COSEWIC
Assessment and Status Report

on the

Soapweed
Yucca glauca

in Canada

THREATENED
2013

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
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:

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Fairbarns, M. 1985. COSEWIC status report on the Soapweed *Yucca glauca* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 16 pp.

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COSEWIC
Assessment Summary

Assessment Summary – May 2013

Common name
Soapweed

Scientific name
Yucca glauca

Status
Threatened

Reason for designation
This long-lived perennial is known from only three sites in southeastern Alberta and southwestern Saskatchewan, where it occurs mainly on south-facing coulee slopes. Plants are pollinated exclusively by Yucca Moth, which lays eggs in the flowers. In Canada, the species reproduces almost exclusively by vegetative spread. Seed production is limited by low numbers of Yucca Moth pollinators, while seedling establishment is negatively impacted by lack of natural disturbance, including fire suppression. Herbivory of flowering stalks by native ungulates also limits seed set. Despite improved management to limit the impact of threats, this perennial is designated Threatened. It is the only host for Yucca Moth, Non-pollinating Yucca Moth and Five-spotted Bogus Yucca Moth, all of which were assessed as Endangered.

Occurrence
Alberta, Saskatchewan

Status history
Designated Special Concern in April 1985. Status re-examined and designated Threatened in May 2000 and May 2013.

COSEWIC
Executive Summary

Soapweed
Yucca glauca

Wildlife Species Description and Significance

Soapweed (*Yucca glauca*) is a long-lived perennial that grows as rosettes of long, sharp leaves. Each rosette can produce a single inflorescence up to 85 cm tall that typically contains 15 to 75 large, nodding, white flowers. Fruit are kiwi-sized and dehiscent, each usually containing six rows of flat, black seeds.

Soapweed engages in a mutualistic relationship with its pollinator, the Yucca Moth, whose larvae depend on Soapweed fruit as a food source; this is a relatively rare type of interaction. Soapweed is also the obligate host plant to the Non-pollinating Yucca Moth, the Five-spotted Bogus Yucca Moth and the Strecker's Giant Skipper.

Soapweed and Yucca Moths reach their northern range limits in Canada, and have some unique characteristics that allow them to persist despite highly variable biological and environmental conditions. Alberta Soapweed have the longest documented flowering seasons for the species. Not all fruits of Soapweed reach maturity, but Soapweed plants in Alberta have the ability to selectively abort fruits with fewer moth eggs, thus maximizing the reproductive potential of the moths. Soapweed in Alberta have also been shown to be capable of self-pollination, and offspring show no evidence of early inbreeding depression.

Distribution

The native range of Soapweed extends throughout the Great Plains from Texas north to Alberta and from the Rocky Mountains east to the Mississippi River. In Canada, Soapweed occurs in two sites in Alberta, along the Milk River and its tributary, the Lost River. A previously reported small population of Soapweed near Rockglen, Saskatchewan is growing in natural conditions, and is included as a third Canadian population.

The nearest populations of Soapweed to the south are roughly 100-120 km away along the Missouri River in Montana. Rescue from those populations is unlikely because of the limited dispersal distance of Soapweed seeds and because most of the intervening habitat has been converted to strip-farming, and is unsuitable for Soapweed.

Habitat

Soapweed occupies well-drained, sparsely vegetated, south-facing coulee slopes along the Milk River drainage in southeastern Alberta and southwestern Saskatchewan. The area has hot, dry summers and low precipitation with large daily variation and weather extremes including high winds and heavy rains.

Coulee habitat of this nature is rare and naturally limiting to Soapweed. Intervening prairie, which is needed for range expansion, may have declined in quality for Soapweed because of fire suppression and declines in other forms of natural disturbance such as wallowing by bison.

Biology

Soapweed populations are maintained by asexual (clonal) production of rosettes and sexual reproduction through seeds. Soapweed seedlings flower at 20-25+ years of age, but a rosette derived asexually can flower within several years. Each rosette flowers once and then dies, although clones (genetically distinct individuals) are thought to live over 50 years. Sexual reproduction can only be achieved through an obligate pollination-seed predation mutualism with the Yucca Moth. In Canada, Soapweed reproduced almost exclusively asexually; very few seedlings are able to become established, and thus sexual reproduction currently contributes little to population persistence (though it is essential for survival of the mutualism with yucca moths.

Soapweed flowers from early June through September. Yucca Moths mate in Soapweed flowers during the day. Female moths disperse to other flowers at dusk, where they complete pollination and lay eggs in the flowers' ovules.

Only about 10% of pollinated flowers mature into fruits; the rest of the fruits are selectively abscised (dropped before they mature). Based on surveys conducted on the population of Soapweed at the Onefour Research Station (Onefour), Soapweed produces 3-4 fruits per flowering stem

Population Sizes and Trends

Total number of Soapweed clones at Onefour was estimated as between 45,000 and 72,000 in 2006, which is consistent with the 1977 estimate of 55,000 clones. There has been some expansion of the Onefour population onto the adjacent prairie since the late 1970s (~1000 clones), likely in association with a prairie fire that reduced the density of competing grasses.

Total population size at Pinhorn has apparently been stable, with ~400-450 clones since 1977. However, improvements in clone identification in 2004 resulted in a revised estimate of 1366 clones. No mortality or recruitment of new clones has been documented since 1998.

The Rockglen population first discovered in 2000 contained six clones in 2000, 2005 and 2011.

Survival of mature clones was estimated at 0.997 at Onefour. Germination fluctuates greatly among years with increases in seedlings following large fruiting years and years with activities creating some disturbance of the substrate. The population growth rate at Onefour was estimated to be slightly positive at $\lambda = 1.004$ using population projection models.

Threats and Limiting Factors

Soapweed is naturally limited in Canada by its relationship with the Yucca Moth. Other possible limiting factors in Canada include herbivory by wild ungulates and insects, and extreme weather events such as high winds or heavy rains.

The primary sources of anthropogenic threats to Soapweed include habitat alteration through lack of disturbance (including fire suppression) and degradation through agriculture, oil and gas development and off-road vehicle use. Soapweed is collected for the horticultural trade and for medicinal use.

Protection, Status, and Ranks

Soapweed is listed as Threatened under Canada's *Species at Risk Act* and as Endangered under Alberta's *Wildlife Act*. Soapweed is the subject of an Alberta Recovery Plan and an Environment Canada Recovery Strategy. Soapweed is assessed as globally secure (G5) throughout its range and as critically imperiled in Canada (N1), and in Alberta (S1).

In Canada, the species occurs on public land that is managed by Alberta at the Pinhorn Grazing Reserve, and by Agriculture and Agri-Food Canada at the Onefour Research Substation. Its habitat is protected through critical habitat designation under SARA and regulations associated with Alberta natural areas. The land ownership of the Rockglen population is mostly private, with one plant on provincial land (roadside). Because this population has not previously been part of the species' assessment, critical habitat has not been designated at this site.

TECHNICAL SUMMARY

Yucca glauca
Soapweed Yucca glauque
Range of occurrence in Canada (province/territory/ocean): Alberta, Saskatchewan

Demographic Information

Generation time Base on time to maturity for a sexual recruit.	~25 yrs; perhaps longer
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	No
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	No decline
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]. A slight increase has been observed at Onefour over the last generation, based on newly reproducing clones; longer-term trends are uncertain.	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations]. A slight increase (0.4%) projected under current conditions, based on stage based modelling. However, conditions are unlikely to remain stable over 3 generations (75 years).	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Not applicable
Are there extreme fluctuations in number of mature individuals? *Not in Soapweed, but there are extreme fluctuations in its obligate pollinator, which affect seed set in Soapweed*	No

Extent and Occupancy Information

Estimated extent of occurrence *Includes the two previously known Alberta sites and the Rockglen, SK site. Omission of Rockglen reduced the EO to 32 km^2.*	2040 km²
Index of area of occupancy (IAO) Based on number of 2 x 2 km squares that are occupied by the species on 1:50,000 scale topographic maps. Biological area of occupancy is 185 ha based on critical habitat designation in Environment Canada (2011)	16 km^2 1.85 km²
Is the total population severely fragmented?	No
Number of locations*	3

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] continuing decline in number of populations?	No
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	No
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat? Area and extent are unchanged in recent years, and there are no data to support recent changes in habitat quality. Fire suppression likely limits sexual recruitment, but does not appear to impact established clones, which can live at least 50 years.	Unknown
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations∗?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	**N Clones (index of Mature Individuals)**
1. Onefour Research Station, AB 2. Pinhorn Grazing Reserve, AB 3. Near Rockglen, SK	46,000 – 72,000 423 6
Total Note that the number of clones is used here as an index of the number of mature individuals, but likely underestimates the true value. The number of mature individuals is probably best measured as the number of rosettes above a certain age or size, but these data are not available.	 46,500 – 72,500 clones

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not applicable

Threats (actual or imminent, to populations or habitats)

Lack of disturbance resulting from fire suppression and lack of grazing
Wild ungulate herbivory
Oil and gas development
Extreme weather events

Additional threats and limiting factors have been previously identified, but due to changes in management, their effects are thought to be negligible at present.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Stable and secure throughout most of the range	
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes

∗ See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Is rescue from outside populations likely?	No

Status History

COSEWIC: Designated Special Concern in April 1985. Status re-examined and designated Threatened in May 2000 and May 2013.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Threatened	Does not strictly meet any criteria, but assessed Threatened because of interdependency with its Endangered sole pollinator.

