# COSEWIC
# Assessment and Status Report

on the

# Hare-footed Locoweed
*Oxytropis lagopus*

**in Canada**

**THREATENED**
**2014**

**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:

COSEWIC. 2014. COSEWIC assessment and status report on the Hare-footed Locoweed *Oxytropis lagopus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 61 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Previous report(s):

COSEWIC. 1995. COSEWIC status report on the Hare-footed Locoweed *Oxytropis lagopus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 24 pp.

Smith, Bonnie. 1995. COSEWIC status report on the Hare-footed Locoweed *Oxytropis lagopus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 24 pp.

Production note:
C COSEWIC would like to acknowledge Juanita Ladyman for writing the status report on the Hare-footed Locoweed (*Oxytropis lagopus*) in Canada, prepared under contract with Environment Canada. This report was overseen and edited by Bruce Bennett, Co-chair of the Vascular Plant Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur L'oxytrope patte-de-lièvre (*Oxytropis lagopus*) au Canada.

Cover illustration/photo:
Hare-footed Locoweed — Photo credit: Cheryl Bradley (with permission).


Catalogue No. CW69-14/47-2014E-PDF
ISBN 978-1-100-24010-7

Recycled paper

# COSEWIC
# Assessment Summary

**Assessment Summary – May 2014**

**Common name**
Hare-footed Locoweed

**Scientific name**
*Oxytropis lagopus*

**Status**
Threatened

**Reason for designation**
This member of the pea family occurs in highly restricted habitat within a small area of rough fescue prairie on gravelly soils in southern Alberta and western Montana. Alberta occurrences represent a large portion of the world population. The plants face numerous threats including competition with invasive alien plant species, mining and quarrying, cultivation, oil and gas drilling, road development, and intensive livestock grazing, all of which have not been mitigated and are contributing to continuing habitat loss and degradation.

**Occurrence**
Alberta

**Status history**
Designated Special Concern in April 1995. Status re-examined and designated Threatened in May 2014.

# COSEWIC
# Executive Summary

## Hare-footed Locoweed
*Oxytropis lagopus*

### Wildlife Species Description and Significance

Hare-footed Locoweed (*Oxytropis lagopus* var. *conjugans*) is a member of the Fabaceae (pea family). It is a perennial forb, having a stout taproot crowned by leaves and large, purple, attractive flowers. Despite its attractiveness it has little interest for the horticultural trade. Plants can be poisonous to livestock, especially horses. Parts of the plant have medicinal properties and they were used by First Nation peoples to treat several ailments.

### Distribution

There are three varieties of *Oxytropis lagopus*: *atropurpurea, conjugans* and *lagopus*. Variety *conjugans* is restricted to the prairies in southern Alberta and western Montana. The other two varieties occur in Montana, Wyoming, and Idaho, USA. In Canada, Hare-footed Locoweed is known from 11 subpopulations in an area of approximately 229 $km^2$ on the uplands of the Milk River Ridge and Del Bonita Plateau in southern Alberta. The number of subpopulations in Montana is unknown. The nearest US subpopulation is approximately 48 km south of the Canadian-USA in Glacier County, Montana.

### Habitat

In Canada, Hare-footed Locoweed grows within the Foothills Fescue and Mixedgrass Subregions south of Lethbridge. Plants grow on thin gravelly soils in open grassland at elevations between 1,189 and 1,995 m (3,900 to 6,545 feet) in Alberta. Native rough fescue grassland communities, in which it occurs, are themselves becoming rarer and are considered a high priority for conservation efforts. A notable characteristic of the habitat descriptions is the almost continuous cover of microbiotic crust (primarily lichens) and Dense Spikemoss. There is also indication that a calcium carbonate (limestone) component to substrate materials may be important.

## Biology

Hare-footed Locoweed blooms in late April to early June. The flowers are insect-pollinated. The plants take advantage of spring moisture and pods mature early in the year. Seed predation by insects may be heavy in some years and annual seed production is likely to fluctuate between years and localities. Seed is dispersed primarily by gravity. Wind and rodents may also contribute to seed dispersal. The longevity of the seed in the soil and the state of the seed bank is unknown.

## Population Sizes and Trends

Hare-footed Locoweed occurrences are fragmented and sites that comprise one to several dozen plants may be separated by several kilometres. One subpopulation, south of Cardston has been extirpated within the last 40 years. Currently there are 11 subpopulations, of which one subpopulation needs to be confirmed to be extant.

## Threats and Limiting Factors

Gravel extraction, energy (oil and gas) development, cultivation, off-road vehicles, road building and intensive livestock grazing have, and potentially may, contribute to habitat loss and modification. Recent observations have also concluded that the invasive species Crested Wheat Grass is adversely influencing the numbers of plants in at least five occurrences. These plants are likely direct competitors for nutrients, water and light and may contribute to habitat modification.

## Protection, Status, and Ranks

Hare-footed Locoweed has no legal protection in Alberta or the USA. The taxon was last assessed by COSEWIC in April 1995 when it was designated a species of Special Concern, and it is currently on Schedule 3 under the *Species at Risk Act* (SARA). The NatureServe Conservation Rank in Canada is Critically Imperilled (N1) and in Alberta is also Critically Imperilled (S1).

In Alberta, three subpopulations are on private land (includes the extirpated site), four subpopulations are divided between private and public land, three are on Land Trust property, one is in a provincial protected area (Ross Grassland Natural Area North) and one is divided between the provincial protected area (Ross Grassland Natural Area), land trust properties and private land.

The variety *conjugans* is listed by NatureServe as Vulnerable (S3) in Montana, N3 in the USA, and G4G5T3 globally. The full species *Oxytropis lagopus* has not yet been assessed for the most current IUCN Red List.

# TECHNICAL SUMMARY

*Oxytropis lagopus*
Hare-footed Locoweed — Oxytrope patte-de-lièvre
Range of occurrence in Canada: Alberta

**Demographic Information**

| | |
|---|---|
| Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2008) is being used)<br><br>*Estimate comes from lifespan estimates of herbaceous perennial species of Astragalus* | ≥ 10 years |
| Is there an inferred continuing decline in number of mature individuals? | Probable |
| Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations] | Unknown |
| [Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]. | Unknown |
| [Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations]. | Unknown |
| [Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future. | Unknown |
| Are the causes of the decline clearly reversible and understood and ceased? *The threats attributed to the inferred continuing decline are understood but have not ceased*. | No |
| Are there extreme fluctuations in number of mature individuals? *Inferred by some observations, but monitoring surveys are needed.* | No |

**Extent and Occupancy Information**

| | |
|---|---|
| Estimated extent of occurrence (EO) | 229 km² |
| Index of area of occupancy (IAO)<br>(Always report 2x2 grid value). *Actual land covered may be <1 km$^2$ within at 14 km$^2$ area.* | 124 km² |
| Is the population severely fragmented? | No |
| Number of locations*<br>*11 subpopulations; includes 1 subpopulation that needs to be confirmed extant and 1 that has only a single plant recorded that may not be viable* | 9-11 |
| Is there an inferred continuing decline in extent of occurrence? | No |
| Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy? | No |

* 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 number of subpopulations?<br>*One subpopulation is believed to have been extirpated within last 40 years.* | No |
| Is there an [observed, inferred, or projected] continuing decline in number of locations*? | No |
| Is there an observed continuing decline in extent and/or quality of habitat? | Yes |
| Are there extreme fluctuations in number of populations? | No |
| Are there extreme fluctuations in number of locations*?<br>*Unlikely 'extreme' but it appears there are fluctuations*. | No |
| Are there extreme fluctuations in extent of occurrence?<br>*Data are weak. Fluctuations likely due to survey effort. Extreme fluctuations are unlikely given life history*. | No |
| Are there extreme fluctuations in index of area of occupancy? | No |

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

| **Population**<br>Name of site (see Table 3)<br>(*maturity not given at all sites; final total estimated from a ratio of 3:1 mature to juvenile plants at each occurrence*); | **N Mature Individuals**<br>Date last observed |
|---|---|
| Whiskey Gap South | Present; 1992 |
| Whiskey Gap Northeast | 1; 2011 |
| Whiskey Gap North | 341; 2011 |
| Milk River Ridge NCC | 838; 2011 |
| Milk River Ridge | 2,540; 2011 |
| Ross Lake NA | ~200; 2011 |
| North Milk River Terrace | >50; 1996 |
| Sandstone Ranch | 940; 2011 |
| Shanks Lake West | 10,300; 2011 |
| Shanks Lake South | 820; 2011 |
| Del Bonita East | 18,400; 2011 |
| Total | ~34,430 |

**Quantitative Analysis**

| | |
|---|---|
| Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]. | Unknown – no analyses |

**Threats (actual or imminent, to populations or habitats)**

| |
|---|
| Invasive alien plant species, mining and quarrying, annual and perennial non-timber crops (especially *Agropyron cristatum*), cultivation, oil and gas drilling, road development (includes informal vehicle tracks and trails), and livestock farming and ranching are currently threatening Hare-footed Locoweed plants and subpopulations. Wind farm and coalbed methane development are considered to be potential future threats. |

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

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

| | |
|---|---|
| Status of outside population(s)?<br><br>Vulnerable (S3) in Montana, USA<br>NatureServe's USA National Status Vulnerable (N3). | |
| Is immigration known or possible? | Unknown |
| Would immigrants be adapted to survive in Canada? | Likely yes |
| Is there sufficient habitat for immigrants in Canada?<br>*Suitable habitat is limited in Canada*. | Unknown |
| Is rescue from outside populations likely? | No |

**Data-Sensitive Species**

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

**Status History**

| |
|---|
| **COSEWIC:** Designated Special Concern in April 1995. Status re-examined and designated Threatened in May 2014. |

**Status and Reasons for Designation:**

| **Status:** | **Alpha-numeric code:** |
|---|---|
| Threatened | B1ab(iii)+2ab(iii) |
| **Reasons for designation:** This member of the pea family occurs in highly restricted habitat within a small area of rough fescue prairie on gravelly soils in southern Alberta and western Montana. Alberta occurrences represent a large portion of the world population. The plants face numerous threats including competition with invasive alien plant species, mining and quarrying, cultivation, oil and gas drilling, road development, and intensive livestock grazing, all of which have not been mitigated and are contributing to continuing habitat loss and degradation. | |

**Applicability of Criteria**

| |
|---|
| **Criterion A** (Decline in Total Number of Mature Individuals):<br>Not met. The magnitude of decline is unknown. |
| **Criterion B** (Small Distribution Range and Decline or Fluctuation):<br>Meets Threatened B1ab(iii)+2ab(iii) because the EO (229 km²) and IAO (124 km²) are below thresholds for Endangered. Although 11 extant subpopulations are known, some subpopulations may contain only a single individual and may not be viable. There is a continuing observed, projected, and inferred decline in the area, extent and quality of habitat. The population is not considered severely fragmented nor does it undergo extreme fluctuations. |
| **Criterion C** (Small and Declining Number of Mature Individuals):<br>Not met. Number of mature individuals exceeds thresholds. |
| **Criterion D** (Very Small or Restricted Population):<br>Not met. Population size and IAO exceed thresholds. |
| **Criterion E** (Quantitative Analysis):<br>Not done. |

## PREFACE

Since Hare-footed Locoweed (*Oxytropis lagopus*) was last assessed by COSEWIC in 1995, four additional subpopulations have been discovered generating a slight increase in the extent of occurrence (EO) from 1995 levels but still much less than the historical range. Many more individual plants have been observed. There has been no active management for this species and the change in EO and greater numbers of plants is the result of more intensive search efforts. Population trends cannot be evaluated with the available information. Monitoring studies need to be established to understand the taxon's demographic characteristics and also permit quantitative analyses of population dynamics.

Threats to the taxon remain essentially the same and at the same levels as reported in the previous 1995 status assessment. Threats include: invasive non-native plant species encroachment, cultivation, gravel removal, energy development, recreational vehicles, and livestock disturbance. Gravel removal has been discontinued at one subpopulation in order to protect habitat. However, encroachment by the invasive species Crested Wheat Grass (*Agropyron cristatum*) appears to have increased and is affecting Hare-footed Locoweed occurrences both by direct competition and through habitat loss in at least five of the 11 subpopulations.

## 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
## (2014)

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

# COSEWIC Status Report

on the

# Hare-footed Locoweed

*Oxytropis lagopus*

**in Canada**

2014

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## WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

### Name and Classification

Scientific name: *Oxytropis lagopus* Nutt. var. *conjugans* Barneby

Synonyms: *Aragallus lagopus* (Nutt.) Greene, *Astragalus blankinshipii* (A. Nelson) Tiderstr., *Astragalus lagopus* (Nutt.) Tidestr., *Oxytropis blankinshipii* (A. Nelson) K. Schum., and *Spiesia lagopus* (Nutt.) Kuntze (ITIS 2012).

Common names: Hare's-foot Locoweed, Hare's-foot Crazyweed, Hare's-foot Point-vetch, Rabbit-foot Crazyweed, Hare Oxytrope, and Oxytrope patte-de-lièvre (Welsh 2001; Public Works and Government Services Canada 2012)

Family: Fabaceae

Subfamily: Papilionoideae

Major plant group: Dicotyledoneae (dicot)

The genus *Oxytropis* is a member of the Fabaceae or Leguminosae, commonly known as the pea family. There are between 310 and 350 species of *Oxytropis* distributed throughout Africa, Asia, Europe, and North America (Xiangyun *et al.* 2010; Li *et al.* 2012). Moss (1983) lists nine species, and an additional four varieties or subspecies, of *Oxytropis* in Alberta.

In 1833, Nathanial Wyeth collected a "remarkable" plant in western Montana (Barneby 1952). This specimen was described by Thomas Nuttall (1834) as *Oxytropis lagopus* (Nutt.). The epithet "*lagopus*" is derived from the Greek meaning 'hare-footed" (Stearn 1992). This name may refer to the fuzzy sepals that could, with some imagination, be thought to resemble a hare or rabbit's foot (Taylor 1992). Sepals are the outermost whorl of parts that form a flower. The type specimen for *Oxytropis lagopus* is at Montana State Herbarium (MONT) collected by J.W. Blankinship (s.n.) at Middle Creek, 15 miles southwest of Bozeman in Gallatin County, Montana, USA on July 4 1898.

There are three varieties of *Oxytropis lagopus*: *lagopus, atropurpurea* and *conjugans*. Varieties *lagopus* and *atropurpurea* are more widespread than variety *conjugans.* An isotype of variety *conjugans* was collected by E.O. Wooton (s.n.) on June 1, 1921 in the "vicinity of Helena," Lewis and Clark County, Montana, USA and is deposited at the New York Botanical Garden Herbarium. The fate of the holotype of *Oxytropis lagopus* var. *conjugans* could not be determined during the preparation of this report.

Barneby (1952) described an affinity between *Oxytropis lagopus, O. besseyi*, *O. multiceps,* and possibly with *O. nana* (Barneby 1952). In the past, there has been some confusion amongst these species and many specimens have received several annotations referring a given specimen to one or other of these species over the years (e.g. MONTU: 104347, 088376, 29044, 44549, and MONT: 028726, 028734, 028735).

Only one variety of *Oxytropis besseyi* (var. *besseyi*) occurs in Canada in Saskatchewan (USDA, NRCS 2012). Where the two species occur together in the USA, hybridization is avoided because *O. lagopus* blooms and sets fruit significantly earlier in the year than *O. besseyi* at the same elevation. *Oxytropis lagopus* is a smaller, more densely hairy plant than *O. besseyi* and has short black hairs mixed in with the long white ones on the calyx whereas *O. besseyi* has only long white hairs (Barneby 1952; Welsh 2001).

**Morphological Description**

Hare-footed Locoweed is a low, tufted perennial 5 to 15 cm tall (Figure 1). The tap root is large and stout and may be intact or divided. Several crowns of leaves are clustered at the top of the taproot. The leaves are 1 to 5 cm long and comprise 5 to 9 leaflets crowded on the stem. The outline of the leaf is oblong, tending towards oval because the leaflets are often so congested. The leaves (leaflets) and stems are covered with silky, long, silvery hairs. The stipules are membrane-like and also intensely woolly. There are 5 to 9 dark blue-purple flowers, each between 15 to 19 mm long, on the flowering stalks. The pods (legume) are oval-oblong in shape, 8 to 13 mm long, about 5 mm thick and covered by dense, long (villous) hairs.

