COSEWIC
Assessment and Status Report

on the

Non-pollinating Yucca Moth
Tegeticula corruptrix

in Canada

ENDANGERED
2006

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

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AU CANADA

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Non-pollinating Yucca Moth — Photograph by D. Hurlbert.

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COSEWIC
Assessment Summary

Assessment Summary – April 2006

Common name
Non-pollinating Yucca Moth

Scientific name
Tegeticula corruptrix

Status
Endangered

Reason for designation
This highly specialized moth exists in Canada as a single viable population that occurs in a very small, restricted area, isolated from the main range of the species in the United States. A second isolated population is on the verge of disappearing or has already been lost. The moth is entirely dependent on the obligate mutualistic relationship between its host plant (Soapweed), which is Threatened, and the plant's pollinator (Yucca Moth), which is Endangered. 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

Non-pollinating Yucca Moth
Tegeticula corruptrix

Species information

Non-pollinating Yucca Moths are small white moths of the family Prodoxidae. They have a wingspan of 22.5-35.0 mm, and are most easily identified by their larger size compared to other yucca moths. They are usually observed within the flowers of their host plant, the Soapweed (a yucca species), late in the flowering season. Under microscopic examination, Non-pollinating Yucca Moths have a maxillary palp without a rudimentary tentacle.

Distribution

The Non-pollinating Yucca Moth is restricted to Soapweed populations. In Canada, the only sustainable population of this moth exists in a Soapweed population in Onefour, Alberta. There is a second Soapweed population on the Pinhorn Grazing Reserve, Alberta in which only a single Non-pollinating Yucca Moth individual has been observed.

Habitat

In Canada, Soapweed populations inhabited by Non-pollinating Yucca Moths occupy sparsely vegetated south-facing slopes on the Milk River drainage in southeastern Alberta. In more central and southern parts of the species' distribution, the moth uses Soapweed and several other yucca species as host plants.

Biology

As their name implies, Non-pollinating Yucca Moths do not pollinate their host plant, but are obligate seed predators of yuccas. They lay their eggs only in early stage yucca fruit. After hatching, the developing larvae feed only on yucca seeds. In late summer, moth larvae chew their way out of the fruit, burrow into the soil and enter prepupal diapause. They remain in this state for up to several years before emerging from the soil as adult moths.

Population sizes and trends

Numbers of Non-pollinating Yucca Moths fluctuate greatly among years and populations, and the moths are difficult to count as adults. The available indices of moth activity (1999 to 2003) at Onefour, Alberta are insufficient to detect population decline or trends in abundance. Only a single individual was observed in the Pinhorn, Alberta population from 1998 to 2003.

Limiting factors and threats

Non-pollinating Yucca Moths in Canada are naturally restricted by their northern location and by the limited distribution of their host plant and its sole pollinator, the Yucca Moth. The greatest threats to their survival in Canada are factors that negatively affect their host plant (Soapweed), the pollinator of the host plant (Yucca Moth), or the beneficial interaction between the two. Potential factors threatening the survival of these species include: browsing of plant stalks, flowers and fruit by mule deer and pronghorn antelope; collection of plants for horticultural or medicinal purposes; off road vehicle travel; cattle grazing; and application of agricultural herbicides and insecticides.

Special significance of the species

In Canada, the Non-pollinating Yucca Moth is a member of a complex of species that requires the Soapweed to survive. This species and other members of the Soapweed community are at the northern peripheries of their distributions and, compared to more southerly populations, are expected to have unique attributes that enhance their survival. To date, research has demonstrated that both the Soapweed and the Yucca Moth have unique survival strategies in northern regions of their range relative to other locations.

Existing protection

The Non-pollinating Yucca Moth has no existing legal protection in any part of its distribution. In Canada, the host plant (Soapweed) has been designated as Threatened by COSEWIC and as Endangered by the Province of Alberta. In addition, the mutualist pollinator of the plant, the Yucca Moth, has been designated as Endangered by both COSEWIC and Alberta.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS
(2006)

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

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

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

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

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SPECIES INFORMATION

Name and classification

In 1872, Engelmann (1872a, b) described all small white moths associated with yucca plants as yucca moths. Later, Charles Riley (1892) and William Trelease (1893) formally described these moths as *Pronuba* spp. However, Walsingham (1903) discovered that the genus *Pronuba* was preoccupied and renamed yucca moths *Tegeticula* spp.

Until recently, the genus *Tegeticula* was thought to consist of only three species: *T. maculata*, *T. synthetica* and *T. yuccasella*. *Tegeticula maculata* is monophagous on *Yucca whipplei; T. synthetica* on *Yucca brevifolia;* and *T. yuccasella* is associated with the other 30+ *Yucca* species north of Mexico. Most researchers recognized that *T. yuccasella* represented a complex of yucca moth species that exhibited unique morphologies and behaviours (e.g. Powell 1992, Pellmyr *et al*. 1996, Wilson and Addicott 1998). In 1999, Pellmyr published a systematic revision of *T. yuccasella* using morphological and molecular data, that identified ten new pollinator species, one misclassified non-pollinating species (*T. intermedia*) and one new non-pollinating species (*T. corruptrix*) of yucca moths within this complex. The term "yucca moths" is still often used generically in the literature to refer to any of the moth species, and literature prior to 2000 still uses *T. yuccasella* to refer to all 12 of the moth species described by Pellmyr.

The two non-pollinating species of yucca moths (*T. intermedia* and *T. corruptrix*) oviposit in developing yucca fruit rather than in flowers and do not engage in pollination. Both species are referred to as "cheaters" or "aprovechados" (Spanish for *one who cheats*) in the literature because they are seed predators rather than mutualists like other species of yucca moths. The term "cheater" is also used to refer to individual pollinating yucca moths that oviposit but fail to pollinate. Careful attention is necessary to distinguish in the literature between cheating species and individual yucca moths that exhibit cheating behaviour.