Reasons for designation:

This long-lived perennial is known from only three sites in southeastern Alberta and southwestern Saskatchewan, where it occurs mainly on south-facing coulee slopes. Plants are pollinated exclusively by Yucca Moth, which lays eggs in the flowers. In Canada, the species reproduces almost exclusively by vegetative spread. Seed production is limited by low numbers of Yucca Moth pollinators, while seedling establishment is negatively impacted by lack of natural disturbance, including fire suppression. Herbivory of flowering stalks by native ungulates also limits seed set. Despite improved management to limit the impact of threats, this perennial is designated Threatened. It is the only host for Yucca Moth, Non-pollinating Yucca Moth and Five-spotted Bogus Yucca Moth, all of which were assessed as Endangered.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No evidence of decline in mature individuals; projections suggest slight increase over time.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not met. EO and IAO are below the thresholds for Endangered, and the species is known from fewer than 5 locations, but there is no documented decline and extreme fluctuations do not occur.
Criterion C (Small and Declining Number of Mature Individuals): Not met. Total population exceeds the threshold of 10,000 mature individuals.
Criterion D (Very Small or Restricted Total Population): Not met. Index of area of occupancy and number of locations below thresholds for Threatened D2, but factors that could rapidly lead to endangerment or extirpation are not known.
Criterion E (Quantitative Analysis): Not done.

PREFACE

Soapweed was assessed by COSEWIC in 1985 (Fairbarns 1985) and in 2000 (Csotonyi and Hurlburt 2000). Since 2000, there has been considerable research on the population biology and ecology of Soapweed in Alberta and in the closest Montana populations. In the last 10 years, our knowledge of Soapweed demography, intra- and inter-annual variation in reproduction, and the interactions of Soapweed, its Yucca Moth pollinator (*Tegeticula yuccasella*) and its other associates (Non-pollinating Yucca Moth (*T. corruptrix*), Five-spotted Bogus Yucca Moth (*Prodoxus quinquepunctellus)*, ants and aphids) have been greatly enhanced. COSEWIC assessed the Yucca Moth in 2002 (COSEWIC 2002), Five-spotted Bogus Moth in 2006 (COSEWIC 2006a) and Non-pollinating Yucca Moth in 2006 (COSEWIC 2006b).

A provincial recovery team was struck for the Soapweed and the Yucca Moth (ASYMRT 2006), and a national recovery strategy that includes identification of critical habitat at Onefour and Pinhorn was finalized in 2011 (Environment Canada 2011). Significant strides in mitigating the impacts of human disturbance at the Onefour Research Substation and herbivory at the Pinhorn Grazing Reserve have been made since the last update status report (Environment Canada 2011). No mortality or recruitment of new clones has been documented since 1998. The occurrence of 6 clones near Rockglen, SK has been evaluated and this occurrence is now considered part of the wildlife species in Canada.

This status report on Soapweed is one of two produced in 2011-12 as an experiment in bundling associated species. The second report combines three species of yucca moths, Yucca Moth (*Tegeticula yuccasella*), Non-pollinating Yucca Moth (*T. corruptrix*) and Five-spotted Bogus Yucca Moth (*Prodoxus quinquepunctellus*) into a single report.

Note: Throughout the text, Yucca Moth is capitalized when it refers to *Tegeticula yuccasella*. If yucca moth or yucca is not capitalized it refers more generally to the entire group of organisms. A similar naming convention is used throughout the text with all common names for consistency.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS
(2013)

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

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

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

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

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2013

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific Name: *Yucca glauca* Nuttall

Synonyms: *Yucca angustifolia* Pursh, *Yucca glauca* var. *gurneyi* McKelvey, *Yucca glauca* var. *stricta* (J. Sims) Trelease, *Yucca stricta* J. Sims

Common Name: Soapweed, Yucca, Yucca glauque (French), Eksisoke or aiksisooki (Blackfoot), hupestola (Lakota), Small Soapweed Yucca, Great Plains Yucca, Spanish Bayonet, Beargrass, Narrow-leafed Yucca

Family: Agavaceae; sometimes included in the Liliaceae or Asparagaceae

Yucca glauca Nutt. is the only species of the genus native to Canada. It hybridizes with Palmella (*Y. elata*) in eastern Colorado, central New Mexico, and Arizona and is thought to hybridize with *Y. constricta*, *Y. baileyi* and *Y. angustissima* (Webber 1953; Groen 2005) in parts of the species range. None of these *Yucca* species occurs naturally in Canada, although they may be present in horticultural settings.

Morphological Description

Soapweed is a long-lived, polycarpic perennial that grows as a single rosette or cluster of rosettes of long, narrow, sharply-pointed leaves (Figure 1). Clusters of rosettes are part of the same genetic individual (genet) and are referred to as clones following established terminology for this species. Leaves reach 25 to 40 cm long in mature plants (Kingsolver 1984; Csotonyi and Hurlburt 2000). At flowering, each rosette can produce a single inflorescence containing 15 to 75 nodding, perfect flowers and reaching 30 to 85 cm in height (Csotonyi and Hurlburt 2000). Most inflorescences in Alberta have one or two flowers at each axil; however, they can also be branched with up to 5 flowers at each axil. Flowers are large and white to greenish-white or pinkish-white (Csotonyi and Hurlburt 2000). Fruits are woody once mature, kiwi-sized and dehiscent. The fruits of Soapweed plants at the Onefour Research Substation (henceforth Onefour), contain an average of 146 $\pm$ 94 flat, black seeds arranged in six locules or rows (Hurlburt 2004; Figure 2). Soapweed clones have 1 or 2 large diameter rhizomes from which smaller rhizomes protrude (Groen 2005), forming a mat as deep as the hardpan layer below the soil surface in Alberta (Hurlburt, D., pers. obs.).

Figure 1. Soapweed clone at Pinhorn Grazing Reserve, AB in late June 2002. (Photo: D. Hurlburt.)

Figure 2. A locule of a Soapweed fruit, showing viable (black) and non-viable (white) seeds. The Yucca Moth larva has destroyed a portion of the viable seed through feeding. (Photo: D. Hurlburt.)

Designatable Units

No subspecies of Soapweed are recognized, all the plants occur in a single COSEWIC National Ecological Area (Prairies), and there are no distinctions that warrant consideration of multiple designatable units. This report is based on a single designatable unit.

Special Significance

Soapweed engages in an obligate mutualistic relationship with its pollinator, the Yucca Moth (*Tegeticula yuccasella*), in which both species depend on their interactions to complete their life cycle. Few interspecific relationships of this nature are documented worldwide and this may be the only example of an obligate mutualism among free-living species in Canada.

Soapweed is also the sole host to three other species of Lepidoptera, in addition to the Yucca Moth. The Non-pollinating Yucca Moth (*T. corruptrix*) and the Five-spotted Bogus Yucca Moth (*Prodoxus quinquepunctellus*) use Soapweed fruits and inflorescences respectively, as oviposition sites. These two species and the Yucca Moth are listed as 'Endangered' under Canada's *Species at Risk Act* (SARA), Schedule 1. Strecker's Giant Skipper (*Megathymus streckeri*) relies on the leaves, stems and roots of Soapweed for rearing larvae (Anweiler 2005). This species is on COSEWIC's Candidate list, but it has not yet been assessed. This web of 5 highly interdependent, specialized organisms, plus their complex interactions with ants and aphids (Perry 2001; Perry *et al.* 2004, Snell 2008a; 2008b), illustrates the interdependence of species, in which a decline in one member of the set can negatively alter the fate of all others.

