

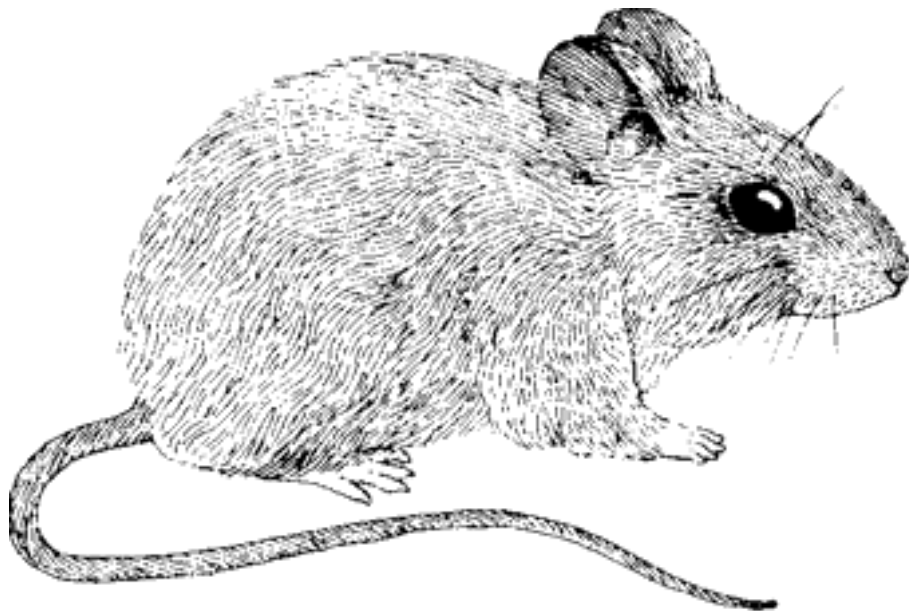
COSEWIC Assessment and Status Report

on the

Western Harvest Mouse *Reithrodontomys megalotis*

Megalotis subspecies *Reithrodontomys megalotis megalotis*
Dychei subspecies *Reithrodontomys megalotis dychei*

in Canada



ENDANGERED
2019

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 assessment and status report on the Western Harvest Mouse *Reithrodontomys megalotis megalotis* subspecies and *dychei* subspecies, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xv + 37 pp. (<https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html>).

Previous report(s):

COSEWIC 2007. COSEWIC assessment and update status report on the Western harvest mouse *Reithrodontomys megalotis megalotis* and *Reithrodontomys megalotis dychei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xvi + 27 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

David W. Nagorsen. 1994. COSEWIC status report on the Western harvest mouse *Reithrodontomys megalotis megalotis* and *Reithrodontomys megalotis dychei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-20 pp.

Production note:

COSEWIC would like to acknowledge Nyree Sharp for writing the status report on Western Harvest Mouse, *megalotis* subspecies and *dychei* subspecies, *Reithrodontomys megalotis megalotis* and *Reithrodontomys megalotis dychei*, in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Chris Johnson, Co-chair of the COSEWIC Terrestrial Mammals Specialist Subcommittee.

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Western Harvest Mouse — Image used with permission, from California Wildlife Habitat Relationships (CWHR), California Department of Fish and Wildlife.

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COSEWIC Assessment Summary

Assessment Summary – November 2019

Common name

Western Harvest Mouse *megalotis* subspecies

Scientific name

Reithrodontomys megalotis megalotis

Status

Endangered

Reason for designation

This tiny mouse occurs at the northern edge of its distribution within the Okanagan and Similkameen valleys of British Columbia, and is one of two designatable units of the species in Canada. It is among Canada's shortest-lived mammals. This species demonstrates extreme fluctuations in the number of mature individuals over time, increasing vulnerability to disturbances when populations are at a low in spring and early summer. The species' limited distribution, extreme fluctuations, and habitat loss are the reasons for designation. Change in status from Special Concern to Endangered is the result of inclusion of extreme fluctuations in the latest assessment. Continued urban and agricultural expansion threaten the persistence of this mouse.

Occurrence

British Columbia

Status history

Designated Special Concern in April 1994 and in April 2007. Status re-examined and designated Endangered in November 2019.

Assessment Summary – November 2019

Common name

Western Harvest Mouse *dychei* subspecies

Scientific name

Reithrodontomys megalotis dychei

Status

Endangered

Reason for designation

This tiny mouse occurs at the northern edge of its distribution at the Suffield National Wildlife Area in southeastern Alberta, and is one of two designatable units of the species in Canada. It is among Canada's shortest-lived mammals. Populations monitored in the United States suggest extreme fluctuations in the number of mature individuals. These fluctuations increase the vulnerability of the species to disturbances, when numbers are low in spring and early summer. Although comprehensive data describing population abundance and trends are lacking, existing capture data suggest a decline in the number of mature individuals since 2011. That decline in the species' small range and extreme fluctuations in abundance are the reasons for designation. Climate change, including the possibility of more frequent wildfires and intense drought, is an increasing future threat.

Occurrence

Alberta

Status history

Species considered in April 1994 and placed in the Data Deficient category. Re-examined in April 2007 and designated Endangered. Status re-examined and confirmed in November 2019.



COSEWIC Executive Summary

Western Harvest Mouse *Reithrodontomys megalotis*

Megalotis subspecies *Reithrodontomys megalotis megalotis*
Dychei subspecies *Reithrodontomys megalotis dychei*

Wildlife Species Description and Significance

Western Harvest Mouse (*Reithrodontomys megalotis*) has a body mass of approximately 11 g and averages 136 mm in total length, half of which is its tail. This brownish mouse has a faint dark dorsal stripe which runs the length of its body from head to tail, and has whitish fur on its belly. Western Harvest Mouse has prominent naked ears, a tail that is sparsely furred and white feet. It is similar in appearance to the larger and more common Deer Mouse and House Mouse; however, the juvenile Deer Mouse is most often grey in colour and the House Mouse has a tail that is completely naked.

Distribution

Western Harvest Mouse is widely distributed in central and western US, as well as in parts of Mexico. In Canada, the species occurs as two subspecies, with *R. m. megalotis* in the Okanagan and Similkameen valleys, and *R. m. dychei* in southern Alberta and Saskatchewan. These subspecies are geographically disjunct in the US and Canada. Each subspecies is considered a designatable unit.

Habitat

The *megalotis* subspecies is found in dry gullies with dense shrub cover as well as shrub-steppe rangelands, old fields, ponderosa pine forests, and both grazed and ungrazed Sagebrush and Antelope Bitterbrush habitats. The *dychei* subspecies is associated with low relief, flat or gently undulating grasslands with sandy soils and vegetation cover. The highest densities of this subspecies are trapped in areas with highly complex plant structure, particularly tall, dense grass.

Biology

Western Harvest Mouse is omnivorous, mainly eating seeds, new plant growth, and invertebrates such as caterpillars and moths. This mouse generally builds small grass nests on the ground or up to 1 m above ground in shrubs. Females can breed at the age of four months and may have up to five litters per season (March through November) with an

average litter size of three. Although they can live for 18 months, most mice do not live past six months. Western Harvest Mouse appears to be able to enter torpor to cope with cold temperatures. In Canada, owls, Western Rattlesnake and Gophersnake are the only confirmed predators, but other likely predators include Prairie Rattlesnake, hawks, jays, shrikes, Raccoon, foxes, weasels, skunks, American Badger and Coyote. The recorded dispersal distance of Western Harvest Mouse is generally < 300 m but movements of 3 km have been recorded along road rights-of-way. However, roads appear to be avoided and may limit dispersal.

Population Sizes and Trends

In the US, Western Harvest Mouse is a prominent member of grassland communities. In Canada, this species is naturally rare and occurs at low densities, typically comprising less than 10% of the small-mammal community. Western Harvest Mouse populations appear to peak in late fall or early winter and decline to low levels in midsummer. There is no comprehensive sampling of the distribution and abundance of either subspecies, thus, population size and trends are unknown.

Threats and Limiting Factors

Western Harvest Mouse is susceptible to habitat change resulting from fire, but populations can increase quickly, provided there is suitable unburned habitat nearby. Habitat fragmentation and loss caused by urban development, roads and agriculture are the most significant threats to the *megalotis* subspecies. The future effects of climate change, including drought and fire, are threats to the *dychei* subspecies.

Western Harvest Mouse is known to fluctuate in abundance. Populations in Canada are small and isolated, and the species has a moderate dispersal distance.

Protection, Status and Ranks

The *megalotis* subspecies of Western Harvest Mouse is found within several protected areas in British Columbia. The *dychei* subspecies is found within the Canadian Forces Base Suffield National Wildlife Area in Alberta. The *megalotis* subspecies is listed as Special Concern and the *dychei* subspecies is listed as Endangered on Schedule 1 of Canada's *Species at Risk Act*.

The species is ranked by NatureServe (2018) as Secure globally and as Vulnerable to Imperilled in Canada. It is ranked as Vulnerable to Imperilled in British Columbia and as Critically Imperilled in Alberta. Western Harvest Mouse is on the Blue List in British Columbia, and has a status of Undetermined in Alberta.