Variety *conjugans* differs from varieties *lagopus* and *atropurpurea* by having fewer leaflets (5 to 9 rather than 9 to 17) per leaf, the leaf is shorter in length, and variety *conjugans* is also covered by more abundant silky hairs than the other varieties (see Table 1).

Only the variety *conjugans* has been reported to occur in Alberta. See Greene (1897), Hitchcock and Cronquist (1961), Boivin (1967), Moss (1983), Dorn (1984, 2001), Looman and Best (1987), Hitchcock and Cronquist (1974), and Welsh (2001), for more information and descriptions. Line drawings of all three varieties of *Oxytropis lagopus* showing details of the leaves, stipules and flower are in Hitchcock and Cronquist (1961).

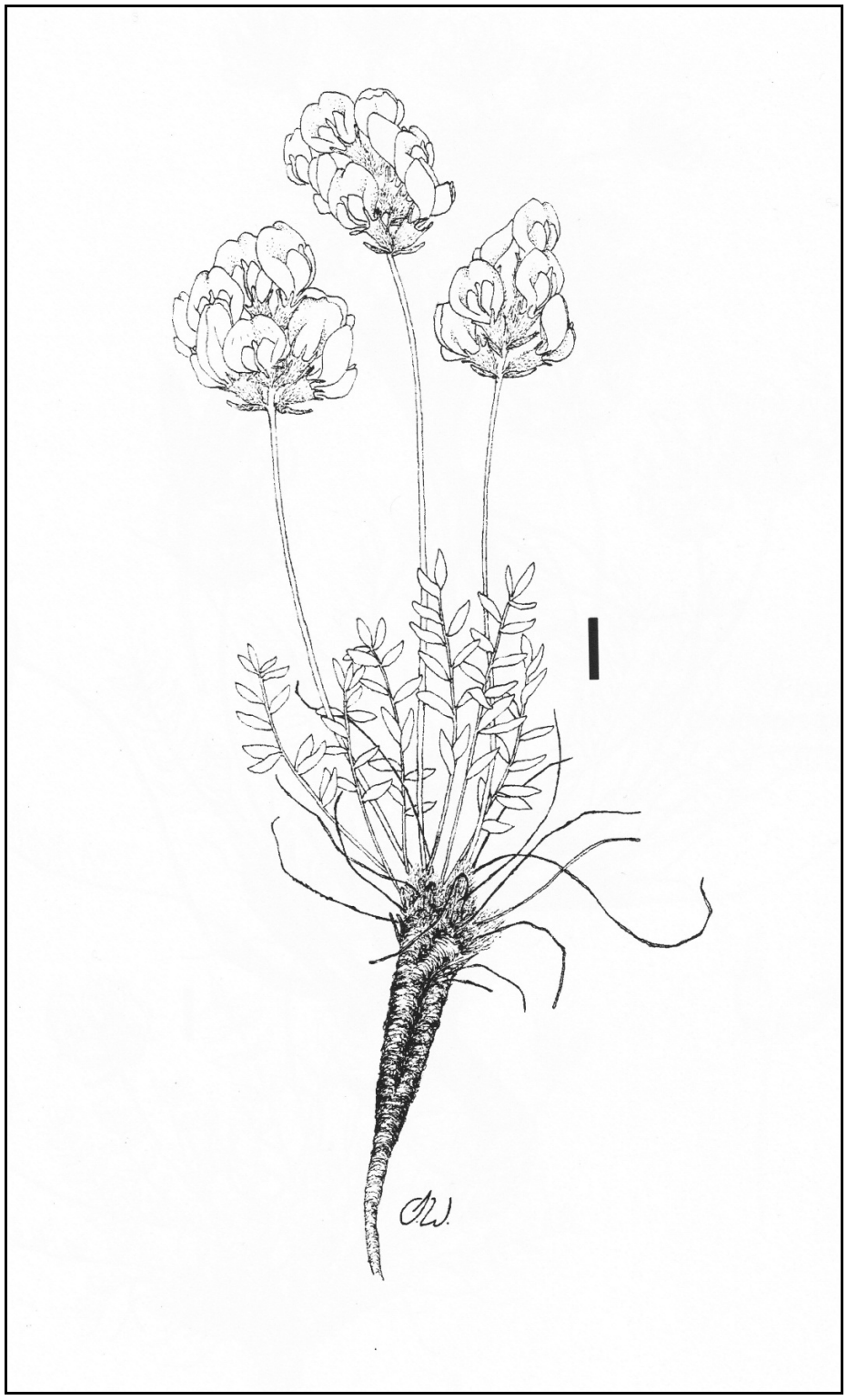

Figure 1. Line drawing of Hare-footed Locoweed (in Welsh (2001) and used with permission of the artist, Stanley L. Welsh).

**Table 1. Morphological characteristics that differentiate between *Oxytropis lagopus* varieties *atropurpurea, conjugans*, and *lagopus* (adapted from Nuttall 1834; Barneby 1952; Boivin 1967; and Welsh 2001).**

| Characteristic | Variety | | |
|---|---|---|---|
| | ***atropurpurea*** | ***conjugans*** | ***lagopus*** |
| Leaflets/leaf | 9 - 17 | 5 - 9 | 9 -17 |
| Rachis length | Longer than longest leaflet | About equal to longest leaflet | At least 2x as long as the leaflets |
| Hairs | Less abundant | Abundant silky long hairs | Less abundant |

## Population Spatial Structure and Variability

The levels of genetic variation between and within Hare-footed Locoweed occurrences, or subpopulations, are not known. There have been no genetic studies for any *O. lagopus* subpopulations. *Oxytropis* plants have a base chromosome number of x=8 but polyploid taxa exist (Welsh 2001; Chung *et al.* 2004). The ploidy level of *O. lagopus* is not known.

The occurrences in Alberta may be genetically differentiated from those in Montana, USA, because they are at the northern edge of their range and may be relatively isolated from the occurrences in Montana. The nearest known occurrence in Montana, in Glacier County, is approximately 48 kilometres from the ones in Alberta. However, the distribution of the species is not well described and the USA and Canadian occurrences may actually be nearer to each other than currently documented. Most of Glacier County has not been thoroughly surveyed.

Most evidence indicates that the species occupies a similar ecological niche in both Canada and the USA. However, some herbarium specimens that were collected in Montana, USA, have been located in atypical habitat (see Habitat section) and therefore the possibility that significant races exist remains a possibility.

## Designatable Units

There is a single designatable unit (DU) for Hare-footed Locoweed in Alberta. Eleven of the 12 known occurrences are within an approximately 229 km² square km area. All are within the same COSEWIC Prairie Ecological Area (COSEWIC Secretariat 2007). There is no evidence of discreteness (see **Population Spatial Structure and Variability** and **DISTRIBUTION).**

## Special Significance

*Oxytropis* and *Astragalus* species are commonly named “locoweeds” for their poisonous effect, termed “locoism,” on livestock (Kingsbury 1964; Stegelmeier *et al.* 1999). Symptoms of locoism include hyperactivity, stiffness, head hanging, salivation, seizures, apparent blindness, increasing un-coordination, weakness and, finally, death (Ralphs and Stegelmeier 2011). Many, but not all, species of *Astragalus* and *Oxytropis* contain high concentrations of the indolizidine alkaloid swainsonine, which is responsible for the effects of “locoism” (Ralphs and Stegelmeier 2011). All livestock, but especially horses, are susceptible to the toxic effects, which also cause reproductive abnormalities. Research within the last decade has indicated that the swainsonine is synthesized by the endophytic fungus, *Undifilum oxytropis*, not by the plant (Braun *et al.* 2003; McLain-Romero *et al.* 2004; Pryor *et al.* 2009).

It is likely that the first documented report that *Oxytropis lagopus* caused toxicity was in 1889 (Anderson 1890). Kelsey (1889) wrote that he had been given a plant identified as *O. lagopus* and expressed surprise it was killing horses. Recent research demonstrated that plants of the same species do not necessarily contain equal amounts of the alkaloid and groups of plants even in the same subpopulation will differ substantially (Cook *et al.* 2009).

McClintock (1909, 1910, 1923) made a collection of plant species and recorded the names used by the Siksika (or Blackfeet[1]) peoples. The plant specimens were identified by O.E. Jennings, and deposited in the Carnegie Institute of Pittsburg (McClintock 1909). *Oxytropis lagopus*, identified by Jennings as *Aragallus lagopus,* was named “A-SAT-CHIOT-AKE” by the Siksika (McClintock 1909, 1923). “A-sat-chiot-ake” is translated as “rattle weed” (Johnson 1970, 1987). McClintock (1909, 1923) noted that “some of the flowers are purple, others blue, yellow and white. It grows on gravel bottoms. The Blackfeet chewed it for sore throat [and] also to allay swelling” (Moerman 1998). This information was also recorded by Murphy (1959) but was likely taken directly from McClintock (1909) rather than be an independent observation. The multiple flower colours described by McClintock (1909) suggest that more than one species of *Oxytropis* were used for the same purposes.

## Horticultural uses

*Oxytropis lagopus* is used in the horticultural trade but appears to have a small presence. Seeds can be purchased online (e.g. Alplains 2012) and there is a report of successful cultivation in Saskatchewan (Lee 2012). However, there is no indication that there is sufficient cultivation or interest in transplanting the taxon for genetic dilution or hybridization to be a concern in the areas where Hare-footed Locoweed is native.

[1] 'Black feet', from the word siksinam meaning 'black' and ka derived from oqkatsh, the root or “foot”

## DISTRIBUTION

### Global Range

The species *Oxytropis lagopus* is native and endemic to Wyoming, Montana, and Idaho in the USA, and Alberta, Canada. There are three varieties: *lagopus, atropurpurea,* and *conjugans* (Table 2, Figure 2). Variety *lagopus* is the most widespread and occurs in Montana, Wyoming, and Idaho. Variety *atropurpurea* is less widespread and occurs in Montana, Wyoming, and in the extreme eastern part of Idaho. The report of *Oxytropis lagopus* in South Dakota (USDA, NCRS 2012) is likely erroneous and due to a single specimen of uncertain origin being considered to be *O. lagopus* approximately 60 years ago (Welsh pers. comm. 2012).

**Table 2. Numbers of *Oxytropis lagopus* specimens at USA and Canadian herbaria. The numbers in parentheses represent specimens unique to each herbarium.**

| Province or State, County | Herbarium Acronym | No variety specified | Number of specimens | | |
|---|---|---|---|---|---|
| | | | Variety | | |
| | | | *atropurpurea* | *conjugans* | *lagopus* |
| Alberta, Canada | ALTA | 0 | 0 | 2 (2) | 0 |
| | BRY | 0 | 0 | 4 (2) | 0 |
| | CAFB | 1 (1)[a] | 0 | 0 | 0 |
| | ISC | 0 | 0 | 2 | 0 |
| | LEA | 0 | 0 | 1 | 0 |
| | UAC | 0 | 0 | 11 (11) | 0 |
| Montana, USA | ARIZ | 1 (1) | 0 | 0 | 0 |
| | BRY | 1 (1) | 0 | 4 (3) | 0 |
| | DAO | 8 (4) | 0 | 0 | 1 |
| | ID | 2 (2) | 1 (1) | 0 | 5 (4) |
| | ISC | 0 | 1 (1) | 2 (2) | 5 (3) |
| | LEA | 0 | 0 | 1 (1) | 0 |
| | MONT | 87 (79) | 2 (2) | 2 (1) | 1 |
| | MONTU | 25 (23) | 2 | 23 (21) | 36 (32) |
| | NY | 20 (14) | 1 | 14 (11)[b] | 21 (17)[c] |
| | RM | 35 (31) | 7 (5) | 0 | 24 (20) |
| | WTU | 16 (7) | 1 | 5 (4) | 2 (92) |
| | PH | 1 (1) | 0 | 0 | 0 |

| Province or State, County | Herbarium Acronym | No variety specified | Number of specimens | | |
|---|---|---|---|---|---|
| | | | Variety | | |
| | | | *atropurpurea* | *conjugans* | *lagopus* |
| | SJNM | 0 | 0 | 1 | 0 |
| Idaho, USA | BRY | 0 | 2 | 0 | 0 |
| | DAO | 0 | 0 | 0 | 1 |
| | ID | 1 (1) | 0 | 0 | 25 (21) |
| | ISC | 0 | 0 | 1 (1) | 1 |
| | MONT | 1 (1) | 0 | 0 | 1 (1) |
| | NY | 7 (7) | 0 | 0 | 19 (14) |
| | RM | 0 | 9 (6) | 0 | 1 (1) |
| | WS | 0 | 0 | 0 | 2 (1) |
| | WTU | 0 | 0 | 0 | 2 |
| | WWB | 0 | 0 | 0 | 1 (1) |
| Wyoming, USA | AC | 1 (1) | 0 | 0 | 0 |
| | ARIZ | 0 | 2 | 0 | 0 |
| | BRY | 0 | 13 (5) | 0 | 0 |
| | CS | 0 | 1 | 0 | 0 |
| | DAO | 9 (7) | 6 (4)[d] | 0 | 5 (4) |
| | ID | 0 | 2 | 0 | 2 |
| | ISC | 0 | 8 (5)[d] | 0 | 2 (2) |
| | NY | 17 (15) | 45 (30)[d] | 0 | 5 (4)[c] |
| | PH | 2 (1) | 0 | 0 | 0 |
| | SJNM | 0 | 1 | 0 | 0 |
| | RM | 9 (9) | 134 (116) | 0 | 66 (61) |
| | UTC | 0 | 0 | 0 | 2 |
| | WTU | 1 (1) | 0 | 0 | 0 |

[a] Although not on the specimen sheet this variety is known to be var. *conjugans*

[b] isotype

[c] Additional three (3) specimens var. *lagopus* collected in 1800s with no reported state at NY; from description of area it is likely one is from WY and two are from Montana

[d] NY, DAO have specimens with no identified variety but specimen with same collector/collection number has been identified as var. *atropurpurea* at ISC.

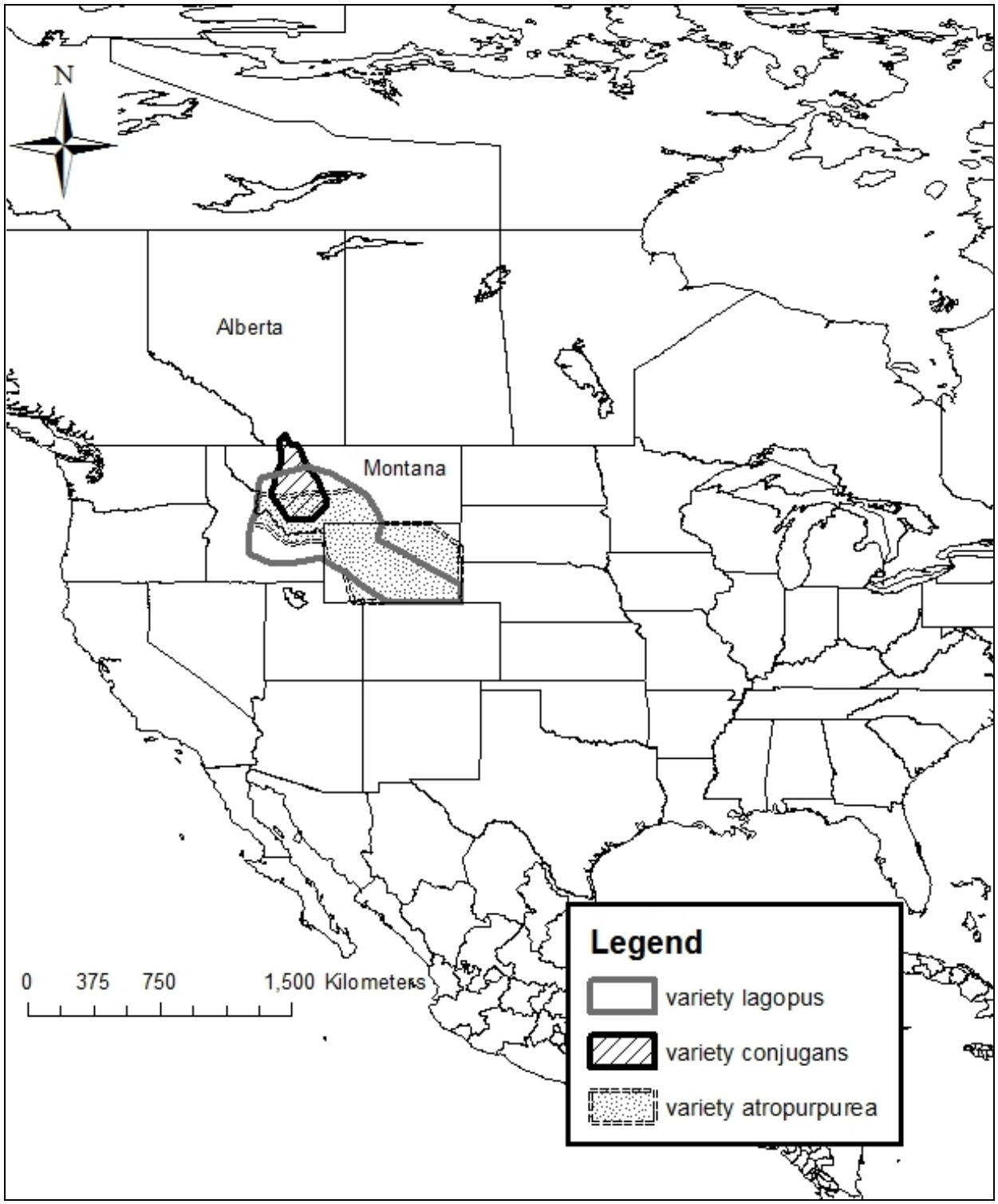


Figure 2. Distribution of the three varieties of *Oxytropis lagopus*, based on herbarium specimens at herbaria listed in Table 2 (**Global Range** section).