The presence of a "cheater" species in southeastern Alberta was first recorded by Csotonyi and Hurlburt in 1998 (Csotonyi and Hurlburt 2000) and the identity of the species was confirmed by D. Hurlburt as *T. corruptrix* using the criteria identified by Pellmyr (1999). There have been no observations of *T. intermedia* in Canada or in other northern yucca moth populations in Montana.

For clarity, "Non-pollinating Yucca Moth" or *Tegeticula corruptrix* is used to refer to the species of concern in this report. "Yucca Moth" (capitalized) refers to the pollinating yucca moth, *Tegeticula yuccasella*, while "yucca moth" (lower case) refers to other members of the complex or the complex as a whole.

Morphological description

Yucca moths of the genus *Tegeticula* are small, nondescript and whitish in color. All adult yucca moths are typically observed within yucca flowers or, in the case of late emerging species such as *Tegeticula corruptrix*, on yucca foliage or dried inflorescences. Three species of white moths may be found in the flowers of Canadian yucca populations: the pollinating Yucca Moth (*Tegeticula yuccasella*), the Five-spotted Bogus Yucca Moth (*Prodoxus quinquepunctellus*), and the Non-pollinating Yucca Moth (*T. corruptrix*). *Tegeticula corruptrix* may be distinguished visually from the other species by its relatively large size, absence of maxillary tentacles and absence of small black dots on its wings (Pellmyr 1999). Adult *T. corruptrix* are not present in flowers until early July, at which time they begin to emerge from the soil.

Non-pollinating Yucca Moths (Figure 1) have a wingspan of 22.5-28.0 mm for males and 25.5-35.0 mm in females. The forewings and hindwings are white dorsally and mostly brown on the ventral surface. The head has white scales, a maxillary palp and no evidence of maxillary tentacles. Antennae are approximately half the length of the forewing and have 50-60 segments. The thorax has white scales and the legs are amber. The abdomen is tan on the dorsal side and white ventrally (Pellmyr 1999).

Figure 1. Adult Non-pollinating Yucca Moth (*Tegeticula corruptrix*, centre) flanked by adult Five-spotted Bogus Yucca Moths (*Prodoxus quinquepuctellus*) in a Soapweed (*Yucca glauca*) flower (Onefour, Alberta; July 2000). (Photo: D. Hurlburt)

To date, no subspecies have been identified and there are no genetic descriptions of different populations.

DISTRIBUTION

Global range

Tegeticula corruptrix has been reported in *Yucca* populations from Mexico and southern Texas north to Alberta and from California east to Nebraska (Crabb and Pellmyr 2004, COSEWIC 2002, Pellmyr 1999) (Figure 2). The detailed distribution of the species in the United States is poorly known, and other records may be reported now that the species is more thoroughly described. Recently, *T. corruptrix* has been recorded in all known Soapweed (*Yucca glauca*) populations in northern Montana, sometimes occurring in apparently high densities (D. Hurlburt, unpubl. data).

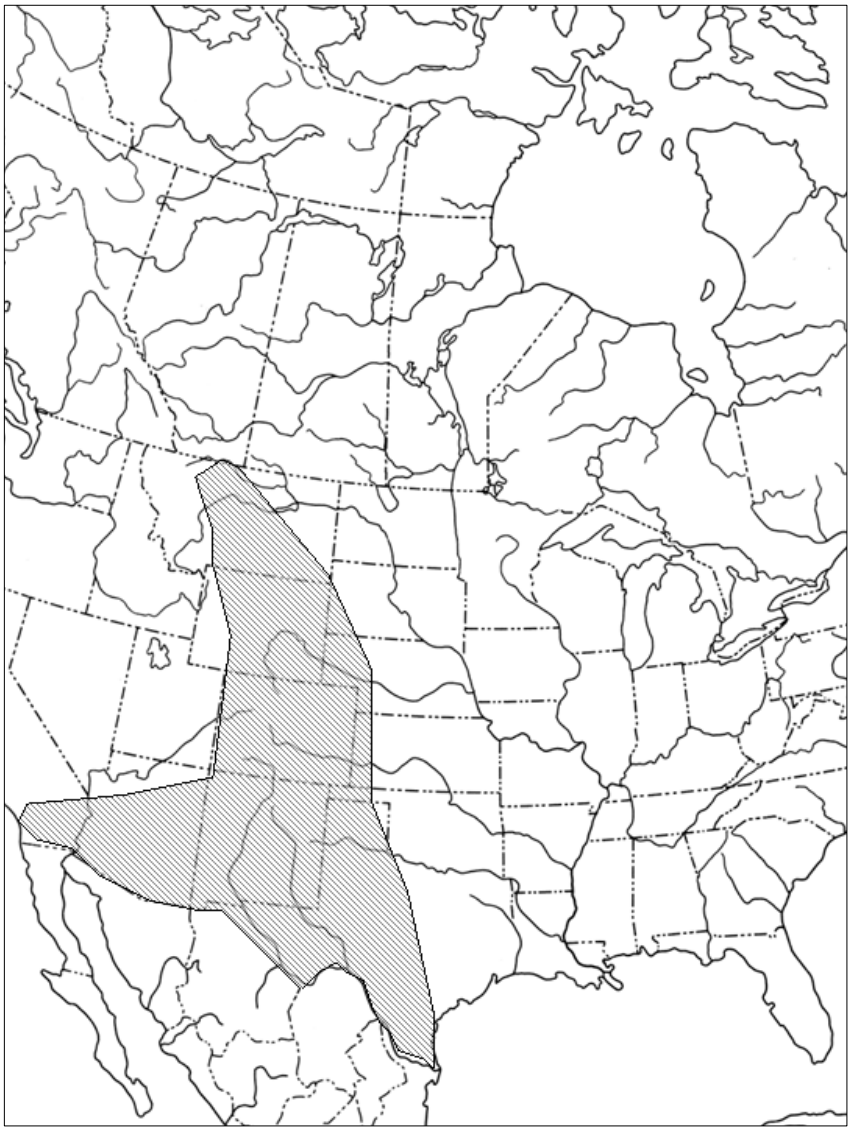

Figure 2. Distribution of the Non-pollinating Yucca Moth (*Tegeticula corruptrix*) in North America.