Soapweed and Yucca Moth have unique characteristics in Canada that allow the species and their mutualism to persist despite highly variable biological and environmental conditions at the northern edge of their ranges. Soapweed in Alberta have the longest flowering seasons documented in any *Yucca* spp., which allows some pollination and seed set to occur even when moth emergence is delayed. The plants can selectively abscise fruits with fewer moth eggs, thus apparently allocating resources for fruit development in a manner that tends to increase the reproductive success of the moths. This process has not been described elsewhere (Hurlburt 2004). Unlike most yuccas, Soapweed in Alberta can readily retain self-pollinated flowers with no apparent negative effect of inbreeding on progeny (Hurlburt 2004, although Yucca Moths are still required for pollination of selfed flowers). The unique attributes of these peripheral populations make them especially significant targets for conservation.

In addition, these peripheral populations of Soapweed and Yucca Moths are expected to be on the leading edge of range expansion and may be adapted to different environmental conditions than populations at the centre of the species' ranges. These populations may be more resilient to anthropogenic disturbance or climate change than others (Lesica and Allendorf 1995, Lomolina and Channell 1998).

Soapweed is of commercial value as horticultural stock and is commonly available in nurseries throughout Canada (Hurlburt 2001). Yucca roots contain steroidal saponigens and have been used as the soapy agent in shampoos and soaps. Yucca extracts are also popular components of herbal remedies and drugs, and have been promoted as cure-alls (Hurlburt 2001). Experimental efforts are ongoing to determine if the addition of Yucca extracts to animal feed can reduce ammonia compounds in manure or reduce methane production (in cattle) without compromising digestion (e.g. Holtshausen *et al.* 2009).

Soapweed is known to be of significance to Aboriginal groups in the United States for food and fibre and it is expected that ATK, including knowledge of the interactions between the Soapweed and Yucca Moth, may exist in those areas where Soapweed is more common. No ATK was found to be available in Canada, nor are any Aboriginal artifacts containing yucca fibre known to occur.

DISTRIBUTION

Global Range

Soapweed is a perennial species of the semi-arid regions of the Great Plains of North America. The species occurs from Texas north to Alberta, from the Rocky Mountains east to the Mississippi River (Figure 3, Fairbarns 1985). Less than 1% of the global range occurs in Canada. Soapweed's obligate pollinator/seed predator, Yucca Moth, pollinates several other species of Yucca, and thus has a broader distribution ranging from southern Texas to Canada and from the Rocky Mountains east to the Atlantic seaboard (Pellmyr 1999).

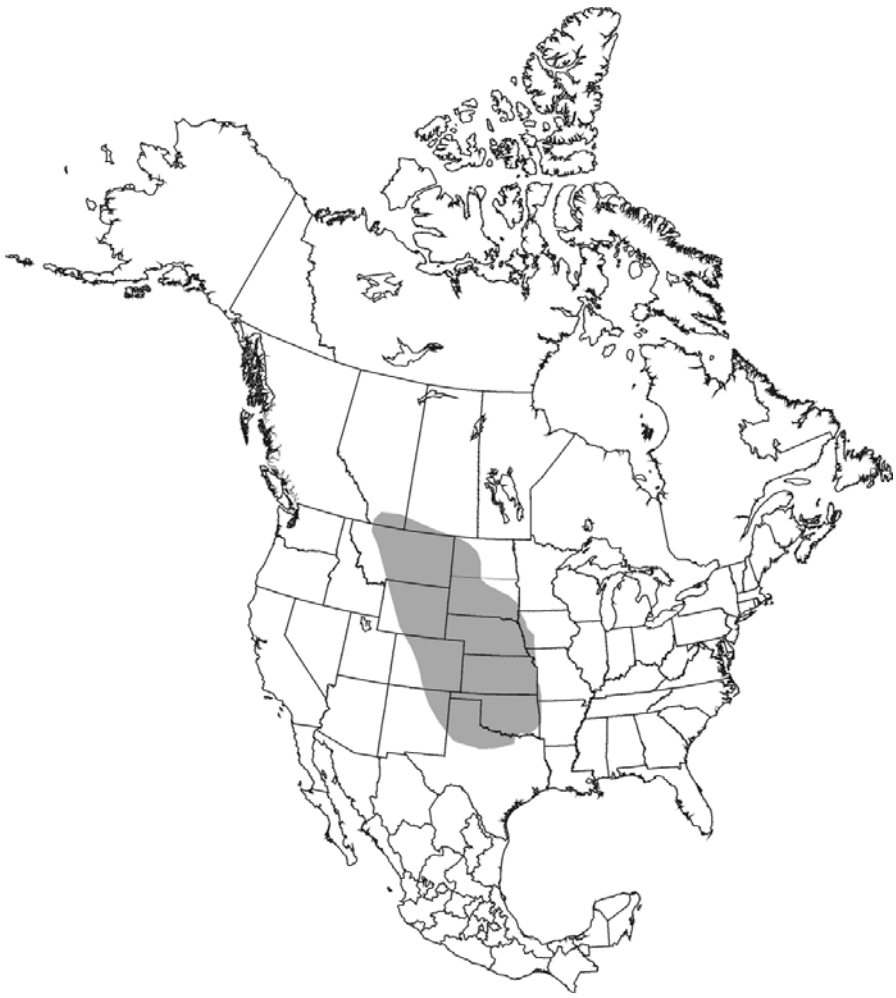

Figure 3. Current global range of native Soapweed (from Hurlburt 2001).

Canadian Range

Soapweed is known to occur in two populations in southeastern Alberta. One population is near Onefour, AB along the Lost River drainage, a tributary of the Milk River. This population is within the boundaries of the Onefour Research Station managed by Agriculture and Agri-Food Canada. The second population is on the Pinhorn Grazing Reserve south of Manyberries (Figure 4).

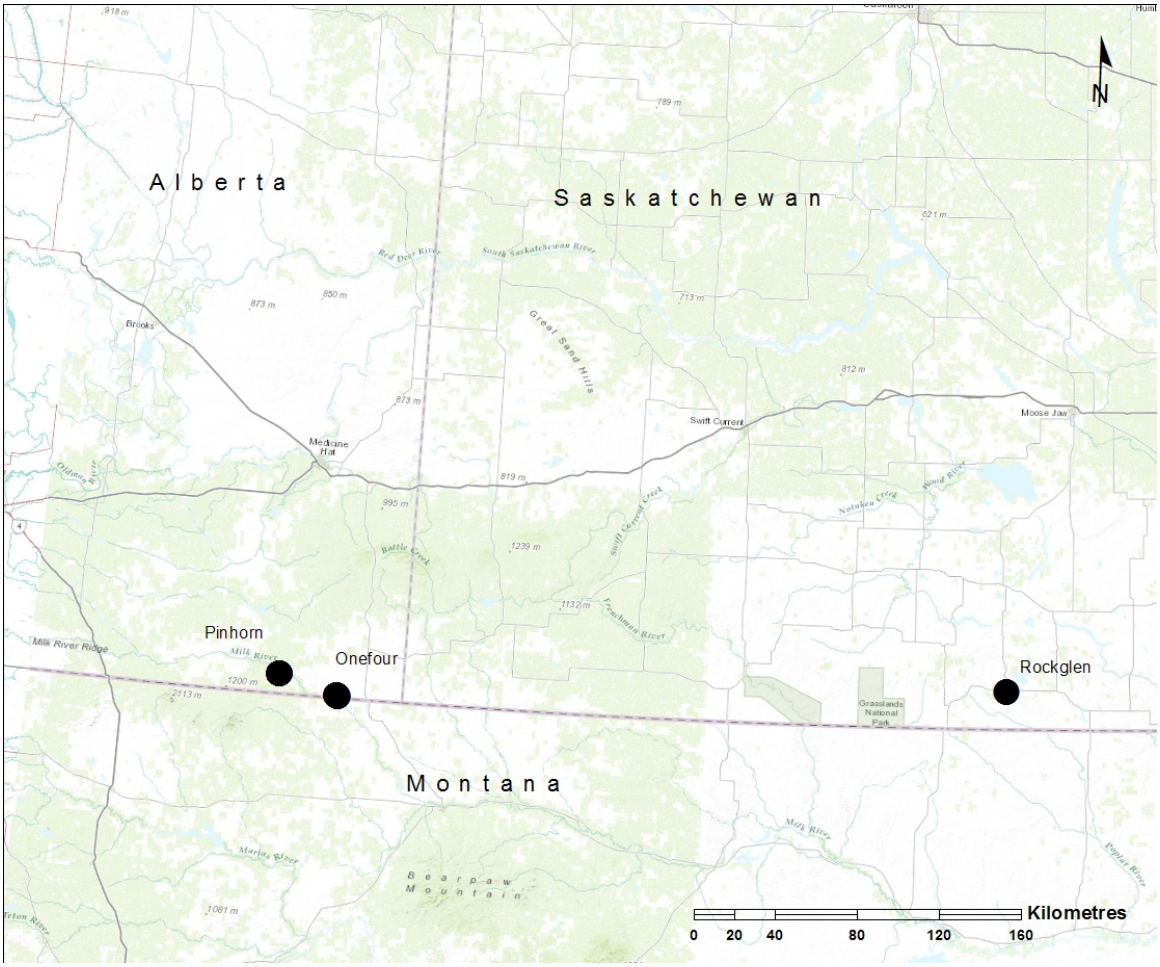

Figure 4. Known native populations of Soapweed (*Yucca glauca*) in Canada.

