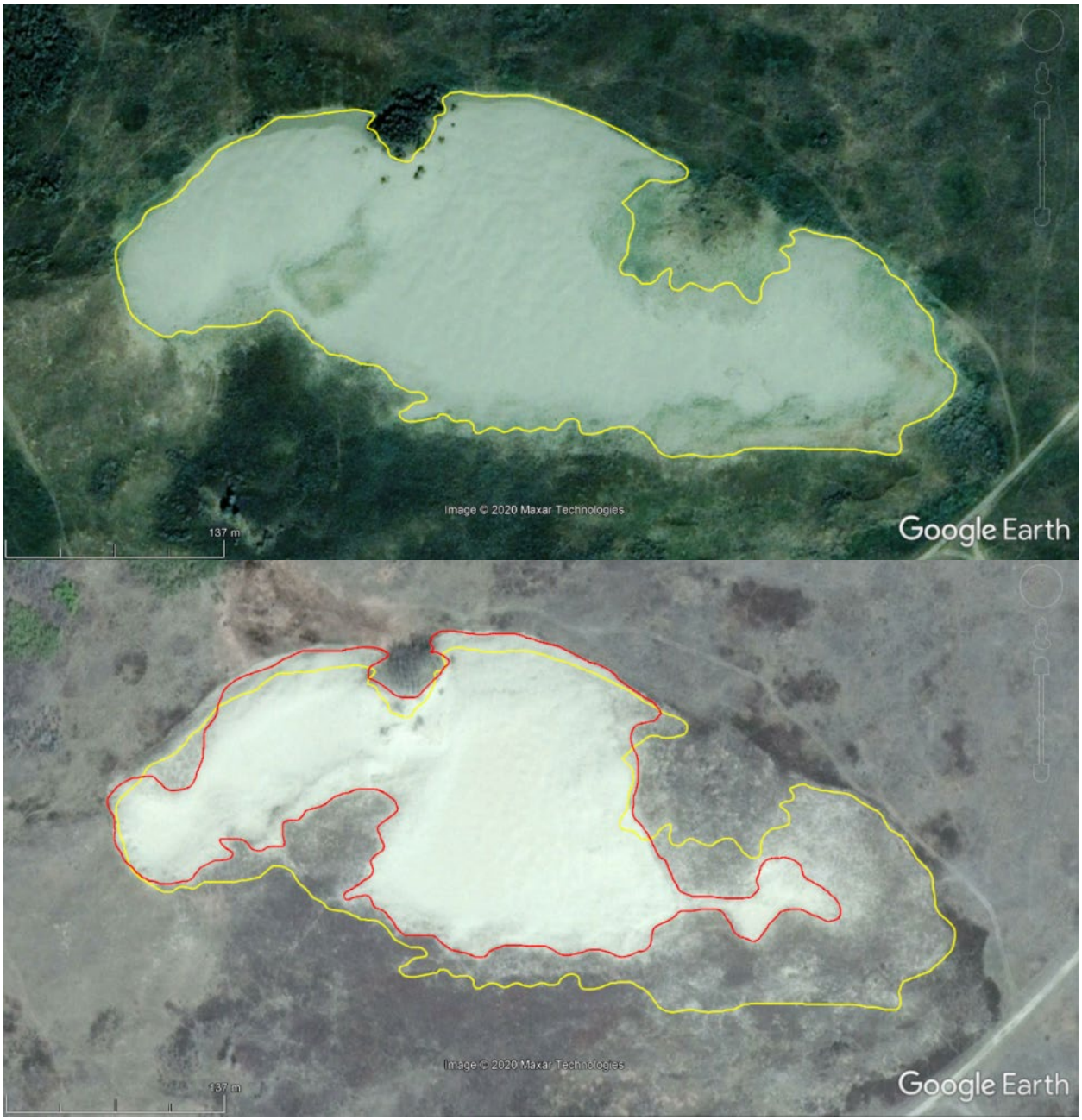


Figure 5. Comparison of 2007 (upper) and 2015 (lower) satellite images of open dune #749 (Wolfe 2010) in the Seward Sand Hills where Dusky Dune Moth was abundant in 2004 (COSEWIC 2007). Red and yellow outlines delimit the approximate edge of the open dune in 2007 and 2015 respectively, showing the decrease in open active sand area.


Figure 6. Comparison of 2012 (upper) and 2019 (lower) satellite images of blowout #339 (Wolfe 2010) in the Cramersburg Sand Hills where Dusky Dune Moth has been observed (Curteanu *et al.* 2011). Red and yellow outlines delimit the approximate edge of the open dune in 2012 and 2019 respectively, showing the increase in open active sand area.

Although regional climate is the primary driver over the long term, widespread irrigation, the decline in abundance of Plains Bison (*Bison bison bison*) herds, and the suppression of fires have also been cited as factors contributing to dune stabilization in the 1900s (Wolfe and Nickling 1997; Forman *et al.* 2001; Hugenholtz *et al.* 2010). Although climate explains a significant portion of the historical trend towards dune stabilization at a regional scale, disturbance accounts for the persistence of some active dunes and blowouts in areas that would otherwise be stabilized by vegetation (Hugenholtz *et al.* 2010). Periodic habitat disturbance from fire, cultivation, logging, off-road vehicle traffic and livestock grazing can increase or restore dune activity and lead to the development of new generations of dunes (Hugenholtz *et al.* 2010). Blowouts develop when a localized disturbance produces a breach in the vegetation cover, thus enabling deflation by wind (Wolfe and Nickling 1997). Vegetation growth is inhibited where high wind stress and low moisture availability prevail, such as at windward and south-facing slopes (Hugenholtz and Wolfe 2005b). The process of dune stabilization tends not to be a linear function of time, with stabilization slowing and following a negative exponential function in later stages (Hugenholtz and Wolfe 2005b). This might account for the persistence of some base level of dune activity (Wolfe *et al.* 2007).

Dune stabilization causes habitat loss and results in a more fragmented habitat as active dune areas shrink and disappear, likely with negative impacts on Dusky Dune Moth subpopulations. Under these dynamics, even a small loss of habitat, such as a large, centrally placed active dune, can significantly reduce subpopulation persistence (e.g., see Bascompte and Soulé 1996), especially if dispersal among sand dunes is disrupted by the loss of connecting habitat patches (Hugenholtz *et al.* 2010; see **Dispersal and Migration**).

Although dune activity is projected to decline in the coming decades under the present climate and disturbance regimes (Wolfe 2010), dunes are extremely sensitive to climatic variability and the potential for reactivation is high (Muhs and Holliday 1995). Although regional reactivation of sand dunes may require several decades (Wolfe 1997; Wolfe *et al.* 2001), this may eventually result in an increasing amount of suitable habitat for Dusky Dune Moths if subpopulations remain nearby to recolonize it.

Because of the small size of some of these active dunes, their decline in size, and their isolation from one another, the Dusky Dune Moth population in Canada is considered to be severely fragmented (see **Dispersal and Migration** and Table 4). The viability of moth subpopulations is considered low at seven subpopulations. All subpopulations are widely separated and unlikely to provide rescue effect; the two closest subpopulations are Dune Point SH (#2) and Middle SH (#3) separated by 28 km; and Middle SH (#3) and Burstall SH (#6) separated by 29 km. At least 7 subpopulations have an IAO = 4 $km^2$.

**Table 4. Viability analysis of Dusky Dune Moth subpopulations (sand hills), inferred from observations and GoogleEarth analysis (Cannings pers. comm. 2021; Curteanu pers. comm. 2021). Four of the thirteen subpopulations are considered non-viable; three are of unknown viability and six are considered viable.**

| Sub-pop'n # | Sand Hill (SH) | Year of most recent record | Available open-sand habitat (Google Earth) | Inferred habitat occupancy based on occurrences and search effort | Viability | Rescue Possible | Distance to the closest sand hill | # IAO Squares (31 squares total = 124 km$^2$) | Considerations (D/BO = dunes or blow-outs) within the Sand Hill |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Dominion SH | 1951 | Low | Low | Non-viable | No | 53 km to 4. Pakowski Lake SH | 1 | Very low # D/BO (<=5); Search effort low (only 1-2 targeted surveys) but with low number of individuals and habitat availability and quality is declining |
| 2 | Dune Point SH | 2015 | Low | Low | Non-viable | No | 28 km to 3. Middle SH | 2 | Very low # D/BO (<=5); Search effort low (only 1-2 targeted surveys) but with low number of individuals and habitat availability and quality is declining |
| 3 | Middle SH (2010) | 2010 | Low | Low | Non-viable | No | 29 km to 6. Burstall SH | 3 | Very low # D/BO (<=5); Search effort low (only 1-2 targeted surveys) but with low number of individuals and habitat availability and quality is declining |
| 4 | Pakowki Lake SH (2010) | 2010 | High | Low | Likely Viable | No | 53 km to 1. Dominion SH | 1 | >20 D/BO and good connectivity among dunes; Infer low occupancy but search effort low (2 surveys) |
| 5 | Big Stick SH/ Crane Lake SH (1969) | 1969 | Unknown | Unknown | Unknown | No | 42 km to 11. Seward | 1 | Unknown |
| 6 | Burstall SH (2015) | 2015 | High | High | Viable | No | 29 km to 3. Middle SH | 8 | >20 D/BO; Search effort reasonable and detected occurrences over several years suggest that occupancy could be high; More D/BO are likely occupied nearby |
| 7 | Cramersburg SH (2011) | 2011 | Low | Low | Non-viable | No | 45 km to 10. Great SH | 4 | Fairly low # D/BO (6-20); Infer low occupancy from search effort and detected occurrences (Cobler pers. comm. 2015) |
| 8 | Dundurn SH (2011) | 2011 | Unknown | Unknown | Unknown | No | 103 km to 9. Elbow SH | 1 | Unknown |
| 9 | Elbow SH (2011) | 2011 | High | Low | Discretion needed | No | 103 km to 8. Dundurn SH | 1 | >20 D/BO; Infer low occupancy from search effort (8 trap nights over three years) and detected occurrences (2 individuals found). |
| 10 | Great SH (2009) | 2009 | High | Low | Likely Viable | No | 41 km to 6. Burstall SH | 1 | Habitat quality and size declining |
| 11 | Seward | 2004 | High | High | Likely Viable | No | 42 km to 5. Big Stick SH | 1 | >20 D/BO; Infer high occupancy but this is based on one single survey; Habitat quality and size declining |

| Sub-pop'n # | Sand Hill (SH) | Year of most recent record | Available open-sand habitat (Google Earth) | Inferred habitat occupancy based on occurrences and search effort | Viability | Rescue Possible | Distance to the closest sand hill | # IAO Squares (31 squares total = 124 km$^2$) | Considerations (D/BO = dunes or blow-outs) within the Sand Hill |
|---|---|---|---|---|---|---|---|---|---|
| 12 | Tunstall | 2010 | High | High | Likely Viable | No | 55 km to 6. Burstall SH | 3 | >20 D/BO; Infer high occupancy but this is based on one single survey; Habitat quality and size declining |
| 13 | Brandon | 2018 | High | High | Viable or premature to consider as non-viable | No | 500 km to 9. Elbow SH | 4 | >20 D/BO including large established dunes; Large numbers of individuals observed over several years, but occurrences may be declining (1 individual in 2018); Habitat size and quality declining |

# BIOLOGY

The biology of Dusky Dune Moth is poorly known, although there is general information available from other *Copablepharon* moths. This nocturnal moth with a short summer flight season is rarely observed. The following information is based on Canadian field observations (e.g., COSEWIC 2007; Curteanu *et al.* 2011; Environment Canada 2015), supplemented with published information in Strickland (1920), Seamans (1925), Fauske (1992) and Lafontaine *et al.* (2004)

## Life Cycle and Reproduction

Dune Moth undergoes complete metamorphosis through four distinct life stages: egg, larva (unknown number of instars), pupa and adult.