Canadian range

Non-pollinating Yucca Moths exist in sustainable numbers in only one Soapweed population in Canada in southeastern Alberta. The Lost River population is distributed along a 2-km stretch of south-facing coulee slope along the Lost River, a tributary of the Milk River (Figure 3). The population is located entirely on lands owned and managed by the Lethbridge Agricultural Research Substation, Agriculture and Agri-Food Canada in Onefour, Alberta.

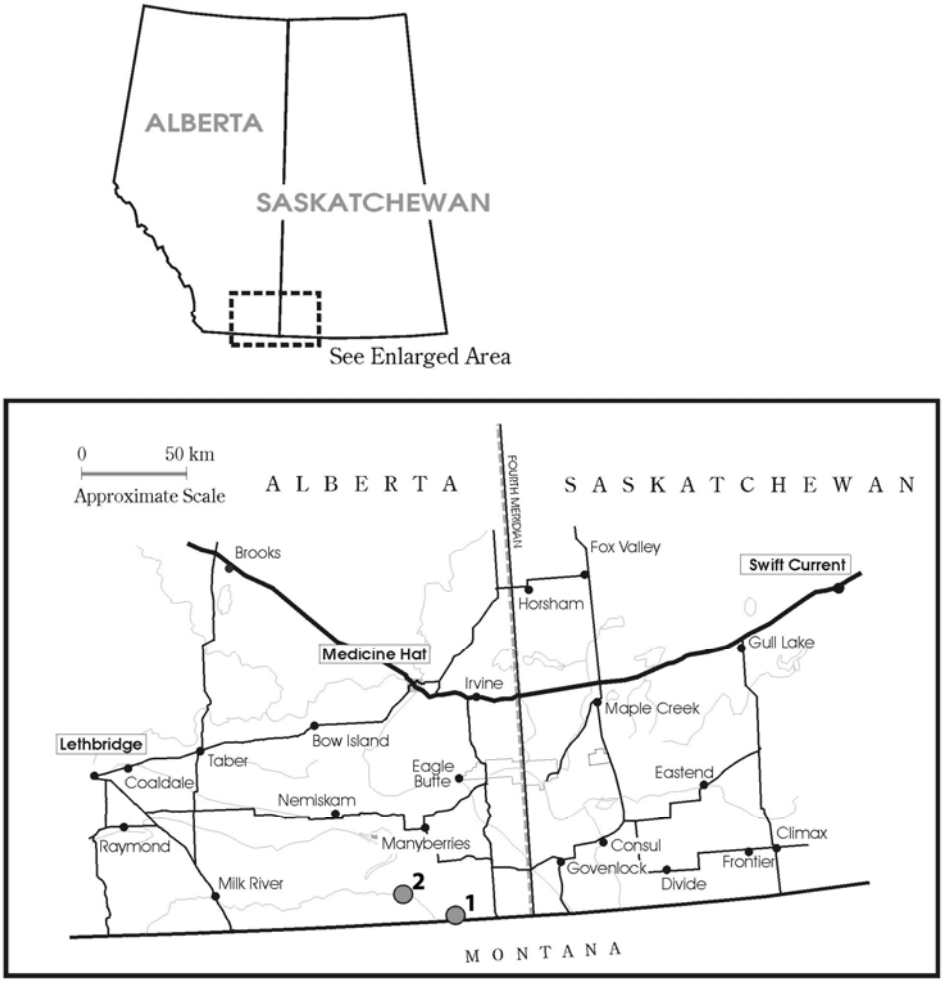

Figure 3. Known occurrences of the Non-pollinating Yucca Moth (*Tegeticula corruptrix*) in Canada at Onefour (1) and Pinhorn (2).

A single adult specimen was reported in a second population of Soapweed located on the Pinhorn Grazing Reserve (Csotonyi and Hurlburt 2000) (Figure 3). No larvae have been reported from the soil or from the few Soapweed fruit produced at the site, although two empty larval cocoons were recovered from the soil in 2001 (D. Hurlburt, unpubl. data). The presence of empty larval cocoons in the soil indicates that there may still be a few moths persisting in the soil in a diapause state despite the near absence of

sexual reproduction in the Soapweed in this population. It is unlikely that a viable population of Non-pollinating Yucca Moths can persist at the current rate of Soapweed reproduction at Pinhorn.

It is plausible that *T. corruptrix* could exist in other small transplanted patches of Soapweed near Medicine Hat, Alberta and Fox Valley, Saskatchewan, or in the few presumably transplanted plants near Rockglen, Saskatchewan. However, like the pollinating Yucca Moth, its survival depends on the sexual reproduction of the Soapweed; thus it would be impossible for viable populations of the Non-pollinating Yucca Moth to occur in non-sexually reproducing patches of yucca plants. A list of Canadian specimens of *T*. corru*ptrix* residing in public collections can be found in Appendix 1.

HABITAT

Habitat requirements

In Canada, Non-pollinating Yucca Moths are restricted to the Dry Mixed Grass Subregion (ANHIC 2004). This region has a continental climate with large daily and seasonal fluctuations in temperature. It is semi-arid in nature, maintained by low precipitation, hot summers and high rates of evaporation (exacerbated by a high average wind speed).