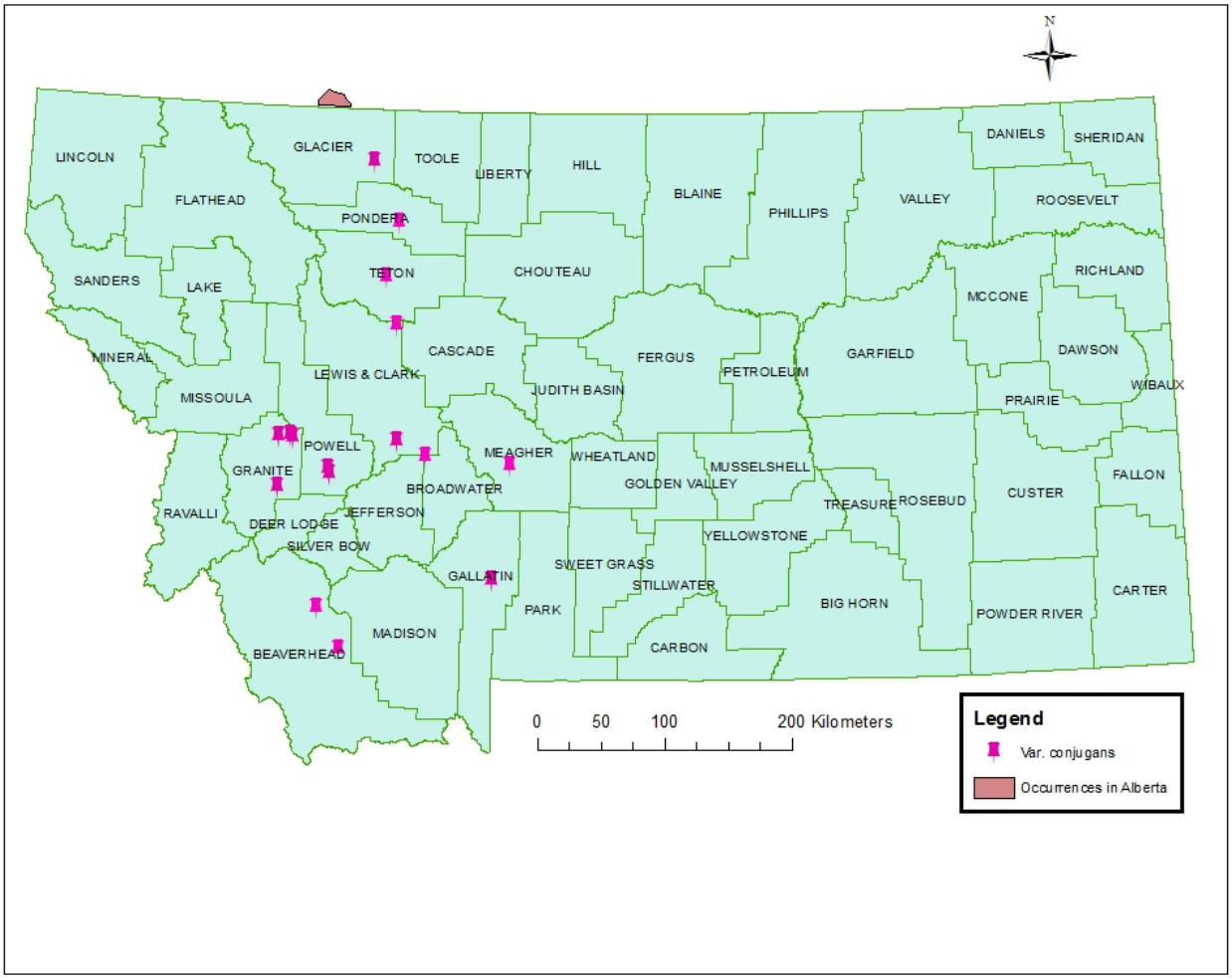


Figure 3. *Oxytropis lagopus* var. *conjugans* distribution in Montana, USA. This distribution is based upon herbarium specimens. The location of the occurrences in Alberta is marked to scale.

Hare-footed Locoweed occurs in southern Alberta and the adjacent state of Montana, USA (ACIMS 2012; USDA NRCS 2012). Occurrences extend from approximately 14 km (historically 20 km) north of the Alberta-Montana border and approximately 425 km south of the Alberta-Montana border. The entire known range is approximately 48,000 square km (Figures 2, 3). Of that area only a small fraction has suitable habitat for the taxon (see **Habitat**).

It is unknown whether all, or any, of the listed occurrences in Montana are still extant. No collections from Montana appear to have been deposited in herbaria within the last decade. Whether this is a consequence of the general decline in plant collecting during the last two decades (Prather *et al.* 2004) or indicative of an increase in the rarity of var. *conjugans* cannot be evaluated.

## Canadian Range

Of the three varieties of *Oxytropis lagopus*, only variety *conjugans* occurs in Canada, where it is restricted to the southern part of Alberta within about 14 km from the Canadian-USA border (Figure 4). Even though the area where it occurs is relatively small these occurrences represent a proportionally large number of the global sites known to be extant.

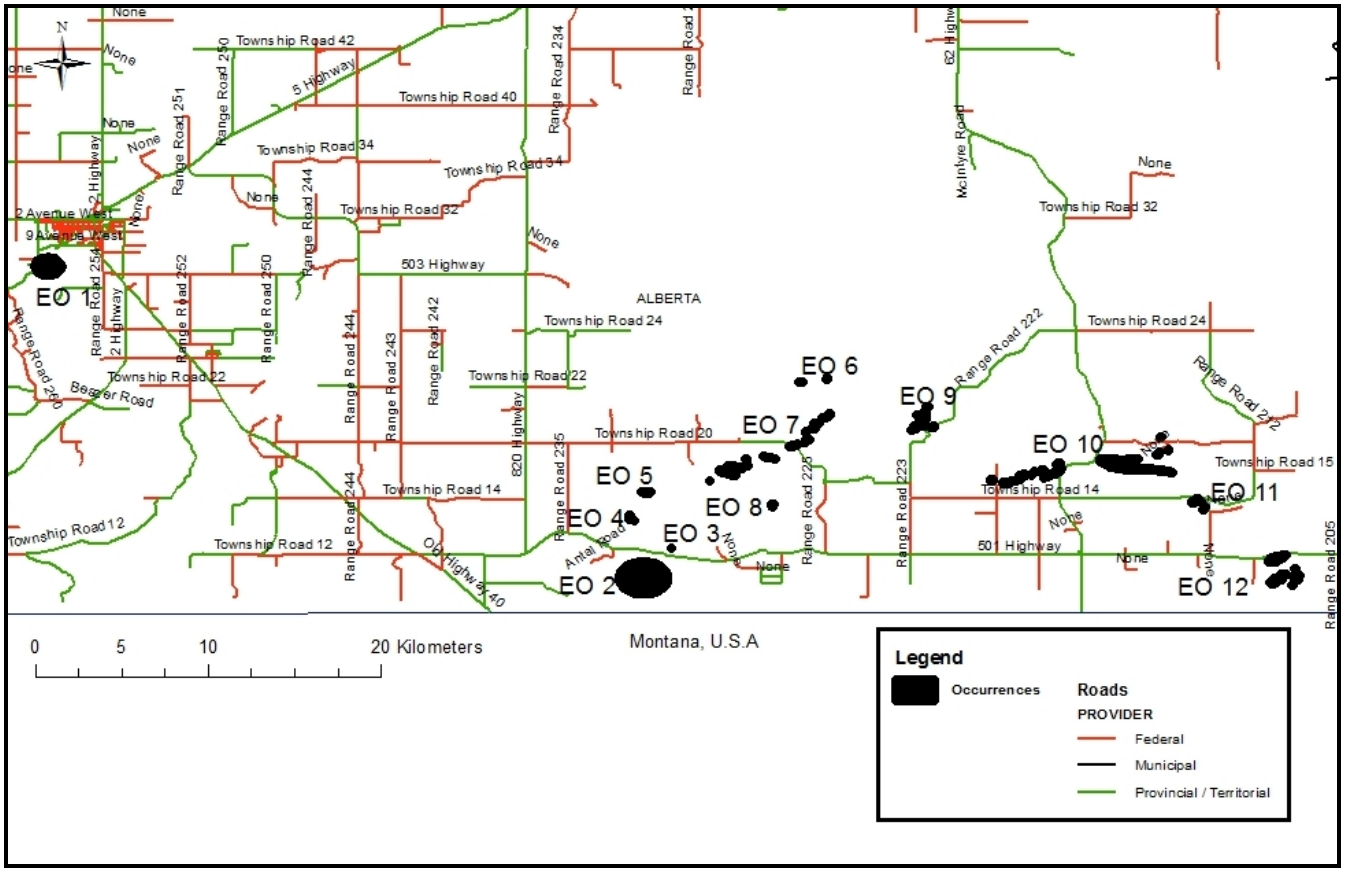


Figure 4. Occurrences of Hare-footed Locoweed in Alberta, Canada (ACIMS 2012). NOTE EO1 is extirpated and EO numbers correspond with Table 5.

There are a total of 12 Hare-footed Locoweed occurrences in southern Alberta (ACIMS 2012; Table 3). Ten of the 12 occurrences (Map EOs 3-12 in Table 3) are extant and occur within 14 km of the Canadian-USA border. One occurrence (Map EO 2 in Table 3) needs to be confirmed (ACIMS 2012). Shaw first collected Hare-footed Locoweed in Canada from near Cardston, Alberta in 1958 (Shaw 1966) and from the same general area in 1967 (Table 4). This occurrence just south of Cardston is disjunct from the other known occurrences and apparently has been extirpated (Wallis *et al.* 1986; Smith 1995; Map EO1; Table 4). Gravel extraction, urbanization and road construction may have contributed to the extirpation (Figure 5). Alternatively the

occurrence may have represented introduced plants and the area may not have been suitable for a sustainable subpopulation (Wallis (1987) *in* Smith 1995). However, Smith (1995) observed suitable habitat at the site and noted that plant species commonly associated with Hare-footed Locoweed were present.

**Table 3. Hare-footed Locoweed occurrences in Alberta, Canada (ACIMS 2012).**

| Map EO site | Occurrence | ACIMS Locality codes | Years observed; number of plants | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1st time | 2nd time | 3rd time | 4th time | 5th time | 6th time | 7th time |
| 1 | Cardston | 8874 | 1958; present | 1966; present | 1967; present | 1986; 0 | 1993; 0 | | |
| 2 | Whiskey Gap South | 8875 | 1986; present | 1992; present | | | | | |
| 3 | Whiskey Gap Northeast | 21825 | 2011; 1 | | | | | | |
| 4 | Whiskey Gap North | 21830 | 2011; 341 | | | | | | |
| 5 | Milk River Ridge NCC | 21719 | 2007; 221 | 2011; 838 | | | | | |
| 6 | Ross Lake NA | 21912 (8876, 21823) | 1983; present | 1985; present | 2009; 176 | 2011; ~200 | | | |
| 7 | Milk River Ridge | 21916 (21829, 8877, 16972, 21828, 21827, 8880) | 1986; 500 to 1,000 | 1993; 250 to 300 | 1996; >50 | 1999; present | 2002; present | 2007; 310 | 2011; 2,540 |
| 8 | North Milk River Terrace | 8878 | 1996; >50 | | | | | | |
| 9 | Sandstone Ranch | 8879 | 1986; present | 2010; 162 | 2011; 940 | | | | |
| 10 | Shanks Lake West | 21924 (8884, 21721, 8885, 8881) | 1976; present | 1986; present | 1993; >1,000 | 2001; present | 2011; 10,300 | | |
| 11 | Shanks Lake South | 8882 | 1993; 1,000 | 2011; 820 | | | | | |
| 12 | Del Bonita East | 21933 (8883, 21716) | 1993; ~500 | 2010; 2,060 | 2011; 18,400 | | | | |

**Table 4. Herbarium specimens of Hare-footed Locoweed collected in Alberta, Canada.**

| Institution Code[1] | Collector # Collector Number | Date Collected | Locality |
|---|---|---|---|
| BRY | Keith Shaw # 35 | May 16, 1958 | South slope near town reservoir, Cardston. Alberta |
| BRY, ISC | S.L. Welsh & G. Moore # 5423 | June 19, 1966 | ~ 2 miles southwest of Cardston. |

| Institution Code[1] | Collector # Collector Number | Date Collected | Locality |
|---|---|---|---|
| BRY, LEA, ISC | Keith Shaw # 340 | June 6, 1967 | 2 miles southwest of Cardston. |
| BRY | Keith Shaw # 1251 | May 22, 1972 | East of North Fork of Milk River, Whiskey Gap, SW Alberta |
| UAC | Fred Fodor # 18 | June 1, 1976 | Del Bonita, 3 miles N. of the United States-Canada border. Highway 493. |
| ALTA | Allen, L., P. McIsaac & M. Bailey # s.n. | June 22, 1983 | Ross Lake Natural Area |
| ALTA | Allen, L. & S. Myers # s.n. | May 23, 1985 | Ross Lake Natural Area |
| UAC | Bonnie Smith # 1035 | May 22, 1992 | Ross Community Pasture, northeast of Whiskey Gap, southern Alberta. |
| UAC | Bonnie Smith # s.n. | May 23, 1993 | Area of Shanks Lake and the North Milk River, southern Alberta. |
| UAC | Bonnie Smith # 1077 | May 23, 1993 | Southeast of Shanks Lake and road to Twin Rivers from Del Bonita, southern Alberta. |
| UAC | Bonnie Smith # 1074 | May 23, 1993 | South side of Shanks Lake and junction of roads, northeast of Del Bonita, southern Alberta. |
| UAC | Bonnie Smith # 1107 | May 23, 1993 | South of the crossing of the North Milk River, Highway 62, north of Del Bonita, southern Alberta. |
| UAC | Bonnie Smith # 1060 | May 23, 1993 | Just south of crossing of North Milk River, Highway 62, north of Del Bonita, southern Alberta. |
| UAC | Bonnie Smith # 1078 | May 23, 1993 | Overlooking North Milk River, west of access road to ranch, northwest of Del Bonita, southern Alberta. |
| UAC | Suzanne Visser, Jamey Podlubny, Reg Ernst # s.n. | June 10, 2007 | Nay Ranch, Nature Conservancy of Canada, north of Whiskey Gap, AB |
| UAC | Suzanne Visser, Jamey Podlubny, Reg Ernst # s.n. | June 3, 2007 | Ross Lake Community Pasture north of Whiskey Gap, AB |
| UAC | Suzanne Visser, Jamey Podlubny, Reg Ernst # s.n. | June 3, 2007 | Ross Lake Community Pasture north of Whiskey Gap, AB |
| CAFB[2] | B. Sommerfeldt # s.n. | May 24, 1986 | Sommerfeldt Ranch, Whisky Gap, AB |

[1] ALTA = University of Alberta, Canada

BRY = Brigham Young University, S. L. Welsh Herbarium, USA

CAFB = Natural Resources Canada, Canadian Forest Service, Canada

ISC = Iowa State University Herbarium, USA

LEA = University of Lethbridge Herbarium, Canada

UAC = University of Calgary Herbarium, Canada

[2]Four (4) specimens on a sheet Identified as "*O. lagopus*" by J. Derek Johnson