There have been two reports of additional populations of Soapweed in Alberta. Olson (1976) reported Soapweed growing about 11 km SE from the known Pinhorn location along the Milk River, on a rough map. Targeted searches were performed in the area from 1999 through 2008 by Dr. Johan Dormaar, but the site was never relocated. Discussions with Olson did not provide any new information. Likewise, A. Fischer in Csotonyi and Hurlburt (2000) reported a population of Soapweed “about an hour north of the United States border along Highway 4”, but this population was never confirmed. These two reports are unconfirmed, and therefore are not considered further in this assessment.

A new occurrence for Soapweed that includes 6 clones was discovered in 2000 near a roadside in Rockglen, Saskatchewan (D. Henderson pers. comm. 2001). In 2003, one flowering stalk observed at Rockglen appeared to have enlarged pedicels, indicating a likely pollination event, and suggesting that Yucca Moth may also have been present (ASYMRT 2006). Although reported as introduced from Montana 15-20 years ago (Environment Canada 2011), the plants at Rockglen occur in undisturbed habitat similar to that of the two Alberta populations (unglaciated upland on native prairie) and include individuals with one to multiple rosettes and evidence of past flowering (Hurlburt, D., pers. comm. 2012, Henderson, D. pers. comm. 2012). COSEWIC Guidelines on Manipulated Populations (COSEWIC 2010) state that even if these individuals were accidentally or intentionally introduced, they can be included as part of the assessment if they are self-sustaining and occur in a natural setting within the natural range of the species. Reproduction in Soapweed includes production of new rosettes (as well as sexual reproduction), and therefore, this set of individuals appears to be self-sustaining. With respect to whether the Rockglen site is part of the natural range, the fact that there are populations of Soapweed in the areas of Montana to the south of both the Alberta and Saskatchewan sites is taken as evidence that the Rockglen site falls within an area that can be considered part of the native range. As a result, the Rockglen population is considered to be part of the wildlife species, and the clones that occur at this site are included as part of the total population in Canada. (There is no evidence that the Rockglen population includes self-sustaining populations of Yucca Moth, Non-pollinating Yucca Moth, or Five-spotted Bogus Yucca Moth, and thus, this site is not considered a location for the moths.)

In contrast, several isolated, small patches of Soapweed are excluded from the assessment. These are either growing in horticultural settings, or do not show evidence of being self-sustaining, and therefore, following COSEWIC Guidelines for manipulated populations, these are not considered in assessing the status of the species. These plants are reported to be transplants originating from Onefour, Pinhorn or the United States, and occur across southern Alberta (Fairbarns 1985; Csotonyi and Hurlburt 2000; Hurlburt 2001, 2007; Saunders and Ernst 1998) and Saskatchewan (Fairbarns 1985; Hurlburt 2001). Soapweed plants, likely derived from wild Alberta stock, can be found growing in gardens with examples known from Etzikom, Medicine Hat, near Manyberries, near Wild Horse, and Lethbridge, AB, as well as in Fox Valley, SK. The plants in Lethbridge occur on coulee slopes, but are not known to have produced rosettes or fruits, and therefore are not considered self-sustaining at this time. At Fox Valley, between 10 and 50 Soapweed plants from potted plants of unknown origin occur in a 5 km square (Maher *et al.* 1979; Fairbarns 1985; Hurlburt 2001). Two recent occurrences of single Soapweed clones along roadways in southeast Alberta are of unknown origins (Bradley *et al.* 2006; Hurlburt 2007), but are not considered self-sustaining. Some of these sites may merit inclusion in future assessments.

Plants at the Etzikom Windmill Museum, Etzikom, AB, Police Point Park, Medicine Hat, AB and in several private gardens near Pinhorn and Onefour, have been observed to produce fruit regularly with emergence holes, indicating that the Yucca Moth is also present (ASYMRT 2006, Foreman *et al.* 2006).

The extent of occurrence has been estimated at 2040 km^2, including the Rockglen site, and the index of area of occupancy is 16 km^2. The biological area of occupancy of Soapweed in Alberta is 185 ha based on critical habitat designation in Environment Canada (2011).

Search Effort

From 1998-2011, several thousand search hours have been expended looking for native Soapweed populations in suitable habitat in Alberta and Saskatchewan, particularly along the Canada-United States border (D. Hurlburt, pers. obs.). To date, additional search effort has only resulted in the identification of one new population, at Rockglen, SK. Because Soapweed is readily identifiable by the public and highly visible when flowering, and new reports are often provided by non-biologists or naturalists as incidental observations. To date, most reports represent non-natural occurrences.

In 2007 and 2008, a media campaign was launched to encourage the public to report yuccas that had fruited in gardens, as a means of tracking the prevalence of Yucca Moth in Alberta (D. Johnson pers. comm. 2011). Despite the increase in attention through newspapers, newsletters and websites across southern Alberta, no new native plants or populations were reported, although incidents of fruiting in gardens were documented in Lethbridge and Magrath in 2007 (D. Johnson pers. comm. 2011, E.B. Cunningham pers. comm. 2011, P. Harris pers. comm. 2011).

HABITAT

Habitat Requirements

In Canada, Soapweed occurs in the Mixed Grass ecoregion (Wilken 1996). The Alberta populations occur in the Dry Mixedgrass Subregion (Natural Regions Committee 2006). This Subregion has very warm summers, high solar gains, long growing seasons and low precipitation with large daily variation and weather extremes. The mean growing season temperature is approximately 16 °C, the regional frost-free season is 100-120 days and the growing season about 180-200 days (Fairbarns 1985). The mean percentage of daylight hours with bright sunshine is the highest in Canada (50%) or 2200 hrs/year (Fairbarns 1985). Total annual precipitation is between 260 to 280 mm, with two thirds of that falling as spring rains (Hurlburt 2001). Due to warm summer temperatures and a high average wind speed, the rate of evaporation is high throughout the summer months (Adams *et al.* 2005; Knapton *et al.* 2005). Wind speeds of 70 to 90 km/hr and gusts over 130 km/hr are common.

At the northern limit of its range, Soapweed is found on well-drained coulee slopes that are generally eroded, dry and sparsely vegetated (Figures 5, 6; Milner 1977; Fairbarns 1985; Csotonyi and Hurlburt 2000). They mostly occur on south-facing slopes. At Onefour, the azimuth of these slopes range from 34° (northeast) to 220° (south-southwest), and except for some sites sheltered by adjacent ridges, generally face away from prevailing southwest winds (Csotonyi and Hurlburt 2000). Soils tend to be alkaline and regosolic without shallow hardpan (Milner 1977; Fairbarns 1985).

Figure 5. Soapweed in heavy flower (early June 1999). South-facing coulee slope is representative habitat of northern populations of Soapweed. (Photo: D. Hurlburt.)

Figure 6. Soapweed habitat is sparsely vegetated and eroded. The Sweetgrass Hills in Montana are visible in the background. (Photo: D. Hurlburt.)

Figure 7. Four year old Soapweed seedling at Onefour, AB. Note the grass-like leaves rather than the sharp, erect leaves of an older plant. (Photo: D. Hurlburt.)

In Onefour, Soapweed is found on eroding kame slopes dominated by Silver Sagebrush (*Artemisia cana*). Major grasses include Blue Grama (*Bouteloua gracilis*) and Plains Muhly (*Muhlenbergia cuspidata*), while Needle and Thread Grass (*Hesperostipa comata*), Prairie Junegrass (*Koeleria macrantha*) and Prairie Sandreed (*Calamovilfa longifolia*) are locally common. Major forbs include Plains Prickly-pear Cactus (*Opuntia polyacantha*), Pincushion Cactus (*Escobaria vivipara*), Smooth Blue Beardtongue (*Penstemon nitidus*), and Broom Snakeweed (*Gutierrezia sarothrae*) (Wershler and Wallis 1986).

