COSEWIC
Assessment and Status Report

on the

Five-spotted Bogus Yucca Moth
Prodoxus quinquepunctellus

in Canada

ENDANGERED
2006

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
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DES ESPÈCES EN PÉRIL
AU CANADA

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC 2006. COSEWIC assessment and status report on the Five-spotted Bogus Yucca Moth *Prodoxus quinquepunctellus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 31 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Production note:

COSEWIC would like to acknowledge Rebecca Snell for writing the status report on the Five-spotted Bogus Yucca Moth *Prodoxus quinquepunctellus* prepared under contract with Environment Canada, overseen and edited by Theresa B. Fowler, Co-chair, COSEWIC Arthropods Species Specialist Subcommittee.

For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment Canada
Ottawa, ON
K1A 0H3

Tel.: (819) 997-4991 / (819) 953-3215
Fax: (819) 994-3684
E-mail: COSEWIC/COSEPAC@ec.gc.ca
http://www.cosewic.gc.ca

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le fausse-teigne à cinq points du yucca (*Prodoxus quinquepunctellus*) au Canada.

Cover illustration:
Five-spotted Bogus Yucca Moth — Photo by R. Snell.

Catalogue No. CW69-14/476-2006E-PDF
ISBN 0-662-43259-2

COSEWIC
Assessment Summary

Assessment Summary – April 2006

Common name
Five-spotted Bogus Yucca Moth

Scientific name
Prodoxus quinquepunctellus

Status
Endangered

Reason for designation
This highly specialized moth exists in Canada as a single population that occurs in a very small, restricted area, isolated from the main range of the species in the United States. The moth is entirely dependent on the obligate mutualistic relationship between its host plant (Soapweed), and the plant's pollinator (Yucca Moth), both of which are at a high level of risk. It is threatened by the high level of wild ungulate herbivory, which in some years greatly reduces recruitment of the moth, its host plant and the host plant pollinator, and by off-road vehicles that destroy the host plant.

Occurrence
Alberta

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

COSEWIC
Executive Summary

Five-Spotted Bogus Yucca Moth
Prodoxus quinquepunctellus

Species information

The Five-spotted Bogus Yucca Moth is a small moth with a wingspan of 11-21 mm. The body of the moth is covered with white scales. The forewings are usually entirely white, but can have up to 18 small, dark spots. The hindwings usually appear darker than the forewings, ranging from grey to almost white. The adults rest inside Soapweed flowers during the day and move onto flowering stalks in the evening.

All of the immature stages of the Five-spotted Bogus Yucca Moth occur within the flowering stalk of their host plant, Soapweed, a species of yucca plant. The eggs are white and approximately 0.4 mm in length. The larvae are whitish in the early stages and turn pale green colour as they mature.

Distribution

The Five-spotted Bogus Yucca Moth is a geographically widespread species in North America. It ranges from Texas north to southern Alberta, and from the Atlantic coast of the United States into the Great Plains. In Canada, the species is known from only one population along the lower Lost River valley at Onefour, Alberta.

Habitat

At the northern edge of its range, the Five-spotted Bogus Yucca Moth uses only Soapweed for ovipositon, larval feeding and development. In Alberta, Soapweed grows on well-drained, eroding, south-facing coulee slopes along the Milk River drainage basin.

Biology

The life cycle of the Five-spotted Bogus Yucca Moth depends entirely upon its host plant, Soapweed, and the plant's pollinator, the Yucca Moth. Adult moths rest in Soapweed flowers during the day and use them as mating sites in the evening. After copulation, females lay their eggs directly into the flowering stalks. The eggs hatch nine days after oviposition, and the larvae start to feed upon the stem tissue. The larvae complete their development protected within the plant stem and remain in the stalk over one or several winters to emerge as adults in a subsequent flowering season.

The most important factor affecting the survival of the Five-spotted Bogus Yucca Moth is the production of yucca fruit, which is driven by the pollination/seed predation mutualism between Soapweed and Yucca Moths. The Five-spotted Bogus Yucca Moth relies on Yucca Moths to pollinate yucca flowers and produce fruit. In the absence of fruit, the yucca flowering stalk quickly withers and the larvae in those stalks suffer almost complete mortality.

Population sizes and trends

The Five-spotted Bogus Yucca Moth is restricted to populations of its host plant, Soapweed. In Canada, the Five-spotted Bogus Yucca Moth is found in only one of the two naturally occurring populations of Soapweed. The moth population in Onefour is estimated at 500-1000s of individuals and appears to be relatively secure; however, there are no long-term data from which to infer trends.

Limiting factors and threats

The success of the Five-spotted Bogus Yucca Moth is limited by the production of Soapweed flower stalks and the retention of fruit. Thus, factors that threaten either Soapweed or Yucca Moths also threaten Five-spotted Bogus Yucca Moths. Herbivory by mule deer and pronghorn antelope can have a huge impact on the reproductive success of Soapweed and their moths as these ungulates can eat the majority of flowers and/or entire flowering stalks. The sole Canadian population of the Five-spotted Bogus Yucca Moth is isolated by about 200 km from populations to the south, making re-colonization unlikely should the population become extirpated. Other possible threats include agriculture, off-road traffic, and collection of Soapweed for horticultural and medicinal uses.

Special significance of the species

The Canadian populations of Soapweed and their associated moths represent the natural northern limit of the distribution of these species. The Five-spotted Bogus Yucca Moth has the potential to be used as an indicator species for this system as it requires healthy and sexually reproducing populations of both yucca plants and pollinators.

Existing protection

There is no existing protection for the Five-spotted Bogus Yucca Moth. COSEWIC has assessed Soapweed as Threatened and the Yucca Moth as Endangered. Both the Soapweed and the Yucca Moth are listed on Schedule 1 of the federal Species at Risk Act and their habitats are under protection. Although the Five-spotted Bogus Yucca Moth has no formal protection, the moth will directly benefit from any activities to protect, manage or recover the Soapweed and the Yucca Moth.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS (2006)

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

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

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

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

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

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TABLE OF CONTENTS

List of figures

List of tables

List of appendices

SPECIES INFORMATION

Name and classification

The Five-spotted Bogus Yucca Moth, *Prodoxus quinquepunctellus* (Chambers), belongs to the family Prodoxidae, commonly known as the yucca moth family. Although there are currently 10 described species in the genus *Prodoxus* (the Bogus Yucca Moths), *P. quinquepunctellus* is the only species known to occur in Canada.

The Five-spotted Bogus Yucca Moth was originally described in 1875 by V.T. Chambers, an amateur entomologist. He named the moth *Hyponomeuta 5-punctella* and used it to challenge C.V. Riley's description of the pollinating Yucca Moth, *Tegeticula yuccasella*. Despite their superficially similar appearance, Riley untangled the confusion and described the physiological and biological differences between the two species. Riley also proposed the new genus name, *Prodoxus* (Gr., "judging of a thing prior to experience"), for the Five-spotted Bogus Yucca Moth (Pellmyr 2003).

Because of the presence/absence of small dark spots on the forewings, the Five-spotted Bogus Yucca Moth was originally thought to be a complex of two separate species. The eastern immaculate form was named *Prodoxus decipiens* and the western spotted form was named *P. quinquepunctellus*. In later years, however, the variability in spotting was thought to have little significance and *P*. *decipiens* was considered a junior synonym of *quinquepunctellus* and thus invalid (Davis 1967).

Morphological description

Prodoxus quinquepunctellus is a small moth (Figure 1A), with females being slightly larger than males (wingspan: female, 11.5 – 21.0 mm; male, 11.0 – 16.5 mm (Althoff *et al*. 2001)). The head, thorax and abdomen are entirely covered with white scales. The upper surfaces of the forewings are usually white, but can have up to 18 small, dark spots. The undersides of the forewings are a medium brown. The dorsal sides of the hindwings are less heavily scaled than the forewings and usually appear darker than the forewings, ranging from grey to almost white (Davis 1967). The undersides are also sparsely scaled in a brownish grey colour. The fringes of both sets of wings are entirely white.

It is difficult to distinguish males from females in the field. Sex identification is usually done by examining the genitalia. Male genitalia: valva mostly linear with the outer margin of the cucullus curved outwards, bearing 2 – 5 short spines (Althoff *et al*. 2001). Female genitalia: ovipositor 4.0 – 6.8 mm long (Althoff *et al*. 2001), shaft relatively stout, dorsal ridge present with 6 – 8 coarse teeth (Davis 1967). Both Davis (1967) and Pellmyr (1999) have done extensive systematic reviews on the Prodoxidae family and have never noted a sex-related colour dimorphism.