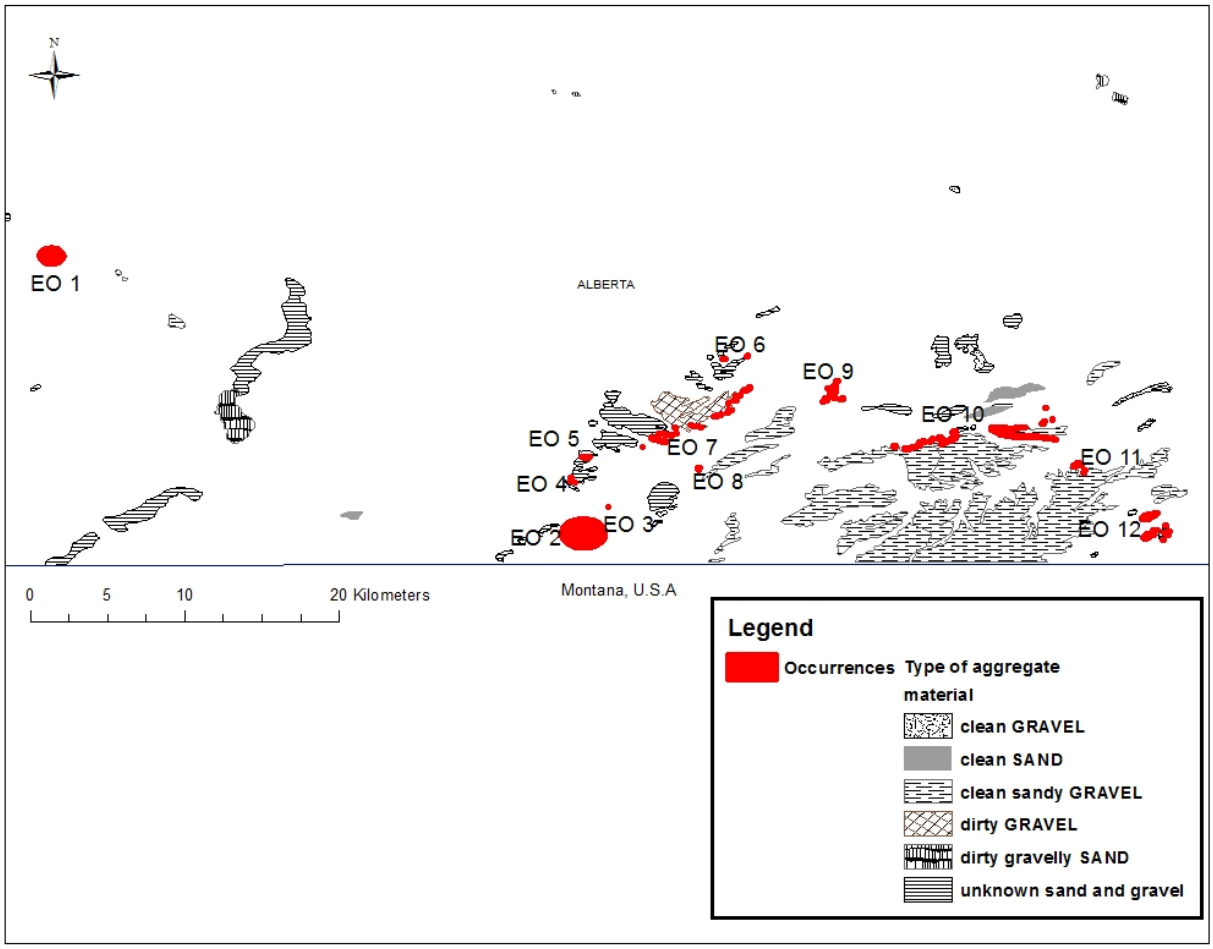


Figure 5. Location of Hare-footed Locoweed occurrences in relation to the aggregate resources in southern Alberta (base map from Alberta Geological Survey (2012).

The numbers of specimens in various herbaria of the three varieties were reviewed (see **Collections Examined**). Given the limitations to the herbaria data, it can be concluded that variety *conjugans* is clearly the least collected and most rare of the three varieties. It occurs only within a limited range within Montana and a relatively small area in southern Alberta (Figure 2). There have been no concerted efforts to survey for Hare-footed Locoweed in Montana. The Montana Natural Heritage Program intends to examine the status of *O. lagopus* in more detail in future (Mincemoyer pers. comm. 2012).

## Extent of Occurrence and Index of Area of Occupancy

With the exception of the Cardston subpopulation (Map EO1, Table 3, Figure 4), which is considered to be extirpated, the extent of occurrence (EO) of Hare-footed Locoweed is 229 $km^2$, which is a slight increase since the last status report (Smith 1995) due to the discovery of the subpopulations at Whiskey Gap North and Milk River

Ridge NCC. The plants are variably distributed within the area occupied. Plants may grow in either a patchy, clumped structure or semi-continuously within an occurrence area. However, this perception that a taxon has a variable distribution may be more a factor of scale that actual pattern (Ludwig and Reynolds 1988). No rigorous analyses of pattern have been undertaken for this taxon.

The area of occupancy estimate is based on currently known subpopulations but may be an underestimate because additional surveys may locate more subpopulations. The index of area of occupancy (IAO) is 124 $km^2$ based on a 2 km X 2 km grid (31 grids).

The biological area of occupancy (AOO), which included the areas within the shapefiles provided by ACIMS (2012), is approximately 14 $km^2$. The patches actually occupied by plants were either extremely small or long and narrow. Even some large swaths, for example around a plateau rim, were approximately only 20 m wide. Even this method may overestimate the actual land occupied because areas without plants must have been included in the shapefiles (for example at Map EO2 Figure 4). An AOO of 0.5 $km^2$ has been estimated from field surveys (Bradley pers. comm. 2012).

**Survey Effort**

The most intensive targeted and reconnaissance survey efforts were made in 1993 by Bonnie Smith, before the last COSEWIC status report was prepared, and in 2011 by Cheryl Bradley in preparation for a report for Alberta's Species at Risk Program (Smith 1995; ACIMS 2012; Bradley pers. comm. 2012). Members of Adopt-a-Plant Alberta conducted targeted surveys in 2010 (Adopt-a-Plant Alberta 2010; Marsh 2010; ACIMS 2012). There have been no monitoring surveys.

More survey work is needed to determine the status of an occurrence at Whiskey Gap South (Map EO2, Figure 4; Table 3). Plants were observed there in 1987 and 1992 (Smith 1995; ACIMS 2012). This site was incorrectly mapped in 1992 and when the purported site was visited in 1993, no plants were observed to be there (Smith 1995; ACIMS 2012). However, the original survey area has been clarified to be south of the highway and therefore needs to be resurveyed to confirm the original observations (Bradley pers. comm. 2012).

The numbers of plants counted at each visit are not directly comparable because the method of counting and the area surveyed is different at each time (see Table 3; **Sampling Effort and Methods** section). Therefore, it can only be concluded that the taxon has been persistent at most occurrences but one cannot objectively comment on any trends observed.

## HABITAT

Hare-footed Locoweed is a plant of the prairies (Looman and Best 1987) and grows within the formally designated Prairie Ecological Area in southern Alberta (COSEWIC Secretariat 2007).

Hare-footed Locoweed grows on thin gravelly soils in open grassland at elevations between 1,189 and 1,995 m (3,900 to 6,545 feet) in Alberta (ACIMS 2012). The occurrences are plotted with respect to the soil parent materials in the map in Figure 6. Although most of the occurrence sites are unglaciated there is a not a strong association with any one surface type on the map. Gravels are reported to be at every occurrence site. Bradley (pers. comm. 2012) describes that the gravels are often associated with traces of calcium carbonate deposits.

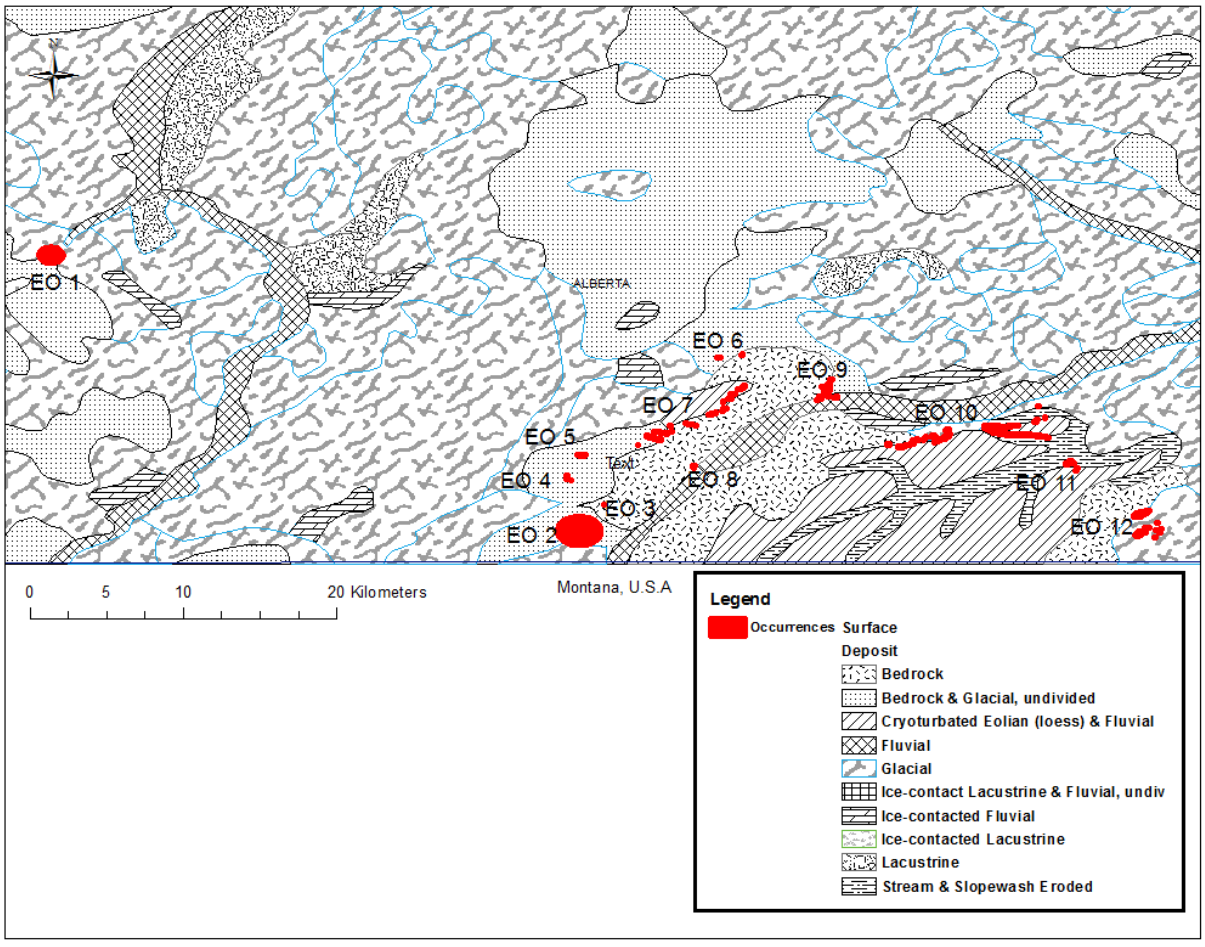


Figure 6. Map of occurrences in relation to the soil parent materials.

ACIMS (2012) has reported Hare-footed Locoweed occurrences in the Foothills Fescue Grasslands Natural Subregion. Some of the easternmost occurrences are in the transition zone between the Foothills Fescue and Mixedgrass Grasslands Natural Subregions but are still likely best considered in the Foothills Fescue zone. The Foothills Fescue Natural Subregion is one of the moistest of the four Natural Subregions that make up the Grassland Natural Region (Bailey *et al.* 2010). Only Tallgrass prairie is more moist (Bailey *et al.* 2010 ). Foothills Fescue grasslands are commonly defined by Orthic Black Chernozemic soils (Adams *et al.* 2004; Adams *et al.* 2005; Bailey *et al.* 2010). However, there are additional soil types and regosols underlie grasslands where there is less soil development due to high levels of sandy gravels (Bailey *et al* 2010). Such soils are in the area occupied by Hare-footed Locoweed.

The most commonly reported associates of Hare-footed Locoweed are fescue grasses (*Festuca* spp.). Native rough fescue grassland communities (composed of Foothills (*Festuca campestris*) and Plains (*F. hallii*) rough fescue) are themselves becoming rarer and are considered a high priority for conservation efforts (Rumsey *et al.* 2003; Bradley 2008a; Nature Conservancy Canada 2012). The largest remaining tracts of Foothills Fescue Grassland exist in Alberta but only approximately 17 percent of the original Alberta Foothills Fescue remains (Adams *et al.* 2005; Nature Conservancy Canada 2012).

Smith (1995) noted that certain species typically co-occurred with Hare-footed Locoweed. For example, Pasture Sage (*Artemisia frigida*), Blue Phlox (*Phlox alyssifolia*), Hood's Phlox (*Phlox hoodii*), and Butte Marigold (*Tetraneuris acaulis*) were invariably found at occurrence sites. It is not known if there is an association between any of the co-occurring species (Appendix 2) or whether they just occur together because they favour the same habitat conditions.

Where aspect has been reported (ACIMS 2012), Hare-footed Locoweed plants have been most often observed on west, south, and southwest-facing slopes, suggesting that they can tolerate full sun and may be intolerant to shading. Individuals with north, east and north-west aspects have also been reported. With the data available it is not possible to relate abundance of plants to the aspect. Moisture and soil conditions are likely more important in defining habitat. Smith (1995) has reported that plants in the Ross Community Pasture occurrence were less common on southwest-facing rims where the exposure is drier. However, grazing was also heavier there, confounding the interpretation of the environmental effects (Smith 1995). The slopes on which plants grow range from negligible up to approximately 35 percent (19.5º) slope (ACIMS 2012).

A notable characteristic of the habitat descriptions at many of the occurrence sites is the almost continuous cover of microbiotic crust (primarily lichens) and Dense Spikemoss (*Selaginella densa*). At many occurrences, cover of this biotic community ranged between 70 to 95 percent and gravels between 5 to 30 percent of the ground cover. There is little litter accumulation at most sites (Bradley pers. comm. 2012).

In Montana, var. *conjugans* occurrences were frequently on dry ridges or slopes with southerly exposures. They were most frequently found in gravel or sandy soils in grassland in habitat similar to that described in Alberta (22 of the 29 herbarium sheets where habitat was noted).

However, the brief habitat descriptions associated with the herbarium specimen labels suggest that var. *conjugans* grows in a slightly wider range of habitat types in Montana than in Canada. In addition to gravelly soils, the association with limestone was notable (6 of 30 occurrences where habitat was reported). In three cases the taxon was growing with trees, Ponderosa (*Pinus ponderosa*) or Limber pines (*P. flexilis*) (19, 25, 43 in Appendix 1). At one occurrence (25, Appendix 1) it was noted that plants were found under trees only in what was described as a "*Pinus ponderosa, Artemisia tridentata* (Big Sagebrush) grassland." These uncommon forested habitats are more similar to the typical habitat for var. *atropurpurea*.

**Habitat Requirements**

Gravel soils have been noted at every occurrence in Canada and most occurrences in Montana. Alberta Geological Survey (2012) mapped areas with potential for commercial sand and gravel resources (Figure 5). Soils high in gravels typically have a low vegetation cover because they are mineral- and plant nutrient-poor and have low water retention properties. Hare-footed Locoweed plants have been found within a relatively narrow (approximately 10 to 20 m wide) strip centred on the plateau rims. The vegetation above and below this strip tends to be more dense and lush than within the strip (Smith 1995).

These observations and the obvious low productivity of the habitat to which Hare-footed Locoweed is adapted suggest the taxon is unlikely to be competitive with other plants. Alternatively, or in addition, seed germination or seedling development may require bare soils.