The Non-pollinating Yucca Moth requires Soapweed for oviposition and larval feeding in Canada; there are no other *Yucca* spp. in Canada that could act as host plants. At the northern periphery of the species' range, the plant grows primarily on south-facing, sparsely vegetated and well-drained slopes (Figure 4) in association with prickly pear cactus (*Opuntia polyacantha*) and Silver Sagebrush (*Artemisia cana*). Colonized slopes face away from prevailing winds, and plants usually thrive only where slopes are protected by adjacent slopes. Extensive searches in the vicinity of the known native Soapweed sites in Canada at Onefour and Pinhorn, Alberta (and a possible native site near Rockglen, Saskatchewan) have failed to produce additional native Soapweed populations. Soils in the occupied sites are alkaline and regosolic without shallow hardpan (Milner 1977, Fairbarns 1985).

In the central and southern portions of the species' distribution in the United States, Soapweed grows on flatter ground and occurs in sand dunes, pine forests and glades in the east and grassland in the southwest (Pellmyr 1999).

Figure 4. Soapweed (*Yucca glauca*) in heavy flower. South-facing coulee slope is representative habitat of northern populations of Soapweed (Onefour, Alberta; June 1999). (Photo: D. Hurlburt).

Habitat trends

Suitable habitat for Non-pollinating Yucca Moths is naturally limited in Canada as there are few south-facing coulee slopes that are protected and sparsely vegetated. Habitat has not been reduced by agricultural practices because the host plant grows mostly on steep coulee slopes that are unusable for crop production (COSEWIC 2002).

Habitat protection/ownership

The Non-pollinating Yucca Moth has no endangered species designation in Canada or elsewhere. It is protected, however, by its association with the Soapweed and the Yucca Moth, which have been designated respectively as Threatened and Endangered by COSEWIC and are listed on Schedule 1 of the federal Species at Risk Act. Both of these species are the subject of the Soapweed / Yucca Moth Recovery Team and a joint recovery plan that is currently being prepared.

Both populations occur in relatively undisturbed sites on government lands. The largest population of Non-pollinating Yucca Moths at Onefour occurs on lands owned and managed by Agriculture and Agri-Food Canada. The small, most likely declining population at Pinhorn is located on a public grazing reserve managed by the province of Alberta.

BIOLOGY

There is very little known about the biology of *T. corruptrix* because the species has never been studied outside of its impact on the moth - yucca mutualism. Additionally, the moth has only recently been formally described, and in statistical analyses in past research, the moth had been lumped together with other yucca moth species exhibiting cheating behaviour. However, we can assume that many aspects of the Non-pollinating Yucca Moth's biology are similar to those of the pollinating species because these species are very closely related.

Life cycle and reproduction

Adult Non-pollinating Yucca Moths emerge from the soil from early July to September (D. Hurlburt, unpubl. data), at which time they gather and mate in late-blooming Soapweed flowers or on Soapweed stems and leaves. These moths become active when it is completely dark (Pellmyr 1999) and lay their eggs in early stage yucca flowers that are about 2.5 – 4.0 cm in length (D. Hurlburt, unpubl. data). Non-pollinating Yucca Moths can lay many eggs and oviposit in numerous locations within a single fruit (D. Hurlburt, unpubl. data, Pellmyr 1999, Snell 2004). In some regions within their distribution, a small droplet of sap exudes from each oviposition site (Pellmyr 1999); however, this does not appear to occur in Alberta or northern Montana, possibly because of high winds (D. Hurlburt, pers. observ.).

Eggs hatch in 7-10 days and developing larvae (Figure 5) go through four instars. Five to six weeks after oviposition, larvae chew their way out of the fruit wall, lower themselves to the ground via a silken thread, and burrow into the soil. Once 10-20 cm under the soil surface, larvae build a cocoon of silk, sand and small woody debris and enter a state of prepupal diapause. As with Yucca Moth larvae, Non-pollinating Yucca Moth cocoons are typically found within 25 cm of the base of the Soapweed clone (D. Hurlburt, unpubl. data). It has been confirmed by field study (D. Hurlburt, unpubl. data) that a small proportion of Non-pollinating Yucca Moth individuals engage in prepupal diapause for up to 3 years; however, the maximum duration of diapause is unknown. After diapause, the moth becomes a pupa for a short period (weeks) and then emerges as an adult part way through the flowering season of the Soapweed.

Figure 5. *Tegeticula corruptrix* larva (2nd instar) in Soapweed (*Yucca glauca*) seed (Onefour, Alberta; August 2003). (Photo: D. Hurlburt).

Individuals of a related species, *Prodoxus y-inversus*, have been reported to experience prolonged diapause (for up to 30 years, Powell 2001); however, there are no data to support the existence of highly prolonged diapause in pollinating or Non-pollinating Yucca Moths. Further, Powell reared *Prodoxus* larvae in the lab under optimal environmental conditions and in the absence of predators, which he believes artificially extended the lifespan of the moths in his study (J. Addicott, pers. comm., based on conversation of Addicott with Powell). The ability of some individuals in a population to extend diapause has been suggested as a way by which moth populations can bet-hedge or ensure that some individuals emerge in years with optimal abiotic or biotic (e.g. flowering) conditions to secure future populations (Wagner and Powell 1988). Given that only 5% of *T. yuccasella* survived diapause for two years at Onefour and that additional mortality occurs on emergence (COSEWIC 2002), it is unlikely that the few individuals exhibiting prolonged diapause in northern populations of *T. corruptrix* will be able to ensure population persistence.

Herbivory / predation

The Non-pollinating Yucca Moth experiences similar problems with wild ungulate herbivory and predation of the Soapweed as does the Yucca Moth (COSEWIC 2002). Fruit set in Soapweed can be severely reduced by herbivory of yucca flowers and fruit by Mule Deer (*Odocoileus hermionus*) and Pronghorn Antelope (*Antilocarpa americana*) (Hurlburt 2004). These activities reduce the availability of oviposition sites for the moth and result in the direct mortality of non-pollinator larvae within the eaten fruit (Hurlburt, unpubl. data).