A.

B.

Figure 1. A) Adult female Five-spotted Bogus Yucca Moth (*Prodoxus quinquepunctellus*) ovipositing on the flowering stalk of Soapweed (*Yucca glauca*). B) Five-spotted Bogus Yucca Moth larvae and feeding tunnels inside a Soapweed flowering stalk. (Photos by R. Snell.)

The immature stages of *P. quinquepunctellus* are not well known, and there are few distinguishing characteristics which can be used to identify them to species. However, all of the immature stages occur within the flowering stalk of their host and each *Prodoxus* species is relatively specific to its host *Yucca* species. It is therefore possible to use the host plant to infer the *Prodoxus* species contained within. The egg of *P. quinquepunctellus* is soft and white. The shape can be quite variable, but it is usually elongated with both ends rounded. The egg has no pedicle and measures approximately 0.4 mm in length and less than 0.1 mm in diameter (Davis 1967). The larva of *P. quinquepunctellus* is whitish in the early stages and turns a pale green as it matures (Figure 1B). It is 5 – 7 mm long when mature (R. Snell, unpublished data). The larva is similar in appearance to most lepidopteron larvae except for the absence of legs and its greater girth (Riley 1892; Davis 1967). The pupa of *Prodoxus* is smooth and has a prominent frontal 'beak', a structure that most likely aids the pupa in creating the exit hole in the yucca stalk.

Adult moths are usually found with the Yucca Moth, *Tegeticula yuccasella*. The flight periods for the Yucca Moth and the Five-spotted Bogus Yucca Moth are similar and both species rest in yucca flowers during the day. However, it is relatively easy to distinguish the Five-spotted Bogus Yucca Moth from the Yucca Moth. Maxillary tentacles used for transporting pollen are a prominent feature in female Yucca Moths, but are completely lacking in the Five-spotted Bogus Yucca Moth. In addition, both male and female Yucca Moths have entirely white wings whereas Five-spotted Bogus Yucca Moths can have up to 18 dark spots on their forewings (Davis 1967). In general, the Five-spotted Bogus Yucca Moth is also smaller and less robust than the Yucca Moth (Davis 1967).

Genetic description

In the past, *Prodoxus quinquepunctellus* was considered to be one species. However, a recent genetic study revealed *P. quinquepunctellus* may be composed of two morphologically and genetically distinct major lineages that may represent two species (Althoff *et al*. 2001). The two groups are roughly divided by geography into east and west (see Althoff *et al*. 2001 for a complete map). Moths in the western lineage have 0-18 small dark spots on their forewings, whereas the forewings are never spotted in the eastern lineage (Althoff *et al*. 2001). The name, *P. quinquepunctellus* applies to the maculate, western lineage, whereas the name *P. decipiens* designates the immaculate, eastern lineage.

Although the Canadian population of *P. quinquepunctellus* was not genetically sampled, it is reasonable to assume it is part of the western lineage. The classification is concurrent with the geographic partition, and moths in the Onefour population have dark spots on their forewings (R. Snell, personal observation). Although *Prodoxus quinquepunctellus* may consist of two separate lineages or even species, for the purpose of this report, the two possible lineages are treated as one species.

DISTRIBUTION

Global range

Prodoxus quinquepunctellus is one of the most geographically widespread species of the genus, feeding within the inflorescence stalks of 15 *Yucca* species (Powell 1992). Corresponding to the range of its potential hosts, the Five-spotted Bogus Yucca Moth can be found from Texas and the Gulf of Mexico to the southern part of Alberta in Canada, and from the Atlantic coast of the United States into the Great Plains (Figure 2).

Specimens of the pollinating Yucca Moth were collected in southern Ontario along Lake Erie as recently as 1956 (Davis 1967, Pellmyr 1999); however, there are no native populations of yuccas in Ontario (P. Achuff, pers. comm.). Without the host plant, there is little possibility that a native population of moths exists. There are natural populations of the Five-spotted Bogus Yucca Moth just south of the Great Lakes, and specimens have been collected from New York, Pennsylvania, and Ohio (Davis 1967). In the

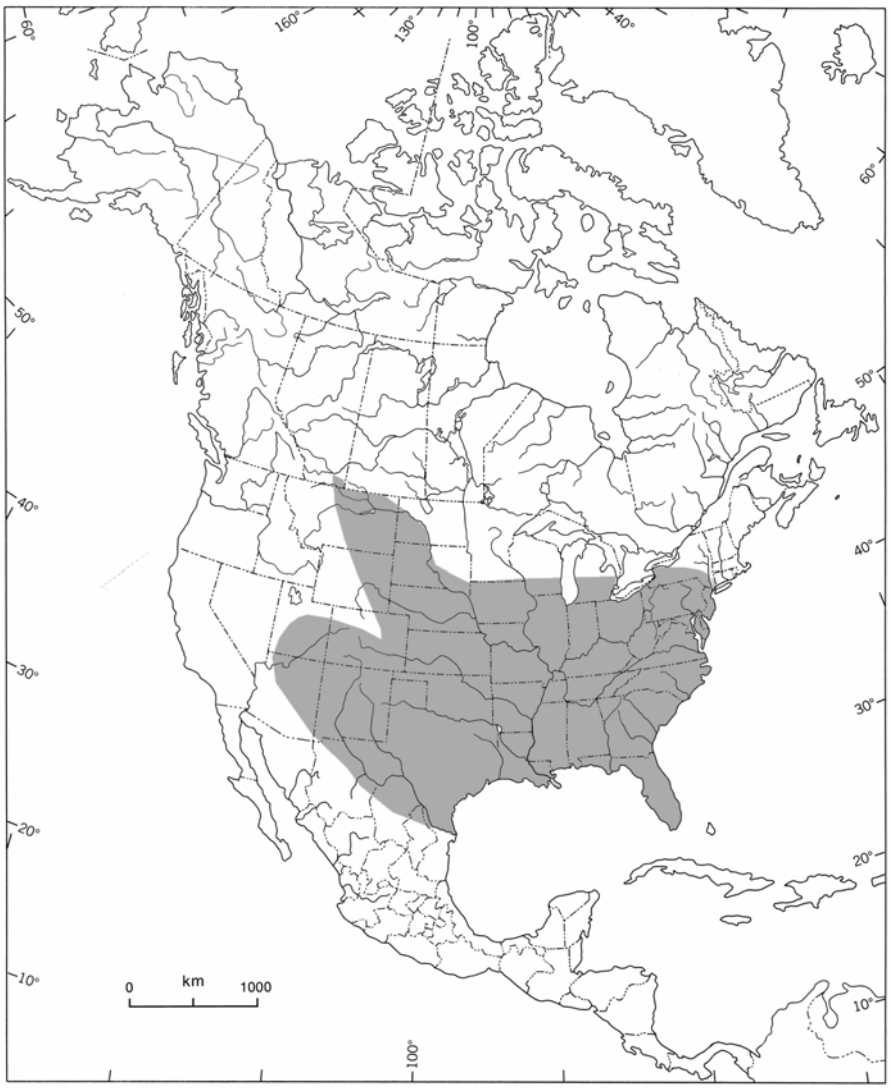

Figure 2. Distribution of the Five-spotted Bogus Yucca Moth (*Prodoxus quinquepunctellus*) in North America. Map adapted from Davis (1967) and Althoff *et al*. (2001).

Canadian National Collection of Insects at Agriculture and Agri-Food Canada, there are 20 specimens of *Prodoxus decipiens*, the eastern lineage of the species, that were collected by W.L. Putnam in 1935-36 from Vineland, Ontario (Appendix 1) (J-F Landry pers. comm.). The labels indicate that these specimens were reared from *Yucca filamentosa*, a species frequently grown in southern Ontario as a garden ornamental. It is not known whether the *Prodoxus* were introduced with the host plant or whether they expanded their range by themselves to take advantage of cultivated yuccas. The former appears more likely as no additional records of *Prodoxus* and no records of *T. yuccasella* from eastern Canada could be found.

Canadian range

There is only one viable population of the Five-spotted Bogus Yucca Moth in Canada. It is located at Onefour in the south-eastern corner of Alberta (Figure 3) and uses Soapweed (*Yucca glauca*) as its host plant. The Soapweed population extends over approximately 2 km along the south-facing coulee slopes of the Lost River, a tributary of the Milk River. The slopes are less than 1 km wide, and the entire population is scattered over an area of less than 2 km^2. Soapweed plants occupy less than half this area.