Habitat Trends

Most of the area occupied by the two previously known populations is designated as Critical Habitat (Environment Canada 2011). Although grazing is the predominant land use in the immediate vicinity of Soapweed, the habitat remains largely undisturbed and has not declined in availability since the area was settled over 100 years ago.

At Onefour, a small proportion of clones grow on the prairie uplands, presumably as a result of a prairie fire in the 1970s. The ability of Soapweed to spread beyond its current range may be dependent on ecological drivers that reduce competitive grasses during years of high fruiting. Historically, heavy grazing and wallowing by bison, and fire may have performed that role (Samson and Knopf 1994; Samson *et al.* 2004). Fire in the mixed-grass prairie was estimated to occur every three to five years prior to European contact (Samson and Knopf 1994; Samson *et al.* 2004), but is thought to have occurred only once in Soapweed habitat at Onefour during the last 35 years.

BIOLOGY

Life Cycle and Reproduction

Soapweed populations are maintained through asexual and sexual reproduction (Csotonyi and Hurlburt 2000); those at the northern edge of range are maintained predominantly through the asexual production of new rosettes or ramets (Hurlburt 2004). Lack of reproduction by seed prevents the species from expanding into new habitats (Csotonyi and Hurlburt 2000). Seeds germinate in spring or early summer, about 10 months after dispersal from the parent plant (Hurlburt 2004). A single rosette derived from seed is thought to become mature at about 20-25+ years of age (Figure 4; Hurlburt unpubl. data); whereas a rosette derived asexually can flower within several years. Each rosette is capable of producing a single inflorescence (Kingsolver 1984; Hurlburt 2004). After flowering, individual rosettes die (Kingsolver 1984); clones, however, likely persist in excess of 50 years (Figure 8). A closely related yucca, *Yucca angustissima*, is known to live over 100 years in the Grand Canyon area of Arizona (Bowers *et al.* 1995). Fewer than 1 in 5000 seeds germinated under natural conditions, almost always in areas of disturbed or eroded soils (Hurlburt 2004). Seeds only remain viable for one year and there is no seedbank (Webber 1953; McCleary and Wagner 1973).

Figure 8. Growth habit of Soapweed showing multiple rosettes, which each flower once and subsequently die. (Photo: D. Hurlburt).

The Yucca Moth, as the sole pollinator, is essential to the survival (over evolutionary time) and sexual reproduction of Soapweed. The plant and moth have an obligate mutualistic relationship where the Yucca Moth pollinates the Soapweed, and the Soapweed provides food (i.e., seeds) and incubation sites for developing Yucca Moth larvae (Riley 1873, 1892). Obligate mutualistic systems are those relationships in which each partner requires the other to survive or reproduce, and as a result, each derives a net benefit from the interaction (Addicott 1995).

Based on observation from Alberta, most Soapweed plants in Canada flower between early June and late July, with peak flowering occurring in late June and relatively few plants flowering into early September (Hurlburt 2004). Canadian populations exhibit longer flowering seasons than those reported anywhere else in the species' range (Hurlburt 2004) and exhibit large interannual variation in flowering rates (Figure 10). During the flowering period, adult Yucca Moths emerge from the soil and reside in open flowers during the day, where mating takes place. At dusk, female moths gather pollen into balls using specialized appendages called maxillary tentacles. Females then fly about the population actively stuffing the pollen into the stylar canals of freshly opened Soapweed flowers. After pollinating the flowers, the moths oviposit through the walls of the ovary, depositing club-shaped eggs among the ovules (Riley 1873).

Studies of pollination and fruit set at the Onefour population have shown that Soapweed plants only retain about 10% (range = 7.6 to 15%) of pollinated flowers and mature them into fruit (Hurlburt 2004; Hurlburt 2007). Plants selectively abscised flowers that were pollen-limited or had fewer moth ovipositions (eggs) (Hurlburt 2004). This is in contrast to most yucca species, in which plants are thought to selectively abscise flowers/fruit with more moth larvae. The latter strategy prevents overexploitation of the plant by the moth, thus preserving the benefit of the relationship to both species (Shapiro and Addicott 2003, 2004). Clones produced an average of 3.8 ± 0.6 fruits per clone per year from 1998 to 2003 at Onefour (Table 1, Figure 9; Hurlburt 2004). An additional feature of Alberta populations is their ability to tolerate selfing (which still requires Yucca Moth as a vector for pollen transfer), with no evidence of early inbreeding depression in offspring produced by selfing (Hurlburt 2004). Fruits dehisce from mid- to late fall through May of the following spring.

Table 1. Measures of mutualistic benefit between Soapweed and Yucca Moths in Alberta and in the nearest populations in Montana (Hurlburt 2004[a]; Hurlburt 2007[b]; Hurlburt 2011[c]; Alberta Fish & Wildlife – unpublished data[d]). Calculations for Pinhorn include the portion of the site protected by exclosures.

Population	Viable seeds/ fruit (± st. dev. (n fruit))	Fruits/ flowering clone (± st. dev. (n fruit))
Onefour, AB (1999-2003)[a]	146.3 ± 93.9 (221)	3.76± 0.63 (589)
Fort Belknap, MT (2000-03)[a]	147.4 ± 89.0 (100)	3.55± 2.675 (162)
Loma, MT (1999-2003)[a]	142.4 ± 87.9 (112)	3.19 ± 1.93 (353)
Fort Benton, MT (1999-2003)[a]	139.6 ± 75.3 (101)	3.56 ± 0.67 (241)
Onefour (2007)[b]	194.6 ± 59.3 (20)	2.65 ± 0.43 (302)
Onefour (2011)[c]	N/A	1.25 (71)
Pinhorn (2004)[d]	N/A	1.67 (5)
Pinhorn (2008)[d]	N/A	n/a*
Pinhorn (2009)[d]	N/A	2.56 (23)
Pinhorn (2010)[d]	N/A	4.21 (160)
Pinhorn (2011)[c]	N/A	n/a* (71)

*The number of flowering clones was not recorded at Pinhorn in 2008 and 2011.

Figure 9. Three Soapweed fruits on a single inflorescence. Fruits at Onefour exhibit a wide-range of coloration from reddish, as in this photo, to pale green. (Photo: D. Hurlburt.)

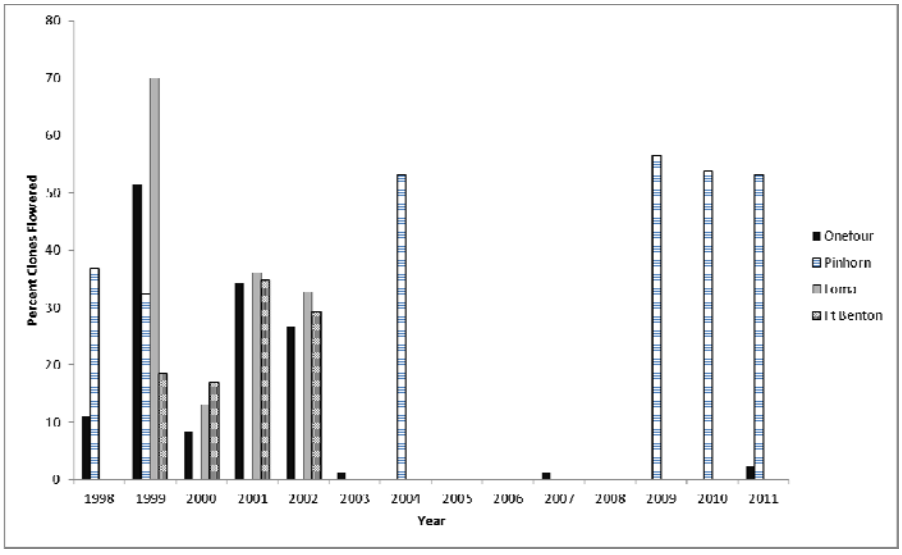

Figure 10. Percent of clones flowering for Onefour, Pinhorn and closest Montana populations (Loma and Ft Benton) from 1998 to 2011 as available (1998-2003: Hurlburt 2004, 2007, 2011). Absence of bars indicates years in which flowering was not assessed rather than no flowering. For the Onefour population, data are not available for 2006 and 2010 when flowering was reported to be high (Bradley *et al.* 2006; Walker, I. pers. comm. 2011).