TECHNICAL SUMMARY – *megalotis* subspecies

Reithrodontomys megalotis megalotis

Western Harvest Mouse *megalotis* subspecies

Souris des moissons de la sous-espèce *megalotis*

Range of occurrence in Canada: British Columbia

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 (2011) is being used)	6 months
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
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 a. clearly reversible and b. understood and c. ceased?	a. unknown b. no c. unknown
Are there extreme fluctuations in number of mature individuals?	Yes, extreme fluctuations (> 1 order of magnitude) observed for the subspecies and US subpopulations

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	2904 km ²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	120 km ²

Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. no b. no
Number of “locations”* (use plausible range to reflect uncertainty if appropriate)	Unknown, but likely > 10
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Unknown
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Unknown
Is there an [observed, inferred, or projected] decline in number of “locations”**?	Unknown
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, inferred decline in area and quality of habitat
Are there extreme fluctuations in number of subpopulations?	Unknown
Are there extreme fluctuations in number of “locations”**?	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Are there extreme fluctuations in index of area of occupancy?	Unknown

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Total	Unknown

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Not done
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* See Definitions and Abbreviations on [COSEWIC web site](#) and [IUCN](#) (Feb 2014) for more information on this term

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes

Threat 2: Livestock farming and ranching (Medium-Low impact)
Threat 1: Housing and urban areas (Low impact)
Threat 2: Annual and perennial non-timber crops (Low impact)
Threat 4: Roads and railroads (Low impact)
Threat 7: Fire and fire suppression (Low impact)
Threat 7: Other ecosystem modifications (Low impact)
Threat 8: Invasive non-native/alien species (Low impact)
Threat 9: Agricultural and forestry effluents (Low impact)

What additional limiting factors are relevant?

Populations in the US and Canada exhibit extreme fluctuations in abundance. Populations in Canada are small and isolated, with limited dispersal distances.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Secure
Is immigration known or possible?	Possible, Canadian population is connected to the US population.
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?+	Yes
Are conditions for the source (i.e., outside) population deteriorating?+	Unknown
Is the Canadian population considered to be a sink?+	No
Is rescue from outside populations likely?	Unlikely

Data Sensitive Species

Is this a data sensitive species?	No
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Status History

COSEWIC Status History:
Designated Special Concern in April 1994 and in April 2007. Status re-examined and designated Endangered in November 2019.

+ See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect)

Status and Reasons for Designation:

Status: Endangered	Alpha-numeric codes: B1b(iii)c(iv)+2b(iii)c(iv)
Reasons for designation: This tiny mouse occurs at the northern edge of its distribution within the Okanagan and Similkameen valleys of British Columbia, and is one of two designatable units of the species in Canada. It is among Canada's shortest-lived mammals. This species demonstrates extreme fluctuations in the number of mature individuals over time, increasing vulnerability to disturbances when populations are at a low in spring and early summer. The species' limited distribution, extreme fluctuations, and habitat loss are the reasons for designation. Change in status from Special Concern to Endangered is the result of inclusion of extreme fluctuations in the latest assessment. Continued urban and agricultural expansion threaten the persistence of this mouse.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. There is insufficient monitoring to detect a trend in the reduction of mature individuals.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered, B1b(iii)c(iv)+2b(iii)c(iv), as the EOO (2904 km ²) is less than 5000 km ² and the IAO (120 km ²) is less than 500 km ² . The extent and quality of habitat continues to decline and the population is assumed to exhibit extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Population size is unknown and there is insufficient monitoring to detect a trend in the decline of mature individuals.
Criterion D (Very Small or Restricted Population): Not applicable. Density estimates suggest population exceeds 1000 mature individuals.
Criterion E (Quantitative Analysis): Not applicable. No quantitative analysis was performed.

TECHNICAL SUMMARY – *dychei* subspecies

Reithrodontomys megalotis dychei

Western Harvest Mouse *dychei* subspecies

Souris des moissons de la sous-espèce *dychei*

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 (2011) is being used)	6 months
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, inferred decline Trend in trapping data (Table 1) and opinion of experts suggests a decline.
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 a. clearly reversible and b. understood and c. ceased?	a. Unknown b. no c. Unknown
Are there extreme fluctuations in number of mature individuals?	Yes, extreme fluctuations (> 1 order of magnitude) observed for US populations

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	562 km ²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	164 km ²
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. no b. no

Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	Unknown, but likely >10
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Unknown
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Unknown
Is there an [observed, inferred, or projected] decline in number of "locations"*?	Unknown
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Unknown
Are there extreme fluctuations in number of subpopulations?	Unknown
Are there extreme fluctuations in number of "locations"*?	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Are there extreme fluctuations in index of area of occupancy?	Unknown

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Suffield	Unknown
Total	Unknown

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Not done
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Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes

Threat 7: Fire and fire suppression (Low impact)

Threat 11: Droughts from climate change (Low impact)

What additional limiting factors are relevant?

Populations in the US exhibit extreme fluctuations in abundance; likely true in Canada as well.
Populations in Canada are small and isolated, with limited dispersal distances.

* See Definitions and Abbreviations on [COSEWIC web site](#) and [IUCN](#) (Feb 2014) for more information on this term

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Secure
Is immigration known or possible?	Unlikely, as there are no observed movements between US and Canadian subpopulations
Would immigrants be adapted to survive in Canada?	Yes, but individuals found in the US and Canada display different nesting behaviours (arboreal versus ground)
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?+	Yes
Are conditions for the source (i.e., outside) population deteriorating?+	Unknown
Is the Canadian population considered to be a sink?+	No
Is rescue from outside populations likely?	Unlikely, as there is an <i>apparent break in range between subpopulations in Canada and the US; distance between Canadian and US subpopulations is ~235 km</i>

Data Sensitive Species

Is this a data sensitive species?	No
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Status History

COSEWIC Status History:
 Species considered in April 1994 and placed in the Data Deficient category. Re-examined in April 2007 and designated Endangered. Status re-examined and confirmed in November 2019.

Recommended Status and Reasons for Designation:

Status: Endangered	Alpha-numeric codes: B1b(v)c(iv)+2b(v)c(iv)
Reason for Designation: This tiny mouse occurs at the northern edge of its distribution at the Suffield National Wildlife Area in southeastern Alberta, and is one of two designatable units of the species in Canada. It is among Canada's shortest-lived mammals. Populations monitored in the United States suggest extreme fluctuations in the number of mature individuals. These fluctuations increase the vulnerability of the species to disturbances, when numbers are low in spring and early summer. Although comprehensive data describing population abundance and trends are lacking, existing capture data suggest a decline in the number of mature individuals since 2011. That decline in the species' small range and extreme fluctuations in abundance are the reasons for designation. Climate change, including the possibility of more frequent wildfires and intense drought, is an increasing future threat.	

+ See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect)

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. There is insufficient monitoring to detect a trend in the reduction of mature individuals.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered, B1b(v)c(iv)+2b(v)c(iv), as the EOO (562 km ²) is less than 5000 km ² and the IAO (164 km ²) is less than 500 km ² . There is an inferred decrease in the number of mature individuals and the population is assumed to exhibit extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Population size is unknown and there is insufficient monitoring to detect a trend in the decline of mature individuals.
Criterion D (Very Small or Restricted Population): Not applicable. Given the area of habitat and density of the species in other locations there likely are more than 1000 mature individuals.
Criterion E (Quantitative Analysis): Not applicable. No quantitative analysis was performed.

PREFACE

This report is an update of the previous status report (COSEWIC 2007) for the two designatable units of Western Harvest Mouse in Canada. For the subspecies *Reithrodontomys megalotis megalotis* the extent of occurrence and area of occupancy are essentially unchanged since the 2007 report. For *R. m. dychei* the extent of occurrence is **562** km² and the area of occupancy is **164** km². New records for the subspecies were reported for south-central Saskatchewan resulting in a possible extent of occurrence of 12,365 km² and an area of occupancy of 580 km². Those records were not corroborated with independent methods despite considerable sampling in that area, thus, the more conservative extent of occurrence and area of occupancy were applied to this status assessment.

The *dychei* subspecies of Western Harvest Mouse is listed on Schedule 1 of the federal *Species at Risk Act* as Endangered and the *megalotis* subspecies is listed as Special Concern. A federal recovery strategy was completed in 2015 (Environment Canada 2015) for the *dychei* subspecies, and an Action Plan for the *megalotis* subspecies is scheduled for 2019.

As part of COSEWIC status assessments, Aboriginal Traditional Knowledge (ATK) reports are prepared by the Aboriginal Traditional Knowledge subcommittee (ATK SC). These reports compile and summarize ATK relevant to status assessment when ATK information is available and readily accessible. A gathering project may be conducted if there are information gaps, or if ambiguity exists between ATK and other forms of knowledge. ATK was unavailable for Western Harvest Mouse during the time the COSEWIC status report was in preparation.



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 (2019)

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.



Environment and
Climate Change Canada
Canadian Wildlife Service

Environnement et
Changement climatique Canada
Service canadien de la faune

Canada

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

COSEWIC Status Report

on the

Western Harvest Mouse *Reithrodontomys megalotis*

Megalotis subspecies *Reithrodontomys megalotis megalotis*

Dychei subspecies *Reithrodontomys megalotis dychei*

in Canada

2019

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Western Harvest Mouse (*Reithrodontomys megalotis* Baird, 1958) belongs to the Family Muridae, and is known as Souris des moissons in French (NatureServe 2017). Five species of *Reithrodontomys* occur in North America but only the *Reithrodontomys megalotis* occurs in Canada. A taxonomic review of the 17 subspecies of Western Harvest Mouse (Hall 1981) is needed (Nagorsen 1990) because the designations are based on morphological differences that may require confirmation using genetic methods. The two subspecies found in Canada are separated by a large mountain range (in Canada and in the US), so they likely possess unique and significant genetic differences. *R. m. megalotis*, which occurs in southern British Columbia, is widely separated (e.g., 600 km) from *R. m. dychei*, which occurs in eastern parts of southern Alberta and possibly south-central Saskatchewan (Figures 1-4). At present, the two subspecies are considered valid.