Mating has been observed on the lower stems of Wolf-willow or on the sand surface near vegetation, with eggs deposited approximately 10 mm below the sand surface in groups of 15-35 (COSEWIC 2007). August observations at the Seward SH suggested that oviposition occurs on the leeward side of active sand dunes, where sand deposition may reduce egg exposure and desiccation, as well as potential egg predation (COSEWIC 2007).

Eggs hatch approximately three weeks after oviposition (COSEWIC 2007). Larval growth occurs between hatching in August and the onset of cool weather in September-October. Larvae may undergo a below-ground diapause (depth unknown) between the fall and early spring (COSEWIC 2007). Larval feeding in the spring or early summer may occur prior to pupation, as is the case in other species of *Copablepharon* (COSEWIC 2007). The pupal life stage likely occurs between early June and late July in Canada and lasts 17-19 days (Seamans 1925). Pupation occurs in an “earthen cell” below ground as for other *Copablepharon* (Strickland 1920).

Based on Canadian observations, the moth's single flight period is from June 27-August 23, with a peak around the end of July (Appendix 1). Mating coincides with the flight season, and adults likely die shortly after reproducing. Sex ratios in collections are evenly split. Adults are nocturnal but are sometimes observed at dusk or resting on dune vegetation during the day (COSEWIC 2007; Curteanu *et al*. 2011; Environment Canada 2015). *Copablepharon* spp. have an unusually long proboscis for a noctuid, and they might nectar preferentially at flowers with deep corollas (Schmidt pers. comm. 2017), such as White Evening-Primrose (*Oenothera nuttalli*). The lifespan of the adult life stage is unknown.

## Physiology and Adaptability

Little is known about the physiology and adaptability of Dusky Dune Moth. The influence of climate on Dusky Dune Moth distribution is not known, but cold temperatures may limit its northern distribution. The species is found across a broad latitudinal gradient in North America with a correspondingly wide variation in precipitation and temperatures.

Observations to date indicate Dusky Dune Moth is not dependent on a unique host plant for feeding or oviposition. Seamans (1925) noted that "this species was found feeding entirely on rose bushes"; however, several sites in which Dusky Dune Moth were captured in 2004–2005 did not support rose species (COSEWIC 2007). The larvae of Dusky Dune Moth could potentially feed on grasses (e.g., Canada Wildrye and wheat grasses), shrubs such as Prickly Rose and Wolf-willow, or dune forbs like Lance-Leaved Surf-pea and Sand Dock. Sand appears be the preferred medium for egg deposition (COSEWIC 2007).

## Dispersal and Migration

Sand dunes and sandy grasslands in the southern Canadian prairies are widespread, rare, discontinuous, and often separated by large patches of habitat not suitable for dune moths; therefore, local subpopulations may be isolated (Environment Canada 2016). The dispersal abilities of the Dusky Dune Moth have not been measured, but field observations suggest it is a strong flier based on its ability to easily evade capture with hand-nets during strong winds (COSEWIC 2007). Dune habitats are often patchily distributed across the landscape (100 m to 2 km apart) and there is likely infrequent dispersal at this scale. However, dispersal between regionally isolated dunes systems (>10 km) is unlikely or very infrequent (COSEWIC 2007). The potential for long-distance dispersal may have declined as agricultural or other habitat conversion in the intervening landscape has eliminated habitat linkages. There is no information that suggests that the Dusky Dune Moth migrates.

Dusky Dune Moth subpopulations are considered severely fragmented[11]. Each of the subpopulations was evaluated for its isolation (i.e., distance from other sand hills) and its viability. The viability was scored based on the abundance of moths (based on records and search effort), the area of suitable open-sand habitat and whether the habitat is in decline (Table 4).

## Interspecific Interactions

Interspecific interactions such as competition, predation, parasitism, and disease have not been well documented for Dusky Dune Moth. Like most Lepidoptera, Dusky Dune Moth is undoubtedly subject to competition, predation, and parasitism by a variety of insects, birds, and other animals during all life stages. Predation of adult Dusky Dune Moths by birds was observed frequently during surveys in July 2005, with the discarded wings found at dawn in association with bird tracks (COSEWIC 2007). Small birds appeared to actively search for moths hiding in the shrub and forb vegetation along the margins of active dunes. Common Nighthawks (*Chordeiles minor*) were also observed feeding on aerial insects above sand dunes in Saskatchewan (COSEWIC 2007).

# POPULATION SIZES AND TRENDS

## Sampling Effort and Methods

There is little information from which to determine the Canadian population size, or the subpopulation sizes and trends. Sampling effort and methods to date have focused on recording the species' presence (null results do not confirm absence) and most sites have had limited trapping, often only one night (see **Search Effort**).

## Abundance

There are no data available to estimate the Canadian population abundance. The focus of most surveys has been presence/not detected and not total moth counts. Subpopulation sizes of many moth species vary greatly from year to year due to weather and other factors (Pohl *et al*. 2018).

Dusky Dune Moth was first recorded in Canada in 1910 and approximately 1000 specimens have been caught or observed in Canada to date (Table 1). The greatest number of Dusky Dune Moths (n=294) has been captured at the Burstall SH followed closely by the Seward SH (n=286). However, for recent surveys where effort was available (Appendix 2), there was much higher catch-per-unit-effort (moths/trap-night) at Seward SH in 2004 (95.3) compared to 2015 for Burstall SH (14.0). Care must be made not to overinterpret such limited data, however, as factors other than just actual abundance can

[11] COSEWIC definition of severely fragmented: A taxon can be considered to be severely fragmented if most (>50%) of its total area of occupancy is in habitat patches that are (1) smaller than would be required to support a viable population, and (2) separated from other habitat patches by a large distance. Fragmentation must be assessed at a scale that is appropriate to biological isolation in the taxon under consideration (IUCN 2010).

greatly affect trapping success (e.g., weather [Johnson 2018]). If subpopulation size is a function of suitable dune or blowout habitat (Table 2), however, then the Great SH and Brandon SH have the largest Canadian subpopulations.

During 2004-2005 fieldwork in preparation for the first COSEWIC (2007) status report, a total of 409 Dusky Dune Moths were captured, with 1-142 individuals per trap per night (mean 41). These captures ranged from approximately 5–65% of the total number of moths captured in these sites and indicate that Dusky Dune Moth can be locally abundant. However, because of uncertainties in measuring capture success, available habitat, and other factors, a population estimate cannot be calculated for Dusky Dune Moth (COSEWIC 2007). Sporadic light-trapping is insufficient for providing accurate estimates of population size and should be used cautiously for characterizing population density within or between sample sites (COSEWIC 2007).

## Fluctuations and Trends

The progressive stabilization and loss of active dune complexes in Canada during the past 100 years (Wolfe *et al.* 2000) has likely resulted in declines in abundance of Dusky Dune Moth during that period. Based on the stabilization trends of active sand dunes in the southern Canadian prairies (Hugenholtz and Wolfe 2005; Wolfe 2001), COSEWIC (2007) inferred that Dusky Dune Moth subpopulations are declining at a rate of 10–20% per decade. It is not known how accurate that estimate is because the rate of decline in active dune area has varied through time and among dunes, and it is not known how closely Dusky Dune Moth subpopulations are tied to dune area. Even presence/not detected information is conflicting: two historical subpopulations have been lost at Lethbridge and Sunnydale[12], yet for at least 90 years they have persisted at both Pakowki Lake, and the Brandon SH. Current numbers may be lower at the Brandon SH than in the past if historical sites near Onah and Aweme[13] are no longer occupied due to dune stabilization. Within the last ten years, no subpopulations of Dusky Dune Moth have been extirpated; however, there is insufficient data from repeat surveys to provide evidence of a decline in abundance. Dusky Dune Moth is not thought to experience extreme fluctuations in abundance.

## Rescue Effect

The nearest known record of Dusky Dune Moth in the United States is Fort Peck, Montana, approximately 280 km south of the closest Canadian subpopulation in the Seward SH. It is unknown if the Fork Peck occurrence is extant, but the intervening landscape has been heavily developed by agriculture (based on GoogleEarth imagery), and recolonization over this distance is unlikely (COSEWIC 2007).

[12] The precise collection site is not known so the exact mechanism for the extirpation is unknown, but presumed to be habitat loss.
[13] The precise collection site is unknown but may fall within what is now Canadian Forces Base Shilo.

# THREATS AND LIMITING FACTORS

## Threats

The Dusky Dune Moth threat assessment (Table 5) is based on the IUCN-CMP (International Union for Conservation of Nature–Conservation Measures Partnership) unified threats classification system. The IUCN-CMP Threats Classification system is consistent with methods used by COSEWIC across taxa, as well as the federal, provincial, and territorial governments, and it adopts an international standard. For a detailed description, see the Open Standards website (Conservation Measures Partnership 2016a). For information on how the values are assigned, see Salafsky *et al*. (2008), Master *et al*. (2012), and Table 5 footnotes for details.