Dispersal

Compared to other species of moths, yucca moths in general are weak flyers that do not exhibit direct flying from plant to plant. Non-pollinating Yucca Moths may have a

slight advantage over other yucca moths given their larger size; however, isolated plants and populations of yuccas escape infection, indicating that non-pollinators either cannot get to new sites or cannot detect yucca plants from a distance. There have been no recorded studies where non-infected populations have become infected over time as a result of dispersal of *T. corruptrix*, although few populations of yuccas are monitored over the long term. Also, there are no documented instances where any type of yucca moth has dispersed via storm fronts as with other types of insects. Consequently, it is unlikely that there is any natural dispersal of Non-pollinating Yucca Moths between the Pinhorn and Onefour populations, and it is even more unlikely that either Canadian population can be bolstered by immigration of moths from Montana, where the closest populations of yuccas are 200 km away. It is plausible, however, that yucca moths can be transported from location to location as larvae within fruit, or in soil when the moth is in prepupal diapause (as would occur with the transplantation of the host plant). It is speculated that the Blackfoot may have transported yucca seeds and moths in such a way, although no evidence of use of yuccas by First Nations people in Canada has been documented.

Interspecific interactions

Tegeticula corruptrix is a seed predator of several species of yuccas, including *Yucca baccata*, *Y. kanabensis*, *Y. torreyi* (*Y. treculeana*), *Y. schidigera*, *Y. glauca*, *Y. baileyi* and *Y. elata* (James 1998, Pellmyr 1999). In Canada, the moth is restricted to our only native yucca species, *Y. glauca*, the Soapweed.

The survival of the Non-pollinating Yucca Moth depends on the mutualism between yuccas and pollinating yucca moths. Since the species oviposits and feeds only in yucca fruit, the beneficial interaction between the yucca plant and pollinating yucca moths must be in place for the non-pollinator to reproduce.

The mutualism between pollinating yucca moths and yuccas is exploited by *T. corruptrix*, which can decrease seed set by up to 30% through larval feeding (James 1998). On *Y. kanabensis* in the United States, pollinator larvae limit *T. corruptrix* survival by competing for yucca seeds and presumably having an advantage because the pollinator larvae are larger because they are at a later instar than the non-pollinators (James 1998). It has been found that the isolation of plants in time and space from other flowering yuccas also reduces infection rates by non-pollinators (Hurlburt, unpubl. data).

Preliminary experiments by D. Hurlburt (unpubl. data) were conducted to assess the impact of *T. corruptrix* on northern Soapweed and Yucca Moths. It was hypothesized that the lower densities of pollinators at the northern edge of the species' range could not limit non-pollinators which may allow non-pollinators to exploit yuccas to a higher degree than elsewhere. However, *T. corruptrix* infection only resulted in a slight increase in the proportion of non-viable seeds per fruit and a decline in the number of viable seeds eaten. There was no impact of infection on the number of yucca moth larvae per fruit. The mechanisms by which non-pollinators exist at high densities in northern populations are not yet understood.

Adaptability

Although the ability of *T. corruptrix* to adapt to changing conditions has not been studied, it warrants further exploration. Both *T. yuccasella* and the Soapweed exhibit unique adaptations that seem to enhance their respective survival at the northern periphery of their ranges (Hurlburt 2004). Despite northern Yucca Moths occurring at lower and more variable abundances than elsewhere, both the plant and the moth have similar rates of reproduction to populations further south. In Alberta and Montana, Soapweed exhibit longer flowering and Yucca Moths exhibit longer flight seasons and have unique breeding systems and oviposition behaviours. Because populations of *T. corruptrix* are robust at the northern edge of their range despite the variability in the pollination and flowering of Soapweed, it would be expected that they would have similar adaptations to ensure their survival.

POPULATION SIZES AND TRENDS

Search effort

Approximately 30 to 200 yucca fruit per population per year (Table 1) were dissected after fruit maturation to estimate *T. corruptrix* abundance. Non-pollinating Yucca Moths leave permanent records of their total activity during a season via oviposition scars in the carpel walls of yucca fruit. Recruitment of new moths was assessed by counting numbers of live larvae per fruit. Because this method of determining recruitment requires careful fruit dissection, it is destructive to both the plants and the larvae. Unfortunately, it is difficult to count adult Non-pollinating Yucca Moths because (1) they are free-flying and (2) because of their late emergence, they do not usually have yucca flowers in which to hide during the day, like the pollinators.

Abundance

Abundance of Non-pollinating Yucca Moths was estimated through the number of ovipositions per fruit and larvae per fruit (during fruit dissection) (Table 1). In the Lost River population at Onefour, ovipositions per fruit and larvae per fruit over a 5-year period were within the range determined from other populations (Montana and Utah) by D. Hurlburt and from the literature (Table 1). However, there are few data available from the central and southern portions of the species' range, making it impossible to determine how Canadian populations fare overall. The values obtained from Utah (see James 1998) were collected in a different manner than those in the northern part of the range, limiting the comparability of the data.

Table 1. Variation in vital rates of the Non-pollinating Yucca Moth (*Tegeticula corruptrix*) among years and sites. Both indices of moth abundance and density (ovipositions per fruit and larvae per fruit) include fruit without ovipositions and larvae. Fruit infection rate is the percentage of early stage fruit that received non-pollinator ovipositions. Survival rate is the proportion of eggs that survived to larval emergence at the 4th instar.