Morphological Description

With an average mass of 11.0 g (range 8.0–15.0; Nagorsen 2005), Western Harvest Mouse is one of the smallest mouse species in North America (Banfield 1974; Forsyth 1999). Total length is 136 mm (range: 116–151), of which nearly half is a sparsely furred, bicoloured tail that is white ventrally (Cahalane 1961; Nagorsen 2005). This mouse has prominent naked ears, tawny pelage, buff sides, white to deep grey undersides, a dark mid-dorsal stripe that runs from the forehead to tail, and white hind feet (Banfield 1974; Burt and Grossenheider 1976; Nagorsen 2005).

Western Harvest Mouse may be confused with the larger Deer Mouse (*Peromyscus maniculatus*) and with House Mouse (*Mus musculus*; Nagorsen 2005). A juvenile Deer Mouse of comparable size to a Western Harvest Mouse can be distinguished by its dull grey pelage, and a House Mouse can be distinguished by its naked tail (Nagorsen 2005).

Population Spatial Structure and Variability

There are two subspecies of Western Harvest Mouse in Canada. The *megalotis* subspecies is found only in the Okanagan and Similkameen valleys of British Columbia and the *dychei* subspecies is found in the Canadian Forces Base (CFB) Suffield National Wildlife Area (Suffield NWA) in Alberta. Hairs of *dychei* were reported from carnivore scat collected in south-central Saskatchewan. Those data were not confirmed using other sampling methods (e.g., DNA, live-capture, skull/dentition); thus, the current distribution of the subspecies is restricted to Alberta.

Designatable Units

There are two designatable units for Western Harvest Mouse in Canada. The subspecies *R. m. megalotis* occurs in arid valleys of southern British Columbia, and the subspecies *R. m. dychei* occurs in arid grasslands of southern Alberta and possibly

Saskatchewan. Broad-scale geographic separation allows the two DUs to meet the requirement of discreteness. Morphological differences recognized since the 19th century resulted in the recognition of two subspecies and suggest evolutionarily significant differences between the two DUs. Compared to *R. m. megalotis*, the *dychei* subspecies has a longer tail, smaller ears that are more distinctly spotted, and a more fulvous pelage (Allen 1895). Genetic analyses of the species have not been conducted and the 17 subspecies presently identified may change. However, the two northern subspecies (*R. m. dychei* and *R. m. megalotis*) would likely remain unique because they are separated by a long distance and the Rocky Mountain range acts as an ecological barrier for the species in Canada (Figure 1).

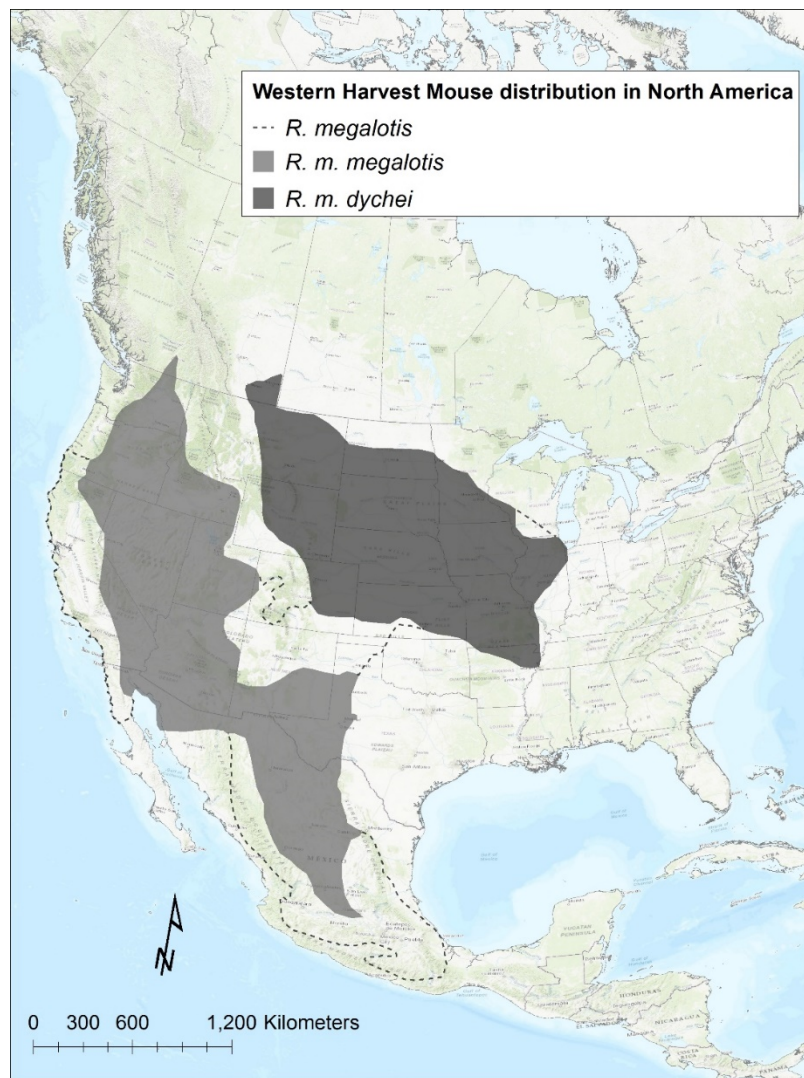


Figure 1. Distribution of Western Harvest Mouse within North America. Note: Species' boundary does not include recent locations identified for Saskatchewan (Proulx and Proulx 2012).

Special Significance

In Canada, Western Harvest Mouse occurs only in restricted habitats of the intermontane grasslands of British Columbia and the mixed-grass prairie of southern Alberta and possibly south-central Saskatchewan. The two designatable units are both at the northernmost limits of their North American range. Populations at a species' geographic extent may be instrumental for maintaining evolutionary potential (Scudder 1993).

DISTRIBUTION

Global Range

Western Harvest Mouse is endemic to North America and found in parts of west-central Mexico and the west and central US (Figure 1). The species occurs at its northern limit in southwestern Canada (Hall 1981).

Canadian Range

The Canadian distribution of Western Harvest Mouse is restricted to the intermontane grasslands of south-central British Columbia (*R. m. megalotis*) and the dry mixed-grass prairie of southeastern Alberta (*R. m. dychei*). The British Columbia and Alberta populations account for 0.3 and 1.7% of the total range of the *megalotis* and *dychei* subspecies, respectively.

The *megalotis* subspecies is found in the Okanagan Valley, as far north as Vernon, and in the Similkameen River Valley, as far north as Keremeos (Nagorsen 1995; Figure 2). The mouse has not been captured in the central Okanagan near Kelowna, suggesting that the Vernon subpopulation is isolated from subpopulations to the south. The mouse has not been captured in adjacent valleys, including the Thompson and Kettle River valleys (Nagorsen 1995). However, low trapping effort and success (Sullivan and Sullivan 2004) make the absence of records an unreliable means of fully documenting distribution. Historical records are for Skaha Lake (1942), Vaseux Lake (1947) and Okanagan Lake (1956) (Figure 2), and all occur within the extant range. It is unclear whether these specific sites have been re-surveyed adequately.