Dispersal and Migration

Soapweed seeds are wingless, smooth and flat, and likely disperse only short-distances by gravity, though dispersal may also be aided by the high winds that are common in these habitats. Most seeds fall around the base of the parent plant (Fairbarns 1985). At Onefour, seeds that colonized the prairie uplands were likely dispersed by wind in the mid- to late-seventies (Csotonyi and Hurlburt 1998), landing on recently burned prairie allowing for germination in a minimally competitive environment. These upland prairie clones are all located within 100 m of the coulee slopes suggesting that even in high winds most Soapweed seeds do not disperse more than 100 m.

Seeds do not survive gut passage and are not dispersed by the few ungulates that feed upon mature fruit. It is plausible, but unlikely, that the occasional seed may be carried on the bodies of animals or that yucca fruit could float by water to new locations. Most Soapweed plants 'migrate' to new locations aided by people for gardens, by vehicles (along railways in Montana) or possibly in substrate used to build roads.

Interspecific Interactions

In addition to Soapweed's obligate relationship with the Yucca Moth, the plant is the sole host of two other closely related species of moths. The Non-pollinating Yucca Moth is a seed predator and lays its eggs in early-stage Soapweed fruit. Its developing larvae eat a proportion of developing seeds, alongside Yucca Moth larvae (COSEWIC 2006b). The second species, the Five-spotted Bogus Yucca Moth, a stem borer, lays its eggs in Soapweed inflorescences (COSEWIC 2006a). Neither of these species provide any known benefit to the Soapweed; however, their survival greatly depends upon the mutualism between Soapweed and Yucca Moths.

Aphids, which are tended by several species of ants, often live on Soapweed fruit. This facultative mutualistic relationship between ants and aphids, which is dependent on the obligate mutualism between the Soapweed and Yucca Moth, has some interesting implications for its associates. Soapweed inhabited by ants experienced a 60% increase in the number of viable seeds produced per fruit, because ants reduced ovipositing by the Non-pollinating Yucca Moth. Ants were also less likely to chew on and damage yucca buds when aphids were present (Perry *et al.* 2004; Snell and Addicott 2008b).

In Alberta and northern Montana, the survival of Five-spotted Bogus Moth larvae is dependent upon the presence of Soapweed fruits and the presence of aphids feeding on the sap associated with the stalk. Five-spotted Bogus Moth larvae only survive in the green portions of the Soapweed stalk, although their eggs are spread throughout. Soapweed stalks only remain green up to the position of the highest fruit along the stalk, unless aphids are present, in which case the stalks remain greener for longer (Snell and Addicott 2008a).

Numerous additional interspecific interactions are less well documented. Kerley *et al.* (1993) proposed a closely related species of yucca, Parmella (*Yucca* elata), supported over 70 species of arthropods. Soapweed at Onefour provide a food source for birds (who strip larvae from inflorescences), Mule Deer (*Odocoileus hemionus***)**, White-tailed Deer (*Odocoileus virginianus*), Pronghorn Antelope (*Antilocapra americana*), Elk (*Cervus canadensis*) and Nuttall's Cottontail (*Sylvilagus nuttallii*). Soapweed also provides shelter to Prairie Rattlesnake (*Crotalus viridis*), Bull Snake (*Pituophis catenifer*) and the Greater Short-horned Lizard (*Phrynosoma hernandesi*) (Hurlburt 2007). Mule Deer and Pronghorn have been observed to feed extensively on Soapweed stalks, flowers and fruits (see **THREATS AND LIMITING FACTORS**).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

The two Alberta populations have been monitored repeatedly over the last several decades using a variety of approaches. Methodologies for estimating abundance of Soapweed have varied greatly from 1976 to 2011 (see **Abundance**).

Abundance

Onefour

Abundance of Soapweed at Onefour has been determined on three occasions using different methods and producing highly variable estimates. In 1976, B. Milner estimated the population to contain about 55,000 clones by trying to count each individual along a 2 km stretch of coulee (Milner 1977; B. Milner pers. comm. 2011). In 1998, a second survey attempted to count all clones in the population using a spotting scope from high vantage points, and a hand-held tally clicker, and estimated rosettes per clone using randomly placed belt transects (2 X 50 m) along the coulee slopes (Csotonyi and Hurlburt 2000). Using these methods, roughly 28,000 rosettes among 8,500 clones were estimated, although the authors acknowledge that small clones and those hidden by rolling terrain would not be visible using this technique. In 2006, a third survey was conducted using restricted random sampling and 103 – 2 X 20 m quadrats. This approach yielded an estimate of 45,000 to 72,000 clones and 154,000 to 247,000 rosettes (Bradley *et al.* 2006). Estimates from 1977 and 2006 are roughly consistent with one another despite differing methods, while the low numbers estimated in 1998 are likely an artifact of the methodology used in that survey rather than an indication of actual fluctuation in population size.

There are some indications that the population has spread onto the prairie uplands since Milner's work. From 1999 to 2003, a large proportion of the clones growing on the uplands flowered for the first time placing them at about 20-25 years of age (Hurlburt 2004). Although Milner (1977) made no mention of Soapweed growing on the prairie, only mentioning plants on the coulee slopes, recent examination of old photos suggests there were a few sparsely distributed clones north of the prairie rim trail (B. Milner pers. comm.). Onefour staff reported that a large prairie fire in the late 1970s burned vegetation up to the coulee edge, and may have created more favourable conditions for germination due to a reduction in competition from grasses (Hurlburt 2004). Bradley *et al.* (2006) reported 4,004 rosettes among 1,107 clones on the prairie side of the coulee rim trail. It is believed that most of these clones resulted from germination after the fire (Hurlburt, pers. obs.).

Pinhorn

Population abundance of Soapweed at Pinhorn Grazing Reserve was estimated in 1976, 1998 and 2004 using differing methods. In 1976, Milner (1977) counted about 450 clones. In 1998, 1,383 rosettes among 404 clones were counted (Csotonyi and Hurlburt 2000), and in 2004, 3,510 rosettes among 1,366 clones (Foreman *et al.* 2006). The 2004 survey included a patch of 19 mature clones that were not located in 1998. Methodological differences concerning the identification of clones contributed to differences in abundance between years, and in particular, the high numbers reported by Foreman *et al*. (2006) may be an overestimate. A population assessment in 2011 did not locate any seedlings at the site (Hurlburt 2011), which suggests that the increase in abundance in 2004 was not due to recruitment. The estimate for the number of clones at this site is based on 1998 data (404 clones, Csotonyi and Hurlburt 2000), as these are comparable to estimates for the Onefour site, with the addition of the 19 clones from the previously uncounted patch (Foreman *et al.* 2006), resulting in an estimate of 423 clones.

Rockglen

The Rockglen site has contained the same six clones since its discovery in 2000, and was revisited in 2005 and last observed in 2011 (D. Henderson, pers. comm. 2012). The number of rosettes has not been assessed at this site (D. Henderson, pers. comm. 2012).

Fluctuations and Trends

Populations of Soapweed are not expected to exhibit much fluctuation among years in mature life history stages because of their 50+ year longevity and low mortality. The survival rate of mature clones was estimated to be 0.997 at Onefour over the period from 1999 through 2007 (Hurlburt 2004). Germination fluctuates greatly among years with increased seedling establishment following years of high fruiting and disturbance events (e.g. fire, or increased erosion following heavy rain events). Stage-based projection models and elasticity analyses suggested that Soapweed at Onefour had a slightly positive population growth rate ($\lambda = 1.004$) and that stasis in adult reproductive stages was more important to the persistence of the population than the recruitment of new seedlings (Hurlburt 2004).

A critical component of Soapweed population health in the long term is the persistence of the mutualism and the degree of benefit achieved through the interaction with the Yucca Moth. Measures of mutualism health, including viable seeds per fruit and fruits produced per clone, are highly variable among years and sites (Table 1). Data collected between 1998 and 2003 for Onefour and the closest populations in Montana are used as benchmarks for population maintenance and recovery (ASYMRT 2006). The mean number of fruits per clone at Onefour was lower in 2007 (Hurlburt 2007; Table 1) and 2011(Hurlburt 2011) than previously reported; however, fruit production in other years since 2003, such as in 2006, was high but not estimated quantitatively (Bradley *et al.* 2006). Fruiting rates at Pinhorn have increased since 2004 (there was no fruit production between 1998 and 2003), but remain significantly below those in the closest populations (Table 1).

Rescue Effect

Soapweed populations in Canada are approximately 100 km from the nearest known native populations located along the Milk River in Montana. There may be closer populations in Montana, but tributary valleys branching north from the Milk River have not been searched. Canadian populations are isolated from United States populations by distance and unsuitable habitat, including heavily converted cropland dominated by strip farming. Immigration from populations to the south is unlikely to occur naturally.