There is a second natural population of Soapweed in Alberta (Figure 3). This population is located on the Pinhorn Grazing Reserve along a 200-metre stretch of southwest-facing coulee slopes on the Milk River drainage (Hurlburt 2001), but it does not appear to support a population of the Five-spotted Bogus Yucca Moth.

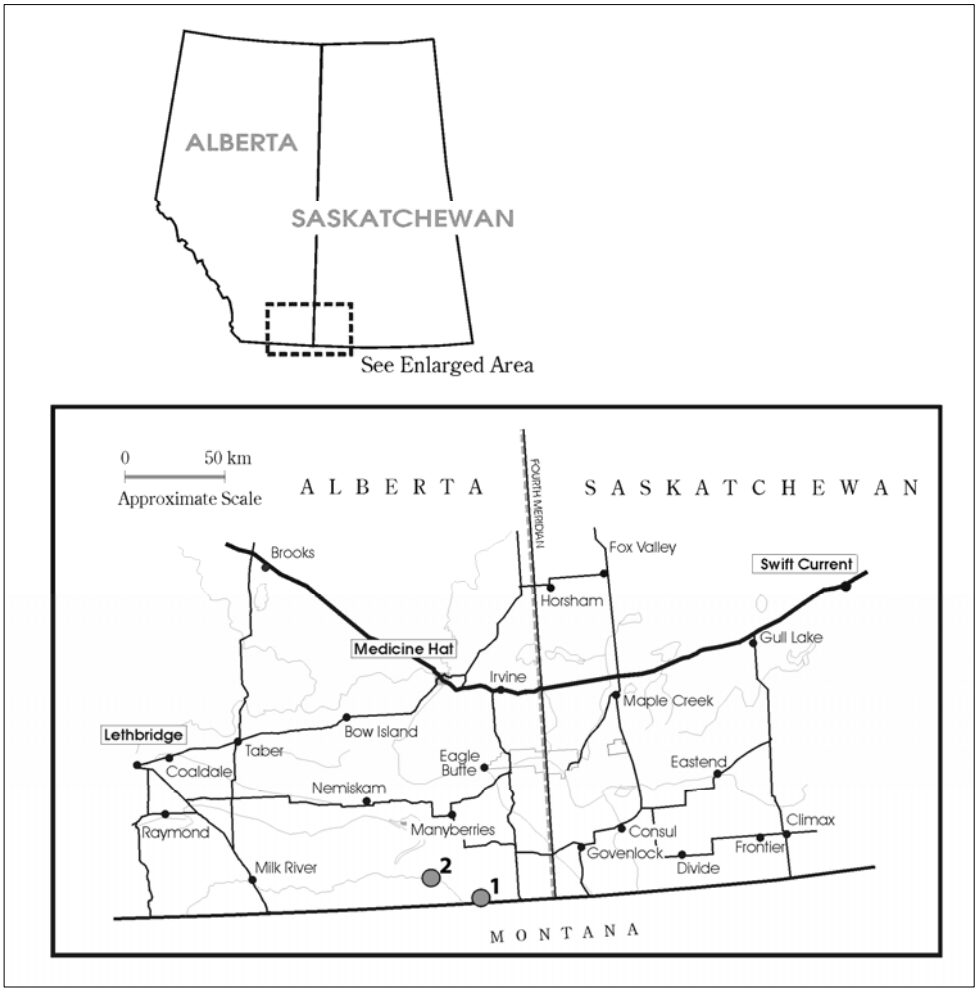

Figure 3. Known occurrences of Soapweed populations (*Yucca glauca*) in Canada. The only viable population of the Five-spotted Bogus Yucca Moth is at site 1 along the Lost River valley near Onefour, Alberta. Site 2 in the Pinhorn Grazing Reserve does not support the Five-spotted Bogus Yucca Moth. (Map taken from the COSEWIC status report on *Tegeticula yuccasella* (COSEWIC 2002).)

HABITAT

Habitat requirements

At the northern edge of its range in Alberta and Montana, the Five-spotted Bogus Yucca Moth uses only Soapweed for oviposition, larval feeding and development. There are no other *Yucca* species naturally occurring in Canada that can act as a host plant for *Prodoxus*. The pollinating Yucca Moth is also at the northern edge of its range in Alberta and is also restricted to Soapweed, and thus the habitat requirements for both moth species are identical. The following information has been taken from the COSEWIC status report on *Tegeticula yuccasella* (COSEWIC 2002).

In Alberta, Soapweed is restricted to the Dry Mixed Grass Subregion (ANHIC 2004). This semi-arid subregion has a continental climate with extremes of weather and large daily and seasonal variations in temperature characterized by low precipitation, hot summers and a high rate of evaporation. The evaporation rate is exacerbated by a high average wind speed, at times approaching 100 km/hr (COSEWIC 2002).

Soapweed grows in sparsely distributed populations on well-drained, mostly south-facing coulee slopes (Figure 4). Typically, these slopes are eroded, dry and sparsely vegetated with prickly pear cactus (*Opuntia polyacantha*) and Silver Sagebrush (*Artemisia cana*). The aspects of slopes supporting Soapweed in Alberta range from 34º (northeast) to 200º (south-southwest), and generally face away from prevailing southwest winds, except in cases where slopes are protected by adjacent slopes. Soils tend to be alkaline and regosolic without shallow hardpan (Milner 1977, Fairbarns 1984). In areas further south (northern Wyoming), Soapweed grows on flatter ground and occurs in sand dunes, pine forests and glades in the east and grassland in the southwest, and ranges in altitude from 0 to 1920 m (Pellmyr 1999) (COSEWIC 2002).

Figure 4. Habitat of the Five-spotted Bogus Yucca Moth. Dry mixed-grass coulee slopes near Onefour, Alberta. (Photo by R. Snell).

Habitat trends

Appropriate habitat for Soapweed, and therefore for the Five-spotted Bogus Yucca Moth, is naturally limited at the northern edge of the species' range in Alberta. Although there are numerous south-facing coulee slopes throughout the southeastern part of Alberta, many of these locations are grass-covered rather than eroding and are not inhabited by Soapweed, Yucca Moths or Five-spotted Bogus Yucca Moths.

Available habitat has not been reduced by agricultural practices. Soapweed grows on steep coulee slopes that are unusable for crop production (COSEWIC 2002). Although cattle grazing can damage the habitat, cattle have rarely been allowed to graze among the Soapweed plants, and to date, their effects on the habitat have been negligible.

Habitat protection/ownership

COSEWIC has assessed Soapweed as Threatened and the Yucca Moth as Endangered. The largest population of Soapweed with the only viable population of the Five-spotted Bogus Yucca Moth occurs on the slopes of the Lost River valley, near Onefour, AB on land owned and managed by Agriculture and Agri-food Canada. Both Soapweed and the Yucca Moth are listed on Schedule 1 of the federal Species at Risk Act. The protection and recovery plan for the Onefour population of Soapweed and Yucca Moths will also benefit the Five-spotted Bogus Yucca Moth.

BIOLOGY

Relatively little is known about the Five-spotted Bogus Yucca Moth because most of the work has focused specifically upon the obligate mutualism between yucca plants and the pollinating yucca moths. Most of what is known about the biology of *Prodoxus* comes from a few sources (Davis 1967; Powell 2001), including Riley's original observations in the late 1800s (Riley 1892; Riley 1894).

Life cycle and reproduction

Prodoxus quinquepunctellus has only one generation per year. Each adult lives for only a few days but adult emergence is staggered over the season and is synchronized with the flowering period of the host plant (Davis 1967). The first adults start to emerge before the first Soapweed flower has opened and appear to peak in abundance about a week after flowering has started (Table 1). The peak in population lasts only a few days and moth numbers quickly drop off until they disappear altogether. In the northern part of the species' range, adults can be found from early June to mid-July (Table 1).

Table 1. An index of *Prodoxus quinquepunctellus* abundance at the Onefour population during the summer of 2002.