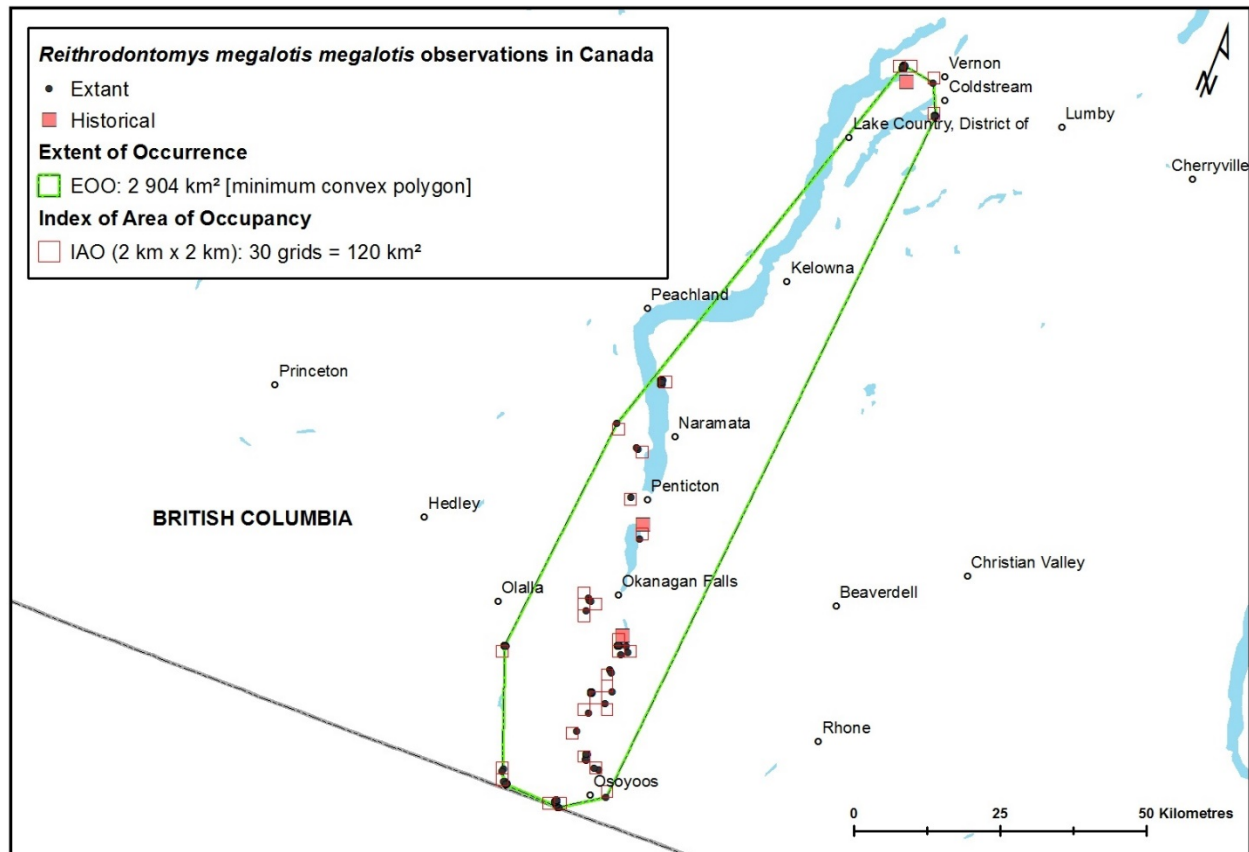


Figure 2. Distribution of the *megalotis* subspecies of Western Harvest Mouse (*Reithrodontomys megalotis megalotis*) in British Columbia. Historical records are from 1942 to 1956 (data from British Columbia Conservation Data Centre; Canadian Department of National Defence).

Little is known about the distribution of the *dychei* subspecies. In Alberta, the mouse has been documented at only four localities. Prior to 1994, its distribution was based on three museum specimens collected near Milk River, Medicine Hat, and in the Pinhorn Grazing Reserve near Manyberries (Moore 1952; Smith 1993). The only recent records of Western Harvest Mouse within Alberta are from the Suffield NWA (Reynolds *et al.* 1999; G. Wilson pers. comm. 2018). During 1994 and 1995, a total of 95 mice were captured along the South Saskatchewan River within the Suffield National Wildlife Area (Reynolds *et al.* 1999), and 48 were trapped from 2009–2011 (Figure 3).

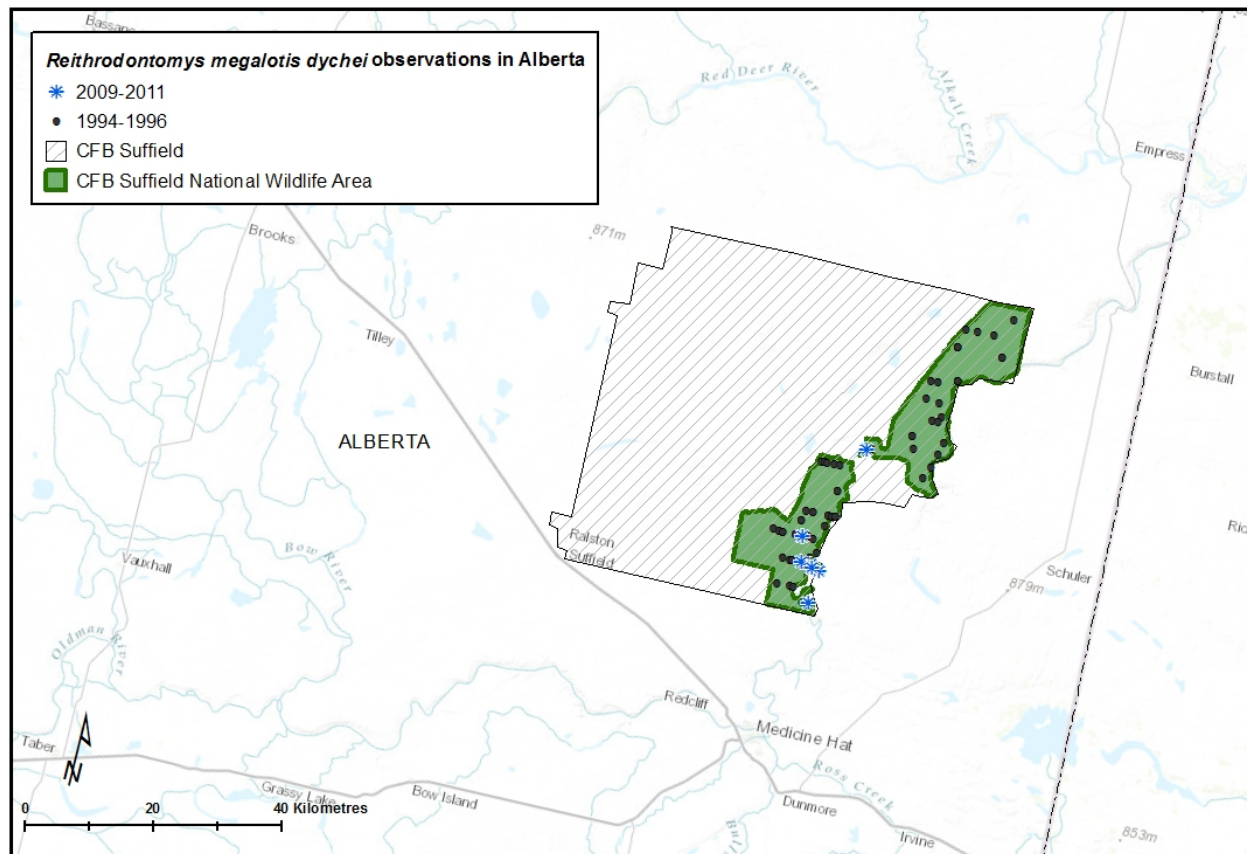


Figure 3. Distribution of the *dychei* subspecies of Western Harvest Mouse (*Reithrodontomys megalotis dychei*) in Alberta, showing location of Suffield NWA and CFB Suffield (data from Environment and Climate Change Canada; COSEWIC 2007).

With the exception of the Suffield records, and one unconfirmed report from an owl pellet located 20 km north of CFB Suffield (Environment Canada 2015), the species has not been documented in Alberta since 1966. Historical records from 1951 to 1966 exist along the US-Alberta border (COSEWIC 2007) but the species was not located in these areas during 6000 trap nights in 69 surveys at 14 sites conducted from 1982–2005 (D. Gummer, pers. comm. in COSEWIC 2007). These results and extensive analysis of owl pellets (Schowalter 2004; R. Poulin and R. Schmelzeisen, pers. comm. in COSEWIC 2007) collected from within the assumed range of this species in Alberta suggest that the species is absent, or very rare, outside the Suffield NWA.

The only records of *R. m. dychei* elsewhere in Canada are 71 hair found during an analysis of 1424 mammalian predator scats (Red Fox [*Vulpes vulpes*], Coyote, American Badger, and Long-tailed Weasel [*Mustela frenata*]) collected in south-central Saskatchewan (Proulx and Proulx 2012; Figure 4). However, despite other sampling efforts there are no live or dead captures from Saskatchewan and there are no records associated with owl pellets, a common method for identifying the distribution of the species.

