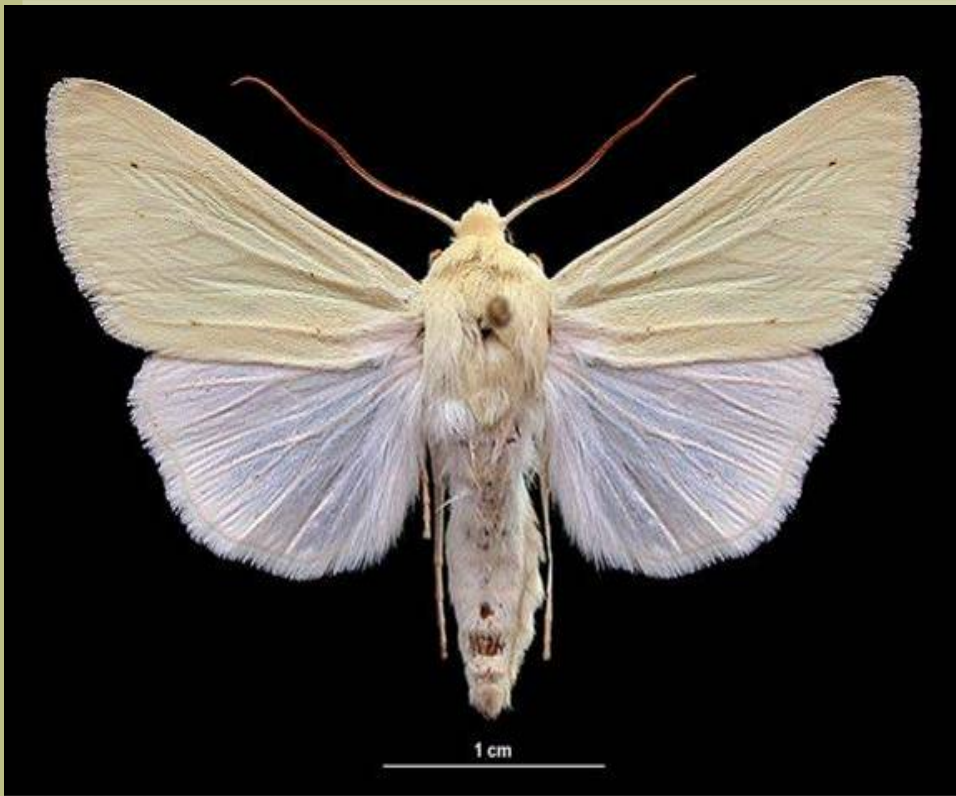


Management Plan for the Pale Yellow Dune Moth (*Copablepharon grandis*) in Canada

Pale Yellow Dune Moth



2016



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For copies of the management plan, or for additional information on species at risk, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the [Species at Risk \(SAR\) Public Registry](http://www.registrelep-sararegistry.gc.ca)¹.

Cover illustration: G.G. Anweiler, Strickland Museum

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¹ <http://www.registrelep-sararegistry.gc.ca>

Preface

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

The Minister of the Environment is the competent minister under SARA for the Pale Yellow Dune Moth and has prepared this management plan as per section 65 of SARA. To the extent possible, it has been prepared in cooperation with the Provinces of Alberta, Manitoba, and Saskatchewan.

Success in the conservation of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this plan and will not be achieved by Environment Canada, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this plan for the benefit of the Pale Yellow Dune Moth and Canadian society as a whole.

Implementation of this management plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Acknowledgments

The 2012 draft management plan was written by Nick Page (Raincoast Applied Ecology). Gary Anweiler (Strickland Museum), Chris Friesen (Manitoba Conservation Data Centre), Chris Schmidt (Canadian National Collection of Insects, Arachnids and Nematodes), Sharilyn Westworth (Environment Canada – Canadian Wildlife Service), and Stephen Wolfe (Natural Resources Canada) generously provided information. Marie-Christine Belair and Mark Wayland (Environment Canada – Canadian Wildlife Service) reviewed the document and provided valuable comments. Updates to the draft management plan were completed in 2014 by Diana Ghikas and Victoria Snable (Environment Canada – Canadian Wildlife Service).

² <http://registrelep-sararegistry.gc.ca/default.asp?lang=En&n=6B319869-1%20>

Executive Summary

The range of the Pale Yellow Dune Moth extends through the arid interior of western North America. Although the species' Canadian range covers a large area within the Prairie Provinces, it is typically associated with sparsely-vegetated sandy sites within the mixed grassland, moist-mixed grassland, and aspen parkland ecoregions, which are rare. It has been recorded at 12 localities in Canada: six in Saskatchewan, five in Alberta, and one in Manitoba. Additional populations in the Canadian prairies likely occur in unsurveyed sandy grasslands. There are currently no estimates of population abundance and no data available to estimate its population size in Canada.

Adults are active around dusk and early evening, and rarely observed during the day. Unusual for noctuid moths are the light-coloured wings and body, and the distinctive colour difference between the forewings (yellow) and hindwings (white) which lack streaks, spots, or other patterns. Suitable habitat appears to occur in the transition between active dunes, with frequent sand movement, and stable dunes, which are fully vegetated and have little or no open sand. Field observations suggest open sand is required for egg laying and larval development. Adult moths have been captured in blowouts with remnant open sand, dune ridges, road cuts, and unvegetated fire guards. Larval host plants and adult nectar plants have not been identified for the Pale Yellow Dune Moth. However, this species does not appear to be limited to a unique host-plant for adult nectaring, ovipositing, or larval feeding.