The presence of a cover of Dense Spikemoss and lichens may be significant. Studies on the interactions between microbiotic crusts and higher plants have not been extensive but there are at least two interesting examples of a positive relationship between biotic crusts and endemic plant species in the United States. *Agropyron-Festuca* grasslands are one of the habitats of Montana's regional endemic Mt. Sapphire Rock-cress (*Boechera fecunda*). Even in areas not subject to trampling, *B. fecunda* was found to be more abundant in microbiotic-covered areas (Lesica and Shelly 1992). Studies designed to determine the habitat requirements of the USA federally listed Dwarf Bear-claw Poppy (*Arctomecon humilis*) showed that a soil-surface cryptogam community contributed 84 percent or more of the total living cover on sites that supported the poppy (Nelson and Harper 1991). The interactions may be complex because microbiotic crusts may affect the nutritional composition and microclimate of a site (Ladyman and Muldavin 1996).

Gravels are associated with calcium carbonate at some of the occurrence sites in Canada (Bradley 2012). These observations, along with reports that plants are growing on limestone at several sites in Montana, suggest that the presence of calcium carbonate may be significant in defining potential habitat for Hare-footed Locoweed and needs to be examined further.

The importance of elevation and slope was discussed in Smith (1995). In the field, observations were made that plants were not found on low ridges with gentle slopes (Smith 1995).

### Habitat Trends

The habitat for this species appears to be limited by soil type. There is a substantial portion of the area within which Hare-footed Locoweed grows that has not been surveyed. One approach to prioritizing the areas for future survey would be to examine areas with respect to their potential for commercial aggregate material (Figure 5).

Habitat has been clearly lost due to anthropogenic activities (see **Threats**). However, the extent of the loss cannot be estimated given that the precise habitat requirements are not known. There are also indications that invasive species, especially Crested Wheat Grass (*Agropyron cristatum*), are an ongoing factor in adverse habitat modification.

## BIOLOGY

The biology of this species comes from published accounts of the species (Smith 1995; Welsh 2001) and observations made in the element occurrence reports (ACIMS 2012). Because information on Hare-footed Locoweed is scant some observations on other species of *Oxytropis* and *Astragalus* are discussed for comparative purposes.

### Life Cycle and Reproduction

Hare-footed Locoweed is a perennial plant. No detailed studies have been made on the reproductive biology of this species. Peak flowering occurred in the last two weeks in May and in the first week of June in 2010 and 2011 (ACIMS 2012). Approximately 75 to 80 percent of plants were in flower between May 28 and June 4. Flowers were in bud around May 17 and had maturing pods by June 14th (ACIMS 2012). In previous years, it has been reported that flowering peaked in late April and early May (Smith 1995). Herbarium samples from Montana indicate that plants can have flowers from April 10th to as late in the year as July 31st although plants mostly only had fruits after mid-June (data not presented). It is not documented as to how many plants remain vegetative in any given year.

Considering other *Oxytropis* species, Hare-footed Locoweed is likely to be primarily a cross-pollinating species or "outcrosser." Therefore seed set relies on available pollen from neighbouring plants along with adequate pollinator activity. The primary pollinators are likely to be bees because Hare-footed Locoweed have typical papilionaceous flowers (Kalin-Arroyo 1981). Specific pollinators may be bumblebees (*Bombus* spp.) because they have been observed to pollinate other *Oxytropis* species (Kožuharova *et al.* 2012). Insect collections and exclosure studies indicated that Field Locoweed (*Oxytropis campestris*) is highly reliant on long-tongued bumblebee pollinators (Bauer 1983). Flower abundance, both of Hare-footed Locoweed and associated species, may influence successful seed set (Geer and Tepedino 1993).

If bumblebees are pollinators, cross-pollination among subpopulations may be frequent. Osborne *et al.* (1999) tracked individual bumblebees using harmonic radar and recorded that most bees regularly fly over 200 m (range 70 to 631 m) from the nest to forage even when apparently plentiful food was available. Honeybees (*Apis mellifera*) apparently can regularly forage 2 km away from their hive (Ramsey *et al.* 1999).

Physical seed dormancy occurs in some *Oxytropis* species and scarification has been needed for germination (Baskin and Baskin 2001). The optimal temperature for germination was 20-22$^{o}$C depending upon species. There is no information as to the size of the seed bank or the longevity of viable seed in the field.

*Astragalus* and *Oxytropis* are closely related genera. Some *Astragalus* spp., which have similar life strategies to *O. lagopus*, exhibit prolonged dormancy of the rootstock (Lesica and Steele 1994; Van Buren and Harper 2003; US Fish and Wildlife Service 2006). It is unknown if Hare-footed Locoweed behaves similarly but that would explain annual fluctuating numbers of mature plants. Lesica and Steele (1994) discussed the monitoring implications of prolonged dormancy in vascular plants. They concluded that establishing permanent monitoring plots with repeated measure analysis was likely to be the most effective way to monitor changes in population density (Lesica and Steele 1994). Demographic monitoring studies of species with prolonged dormancy require longer periods of time to obtain useful information as compared to studies of species that do not have an organ of prolonged dormancy (Lesica and Steele 1994).

The life span and mortality rates of individual Hare-footed Locoweed plants are not known. More research has been conducted on *Astragalus* species life cycles than those of *Oxytropis* species. Bitterroot Milk-vetch (*Astragalus scaphoides*) and Sentry Milk-vetch (*A. cremnophylax* var. *cremnophylax)* are herbaceous perennials that grow in somewhat similar habitats to Hare-footed Locoweed. Sentry milk-vetch grows in rock, rather than gravels, but has a similarly low-vegetation, dry habitat. Using size- and stage-structured population matrix models, estimates of life span for both *Astragalu*s species are approximately 21 years (Ehrlén and Lehtilä 2002). From field observations, Lesica (1995) reported that individual Bitterroot Milk-vetch plants lived for 10 years or longer. He also observed 50 percent mortality occurring within in the first 3 to 4 years after germination but that most individuals past 4 years of age went on to be long-lived (Lesica 1995). Another *Astragalus* species, Tygh Valley Milk-vetch (*A. tyghensis)*, that

grows in dry, sandy, rocky soils in shrub-communities has an estimated average life span of over 12 years (García *et al.* 2008). It is thought therefore that 10 years is a reasonable minimum generation time.

### Physiology and Adaptability

Flowering and fruiting early in the year is likely to be an adaption to the stressful environment of Hare-footed Locoweed. By completing seed set before summer, plants take advantage of early season moisture. The disadvantage of this strategy is that there is only a limited time in which to complete flowering and pod fill and that an inclement spring may lead to poor reproductive success in any given year. It may be strategically important to sustainability that high numbers of plants flower and set seed in a good year. This may compensate for low seed set, for whatever reason, in a poor year. The observation from an older herbarium specimen in Montana that showed a plant was in flower at the end of July hints that the taxon may be able to capitalize on late precipitation. However, the elevation of this occurrence was not given (Appendix 1). The longevity and dormancy requirement of Hare-footed Locoweed's seed in the seed bank is not known.

### Dispersal and Migration

The typically clustered pattern of individual plants suggests that seed pods and seeds remain near the parent plant and dispersal is primarily done by gravity (Smith 1995). However, winds are prevalent in the area of Alberta where it grows. The pods are particularly hairy, some have called them "shaggy," and may catch the wind. Therefore wind-facilitated dispersal of the pods may also occur. Ground squirrel predation has been observed (ACIMS 2012) so possibly ground squirrels also move seeds or seed pods away from the parent plant. Seed dispersal distances are not known.

### Interspecific Interactions

No research on the association between Hare-footed Locoweed and the nitrogen-fixing bacteria, rhizobia, has been made. However, a symbiosis is likely because nodulation has been documented for many other *Oxytropis* species (Allen and Allen 1981; Laguerre *et al.* 1997). Research within the last decade has indicated that an endophytic fungus, *Undifilum oxytropis*, is associated with some *Oxytropis* species (Braun *et al.* 2003; see **Special Significance** section).

In 1999, Reg Ernst reported heavy flower predation of Hare-footed Locoweed with only a few plants producing pods and those were at the edge of main population (ACIMS 2012). The predator insect was not identified. However, substantial seed predation is common amongst other *Oxytropis* species. During a study of Cotton's Milk-vetch (*Astragalus australis* var. *olympicus*), Kaye (1999) reported a weevil (*Tychius* sp.), was common on buds, flowers, and immature fruits of not only his species of interest but also on Field Locoweed and Boreal Locoweed (*O. boreale*). The weevil larvae

apparently pupate in the soil beneath the host plants because all reared adults were found in small rock cases in the gravel, not in the fruits. Weevil larvae were found in fruits of both species of *Oxytropis* spp. and Cotton's Milk-vetch, but not in any other adjacent legumes, suggesting that the weevil may be somewhat host-specific (Kaye 1999). The observed irregular seed production by Boreal Locoweed may also be partly due to insect predation (McKendrick 2000). Although considered likely to be partly due to variable weather conditions, McKendrick (2000) observed heavy seed predation caused by wasps laying their eggs within the flowers.

Rodent seed predation could also be a factor in reproductive success. A management comment was made that the potential for ground squirrel predation on the plants at Map EO7 (Figure 4) is unclear and needs assessment (ACIMS 2012). Ground squirrels (no zoological name reported) have been reported to eat *Oxytropis* flowers and contribute to irregular seed production (McKendrick 2000). It is not known if swainsonine causes the symptoms of "locoism" in squirrels but the chemical is toxic to rodents (McLain-Romero *et al.* 2004).

Pollination is likely by bees (see **Life Cycle and Reproduction** section). In a pollination study of several alpine species, Field Locoweed attracted bees with long tongues (Bauer 1983). However, that may have been a general function of having long-tubed flowers rather than species specificity per se (Bauer 1983).

Hare-footed Locoweed is likely pollinated by bumblebees (see **Life Cycle and Reproduction**). Therefore, any reduction in pollinator abundance and/or activity may be detrimental to successful seed set. Pesticide applications and any actions that locally reduce the pollinator bee populations are a potential threat. Because specific pollinator species are not known, the importance of pollinator species assemblage is also unknown.

In addition to the presence of adequate pollinators, any changes to climate that would cause asynchrony between flowering time and pollinator activity would impact seed set. Bees are density dependent foragers and will avoid areas where the reward (i.e. flowers) is potentially low (Heinrich 1976; Geer and Tepedino 1993). This may be a potential concern for Hare-footed Locoweed plants growing in small patches because their habitat has generally low vegetation cover.

An association between a Dense Spikemoss-lichen ground cover and Hare-footed Locoweed plants has been observed (ACIMS 2012; see **Habitat** section). This association may be a function of all the species sharing similar habitat requirements. On the other hand the cryptogamic community may influence the habitat and create suitable habitat conditions for Hare-footed Locoweed. For example, microbiotic crusts composed of lichens associated with cyanobacteria would fix nitrogen, thus increasing available nitrogen in the soil, and also be darker in colour than bare soil (Ladyman and Muldavin 1996). The latter characteristic would raise soil temperatures, which may increase the germination rate or timing of seedling emergence (Harper and Pendleton 1993). In addition, such a biotic crust may trap snow for potential snowmelt infiltration.

This function of vegetation is critical to soil water recharge in the fescue grasslands in Alberta (Naeth and Chanasyk 1995). Areas where spikemoss-lichen cover exists will have greater soil moisture for Hare-footed Locoweed in the spring. The spikemoss-lichen cover would also be likely to slow sheet run-off and lessen water loss after a rain storm (Ladyman and Muldavin 1996).

## POPULATION SIZES AND TRENDS

COSEWIC (2011) defines a population as being the total number of individuals in Canada. Therefore, in this report, a subpopulation can be generally ascribed to an occurrence as proposed by the Alberta Conservation Information Management System (ACIMS). Subpopulations are defined as "geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less) (COSEWIC 2011).

A delineation of Hare-footed Locoweed occurrences proposed by the ACIMS (ACIMS element occurrence records 2012) uses Natural Heritage Methodology in delimiting element occurrences (ACIMS 2012). In this method of habitat-based element occurrence delimitation (NatureServe 2004), one occurrence includes all patches (source features) of plants that are less than 1 km apart (NatureServe 2004). If plant occurrences are greater than 10 km apart they are automatically considered separate occurrences. If sub-occurrences are between 1 km and 10 km, the suitability of the habitat for occupation is evaluated and, depending on whether there is continuous suitable habitat or not, they may be grouped under one occurrence or considered separate. For example there are six sub-occurrences associated with Map EO7 (Table 3; Figure 4).

There are ten subpopulations confirmed to be currently extant in southern Alberta (ACIMS 2012; Table 3). One subpopulation (Map EO 2) needs to be confirmed. The number of individuals in an occurrence varies widely; from one individual on an isolated plateau (Map EO3) to an estimate of more than eighteen thousand (18,400) distributed across several small hills (Map EO12).

The reported spatial pattern is variable. Isolated patches and semi-continuous distribution of plants, or "clumps," over several hundred metres of valley rim have both been described. "Clumps," which may comprise one or more individual plants, may be approximately 1 $dm^2$ to 0.25 $m^2$. The number of stems and number of plants is not always clearly differentiated in the observations on occurrences (ACIMS 2012).

The variability in density can be described by considering the ranges reported. Where numbers per area were reported, the range was 0.02 plants per $m^2$ to 13 plants per $m^2$. On the other hand, these data may be better visualized as one plant per 44.7 $m^2$ to one plant per 0.1 $m^2$. Most commonly the spacing was approximately 0.2 plants per $m^2$ or 1 per 5 $m^2$.

Individuals within an occurrence or subpopulation may interact through pollination. Sub-occurrences that comprise a subpopulation may interact either through pollination or seed dispersal and, unless precluded by complete autogamy or apomixis, are likely to share a relatively recent common ancestor (Frankel *et al.* 1995). Currently there is insufficient information on the biology of Hare-footed Locoweed and an absence of field survey data to make an accurate delineation of sub-occurrences based on interactions between plants or their genetic isolation.

The widely distributed, patchy pattern of small “clumps” across the landscape or the long but narrow strips at the edge of the plateaus suggests that colonies may be limited by habitat. However, Harper (1977) suggested several other reasons why sub-occurrences may be small and, although speculative, they may apply to Hare-footed Locoweed. The carrying capacity of the site may be low; the available sites suitable for the taxon may be few and/or separated by distances beyond the species’ normal dispersal ability. The habitability of the site may be of short duration because of successional displacement, or colonization is in its early stages and full exploitation of the site has not yet occurred. In the case of Hare-footed Locoweed, the low carrying capacity of the habitat may contribute to the observed patterns. There is insufficient information to evaluate the possibility that community succession is occurring.

In 1993, Smith counted 500 plants on a hill at Del Bonita East but estimated that the set of low hills there “contain in the low thousands of plants”‘ (Smith 1993). She indicated that it had the highest concentration of plants found in Alberta and should be designated as the primary site for protection in order ensure the species survival in Canada. This suggestion appeared to be equally true in 2011 when it was estimated that there were approximately 18,400 plants there (ACIMS 2012).

**Sampling Effort and Methods**

Both ‘reconnaissance’ and ‘targeted’ surveys have been made for Hare-footed Locoweed but monitoring surveys have not been conducted. Recent surveys have aimed to expand the areas that have been surveyed in the area where the species is known to occur. Intensive searches in several existing and potential occurrence areas were made in 1993 by Bonnie Smith (Smith 1995), in 2010 by Adopt-a-Plant Alberta survey teams (Adopt-a-Plant Alberta 2012), and by Cheryl Bradley and others in 2011 (ACIMS 2012).

In 2007, the Milk River Ridge, which includes the Nay Ranch (a Nature Conservancy of Canada (NCC) property), was surveyed by about two dozen botanists from the Alberta Native Plant Council’s “Botany Alberta,” Adopt-a-Plant Alberta, and the NCC (Bradley 2008b). Hare-footed Locoweed was one of the target species.

The numbers of individuals per site are estimates with no associated measures of accuracy. Counting procedures have not been consistent either between or even within years amongst the various survey teams. Four basic methods have been described:

(1) Presence or absence.

(2) Individuals have been reported as counts within a qualitative area ("per patch"). For example at Map EO7 "310 plants were counted in 11 areas" in 2007 and "3,540 plants were counted in 9 patches" in 2011.

(3) Plants have been estimated within a given area. For example "820 plants occupying 11,460 $m^2$ (estimate)" at Map EO11.

(4) Plants have been counted along a transect line of defined length and width and the number of plants and the occupied area estimated accordingly. For example, "surveyed 4,500 $m^2$ and estimated 970 plants (based on 2 m x 80 m transect through patch)."

Further survey is needed to fully describe the numbers of plants and areas they occupy. However, there is no information as to the natural range of variability between years. What appears to be a decline or increase in numbers of individuals between years may be natural variation due to environmental or other, unknown, factors. Establishing long-term permanent monitoring plots (or transects) would be very valuable in clarifying the demographics of the taxon and also in clarifying population trends.