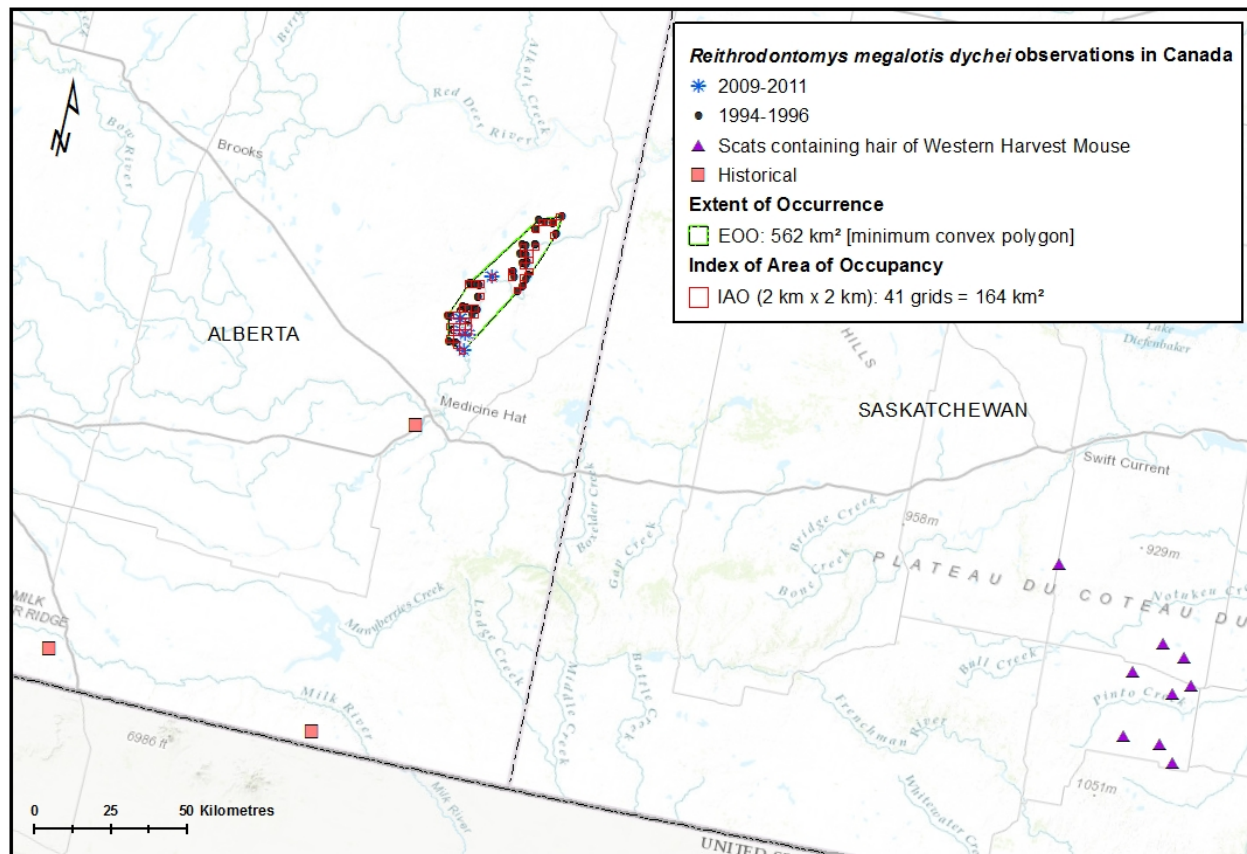


Figure 4. Distribution of the *dychei* subspecies of Western Harvest Mouse (*Reithrodontomys megalotis dychei*) in Canada. Historical records are from 1951 to 1966 (data from Environment and Climate Change Canada; COSEWIC 2007; Proulx and Proulx 2012).

Extent of Occurrence and Area of Occupancy

The extent of occurrence for the *megalotis* subspecies is 2904 km², based on the minimum convex polygon around observations of the species (British Columbia Conservation Data Centre; Canadian Department of National Defence). The area of occupancy, based on a 2 km by 2 km grid over those observations, is 120 km² (Figure 2).

For the *dychei* subspecies, the extent of occurrence is 562 km² and the area of occupancy is 164 km² (Environment Canada 2015). New records from south-central Saskatchewan (Proulx and Proulx 2012) resulted in an extent of occurrence of 12,365 km² and an area of occupancy of 580 km². However, those data are unconfirmed despite much sampling in that portion of Saskatchewan (Environment Canada 2015).

Search Effort

Distribution, abundance and population trends for this species are based on trap effort and scat and pellet analysis of predators, which are discussed in **Sampling Effort and Methods**.

HABITAT

Habitat Requirements

Little is known about the specific habitat requirements of Western Harvest Mouse; habitat use has been inferred from the types of habitats where the mouse is most often captured. This species prefers habitats characterized by tall herbaceous cover (Kaufman and Fleharty 1974; Moulton *et al.* 1981; Davis *et al.* 2000). In the western US and Mexico, they inhabit grasslands, shrub-steppe, edge habitats bordering agricultural areas, coastal salt marshes, and riparian habitats (Webster and Jones 1982). Although the species has been found at elevations up to 4000 m in Mexico, in Canada the mouse is confined to lower elevations (Nagorsen 1994).

The *megalogotis* subspecies is restricted to valley bottoms, or south-facing slopes (up to 780 m) of the South Okanagan Basin, South Okanagan Highland, Okanagan Range, and North Okanagan Basin ecosections (Meidinger and Pojar 1991). Suitable habitats within these ecosections include the very dry and hot subzones of the Bunchgrass, Ponderosa Pine, and Interior Douglas-fir Biogeoclimatic Zones (Meidinger and Pojar 1991; Nagorsen 1995). These areas are shrub-steppe grasslands with abundant tall grasses such as Bluebunch Wheatgrass (*Pseudoroegneria spicata*) and shrubs such as Sagebrush (*Artemisia tridentata*) and Antelope Bitterbrush (*Purshia tridentata*) (Nagorsen 1994; 2005).

Most captures of Western Harvest Mouse by Nagorsen (1995) occurred in dry gullies with dense shrub cover that bordered grassland and shrub-steppe rangeland (n=16 animals). Sullivan (2004) and Sullivan and Sullivan (2006) reported that 58.9% of the 321 Western Harvest Mouse captures occurred in old fields (abandoned (≥ 25 years) hay fields), 20.6% in sagebrush habitats, 15.6% in conventional apple orchards, 2.2% in riparian areas, 1.6% in Ponderosa Pine (*Pinus ponderosa*) forests, 0.9% in hedgerows, and 0.3% in Dwarf Apple (*Malus domestica*) orchards. Western Harvest Mouse occurred at densities of up to 10/ha in old, abandoned (≥ 25 years) hay fields dominated by Crested Wheatgrass (*Agropyron cristatum*) and Quack Grass (*A. repens*) and an unmanaged apple orchard, and up to 5/ha in sagebrush habitats (Sullivan and Sullivan 2005; 2008). Mean density during fall-winter months ranged from 54.3/ha in old fields, which had abundant Alfalfa (*Medicago sativa*) and grass cover, to 4.7/ha in old fields with no Alfalfa and limited grass cover. Consequently, habitat quality is inferred to increase with a well-developed and abundant herb layer. In a study at the Agriculture Canada Summerland Research Station (Summerland, British Columbia), Western Harvest Mouse was captured on two irrigated old fields that had been abandoned for ≥ 25 years (Sullivan and Sullivan 2004).

W. Klenner (unpubl. data) found that Western Harvest Mouse occurred at relatively high densities (up to 22/ha) within ungrazed shrub-steppe habitats dominated by Antelope Bitterbrush (livestock excluded for at least 25 years). The amount of this habitat in the Okanagan is limited. Similar habitats that had been burned in 1991 (three years prior to sampling) supported a Western Harvest Mouse population, although at reduced densities

(up to 13/ha). The mouse was also frequently captured in heavily grazed habitats (little grass cover) dominated by Sagebrush or Antelope Bitterbrush (W. Klenner unpubl. data). These results suggest that, although preferring well-developed grass cover found in habitats without heavy grazing, Western Harvest Mouse is able to persist, or at least disperse, through grazed habitats, as long as there is enough cover provided by shrubs such as Antelope Bitterbrush or Sagebrush.

The only information on habitat associations of the *dychei* subspecies comes from small mammal surveys conducted within the Suffield NWA (Reynolds *et al.* 1999; Bloom *et al.* 2009; Bloom and Wilson 2010; Kemper *et al.* 2013). Based on these records, the mouse is strongly associated with low relief, flat or gently undulating grasslands with sandy soils and an associated dense cover of vegetation. The highest densities are generally associated with microhabitats containing high-quality litter and complex, vertical vegetation structure, particularly tall, dense grass cover (Environment Canada 2015). No captures were made in wet habitats.

Habitat Trends

The amount of shrub-steppe habitat available for Western Harvest Mouse in the Okanagan Valley is limited. Gayton (2016) identified Antelope-brush Steppe and Sagebrush Steppe as sensitive ecosystems that represented only 0.9 and 2.5%, respectively, of the land area of the South Okanagan. The area of those ecosystems has declined over the past 80 years because of the combined effects of agriculture and urbanization and to a lesser extent cattle grazing. In an analysis of Antelope Bitterbrush shrub-steppe habitat, Wood (2003) calculated the rate of loss (primarily due to vineyard development) to be 90 ha/year during 1995–2001. The rate of habitat loss increased to 220 ha/year during 2001–2003. Grazing may alter the species composition of natural grasslands (Tisdale 1947). Within the southern Okanagan, intensive grazing has taken place since the late 1880s (Cannings *et al.* 1987; Gayton 2016). However, there is no evidence that grazing has excluded Western Harvest Mouse from large areas of their range. Vegetation management practices associated with agriculture (e.g., mowing and herbicides) are assumed to decrease the quality of habitat for Western Harvest Mouse, which is associated with vertical structure and cover. However, this mouse appears somewhat flexible in habitat use and has been captured within orchards in the Okanagan, although at lower densities compared to habitats with abundant cover such as old fields (Sullivan 2004; Sullivan and Sullivan 2005; 2006; 2008). The rapidly expanding cities of Penticton, Kelowna, and Vernon likely pose the most significant threat to the habitat of Western Harvest Mouse. The projected trend is for a 30% increase in the population of those cities during 2004–2021 (South Okanagan Regional Growth Strategy 2006).

Given the lack of knowledge of Western Harvest Mouse in Alberta, evaluation of habitat trends is only speculative. It is likely that Alberta's history of cultivation and grazing, as well as urbanization around cities, reduced the area and quality of habitat for small mammals in a similar manner as for British Columbia. However, habitat within the Suffield NWA is relatively stable and there is no evidence that grazing has reduced the distribution of the species.

BIOLOGY

Western Harvest Mouse has not been studied comprehensively, and most information is derived from studies conducted in the US.

Life Cycle and Reproduction

Western Harvest Mouse is nocturnal and forages primarily on the ground for seeds and invertebrates (e.g., caterpillars and moths; Cahalane 1961; Whitaker and Mumford 1972; Meserve 1977; Johnson and Gaines 1988; Jekanoski and Kaufman 1995). The mouse frequently climbs shrubs (as high as 1 m) in search of seeds, flowers and invertebrates, and climbs grass stalks to harvest seeds (Cahalane 1961; Meserve 1977; Jekanoski and Kaufman 1995). In coastal California, up to 50% of spring forage consisted of flowers and seeds; arthropods (primarily lepidopterans) contributed up to 30% of the diet (Meserve 1976).