**Table 5. Results of the Dusky Dune Moth (*Copablepharon longipenne*) threats assessment in Canada. The classification below is based on the IUCN-CMP (International Union for the Conservation of Nature–Conservation Measures Partnership) unified threats classification system. For a detailed description of the threat classification system, see the CMP web site (CMP 2010). Threats may be observed, inferred, or projected to occur in the near term. Threats are characterized here in terms of scope, severity, and timing. Threat "impact" is calculated from scope and severity. For information on how the values are assigned, see Master *et al.* (2009) and table footnotes.**

| | |
|---|---|
| **Species:** | Dusky Dune Moth (*Copablepharon longipenne*) |
| **Date:** | December 14, 2020 (original assessment) and subsequent edits based on reviewer comments and additional information as of May 2022. |
| **Assessors:** | Dave McCorquodale (Arthropods Specialist Subcommittee (SSC) Co-chair), Jennifer Heron (Arthropods SSC Co-chair and facilitator), Rosana Soares (COSEWIC Secretariat), Rob Foster (report writer); Arthropods SSC members Jeremy deWaard, Jeff Ogden, Sarah Semmler, Leah Ramsay, John Richardson, Syd Cannings; Chris Friesen (Manitoba CDC); Gina Schalk and Medea Curteanu (CWS), John Acorn (U of Alberta). |
| **References:** | Recovery Strategy for Dusky Dune Moth in Canada (Environment Canada 2015); COSEWIC Report on Dusky Dune Moth (COSEWIC 2007); White Flower Moth COSEWIC Report (COSEWIC 2014) and other sand ecosystem species with a similar range and habitat. |

| **Overall Threat Impact Calculation** | | **Level 1 Threat Impact Counts** | |
|---|---|---|---|
| **Threat Impact** | | **high range** | **low range** |
| A | Very High | 0 | 0 |
| B | High | 0 | 0 |
| C | Medium | 1 | 0 |
| D | Low | 0 | 1 |
| **Calculated Overall Threat Impact:** | | Medium | Low |
| **Assigned Overall Threat Assessment** | | **Medium** | |
| **Impact Adjustment Reasons** | | Adjusted overall threats assessment to Medium based on the decline in habitat size and uncertainty about habitat to sustain moth subpopulations over the longer term. Climate is changing the habitat. | |
| **Overall Threat Comments** | | See **Threats and Limiting Factors**. | |

| Threat | | Impact[1] (calculated) | Scope[2] (Next 10 Yrs) | Severity[3] (10 Yrs or 3 Gen.) | Timing[4] | Comments |
|---|---|---|---|---|---|---|
| 1 | Residential and commercial development | Negligible | Negligible (<1%) | Negligible (<1%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | |
| 1.1 | Housing and urban areas | Negligible | Negligible (<1%) | Negligible (<1%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Not considered threats. Active dune areas are generally unsuitable for these types of development. |
| 1.2 | Commercial and industrial areas | Negligible | Negligible (<1%) | Negligible (<1%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Not considered threats. Active dune areas are generally unsuitable for these types of development. |
| 1.3 | Tourism and recreation areas | Negligible | Negligible (<1%) | Negligible (<1%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Not considered threats. Hiking trail expansion at Spruce Woods Provincial Park is unlikely. Other recreational development is unlikely. Dusky Dune Moth seems to like the middle of the dune areas, not the periphery, and new trails are likely to go on the periphery of the dunes (e.g., not the middle). |
| 2 | Agriculture and aquaculture | Negligible | Large – Restricted (11-70%) | Negligible (<1%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | |
| 2.1 | Annual and perennial non-timber crops | | | | | Not considered threats. Due to the dry and sandy soils of Dusky Dune Moth habitat and surrounding areas, conversion to crop or forage is not likely. Although there is some irrigated potato farming and haying in marginal adjacent areas in southern Alberta and Manitoba, these crops are unlikely to occur in dunes. |
| 2.2 | Wood and pulp plantations | | | | | Not considered threats. Historically planted trees to provide windbreaks for areas prone to severe wind erosion particularly during dry periods. But no wind breaks within occupied moth habitat or nearby. |

| Threat | | Impact[1] (calculated) | | Scope[2] (Next 10 Yrs) | Severity[3] (10 Yrs or 3 Gen.) | Timing[4] | Comments |
|---|---|---|---|---|---|---|---|
| 2.3 | Livestock farming and ranching | | Negligible | Large - Restricted (11-70%) | Negligible (<1%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Although heavy cattle grazing has been cited as a potential threat (COSEWIC 2007; Environment Canada 2015), the effects of livestock are complex and their potential impact on Dusky Dune Moths is poorly understood. Ranching with cattle and other livestock may replace, in part, the ecological role that was historically played by Plains Bison. Grazing and trampling may enable sparsely vegetated habitats required by Dusky Dune Moth to remain open, but overgrazing could have negative impacts on Dusky Dune Moth, potentially through soil compaction. Livestock farming or ranching occurs within some of the extant sites, but not others (e.g., parks and military bases).<br><br>The sand hills used by Dusky Dune Moth are generally too dry and sandy for agriculture but are widely used as pasture for livestock. Cattle are grazed at several known Dusky Dune Moth sites, including those on private land, community pastures, or government grazing leases (COSEWIC 2007; Environment Canada 2015).<br><br>It is possible that cattle may graze on vegetation used by the larval life stage for feeding, or may result in soil compaction, or trampling of eggs, larvae, or pupae (COSEWIC 2007). Cattle could have a beneficial impact on Dusky Dune Moth habitat in Canada by slowing the rate of dune stabilization due to disturbance by trampling and grazing, especially at small blowouts that would otherwise become overgrown. In this way, cattle may help compensate for the loss of disturbance historically caused by a large abundance of Plains Bison (Fox *et al.* 2012). Compared to Plains Bison, cattle are considered a poor ecological substitute for creating open-sand habitats for sensitive sand dune species (Environment Canada 2015). Unlike Plains Bison, cattle do not create blowouts by wallowing (Fox *et al*. 2012). Nonetheless, cattle disturbance by over-grazing and trampling, compounded by drought, is responsible for the only documented example of historical dune reactivation (Hugenholtz and Wolfe 2005a,b). Cattle can be a vector for establishing invasive species (Chuong *et al*. 2015), although impacts on Dusky Dune Moths have not been demonstrated. |
| 3 | Energy production and mining | | Unknown | Restricted - Small (1-30%) | Unknown | Moderate (Possibly in the short term, < 10 yrs/3 gen) | |
| 3.1 | Oil and gas drilling | | Unknown | Restricted - Small (1-30%) | Unknown | Moderate (Possibly in the short term, < 10 yrs/3 gen) | See **Threats and Limiting Factors.** |
| 3.2 | Mining and quarrying | | Unknown | Small (1-10%) | Unknown | Moderate (Possibly in the short term, < 10 yrs/3 gen)) | Sand extraction could potentially affect some small sites, particularly on private land. Sand is not suitable for fracking so commercial extraction unlikely. |
| 3.3 | Renewable energy | | | | | | Not considered threats. The probability of solar energy or wind turbine construction within the area is unlikely. Moths are attracted to lights, but Dusky Dune Moth habitats are mostly far away from lights and light pollution, so this is unlikely a threat. |
| 4 | Transportation and service corridors | | Negligible | Negligible (<1%) | Extreme (71 - 100%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | |

| Threat | | Impact[1] (calculated) | Scope[2] (Next 10 Yrs) | Severity[3] (10 Yrs or 3 Gen.) | Timing[4] | Comments |
|---|---|---|---|---|---|---|
| 4.1 | Roads and railroads | Negligible | Negligible (<1%) | Extreme (71-100%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | There is an increasing extent of access corridors associated with natural gas extraction in southwestern Saskatchewan, with more than 240 km of new access roads and trails constructed between 1991 and 2005 to access the oil and gas wells in the Great SH (Government of Saskatchewan 2007; Hugenholtz *et al*. 2011). Given the infrequent use, relatively low vehicle speeds, and nocturnal behaviour of Dusky Dune Moths, it is unlikely that motor vehicles pose a significant mortality risk. Although these linear disturbances may increase the risk of invasive species (see IUCN Threat 8), their verges can provide semi-stabilized sandy habitat that may be suitable for Dusky Dune Moths. |
| 4.2 | Utility and service lines | | | | | Not considered threats. There is increased pipeline activity related to gas drilling in certain areas of southern Saskatchewan and Alberta. Pipeline construction and maintenance (e.g., hydrostatic testing) can create a network of linear disturbance in sandy habitats, although actual impacts on Dusky Dune Moth or their host plants have not been documented. Pipelines can also be a source of invasive plants. |
| 5 | Biological resource use | Negligible | Negligible (<1%) | Extreme (71-100%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | |
| 5.1 | Hunting and collecting terrestrial animals | Negligible | Negligible (<1%) | Extreme (71-100%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Not considered threats. Specimen collection was not considered a threat in the first COSEWIC (2007) status report or the recovery strategy (Environment Canada 2015). Overall mortality from targeted or inadvertent collecting is not expected to threaten Canadian subpopulations since permits are required, search effort is low, and live-trapping is often used at the few sites with repeat visits. |
| 6 | Human intrusions and disturbance | Negligible | Negligible (<1%) | Slight (1-10%) | High (Continuing) | |
| 6.1 | Recreational activities | Negligible | Restricted (11-30%) | Negligible (<1%) | High (Continuing) | Sand dunes are popular with all-terrain vehicle (ATV) users and ATV tracks have been observed at a small number of dunes or blowouts with Dusky Dune Moth (COSEWIC 2007), particularly the Burstall SH which are frequently targeted by local ATV users (Environment Canada 2015). There is a small risk of Dusky Dune Moths (particularly larvae or pupae) being crushed by ATVs. This risk may be partially mitigated by the beneficial effect that ATV use likely has on slowing down the rate of dune stabilization. ATVs and other vehicles can introduce invasive plants e.g., White Sweet Clover (*Melilotus albus*) seeds on tires (Hayley 2013) but impacts on Dusky Dune Moth habitat have not been demonstrated (see IUCN Threat 8).<br><br>Dusky Dune Moths and their habitat could be similarly impacted by high visitor use at occupied sites at Spirit Sands (Brandon SH) in Spruce Woods PP and in the Elbow SH at Douglas PP (Environment Canada 2015). Most of the thousands of visitors annually at Spirit Sands likely stay on the marked self-guiding trail, but there remains a small risk of trampling. Trampling by visitors may also have a beneficial effect in helping slow the rate of dune stabilization at a local scale. |