Date	Number of open flowers checked	Number of open flowers occupied by at least one *Prodoxus* moth	Proportion of open flowers with at least one *Prodoxus* moth
June 27 2002	10	8	0.800
June 28 2002	67	22	0.328
June 30 2002	317	58	0.183
July 1 2002	512	63	0.123
July 2 2002	640	72	0.113
July 4 2002	832	83	0.100
July 5 2002	930	58	0.062
July 7 2002	1161	53	0.046
July 9 2002	1599	19	0.012
July 11 2002	1148	34	0.030
July 12 2002	511	19	0.037
July 13 2002	672	15	0.022
July 15 2002	127	6	0.047
July 16 2002	8	0	0.000
July 18 2002	10	0	0.000
Total	8544	510	

The adults rest in yucca flowers during the day and use them as mating sites in the evening. After copulation, the female leaves the flower and moves onto the flowering stalk. Before ovipositing, she positions herself lengthwise along the flowering stalk with her head facing up. She then raises her abdomen and inserts her serrated ovipositor into the inflorescence (Figure 1A). Several abortive attempts may be made over the stalk until she finds an area where she can insert her ovipositor. Eggs are deposited at a depth of approximately 1-2 mm (Davis 1967). Eggs are laid one at a time; however, a female may lay multiple eggs within the same stalk (R. Snell, personal observation). Occasionally, females also lay eggs in flower pedicles. The total number of eggs an individual female can lay during her life is unknown. A slight discolouration of the stem, which later develops into a small scar, marks each spot where the female oviposits. This scar does not cause any deformation or retardation of plant growth.

The eggs hatch 9 days after oviposition (Davis 1967). The larvae burrow into the main flower stalk and start to feed on stem tissue. They go through 3 moults in approximately 30 days (Riley 1892). At the end of the flowering season, they excavate a tunnel just below the surface of the stalk which remains covered by a thin layer of plant tissue (Davis 1967). They then retreat back into their burrows and create a cocoon of white silk. The prepupal larvae remain in diapause over one or several winters.

In spring, pupation occurs in the old flowering stalks prior to the start of flowering of the host plants. The pupal period is thought to be relatively short, occurring in less than a week (Davis 1967). Immediately prior to the emergence of the adult, the pupa creates an exit hole by pushing through the thin layer of plant tissue that covers the larval burrow. Once the pupa has pushed itself about half way through the hole, the adult can emerge. Adults usually emerge around dusk (Davis 1967).

Predation

The larvae and pupae of *P. quinquepunctellus* are well protected within Soapweed stems. The only known predators on these life stages are ungulates which inadvertently eat the larvae when consuming yucca flower stalks. Adult moths spend a great deal of time hidden within yucca flowers and are probably not usually vulnerable to avian predators. They are, however, sometimes caught and eaten by wood ants (*Formica ravida*) (Snell 2004) and may be preyed upon by some other predatory arthropods, such as spiders of the family Thomisidae.

Physiology

Diapause in insects is a state of arrested development and is common in temperate zones (Tauber *et al*. 1986). Most species enter a period of dormancy during unfavourable conditions and synchronize their emergence to the availability of their resource. *Prodoxus* is known to exhibit simple diapause in nature, overwintering and emerging the following spring.

Evidence of prolonged diapause in *Prodoxus* was first observed in the late 1800s by C.V. Riley. Yucca stems were collected in May of 1887. In the fall of 1893, the stems were cut open and two healthy larvae were found still in their cocoons (Riley 1894). The longest insect dormancy recorded comes from a closely related species, *Prodoxus y-inversus*. Under laboratory conditions, adult moths successfully emerged after 30 years in diapause (Powell 2001). Overwinter temperature was found to be the primary factor initiating diapause development in this study (Powell 2001).

Prolonged diapause may be an adaptation to resources which are limited to a specific season and are erratic in availability or abundance from year to year (Powell 2001). Flowering in yuccas can be erratic between years (Aker 1982; Addicott 1998), especially in northern Soapweed populations (Hurlburt 2004). In Canada, the Five-spotted Bogus Yucca Moth exhibits both simple and prolonged diapause (R. Snell, personal observation); however, the extent to which genetic or external factors influence the length of diapause is unknown.

Dispersal/migration

There is no information on the dispersal distances for the Five-spotted Bogus Yucca Moth. In general, Prodoxidae moths live as adults for a few days only, are poor flyers and are probably unable to travel great distances (Kerley *et al*. 1993; Marr *et al*.

2000; COSEWIC 2002; J. Addicott, pers. comm.). There is no dispersal during the larval stages because all immature development occurs within the natal flowering stalk.

Interspecific interactions

The success of the Bogus Yucca Moth relies not only upon its host, *Yucca glauca*, but also upon the pollinating Yucca Moth (*Tegeticula yuccasella*). In order to fully understand this dependency, it is necessary to understand the biology of the host plant, its pollinator and their obligate mutualism.

Host biology

Yucca glauca Nutt. (Agavaceae), or Soapweed, is a long-lived polycarp, commonly found in grasslands and arid regions from the Rocky Mountains east to the Mississippi River and from Texas north into southern Alberta (Hurlburt 2001). *Yucca glauca* produces one or a cluster of basal rosettes with sharp-tipped, fibrous leaves. At flowering, each rosette produces a single, typically unbranched raceme, about 40-80 cm in height. Each raceme bears 20-70 perfect, off-white flowers which open sequentially, starting at the bottom (Figure 5). Each rosette can reproduce sexually only once and dies after flowering. Clones stay alive by reproducing asexually, via the production of new vegetative rosettes from the base of a mature rosette (Kingsolver 1986). In northern Montana and southern Alberta, *Y. glauca* flowers from June to mid-July, with some individuals flowering as late as August.

Figure 5. Soapweed (*Yucca glauca*), host plant of the Five-spotted Bogus Yucca Moth (*Prodoxus quinquepunctellus*). (Photo by R. Snell.)

Most of the flowers are abscised by the plant, with only 3-10% of the flowers maturing into fruit (Kingsolver 1984; Dodd and Linhart 1994). The dehiscent capsular fruit is composed of three carpels, each with two locules. Each locule contains a row of 40-60 ovules. At the end of the summer, the fruit dries and splits along the carpel walls, allowing the wind to disperse the flat seeds over relatively short distances.

Pollinator biology

In Canada, the Yucca Moth, *Tegeticula yuccasella* Riley (Prodoxidae), is the sole pollinator of *Yucca glauca*. The emergence of moths is roughly coincident with the start of flowering. Female Yucca Moths use specialized mouth parts known as maxillary tentacles to collect and transport pollen (Riley 1892). After flying to an inflorescence, females enter a flower and oviposit into the flower's ovary. Oviposition is usually followed by pollination, in which moths climb to the top of the stigma and place some pollen in the stigmatic depression (Riley 1892). By using their tentacles to push and pack the pollen further down the style, female moths ensure pollination and a food source for their offspring.

Tegeticula yuccasella eggs hatch within a few days after oviposition (Pellmyr 2003) and the larvae feed on the developing seeds. When the larvae are mature, they chew an exit hole in the fruit and lower themselves to the ground via a silken thread. Once on the ground, they burrow into the soil and create a cocoon of silk and soil particles (Pellmyr 2003). They remain in diapause underground before pupating a few weeks prior to emergence.

Impact on the Five-spotted Bogus Yucca Moth

The factor with the greatest impact on the survival of the Five-spotted Bogus Yucca Moth is the pattern of fruit retention in yuccas that is driven by the pollination/seed predation mutualism with Yucca Moths. The Five-spotted Bogus Yucca Moth relies on Yucca Moths to ensure fruit production. In the absence of fruit, flower stalks quickly wither and the larvae in those stalks experience almost complete mortality (Snell 2004). Even in flowering stalks which retain and mature fruit, the larvae are indirectly influenced by the position of the highest fruit. *Yucca glauca* produces 20-70 flowers, but only 3-10% of the flowers are retained as fruit (Kingsolver 1984; Dodd and Linhart 1994). Once all of the flowers have abscised, the flowering stalk above the highest fruit starts to dry from the top down and stops only once a fruit is reached. The stalk below the highest fruit remains green until the end of the summer (R. Snell, personal observation). Larvae located above the highest fruit experience a higher mortality rate than those resulting from eggs laid below the highest fruit (Snell, 2004).

Another factor that may influence larval survivorship is aphid feeding. Aphids occasionally feed on the flowering stalk above the highest fruit (R. Snell, personal observation). Aphid feeding can slow down the rate of stalk drying, causing a greater proportion of the stalk to remain green until the end of the season (Snell 2004). This can increase survivorship of Five-spotted Bogus Yucca Moth larvae, especially in the section of the stalk that would have otherwise dried out.

Parasitism

The larvae of *P. quinquepunctellus* are known to be parasitized by three species of hymenoptera (Davis 1967), Eurytomidae: *Eudecatoma flammineiventris* (Girault); Ichneumonidae: *Calliephialtes notandus* (Cresson); and Braconidae: *Heterospilus prodoxi* (Riley). In the Onefour population, parasitism rates appear to be very low (Snell 2004). Assuming that any unidentified larvae were parasitoids, then only 17 out of 1,829 *Prodoxus* larvae were parasitized in 2002. There was no evidence of parasitism in 2003.