Western Harvest Mouse can live for up to 18 months in the wild; however, few survive more than six months (Nagorsen 2005). Females become reproductive at 4–12 months of age. Gestation is 21–24 days with an average of 4.1 embryos (range of 1–9) and 2.6 young (range of 1–7; Hayssen *et al.* 1993; Nowak 1999). The maximum number of litters per season is four or five (Hayssen *et al.* 1993). Young are 1–1.5 g at birth, 7–8 mm in length (Jackson 1961), and are weaned at approximately 20 days (Hayssen *et al.* 1993). Generation time is estimated to be 6 months.

Based on an intensive study in southern British Columbia, Western Harvest Mouse bred from March to November producing a variable number of litters per year. Early juvenile survival (an index relating recruitment of young into the trappable population to the number of lactating females) ranged from three young per pregnant female in old fields to five in orchard and six in sagebrush habitats (Sullivan and Sullivan 2005; 2008).

Nests in the US are spherical or cup-shaped, approximately 7.5–12.5 cm in diameter (Webster and Jones 1982; Wilson and Ruff 1999), and usually occur in shrubs up to 1 m above the ground (Webster and Jones 1982), but occasionally in burrows or on the ground (Birkinholz 1967). In general, these nests are composed of plant material with an outer layer of coarsely woven grasses and fibrous plant material and an inner layer of softer plant material such as down or dandelion fluff (Wilson and Ruff 1999). Surveys in the Suffield National Wildlife Area in Alberta reported nests that were low mounds up to 10 cm high and 1 m in diameter, that consisted of thatched grasses at the base of shrubs, resembling the surrounding litter (Kemper *et al.* 2013).

Physiology and Adaptability

Western Harvest Mouse enters a shallow state of torpor when starved and exposed to cold temperatures in a laboratory setting (Thompson 1985). The ability to enter torpor under

natural conditions is likely important for the survival of individuals in Canada due to the cold temperatures experienced by the species at the northern periphery of the distribution (Nagorsen 2005). Although an ability to hibernate has been suggested (O'Farrell 1974), this mouse has been captured throughout the year in British Columbia (Sullivan and Sullivan 2004).

The potential for Western Harvest Mouse to enter torpor when faced with a lack of food and extreme cold (Thompson 1985), its high rates of reproduction (Bancroft 1967; Hayssen *et al.* 1993) and recruitment (Sullivan and Sullivan 2008), and some moderate dispersal ability (Whitaker and Mumford 1972; Ford 1977) combine to make it adaptable to environmental stochasticity. Given adequate connectivity among suitable patches of habitat, these mice appear to be resilient to local extirpation events. For example, despite being susceptible to fire (Kaufman *et al.* 1988), this mouse is a common resident throughout the fire-dependent grasslands of most of North America.

Dispersal and Migration

O'Farrell (1978) estimated a mean home range of 0.95 ha for Western Harvest Mouse, while Meserve (1977) reported home ranges of between 0.44 and 0.56 ha. Dispersal distances are generally <300 m (Brant 1962; Clark *et al.* 1988; Skupski 1995); however, movements of 375–3200 m have been reported for some individuals (Clark *et al.* 1988). Males generally move farther than females (Clark *et al.* 1988; Skupski 1995).

Western Harvest Mouse has the ability to relocate to previously disturbed habitat. For example, individuals returned to their home areas after being displaced by up to 300 m (Fisler 1966). However, Kozel and Fleharty (1979) found that mice did not return after having been transported to the other side of a road on the edge of their home range.

Documented range expansions of Western Harvest Mouse in Illinois and Indiana indicate the potential for dispersal when appropriate habitats are available. Dispersal corridors could include road rights-of-way (Whitaker and Mumford 1972; Ford 1977). Western Harvest Mouse had the highest recruitment and immigration rates of any small mammal species trapped during a study near Summerland, British Columbia (Sullivan and Sullivan 2008). This suggests that the species is capable of colonizing new areas of suitable habitat that are within the typical, but relatively limited dispersal distance (<300 m) or annual range (0.95 ha) of an individual mouse.

Interspecific Interactions

Possible predators of Western Harvest Mouse include owls (Marti 1974; Cannings 1987), hawks, jays, shrikes, Prairie Rattlesnake (*Crotalus viridis*), Gophersnake (*Pituophis catenifer*), Raccoon (*Procyon lotor*), foxes, weasels, skunks, American Badger (*Taxidea taxus*) and Coyote (*Canis latrans*) (Brant 1962; Kaufman *et al.* 1993; Brillhart and Kaufman 1994; Forsyth 1999; Wilson and Ruff 1999). Cannings (1987) found that Western Harvest Mouse made up <5% of the diet of Northern Saw-whet Owl (*Aegolius acadicus*) in southern British Columbia.

Western Harvest Mouse may compete locally with other similarly sized rodents such as Deer Mouse, House Mouse, and Montane Vole (*Microtus montanus*) (Johnson and Gaines 1988; Heske *et al.* 1994; Fa *et al.* 1996; Stapp 1997). In grassland communities of California, Heske *et al.* (1984) observed that in years when California Vole (*Microtus californicus*) were abundant, Western Harvest Mouse became locally extinct. Removal of kangaroo rats (*Dipodomys* spp.) in Arizona resulted in higher densities of Western Harvest Mouse (Skupski 1995). In British Columbia, Montane Vole may be an important competitor (Sullivan and Sullivan 2004). Competition with Deer Mouse, the dominant mouse in habitats with Western Harvest Mouse, is less likely because these species appear to exploit different microhabitats (Cahalane 1961; Kaufman *et al.* 1988).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Trapping has been the primary method to determine the presence and abundance of Western Harvest Mouse in Canada. The distribution of the species also has been documented through the analysis of hair and hard body parts in the scat of avian and terrestrial predators. Owl pellets, for example, represent extensive temporal and geographical foraging effort of the predator, as compared to the relatively short-term (e.g., 5–7 days per site) and limited area sampled by traps.

Search effort for trapping data is most often described in terms of trap nights. Kill trapping along transects was commonly used to determine presence/absence (e.g., Reynolds *et al.* 1999), whereas 1-ha live-trapping grids were used to estimate abundance (e.g., Sullivan and Sullivan 2004; Kemper *et al.* 2013; W. Klenner unpubl. data).

Nagorsen (1995) used a combination of live and kill trapping along 500-m transects in the summers of 1990 to 1992 to assess presence/absence of the *megalotis* subspecies in British Columbia. More recently, Sullivan and Sullivan (2008) used live trapping to examine the dynamics of Great Basin Pocket Mouse (*Perognathus parvus*) and Western Harvest Mouse in southern British Columbia. In 2008, a natural resource inventory was conducted in the Vernon Military Camp, comprising 2843 trap nights (Manweiler pers. comm. 2018).

For the *dychiei* subspecies, the Suffield National Wildlife Area, Alberta, was extensively live trapped from 2009–2014 (Table 1). In a study of owl pellets from the northern Great Plains in Alberta, Saskatchewan and Manitoba, remains of 33,697 small mammals were found (Heisler *et al.* 2014). In Saskatchewan, Proulx and Proulx (2012) collected mammalian carnivore scat from 2008–2010 and examined it for small mammal remains. Small mammal trapping and owl pellet surveys have also been used extensively in south-central Saskatchewan (Poulin pers. comm. 2017).

Table 1. Sampling effort and capture success for Western Harvest Mouse, *dychiei* subspecies, in and near Suffield National Wildlife Area, Alberta, 2009–2014.

Year	Trap nights	Captures	References
2009	4469	15	Bloom <i>et al.</i> 2009
2010	5739	10, plus 1 recapture	Bloom and Wilson 2010, Kemper <i>et al.</i> 2013
2011	3705	23, plus 6 recaptures	Kemper <i>et al.</i> 2013
2013	1140	0	Wilson and Westworth 2014, Zimmer pers. comm. 2018
2014	1080	0	Wilson and Westworth 2014, Zimmer pers. comm. 2018

Abundance

There are no absolute or relative estimates of abundance for either designatable unit of Western Harvest Mouse. However, subpopulations of both subspecies likely fluctuate widely and rapidly, in response to changes in vegetation cover and climatic conditions (Environment Canada 2015).

There is strong evidence that the species is naturally rare within Canada, typically comprising <10% of the total number of small mammals within a given site (Nagorsen 1995; Cannings *et al.* 1999; Reynolds *et al.* 1999). As examples of the rarity of the species, one Western Harvest Mouse was noted within the remains of 33,697 small mammals observed in owl pellets collected over 15 years from Alberta, Saskatchewan and Manitoba (Heisler *et al.* 2014). Western Harvest Mouse has not been captured or directly observed in Saskatchewan, despite extensive trapping efforts (many thousands of small mammals) and owl pellet sampling (more than 80,000 small mammals) (Poulin pers. comm. 2017). However, Proulx and Proulx (2012) reported Western Harvest Mouse hair in 71 of 1,424 carnivore scats collected in south-central Saskatchewan.