The primary threat facing the Pale Yellow Dune Moth is the progressive loss of sparsely-vegetated sandy grasslands. The loss of this habitat type is caused by: alteration of the natural disturbance regimes affecting the sand dunes; reduced drought conditions at the sand dunes; and establishment of invasive non-native plant species. Due to the patchy and widespread distribution of sand dunes, which has been caused to some degree by habitat loss and fragmentation, sub-populations are isolated and at added risk of local extinctions.

The objective of this management plan is to maintain the persistence of Pale Yellow Dune Moth at all localities identified with a confirmed location, specifically the following dune fields: Buffalo Park, Sounding Lake, and Edgerton in Alberta; Brandon in Manitoba; and Dundurn, Manitou Lake, and Pelican Lake in Saskatchewan; as well as at any additional localities confirmed in the future. The lack of comprehensive surveys throughout the Canadian range of the Pale Yellow Dune Moth, and the poor understanding of its population size and variability, and life history, precludes the development of a quantitative management objective at this time.

Management and restoration activities in sand dune habitats should be coordinated and carefully implemented to assist the recovery of multiple dune species at risk. Stewardship initiatives linked to collaborative planning and beneficial to several rare dune species, including the Pale Yellow Dune Moth, are encouraged.

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1. COSEWIC* Species Assessment Information

Date of Assessment: November 2007

Common Name (population): Pale Yellow Dune Moth

Scientific Name: *Copablepharon grandis*

COSEWIC Status: Special Concern

Reason for Designation: Although the area of occupancy is small, there is some evidence of decline in its extent of occurrence and area of occupancy, the species persists in widely separated dune systems, the declines are not well documented, and the status of threats is unclear. It requires semi-stable sand dunes which are declining.

Canadian Occurrence: Alberta, Saskatchewan, Manitoba

COSEWIC Status History: Designated Special Concern in November 2007.

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

2. Species Status Information

The Pale Yellow Dune Moth (*Copablepharon grandis*) has a global conservation status of Apparently Secure - Secure (G4G5). Its national status is Imperiled (N2). Provincially, its status in Alberta and Manitoba is Critically Imperiled (S1) and in Saskatchewan its status is not ranked (SNR) (NatureServe, 2014). The range in Canada represents less than 10% of the species' global range (COSEWIC, 2007). In the United States, its status is not ranked (SNR) nationally nor at a state scale.

The species is listed as Special Concern under Schedule 1 of Canada's *Species at Risk Act* (SARA) and as Endangered under Manitoba's *Endangered Species and Ecosystems Act*.

3. Species Information

3.1. Species Description

The Pale Yellow Dune Moth is a member of the Order Lepidoptera (butterflies and moths), Family Noctuidae (owlet or cutworm moths), and Subfamily Noctuinae (dagger moths). Adults are medium in size: the wingspan measures 3.8 to 4.1 cm (E. H. Strickland Museum, 2014). Specimens from the Great Basin (most of Nevada and parts of Utah, Oregon, Idaho, and California) tend to be smaller in size than those

from the Great Plains including Canada (Lafontaine, 2004).

Unusual for noctuid moths are the light-coloured wings and body, and the distinctive colour difference between the forewings (yellow) and hindwings (white) which lack streaks, spots, or other patterns (Figure 1). Pupae (cocoons) are about 19 mm long with an external sheath enclosing a long proboscis. Larvae (caterpillars) are light brown with white median and lateral lines (COSEWIC, 2007). Eggs are nearly globular and greenish-white, with a shallowly-wrinkled upper surface and smooth underside (Strickland, 1920).



Figure 1. Pale Yellow Dune Moth, G.G. Anweiler

Little is known about the life history of the Pale Yellow Dune Moth. Rarely has it been observed, in part because adult moths are active primarily around dusk and early evening. Also, in Canada, the single flight period is short, about eight weeks from early July to late August (COSEWIC, 2007). Limited field observations; the results of rearing a single captive larva to pupation (Strickland 1920); and known characteristics of similar species (e.g., *C. fuscum* and *C. longipenne*) have been used collectively to make inferences about the life history of the Pale Yellow Dune Moth. Eggs are fully formed in newly emerged adult females, and likely deposited in loose, sandy soil. Larval growth and feeding likely occurs from hatching in August to the onset of cool weather, and may resume the following spring. Larvae may undergo diapause, below the soil surface, during winter (COSEWIC, 2007). Pupation likely occurs in late June or early July below-ground in an earthen cell (Strickland, 1920).

3.2. Populations and Distribution

The estimated range of the Pale Yellow Dune Moth (Figure 2) is based on the limited data available since the species was first described in 1874 and encompasses approximately 85 localities in the arid interior of North America (Lafontaine, 2004). Sampling records to date suggest it is most prevalent in the Great Basin and the southern Rocky Mountains of the United States, although it occurs within the Prairie Provinces of Canada and the north-central United States (COSEWIC, 2007).

Canadian range and population

The Pale Yellow Dune Moth has been recorded at 12 localities in Canada since 1902 (Table 1; Figure 3): six in Saskatchewan, five in Alberta, and one in Manitoba. A new locality, Carseland, Alberta, has been added since the COSEWIC status report (2007), based on a collection by J. Hilchie and reviewed by G. Anweiler (G. Anweiler, pers. comm. 2012).