Adaptability

The Five-spotted Bogus Yucca Moth is very sensitive to extreme habitat alteration because of its complete dependency upon Soapweed and the Yucca Moth. Established moth populations, however, are relatively robust against between-year variability in their resource. Yucca populations are known to have large variations between years in flowering intensity and Yucca Moth density (Aker 1982; Addicott 1998; Hurlburt 2004). Prolonged diapause, where only a proportion of the population emerges as adults each year, provides a contingency plan against low flowering/fruiting years. A Soapweed population that consistently fails to produce flowers/fruit over multiple successive years could lead to long-term population decline for the moth.

POPULATION SIZES AND TRENDS

Search effort

No data are available on population sizes and trends for the Five-spotted Bogus Yucca Moth in Canada. However, several life history measures are available and may be used to directly and indirectly estimate the health and size of the population. During the summer of 2002, 142 Soapweed plants were selected at the Onefour population. The site was visited by R. Snell four or five times per week from June 14, 2002 until August 28, 2002. This time frame allowed for the monitoring of Soapweed and the Five-spotted Bogus Yucca Moth from flowering through to fruit and stalk maturation. During flowering, all open Soapweed flowers were checked at each visit and considered ‘occupied’ if they contained at least one Five-spotted Bogus Yucca Moth (Table 1). Five-spotted Bogus Yucca Moths and pollinating Yucca Moths are often found together. The females of the two species are easy to distinguish (see Morphological Description above), and the males were separated by using the presence of spotting on the forewings. Note that the data for males are a conservative estimate as some Five-spotted Bogus Yucca Moths can have few or no spots. The actual number of moths in each flower was not counted. Once a flower was opened, the moths inside were visibly disturbed and began moving around the flower. If the flower was held open too long, the moths often flew away. Therefore, to reduce the time spent looking inside each flower, researchers just peeked inside and recorded the presence/absence of at least one Five-spotted Bogus Yucca Moth. The total number of flowers examined versus the number of flowers occupied was used as an indirect index of abundance.

In 2003, the total number of ovipositions per flowering stalk was counted on 16 Soapweed plants in Onefour. Plants were checked several times when *P. quinquepunctellus* was active and once after the moths had disappeared. During each visit, R. Snell counted and marked any new oviposition marks. To avoid miscounts, she placed a black dot over each oviposition site using a Sharpie® marker. Oviposition scars are clearly visible on flowering stalks while in flower, but can become confused with other scars once the fruit are mature and the stalk has started to dry. The stalks were allowed to mature in the field and were collected at the end of the season. They were dissected and the number of larvae per flowering stalk was recorded. At the end of the 2002 season, 136 flowering stalks were also collected and dissected to count the number of larvae. Dissecting flowering stalks is a destructive sampling technique; however, it is impossible to determine the number of larvae or survivorship without looking inside the stalks. This is especially true since this species practices prolonged diapause. Therefore, counting the number of ovipositions and then recording the number of adults that emerge the next year is not an accurate measure of the success of each year's ovipositions. Long-term studies could be put in place for a non-destructive measure, where a sample of stalks is monitored every year for the appearance of new emergence holes.

Old flowering stalks were examined during the 2003 field season as they retain some useful information. Each adult moth leaves a clearly visible emergence hole when it leaves the stalk. Although it is impossible to determine exactly how many years have passed since an old stalk flowered, it was possible to distinguish those stalks that had flowered in the previous season from those which were more than a year old.

In Onefour, 149 old flowering stalks were examined for emergence holes. No emergence holes were observed in the Pinhorn Soapweed population, although some of the old stalks had marks which may possibly have been old ovipositions (K. Foreman, pers. comm.); however, stalks were not dissected to look for additional evidence of *Prodoxus* (i.e. feeding tunnels, larvae, or pupae). In addition, oviposition marks are very difficult to accurately recognize in dried flowering stalks and are really only identifiable when the stalks are green.

Abundance

The yuccas in Alberta were part of a complete census in 1998. The Onefour population was estimated at 28,174 rosettes among 8,499 clones (Csotonyi & Hurlburt 1999). The Pinhorn population was estimated at 1,383 rosettes among 404 clones (Csotonyi & Hurlburt 1999). Updated population data for Soapweed and its associated moths are currently being collected and analyzed for the Pinhorn population (J. Nicholson, pers. comm.).

During the 2002 flowering period, 8,544 Soapweed flowers at the Onefour population were examined. At least one Five-spotted Bogus Yucca Moth was found inside 510 of those flowers (Table 1). The average number of oviposition marks in Onefour in 2003 was 652 per stalk (Table 2). This number is significantly higher than in sites located in northern Montana. However, the Soapweed population in Onefour had

extremely low flowering in 2003, with less than 1% of the clones producing flowering stalks. The high number of ovipositions was likely the effect of limited suitable oviposition sites. In 2002, a year with a large number of flowering stalks, the number of larvae per stalk was more similar to that in populations located in Montana (Table 2).

In Onefour, stalks that had flowered in 2002 had an average of 2.301 ± 0.896 SE emergence holes per stalk. Stalks that had flowered prior to 2002 had an average of 29.36 ± 6.437 SE emergence holes. These data do *not* suggest that the moth population is declining. Rather, because the number of emergence holes is similar to the number of larvae found during stalk dissections (Table 2), it provides supporting evidence for prolonged diapause. Stalks that are only a year old still have larvae inside and generally develop additional emergence holes as adult moths continue to leave in subsequent years.

Table 2. Population and life history data for the Five-spotted Bogus Yucca Moth (*Prodoxus quinquepunctellus*) in Onefour, Alberta. Two sites in northern Montana are included for comparison. Numbers shown are mean values ± standard error.

Site & Year	n	# Ovipositions per Stalk	# Larvae per Stalk	Survivorship
Onefour, AB				
2002		Not monitored	15.765 ± 1.637	
2003	16	651.937 ± 130.452	27.437 ± 8.200	0.040 ± 0.09
Loma, MT				
2002		Not monitored	23.667 ± 4.465	
2003	68	273.691 ± 25.419	18.397 ± 3.519	0.053 ± 0.010
Fort Benton, MT				
2003	38	300.632 ± 32.458	41.868 ± 7.500	0.122 ± 0.016

At the Pinhorn site, no adult Bogus Yucca Moths have ever been observed, and there are no confirmed emergence holes in the old flowering stalks. The possibility that the Five-spotted Bogus Yucca Moth once occurred there cannot, however, be ruled out. If some of the marks on old flower stalks were indeed ovipositions, they would indicate the historical presence of the Five-spotted Bogus Yucca Moth at Pinhorn. Although the moths would have laid their eggs in the flowering stalks, the larvae would have failed to develop because of the absence of fruit. This would explain the presence of possible oviposition marks and the lack of emergence holes. Despite the availability of a Soapweed population in Pinhorn, the decline of the Yucca Moth at the site and the subsequent lack of fruit ensure the failure of a Five-spotted Bogus Yucca Moth population at Pinhorn, if one ever occurred there.

Fluctuations and trends

Without long-term data, it is unknown if the *Prodoxus* population is increasing, decreasing or stable. Variation in moth abundance is not uncommon in yucca populations (Aker 1982; Addicott 1998; Hurlburt 2004). However, without long-term data it is not possible to predict what effect these fluctuations have on the persistence of the moth population. Small isolated populations may be more sensitive to stochastic variation than large populations and more susceptible to decline (COSEWIC 2002).

Within a season, there are fluctuations in the size of the adult Five-spotted Bogus Yucca Moth population (see Life cycle and reproduction). There are also substantial, though unquantified, population fluctuations from year to year. In years of abundant Soapweed flowering, only a small percentage of flower stalks are destroyed by ungulate herbivory and *Prodoxus* reproductive success is high. In years when few Soapweed plants flower, almost all flower stalks may be eaten and the moth's reproductive success can approach zero. The degree of reproductive success in any year has a proportional effect on the number of adult *Prodoxus* emerging the following year.

Yucca densities at Onefour have been estimated at 8,499 clones, or 28,174 rosettes (Hurlburt 2001). Each year, flowering ranges from less than 1% to 50% of the rosettes, which is approximately 280 – 14,000 inflorescences produced in a year. The average number of *Prodoxus* larvae produced per inflorescence in a high flowering year (close to 50% flowering) was 15.8 ± 1.6 SE, and in a low flowering year (less than 1% flowering) it was 27.4 ± 8.2 SE (Snell, unpublished data). From multiplying the average number of larvae per inflorescence by the total number of inflorescences, it is possible to obtain a very rough estimate of the average larval population size for a low flowering and a high flowering year of 7,672 and 221,200 respectively. If, instead of using the average number of larvae per inflorescence, we take the lowest number for low flowering years and the highest number for high flowering years, the estimate of the maximum range is 5,376 to 243,600 larvae produced per year.