Fluctuations and Trends

Dramatic seasonal fluctuations have been reported for the *megalotis* subspecies (Sullivan and Sullivan 2008). During several multi-year studies, population densities were reported to peak during the fall and winter months and drop off sharply during midsummer (Sullivan and Sullivan 2004, 2005, 2008; W. Klenner, unpubl. data). A four-year study did not detect any multi-annual cycle (Sullivan and Sullivan 2005); however, density fluctuated between (10 to 40/ha; W. Klenner, pers. comm. in COSEWIC 2007) and within years (~1 to 10/ha; Sullivan and Sullivan 2008). Consistent with other rodent species, extreme fluctuations (>1 order of magnitude) were reported for populations in the United States (Skupski 1995; Brady and Slade 2004).

There are no direct quantitative estimates of population numbers or interyear variation in abundance for the *dychiei* subspecies. However, the number of Western Harvest Mouse captured within the Suffield National Wildlife Area ranged from 80 in 1994, to 15 in 1995, and 0 in 1996. While sampling effort was not equal among years it was of a similar magnitude (Reynolds *et al.* 1999). Consistent with populations in the United States (Skupski 1995; Brady and Slade 2004), extreme fluctuations are assumed to occur for the *dychiei* subspecies.

Rescue Effect

Western Harvest Mouse is considered common within the US states that border the Canadian populations (NatureServe 2018), and thus there is the potential for a rescue effect. Rescue is a function of moderate dispersal ability (i.e., approximately 300 m; Whitaker and Mumford 1972; Ford 1977) and the high rates of recruitment (Sullivan and Sullivan 2008). However, in the event of a significant population decline or local extirpation within Canada, a successful rescue effect may be impeded by the lack of connectivity among suitable habitat fragments located between the secure subpopulations to the south and the range in Canada. A better understanding of the habitat requirements of this mouse, as well as its ability to disperse through the existing fragmented landscape of southern British Columbia, Alberta and Saskatchewan, is required before the likelihood of population rescue can be estimated.

THREATS AND LIMITING FACTORS

Threats

Threats for the Western Harvest Mouse were assessed, organized, and based on the IUCN-CMP (World Conservation Union-Conservation Measures Partnership) unified threats classification system (Master *et al.* 2012) using definitions in Salafsky *et al.* (2008). Threats are defined as the proximate activities or processes that directly and negatively affect the population.

The primary immediate threat to the *megalotis* and *dychei* subspecies are the removal of native grass and shrubs and a changing climate, respectively. The corresponding overall threat impact is High-Medium and Low (Appendices 1 and 2).

Megalotis Subspecies

Threat 2.3: Livestock farming and ranching – MEDIUM-LOW IMPACT

Intensive cattle and horse grazing is a threat to Western Harvest Mouse. Grazing can decrease cover and food availability, resulting in a reduction in the quality of habitat. At high densities, livestock can trample mouse nests, and grazing can induce changes to plant communities and vegetative cover. In eastern Colorado, for example, Moulton *et al.* (1981) found that Western Harvest Mouse was not present on grazed sagebrush habitats but was common in ungrazed areas. Although this mouse may prefer the cover provided within ungrazed habitats, it is found on grazed sites when shrub cover is present (W. Klenner, pers. comm. in COSEWIC 2007).

Threat 1.1: Housing and urban areas – LOW IMPACT

Urbanization is likely one of the greatest threats to the habitat of Western Harvest Mouse in British Columbia. To date, urban development has eliminated large areas of shrub-steppe habitats important to this mouse (British Columbia Ministry of Environment, Lands and Parks 1998; Wood 2003; Gayton 2016) and development is expected to increase by 5% by 2022 (B.C. Ministry of Environment 2014). Urban development eliminates habitat for Western Harvest Mouse; however, the threat is localized and the overall impact is low.

Threat 2.1: Annual and perennial non-timber crops – LOW IMPACT

Agriculture can affect the area and quality of habitat for Western Harvest Mouse, and intensification is continuing in the Okanagan. Conversion of grasslands to orchards, cultivated fields and, more recently, vineyards has eliminated large areas of shrub-steppe habitats important to this mouse (British Columbia Ministry of Environment, Lands and Parks 1998; Wood 2003; Gayton 2016), and much of what is left is fragmented. Fields and orchards provide only marginal habitat for this species, and vineyards are sub-marginal.

Threat 4.1: Roads and railroads – LOW IMPACT

Roads may be a barrier to dispersal and movement of Western Harvest Mouse. Kozel and Fleharty (1979) found that Western Harvest Mouse did not return after having been transported to the other side of a road on the edge of the home range. Mowing of roadside habitats also poses a significant threat, although the use of edge habitats associated with roads may be important for the dispersal of this species among habitat fragments (British Columbia Ministry of Environment 2014).

Threat 7.1: Fire and fire suppression – LOW IMPACT

Western Harvest Mouse is likely susceptible to the direct effects of fire (i.e., mortality; Kaufman *et al.* 1988) as well as indirect effects that fire has on habitat (i.e., removal of cover and food). Kaufman *et al.* (1988) and McMillan *et al.* (1995) noted population declines following fire in ungrazed tall prairie in Kansas. In British Columbia, a 1993 fire burned the entire Hayne's Lease Ecological Reserve near Osoyoos Lake and a 2003 fire burned most of Okanagan Mountain Park likely reducing the habitat and number of Western Harvest Mouse in those areas. However, densities of up to 13 mice/ha were recorded 3 years following a fire in the southern Okanagan (W. Klenner, pers. comm. in COSEWIC 2007), suggesting that the impacts of fire may be short-lived. In addition, Masters *et al.* (1998) found that prescribed burning of dense pine stands in Oklahoma resulted in an increase in herbaceous forage and an increase in densities of Fulvous Harvest Mouse (*Reithrodontomys fulvescens*), a species with similar habitat requirements. Fire suppression could result in forest ingrowth as well as extreme fire events. Both processes would result in the loss of habitat for Western Harvest Mouse.

Threat 7.3: Other ecosystem modifications – LOW IMPACT

Ecosystem modifications that remove grass or shrub cover, such as the mowing of roadside habitat, can affect Western Harvest Mouse.

Threat 8.1: Invasive non-native/alien species – LOW IMPACT

Although there has been no direct research in the Okanagan, house and other feral cats are believed to be found within 15-20% of Western Harvest Mouse habitat (British Columbia Ministry of Environment 2014), not necessarily in proximity to housing. The impact of non-native plants on Western Harvest Mouse is unknown (B.C. Ministry of Environment 2014). However, lower densities of small mammals is correlated with increased prevalence of invasive Cheatgrass (*Bromus tectorum*) (Melaschenko 2010). The spread and establishment of Cheatgrass in the Okanagan has the potential to affect the distribution and abundance of Western Harvest Mouse.

Threat 9.3: Agricultural and forestry effluents – LOW IMPACT

The use of rodenticides to control vole (*Microtus* spp.) and Northern Pocket Gopher (*Thomomys talpoides*) populations in old-field and orchard habitats in British Columbia may have significant impacts on local populations of Western Harvest Mouse. Orchards are not the preferred habitat for Western Harvest Mouse; thus, mortality from poisoning is assumed to be low (Sullivan and Sullivan 2005). A high-density of animal waste, including manure, could influence the quality of habitat for Western Harvest Mouse.

Dychei Subspecies

Threat 7.1: Fire and fire suppression – LOW IMPACT

Western Harvest Mouse is likely susceptible to the direct and indirect effects of fire, as described in the section for the *megalotis* subspecies. Frequency of fire in the Suffield NWA is relatively low as the result of fire suppression. Fires created by military activities could be large and encroach on the NWA.

Threat 11.2: Droughts – LOW IMPACT

Although exact patterns of climate change across the Canadian prairies are temporally uncertain and spatially variable, droughts may become more frequent and last longer (Lemmen *et al.* 2008; Bonsal *et al.* 2017; Cui *et al.* 2017). This can result in a change in community composition and plant phenology with a reduction in the availability and quality of forage for Western Harvest Mouse, as is predicted for Black-tailed Prairie Dog (*Cynomys ludovicianus*), another grassland-dependent species that is found in Canada at the northern periphery of its range (Stephens *et al.* 2018).

Limiting Factors

Populations of Western Harvest Mouse in the US demonstrate annual fluctuations in abundance (Skupski 1995; Brady and Slade 2004); such population dynamics are likely typical of Canadian populations as well (Environment Canada 2015). During such fluctuations, low abundance may result in greater risk from demographic and environmental stochasticity. Small and isolated populations, typical of Western Harvest Mouse, are more prone to the negative effects of stochastic events (Environment Canada 2015).

Number of Locations

The number of locations for the *megalotis* subspecies is likely many. Although there appears to be an isolated subpopulation in the Vernon area, the remaining records extend over an approximately 70 km length of the Okanagan Valley, with other records in the Similkameen Valley. The most plausible threats are habitat loss due to fire and conversion of grassland/steppes to wineries and housing. These threats are likely to vary across subpopulations and occur over a relatively long time period (> 3 years) resulting in many locations (i.e., > 10).

The number of locations is likely many for the *dychei* subspecies. The Suffield NWA covers a relatively large area (~458 km²) and critical habitat was identified within the surrounding Canadian Forces Base Suffield as well as provincial Crown Land (Environment Canada 2014). Given the geographic distribution of the *dychei* subspecies and the nature of the threats, it is unlikely that a single threatening event, such as fire, would affect all individuals within a subpopulation. As with the *megalotis* subspecies, the number of locations likely exceeds 10.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

The *dychei* subspecies is listed as Endangered, and the *megalotis* subspecies is listed as Special Concern under Canada's *Species at Risk Act*.