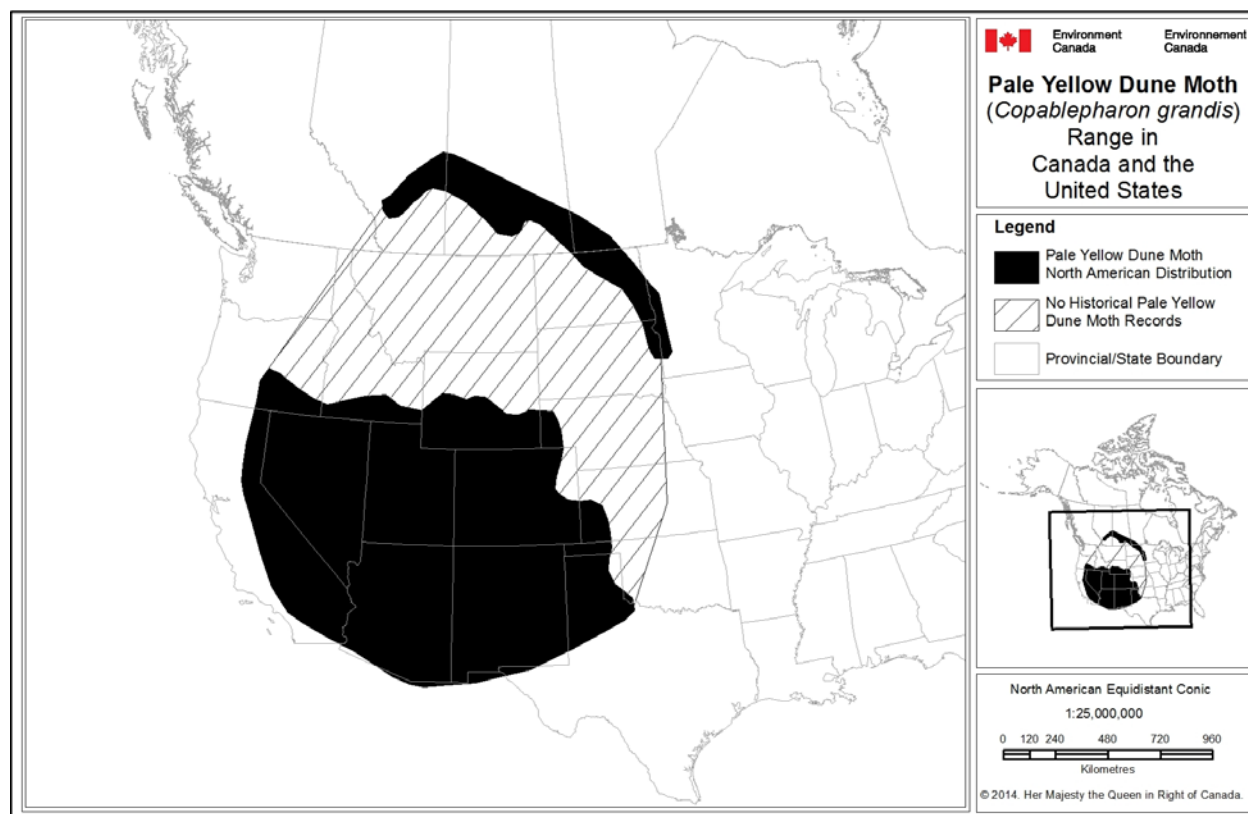


Figure 2. Range of the Pale Yellow Dune Moth in North America, indicating areas within the range where no historical observations exist (adapted from Lafontaine, 2004).

The species' range in Canada (Figure 2) extends between the 52nd parallel near Edgerton, Alberta and the 49th parallel near Brandon, Manitoba; and between the 114th meridian near Calgary, Alberta and the 99th meridian near Brandon, Manitoba. Although its range covers a large area within the Prairie Provinces, the Pale Yellow Dune Moth is associated with sparsely-vegetated sandy sites near sand dunes³, within the mixed grassland, moist-mixed grassland, and aspen parkland ecoregions, which are rare. This distribution pattern suggests populations of the dune moth may be composed of subpopulations connected through local dispersal but potentially isolated at a regional scale (COSEWIC, 2007).

Interestingly, despite some surveys, the species has not been observed at active dunes in the Rolling Hills of Alberta; near Lauder, Portage, Oaklake, Routledge, and St. Lazare in southern Manitoba; nor in the Burstall, Cramersberg, Elbow, Great, and Seward sand hills⁴ of southern Saskatchewan (Murray, 2014; Saskatchewan Conservation Data Centre, 2014; Murray, 2013; Murray and Friesen, 2012; COSEWIC, 2007). Additional

³ 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).

⁴ A sand hill is a "mound or hill of sand of either constructional or erosional origin resulting from either physical or anthropogenic processes. A sand hills area is a specific, well-defined occurrence of sand dunes and other sand hills" (David, 1977).

populations in the Canadian prairies likely occur in unsurveyed sandy grasslands with appropriate habitat, and further investigation is required.

Currently, there are no estimates of population abundance and no data available to estimate the population size of the Pale Yellow Dune Moth. However, according to the COSEWIC status report (2007), the Canadian population is possibly declining.