| Threat | | Impact[1] (calculated) | | Scope[2] (Next 10 Yrs) | Severity[3] (10 Yrs or 3 Gen.) | Timing[4] | Comments |
|---|---|---|---|---|---|---|---|
| 6.2 | War, civil unrest and military exercises | | Unknown | Small (1-10%) | Unknown | High (Continuing) | See **Threats and Limiting Factors.** |
| 6.3 | Work and other activities | | | | | | Not considered threats. This includes potential incidental mortality from research activities other than moth trapping (accounted for under Hunting and Collecting). Permits that stipulate capture techniques and limits are typically required (e.g., in parks and military bases) which will limit incidental mortality. |
| 7 | Natural system modifications | CD | Medium - Low | Pervasive (71-100%) | Moderate - Slight (1-30%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | |
| 7.1 | Fire and fire suppression | | Unknown | Pervasive (71-100%) | Neutral or Potential Benefit | High (Continuing) | See **Threats and Limiting Factors**. |
| 7.2 | Dams and Water Management/ Use | | Not Calculated (outside assessment time frame | Small (1-10% | Extreme (71-100%) | Low (Possibly in the long term, >10 yrs/3 gen) | Not considered threats. There is a dam planned for construction on South Saskatchewan River (Meridian Project), if it ever went ahead, could potentially flood some Dusky Dune Moth habitat |
| 7.3 | Other ecosystem modifications | CD | Medium - Low | Pervasive (71-100%) | Moderate - Slight (1-30%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | See **Threats and Limiting Factors**. |
| 8 | Invasive and other problematic species and genes | | Unknown | Unknown | Moderate - Slight (1-30%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | |
| 8.1 | Invasive non-native/alien species | | Unknown | Unknown | Moderate - Slight (1-30%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | See **Threats and Limiting Factors**. Invasive plants scored under 7.3 since mechanism is considered an ecosystem modification. |
| 8.2 | Problematic native species | | | | | | Scored under 7.3 and is considered an ecosystem modification. Native plants (including trees such as aspens and pines) encroach and stabilize dunes due to the climate regime that is wetter and warmer than historically. This is likely to continue within the coming decades. Encroachment is coming from the edges of the habitat, but not happening throughout the entire habitat and is not equally distributed. |
| 9 | Pollution | | Negligible | Negligible (<1%) | Negligible (<1%) | Low (Possibly in the long term, >10 yrs/3 gen) | |
| 9.1 | Domestic and Urban Wastewater | | | | | | Not considered threats. Canadian Forces Detachment (CFD) Dundurn and Canadian Forces Base (CFB) Shilo have their own garbage dumps, although the scope is negligible, and the debris is contained. |

| Threat | | Impact[1] (calculated) | Scope[2] (Next 10 Yrs) | Severity[3] (10 Yrs or 3 Gen.) | Timing[4] | Comments |
|---|---|---|---|---|---|---|
| 9.3 | Agricultural and forestry effluents | Negligible | Negligible (<1%) | Negligible (<1%) | Low (Possibly in the long term, >10 yrs/3 gen) | It is unlikely that pesticides or herbicides are sprayed by ranchers on native prairie near Dusky Dune Moth habitat. Dusky Dune Moths, as well as their larval food plants could potentially be impacted by the drift of agrochemicals used to control pest insects or weeds on adjacent agricultural fields or hayfields (e.g., Davis *et al.* 1991). However, most known Dusky Dune Moth habitats are more than 1 km from adjacent agricultural fields, so it appears that there is a negligible risk. Chemical control methods were used from 1983 to 2009 in Spruce Woods PP to control Leafy Spurge (MCWS 2012). Impacts, if any, on Dusky Dune Moths are unknown. |
| 9.4 | Garbage and solid waste | | | | | Not considered threats. CFD Dundurn and CFB Shilo have their own garbage dumps, although the scope is negligible, and the debris is contained. |
| 11 | Climate change and severe weather | Unknown | Pervasive (71-100%) | Unknown | Moderate (Possibly in the short term, < 10 yrs/3 gen) | |
| 11.1 | Habitat shifting and alteration | Unknown | Pervasive (71-100%) | Unknown | Moderate | The projected human-influenced climate change to warmer and drier conditions on the Canadian Prairies may eventually be enough to initiate dune activity, which would likely benefit Dusky Dune Moth. However, the likelihood of this occurring in the next 10 years is unknown. |
| 11.2 | Droughts | | | | | Not considered threats. The increase in droughts would likely benefit Dusky Dune Moth due to reduced dune stabilization |
| 11.3 | Temperature extremes | Unknown | Pervasive (71-100%) | Unknown | Moderate (Possibly in the short term, < 10 yrs/3 gen) | In the short-term, small, isolated subpopulations of Dusky Dune Moth are likely vulnerable to stochastic events and could be threatened by hailstorms or severe early or late frosts, particularly if the frequency and intensity of severe weather events increases due to climate change. |
| 11.4 | Storms and flooding | | | | | Not applicable. No evidence of impacts on Dusky Dune Moth. |

[1]**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%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity is unknown).

[2]**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%)

[3]**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%).

[4]**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.

Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of Dusky Dune Moth in Canada. Limiting factors are not considered during this assessment process. For purposes of threat assessment, only present and future threats are considered. Historical threats, indirect or cumulative effects of the threats, or any other relevant information that would help understand the nature of the threats are presented under the subheadings below.

Threats for Dusky Dune Moth were assessed for the entire Canadian Range. The progressive stabilization of sand hill habitat is the most significant threat to Dusky Dune Moth (COSEWIC 2007; Environment Canada 2015). This natural process is largely driven by regional climate trends, but has accelerated over the last 150 years, in part due to decreasing aridity, reduced wildfire and the decline in abundance of Plains Bison, which otherwise prevent the natural succession of native vegetation. The overall assigned threat impact is Medium based on input from various regional experts and moth specialists (see Table 5 for full list of participants). Threats below are written highest to least impact and only those scored or unknown are discussed.

Threat 7 Natural system modifications (Medium – Low impact)

*7.3 Other ecosystem modifications (Medium – Low impact).*

Dune stabilization is the predominant threat to Dusky Dune Moth subpopulations and habitat, particularly at small (<1 ha) blowouts that now support many of the known occurrences (Table 1). This is a pervasive and continuing threat at all known sites throughout its Canadian range and is largely driven by long-term climate trends (see **Habitat Trends**), natural and non-native plant succession and the lack of disturbance from fire and the decline in abundance of Plains Bison. These threats are discussed under the appropriate subheadings; however, they are scored under this subcategory because the threat of dune stabilization is the proximate threat to the moth.

Invasive non-native plant species can accelerate the process of dune stabilization and may also negatively impact larval host plant growth (e.g., due to competition). Non-native plant species such as Smooth Brome (*Bromus inermis*), Leafy Spurge (*Euphorbia esula*), Crested Wheatgrass (*Agropyron cristatum*), and sweet clovers (*Melilotus* spp.) are present in Canadian dunes and have the potential to out-compete native vegetation, altering ecosystem properties and ecological integrity (Schykulski and Moore 1996; Henderson and Naeth 2005; Catling and Mitrow 2012; MCWS 2012). Invasive non-native plant species can rapidly colonize active dune areas, accelerating the establishment of both native and non-native vegetation (Environment Canada 2016).

At present, non-native invasive plants are generally not abundant in dry grasslands or sand dunes with Dusky Dune Moth subpopulations and are mainly associated with cattle grazing and infrastructure development (Page pers. obs. in Environment Canada 2016; Foster pers. comm 2021). However, at the Pakowki Lake SH, Crested Wheatgrass and Baby's Breath were observed growing in dense stands near the active dunes (Jensen *et al*. 2009).

At Spruce Woods PP (MB), Sweet Clover, Smooth Brome, and particularly Leafy Spurge are considered major threats for the long-term integrity and sustainability of the native habitat at this site (Schykulski and Moore 1996) and control is ongoing (Province of Manitoba 2015). Nearby farmsteads, gas wells, roads, and associated infrastructure in the sand hills near many known Dusky Dune Moth sites likely increase the likelihood of non-native species invading the moth's habitat.

Although the effects of fire suppression on Dusky Dune Moth habitat are not well understood, fire suppression likely exacerbates vegetation encroachment and dune stabilization, reducing habitat availability for moths.

The loss of Plains Bison may have also contributed to dune stabilization. Grazing, trailing, wallowing, horning, and trampling by Plains Bison helped create and maintain a patchy disturbance mosaic in the sand hills of the southern Canadian prairies; the beneficial effects of which could potentially be re-established by the reintroduction of Plains Bison (Fox *et al.* 2012).

*7.1 Fire and fire suppression (Unknown).*

Historically, prairie grasslands burned every 5-10 years (Wright and Bailey 1982), although it is unclear to what extent dunes burned due to lack of fuel load. Wildfire is now relatively uncommon and actively suppressed at or near most known Dusky Dune Moth sites in Canada. This is not necessarily the case for fires on military bases unless they threaten infrastructure or adjacent properties. Fires may extirpate local occurrences of Dusky Dune Moths, but prairie wildfires tend to move rapidly, and dune habitats likely have relatively low fuel loads. Moth mortality may also be mitigated by the mobility of adults and if pupae are buried in the sand at a sufficient depth to avoid mortality by a surface fire.

Threat 3: Energy production and mining (Unknown impact)

*3.1 Oil and gas drilling (Unknown).*

Over the past several decades there has been a dramatic increase in natural gas extraction activities and associated infrastructure (e.g., gas wells, trails, pipelines, compressors) in the sand hills in southwestern SK and adjacent AB (Hugenholtz *et al.* 2010). The footprint of these activities is relatively small, however, and typically situated on level and stable ground. These developments are often in proximity to known Dusky Dune Moth subpopulations (i.e., Cramersburg SH [Anweiler 2009]), and none appear to have been developed on occupied Dusky Dune Moth habitat. Oil and gas drilling is a potential threat at the Seward, Middle, and Tunstall SH (Environment Canada 2015).