Site	Year	Ovipositions / fruit	Larvae / fruit	Proportion fruit infected	Survival rate	Source
Onefour, AB	1999	5.400+1.443	1.560+0.451	---	0.289	Hurlburt, unpubl.
	2000	7.846+5.329	0.692+0.328	0.385	0.088	Hurlburt, unpubl.
	2001	2.350+1.091	0.100+0.069	0.100	0.042	Hurlburt, unpubl.
	2002	3.648+5.376	0.110+0.379	---	0.030	Hurlburt, unpubl.
	2002	13.939+0.875	3.636+0.254	---	0.261	Snell 2004
	2003	1.000+0.235	0.033+0.033	0.500	0.033	Hurlburt & Smith, unpubl.
Fort Belknap, MT	2001	15.211+22.233	0.947+1.810	---	0.062	Hurlburt, unpubl.
	2002	17.726+23.004	4.569+6.061	---	0.258	Hurlburt, unpubl.
	2003	4.467+0.0899	0.200+0.088	0.733	0.045	Hurlburt & Smith, unpubl.
Loma, MT	1999	2.789+1.502	1.053+0.492	0.211	0.378	Hurlburt, unpubl.
	2000	28.00+24.458	0.273+0.467	---	0.010	Hurlburt, unpubl.
	2001	1.200+2.397	0.050+0.224	---	0.042	Hurlburt, unpubl.
	2002	14.167+14.049	0.500+1.225	---	0.035	Hurlburt, unpubl.
	2002	0.534+0.206	0.125+0.084	---	0.234	Snell 2004
Decision Pt, MT	2002	8.933+12.753	0.067+0.258	---	0.008	Hurlburt, unpubl.
Ft Benton, MT	2000	0.384+0.768	0.231+0.599	---	0.602	Hurlburt, unpubl.
	2001	4.250+7.615	0.300+0.657	---	0.071	Hurlburt, unpubl.
	2002	0.171+1.014	0.000+0.000	0.000	0.000	Hurlburt, unpubl.
	2003	8.182+2.064	0.227+0.066	---	0.028	Snell 2004
Ft Benton 2, MT	2000	1.5 to 9	---	---	---	Perry 2001
Cascade, MT	2000	0 to 6 (Zeros) 14 to 22 (No zeros)	---	---	---	Perry 2001
Judith River, MT	2001	2.790+6.197	0.000+0.000	0.000	0.000	Hurlburt, unpubl.
	2002	0.113+0.375	0.000+0.000	0.000	0.000	Hurlburt, unpubl.
Highwood Mtn, MT	2002	0.627+1.165	0.030+0.244	---	0.048	Hurlburt, unpubl.
Wolf Creek, MT	1999	7.278+4.281	0.556+0.856	1.000	0.076	Hurlburt, unpubl.
	2001	5.962+11.643	0.269+0.667	1.000	0.045	Hurlburt, unpubl.
	2002	0.556+1.653	0.056+0.236	---	0.101	Hurlburt, unpubl.
Roundup, MT	2001	0.500+1.689	0.056+0.234	---	0.112	Hurlburt, unpubl.
	2002	0.900+2.183	0.000+0.000	0.000	0.000	Hurlburt, unpubl.
Billings, MT	2002	3.925+5.203	0.170+0.427	---	0.043	Hurlburt, unpubl.
	2003	3.368+1.051	0.316+0.188	0.684	0.094	Hurlburt & Smith, unpubl.
Little Big Horn, MT	2001	3.250+5.437	0.000+0.000	0.000	0.000	Hurlburt, unpubl.
	2002	0.213+0.650	0.000+0.000	0.000	0.000	Hurlburt, unpubl.
Kanab 1 – Yellowjacket, UT	1995	0 to 55	6.62+0.65 (No zeros)	0.907	---	James 1998
Kanab 2 – Old 89, UT	1996	0 to 32	5.12+0.35 (No zeros)	0.550	---	James 1998

Fluctuations and trends

Without longer-term data, it is unclear whether Non-pollinating Yucca Moth populations are declining, stable or increasing at Onefour. Moth populations are highly variable among years, ranging from 1 to 14 ovipositions per flower and 0.03 to 1.60 larvae per fruit over a 5-year period (1999-2003). Furthermore, fruit infection rates varied from 10 – 50% of fruit and larval survival from 0 to 60% (Table 1).

The number of populations of *T. corruptrix*, however, seems to be declining. Because of the poor dispersal capabilities of Non-pollinating Yucca Moths, and because there is no evidence of the species colonizing isolated patches of yuccas in the United States where both the plant and the moth are much more common, it is reasonable to assume that the individuals recorded from the Pinhorn Grazing Reserve are not occasional strays or a new population, but rather the remnants of a once larger population. This conclusion is supported by evidence that the Yucca Moth (without which *T. corruptrix* cannot exist) has declined at the Pinhorn site (COSEWIC 2002). Non-pollinating Yucca Moths appear to have all but disappeared from the Pinhorn Grazing Reserve population, indicating a decline from two populations down to one in Canada. It is expected that, as with *T. yuccasella* (COSEWIC 2002), the Non-pollinating Yucca Moth is on a similar downward trajectory in this site as a result of repeated bouts of Soapweed herbivory by Mule Deer. The Non-pollinating Yucca Moth is entirely dependent on the obligate mutualism between the Soapweed and the Yucca Moth and on the reproductive success of both species; factors influencing the survival of either of these species will also affect *T. corruptrix*.

Rescue effect

The distribution of the Non-pollinating Yucca Moth spans across international borders, ranging from Canada into the United States and likely into Mexico. Because the species has only recently been formally described, there is little information available on its overall distribution in North America. The species has no endangered status designation in any part of its range, and information from most regions is lacking. The most intensive research on this species has been conducted by D. Hurlburt in the northern portions of the moth's range where the abundance and density of populations of Non-pollinating Yucca Moths in Montana were found to be similar to that in Canada (Table 1).

Soapweed populations in Canada are approximately 200 km north of the nearest known populations located near the Missouri River in Montana. Canadian populations are isolated from United States populations by distance and inhospitable habitat. Immigration from populations to the south is highly unlikely to occur and is expected to be extremely rare.