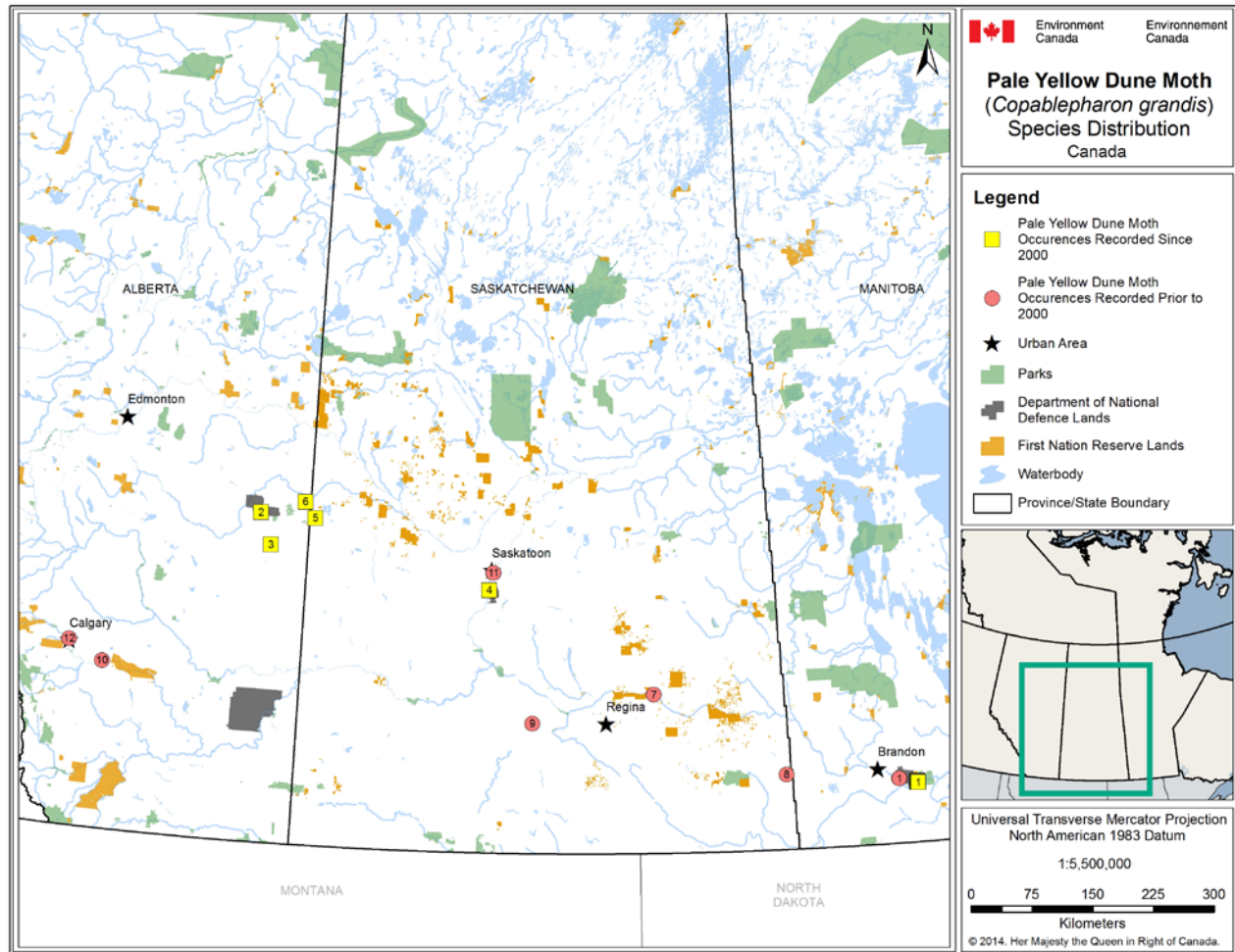


Figure 3. Distribution of Pale Yellow Dune Moth occurrence records in Canada (numbered chronologically: most recent = 1). One locality near Brandon, MB has both recent and historical records (Table 1).

Table 1. Summary of Pale Yellow Dune Moth Occurrence Records in Canada^a

Map Label ^b	Locality	Dune Field ^c	Province	Year First Observed	Year Last Observed	Total Number of Individuals Observed ^d
1	Aweme - Spruce Woods Provincial Park	Brandon	MB	1904	2013	67
2	CFB Wainwright	Buffalo Park	AB	2005	2005	2
3	Provost	Sounding Lake	AB	2005	2005	2
4	CFB Dundurn	Dundurn	SK	2004	2004	14
5	Artland - Suffern Lake Regional Park	Manitou Lake	SK	2004	2004	1
6	Chauvin - Siegnier Lake	Edgerton	AB	2004	2004	15
7	Fort Qu'appelle ^e	Unknown	SK	1985	1985	1
8	Maryfield ^e	Unknown	SK	1980	1980	1
9	Caron	Pelican Lake	SK	1968	1968	1
10	Carseland ^e	Unknown (Gleichen?)	AB	1976	1976	1
11	Saskatoon ^e	Unknown	SK	1939	1939	2
12	Calgary ^e	Unknown	AB	1902	1902	1

^a This is the best information available to Environment Canada at the time this management plan was written. Sources are the Canadian National Collection of Insects, Arachnids and Nematodes (2014), Manitoba Conservation Data Centre (2014), Northern Forestry Centre (2014), E. H. Strickland Museum (2014), G. Anweiler, pers. comm. (2012), and COSEWIC (2007).

^b The localities are labelled chronologically by "Year Last Observed"; most recent=1. The Aweme –Spruce Woods Provincial Park locality contains both recent and historical occurrence records.

^c Dune field names according to Wolfe (2010). A "dune field" is an area comprised of sand dunes whose origins are attributed to eolian processes (S. Wolfe, pers.comm. 2014).

^d Minimum counts. Specimens were identified and deposited with a national, provincial, or regional collection: the Canadian National Collection of Insects, Acari and Nematodes; Manitoba Museum of Man and Nature; Northern Forestry Centre of Canada; Royal Saskatchewan Museum; E. H. Strickland Entomological Museum; Los Angeles County Museum of Natural History; or the United States National Museum, Smithsonian Institute.

^e Detailed location information is not available for this record; therefore only a representative location is mapped.

3.3. Needs of the Pale Yellow Dune Moth

Habitat and biological needs

Knowledge of the biology and habitat needs of the Pale Yellow Dune Moth is poor. Habitat conditions observed at capture and non-capture sites in southern Alberta and southern Saskatchewan during 2004 and 2005 field sampling programs, as well as known habitat use by other *Copablepharon* species, are the basis for the following habitat descriptions (COSEWIC, 2007).