It should be noted that Hare-footed Locoweed plants are not always found in areas defined as potential habitat (see **Habitat** section). Considerable areas of 'potential habitat' have been surveyed without finding plants and several kilometres between individuals or patches of plants is not uncommon. The reasons for the patchy distribution are not known. Patches frequently include fewer than a dozen individuals. Only one solitary individual was found on one plateau (Map EO3, Figure 4; ACIMS 2012) but so few plants in such a large area appears to be unusual. On the other hand it may be argued that the habitat is very specific and that in those cases where habitat is available, it is generally filled. For example, the long but narrow strips at the edge of the plateaus may represent all available suitable habitat and plants cannot extend past the narrow strip (see **Population sizes and Trends** section).

**Abundance**

An estimate of the total number of Hare-footed Locoweed plants over all occurrences in 2011 was more than 35,000. Not all the known occurrences or potential habitat were surveyed so it is likely that this number is a conservative estimate.

The numbers of flowering and vegetative plants at occurrences have frequently been described but information on recruitment is lacking. In general, counts of plants are made without indicating reproductive status. At one sub-occurrence, in 1998, the composition was described as “2000 adult; 600 juvenile; 100 other.” “Other” may have been senescent plants and the criteria for a “juvenile” were not described (ACMIS 2012). Based on this, the ratio of the number of “mature individuals” as defined by COSEWIC (2007) to “juvenile individuals” is approximately 3:1. Applying this result to the Canadian estimate of 35,000 total individuals, the number of mature individuals can be calculated as 26,250. The 3:1 ratio was derived for only one sub-occurrence in a single year and assumes ongoing recruitment. The true ratio would vary among years and occurrences.

### Fluctuations and Trends

The data available indicate that whereas Hare-footed Locoweed has been extirpated from one area (Map EO1; see **Extent of Occurrence and Area of Occupancy**) plants have persisted at most of the remaining sites, although not necessarily at each sub-occurrence. For example, plants were found in 2009 but not in 2011 at a sub-occurrence of Map EO6 (Figure 4; ACIMS 2012). At many of the Hare-footed Locoweed sites, the survey area has been expanded in subsequent surveys and so the total numbers of plants found cannot be directly compared to previous observations. There are indications within the available data and anecdotal observations that the numbers of plants at a given occurrence fluctuate but the extent of the fluctuations is not clear. For example, Ernst noted that there appeared to be substantially fewer plants at a sub-occurrence of Map EO7 in 2002 than “when he was there previously” (ACIMS 2012). No abundance trends can be inferred from current data.

### Rescue Effect

The nearest known population outside Canada is approximately 48 km to the south. Given that seed dispersal for Hare-footed Locoweed is unlikely over long distances, and the US populations are subjected to many of the same threats as those in Canada, unassisted rescue from the US is also unlikely.

## THREATS AND LIMITING FACTORS

Threats may be divided into those that are of anthropogenic, biological and environmental origin (Table 5). The greatest threat to sustainability of the taxon is habitat loss and fragmentation.

**Table 5. Threats and potential threats at each occurrence (ACIMS data 2012; Bradley, 2012 ).**

| Map EO number | Occurrence | ACIMS locality codes | Ownership | Threats |
|---|---|---|---|---|
| 1 | Cardston (extirpated) | 8874 | Private land | Mining and quarrying (gravel extraction), urban development, vehicle access |
| 2 | Whiskey Gap South | 8875 | Private and Public land | Livestock farming and ranching; site used as winter range for cattle. |
| 3 | Whiskey Gap Northeast | 21825 | Private | Livestock farming and ranching. |
| 4 | Whiskey Gap North | 21830 | Private | Mining and quarrying (gravel extraction), cultivation, vehicle access, livestock farming and ranching, invasive non-native species especially Crested Wheat Grass. |
| 5 | Milk River Ridge NCC | 21719 | Land Trust property | Livestock farming and ranching. (Low threat risk due to management guidelines). |
| 7 | Milk River Ridge | 21916 (21829, 8877, 16972, 21828, 21827, 8880) | Provincial protected area and land trust properties, private land | Mining and quarrying (gravel extraction), oil and gas development, cultivation, vehicle access, Livestock farming and ranching, invasive non-native species especially Crested Wheat Grass. (Threat risk varies according to management.) |
| 6 | Ross Lake NA | 21912 (8876, 21823) | Provincial protected area | Livestock farming and ranching. (Low threat risk due to management guidelines). |
| 8 | North Milk River Terrace | 8878 | Land trust property | Livestock farming and ranching. (Low threat risk due to management guidelines). |
| 9 | Sandstone Ranch | 8879 | Land trust property | Oil and gas development (a gas well and access route occur in *Oxytropis* habitat), vehicle access, livestock farming and ranching, invasive non-native species especially Crested Wheat Grass. |
| 10 | Shanks Lake West | 21924 (8884, 21721, 8885, 8881) | Private and public land | Mining and quarrying (gravel extraction) cultivation, urban development, vehicle access, livestock farming and ranching, invasive non-native species especially Crested Wheat Grass. |
| 11 | Shanks Lake South | 8882 | Private and public land | Cultivation, vehicle access, livestock farming and ranching, invasive non-native species. |

| Map EO number | Occurrence | ACIMS locality codes | Ownership | Threats |
|---|---|---|---|---|
| 12 | Del Bonita East | 21933 (8883, 21716) | Private and public land | Livestock farming and ranching. |

Threats include invasive plants, resource extraction, conversion of prairie to cultivated land and urbanization. Over-grazing as some sites may also be affecting some subpopulations.

### Invasive Alien Plant Species

The competitive ability of Hare-footed Locoweed is likely low considering both the habitat to which it is adapted and the spatial patterns exhibited by individual plants. Therefore, invasive alien plants are likely to pose the greatest threat. Crested Wheat Grass, a non-native, persistent species used in agriculture and re-vegetation projects, was recorded as encroaching Hare-footed Locoweed habitat. This encroachment resulted in an apparent reduction in the number of Hare-footed Locoweed plants at five or more of the subpopulations (ACIMS 2012). Crested Wheat Grass plants are likely to be direct competitors for nutrients, water and light. The impacts of this alien species on the opportunities for Hare-footed Locoweed colonization and the sustainability of existing populations are unknown. There have been differing opinions as to Crested Wheat Grass impacts on native plant communities, but the potentially detrimental effects of Crested Wheat Grass plantings are being recognized (Hulet *et al.* 2010). A study within the mixed-grass prairie region of Canada, which included Hare-footed Locoweed range, concluded that Crested Wheat Grass dominated both the native vegetation and the seedbank in areas where it grew and that Crested Wheat Grass will lead to the decline of many native plant species (Henderson and Naeth 2005).

Livestock, vehicle traffic, and recreation activities, such as hiking and ORVs, all contribute to the spread of invasive alien species such as Crested Wheat Grass.

### Mining and Quarrying

Gravel extraction (gravel pits) have led to substantial loss of habitat and habitat disturbance. Active or abandoned pits are reported at several Map EOs (i.e. 1, 4, 7 and 10, Table 5). The existing occurrences are plotted with respect to aggregate resources that have been mapped by the Alberta Geological Survey (Figure 5). Gravel extraction at the Ross Lake Community Pasture site was discontinued in the 1990s in order to protect Hare-footed Locoweed habitat (Smith 1995).

## Annual and Perennial Non-timber Crops

Crested Wheat Grass, a perennial bunch grass originally from Asia, is planted for livestock forage and reclamation. In five Hare-footed Locoweed subpopulations (see Table 5) invasion by Crested Wheat Grass "has occurred and is likely to continue to occur as a result of human land use activities" (Bradley 2012).

Cultivation is a potential threat to Hare-footed Locoweed subpopulations at Whiskey Gap North, Milk River Ridge, Shanks Lake West, and Shanks Lake south (Table 5; Bradley 2012).

## Oil and Gas Drilling

There is some oil and gas development in areas occupied by Hare-footed Locoweed*,* for example a well is currently at Map EO 6 (Table 5). Therefore, disturbance and habitat loss from oil and gas development is a potential threat. The Alberta Geological Survey shows significant oil and gas reserves are under only a portion of the area occupied by Hare-footed Locoweed (Alberta Energy 1995-2012a, b; Centre for Energy 2012). However, as well as drilling and well sites, significant foreseeable threats are the activities associated with resource development such as road building, pipeline installation, temporary storage sites, the installation of associated buildings and holding tanks and an increase in incidental impacts such as more informal vehicle turn-around sites.

## Road Development

Road development has led to localized fragmentation of the plant spatial patterns (Figure 4). The occurrence of plants on each side of a road (e.g. Map EO12), suggest that the subpopulation has been subdivided by road construction in the past. Detrimental effects of off-road vehicle (ORV) traffic are largely from disturbance but tracks and trails may also affect plants' spatial patterns. For example, off-road vehicle use is evident at Map EO7 (Table 5).

"Vehicle roads and trails run through Hare-footed Locoweed habitat at several sites within five extant subpopulations. Hare-footed locoweed is not growing on the travel tracks or graded road beds, but in some places plants were observed in the disturbed gravels along the edges of these vehicle access routes (Bradley 2012)".

The impact of localized as well as large-scale population fragmentation on gene flow, seed dispersal and pollination is not understood. Seed dispersal influences occupation of hitherto unoccupied suitable habitat in addition to facilitating gene flow between subpopulations. Altering plant distribution may influence pollinator activity, which may be affected by plant spacing *per se* (see **Interspecific Interactions** section). Therefore gene flow and successful seed set may be affected by relatively small disturbances.

## Livestock Farming and Ranching

Hare-footed Locoweed evolved in the presence of large grazers such as Bison (*Bison bison*), Elk (*Cervus canadensis*), Mule Deer (*Odocoileus hemionus*), and Pronghorn (*Antilocapra americana*). These species moved freely over the prairie. Domestic livestock are restricted in their movements so the potential for over-grazing may occur.

Livestock (cattle and/or bison) occur at many subpopulations. Livestock are likely to cause habitat disturbance. *Oxytropis* plants are frequently unpalatable to livestock and may increase under grazing pressure (Heidel and Cooper 1998). This increase has not been observed for Hare-footed Locoweed; plant density has been observed to be lower in areas with heavy grazing as compared to other areas (see **Habitat** section). The reason for this observation was not clear and the effects from grazing could not be separated from other environmental variables. However, grazing can have significant adverse effects on soil water content (Naeth and Chanasyk 1995). This may influence Hare-footed Locoweed density.

It is possible that if livestock is present during the growing season plants may suffer herbivory or habitat disturbance may interfere with plant development and growth. Livestock may influence *Oxytropis* seed production as cattle demonstrated a preference for immature White Locoweed (*Oxytropis sericea*) seed pods (Ralphs *et al.* 1986, 1987). Succulent immature seed pods were preferentially selected until the supply was exhausted (Ralphs *et al.* 1987). In contrast, locoweed flowers or mature seed pods were not grazed and very few locoweed leaves were consumed (Ralphs *et al.* 1987). It is unknown if this grazing behaviour is applicable to Hare-footed Locoweed but this may be a factor particularly in years when forage is scarce.

Where Hare-footed Locoweed habitat is used as winter range, grazing is unlikely to be an issue (e.g. Map EO2; Table 5; Willms and Rode 1998). However, hoof disturbance of the rootstocks may be an issue where livestock congregate.

## Potential Threats

The potential for coalbed methane development may present a threat to Hare-footed Locoweed habitat (Alberta Energy 1995-2012c). Occurrences are within the “Belly River Group.” This group generally comprises thin coals and restricted lateral continuity of coal seams which has resulted in limited exploration of the area (Alberta Energy 1995-2012c). However, as technology becomes more sophisticated and energy prices increase, there may be more pressure to develop coalbed methane in areas that are currently less attractive.

Wind energy has been extensively developed north and west of the known range of Hare-footed Locoweed (Centre for Energy 2012). It is not clear if there are any plans to develop wind energy within Hare-footed Locoweed habitat (Canadian Wind Energy Association 2012).

Environmental stochasticity, or uncertainty, lies in random, partly unpredictable, changes in weather patterns or in biotic members of the community (Frankel *et al.* 1995). Specific environmental uncertainties that affect survival and reproductive success of Hare-footed Locoweed include variation in temperature, precipitation and, most likely, in populations of arthropods (pollinators, herbivores, granivores) and certain mammalian herbivores and granivores, such as squirrels.

The impact of the global changes in climate on a single species is very difficult to evaluate. After assessment of five climate models, Barrow and Yu (2005) concluded that the annual mean temperature in Alberta is projected to increase between 3$^{o}$C and 5$^{o}$C by 2050 and the annual precipitation changes will be in the range of –10% to +15% by 2050. Using data from the Lethbridge site (nearest to that where Hare-footed Locoweed occurs) the annual temperature will increase from a mean of 5.4$^{o}$C in the 1961-1990 period to a mean of 8.3$^{o}$C by 2050 but the annual precipitation is not predicted to increase (Barrow and Yu 2005). This situation is not the same as in other parts of Alberta where precipitation is expected to increase (Barrow and Yu 2005). An increase in temperature with a concurrent decrease in precipitation will cause a more stressful environment.

By 2050, Calgary, Edmonton, Grande Prairie, and Fort McMurray are projected to experience degree-day totals similar to Lethbridge's present degree-day totals (Alberta Agriculture and Rural Development 2007). This suggests that the species may be able to grow north of its current range if appropriate habitat exists and seed can be dispersed.

Warmer temperatures and shorter winters may contribute to larger populations of insects and rodents. Therefore, although it is somewhat speculative, an indirect impact of climate change may be to increase the levels of insect and rodent seed predation.

The potential for flooding along the Milk River appears to be very low because the flow is currently managed by a diversion canal that has been built west of the area occupied by Hare-footed Locoweed (Herd and Novlesky 2007).

**Number of Locations**

As there is no single threatening event that has the potential to rapidly affect all individuals in more than one subpopulation, the number of locations is set to the number of subpopulations as recommended by IUCN (2012a). There are 11 locations based on the known and potential threats for each subpopulation (Table 5). The number of locations is estimated to exceed 10 based on land ownership (Table 5).

## PROTECTION, STATUS AND RANKS

### Legal Protection and Status

Hare-footed Locoweed has no legal protection or status in either Canada or the USA.

Hare-footed Locoweed was last assessed by COSEWIC in April 1995 when it was designated a species of Special Concern (Species at Risk Public Registry 2012). Hare-footed Locoweed is currently on Schedule 3 under the *Species at Risk Act* (SARA; Species at Risk Public Registry 2012). “Species listed in Schedule 3 are species that had been designated as special concern, and have yet to be re-assessed by COSEWIC using revised criteria. Once these species have been re-assessed, they may be considered for inclusion in Schedule 1” (Species at Risk Public Registry 2012).

### Non-Legal Status and Ranks

*Oxytropis lagopus* has not yet been assessed for the most current IUCN Red List (IUCN 2012b). The global status of *O. lagopus* var. *conjugans* is listed as “R” for “Rare” in the 1997 IUCN Red List of Threatened Plants (Walter and Gillett 1998). The local status is “E” for Endangered in Alberta and “R” for Montana. Rare is reserved for “Taxa with small world populations that are not at present ‘Endangered’ or ‘Vulnerable’, but are at risk.

The NatureServe global status, which was last reviewed in February 1994, for this taxon is G4G5T3 (NatureServe 2012). “G4G5” indicates that the species is apparently secure to secure but “T3” indicates that the variety is “Vulnerable.” The reasoning is that the taxon is “Apparently secure at the species level (Wyoming, western Montana, and Idaho); (but the) variety is known only from Alberta, Canada (where it is) rare and from Montana. In Montana, it is known from about 10 locations (sic localities) in the central part of the state, mostly east of the continental divide and habitat possibly threatened” (NatureServe 2012). The NatureServe National Status in the USA and Montana is Vulnerable (N3 and S3 respectively), but in Canada and Alberta it is Critically Imperilled (N1and S1 respectively) (NatureServe 2012). The Montana Natural Heritage Program, in the USA, lists all varieties of *Oxytropis lagopus* as “Species of Concern” (Montana Natural Heritage Program 2012).

### Habitat Protection and Ownership

In Alberta, three occurrences are on private land (includes the extirpated site), four occurrences are divided between private and public land, three are on Land Trust property, one is in a provincial protected area (Ross Grassland Natural Area North) and one is divided between the Provincial protected area, land trust properties and private land (Table 5).