THREATS AND LIMITING FACTORS

There are a number of natural and anthropogenic factors that may limit the distribution and abundance of Soapweed and therefore also affect its associated Yucca Moth, Non-pollinating Yucca Moth and Five-Spotted Bogus Yucca Moth in Canada. Soapweed relies primarily on asexual reproduction in its Canadian range, but lack of sexual reproduction may impact the long-term persistence of Soapweed, in addition to having immediate and severe effects on the persistence of the three moth species listed above. As a result, factors that affect sexual reproduction of Soapweed are important to consider even if they do not appear to be critical to short-term persistence.

Natural Limiting Factors

Wild Ungulate Herbivory

Herbivory by Pronghorn and Mule Deer on Soapweed inflorescences, flowers and fruit has a negative impact on Soapweed sexual reproduction and the recruitment of yucca moths in some years and sites (Hurlburt 2004). Pronghorn eat individual Soapweed flowers, whereas Mule Deer most often eat large portions of or the entire flowering stalk. Fruits are also susceptible to consumption by both Pronghorn and Mule Deer. Herbivory can directly destroy adult moths within flowers, moth eggs in flowers or early stage fruit, and larvae within older fruits.

When the number of available inflorescences is low, the impact of herbivory can be severe (affecting 80-100% of flowers). Under such situations, herbivory can be considered a threat rather than a limiting factor because of the severity of the impact, especially at Pinhorn. A small number of Mule Deer (2 or 3) can consume hundreds of Soapweed stalks in a single evening. In years of high flowering at Onefour, the impact of herbivory has been low (less than 1% of flowers) (COSEWIC 2002). At Pinhorn, the number of clones is smaller and Mule Deer almost always eat most or all available inflorescences (Csotonyi and Hurlburt 2000, Hurlburt 2001, COSEWIC 2002, Hurlburt 2004). Prior to the construction of exclosures, sexual reproduction and yucca moth populations were severely impacted by wild ungulate herbivory.

Over the short term, the impact of herbivory on population projections for Soapweed in Canada is expected to be low because individuals are long-lived and populations rely mostly on asexual reproduction, as shown in the population projection models presented in Hurlburt (2004). The population projection models incorporated patterns of flowering and intensity of herbivory into population projections for Soapweed based on data for the Onefour population.

At Pinhorn failure of Soapweed to set fruit between 1997 and 2002 was attributed to repeated, intense herbivory of inflorescences, which resulted in the apparent loss of Yucca Moth from this site (COSEWIC 2002). Prior to 1997, the last known occurrence of fruiting was 1975 (Csotonyi and Hurlburt 2000). Since the Yucca Moth assessment in 2002, there have been some improvements for Soapweed and Yucca Moth at Pinhorn. In 2004 and in 2007, several fruits with Yucca Moth emergence holes and/or larval damage to seeds were located at the site (Foreman *et al.* 2006; Environment Canada 2011). In 2004, 3 clones produced a total of 5 fruits with a total of 6 Yucca Moth emergence holes (Foreman *et al.* 2006). In August 2007, a single old Soapweed fruit was observed at Pinhorn. The fruit, thought to have originated from 2006 (D. Johnson pers. comm. 2011), contained seeds with Yucca Moth larval damage from feeding.

In 2008, Alberta Fish and Wildlife constructed deer exclosures to protect a portion of the Soapweed plants at the Pinhorn site. Soapweed fruit set and observations of yucca moths have increased steadily within the exclosures since 2008. By 2010, 160 fruits were produced by 38 clones, with a total emergence of 36 moths (AB Fish and Wildlife, unpublished data). In 2011, 71 fruits were produced at the site; all but 1 were within the exclosures. At the time of sampling in 2011, moth larvae had not yet emerged from the fruits. These results indicate the potential to recover fruit set and restore a healthy population of Yucca Moth to Pinhorn with ongoing protection from herbivores. However, it is not clear whether Yucca Moth abundance at the site is adequate for long-term survival of the moth and the mutualism, as fruiting and moth emergence remain low compared to elsewhere (Hurlburt 2004, Hurlburt 2011).

Extreme Weather Events

The Dry Mixedgrass prairie, where the Alberta populations occur, is characterized by extreme weather events, including high temperatures, high or low levels of rainfall and high winds. Days of heavy rain or high winds are not uncommon and can have considerable impacts on the reproductive success of Soapweed within a given year.

Intense wind gusts over 100 km/hr can cause significant loss of Soapweed flowers and buds, reducing availability of Soapweed flowers to moths for pollination or destroying larvae in early stage fruit through premature removal of fruit from the stalk (COSEWIC 2002). In 1999, over half of the flowers and developing fruits at the Onefour site, and 100% of uneaten flowers at the Pinhorn site, were destroyed on a particularly windy day (COSEWIC 2002). Individual plants located at the tops of coulee slopes or on the prairie flats were particularly susceptible. Yucca Moth may be affected further during such adverse conditions because the wind makes it more difficult for moths to fly among inflorescences to collect pollen or to pollinate (Cruden *et al.* 1976, Aker 1982, Hurlburt 2004); moths have been observed to remain in Soapweed flowers during extreme periods of wind (COSEWIC 2002, Hurlburt 2004). Heavy rains can also lead to erosion of the coulee slopes, and such events could cause mortality of clones, but may also provide open habitat that may favour establishment of seedlings.

Obligate Mutualistic Relationships

Although Soapweed populations can persist through asexual propagation, the absence of sexual reproduction may limit population growth and range expansion and restrict the ability of a species to adapt to changing conditions. Sexual reproduction in Soapweed requires the presence of its highly co-evolved pollinator, the Yucca Moth.

Small or newly established populations of Soapweed may not have adequate numbers of Yucca Moths to sustain successful sexual reproduction. Yucca moths are short-lived, particularly weak flyers, and therefore are unlikely to disperse long distances (Kerley *et al.* 1993; Marr *et al.* 2000). Further, there is evidence to suggest that small populations of Soapweed may not contain enough flowering plants to sustain permanent populations of Yucca Moths (Dodd 1989; Dodd and Linhart 1994; COSEWIC 2002).

All three yucca moth species require regular sexual reproduction of Soapweed in order to reproduce and allow yucca moth populations to persist. To some degree, extended prepupal diapause in yucca moths is thought to allow moth populations to persist in times of limited host plant sexual reproduction or flowering; however, the exact duration of diapause is unknown and the extent of host plant reproductive failure moths can withstand is unknown. Repeated reproductive failure of the plant over a 25-30 year period (due to wild ungulate herbivory) is thought to have led to declining Yucca Moth populations on the Pinhorn Grazing Reserve.

Insect Herbivory

The mutualism between Soapweed and the Yucca Moth is likely to be negatively impacted by the presence of the Non-pollinating Yucca Moth (Perry 2001; D. Hurlburt, unpubl. data), whose larvae consume Soapweed seeds (Addicott 1996) and compete with Yucca Moth larvae for food (James 1998). At Onefour, Non-pollinating Yucca Moth larvae are abundant in some years and can consume up to 40% of seeds (COSEWIC 2002; COSEWIC 2006b). The presence of ants on Soapweed reduces the impact of Non-pollinating Yucca Moth (see **Interspecific Interactions**), resulting in indirect benefits to fruit set of Soapweed and to the Yucca Moth (Snell 2008b).

Ants can, however, significantly reduce the availability of Soapweed flowers in which moths can oviposit, and may kill or harass adult moths in flowers patrolled by the ants (Perry 2001). Ants reduce the availability of Soapweed flowers by chewing on buds and subsequently causing the premature abscission of those buds. In some years, some plants at Onefour lose up to 90% of their buds through ant damage (COSEWIC 2002). Ants are also attracted to Soapweed plants by aphids, but ants tend to be present on Soapweed even in the absence of aphids.

Anthropogenic Threats

A number of anthropogenic threats have been identified with the potential to threaten persistence and/or sexual reproduction of Soapweed and yucca moths in Canada. At present, these are mostly considered potential threats, as some occurred at the time of the last assessment, but have since been mitigated. Few are known to have ongoing negative impacts on known populations at present, but may impact future trends.

Lack of Disturbance

A lack of natural disturbance limits the availability of open patches that favour the establishment of new Soapweed plants. Historically, heavy grazing and wallowing by bison, as well as periodic fires, may have helped reduce the abundance and density of competitive grasses (Samson and Knopf 1994; Samson *et al.* 2004). Fire in the mixed-grass prairie was estimated to occur every three to five years prior to European contact (Samson and Knopf 1994; Samson *et al.* 2004), but is thought to have occurred only once in Soapweed habitat at Onefour during the last 35 years.