LIMITING FACTORS AND THREATS

Populations of the Non-pollinating Yucca Moth are naturally limited in Canada by the restricted distribution of Soapweed at the northern periphery of the species' range. The Soapweed, the Yucca Moth and likely the Non-pollinating Yucca Moth are physiologically restricted by temperature and primarily reside on south-facing coulee slopes in Canada. Additionally, the survival and reproductive success of *T. corruptrix* is dependent on the survival of the mutualism between the Soapweed and the Yucca Moth. The Non-pollinating Yucca Moth requires early stage yucca fruit for oviposition, which are available only if Yucca Moths successfully pollinate Soapweed flowers and if the plants retain fertilized flowers. As a result of the intimacy of the relationship, the Non-pollinating Yucca Moth is threatened by the same factors that threaten the Soapweed and the Yucca Moth (COSEWIC 2000, 2002).

The most serious current threat to the Non-pollinating Yucca Moth is the high level of wild ungulate herbivory on Soapweed. Pronghorn Antelope and Mule Deer eat Soapweed flowering stalks, flowers, and fruit, which greatly reduces recruitment of the Soapweed, Yucca Moth and Non-pollinating Yucca Moth. Herbivory reduces the numbers of fruit produced, which decreases seed production. In addition, all moth eggs within the flowers or fruit that are eaten are destroyed. Northern populations of Soapweed are particularly vulnerable to herbivory because they have frequent bouts of low flowering and fruiting* (resulting from reduced pollinator abundance); during these periods, herbivores are not satiated by the decreased supply of vegetation** and can readily consume all available inflorescences (Hurlburt 2004). Repeated episodes of herbivory are thought to have resulted in the near extirpation of the Yucca Moth from the Pinhorn population of Soapweed (COSEWIC 2002) and similarly are likely responsible for the very low numbers of Non-pollinating Yucca Moths in the same population. It appears that the *T. corruptrix* population at Pinhorn is not viable and is at the verge of extirpation.

In many parts of the Soapweed's range in the United States, plants are deliberately destroyed by agricultural machinery as land is tilled for crop production. More stubborn plants are injected with herbicide to eradicate them from the landscape as aerial spraying is not effective. In Canada, yuccas are primarily restricted to steep slopes which are not used for agriculture. However, all Soapweed in Canada grows within agriculturally managed areas and may be affected in other ways. Spot spraying for thistle has been observed near both populations of Soapweed.

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*Low flowering and fruiting in certain years is mostly the result of the way in which yuccas produce asexually. Each rosette within a yucca clone can only flower once before it dies. If flowering is high, more rosettes flower, leaving fewer rosettes capable of flowering the next year; this results in a flowering cycle (which has no correlation with temperature, precipitation, etc.). Oddly enough, levels of yucca moth emergence do not coincide with flowering. Yuccas are desert plants and flowering is resistant to drought; if anything, yuccas in Alberta get more rain than elsewhere.

** Yuccas are a juicy target at any time because they are a quick and easy snack compared to other available vegetation. Small populations of flowers are a target at any time, but the impact of herbivores is higher during drought, especially if the population is at the low part of the flowering cycle. So drought impacts deer behaviour, not yucca flowering.

At present, there is little impact of grazing by cattle on Soapweed in Canada, likely because cattle are unable to easily feed on steep slopes. Biologists in the southwestern United States, however, report high levels of feeding by cattle on yuccas (COSEWIC 2002), and in New Mexico, yuccas are harvested for fodder.

Soapweed is commonly transplanted from wild populations into household gardens. At present, the impact in Canada of this activity is negligible on Soapweed and moth success. However, larger scale collection of seed for greenhouse activities remains a real threat as there has been some interest in seed from the Alberta populations in the last five years. In addition, Soapweed has many medicinal properties, and yuccas in general are used in a variety of herbal products (COSEWIC 2000). Although not currently an issue in Canada, yucca flowers are harvested in several locations in the southwestern United States for beauty products (J. Addicott, pers. comm.).

Finally, Soapweed and yucca moths in Canada may be threatened by vehicular traffic. Each year, the Soapweed population at Onefour attracts numerous visitors who typically drive to the site and park among the yuccas that grow on the uplands. Trucks are also commonly used to round-up cattle in these areas and little heed is paid to yuccas in the process. There have been numerous observations of vehicles running over Soapweed plants in both Pinhorn and Onefour, especially in areas where the plants grow in flatter, more accessible locations. Not only does this activity destroy the plants, but it also damages fragile cryptogramic soil crusts which serve to reduce erosion.

SPECIAL SIGNIFICANCE OF THE SPECIES

Tegeticula corruptrix warrants recognition as a member of a complex of species that rely on the Soapweed for food and shelter. In Canada, three species of “yucca moth” (*T. yuccasella, T. corruptrix* and *P. quinquepunctellus*) obligatorily rely on Soapweed for survival and reproduction. In addition, several other species of moths and a skipper have been reported only once in Canada, all within the Onefour population of Soapweed (Tuttle 2005; Norbert Kondla pers. comm.). Other rare species, including short horned lizards, are also frequently observed in the Onefour yucca population.

The Canadian populations of *T. corruptrix* should also be recognized as part of a group of organisms that are naturally located at the northern periphery of their ranges in southeastern Alberta. Presumably many of these populations were restricted to warmer regions as glacial ice retreated after the hypsithermal. In the absence of habitat destruction, some of these species are expected to be well adapted to conditions at the northern periphery of their ranges (Hurlburt 2004) and may retain higher levels of genetic diversity than their more southern counterparts.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The Non-pollinating Yucca Moth has no existing protection or status designations anywhere in its range, likely because the species has only recently been formally described. However, in Canada, the species obligately relies on the Soapweed for oviposition sites and food, and because of its dependence on yucca fruit, relies on the pollination services of the Yucca Moth, *Tegeticula yuccasella*. The Soapweed is designated as Threatened and the Yucca Moth as Endangered by COSEWIC. Because both species are listed on Schedule 1 of the federal Species at Risk Act, all the provisions of the Act apply and recovery actions for the Yucca Moth and the Soapweed will also be beneficial for the Non-pollinating Yucca Moth. Both Soapweed and the Yucca Moth are designated as Endangered by the province of Alberta.