Pale Yellow Dune Moths occur in sparsely-vegetated grasslands, with open sand, but do not appear to require habitats with active sand movement (COSEWIC, 2007; N. Page, pers. obs.). Suitable habitat seems to occur in the transition between active dunes, with frequent sand movement, and stable dunes, which are fully vegetated with little or no open sand. Results of surveys done in 2004 and 2005 indicate the moths do not use habitats with dense vegetation or grass thatch (N. Page, pers. obs.). Adult moths were captured in blowout⁵ depressions with remnant open sand, dune ridges⁶, road cuts, and unvegetated fire guards. Road cuts and other disturbed areas can be a source of open sand in otherwise stabilized sand dunes. Open sand may be required for egg laying and larval development, including winter diapause (N. Page, pers. obs.).

The Pale Yellow Dune Moth has not been captured in some sand dune areas in southern Alberta and southern Saskatchewan, where other *Copablepharon* species occur, suggesting currently-unknown factors (e.g., climate, dispersal) may limit habitat use by this species. 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 sub-populations may be isolated.

Observations to date indicate the Pale Yellow Dune Moth is not dependent on a unique host-plant for feeding or laying eggs. A Pale Yellow Dune Moth larva fed on both a common legume species and grass species, while reared in captivity, suggesting the moth is a generalist feeder (Strickland 1920). In addition, plants may not be important for reproduction. The moth has not been observed using leaves or flowers for ovipositing. Sand may be the preferred medium for egg deposition (COSEWIC, 2007). Adult Pale Yellow Dune Moths have been observed resting inside Nuttall's Evening-primrose (*Oenothera nuttallii*) blossoms during the day (C. Schmidt, pers. comm. 2012).

⁵ A blowout "refers to a small, typically less than one hectare in size, area of wind-blown 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 dune ridge, is a "specific case where the higher elevation portion of a sand dune contains bare wind transported sand, which commonly occurs on the wings or arms of the dune. Dune ridges are typically one to ten hectares in size." (Wolfe, 2010)

The Pale Yellow Dune Moth is associated with certain plant community types, such as midgrass and bunchgrass prairies (Fauske, 1992 *in* COSEWIC, 2007). Two sand dune plant communities, identified in east central Alberta, characterize Pale Yellow Dune Moth habitat: 1) sand grass–sand dropseed–hay sedge herbaceous vegetation; and 2) creeping juniper–sand grass–sun-loving sedge dwarf shrubland. These two communities develop on sloped, well-drained sandy soils with some sand movement; the former has approximately 60% open sand while the latter has 30% (Coenen 2003 *in* COSEWIC 2007). Similar plant communities were observed at several localities (i.e., CFB Wainwright and Dundurn; Chauvin-Siegner Lake; Sufferin Lake; Table 1) during the Alberta and Saskatchewan sampling programs in 2004 and 2005. Although plant communities in semi-stable, sparsely-vegetated sand dunes in Alberta, Manitoba, and Saskatchewan vary regionally, often they are similar in composition and structure (COSEWIC, 2007).

3.4. Limiting Factors

Isolated Sub-Populations

Dune fields in the southern Canadian prairies are often isolated, and separated from other dune fields by extensive tracts of habitat unsuitable for the Pale Yellow Dune Moth, making successful dispersal, migration, and re-colonization unlikely. Dispersal distances are not known but likely do not exceed 10 km for this species (COSEWIC, 2007). The patchy spatial distribution of sand dunes in Canada, caused to some degree by habitat loss and fragmentation, exhibits a metapopulation structure (Hugenholtz et al., 2010). Isolated sub-populations can be vulnerable to local extinction events, reducing the population's potential to persist.

4. THREATS

4.1. Threat Assessment

Table 2. Threat Assessment Table

Threat	Level of Concern ^f	Extent	Occurrence	Frequency	Severity ^g	Causal Certainty ^h
Changes to Ecological Dynamics or Natural Processes						
Alteration of natural fire and grazing regimes	Medium	Widespread	Historical and Current	Seasonal	High	Medium
Stochastic events	Low	Widespread	Historical and Current	Continuous	Unknown	Low
Climate and Natural Disasters						
Reduced drought conditions at sand dunes	Medium	Widespread	Historical and Current	Continuous	Medium	High
Exotic, Invasive, or Introduced Species						
Establishment of invasive non-native plants	Medium	Widespread	Historical and Current	Continuous	Medium	Medium
Habitat Loss and Degradation						
Construction of roads and energy infrastructure in sand dunes	Low	Localized	Historical and Current	Continuous	Unknown	Medium
Sand or gravel extraction	Low	Localized	Current and Anticipated	Continuous	Low	Medium
Cultivation	Low	Localized	Historical and Current	Continuous	Unknown	Low
Biological Resource Use						
Collecting specimens	Low	Localized	Historical and Current	Seasonal	Unknown	Low

Accidental Mortality, Disturbance, or Harm						
Trampling by animals or people	Low	Widespread	Historical and Current	Seasonal	Unknown	Medium
Off-road vehicle use in sand dunes	Low	Widespread	Historical and Current	Seasonal	Unknown	Medium
Military activities in sand dunes	Low	Localized	Historical and Current	Continuous	Unknown	Medium
Pesticide and chemical use and drift	Low	Widespread	Historical and Current	Seasonal	Unknown	Low

^f Level of Concern: signifies that managing the threat is of (high, medium or low) concern for the conservation of the species, consistent with the management objectives. This criterion considers the assessment of all the information in the table.

^g Severity: reflects the population-level effect (high: very large population-level effect, moderate, low, unknown).

^h Causal certainty: reflects the degree of evidence that is known for the threat (high: available evidence strongly links the threat to stresses on population viability; medium: there is a correlation between the threat and population viability e.g. expert opinion; low: the threat is assumed or plausible).