Natural Areas are managed by Alberta Parks to “preserve and protect sites of local significance and provide opportunities for low-impact nature-based recreation and nature appreciation activities” (Alberta Tourism, Parks and Recreation. 1995–2012). The Alberta Parks (Alberta Tourism, Parks and Recreation. 1995–2012) describe the Ross Lake Natural Area (map site EO6) as including “the largest Crown-owned area of foothills fescue grassland in Alberta.” Because this area is managed to maintain the grasslands, Hare-footed Locoweed should face low anthropogenic threats in this area.

The Land Trust property managed by the NCC includes occurrences 5, 8 and 9 (Figure 4). Canadian Land Trust Standards and Practices (Canadian Land Trust Alliance 2005) require that the land trust works with the landowner to “protect the property’s important conservation values over time.” The NCC’s priority is to maintain or restore Alberta’s Foothills Fescue Grassland (Nature Conservancy Canada 2012). Therefore, it is likely that they are also managing for Hare-footed Locoweed. Hare-footed Locoweed is not listed as a conservation target in the appendix to the current Canadian Rocky Mountains Ecoregional Assessment (Rumsey *et al.* 2003). However, NCC works closely with ACIMS and all rare plant programs in Alberta and provides ACIMS tracked element occurrence data from their properties on an annual basis (ACIMS 2012; Blouin pers. comm. 2012). Targeted surveys have been made on NCC managed properties in 2007 and 2011 (ACIMS 2012). Both livestock grazing and Crested Wheat Grass encroachment have been observed on NCC managed property (ACIMS 2012).

## ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

The time spent and help given by all the people and institutions mentioned in the reference section are gratefully acknowledged by the author. Access to the element occurrence data, the shapefiles, and the assistance provided by Lorna Allen at the ACIMS are appreciated. This information was crucial in the preparation of this report. The author also thanks Cheryl Bradley, Bonnie Smith - University of Calgary, and Professor Stanley Welsh - Brigham Young University for their time and information. The shapefile provided by Jenny Wu - NCR is appreciated. The author appreciates the information sent from John Bain - University of Lethbridge; Dana Blouin - Nature Conservancy of Canada; Donna Cherniawsky - Royal Alberta Museum; Bonnie Heidel - Wyoming Natural Diversity Database; Ken Heil - San Juan College Herbarium, Leigh Johnson - Brigham Young University, Deborah Q. Lewis - Iowa State University; Scott Mincemoyer – Montana Natural Heritage Program; Gisèle Mitrow- DAO Herbarium; David Dyer, University of Montana; David J. Ode – South Dakota Game, Fish and Parks Department; Greg Pohl - Canadian Forest Service; and Karen B. Searcy - University of Massachusetts Herbarium. The author would like to particularly thank Thomas A. Zanoni, of the New York Botanical Garden, for entering all the herbarium specimen data specifically for this report (and within a day after Hurricane Sandy), and Lucy Klebieko at the same institution for preparing the virtual loan package. Thanks to Peter Lesica for reviewing collections at the University of Montana. The author is grateful to Elaine Zummer and other Librarians at the Helen Fowler Library at Denver Botanic Gardens for

finding several somewhat obscure journal articles for this report. Finally, the author wishes to thank the Bruce Bennett, co-chair of the Vascular Plant Specialist Subcommittee for his support in preparing this report.

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## BIOGRAPHICAL SUMMARY OF REPORT WRITER

Juanita A. R. Ladyman received her B.Sc. degree (with First-class honors) in Biochemistry from London University, England. She obtained her Ph.D. degree in Botany and Plant Pathology from Michigan State University where she was also a research assistant with the Dept. of Energy Plant Research Laboratory. She worked as a plant physiological ecologist and plant scientist for Shell Development Company conducting research on the physiology, ecology, and reproductive biology of economically important plant species and their wild relatives. She then worked for a plant biotechnology company in their Genetic Transformation and Plant Tissue Culture

Division. For the last 20 years she has worked in the area of conservation, particularly on rare, endemic, and sensitive plant species in the United States. For three years of that time, she was the botanist with the New Mexico Natural Heritage Program, Albuquerque, NM, USA. She has conducted research and monitoring programs on both non-vascular and vascular species. She has had extensive experience with vegetation mapping and preparing conservation assessments for individual plant species. Currently she is a partner in JnJ Associates LLC, an environmental consulting company in Colorado, USA.

## COLLECTIONS EXAMINED

The herbariums contacted for information either directly by contacting the appropriate curators or by searching online—databases are listed below by name with the acronym according to Thiers (2012) in parentheses. Where possible the database was accessed online (web-based database). Curators were contacted in cases where specimens were reported to be deposited but could not be located online. In several cases herbaria had posted specimens on several different websites (for example University of Wyoming, Rocky Mountain Herbarium (RM)). In these cases the home database was accessed in addition to the others because some databases were more complete than others.

Specimens were examined only as scanned herbarium sheets on the web (see text in **Morphological Description** and Appendix 1).

The herbariums contacted for information either directly by contacting the appropriate curators or by searching online- databases are listed below by name with the acronym according to Thiers (2012) in parentheses. Where possible the database was accessed online (web-based database). Curators were contacted in cases where specimens were reported to be deposited but could not be located on line. In several cases Herbaria had posted specimens on several different web sites (for example University of Wyoming, Rocky Mountain Herbarium (RM). In these cases the home database was accessed in addition to the others because some databases were more complete than others.

A specimen reported to be at Iowa State College Herbarium (ISC) is no longer there (Lewis pers. comm. 2012) but ISC does have other specimens collected by Shaw (Table 4).

Some specimens collected by Shaw from Alberta had been deposited at AC (ACIMS 2012). In the ACIMS (2012) records AC stands for Agriculture Canada Herbarium – Ottawa (Vujnovic pers. comm. 2012). However, this herbarium holds no specimens of *O. lagopus* from Canada (Mitrow pers. comm. 2012). The University of Massachusetts Herbarium, Amherst, currently includes the holdings of the Amherst College Herbarium, the internationally recognized acronym of which is AC (Thiers 2012). However, only one specimen of *O. lagopus* was located at AC (Searcy pers.

comm. 2012). This specimen was originally identified as *Aragallus blankinshipii* Aven Nelson from Natrona Co., Wyoming, USA (Searcy pers. comm. 2012).

Many herbarium specimens have little information on population size or habitat (Table 4). Some of these specimens have been scanned and can be examined online.

Curator contacted by email at:

Agriculture Canada Herbarium (DAO)

Brigham Young University (BRY)

Iowa State University Herbarium (ISC)

Natural Resources Canada, Canadian Forest Service (CAFB)

New York Botanical Garden (NY; *O. lagopus* specimens now available online)

San Juan College Herbarium (SJNM)

Royal Alberta Museum Herbarium (PMAE); No specimens.

University of Calgary Herbarium (UAC)

University of Massachusetts Herbarium (MASS)

University of Lethbridge Herbarium (LEA)

Database searched directly online from:

University of Colorado Herbarium (COLO); *O. lagopus* specimens

University of Wyoming, Rocky Mountain Herbarium (RM)

University of Montana (MONTU)

Montana State University (MONT)

Consortium of Pacific Northwest Herbaria:

B. A. Bennett Herbarium, Yukon (BABY)

College of Idaho, Harold M. Tucker Herbarium (CIC)

The Evergreen College (EVE)

H.J. Andrews Experimental Forest (HJAEF)

University of Idaho, Stillinger Herbarium (ID)

Montana State University (MONT)

The New York Botanical Garden (NY)

Oregon State University (OSC)

Pacific Lutheran University (PLU)

REED College (REED)

University of Wyoming, Rocky Mountain Herbarium (RM)
Boise State University, Snake River Plains Herbarium (SRP)
University of Alaska, Fairbanks - Museum of the North (UAM)
University of British Columbia (UBC)
Royal British Columbia Museum (V)
Whitman College (WCW)
Washington State University, Marion Ownbey Herbarium (WSU)
University of Washington (WTU)
Western Washington University (WWB)
University of Montana (MONTU)
Rocky Mountain Herbarium (RM)
Academy of Natural Sciences, Herbarium, Philadelphia (PH)
Southwest Environmental Information Network (SEINET)
Arizona State University Vascular Plant Herbarium (ASU)
Cochise County Herbarium (COCHISE)
Deaver Herbarium (Northern Arizona University) (ASC)
Desert Botanical Garden Herbarium Collection (DES)
Grand Canyon National Park (GCNP)
Museum of Northern Arizona (MNA)
Navajo Nation Herbarium (NAVA)
Southwestern Research Station (SWRS)
University of Arizona Herbarium (ARIZ)
US Forest Service Southwestern Region - TEUI Herbarium (TES)
Arizona State University Pollen Collection (ASU)
Arizona State University Fruit and Seed Collection (ASU)
ENMU Natural History Collection Herbarium (ENMU)
Gila Center for Natural History (WNMU) Herbarium (SNM)
New Mexico State University Herbarium (NMC) more info
NMSU Center for Natural History Collections Range Science (NMCR)
San Juan College Herbarium (SJNM)
University of New Mexico Herbarium (UNM)
Eastern Nevada Landscape Coalition (ENLC)
Brigham Young University, S. L. Welsh Herbarium (BRY)

Intermountain Herbarium (Utah State University) (UTC)
Snow College Herbarium (EPHR)
Southern Utah University (SUU)
USU-Eastern (PRI)
Utah State University Uintah Basin (USUUB)
Utah Valley University Herbarium (UVSC)
Bitterroot National Forest herbarium (BNF)
Colorado Mesa University, Walter A. Kelly Herbarium (MESA)
Colorado State University Herbarium (CS)
Denver Botanic Gardens (KHD)
Fort Lewis College (FLD)
Mesa Verde National Park (MEVE)
Trinidad State Junior College (TSJC)
Rocky Mountain Herbarium (RM)
Rocky Mountain Biological Laboratory (RMBL)
Western State Colorado University (WSC)
Pacific Union College Herbarium (PUA)
University of California, Riverside Plant Herbarium (UCR)
New York Botanical Garden (NY)
Herbario de la Universidad de Sonora (DICTUS) (USON)
Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO)
Madrean Archipelago Biodiversity Assessment Observations (MABA)
Sonoran Desert Plants: An Ecological Atlas (Sonoran Atlas)

## Appendix 1. Herbarium specimens of *Oxytopis lagopus* var. *conjugans* collected in Montana, USA.

| | Herbarium code(s)[1] | Collectors #collector number | Date collected | County | Locality | Habitat | Elevation (m) |
|---|---|---|---|---|---|---|---|
| 1 | WTU | C. L. Hitchcock & C. V. Muhlick #13022 | July 31, 1945 | Beaverhead | At top of road leading to Canyon Creek from Vipont Park. | Limestone outcrop. | Not recorded |
| 2 | MONT | D. Culver # 73 | May 28, 1993 | Beaverhead | Centennial Valley-Upper Red Rock Creek Campground-roadside. | Roadside area-disturbed. | 1995 |
| 3 | NY | P. C. Lesica #6753 | June 19, 1995 | Beaverhead | 0.5 mile east of Hall Spring. | In gravelly soil on a windswept ridge. With *Draba oligosperma* and *Artemisia frigida*. | 2316 |
| 4 | WTU | C. L. Hitchcock #11776 | July 1, 1945 | Broadwater | 10 miles southeast of Helena, on road to Townsend. | Rolling grassy prairie. | Not recorded |
| 5 | MONTU | Blankinship #507a | July 11, 1906 | Gallatin | Bozeman and Anaconda | Dry ridges | 1524 |
| 6 | LEA | M. Maxie #4 | May 17, 1968 | Gallatin | Bozeman, 28 miles W. on Highway 289 | open prairie along Madison River | Not recorded |
| 7 | MONTU | C. L. Hitchcock #2298 | May 4, 1934 | Granite | Drummond; n. or highway, about 1 mi. e. of town | dry, barren hills | Not recorded |
| 8 | MONTU | P. C. Lesica #3753 | May 30, 1986 | Granite | Emerine Gulch; ca. 13 miles southeast of Phillipsburg | Uncommon on a steep sparsely vegetated, south-facing slope above a gulch just east of Emerine Gulch. With *Agropyron spicatum* and *Artemisia frigida*. | Not recorded |
| 9 | MONTU | Davis and Lesica #3644 | May 4, 1986 | Granite | Clark Fork River; ca 1/2 miles west of Maukey Gulch | Common in shallow, limestone-derived soil on a west-facing slope of the ridge on the north side of the Clark Fork River. With *Erigeron compositus* and *Poa secunda.* | Not recorded |
| 10 | MONTU | Harvey #7234 | May 25, 1966 | Granite | West Fork of Rock Creek | Prairie on SW to SE facing slopes | Not recorded |
| 11 | MONTU | K.H. Lackschewitz & Woodland #292 | June 26, 1966 | Granite | West Fork of Rock Creek Buttes | Collected along the south slope of the south butte. | 1829 |
| 12 | MONTU, NY | K. H. Lackschewitz #7169 | May 13, 1977 | Granite | Rattler Gulch; W of the road. 5 mi W. of Drummond | On E-W extending crest of bare ridge | Not recorded |

| | Herbarium code(s)[1] | Collectors #collector number | Date collected | County | Locality | Habitat | Elevation (m) |
|---|---|---|---|---|---|---|---|
| 13 | BRY | K. Shaw # 2911 | May 15, 1976 | Glacier | South side Two Medicine River, Highway 89. | No information | Not recorded |
| 14 | NY (isotype) | E. O. Wooton #sn | June 1, 1921 | Lewis and Clark | Vicinity of Helena | No information | Not recorded |
| 15 | NY[2] | F. W. Anderson #1880 | June 1887 | Lewis and Clark | Helena | No information | Not recorded |
| 16 | MONTU | F. D. Kelsey #s n | 06/01/1888 | Lewis and Clark | Helena | No information | Not recorded |
| 17 | NY | F. D. Kelsey* #s n | s.d. | Lewis and Clark | Collected in the vicinity of Helena | No information | Not recorded |
| 18 | MONTU | Anderson #442 | May 15, 1987 | Lewis and Clark | Helena | No information | Not recorded |
| 19 | MONTU | Ramsden #534 | May 16, 1980 | Lewis and Clark | Helena; grassy hills north of town (N of Lincoln rd.) | Under scattered ponderosa pine; uncommon in small fling colonies. | Not recorded |
| 20 | MONTU | Brandegee #s.n. | 06/02/1899 | Lewis and Clark | Mt. Helena | No information | Not recorded |
| 21 | NY | A. Breuninger & Nan Breuninger #635 | June 25, 1991 | Lewis & Clark | Helena, Mount Helena slopes on Le Grande Cannon Blvd, 0. miles west of Glendale St. | On dolostone[3] | 1280 |
| 22 | MONTU, NY | P. C. Lesica #3060 | June 28, 1984 | Lewis and Clark | Lake Helena; ca 8 mi NE of Helena at the NW end of the lake. | Common in shallow limestone soil in grasslands on a gentle south-facing slope. With *Eriogonum macum* and *Hymenoxys acaulis.* | 1189 |
| 23 | MONTU | P. C. Lesica #482 | May 18, 1978 | Lewis and Clark | Willow Creek Reservoir; SW end | Grassland | Not recorded |
| 24 | NY | A. Breuninger & Nan Breuninger #633 #634 | May 5, 1991 | Lewis & Clark | Willow Creek Reservoir, 6 miles west of Augusta. | On clayey, gravelly silt. Dry grassland with *Astragalus, Potentilla, Viola, Townsendia, Phlox*. | 1280 |
| 25 | MONTU | Ramsden #531 | May 14, 1980 | Lewis and Clark | Canyon Ferry Lake (Missouri R.); Overlook campground on the w-shore | *Pinus ponderosa, Artemisia tridentata* grassland; under trees only | Not recorded |
| 26 | ISC | Duane Isely & Isabelle Isely #11180 | June 18, 1971 | Lewis & Clark | Adjacent to US Hwy 287, 11 mi southeast of Augusta; | abundant along sandstone outcrops | 1311 |
| 27 | NY | B. T. Butler #4061 | June 26, 1909 | Powell [Now in Lewis & Clark Co] | Mt. Ascension, Helena. | No information | Not recorded |