TECHNICAL SUMMARY

Tegeticula corruptrix
Non-pollinating Yucca Moth — Teigne tricheuse du yucca
Range of Occurrence in Canada: Alberta

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* [Information obtained from the COSEWIC status report on the Yucca Moth (*T. yuccasella*) – this information is identical for both species and was calculated as the total area of land that occurs between the two known locations of Soapweed (*Yucca glauca*) that support Non-pollinating Yucca Moths.]	< 400 km²
• *Specify trend in EO*	Declining?
• *Are there extreme fluctuations in EO?*	No
• *Area of occupancy (AO) (km²)* [Information obtained from the COSEWIC status report on the Yucca Moth (*T. yuccasella*) – this information is identical for both species and was calculated as the total area occupied by both the Pinhorn and Onefour population of Soapweed (*Yucca glauca*), i.e., Pinhorn (450 m X 50 m) + Onefour (2000 m X 50 m)]	< 1 km²
• *Specify trend in AO*	Declining ?
• *Are there extreme fluctuations in AO?*	No
• *Number of known or inferred current locations*	2
• *Specify trend in #*	Declining from 2 to 1
• *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)*	Estimated 1 – 3 yrs
• *Number of mature individuals*	Unknown
• *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?*	Yes
• *Is the total population severely fragmented?*	Yes
• *Specify trend in number of populations*	Declining?
• *Are there extreme fluctuations in number of populations?*	No
• *List populations with number of mature individuals in each*: – Lost River population at Onefour, AB – Milk River population at Pinhorn Grazing Reserve, AB	
Threats (actual or imminent threats to populations or habitats)	
Actual threats: Herbivory by Mule Deer and Pronghorn Antelope Off-road vehicular traffic Potential threats: Agricultural activity – herbicide and insecticide application, grazing Horticultural and medicinal collection	

Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?*	USA: No formal evaluation in any state, but US populations appear robust
• *Is immigration known or possible?*	Not known; predicted to be extremely rare in isolated populations
• *Would immigrants be adapted to survive in Canada?*	Yes, if from northern populations in Montana and North Dakota
• *Is there sufficient habitat for immigrants in Canada?*	Only within known natural populations of Soapweed
• *Is rescue from outside populations likely?*	No, not through natural processes as closest yucca population is 200 km away in Montana
Quantitative Analysis	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 viable population that occurs in a very small, restricted area, isolated from the main range of the species in the United States. A second isolated population is on the verge of disappearing or has already been lost. The moth is entirely dependent on the obligate mutualistic relationship between its host plant (Soapweed), which is Threatened, and the plant's pollinator (Yucca Moth), which is Endangered. 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): could apply if it is accepted that the decline from two sites to one represents a 50% population decline. However, there is some question as to whether there ever were two populations (or only stray individuals at Pinhorn), the time frame within which the purported population declined is unknown, and the original size of the declining/lost population is also unknown.

Criterion B: (Small Distribution, and Decline or Fluctuation): the extent of occurrence is smaller than 5,000 km^2 (smaller than 400 km^2) – B1 the area of occupancy is smaller than 500 km^2 (smaller than 1 km^2) – B2 the population is severely fragmented (if the presence of a population at Pinhorn is accepted) and is known to exist at fewer than 5 (1 or 2) locations – (a) if one accepts that there was an actual population at Pinhorn, the species is undergoing a continuing decline in its area of occupancy – (b) (ii) and in the number of locations and populations (from 2 to 1) – (b)(iv) and it undergoes extreme fluctuations in the number of mature individuals, based on the grazing of flowerheads by ungulates – (c)(iv).

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

Criterion D: (Very Small Population or Restricted Distribution): Meets Threatened under D2. The population has a very restricted area of occupancy (smaller than 1 km^2) and number of locations (1 or 2).

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

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Donna Hurlburt obtained a Ph.D. in Environmental Biology and Ecology from the University of Alberta, Edmonton, AB in 2004 for her work on the persistence of the mutualistic relationship between yuccas and yucca moths at the northern edge of their range in Alberta and Montana. During her doctoral research, she collected detailed information on the distribution and demography of Soapweed (*Yucca glauca*) and its associated community of moths in Canada, including *Tegeticula yuccasella* and *Tegeticula corruptrix*. Donna has written several provincial and federal species-at-risk status reports based on this information and is the scientific advisor for the Soapweed and Yucca Moth Recovery Team. At present, Donna is working with several other populations of species at risk in Nova Scotia (e.g. Blanding's Turtle and Northern Ribbon Snake) that are also at the northern peripheries of their ranges.

COLLECTIONS EXAMINED

The following collections were examined for specimens of *Tegeticula corruptrix*; however, no specimens were maintained in any collection.

Bowman Collection, University of Alberta, CW405 Biological Sciences Building, University of Alberta, Edmonton, Alberta. T6G 2E9.
Canadian Museum of Nature, PO Box 3443, Stn. D., Ottawa, Ontario. K1P 6P4.
Invertebrate Zoology Collection, The Provincial Museum of Alberta. 12845-102 Avenue, Edmonton, Alberta. T5N 0M6.

Appendix 1. Summary of data for Canadian specimens of *Tegeticula corruptrix.*

Country	Province	Locality	Date	Quantity	Collector	Collection
Canada	AB	Lost River Valley, I km N of Montana border	2001-06-28	2	Pohl, Macaulay and Machney	NFRC
Canada	AB	Onefour	1950-07-09	1	A. Hewitt	AGRL
Canada	AB	Onefour	1950-07-09	1	K. Bowman	UASM

NFRC – Northern Forestry Centre Research Station
AGRL – Agriculture and Agri-Food Canada Research Lab collection
UASM – University of Alberta Strickland Museum