4.2. Description of Threats

The progressive loss of sparsely-vegetated grasslands in sandy soils, present in conditions that transition between active and stable sand dunes, has reduced the quantity and quality of habitat for the Pale Yellow Dune Moth.

Stratigraphic and chronological studies of the northern Great Plains region show alternating periods of dune activity and stability. The early explorer accounts from the 1850s document extensive areas of open sand in south-eastern Alberta and south-central Saskatchewan (Hugenholtz et al., 2010). However, a period of dune stabilization has occurred on the Canadian prairies during the past 200 years, with notable decreases in the area of open sand observed more recently. Extreme examples of recent dune stabilization are the Middle Sand Hills (Alberta) where the area of open sand decreased by 94% between 1947 to 2005 (Hugenholtz et al., 2010) and the Brandon Sand Hills (Manitoba) where the area of open sand at the Brandon North dune complex decreased by 91% between 1928 to 1988 (Hugenholtz and Wolfe, 2005).

Under certain conditions, natural succession by grasses and forbs, then shrubs, and eventually trees, will cover sand dunes with vegetation (Environment Canada, 2014). Vegetation cover limits wind erosion, transport, and deposition of sand on the dunes. In Canada's prairie grasslands, stabilization of sand dunes has occurred through a combination of changes in climate, natural disturbance regimes, and land-use practices since European settlement.

Threats to the Pale Yellow Dune Moth are listed in order of decreasing level of concern.

Alteration of Natural Fire and Grazing Regimes

A lack of natural disturbances during recent history, mainly drought (discussed below), fire, and bison herds, which remove vegetation cover, has led to vegetation-stabilized sand dunes with less open sand habitat (Fox et al., 2012). Grasslands burned approximately every four to ten years in the North American Great Plains prior to European settlement (Wright and Bailey, 1982). Fire suppression, implemented since European settlement, has substantially reduced the amount of wildfires and anthropogenic burning, an important form of natural disturbance to prairie grassland ecosystems (Forman et al., 2001; Boyd, 2002). Fire maintains grass-dominated communities, prevents shrub establishment, and removes accumulated thatch. The effect of fire suppression on habitat for Pale Yellow Dune Moth is not well understood, but it likely contributes to the development of more densely-vegetated plant communities which are less suitable for this species.

There is archeological, historical, and modern evidence that bison used sand dunes, seasonally in southern Canada, up until European settlement. Behaviours such as grazing, trailing, wallowing, horning, and trampling create a mosaic of disturbance effects (Fox et al., 2012). Bison prefer sandy soils for wallowing (rolling) and will travel to sandy areas for this purpose (Soper 1941 and Coppedge et al. 1999 in Fox et al., 2012). Wallows in sand dunes created concave depressions of exposed sand which could develop into large blowouts through a positive feedback process (Fox et al., 2012). The eradication of wild bison in the 1800s, and the present-day lack of free-ranging bison herds on Canada's prairies, has removed this source of disturbance to sand dunes in southern Alberta, Manitoba, and Saskatchewan.

Compared to bison, cattle are considered a poor ecological substitute for creating open-sand habitats for sensitive sand dune species. Studies have shown there are measurable differences in diet, behavior, and life history, in addition to the apparent features, such as body weight. One behavioural difference, considered significant for contributing to habitat heterogeneity in sand dunes, is that cattle do not wallow (Fox et al., 2012). Interestingly though, Hugenholtz and Wolfe (2005) noted "the increase in [dune] activity at [Great Sand Hills northwest portion] may be the result of the combined effects of mid to late 1980s drought and grazing stress from livestock".

Reduced Drought Conditions at Sand Dunes

Dune activity (i.e., active sand transport and deposition) is synchronous with hydrological drought and water-table decline (Mason et al., 2004 in Wolfe and Hugenholtz, 2009). During dry cool windy climatic conditions, sufficient amounts of sand are transported and deposited which effectively "outcompete" vegetation stabilization of sand dunes. Dune fields in southern Alberta, Manitoba, and Saskatchewan were more active in the recent past, than today. Severe drought conditions during the late 1700s caused significant widespread dune activity on Canada's prairies (Wolfe and Hugenholtz, 2009). However, a dune stabilization trend has been evident since that time, partially associated with increased precipitation and increased temperature, and less so, with reduced wind speeds (Hugenholtz and Wolfe, 2005).

Climate modelling projections predict increased warming and drought severity (Lemmen et al., 2007 in Wolfe and Hugenholtz, 2009) which suggests wide-spread dune activity on the Great Plains may resume in the distant future (Muhs and Maat, 1993 and Wolfe and Nickling, 1997 in Wolfe and Hugenholtz, 2009).

Establishment of Invasive Non-native Plants

Exotic plant species, such as Baby's Breath (*Gypsophila paniculata*) and Leafy Spurge (*Euphorbia esula*), as well as introduced forage species such as Crested Wheat Grass (*Agropyron cristatum*) and Sweet Clover (*Melilotus* sp.), have the potential to out-compete native vegetation in dunes, and with time, dominate and alter ecosystem properties and functions (Gordon 1998; Henderson and Naeth, 2005). Specifically, invasive plant species can rapidly colonize active dune areas, accelerating the establishment of native and non-native vegetation (Environment Canada, 2014).

At present, invasive plants are not abundant in dry grasslands or sand dunes with Pale Yellow Dune Moth (N. Page, pers. obs.), and are associated with cattle grazing and infrastructure development. The four most common invasive non-native plant species in the Great Sand Hills (Saskatchewan) are Crested Wheatgrass, Smooth Brome (*Bromus inermis*), Canada Thistle (*Cirsium arvense*), and Kentucky Bluegrass (*Poa pratensis*) (Nielsen and Bjork, 2007). At the Pakowki Lake Sand Hills (Alberta), Crested Wheatgrass and Baby's Breath were observed growing in dense stands near the active dunes (Jensen et al., 2009). Leafy Spurge has been present at the Routledge and Lauder (Manitoba) and Elbow (Saskatchewan) sand dunes (Environment Canada, 2013).