| | Herbarium code(s)[1] | Collectors #collector number | Date collected | County | Locality | Habitat | Elevation (m) |
|---|---|---|---|---|---|---|---|
| 28 | NY | J. Pearsall #sn | [1852-1862] | No information | Big Black Foot River | No information | Not recorded |
| 29 | WTU | C. L. Hitchcock #15973 | July 1, 1947 | Meagher | 5 miles northeast of Ringling. | Granitic outcrop in sagebrush. | Not recorded |
| 30 | MONTU | P. C. Lesica #8245 | June 15, 2001 | Meagher | Eightmile Creek, Little Belt Mountains; 1/2 mile east of Lake Sutherlin | Common in gravelly soil on a south-facing bluffs above Eightmile Creek. *Artemisia frigida* and *Senecio canus*. | 1737 |
| 31 | MONTU | Rose #24 | May 5, 1938 | Missoula | Drummond; near town | Gravelly, clay, rocky loam in full sun | Not recorded |
| 32a | BRY, NY, WTU | S. Welsh & R. Foster [3] #24547 | June 18, 1990 | Pondera | Circa 1 mile north of Dupuyer. | Gravelly terrace, in fescue prairie. | 1250 |
| 32b | SJNM | S. Welsh & R. Foster #sn[3] | June 18, 1990 | Pondera | no information | No information | Not recorded |
| 33 | NY | F. W. Traphagen #sn | May 1888 | Powell | Deer Lodge | No information | Not recorded |
| 34 | MONT, MONTU[4] | Rose #20B | April 10, 1934 | Powell | Phosphate Creek; west of Garrison | Gravelly exposed and ridge tops | Not recorded |
| 35 | MONTU | Rose #20A | April 11, 1934 | Powell | Garrison Hill | Gravelly exposed and ridge tops | Not recorded |
| 36 | MONTU | Jones sn | July 10, 1909 | Powell | Garrison | Middle Temperate Life Zone | 1372 |
| 37 | MONTU | P. C. Lesica #484 | May 14, 1978 | Powell | Garrison; 1.5 mi E. of town on Hwy 12 | Dry limestone hillside. | Not recorded |
| 38 | WTU | C. L. Hitchcock # 18088 | July 6, 1948 | Teton | 15 miles west of Choteau. | No information | Not recorded |
| 39 | MONTU | Shaw #3394 | May 2, 1981 | Teton | North Fork Teton River; 15 miles west Choteau | Gravel soil on riverbottom flats. | 1219 |
| 40 | NY | M. S. Williams #sn | [1977] | Teton | Near the mountains, Chouteau | No information | Not recorded |
| 41 | MONTU | K.H. Lackschewitz & P.C. Lesica #10005 | June 6, 1982 | Teton | Teton River Rd; near road | A common species on the high, rocky bank of the river with *Hymenoxis acaulis, Eritrichium howardii, Douglasia*. | Not recorded |
| 42 | BRY | K. Shaw #2939 | May 21, 1977 | Teton | Along Teton River; 25 miles west of Choteau | No information | Not recorded |
| 43 | MONTU | Lackschewitz #3526 | June 8, 1972 | Teton | Front Range; 2 mi. E. of Ear Mtn. Ranger Sta., S of the Teton River | Foothills of the 'Front Range'. On rocky, dry soil between scattered limber pines. | 1463 |

| | Herbarium code(s)[1] | Collectors #collector number | Date collected | County | Locality | Habitat | Elevation (m) |
|---|---|---|---|---|---|---|---|
| 44 | BRY | S. L. Welsh #11041 | May 12, 1971 | Teton | Ca 5 miles north of Augusta and 2 miles north Sun River, along Highway 287. | No information | Not recorded |

[1] BRY = Brigham Young University, S. L. Welsh Herbarium, USA ; ISC = Iowa State University Herbarium, USA; LEA = University of Lethbridge Herbarium, Canada; MONT = Montana State University, USA; MONTU = University of Montana, USA; NY= New York Botanical Garden, USA; RM = Rocky Mountain Herbarium , USA; SJNM = San Juan College Herbarium, USA; WTU = University of Washington, USA

[2]Specimen Notes: Two plants on this NY sheet: *Oxytropis lagopus* var. *conjugens* (NY 1583867) and *Oxytropis lagopus* var*. lagopus* (NY 1583868)

[3]Dolomite rock, also sometimes called dolostone, is a former limestone in which the mineral calcite is altered to dolomite.

[4]MONT specimen identified on sheet as *O. lagopus* (no variety). Duplicate of MONTU specimen (identified by Welsh 1988) and is consistent with *O. lagopus* var. *conjugans* characters as observed by report writer on scanned sheet accessible after search online at: http://www.pnwherbaria.org/data/search.php

## Appendix 2. List of plant species that have been observed with Hare-footed Locoweed in Alberta, Canada

| Botanical name | Common name[1] |
|---|---|
| **Grasses** | |
| *Agropyron cristatum* (non-native; invasive) | Crested Wheatgrass |
| *Bouteloua gracilis* | Blue Grama |
| *Festuca brachyphylla* | Short-leaved Fescue |
| *Festuca campestris* (and the synonym= *Festuca. scabrella)* | Mountain Rough Fescue, |
| *Festuca idahoensis* | Idaho Fescue, |
| *Koeleria macrantha* | Prairie June Grass |
| *Poa cusickii* | Cusick's Blue Grass |
| *Poa* sp. | Blue Grass |
| *Stipa comata* | Needle-and-thread grass |
| **Sedges** | |
| *Carex inops* ssp. *heliophila* (reported as the synonym=*Carex pensylvanica* var. *digyna*) | Sun Sedge |
| *Carex filifolia* | Thread-leaved Sedge |
| *Carex obtusata* | Blunt Sedge |
| *Carex* spp. | Sedge |
| **Forbs** | |
| *Allium textile* | Prairie Onion |
| *Androsace septentrionalis* | Northern Fairy-candelabra |
| *Anemone patens* | Prairie Pasqueflower |
| *Antennaria microphylla* | Little-leaved Pussytoes |
| *Antennaria parvifolia* | Small-leaved Pussytoes |
| *Antennaria umbrinella* (both male and female plants) | Umber Pussytoes |
| *Arabis nuttallii* | Nuttall's Rockcress |
| *Artemisia frigida* | Prairie Sagebrush |

| Botanical name | Common name[1] |
|---|---|
| *Artemisia campestris* | Field Wormwood |
| *Astragalus vexilliflexus* | Bent-Flowered Milk-vetch |
| *Astragalus crassicarpus* | Ground Plum |
| *Astragalus gilviflorus* | Plains Milk-vetch |
| *Balsamorhiza sagittata* | Arrow-leaved Balsamroot |
| *Bupleurum americanum* | American Thorough-wax |
| *Comandra umbellata* | Bastard's Toadflax |
| *Cryptantha celosioides* | Cock's-comb Cryptantha |
| *Cryptantha nubigena*[2] | Clustered Oreocarya |
| *Draba oligosperma* | Few-seeded Whitlow-grass Draba |
| *Erigeron compositus* | Cut-leaved Fleabane |
| *Eriogonum flavum* | Yellow Buckwheat |
| *Geum triflorum* | Three-flowered Avens |
| *Hedysarum sulphurescens* | Yellow Sweet-vetch |
| *Heterotheca sessiliflora* (reported as the synonym=*Chrysopsis villosa*)[2] | Sessileflower False Goldenaster |
| *Heuchera parviflora* (reported as the synonym = *H. flabellifolia* )[3] | Little-leaved Alumroot |
| *Hymenoxys richardsonii* | Richardson's Bitterweed |
| *Tetraneuris acaulis* (reported as the synonym = *Hymenoxys acaulis*) | Stemless Four-nerved Daisy |
| *Lesquerella arenosa* | Great Plains Bladderpod |
| *Lupinus sericeus* | Silky Lupine |
| *Minuartia rubella* | Reddish Stitchwort |
| *Musineon divaricatum* | Leafy Wild Parsley |
| *Oxytropis borealis* (reported as the synonym = *O. viscida*) | Boreal Locoweed |
| *Oxytropis sericea* | White Locoweed |
| *Oxytropis* spp. | Locoweed |
| *Penstemon nitidus* | Wax-leaved Beardtongue |
| *Phlox alyssifolia* | Blue Phlox |

| Botanical name | Common name[1] |
|---|---|
| *Phlox hoodii* | Hood's Phlox |
| *Physaria didymocarpa* | Common Twinpod |
| *Plantago canescens* | Hairy Plantain |
| *Potentilla concinna* | Early Red Cinquefoil |
| *Potentilla hippiana* | Woolly Cinquefoil |
| *Selaginella densa* | Dense Spikemoss |
| *Thermopsis rhombifolia* | Prairie Golden Bean |
| *Zigadenus venenosus* | Meadow Death Camas |

[1] Common name according to most recent name in 'Wild Species 2010: the general status of species in Canada'. (Canadian Endangered Species Conservation Council 2011).

[2] Species apparently not in the "Wild Species" database.

[3] *Heuchera flabellifolia* does not occur in Alberta Canada, USDA NRCS 2012.

## Appendix 3. Threats Assessment for Hare-footed Locoweed

**THREATS ASSESSMENT WORKSHEET**

| | |
|---|---|
| **Species or Ecosystem Scientific Name** | Hare-footed Locoweed |
| **Element ID** | **Elcode** |
| **Date (Ctrl + ";" for today's date):** | 19/05/2013 |
| **Assessor(s):** | Bruce Bennett, Cochair COSEWIC SSC; Robin Gutsell review |
| **References:** | Bradley, C.E. 2012. Draft Alberta Wildlife Status Report #69; COSEWIC draft Status Report |

**Overall Threat Impact Calculation Help:**

| | | Level 1 Threat Impact Counts | |
|---|---|---|---|
| **Threat Impact** | | **high range** | **low range** |
| A | Very High | 0 | 0 |
| B | High | 1 | 1 |
| C | Medium | 2 | 1 |
| D | Low | 1 | 2 |
| | **Calculated Overall Threat Impact:** | Very High | High |

**Assigned Overall Threat Impact:** AB = Very High - High

**Impact Adjustment Reasons:**

**Overall Threat Comments**

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 1 | Residential & commercial development | | Unknown | Unknown | Unknown | Unknown | |
| 1.1 | Housing & urban areas | | Unknown | Unknown | Unknown | Unknown | Urban development has been listed as a potential threat. Seems only to be at Cardston (which is extirpated). |
| 1.2 | Commercial & industrial areas | | | | | | |
| 1.3 | Tourism & recreation areas | | | | | | |
| 2 | Agriculture & aquaculture | C | Medium | Restricted (11-30%) | Serious (31-70%) | High (Continuing) | |
| 2.1 | Annual & perennial non-timber crops | C | Medium | Restricted (11-30%) | Serious (31-70%) | High (Continuing) | Ladyman and Bradley list cultivation as a threat at Whiskey Gap North, Milk River Ridge, Shanks Lake West, and Shanks Lake south. It is not clear how much of the Canadian population would be affected. |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 2.2 | Wood & pulp plantations | | | | | | |
| 2.3 | Livestock farming & ranching | D | Low | Pervasive (71-100%) | Slight (1-10%) | High (Continuing) | Livestock grazing is listed as a threat at all the extant subpopulations (Ladyman 2013). “Loitering of livestock in habitat of HFL was observed at several sites within three subpopulations in 2011 (Whiskey Gap NE, Milk River Ridge, Shanks Lake West). Livestock may seek out wind-blown sites to be free of biting insects. In addition, livestock corrals have been constructed within or near HFL habitat within two subpopulations (Whiskey Gap North and Shanks Lake West) that may result in loitering. Where cattle loiter, hoof action has destroyed the biological crust and exposed the finer sands and silts on the surface to erosion and the soil to drying winds and sun. There is also a build-up of manure. Vascular plant cover is noticeably reduced compared to adjacent vegetation. HFL continues to grow in these sites, suggesting it is unpalatable to livestock; however, its long-term survival is likely to be adversely affected under persistent heavy livestock use (Bradley 2012).” |
| 2.4 | Marine & freshwater aquaculture | | | | | | |
| 3 | Energy production & mining | CD | Medium - Low | Restricted - Small (1-30%) | Extreme (71-100%) | High - Moderate | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 3.1 | Oil & gas drilling | D | Low | Small (1-10%) | Slight (1-10%) | High (Continuing) | An operating gas well is situated in habitat for HFL within one subpopulation (Sandstone Ranch) and an abandoned well site was noted within 100m of another occurrence (Milk River Ridge). The former appears to have been constructed using minimum disturbance techniques, whereas the latter has resulted in the introduction of invasive non-native species (Crested Wheat Grass). Oil and gas exploration and development activity has recently dramatically increased in the Del Bonita area. Light oil has been found in the Bakken shale formation underlying the Plateau. Extracting the oil requires horizontal drilling and multi-stage fracturing technology. The implications of this activity with respect to loss or fragmentation of habitat for HFL have not been assessed (Bradley 2012)". |
| 3.2 | Mining & quarrying | CD | Medium - Low | Restricted - Small (1-30%) | Extreme (71-100%) | High - Moderate | "Gravel extraction may have led to the extirpation of the one known historical subpopulation near Cardston. A gravel pit in HFL habitat within the Ross Grassland Natural Area (Milk River Ridge) was halted in 1986. HFL is growing near, but not on, the reclaimed site. There is a large active gravel mining operation on the plateau north of Shanks Lake that is impacting habitat for Hare-footed Locoweed and expanding further into the plant's habitat (Bradley 2012)". |
| 3.3 | Renewable energy | | | | | | |
| 4 | Transportation & service corridors | D | Low | Large - Restricted (11-70%) | Slight (1-10%) | High (Continuing) | |
| 4.1 | Roads & railroads | D | Low | Large - Restricted (11-70%) | Slight (1-10%) | High (Continuing) | Vehicle roads and trails run through HFL habitat at several sites with five extant subpopulations. HFL is not growing on the travel tracks or graded road beds, but in some places plants were observed in the disturbed gravels along the edges of these vehicle access routes Bradley 2012". |
| 4.2 | Utility & service lines | | | | | | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 4.3 | Shipping lanes | | | | | | |
| 4.4 | Flight paths | | | | | | |
| 5 | Biological resource use | | | | | | |
| 5.1 | Hunting & collecting terrestrial animals | | | | | | |
| 5.2 | Gathering terrestrial plants | | | | | | |
| 5.3 | Logging & wood harvesting | | | | | | |
| 5.4 | Fishing & harvesting aquatic resources | | | | | | |
| 6 | Human intrusions & disturbance | | | | | | |
| 6.1 | Recreational activities | | | | | | |
| 6.2 | War, civil unrest & military exercises | | | | | | |
| 6.3 | Work & other activities | | | | | | |
| 7 | Natural system modifications | | Unknown | Unknown | Unknown | Unknown | |
| 7.1 | Fire & fire suppression | | | | | | |
| 7.2 | Dams & water management/use | | | | | | |
| 7.3 | Other ecosystem modifications | | Unknown | Unknown | Unknown | Unknown | loss of pollinators |
| 8 | Invasive & other problematic species & genes | B | High | Large (31-70%) | Extreme - Serious (31-100%) | High (Continuing) | |
| 8.1 | Invasive non-native/alien species | B | High | Large (31-70%) | Extreme - Serious (31-100%) | High (Continuing) | "In five subpopulations invasion by non-native plant species, primarily Crested Wheat Grass (*Agropyron cristatum*), has occurred and is likely to continue to occur as a result of human land-use activities (Bradley 2012)." |
| 8.2 | Problematic native species | | | | | | |
| 8.3 | Introduced genetic material | | | | | | |
| 9 | Pollution | | | | | | |
| 9.1 | Household sewage & urban waste water | | | | | | |
| 9.2 | Industrial & military effluents | | | | | | |
| 9.3 | Agricultural & forestry effluents | | | | | | |
| 9.4 | Garbage & solid waste | | | | | | |
| 9.5 | Air-borne pollutants | | | | | | |
| 9.6 | Excess energy | | | | | | |
| 10 | Geological events | | | | | | |
| 10.1 | Volcanoes | | | | | | |
| 10.2 | Earthquakes/tsunamis | | | | | | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 10.3 | Avalanches/landslides | | | | | | |
| 11 | Climate change & severe weather | | Unknown | Unknown | Unknown | Unknown | |
| 11.1 | Habitat shifting & alteration | | Unknown | Unknown | Unknown | Unknown | |
| 11.2 | Droughts | | | | | | |
| 11.3 | Temperature extremes | | | | | | |
| 11.4 | Storms & flooding | | | | | | |

Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).