These estimates represent the most optimistic larval population size produced each year. In some years, all flower stalks are eaten by ungulates and no larvae survive. In addition, the number of larvae produced each year is much higher than the effective adult population the following year. There are larvae which will die during the winter and never become adults. There are also larvae which remain in diapause to emerge as adults in subsequent years. Even the larvae which survive to pupate and emerge as adults may do so in an area without any flowering yuccas, and can die without ever reproducing. Taking all these factors into consideration, the adult *Prodoxus* population size can approach zero, especially in those years following complete ungulate herbivory where the only adult moths are those resulting from prolonged diapause. In 2002, a total of 510 *Prodoxus* adults were observed during a survey of 142 Soapweed plants (Table 1). However, the total moth population following favourable years is likely to be in the thousands.

Rescue effect

Although the Five-spotted Bogus Yucca Moth is relatively common in yucca populations further south, there is little chance of the species re-colonizing the Canadian population should it become extirpated, or of individuals from the Canadian population dispersing to another population. The site in Alberta is isolated from other yucca populations in the main range to the south by a minimum distance of 200 km (D. Hurlburt, pers. comm.), with little intervening native habitat in which Soapweed could live (COSEWIC 2002). It would be almost impossible for moths to traverse this distance because Prodoxidae moths are particularly weak flyers, are short-lived and are likely

incapable of dispersing long distances over inhospitable terrain (Kerley *et al*. 1993, Marr *et al*. 2000; COSEWIC 2002; J. Addicott, pers. comm.). Moreover, there are no records of moth-depauperate populations being recolonized by Yucca Moths (COSEWIC 2002).

LIMITING FACTORS AND THREATS

The Five-spotted Bogus Yucca Moth is limited by the number of Soapweed flowering stalks and the production of fruit. Thus, factors which threaten/limit either the host plant or the pollinating Yucca Moth will also have detrimental effects for the Five-spotted Bogus Yucca Moth. Some of the information below was taken from the COSEWIC status report on *Tegeticula yuccasella* (COSEWIC 2002).

Natural limiting factors

Peripheral distribution and isolation

In Alberta, the Five-spotted Bogus Yucca Moth is limited to locations where Soapweed and the pollinating Yucca Moth exist, sexually reproduce and produce fruit. Further, the moths are likely physiologically limited by temperature and probably can only survive on south-facing, highly eroded, dry slopes, similar to the habitat characteristics preferred by their host plant (COSEWIC 2002). Soapweed populations growing at high elevations suffer from low levels of pollination. This is likely because cold night-time temperatures affect moth activity (Dodd & Linhart 1994). At the northern edge of their range, Soapweed plants not located on south-facing slopes also have fewer ovipositions, fewer fruit and lower larval production than those in ideal locations (Hurlburt 2004).

Onefour represents an isolated northern outlier for populations of Soapweed, along with the associated *Tegeticula* and *Prodoxus* moths. There is evidence to suggest that small, declining, peripheral populations of Soapweed may not contain enough plants to sustain Yucca Moths (Dodd & Linhart 1994, D. Hurlburt, pers. comm.). Soapweed populations with few Yucca Moths would produce fewer fruit, which would likely lead to the decline of the Five-spotted Bogus Yucca Moth.

Availability of host plant and pollinator

The Five-spotted Bogus Yucca Moth relies on its host plant Soapweed and the Yucca Moth. The Bogus Yucca Moth lays its eggs into the flowering stalk of Soapweed; however, the larvae only survive in those stalks where fruit develop (Snell 2004). In the absence of fruit, the stalks quickly wither and the larvae inside perish. Although there are two populations of Soapweed in Canada, the Five-spotted Bogus Yucca Moth occurs only in the Onefour population. It is not known whether the Five-spotted Bogus Yucca Moth ever occurred at the Pinhorn site, but its absence there may have resulted from the recent decline in the Yucca Moth population (see Ungulate herbivory).

Ungulate herbivory

Herbivory by pronghorn antelope (*Antilocapra americana*) and mule deer (*Odocoileus hemionus*) can have a large negative effect on the reproductive success of Soapweed and the associated moths. Pronghorn eat individual Soapweed flowers, whereas mule deer usually eat the entire flowering stalk. Mule deer also eat developing fruit during times of drought (R. Snell, personal observation).

Extensive ungulate herbivory occurs at both the Onefour and Pinhorn sites, but is particularly destructive at Pinhorn because this site has a smaller Soapweed population. In 1998 and 2000, 80 – 100% of the inflorescences at the Pinhorn site were destroyed by ungulate herbivores (Csotonyi and Hurlburt 1999; COSEWIC 2002). Heavy ungulate herbivory has severely limited fruit production; no fruit were produced at Pinhorn in six of the past seven years. This situation has caused a population decline in the Yucca Moth, perhaps below sustainable numbers (COSEWIC 2002). During the 2004 season, there was a total of five fruit produced and all were severely pollen limited (J. Nicholson, pers. comm.).

The extent of herbivore damage may depend upon flowering intensity. When the number of inflorescences was low due to small population size of yuccas or low flowering intensity, herbivory has been high (between 80-100% of flowers). In episodes of high flowering, herbivory has been low (less than 1% of flowers) (COSEWIC 2002). Thus, in an unpredictable system, where flowering varies between years, herbivory may have the greatest impact during years of low flowering. This problem can be exacerbated by drought and the resulting absence of other vegetation for ungulates to feed on (D. Hurlburt, pers. comm., R. Snell, personal observation). Removal of flowers by herbivores in an unpredictable population of flowering plants causes a decline in fruit production and moth survival and has the potential, through decreased recruitment, to lead to long-term population declines in isolated peripheral populations (Kerley *et al*. 1993).

In years where 80 – 100% of the flowers at Onefour are consumed, the success of the Five-spotted Bogus Yucca Moth may be in jeopardy. If all of the flowers are consumed, the stalk does not retain any fruit and dries, so the larvae inside those stalks suffer almost complete mortality (Snell 2004). Mule deer in particular, represent a serious threat as they consume the entire flowering stalk, ensuring complete failure for the Five-spotted Bogus Yucca Moth.

Insect herbivory and interference

At the northern edge of the Soapweed's range, wood ants (*Formica ravida*) are often found foraging on the plants. Ants can directly affect yuccas and moths by consuming plant tissues, such as buds, flowers or fruit. Ant-damaged buds and flowers are usually abscised, which may reduce the number of Soapweed flowers available to pollinators. Ants can occasionally damage more than 90% of the buds (R. Snell, personal observation). However, ants usually consume no more than 30% of the total

number of available flowers, and there was no effect of the proportion of flowers lost to ants on the final fruit production (Snell 2004). Ants are also attracted to Soapweed plants by aphids; however, ants are present on Soapweed with or without aphids. When ants encounter an insect that is not an aphid on a Soapweed plant, they either disturb the insect so that it moves away or catch the insect and consume it (Snell 2004). Although ants disturbed Yucca Moths and reduced the number of ovipositions per flower, there was no effect on fruit retention (Snell 2004). Ants also interrupted the Five-spotted Bogus Yucca Moth while ovipositing and significantly reduced the number of ovipositions and larvae per stalk (Snell 2004).

Sap beetles (Nitidulidae) occasionally feed upon yucca buds, flowers or developing fruit (Davis 1967; Udovic 1986; Bronstein & Ziv 1997; Huth & Pellmyr 1997). Beetle-damaged buds and flowers are more likely to be aborted than undamaged buds (Udovic 1986; Huth & Pellmyr 1997), which can reduce the number of flowers available to pollinators. Beetles can damage 15-45% of the flowers, but they inflict a much more serious cost to yuccas when they feed inside the fruit (Bronstein & Ziv 1997).

Anthropogenic limiting factors

The anthropogenic limiting factors all centre on issues that threaten Soapweed. The following information was taken from the COSEWIC status report on *Tegeticula yuccasella* (COSEWIC 2002).

Agricultural activities

Agricultural practices have restricted the Soapweed to unarable land in many areas of Montana (D. Hurlburt, pers. comm.). Although, with the exception of grazing, agricultural activity is not currently a serious threat to Soapweed or the moths in Alberta, it is possible that an increase in such activity may take place in the future.