Oil and gas activity, and their associated roads (see *Transportation and Service Corridors* in Table 5) can facilitate the introduction of non-native plants, but the road verge can also provide potentially suitable semi-stabilized dune habitat. Shallow gas drilling could lower water tables, which could improve habitat for Dusky Dune Moth if it leads to less dune stabilization.

*3.2 Mining and Quarrying (Unknown impact).*

Large-scale sand excavation for industrial use (e.g., construction, fracking) is a potential risk to Dusky Dune Moth habitat, particularly on private land. The commercial-scale removal of sand from active sand dunes would destroy habitat; however, the periodic disturbance from sand removal activities in stabilized dunes has the potential to create suitable habitat (Environment Canada 2015).

Threat 6. Human intrusions and disturbance (Negligible)

*6.2 War, civil unrest and military exercises (Unknown impact)*

This threat is potentially applicable at the habitats of three extant subpopulations: Canadian Forces Base (CFB) Shilo, CFB Suffield, and CFD Dundurn. The scope of current activities is not fully known, but military training with heavy vehicles, the use of explosives, and disturbance from associated fires may help maintain semi-open dune habitats on these bases. These activities may also cause mortality of Dusky Dune Moth individuals. Dusky Dune Moths have been observed at a firebreak created on CFD Dundurn, and similar habitat at CFB Shilo (Brandon SH) may also be occupied by Dusky Dune Moths (i.e., historical records from Aweme and Onah). The known Middle SH Dusky Dune Moth subpopulation is located within the National Wildlife Area (NWA) which does not have military activity; it is not known if there is any occupied habitat on the adjacent military base.

Threat 8. Invasive and other problematic species and genes (Unknown impact)

*8.1 Invasive non-native/alien species (Unknown impact).*

The Rose Stem Girdler (*Agrilus cuprescens*[14]) is a buprestid beetle that was introduced to North America in the early 1900s (Paiero *et al*. 2012) and has since spread through to the Prairie provinces. There has been a noticeable reduction in the abundance of wild roses (*Rosa* spp.) over the last two decades in southwestern SK, which has been attributed to the Rose Stem Girdler (Larson 2003, 2009). Areas affected include sand hills where Dusky Dune Moth are found (e.g., Great SH). Roses are a known larval host plant for the Dusky Dune Moth, but the extent to which the girdler has impacted roses at known Dusky Dune Moth sites is unknown. Invasive plant species are not scored here because they are proximate, result in ecosystem modifications, and are scored in threat category 7.3.

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

*11.1 Habitat shifting and alteration (Unknown impact).*

The potential impact of climate change on Canadian Dusky Dune Moths and their habitats is unknown and unlikely to be demonstrated in the short term, but likely beneficial over the long term (>10 years). Decreased precipitation and increased mean annual temperatures and aridity associated with climate change could slow stabilization of dune habitats, particularly if there are prolonged and/or severe droughts (Hugenholtz *et al.* 2010). The impacts are difficult to predict, however, and the long-term impact of climate change on future Dusky Dune Moth habitat may depend on the unknown interplay of temperatures, aridity, and vegetation dynamics.

*11.3 Temperature extremes (Unknown impact).*

In the short-term, small, isolated subpopulations of Dusky Dune Moths are likely vulnerable to stochastic weather events and could be threatened by hailstorms or severe early or late frosts, particularly if the frequency and intensity of severe weather events increases due to climate change.

## Limiting Factors

The distribution and abundance of Dusky Dune Moths are inherently limited by the scarcity of active sand dune habitats in Canada. Dune fields within the moth's Canadian range are often isolated and separated from each other by extensive tracts of unsuitable habitat, making successful dispersal, migration, and re-colonization unlikely (Environment Canada 2016). Dispersal distances are unknown but are likely less than 10 km for this species (COSEWIC 2007; NatureServe 2020) and may limit dispersal among patches of suitable habitat within and among sand hills. Isolated subpopulations can be vulnerable to local extinction events, reducing the subpopulation's potential to persist.

[14] Formerly *A. aurichalceus*

## Number of Locations

Dune stabilization is the greatest single threat to Canadian Dusky Dune Moth subpopulations. However, dune stabilization is ultimately driven by longer-term trends in regional climate and fire suppression, and non-climatic factors such as cattle grazing, fire, and other disturbance factors are likely important at the local scale for increasing dune activity (Hugenholtz *et al.* 2010). Local variation in land management may therefore be important in mitigating dune stabilization and reducing the threat to Dusky Dune Moth subpopulations. In addition, many Dusky Dune Moth subpopulations (including the numerous sites within some subpopulation habitats) are relatively isolated from each other and are unlikely to be affected by a single threatening event. Based on these factors, each of the 13 extant Dusky Dune Moth subpopulations in Canada represents a separate location[15]. Given that only a small proportion of potentially suitable habitat has been surveyed for Dusky Dune Moth, it is likely there are an additional undocumented 5 subpopulations.

# PROTECTION, STATUS AND RANKS

## Legal Protection and Status

Dusky Dune Moth is listed as Endangered (February 2010) under Schedule 1 of the federal *Species at Risk Act*.

Dusky Dune Moth is listed as Endangered by the province of Manitoba under its *Endangered Species and Ecosystems Act* (Government of Manitoba 2020). It is not protected under the wildlife acts of Alberta (Government of Alberta 2017) or Saskatchewan (Government of Saskatchewan 1999; Benville pers. comm. 2020).

## Non-Legal Status and Ranks

Dusky Dune Moth is globally ranked as Apparently Secure (G4) and in Canada is nationally ranked as Imperilled (N2) (NatureServe 2020). It is ranked as Critically Imperilled (S1S2) in Manitoba (MB CDC 2020) and Saskatchewan (SK CDC 2020) and Imperilled (S2) in Alberta (ACIMS 2020). In the United States, it has not been ranked at the national or any state level (NatureServe 2020).

Dusky Dune Moth is not listed under the United States *Endangered Species Act* or the *Convention on International Trade in Endangered Species of Wild Fauna and Flora*.

[15] The COSEWIC (2021) definition of location is “a geographically distinct area in which a single threatening event can rapidly affect all individuals of the species”.

## Habitat Protection and Ownership

Most Canadian Dusky Dune Moth subpopulations occur on publicly owned lands (Table 3), primarily provincial lands that are leased for cattle grazing. Dusky Dune Moths at Spirit Dunes (Spruce Woods PP) occur in a protected area, and those at CFB Suffield NWA and Canadian Forces Detachment (CFD) Dundurn are afforded a degree of protection under the federal *Species at Risk Act*. Critical habitat has been identified in the federal recovery strategy for 10 of the 13 sand hills that have known subpopulations (Table 3), including 21 individual active sand dunes or blowouts in Alberta (n=6), Saskatchewan (n=14) and Manitoba (n=1) (Environment Canada 2015). Critical habitat was identified as the active open sand dunes and/or blowouts, encompassing the area from the crest of the dune to the edge where native vegetation grows and the dune is stabilized.

Two sparsely vegetated plant communities in which Dusky Dune Moth may occur are ranked by Alberta Natural Heritage Information Centre: 1) sand grass–sand dropseed–hay sedge herbaceous vegetation and 2) creeping juniper / sand grass–sun-loving sedge dwarf shrubland. Both are ranked as Imperilled/vulnerable (S2S3); this designation does not provide habitat protection, however (COSEWIC 2007).

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Front cover photo by Medea Curteanu (Pakowki Sand Hills, August 7, 2010).

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## BIOGRAPHICAL SUMMARY OF REPORT WRITER

Robert Foster is co-founder and principal of Northern Bioscience, an ecological consulting firm offering professional consulting services supporting ecosystem management, planning, and research. Dr. Foster has a B.Sc. in Biology from Lakehead University and a D. Phil in Zoology from the University of Oxford. Rob has worked as an ecologist in Canada for over 25 years and has conducted numerous insect surveys for protected areas planning and environmental assessments in Ontario, as well as Manitoba, Minnesota, Quebec, and British Columbia. Rob has written or co-written more than twenty COSEWIC status reports on vascular plants and arthropods, including ten butterflies and moths, and has conducted COSEWIC field surveys in the sand hills of Alberta, Saskatchewan, and Manitoba.

## COLLECTIONS EXAMINED

A search of the Symbiota Collections of Arthropods Network (SCAN) was completed (SCAN 2020). SCAN serves specimen occurrence records and images from over 100 North American arthropod collections (see SCAN 2020) for all arthropod taxa, including Lepidoptera. SCAN is the primary repository for occurrence data produced by the Lepidoptera of North America Network (LepNet) and three other thematic collection networks, as well as hosting observational data such as iNaturalist®.

Collections searched for Canadian specimens of Dusky Dune Moth:

American Museum of Natural History (AMNH), New York, New York, United States

Canadian National Collection (CNC) of Insects, Acari and Nematodes, Ottawa, Ontario

E.H. Strickland Entomological Museum (UASM), University of Alberta, Edmonton, Alberta

J. B. Wallis / R. E. Roughley Museum of Entomology (JBWM), Winnipeg, Manitoba

Manitoba Museum of Man and Nature (MMMN), Winnipeg, Manitoba

Milwaukee Public Museum (MPM), Milwaukee, Wisconsin, United States

Musée National d'Histoire Naturelle (MNHN), Paris, France

Museum of Southwestern Biology (MSB), University of New Mexico, Albequerque, New Mexico, United States

Museum of Zoology (BDUC), Department of Biological Sciences, University of Calgary, Calgary, Alberta

Natural History Museum (NHM), London, England

Northern Forestry Centre (NRC-FRS, NFRC), Natural Resources Canada, Edmonton, Alberta

Olds College, Olds, Alberta

Royal Alberta Museum (RAB), Edmonton, Alberta

Royal British Columbia Museum (RBCM), Victoria, British Columbia

Royal Ontario Museum (ROM), Toronto, Ontario

Royal Saskatchewan Museum (RSM), Saskatoon, Saskatchewan

Severin-McDaniel Insect Research Collection (SDSU), South Dakota State University, Brookings, South Dakota, United States

Smithsonian National Museum of Natural History (USNM), Washington, D.C. United States

Spencer Entomological Collection, Beaty Biodiversity Museum (UBCZ), University of British Columbia, Vancouver, British Columbia