Threats of Low-Level Concern

Population-level effects are mostly unknown for the following threats. However, should the threat occur within Pale Yellow Dune Moth habitat, adverse effects to individuals and/or habitat are expected.

Stochastic events can cause random fluctuations in the size of a population which may lead to extinction. Small, isolated populations are especially vulnerable (see 3.4) to demographic stochasticity (for example, a population comprised mostly of females with low reproductive rates) and environmental stochasticity (for example, an extreme weather event).

Construction of roads and energy infrastructure and sand extraction in sand dunes with suitable habitat will likely decrease and/or degrade the habitat, long term, for the Pale Yellow Dune Moth.

Cultivation activities, producing either no vegetation (e.g., fallow fields) or dense vegetation (e.g., irrigated crops), in otherwise suitable habitat for the Pale Yellow Dune Moth, are a concern as they require sparsely vegetated habitat.

Specimen collecting would result in a few individuals being removed from a population, which may impact population growth rates.

Trampling by animals or people, off-road vehicle use, and military training exercises (e.g., infantry, heavy machinery, artillery) in sand dunes may physically impact Pale Yellow Dune Moths through compression or collision causing harm and/or death. Sessile life stages (i.e., egg and pupae) of the Pale Yellow Dune Moth are probably most vulnerable.

Pesticide or chemical applications near Pale Yellow Dune Moths may have adverse health effects, resulting in lower population growth rates.

5. Management Objective

The objective of this management plan is to maintain the persistence of Pale Yellow Dune Moth at all localities identified with a confirmed location, specifically the following dune fields: Buffalo Park, Sounding Lake, and Edgerton in Alberta; Brandon in Manitoba; and Dundurn, Manitou Lake, and Pelican Lake in Saskatchewan (see map labels 1-6 and 9 in Figure 3 and Table 1); as well as at any additional localities confirmed in the future.

The lack of comprehensive surveys throughout the Canadian range of the Pale Yellow Dune Moth, and the poor understanding of its population size and variability and life history characteristics, precludes the development of a quantitative management objective at this time.

6. Broad Strategies and Conservation Measures

6.1. Actions Already Completed or Currently Underway

There have been a few conservation actions completed or initiated for the Pale Yellow Dune Moth or its habitat:

- The Manitoba Conservation Data Centre conducted rare species surveys, including for the Pale Yellow Dune Moth, in 2009, 2011, 2012, and 2013 in Manitoba (Murray, 2014; Murray, 2013; Murray and Friesen, 2012; Friesen and Murray, 2010).
- Environment Canada conducted light-trapping surveys during the adult emergence period in sand dunes of Alberta and Saskatchewan in 2010 and 2011. However, surveys were targeting Dusky Dune Moth and no Pale Yellow Dune Moth was observed (Belair et al., 2011).

- Lepidopterists associated with the Edgar Harold Strickland Entomological Museum have collected specimens during field trips from 2003–2005, extending the known species' distribution.
- Spruce Woods Provincial Park (SWPP) in Manitoba has adopted several management approaches, including prairie management burns and aspen mowing along prairie margins, to maintain a range of successional stages of the vegetation communities in the Park (Schykulski and Moore, 1996). These management activities help reduce shrub encroachment of a few sand dune areas. Future management approaches may also include options to reactivate a portion of the Spirit sand dunes within SWPP.

6.2. Broad Strategies, Conservation Measures and Implementation Schedule

The management objective will be achieved using four broad strategies: (1) inventory and surveys; (2) research; (3) habitat management and stewardship; and (4) outreach and education.

Table 3. Conservation Measures and Implementation Schedule

Conservation Measure	Priority ¹	Threats Addressed	Timeline
Strategy 1: Inventory and Surveys			
1.1 Assess habitat requirements for each developmental stage, and identify host plant use if any.	High	All threats and knowledge gaps	2015-ongoing
1.2 Assess life cycle characteristics (e.g., seasonal timing; duration; conditions).			
1.3 Assess population size.			
1.4 Conduct surveys in occupied areas to ensure known occurrences are maintained, and in suitable habitat to discover additional occurrences.			
1.5 Develop standardized survey protocols to ensure consistency of results throughout the species range in Canada.			
1.6 Coordinate Pale Yellow Dune Moth survey efforts with programs monitoring other lepidopterans associated with open sand habitats in Canada.			
Strategy 2: Research			
2.1 Study the Pale Yellow Dune Moth life cycle characteristics and microhabitat requirements to fill key knowledge gaps, and identify key habitat features.	High	All threats and knowledge gaps	2016-ongoing

2.2 Investigate appropriate disturbance regimes (type, duration, frequency, intensity) effective at maintaining or creating suitable habitat for multiple dune species at risk including the Pale Yellow Dune Moth.	Medium	All threats and knowledge gaps	2016-ongoing
Strategy 3: Habitat Management and Stewardship			
3.1 Identify and implement beneficial management practices focused on conserving habitat for the Pale Yellow Dune Moth and other dune species at risk.			
3.2 Collaboration among species specialists, government agencies, land owners/managers, and other interested parties, to identify suitable approaches to restore important habitats which benefit multiple dune species at risk, including the Pale Yellow Dune Moth.	High	All threats except climate change	2016-ongoing
3.3 Deliver stewardship initiatives through agreements with land owners aimed at protecting (i.e., habitat securement) or conserving important habitat for the Pale Yellow Dune Moth.			
Strategy 4: Outreach and Education			
4.1 Raise public awareness and promote conservation of the Pale Yellow Dune Moth and its life cycle requirements.			
4.2 Raise awareness of the suite of rare species, including Pale Yellow Dune Moth, found in dry sandy grasslands.	Medium	All threats except climate change	2016-ongoing
4.3 Develop communication tools (e.g., booklets, webpage, etc.) to educate land users on how to decrease the impact of their activities on Pale Yellow Dune Moths and its habitat.			