In Alberta, Soapweed plants and their moths must coexist with cattle and current grazing practices. Fortunately, most plants occur on steep, rocky slopes that are not preferred by cattle; however, those at the tops of slopes and on prairie in Onefour are particularly susceptible, and most of their flowers and fruit were eaten by cattle in 2001. In the past, the Onefour Research Substation has not pastured cattle in the area of the Soapweed during flowering and fruiting; however, during periods of drought, such as in 2001, such a luxury cannot be afforded as feed for cattle is in short supply (I. Walker, pers. comm.). Flowering stalks of *Yucca* populations in the southwestern United States are routinely destroyed by grazing cattle (J. Addicott, pers. comm.), and it is plausible, though not very likely, that grazing could become a substantial threat in Alberta.

In Alberta, an estimated two-thirds of original grasslands have been lost to cultivation (Samson and Knopf 1994); however, most areas inhabited by Soapweed and its pollinator are not ideal for cultivation and are in no immediate threat of such activity. Strip-farming and irrigation are prevalent in Montana immediately across the coulee from the Soapweed at Onefour, and there is no reason to assume that such activity

could not take place on the flats immediately adjacent to the plants in Alberta. In the past 25 years, Soapweed has spread onto these flats in a northerly direction (Csotonyi & Hurlburt 1999), and these clones and the spread of the population would be immediately threatened by intensive agricultural practices.

Although herbicides are currently used only to eliminate individual weedy plants near the Onefour Soapweed site, widespread use of herbicides and insecticides could cause plant and moth mortality and reduce reproductive success. Soapweed throughout the Great Plains is routinely killed through tilling and by the use of Round-up (D. Hurlburt, pers. comm.). In Montana, Soapweed plants along roadsides sprayed for weeds tend to have fewer ovipositions and produce few fruit (D. Hurlburt, pers. comm.).

Since both Soapweed and the Yucca Moth have been listed on Schedule 1 of the federal Species at Risk Act, steps are being taken to protect these species and their habitat. Consequently, grazing by cattle, cultivation of the flats immediately adjacent to the Soapweed colony, or use of pesticides to eliminate Soapweed plants are no longer likely to be permitted, thereby removing these threats to both these species as well as to the Five-spotted Bogus Yucca Moth.

Traffic

Both Soapweed sites in Alberta are well known and directly reachable by road. As a result, both locations are visited daily during the summer and fall by naturalists, hunters, ranchers, border patrol and archaeologists. Plants have been destroyed at both locations by off-road traffic, and in one case a vehicle was noted to be deliberately running over Soapweed plants on the prairie at Onefour (D. Hurlburt, pers. comm.). It should be noted that Soapweed seedlings are more likely to occur on the disturbed soil of roads than in other locations; however, rarely do these seedling survive more than one growing season (D. Hurlburt, pers. comm.). Further, off-road traffic has destroyed cryptogamic soil crusts and caused increased erosion (D. Hurlburt, pers. comm.). A more concerted effort needs to be made to make the public aware of this problem.

Horticultural and medicinal uses

There are numerous examples of Soapweed in household gardens in southern Alberta, transplanted from both the Onefour and Pinhorn populations (Hurlburt 2001). One ranch in the area has well over a dozen Soapweed plants in its garden, all from the declining Pinhorn population (D. Hurlburt, pers. comm.). None of the transplanted Soapweed plants has shown any sign of oviposition or pollination by any yucca moth species (Hurlburt 2001). Transplanting of Soapweed, although discouraged, probably will not affect the long-term success of the plant or the moth. During digging, the roots of the Soapweed plant are often partially removed from the original site and the remaining roots send up new shoots in subsequent years.

Other species of *Yucca* (e.g. *Y. elaphantipes, Y. filamentosa*) that are commercially available in greenhouses are found in household gardens across Canada.

There has been no documentation of these plants having ovipositions or fruit or of observations of moths among their flowers. Although it is plausible that these small, isolated plants (native and non-native) could be visited by Yucca Moths, it is unlikely that they could support moth populations in large numbers or for any length of time. *Yucca* flowers usually need several visits from moths to ensure successful pollination (Hurlburt 2004), and most species and populations require cross-pollination for fertilization. Further, these commercial *Yucca* species may not be pollinated by *T. yuccasella*.

There has been interest in Canada in the collection of Soapweed seed for the development of nursery stock and the collection of roots and petals for herbal remedies. Fruit production is extremely low in some years, and when combined with seed collection, could very well jeopardize the viability of Soapweed and moth populations. To date, the relative importance of the few high-fruiting years to the more frequent low-fruiting years in maintaining Soapweed populations is unknown. Although Alberta populations of Soapweed will never be harvested by large commercial operations because of their small population size, they could be threatened by smaller, grassroots based harvesting (Hurlburt 2001).

SPECIAL SIGNIFICANCE OF THE SPECIES

The Five-spotted Bogus Yucca Moth represents one part of a unique and endangered system in Canada, which includes Soapweed and its associated moth species. The Five-spotted Bogus Yucca Moth has the potential to be used as an indicator species for the system because the moth requires the presence of both Soapweed and the Yucca Moth, whereas the reverse is not true (i.e., neither Soapweed nor the Yucca Moth depends upon the Five-spotted Bogus Yucca Moth). Thus, the decline of either Soapweed or the Yucca Moth may first show up as a decline in the Five-spotted Bogus Yucca Moth population. This hypothesis may explain what may have occurred in the Pinhorn population, if the Five-spotted Bogus Yucca Moth ever existed there; declining numbers of Soapweed plants and of pollinating Yucca Moths may have led to the disappearance of the Five-spotted Bogus Yucca Moth.

There are no recorded uses of the Yucca Moth or the Five-spotted Bogus Yucca Moth by aboriginal people. However, the moths' host plant, Soapweed, was used by some tribes in the more southern parts of the species' range. A variety of *Yucca* species were used for food, beverages, detergents, medicines, clothing and household articles (Webber 1953), and it is probable that the Blackfoot (Alberta) / Blackfeet (Montana) may have used Soapweed for some of these purposes as well (Johnston 1987). Despite records of Soapweed use in other parts of the range, there are no definitive records of use or artefacts containing Soapweed fibres in Alberta (COSEWIC 2002).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The host plant for the Five-spotted Bogus Yucca Moth, Soapweed (*Yucca glauca*), was originally assessed as a species of Special Concern by COSEWIC in 1985. COSEWIC reassessed Soapweed as Threatened in 2000 as it is only found in two sites in southeastern Alberta and it relies upon a very specialized moth for pollination. COSEWIC has assessed the Yucca Moth (*Tegeticula yuccasella*) as Endangered since one population may have recently become extirpated (COSEWIC 2002) and the second population is located in a small and isolated area. In Alberta, both Soapweed and the Yucca Moth are listed as endangered at the provincial level. A recovery plan for both Soapweed and the Yucca Moth in Alberta is almost complete (J. Chandler, pers. comm.) and recovery action will be taking place early in 2006. Soapweed is considered an Exotic in Saskatchewan. In Canada, currently the Five-spotted Bogus Yucca Moth does not receive any formal protection, but activities to protect, manage, or recover the Soapweed and the Yucca Moth will also benefit the Five-spotted Bogus Yucca Moth.

Soapweed is ranked G5 (secure, common and widespread) and the Yucca Moth is G4 (apparently secure, uncommon but not rare) (NatureServe 2004). The Five-spotted Bogus Yucca Moth has not yet been assessed by Alberta and has not been ranked either by General Status or NatureServe (2004).