Wild Ungulate Herbivory

As noted above (under **Natural Limiting Factors**), when levels of flowering are low (as is common at Pinhorn, Table 1), wild ungulate herbivory can severely impact reproductive output of Soapweed, and consequently limit populations of yucca moths. Under such conditions, herbivory is best thought of as a threat to Soapweed.

Oil and Gas Development

Both the Onefour and Pinhorn sites are on public land and could experience degradation of habitat through oil and gas activity (ASYMRT 2006). There has been no oil and gas development at Onefour, but there was some development and new road construction near the Pinhorn site around 2003. Since the last assessment, Alberta Fish and Wildlife has applied to place protective notations on quarter sections containing Soapweed at Pinhorn and Onefour; designation is pending (Environment Canada 2011). At Onefour, all oil and gas dispositions must obtain consent from the Minister of Community Development, given that the Soapweed occur within the boundaries of the Onefour Heritage Rangelands Natural Area (Environment Canada 2011).

Grazing by Cattle

In both Alberta sites, Soapweed and their moths coexist with cattle grazing. Most Soapweed occur on steep, rocky slopes that are not preferred by cattle, but cattle have been known to consume flowering stalks of Soapweed (COSEWIC 2002). Other than using some travel corridors along select slopes to reach the coulee bottom for shelter and water, cattle generally make little use of the steep slopes.

Some Soapweed at the tops of slopes and on prairie in Onefour have been susceptible to cattle grazing during drought, such as the one that occurred in 2001. Typically, 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, feed for cattle can be in short supply and there was need to use the pasture (COSEWIC 2002). Grazing has not been a problem in Pinhorn since 1998 (no information is available prior to 1998), even though cattle have access to the area during the flowering and fruiting season. There are few observations of cow manure within the Soapweed patch. That said, Mule Deer usually consume all of the stalks shortly after the initiation of flowering (D. Hurlburt, pers. obs.), so there may be little incentive for cattle to forage for Soapweed at this site. Destruction of *Yucca* inflorescences by grazing cattle is common in the United States, and it is plausible that grazing could become a substantial threat in Alberta should the Soapweed expand its habitat (COSEWIC 2002).

Agricultural Crop Production

Most areas inhabited by Soapweed are not ideal for cultivation and are in no immediate threat of such activity. It is possible that cropland conversion and associated activities, like pesticide application, could take place in the future, especially on the prairie upland areas at Onefour, as they do occur immediately across the Lost River coulee in Montana. However, existing protections and land ownership make this unlikely (see **Protection, Status and Ranks**)

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Although herbicides have only been used to spot-kill individual weedy plants near the Onefour Soapweed site, widespread use of herbicides and insecticides could cause widespread plant and moth mortality and reduce reproductive success. In Montana, Soapweed plants along roadsides have fewer ovipositions and produce fewer fruits in areas sprayed for weed control, which could impact plants, especially at the Rockglen site in the future.

Off-road Vehicle Use

Prior to 2003, Soapweed sites at Onefour and Pinhorn were well known and highly accessible by passenger vehicles, and the sites were regularly visited. Crushed plants had been observed at both locations. Since 2003, the impact of off-road vehicle use has noticeably declined (Hurlburt 2011) and these activities do not appear to be a major current threat.

Agriculture and Agri-Food Canada has imposed some conditions on access to the lands they manage at Onefour, partly as means to address concerns regarding liability and fire hazard. In 2011, Hurlburt (2011) observed considerable recovery of the vegetation along prairie trails and did not observe any sign of off-trail vehicle use. General access to the Pinhorn Grazing Reserve is more regulated than in the past with restrictions on accessing pastures with cattle and using ungravelled trails.

Harvesting for Horticultural and Medicinal Uses

Prior to 2003, Soapweed plants were routinely dug up at Onefour and Pinhorn and transplanted to home gardens (COSEWIC 2000, 2002), but no such activity has been observed since that time (D. Hurlburt, pers. obs.).

Number of Locations

Three locations are identified, corresponding to each of the three known populations. The population at Onefour is threatened by lack of disturbance, which limits natural recruitment. The most serious threats to the Pinhorn population is grazing of flowers and inflorescences, which severely limits sexual reproduction. While parts of this population are currently protected by an exclosure, this structure is unlikely to be permanent, and a breach by a single deer during the flowering season could eliminate fruit production for the entire population. The population at Rockglen has no clearly identified threats at this time, but it does not support a population of Yucca Moths, and therefore may lack the ability to reproduce sexually, which threatens its long-term persistence.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

Soapweed was previously assessed by COSEWIC in 1985 as Vulnerable (Fairbarns 1985) and in 2000, as Threatened (Csotonyi and Hurlburt 2000). In 2003, it was reassessed under new criteria when the *Species at Risk Act* (SARA) was implemented and was designated as Threatened by COSEWIC and listed on SARA Schedule 1. The three species of yucca moth associated with Soapweed were all assessed as Endangered by COSEWIC and are also listed under SARA Schedule 1 (COSEWIC 2002, COSEWIC 2006a, COSEWIC 2006b).

In 2003, the Minister of Sustainable Resource Development approved the listing of Soapweed and Yucca Moth as ‘Endangered’ under Alberta’s *Wildlife Act* based on recommendations from the Alberta Endangered Species Conservation Committee. At present, however, only Soapweed is listed in Alberta (ASYMRT 2006), but protection of plants and their habitat is not required under this legislation. All three moth species do, however, benefit indirectly from protection of the host plant.

Alberta Sustainable Resource Development developed a Recovery Plan for Soapweed and Yucca Moth in Alberta (2006-2011) (ASYMRT 2006), and in 2011, Environment Canada adopted the provincial plan and amended the plan to make it into a SARA-compliant Recovery Strategy (Environment Canada 2011). An update to the Alberta Recovery Plan is currently in preparation.

Non-Legal Status and Ranks

Soapweed is common throughout most of its range and has been ranked as globally secure (G5; NatureServe 2011). In Canada, Soapweed has a conservation status of critically imperilled (N1) while in the United States it is considered secure (N5; NatureServe 2011). Soapweed is critically imperilled (S1) in Alberta and considered introduced in Saskatchewan (SNA) (NatureServe 2011; Saskatchewan Conservation Data Centre 2011).

Soapweed is apparently secure to secure (S4S5) in Montana, apparently secure (S4) in Wyoming, vulnerable (S3) in Iowa, and imperilled (S2) in Missouri; however, it has not been ranked in most of the states in which it occurs (NatureServe 2011).

Habitat Protection and Ownership

The Onefour population of Soapweed is on provincial land under lease to the federal government (considered to be federal lands) and is protected under SARA. The Onefour population also occurs within the Onefour Heritage Rangeland Natural Area designated by Alberta Tourism, Parks and Recreation (Parks Division), although relatively little public access occurs at the Onefour Soapweed population. Natural Areas protect sites of local significance and provide opportunities for low-impact recreation and nature appreciation activities. Land use in the Natural Area is regulated by the *Alberta Public Lands Act*.

The Pinhorn population occurs on provincial lands leased to the Pinhorn Grazing Association. This grazing reserve provides access to pasture for local ranchers, recreational opportunities for the public and access for resource extraction and development.

Critical habitat for Soapweed and Yucca Moth was described in the Soapweed and Yucca Moth Recovery Plan (ASYMRT 2006) as 182 ha at the AAFC Onefour Research Substation and the 2.65 ha at the Pinhorn site (Alberta Soapweed and Yucca Moth Recovery Team 2006). This description was identified as Critical Habitat in the federal recovery strategy (Environment Canada 2011).

The Rockglen population occurs on private land, with a single clone occupying the roadside, which is under jurisdiction of the province of Saskatchewan. It is unknown whether the landowner is aware of the Soapweed, and no critical habitat has been designated for this site.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

This updated status report is based upon previous COSEWIC status reports for Soapweed, prepared by Fairbarns (1985) and Csotonyi and Hurlburt (2000).

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At present, she owns and operates an environmental consulting business in Annapolis Royal, Nova Scotia. She acts as a Technical Advisor to the Alberta Soapweed and Yucca moth Recovery and Maintenance Team and continues to engage in the monitoring of the Alberta populations of Soapweed, Yucca Moth, Non-pollinating Yucca Moth and Five-spotted Bogus Yucca Moth.

Donna has participated on several COSEWIC Subcommittees, including the Arthropods and Vascular Plants Specialist Subcommittees. She is an Aboriginal Traditional Knowledge Subcommittee Co-chair and is also appointed to COSEWIC.

COLLECTIONS EXAMINED

No collections were consulted in the preparation of this report.