Texas A and M University (TAMU), College Station, Texas, United States

University of Guelph Insect Collection (DEBU), Guelph, Ontario

University of Minnesota (UMSP), St. Paul, Minnesota, United States

University of Nebraska State Museum (UNSM), Lincoln, Nebraska, United States

University of North Dakota Insect Collection (IND-IC), University of North Dakota, Grand Forks, North Dakota, United States

Wisconsin Insect Research Collection WIRC, University of Wisconsin, Madison, Wisconsin, United States

Yale Peabody Museum of Natural History (PMNH), New Haven, Connecticut, United States

## Appendix 1. Known Canadian specimens of Dusky Dune Moth (*Copablepharon longipenne*) and associated subpopulation number (SP #).

| Sand Hill (SH) | SP # | Original Site Name | Collector | Date | DDM | Specimen Location | Information Source |
|---|---|---|---|---|---|---|---|
| Big Stick SH – Crane Lake SH | 5 | Bigstick Sand Hills (Tompkins area) | R. Hooper | 1969-07-22 | 1 | RSM | COSEWIC (2007); Sheffield (pers. comm. 2017) |
| Brandon SH | 13 | Aweme | N. Criddle | 1910-07-20 | 1 | RSM | COSEWIC (2007) |
| Brandon SH | 13 | Aweme | E. Criddle | 1911-08-08 | 1♂ | CNC | COSEWIC (2007) |
| Brandon SH | 13 | Onah | N. Criddle | 1919-07-30 | 1♀ | CNC | COSEWIC (2007) |
| Brandon SH | 13 | Aweme | R.H. Handford | 1931-08-17 | 1 | NFRC | MB CDC |
| Brandon SH | 13 | Bald Head Hills 13 mi N Glenboro | N.B. Chillcott | 1958-08-08 | 20♂, 6♀ | CNC | COSEWIC (2007) |
| Brandon SH | 13 | Bald Head Hills 13 mi N Glenboro | N.B. Chillcott | 1958-08-09 | 1♂ | CNC | COSEWIC (2007) |
| Brandon SH | 13 | Spirit Dunes | J. Troubridge | 2003-07-21 | 50♂ | CNC | COSEWIC (2007) |
| Brandon SH | 13 | Spruce Woods Provincial Park, Spirit Dunes | G.G. Anweiler | 2004-07-29 | 8♂ | UASM | COSEWIC (2007) |
| Brandon SH | 13 | Spruce Woods Provincial Park, Spirit Dunes | G.G. Anweiler | 2004-08-04 | 2♂ | UASM | COSEWIC (2007) |
| Brandon SH | 13 | Spruce Woods Provincial Park, Spirit Dunes | C. Murray | 2012-08-08 | 8 | live-released | MB CDC |
| Brandon SH | 13 | Spruce Woods Provincial Park, Spirit Dunes | C. Murray | 2012-08-08 | 1 | live-released | MB CDC |
| Brandon SH | 13 | Spruce Woods Provincial Park | K.E. Johnson | 2018-07-28 | 1? | | SCAN (2020) |
| Brandon SH | 13 | Aweme | unknown | unknown | 1♂ | USNM | COSEWIC (2007) |
| Burstall SH | 6 | Burstall Dunes | R. Hooper | 1977-08-10 | 2 | RSM | COSEWIC (2007); Sheffield (pers. comm. 2017) |
| Burstall SH | 6 | Burstall Dunes (6 km N) | J.F. Landry | 1985-07-02 | 1♀ | CNC | COSEWIC (2007) |
| Burstall SH | 6 | Burstall Dunes (6 km N) | unknown | 1996-07-10 | 1♂ | LACM | COSEWIC (2007) |
| Burstall SH | 6 | Burstall Dunes | J. Troubridge | 1998-07-01 | 50♂ | CNC | COSEWIC (2007) |
| Burstall SH | 6 | Burstall Dunes | J. Troubridge | 1998-07-01 | 1 | CSUC | SCAN (2020) |
| Burstall SH | 6 | Burstall Dunes | J. Troubridge | 1998-07-01 | 5 | USAM | SCAN (2020); UASM |
| Burstall SH | 6 | Burstall, dunes 3 km north | J. Troubridge | 1999-07-13 | 50♂ | CNC | COSEWIC (2007) |
| Burstall SH | 6 | Burstall, dunes 3 km north | J. Troubridge | 1999-07-13 | 31♂ | UASM | Lafontaine *et al.* (2014); SCAN (2020); UASM |
| Burstall SH | 6 | Burstall (coordinates match 6 km north) | J. Troubridge and G.G. Anweiler | 2001-08-13 | 39 | UASM | SCAN (2020); UASM |
| Burstall SH | 6 | Burstall, dunes 3 km north | J. Troubridge and G.G. Anweiler | 2001-08-13 | 2 | UASM | SCAN (2020); UASM |
| Burstall SH | 6 | Burstall, 6 km north of | B.C. Schmidt | 2004-07-26 | 6♂ | UASM | COSEWIC (2007); UASM |
| Burstall SH | 6 | Burstall, 3 km north of | D. Glaeske | 2009-07-25 | 5 | private | Glaeske pers. comm. 2020 |

| Sand Hill (SH) | SP # | Original Site Name | Collector | Date | DDM | Specimen Location | Information Source |
|---|---|---|---|---|---|---|---|
| Burstall SH | 6 | Burstall: Dune 320 | V. Snable and S. Westworth (CWS) | 2015-07-24 | 5 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall: Dune 320 | V. Snable and S. Westworth (CWS) | 2015-07-25 | 16 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall: Dune 325 | V. Snable and S. Westworth (CWS) | 2015-07-25 | 3 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall: Dune 328 | V. Snable and S. Westworth (CWS) | 2015-07-25 | 5 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall: Dune 328 | V. Snable and S. Westworth (CWS) | 2015-07-25 | 19 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall: Dune 325 | V. Snable and S. Westworth (CWS) | 2015-07-25 | 4 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall: Dune 327 | V. Snable and S. Westworth (CWS) | 2015-07-25 | 3 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall: Dune 324 | V. Snable and S. Westworth (CWS) | 2015-07-26 | 3 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall: Dune 324 | V. Snable and S. Westworth (CWS) | 2015-07-26 | 4 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall: Dune 327 | V. Snable and S. Westworth (CWS) | 2015-07-26 | 15 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall, transect East of Dune 320 | V. Snable and S. Westworth (CWS) | 2015-07-26 | 1 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall, active blowout between Dune 328-332 | V. Snable and S. Westworth (CWS) | 2015-07-29 | 3 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall, dune blowout on Brunner property | V. Snable and S. Westworth (CWS) | 2015-07-30 | 1 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall, semi-stable dune east of Dune 232 | V. Snable and S. Westworth (CWS) | 2015-07-30 | 3 | | Curteanu (unpublished data) |
| Burstall SH | 6 | Burstall: Dune 322 | V. Snable and S. Westworth (CWS) | 2015-07-30 | 21 | | Curteanu (unpublished data) |
| Cramersburg SH | 7 | Cramersburg Sandhills: Site B (southwest edge of active dune) | N. Page and D. Mou | 2005-07-23 | 3♀ | CNC | COSEWIC (2007) |
| Cramersburg SH | 7 | Cramersburg Sandhills: Site C (northeast edge of active dune) | N. Page and D. Mou | 2005-07-23 | 24♂ | CNC | COSEWIC (2007) |
| Cramersburg SH | 7 | Cramersburg Sand Hills | N. Page | 2005-07-24 | 1 | RSM | Sheffield (pers. comm. 2017) |
| Cramersburg SH | 7 | Cramersburg Sand Hills | R. Hooper | 2005-07-24 | 1 | RSM | Sheffield (pers. comm. 2017) |
| Cramersburg SH | 7 | 15 km ENE Abbey | G.G. Anweiler | 2009-08-09 | 1 | none | SCAN (2020) |
| Cramersburg SH | 7 | Cramersburg Sand Hills | G.G. Anweiler and W. Falk | 2010-08-09 | | | Anweiler (2009); Golder Associates Inc (2009) |
| Cramersburg SH | 7 | Cramersburg Sand Hills | G.G. Anweiler and W. Falk | 2010-08-09 | | | Anweiler (2009); Golder Associates Inc (2009) |
| Cramersburg SH | 7 | Cramersburg Sand Hills (15 km ENE Abbey) | G.G. Anweiler and W. Falk | 2010-08-09 | | | Anweiler (2009); Golder Associates Inc (2009) |
| Cramersburg SH | 7 | Carry the Kettle Nakoda First Nation I.R. 76-33: Dune 340 | M.-C. Belair, S.M. Westworth | 2011-08-06 | 14 | RSM | Curteanu *et al.* (2011); Sheffield (pers. comm. 2017) |
| Cramersburg SH | 7 | Carry the Kettle Nakoda First Nation I.R. 76-38: Dune 339 | M.-C. Belair, S.M. Westworth | 2011-08-07 | 1 | | Curteanu *et al.* (2011) |