TECHNICAL SUMMARY

Prodoxus quinquepunctellus
Five-spotted Bogus Yucca Moth — Fausse-teigne à cinq points du Yucca
Range of Occurrence in Canada: Alberta

Extent and Area Information	
• *Extent of occurrence (EO)(km²)*	< 2 km²
• *Specify trend in EO*	Currently stable, may have declined in the past
• *Are there extreme fluctuations in EO?*	No
• *Area of occupancy (AO) (km²)*	< 1 km²
• *Specify trend in AO*	Currently stable, may have declined in the past
• *Are there extreme fluctuations in AO?*	No
• *Number of known or inferred current locations*	1
• *Specify trend in #*	1 population may have recently become extirpated
• *Are there extreme fluctuations in number of locations?*	No
• *Specify trend in area, extent or quality of habitat*	Stable
Population Information	
• *Generation time (average age of parents in the population)*	1 – 6+ years
• *Number of mature individuals*	Few 100s –1000s depending on number of inflorescences and fruit production
• *Total population trend:*	Unknown
• *% decline over the last/next 10 years or 3 generations.*	Not applicable
• *Are there extreme fluctuations in number of mature individuals?*	Very likely, based on high incidence of ungulate herbivory in some years
• *Is the total population severely fragmented?*	No
• *Specify trend in number of populations*	Unknown – 1 population may have recently become extirpated
• *Are there extreme fluctuations in number of populations?*	No
• List populations with number of mature individuals in each:	
• Lost River population, Onefour, AB	Few 100s -1000s of adults. Recruitment varies each year depending on flowering intensity and fruit production
Threats (actual or imminent threats to populations or habitats)	
- Herbivory of Soapweed flowers and flower stalks - Loss of viable pollinating Yucca Moth population - Off-road traffic - Horticultural and medicinal uses of Soapweed	

Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?*	USA: Probably stable and secure
• *Is immigration known or possible?*	Not possible as the closest yucca population is 200 km away, too far for natural immigration
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Yes, provided ungulate herbivory is limited and a viable population of Yucca Moths persists
• *Is rescue from outside populations likely?*	No
Quantitative Analysis [provide details on calculation, source(s) of data, models, etc]	Insufficient data
Current Status COSEWIC: Endangered (2006)	

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code**: B1ac(iv)+2ac(iv)

Reasons for Designation:

This highly specialized moth exists in Canada as a single population that occurs in a very small, restricted area, isolated from the main range of the species in the United States. The moth is entirely dependent on the obligate mutualistic relationship between its host plant (Soapweed) and the plant's pollinator (Yucca Moth), both of which are at a high level of risk. It is threatened by the high level of wild ungulate herbivory, which in some years greatly reduces recruitment of the moth, its host plant and the host plant pollinator, and by off-road vehicles that destroy the host plant.

Applicability of Criteria

Criterion A: (Declining Total Population): Not applicable.

Criterion B: (Small Distribution, and Decline or Fluctuation): The extent of occurrence is smaller than 5,000 km^2 (smaller than 2 km^2) – B1, the area of occupancy is smaller than 500 km^2 (smaller than 1 km^2) – B2, the population is not severely fragmented, but is known to exist at fewer than 5 (1) locations – (a) there is no evidence of continuing declines but the population undergoes extreme fluctuations in the number of mature individuals, based on the grazing of flowerheads – (c)(iv).

Criterion C: (Small Total Population Size and Decline): Not applicable

Criterion D: (Very Small Population or Restricted Distribution): Meets Threatened under D1 – number of mature individuals is fewer than 1,000 (about 510).

Meets Threatened under D2 – the population has a very restricted area of occupancy (smaller than 1 km^2) and number of locations (1), such that the moth is prone to the effects of human activities and stochastic events.

Criterion E: (Quantitative Analysis): Not applicable, no data.

ACKNOWLEDGEMENTS

Dr. Donna Hurlburt wrote the original status report for *Tegeticula yuccasella* for the Alberta Committee of endangered species, and the subsequent COSEWIC status report. As several sections of this report were taken from the COSEWIC status report for *T. yuccasella*, the author, Rebecca Snell, is grateful to her for writing those sections. Rebecca Snell would like to thank Agriculture and Agri-Food Canada, the staff and their families at the Onefour Research Substation for their logistical support and hospitality during her field seasons. Assistance in collecting the data was provided by Jackie Bochek (Nanaimo, B.C.), Kristen Foreman (University of Calgary, Alberta), Erin Smith (University of Alberta), Mandi Walker (Onefour Research Substation) and Noah Nimelman (Toronto, Ontario). Theresa Fowler provided support and valuable assistance in the preparation of this report and edited it.

Rebecca Snell would like to thank the Canadian Wildlife Service, Environment Canada, for providing the funding for this report. The fieldwork was funded in part by the ACA Grants in Biodiversity (supported by the Alberta Conservation Association). Additional financial support was provided by a Post-Graduate Natural Sciences and Engineering Research Scholarship to Rebecca Snell and a Natural Sciences and Engineering Research Operating Grant to Dr. John Addicott (Department of Biological Sciences, University of Calgary).

AUTHORITIES CONTACTED

Achuff, P.L. National Botanist, Ecological Integrity Branch, Parks Canada. Waterton Lakes National Park, Waterton Park, AB T0K 2M0.

Addicott, J.F. Professor, Department of Biological Sciences, 2500 University Drive NW, University of Calgary, Calgary, Alberta, T2N 1N4.

Chandler, J. Wildlife Technician, Alberta Fish and Wildlife, Southeast Region, Medicine Hat Office, Room 301, Provincial Building 346 - 3rd St. S.E. Medicine Hat, Alberta T1A 0G7.

Court, G. Provincial Wildlife Status Biologist, Fish and Wildlife Division, SRD. 2nd Floor, Great West Life Building, 9920-108 Street, Edmonton, AB T5K 2M4.

Foreman, K. Junior Level Biologist, Alberta Fish and Wildlife, Government of Alberta, Medicine Hat, Alberta.

Gould, J. Botanist, Alberta Natural Heritage Information Centre, Alberta Community Development. 2nd Floor, Oxbridge Place 9820 – 106 Street, Edmonton, Alberta, T5K 2J6.

Goulet, G. Aboriginal Traditional Knowledge Coordinator, COSEWIC Secretariat. Canadian Wildlife Service, Environment Canada. Ottawa, ON K1A 0H3.

Hurlburt, D. Biologist. RR # 2, 3619 Granville Rd. Granville Ferry, NS B0S 1K0.

Landry, J-F. Research Scientist, Agriculture and Agri-Food Canada. Ottawa, ON K1A 0C6.

Nicholson, J. Non-Game Biologist, Alberta Fish and Wildlife. Southeast Region, Medicine Hat Office, Room 301, Provincial Building, 346 - 3rd St. S.E. Medicine Hat, Alberta. T1A 0G7.

Quinlan, R. Regional Non-game and Endangered Species Biologist, Sustainable Resource Development, Fish and Wildlife Service, Prairie Region, 2nd Floor, YPM Place 530 - 8 Street South, Lethbridge, Alberta, T1J 2J8.

Walker, I. Onefour Substation Manager. Agri-Food and Agriculture Canada, Onefour, Alberta, T0K 1R0.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Rebecca Snell graduated with a BSc in Biology and Computer Science from Queen's University in 2001. She continued her education at the University of Calgary under the supervision of Dr. John Addicott. Her master's work considered the moth/yucca mutualism in a broader community context. In addition to Soapweed and the pollinating Yucca Moth, she also included the Five-spotted Bogus Yucca Moth, Non-pollinating Yucca Moth, ants and aphids. All of the work was carried out in the northern populations of Soapweed and included the only Canadian population of the Five-spotted Bogus Yucca Moth. She graduated with her MSc in ecology in May of 2004.

COLLECTIONS EXAMINED

Agriculture and Agri-Food Canada Research Lab collection, 5403 - 1st Avenue, P.O. Box 3000, Lethbridge, Alberta, T1J 4B1.

Canadian National Collection of Insects, Arachnids, and Nematodes, Eastern Cereal and Oilseed Research Centre, K.W. Neatby Building, Ottawa, Ontario, K1A 0C6.

E.H. Strickland Entomological Museum, University of Alberta, CW405a Biological Sciences Centre, Edmonton, Alberta T6G 2E9.

Northern Forestry Centre Research Collection, 5320 - 122nd Street, Edmonton, Alberta, T6H 3S5.

Appendix 1. Summary of data for Canadian specimens of *Prodoxus quinquepunctellus.*

Lineage	Country	Province	Locality	Date	Quantity	Collector	Collection
quinque-punctellus	Canada	AB	Lost River Valley, I km N of Montana border	2001-06-28	16	Pohl, Macaulay and Machney	NFRC
quinque-punctellus	Canada	AB	Lost River	1950-07-09	3	A. Hewitt	AGRL
quinque-punctellus	Canada	AB	Onefour	1950-07-09	13	K. Bowman?	UASM
quinque-punctellus	Canada	AB	Onefour	1950-07-09	7	R.H. Strickland	CNC
quinque-punctellus	Canada	AB	Onefour	1950-07-04	1	K. Bowman?	UASM
quinque-punctellus	Canada	AB	Onefour	1950-07-02	3	K. Bowman?	UASM
quinque-punctellus	Canada	AB	Onefour	1950-06-28	1	K. Bowman?	UASM
decipiens	Canada	ON	Vineland	1935-36	20	W.L. Putnam	CNC

NFRC – Northern Forestry Centre Research Station
AGRL – Agriculture and Agri-Food Canada Research Lab collection
UASM – University of Alberta Strickland Museum
CNC – Canadian National Collection of Insects, Arachnids and Nematodes, Agriculture and Agri-Food Canada.