ⁱ "Priority" reflects the degree to which the measure contributes directly to the conservation of the species or an essential precursor to a measure contributes to the conservation of the species. High priority measures are considered those most likely to have immediate and/or direct influences on attaining the management objectives for the species. Medium priority measures may have less immediate or direct influences on reaching the management objectives; however, they are still important. Low priority measures will likely have indirect or gradual influences on reaching the management objectives, but are considered important contributions to the knowledge base, public involvement, and/or acceptance of the species.

6.3. Narrative to Support Conservation Measures and Implementation Schedule

Inventory and Surveys

A standardized protocol to survey Pale Yellow Dune Moth is needed to ensure consistency of survey results across the species range. Currently, there are no standardized protocols for ensuring adequate search effort to detect moths, or for measuring population size. The results of these surveys could be used to assess the size of the Pale Yellow Dune Moth Canadian population. Known occupied locations should be monitored regularly to ensure the management objective is being achieved. Additionally, suitable habitat at previously unsurveyed sites should be sampled to discover new populations and increase knowledge on the species distribution. Imagery or the dataset of Wolfe (2010) identifying open sand areas across the Canadian Prairies could be used to facilitate the selection of potential survey locations. Multi-species surveys investigating open sand ecosystems are encouraged to maximize cost effectiveness.

Research

The life history, ecology and habitat requirements of the Pale Yellow Dune Moth are currently poorly understood. Filling key knowledge gaps through research will be essential for recovery. Research findings will contribute to guiding recovery conservation measures, survey timing, and locations and beneficial management practices. The most critical knowledge gap is the Pale Yellow Dune Moth's use of different plant communities or successional phases of dry, sandy grassland habitats.

Habitat Management and Stewardship

Habitat management is important to reduce or eliminate threats, and restore degraded habitat. Given the lack of proven methods for managing or restoring habitat for the Pale Yellow Dune Moth, collaboration between land owners/managers, government agencies, industry, and researchers is essential. Beneficial management practices for maintaining or enhancing the species habitat should be developed and implemented (e.g., guidelines on prescribed burning, grazing regimes, control of invasive species, siting infrastructure, etc.). The requirements of other species associated with open sand habitats should be considered when implementing the beneficial management practices. Management and restoration activities in dune habitats should be coordinated as part of a broader ecosystem-level plan to ensure benefits to multiple species at risk. Key habitats lost to or degraded by human activities or natural processes described in this document (see Section 4) should be restored using threat cessation and natural recovery, where feasible. Initiation of sand movement in stabilized sand dunes may be an important part of Pale Yellow Dune Moth recovery; however, this approach requires careful consideration of potential impacts. Stewardship initiatives beneficial to the species and linked to collaborative planning are encouraged.

Outreach and Education

Moths and butterflies, such as the Pale Yellow Dune Moth, Dusky Dune Moth, White Flower Moth (*Schinia bimatrix*) and other moths associated with open sand habitats, are often nocturnal, and difficult to observe and identify. Because of this, land users are often unaware of their existence or the impact land use activities can have on the species' habitat.

Increasing public awareness of the habitat requirements of the Pale Yellow Dune Moth and other species associated with sandy grasslands and dunes is important. Communication tools such as booklets, webpages, and signs in protected areas would be beneficial for raising awareness. In addition, land users and managers need specific resources about the species' ecological requirements and management strategies for avoiding or mitigating threats to reduce impacts on the species and their habitats.

7. Measuring Progress

Success in implementing this management plan will be measured against the following performance indicator:

- The distribution of the Pale Yellow Dune Moth in Canada where the species has been known to occur, and any additional sites discovered in the future, have been maintained.

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Appendix A: Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the [Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals](http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1)⁷. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or achievement of any of the [Federal Sustainable Development Strategy](http://www.ec.gc.ca/dd-sd/default.asp?lang=En&n=F93CD795-1)'s⁸ (FSDS) goals and targets.

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

A suite of species of risk are associated with sand dunes and sparsely-vegetated sandy grasslands in the Canadian prairies including Pale Yellow Dune Moth, Dusky Dune Moth, White Flower Moth, Gold-edged Gem (*Schinia avemensis*), Ord's Kangaroo Rat (*Dipodomys ordii*), Small-flowered Sand-verbena (*Tripterocalyx micranthus*), Tiny Cryptantha (*Cryptantha minima*), as well as the threatened Hairy Prairie-clover (*Dalea villosa* var. *villosa*), Smooth Goosefoot (*Chenopodium subglabrum*) and Western Spiderwort (*Tradescantia occidentalis*). All are considered at-risk in Canada because of their association with regionally rare sand habitats, and the shared threats of habitat change and loss. Strategies and actions to recover the Pale Yellow Dune Moth will benefit many of these species. Habitat-focused recovery actions to increase the distribution and abundance of active or partially-stabilized sand habitats which have rapidly declined will be essential. These are anticipated to include better management of grazing, restoration of natural disturbance regimes, and regulation of direct impacts from road, land, and infrastructure development. Collaboration between recovery managers and landowners, and multi-species recovery projects at the site level will address possible conflicts between species-specific management objectives.

⁷ <http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1>

⁸ www.ec.gc.ca/dd-sd/default.asp?lang=En&n=F93CD795-1