| Sand Hill (SH) | SP # | Original Site Name | Collector | Date | DDM | Specimen Location | Information Source |
|---|---|---|---|---|---|---|---|
| Cramersburg SH | 7 | Carry the Kettle Nakoda First Nation I.R. 76-38: Dune 341 | M.-C. Belair, S.M. Westworth | 2011-08-07 | 3 | | Curteanu *et al.* (2011) |
| Dominion SH | 1 | Onefour, Dominion Range Station | D.F. Hardwick | 1951-07-10 | 2♀ | CNC | COSEWIC (2007) |
| Dundurn SH | 8 | Dundurn Base: Site 1 (Fireguard South) | N. Page and D. Mou | 2004-08-03 | 34♂ | CNC | COSEWIC (2007) |
| Dundurn SH | 8 | Dundurn Base: Site 2 (Fireguard North) | N. Page and D. Mou | 2004-08-03 | 44♂ | CNC | COSEWIC (2007) |
| Dune Point SH | 2 | Bindloss (12 km NW of; "Dune point") | B.C. Schmidt | 2004-06-27 | 1♂ | UASM | COSEWIC 2007; Schmidt (pers. comm. 2020) |
| Dune Point SH | 2 | Dune Point: Dune 104 | V. Snable and S. Westworth (CWS) | 2015-07-28 | 6 | | Curteanu (unpublished data) |
| Dune Point SH | 2 | Dune Point: Dune 105 | V. Snable and S. Westworth (CWS) | 2015-07-28 | 16 | | Curteanu (unpublished data) |
| Dune Point SH | 2 | Dune Point: Dune 105 | V. Snable and S. Westworth (CWS) | 2015-07-29 | 1 | | Curteanu (unpublished data) |
| Dune Point SH | 2 | Dune Point: Dune 107 | V. Snable and S. Westworth (CWS) | 2015-07-29 | 10 | | Curteanu (unpublished data) |
| Dune Point SH | 2 | Dune Point: Dune 107 | V. Snable and S. Westworth (CWS) | 2015-07-29 | 3 | | Curteanu (unpublished data) |
| Elbow SH | 9 | Elbow Community Pasture: Dune 419 | M.-C. Belair, S.M. Westworth | 2011-08-09 | 2 | | Curteanu *et al.* (2011); Environment Canada (2011) |
| Great SH | 10 | Great Sand Hills | J. Troubridge | 1999-07-13 | 1♂ | UASM | SCAN (2020); UASM |
| Great SH | 10 | Great Sand Hills (Liebenthal area) | L.G. Crabo and J. Troubridge | 1999-07-13 | 1♂ | CNC | COSEWIC (2007) |
| Great SH | 10 | Great Sand Hills (Liebenthal area): Site A (west edge of Boot dune) | N. Page and D. Mou | 2005-07-24 | 12♂ | CNC | COSEWIC (2007) |
| Great SH | 10 | Great Sand Hills (Liebenthal area): Site B (dune ridge south of Boot dune) | N. Page and D. Mou | 2005-07-24 | 5♂ | CNC | COSEWIC (2007) |
| Great SH | 10 | Great Sand Hills (Liebenthal area): Site C (grass dune ridge north of road) | N. Page and D. Mou | 2005-07-24 | 1♂ | CNC | COSEWIC (2007) |
| Great SH | 10 | Great Sand Hills (Liebenthal area): Ausmus Ranch: Site B | D. Glaeske | 2009-07-28 | 4 | private | Glaeske pers. comm. 2020 |
| Middle SH | 3 | Suffield N.W.R. (Middle Sandhills) | G.G. Anweiler | 2008-08-12 | 1? | no specimen | SCAN (2020) |
| Middle SH | 3 | Suffield National Wildlife Area: Amiens | G.G. Anweiler | 2008-08-13 | 3 | UASM | SCAN (2020); UASM |
| Middle SH | 3 | Suffield National Wildlife Area: Amiens | G.G. Anweiler and CWS | 2008-08-13 | 3 | UASM | Curteanu (unpublished data); SCAN (2020); UASM |
| Middle SH | 3 | Suffield National Wildlife Area: Dune 27 (Ypres East) | M.C. Curteanu, S.M. Westworth | 2010-08-05 | 4 | UASM | Curteanu (2011); Curteanu *et al.* (2011), Environment Canada (2015) |
| Middle SH | 3 | Suffield WMA | M.C. Curteanu | 2010-08-07 | 1 | UASM | SCAN (2020); UASM |
| Middle SH | 3 | Suffield WMA | M.C. Curteanu | 2010-08-09 | 1 | UASM | SCAN (2020); UASM |

| Sand Hill (SH) | SP # | Original Site Name | Collector | Date | DDM | Specimen Location | Information Source |
|---|---|---|---|---|---|---|---|
| Pakowki Lake SH | 4 | Manyberries (Pakowki Lake) | H.L. Seamans | 1925-07-22 | 6♂, 1♀ | CNC | COSEWIC (2007) |
| Pakowki Lake SH | 4 | Manyberries (Pakowki Lake) | H.L. Seamans | 1925-07-22 | 1♂ | LACM | COSEWIC (2007) |
| Pakowki Lake SH | 4 | Pakowki Lake: Dune 60 | G.G. Anweiler and CWS | 2008-08-10 | 9 | UASM | Curteanu (unpublished data); SCAN (2020); UASM |
| Pakowki Lake SH | 4 | Pakowki Lake: Dune 60 | M.C. Curteanu, S.M. Westworth | 2010-08-07 | 1 | UASM | Curteanu (2011); Environment Canada (2011) |
| Pakowki Lake SH | 4 | Pakowki Lake: Dune 66 | M.C. Curteanu, S.M. Westworth | 2010-08-07 | 4 | UASM | Curteanu (2011); Environment Canada (2011) |
| Pakowki Lake SH | 4 | Manyberries (Pakowki Lake) | unknown | unknown | 1♂ | AMNH | COSEWIC (2007) |
| Seward SH | 11 | Seward Sand Hills: Site A (edge of large open dune) | N. Page and D. Mou | 2004-08-05 | 142⚥ | CNC | COSEWIC (2007) |
| Seward SH | 11 | Seward Sand Hills: Site B (stabilized dune to south) | N. Page and D. Mou | 2004-08-05 | 10⚥ | CNC | COSEWIC (2007) |
| Seward SH | 11 | Seward Sand Hills: Site C (open dune to southwest) | N. Page and D. Mou | 2004-08-05 | 134⚥ | CNC | COSEWIC (2007) |
| Tunstall SH | 12 | Bitter Lake Community Pasture: Dune 761 | M.C. Curteanu, S.M. Westworth | 2010-08-08 | 7 | UASM | Curteanu *et al.* (2011) |
| Tunstall SH | 12 | Bitter Lake Community Pasture: Dune 762 (Trap 1) | M.C. Curteanu, S.M. Westworth | 2010-08-08 | 26 | UASM | Curteanu *et al.* (2011) |
| Tunstall SH | 12 | Bitter Lake Community Pasture: Dune 762 (Trap 2) | M.C. Curteanu, S.M. Westworth | 2010-08-08 | 37 | UASM | Curteanu *et al.* (2011) |
| Tunstall SH | 12 | Bitter Lake Community Pasture: Dune 771 | M.C. Curteanu, S.M. Westworth | 2010-08-08 | 10 | UASM | Curteanu *et al.* (2011) |
| unknown | 0 | Lethbridge (specific site unknown) | H.E. Gray | 1922-07-31 | 1♀ | LACM | COSEWIC (2007) |
| unknown | 0 | Lethbridge (specific site unknown) | H.E. Gray | 1922-08-03 | 1♂ | CNC | COSEWIC (2007) |
| unknown | 0 | Lethbridge (specific site unknown) | H.E. Gray | 1922-08-13 | 1♀ | CNC | COSEWIC (2007) |
| unknown | 0 | Lethbridge (specific site unknown) | H.E. Gray | 1922-08-14 | 1♂ | CNC | COSEWIC (2007) |
| unknown | 0 | Lethbridge (specific site unknown) | H.E. Gray | 1922-08-23 | 1♀ | CNC | COSEWIC (2007) |
| unknown | 0 | Sunnydale, Lloydminster | P.F. Bruggemann | 1942-07-03 | 1♂ | CNC | COSEWIC (2007) |

AMNH = American Museum of Natural History

CNC = Canadian National Collection of Insects, Arachnids and Nematodes

CSUC = C.P. Gillette Museum of Arthropod Diversity (CSU-CSUC)

LACM = Los Angeles County Museum

RSM = Royal Saskatchewan Museum

UASM = University of Alberta – Strickland Museum

♂ = female

♀ = male

⚥ = bigender

## Appendix 2. Summary of documented search effort for Dusky Dune Moth (*Copablepharon longipenne*) in Canada.

| Sand Hill (SH) | Sub-pop'n # | Locality | Year | Survey Date(s) | Observer | # Surveyed Sites[1] | | Total Effort[2] | Information Source |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | DDM not detected | DDM detected | | |
| Big Stick SH - Crane Lake SH | 5 | Bigstick Sand Hills (Tompkins area) | 1969 | Jul 22 | R. Hooper | | 1 | | COSEWIC (2007) |
| Brandon SH | 13 | Aweme | 1910 | Jul 20 | N. Criddle | | 1 | | COSEWIC (2007) |
| Brandon SH | 13 | Aweme | 1911 | Aug 8 | E. Criddle | | 1 | | COSEWIC (2007) |
| Brandon SH | 13 | Onah | 1919 | Jul 30 | N. Criddle | | 1 | | COSEWIC (2007) |
| Brandon SH | 13 | Aweme | 1931 | Aug 17 | R.H. Handford | | 1 | | COSEWIC (2007) |
| Brandon SH | 13 | Spruce Woods Provincial Park, Spirit Dunes | 1958 | Aug 8-9 | N.B. Chillcott | | 1-2 | | COSEWIC (2007) |
| Brandon SH | 13 | Spruce Woods Provincial Park, Spirit Dunes | 2003 | Jul 21 | J. Troubridge | | 1 | | COSEWIC (2007) |
| Brandon SH | 13 | Spruce Woods Provincial Park, Spirit Dunes | 2004 | Jul 29 | G.G. Anweiler | | 1 | | COSEWIC (2007) |
| Brandon SH | 13 | Spruce Woods Provincial Park, Spirit Dunes | 2004 | Aug 4 | G.G. Anweiler | | 1 | | COSEWIC (2007) |
| Brandon SH | 13 | Spruce Woods Provincial Park, Spirit Dunes | 2012 | June-Aug | C. Murray | | 3+ | 12+ | Murray (2013); MB CDC unpubl. data |
| Brandon SH | 13 | Spruce Woods Provincial Park, Spirit Dunes | 2013 | July-Aug | C. Murray | | 3+ | 11+ | Murray (2014); MB CDC unpubl. data |
| Brandon SH | 13 | Canadian Forces Base Shilo | 2017 | Aug 14 | K.E. Johnson and S. Bransky | 3 | 0 | 3 | Johnson (2017, 2018) |
| Brandon SH | 13 | Spruce Woods Provincial Park, Spirit Dunes | 2018 | Jul 28 | K.E. Johnson | | 1 | | Johnson (2017, 2018) |
| Brandon SH | 13 | Spirit Sands, Treesbank | 2009 | Jul 7 | C. Friesen and C. Murray | 1 | | 1 | Friesen and Murray (2010); MB CDC unpubl. data |
| Buffalo Park SH | | Wainwright Dunes Ecological Reserve | 2016 | | D. Macaulay | 1 | 0 | | Macaulay (2016) |
| Buffalo Park SH | | Canadian Forces Base (ASU) Wainwright | 2016 | Aug 2,4,5 | Stantec | 12 | 0 | 16 | Stantec Consulting Ltd (2016) |
| Burstall SH | 6 | Burstall SH | 1977 | Aug 10 | R. Hooper | | 1 | | COSEWIC (2007) |
| Burstall SH | 6 | Burstall SH | 1985 | Jul 2 | J.F. Landry | | 1 | | COSEWIC (2007) |
| Burstall SH | 6 | Burstall SH | 1996 | Jul 10 | unknown | | 1 | | COSEWIC (2007) |
| Burstall SH | 6 | Burstall SH | 1998 | Jul 10 | J. Troubridge | | 1 | | COSEWIC (2007) |

| Sand Hill (SH) | Sub-pop'n # | Locality | Year | Survey Date(s) | Observer | # Surveyed Sites[1] | | Total Effort[2] | Information Source |
|---|---|---|---|---|---|---|---|---|---|
| Burstall SH | 6 | Burstall SH | 1999 | Jul 13 | J. Troubridge | | 1 | | COSEWIC (2007) |
| Burstall SH | 6 | Burstall SH | 2001 | Aug 13 | J. Troubridge and G.G. Anweiler | | 2 | | SCAN (2020) |
| Burstall SH | 6 | Burstall SH | 2004 | Jul 26 | B.C. Schmidt | | 1 | | COSEWIC (2007) |
| Burstall SH | 6 | Burstall SH | 2009 | July 25 | D. Glaeske | | 1 | 3 | Glaeske (pers. comm. 2020) |
| Burstall SH | 6 | Burstall SH | 2015 | Jul 24-30 | V. Snable and S. Westworth | 3 | 9 | 21 | Curteanu *et al*. (2011) |
| Cramersburg SH | 7 | Carry the Kettle Nakoda Nation I.R. 76 | 2005 | Jul 23-24 | N. Page and D. Mou | 2 | 2 | 4 | COSEWIC (2007) |
| Cramersburg SH | 7 | Carry the Kettle Nakoda Nation I.R. 76 | 2005 | Jul 24 | R. Hooper | | 1 | | COSEWIC (2007) |
| Cramersburg SH | 7 | Carry the Kettle Nakoda Nation I.R. 76 | 2009 | Aug 9 | G.G. Anweiler and W. Falk | 10 | 3 | 11 | Anweiler (2009) |
| Cramersburg SH | 7 | Carry the Kettle Nakoda Nation I.R. 76 | 2011 | Aug 6-7 | M.-C. Belair and S.M. Westworth | 1 | 3 | 4 | Anweiler (2009) |
| Dominion SH | 1 | Onefour, Dominion Range Station | 1951 | Jul 10 | D.F. Hardwick | | 1 | 1 | COSEWIC (2007) |
| Dundurn SH | 8 | CFD Dundurn, Cranberry Flats | 2004 | Aug 3, 6-7 | N. Page and D. Mou | 3 | 2 | 5 | COSEWIC (2007 |
| Dundurn SH | 8 | CFD Dundurn, Dundurn Community Pasture #2, Rudy Rosedale Community Pasture | 2010 | Aug 2,7 | M. Wayland | 3 | 0 | 3 | Curteanu *et al*. (2011) |
| Dundurn SH | 8 | CFD Dundurn, Dundurn Community Pasture #2 | 2011 | Aug 4, 17 | M. Wayland | 2 | 0 | 2 | Curteanu *et al.* (2011) |
| Dune Point SH | 2 | Dune Point, Blindloss | 2004 | June 27 | B.C. Schmidt | | 1 | | COSEWIC (2007) |
| Dune Point SH | 2 | Dune Point SH | 2015 | July 28-29 | V. Snable and S. Westworth | | 3 | 8 | Environment Canada (2015) |
| Edgerton SH | | Ribstone Creek Heritage Rangeland Natural Area | 2011 | Aug 13 | M.-C. Belair and S.M. Westworth | 1 | 0 | 1 | COSEWIC (2007) |
| Elbow SH | 9 | Douglas Lake Provincial Park | 2004 | Aug 4 | N. Page and D. Mou | 1 | 0 | 1 | COSEWIC (2007) |
| Elbow SH | 9 | Elbow Community Pasture | 2010 | Aug 10 | M. Wayland | 1 | 0 | 1 | COSEWIC (2007) |
| Elbow SH | 9 | Elbow Community Pasture, Douglas Lake PP | 2011 | Aug 9-10 | M.-C. Belair and S.M. Westworth | 2 | 1 | 4 | COSEWIC (2007) |

| Sand Hill (SH) | Sub-pop'n # | Locality | Year | Survey Date(s) | Observer | # Surveyed Sites[1] | | Total Effort[2] | Information Source |
|---|---|---|---|---|---|---|---|---|---|
| Great SH | 10 | Great SH | 1999 | Jul 13 | L.G. Crabo and J. Troubridge | | 1-2 | | COSEWIC (2007) |
| Great SH | 10 | Great SH | 2005 | Jul 24 | N. Page and D. Mou | | 3 | 3 | COSEWIC (2007) |
| Great SH | 10 | Great SH | 2009 | July 28 | D. Glaeske | | 1 | 3 | Glaeske (pers. comm. 2020) |
| Lauder SH | | Lauder SH (Loutitts) | 2009 | Jul 8, 23 | C. Friesen and C. Murray | 1 | | 2 | Friesen and Murray (2010); MB CDC unpubl. data |
| Lauder SH | | MHHC | 2010 | Jun 6, Jul 28 | C. Friesen and C. Murray | 1 | | 2 | Friesen and Murray (2011); MB CDC unpubl. data |
| Lauder SH | | Maple Lake Rd. | 2010 | Jul 28 | C. Friesen and C. Murray | 1 | | 1 | Friesen and Murray (2011); MB CDC unpubl. data |
| Lauder SH | | MHHC | 2011 | Jun 15, 29 | C. Friesen and C. Murray | 1 | | 2 | Murray and Friesen (2012); MB CDC unpubl. data |
| Lauder SH | | Maple Lake Rd. | 2011 | Jun 15, 29 | C. Friesen and C. Murray | 1 | | 2 | Murray and Friesen (2012); MB CDC unpubl. data |
| Lauder SH | | Lauder SH | 2014 | Jun 15, 29 | C. Church and C. Murray | 3 | | 4 | Murray and Church (2015); MB CDC unpubl. data |
| Manitou L. SH | | Dilberry Lake Provincial Park | 2016 | | D. Macaulay | | 0 | | COSEWIC (2007) |
| Manitou L. SH | | Suffern Lake R.P. | 2004 | Aug 31 | N. Page and D. Mou | 3 | 0 | 3 | COSEWIC (2007) |
| Middle SH | 3 | Canadian Forces Base Suffield National Wildlife Area | 2008 | Aug 12-13 | G.G. Anweiler and CWS | | 3 | 3 | Curteanu *et al. (*2011) |
| Middle SH | 3 | CFB Suffield National Wildlife Area | 2010 | Aug 4-9 | M.C. Curteanu, S.M. Westworth | 4 | 3 | 7 | Curteanu *et al.* (2011) |
| North Battleford SH | | Battle River - Cutknife Community Pasture | 2010 | Jul 29 | M.C. Curteanu and S.M. Westworth | 4 | 0 | 4 | Curteanu *et al.* (2011) |
| North Battleford SH | | Sweetgrass I.R. 113A | 2011 | Aug 12 | M.-C. Belair and S.M. Westworth | 1 | 0 | 1 | Curteanu *et al.* (2011) |
| Pakowki Lake SH | 4 | Pakowki Lake | 1925 | Jul 22 | H.L. Seamans | | 1 | | COSEWIC (2007) |
| Pakowki Lake SH | 4 | Onefour, Dominion Range Station | 1951 | Jul 10 | D.F. Hardwick | | 1 | 1 | COSEWIC (2007) |
| Pakowki Lake SH | 4 | Pakowki Lake | 2008 | Aug 10 | G.G. Anweiler and CWS | | 1 | | Curteanu *et al.* (2011) |
| Pakowki Lake SH | 4 | Pakowki Lake | 2010 | Aug 7 | M.C. Curteanu and S.M. Westworth | 1 | 2 | 3 | Curteanu *et al.* (2011) |

| Sand Hill (SH) | Sub-pop'n # | Locality | Year | Survey Date(s) | Observer | # Surveyed Sites[1] | | Total Effort[2] | Information Source |
|---|---|---|---|---|---|---|---|---|---|
| Rolling SH | | Rolling SH | 2005 | Jul 25 | N. Page | 3 | 0 | 3 | COSEWIC (2007) |
| Routledge SH | | Routledge SH North | 2009 | Jul 9, 21 | C. Friesen and C. Murray | 1 | | 2 | MB CDC unpubl. data |
| Routledge SH | | Routledge SH South | 2009 | Jun 25, Jul 21 | C. Friesen and C. Murray | 1 | | 2 | Friesen and Murray (2010); MB CDC unpubl. data |
| Routledge SH | | Routledge SH | 2009 | Jul 12, 26 | C. Friesen and C. Murray | 1 | | 2 | Friesen and Murray (2010); MB CDC unpubl. data |
| St. Lazare SH | | St. Lazare SH | 2013 | Jun 22-23, Jul 23-24 | C. Murray | 1 | | 5 | Murray (2014); MB CDC unpubl. data |
| Seward SH | | Seward (Webb) SH | 2004 | Aug 5 | N. Page and D. Mou | | 3 | 3 | COSEWIC (2007) |
| Sounding Lake SH | | Sounding Lake SH | 2005 | Jul 26 | N. Page | 3 | 0 | 3 | COSEWIC (2007) |
| Tunstall SH | | Bitter Lake Community Pasture | 2010 | Aug 8 | M.C. Curteanu and S.M. Westworth | 1 | 3 | 5 | Curteanu *et al.* (2011) |
| Wainwright SH | | Canadian Forces Base Wainwright | 2005 | Jul 27 | N. Page | 3 | 0 | 3 | COSEWIC (2007) |
| Wainwright SH | | Canadian Forces Base Wainwright | 2010 | Jul 27 | M.C. Curteanu and S.M. Westworth | 4 | 0 | 4 | Curteanu *et al.* (2011) |
| Wainwright SH | | Roadside | 2011 | Aug 13 | M.-C. Belair and S.M. Westworth | 1 | 0 | 1 | Curteanu *et al.* (2011) |

[1] sites are discrete dune or blowout typically separated by a vegetated landscape.

[2] total # of trap-nights, where known (note: at some sites multiple traps may have been set overnight).