Non-Legal Status and Ranks

Western Harvest Mouse is listed on the IUCN Red List of Threatened Species as Least Concern (IUCN 2018). NatureServe (2017) ranks the species as G5, Secure, globally, Vulnerable to Imperiled in Canada (N2N3) and in British Columbia (S2S3), and as Critically Imperiled (S1) in Alberta. The British Columbia Conservation Data Centre (2017) lists the *megalotis* subspecies as S3, on the provincial Blue List. The status of the *dychei* subspecies is Undetermined in Alberta (Province of Alberta 2000).

Habitat Protection and Ownership

Western Harvest Mouse is found within several Crown and private protected areas in British Columbia; for example, Kalamalka Lake Provincial Park, South Okanagan Grasslands Protected Area, White Lake Grassland Protected Area, Vaseux-Bighorn National Wildlife Area, Hayne's Lease Ecological Reserve, and Sage and Sparrow Conservation Area (British Columbia Ministry of Environment 2014). In Alberta, the entire extant population is found within the Suffield NWA — a large area of protected native prairie. The scats and resulting hair samples collected in Saskatchewan were all found on private land (Proulx and Proulx 2012), although the mice may have been predated elsewhere.

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COLLECTIONS EXAMINED

None

Appendix 1. Threats Assessment for Western Harvest Mouse *megalotis* subspecies.

Species or Ecosystem Scientific Name		<i>Megalotis</i> - Western Harvest Mouse	
Element ID		Elcode	
Date (Ctrl + ";" for today's date):		16/10/2018	
Assessor(s):		Nyree Sharp (report writer), Karen Timm (COSEWIC Secretariat), Graham Forbes (Terrestrial Mammals Co-chair); Jennifer Heron (facilitator); Albrecht Schulte-Hostedde (SSC member); Chris Johnson (Terrestrial Mammals Co-chair); Claire Jardine (SSC member); Greg Wilson (ECCC); Dave Fraser (BC Rep).	
References:			
Overall Threat Impact Calculation Help:			
		Level 1 Threat Impact Counts	
Threat Impact		high range	low range
A	Very High	0	0
B	High	0	0
C	Medium	1	0
D	Low	5	6
Calculated Overall Threat Impact:		High	Medium
Assigned Overall Threat Impact:		BC = High - Medium	
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	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	The Western Harvest Mouse in the Okanagan region occupies low-elevation grassland habitats where the human population is growing. Urban development is predicted to increase 5% by 2022 in the Okanagan-Similkameen Regional District. Locations that are particularly at risk are those that are on private land and near residential areas. Habitat loss is usually extreme after development occurs; however, the threat is localized and the overall impact is low (B.C. Ministry of Environment 2014).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Industrial infrastructure is expected to expand, especially in vicinity of built-up areas in Kelowna, Penticton, and Vernon; however, the impact is thought to be negligible in area (B.C. Ministry of Environment 2014). Industrial parks and the airport will expand in the future although the impact is thought to be highly localized and not significant (B.C. Ministry of Environment 2014).
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs)	Threat is negligible although a new golf course in Osoyoos is possible (B.C. Ministry of Environment 2014).
2	Agriculture & aquaculture	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
2.1	Annual & perennial non-timber crops	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	Conversion of grassland into crop production has eliminated large areas of shrub-steppe habitat important to the WHM, although only a small portion of the species' habitat is expected to be affected, therefore the overall impact is thought to be low (B.C. Ministry of Environment 2014).
2.2	Wood & pulp plantations						no
2.3	Livestock farming & ranching	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Cattle grazing may change abundance and composition and structure of plant communities and as a result dependent small mammal communities. Densities of WHM are positively correlated with depth of plant litter and depth of litter can be negatively affected by grazing. WHM may decline due to loss of cover and forage availability. This threat is uncertain and requires further investigation (B.C. Ministry of Environment 2014).
2.4	Marine & freshwater aquaculture						no
3	Energy production & mining		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
3.1	Oil & gas drilling						no
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	There is limited quarrying for gravel, sand and roadside materials across the distribution of the subspecies. Only a negligible amount of habitat is likely to be lost through those activities (British Columbia Ministry of Environment 2014).
3.3	Renewable energy						no
4	Transportation & service corridors	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.1	Roads & railroads	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Roads may be significant barrier to dispersal and movement of WHM. Loss of grasslands due to roads and railways may be significant, but not quantified at this time. More than 90% of all known WHM observations are close to roads or densely populated areas. These features may have a positive impact as WHM may exploit linear and edge habitats (B.C. Ministry of Environment 2014). However, Kozel and Fleharty (1979) found that no WHM returned after having been transported to the other side of a road on the edge of their home range. There is the possibility of direct mortality from road traffic.
4.2	Utility & service lines		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Trenching for installation of utility pipes may trap WHM causing direct mortality, if it is not mitigated. Impact at the population level is expected to be negligible (B.C. Ministry of Environment 2014).
4.3	Shipping lanes						no
4.4	Flight paths						no
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						no
5.2	Gathering terrestrial plants						no
5.3	Logging & wood harvesting						no
5.4	Fishing & harvesting aquatic resources						no
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Off-road vehicles are popular in the Okanagan and may cause long-term damage to grasslands and the habitat of the WHM. Scope is likely negligible. Hikers, bikers, birdwatchers and campers would likely only affect a negligible portion of WHM habitat (B.C. Ministry of Environment 2014).
6.2	War, civil unrest & military exercises						no
6.3	Work & other activities						no

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7	Natural system modifications	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)	
7.1	Fire & fire suppression	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)	WHM are likely susceptible to both the direct and indirect effects of fire. Forest fires will reduce vegetation potentially limiting the extent or quality of habitat for the mouse. WHM nest above ground, thus, fire may result in high mortality of nesting mice. Fire suppression increases the likelihood of a catastrophic fire which may lead to drastic population reductions and severely alter foraging habitat. Also, fire suppression may result in change of the vegetation community (e.g., forest encroachment) that reduces habitat quality. In total, the overall impact of fire is thought to be low. Past studies suggest that population recovery following fire is rapid due to immigration and increased reproduction (B.C. Ministry of Environment 2014).
7.2	Dams & water management/use						no
7.3	Other ecosystem modifications	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	WHM can occupy edge habitats near roadsides and regular roadside maintenance such as mowing can affect the species occupying those habitats. However, this is a negligible portion of the species' habitat (B.C. Ministry of Environment 2014).
8	Invasive & other problematic species & genes	D	Low	Restricted (11-30%)	Moderate (11-30%)	High (Continuing)	
8.1	Invasive non-native/alien species	D	Low	Restricted (11-30%)	Moderate (11-30%)	High (Continuing)	The severity of house cat predation is estimated to be moderate as house cats and other feral cats are believed to be found with 15-20% of WHM habitat. The problem is most severe near human settlement. The impact of invasive plants is not well understood. Cheatgrass and other non-native species will likely influence the composition of plant communities with potential impacts for WHM.
8.2	Problematic native species						no
8.3	Introduced genetic material						no
9	Pollution	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	
9.1	Household sewage & urban waste water						no

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.2	Industrial & military effluents						no
9.3	Agricultural & forestry effluents	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	Rodenticides that are used to target vole and Northern Pocket Gopher populations may impact the WHM. WHM is not specifically targeted, but if the assumption that Western Harvest Mouse rely on edge habitats is correct, then this may have a greater impact than presently known. The impact from rodenticide poisoning is currently low as only a small portion of the species' range occurs where rodenticides are used (B.C. Ministry of Environment 2014). Manure and other animal waste could reduce the quality of habitat.
9.4	Garbage & solid waste						no
9.5	Air-borne pollutants						no
9.6	Excess energy						no
10	Geological events						
10.1	Volcanoes						no
10.2	Earthquakes/tsunamis						no
10.3	Avalanches/landslides						no
11	Climate change & severe weather						
11.1	Habitat shifting & alteration						no
11.2	Droughts						Droughts were estimated to have a Low threat for the <i>dychei</i> subspecies. However, there is no direct or indirect evidence to assess the influence of climate change for the <i>megalotis</i> subspecies.
11.3	Temperature extremes						no
11.4	Storms & flooding						no
Classification of Threats adopted from IUCN-CMP, Salafsky <i>et al.</i> (2008).							

Appendix 2. Threats Assessment for Western Harvest Mouse *dychei* subspecies.

Species or Ecosystem Scientific Name	Dychei - Western Harvest Mouse																												
Element ID		Elcode																											
Date (Ctrl + ";" for today's date):																													
Assessor(s):	Nyree Sharp (report writer), Graham Forbes (Terrestrial Mammals Co-chair); Jennifer Heron (facilitator); Karen Timm (COSEWIC Secretariat); Albrecht Schulte-Hostedde (SSC member); Claire Jardine (SSC member); Greg Wilson (ECCC); Chris Johnson (Terrestrial Mammals Co-chair)																												
References:																													
Overall Threat Impact Calculation Help:	<table border="1"> <thead> <tr> <th colspan="2" rowspan="2">Threat Impact</th> <th colspan="2">Level 1 Threat Impact Counts</th> </tr> <tr> <th>high range</th> <th>low range</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>Very High</td> <td>0</td> <td>0</td> </tr> <tr> <td>B</td> <td>High</td> <td>0</td> <td>0</td> </tr> <tr> <td>C</td> <td>Medium</td> <td>0</td> <td>0</td> </tr> <tr> <td>D</td> <td>Low</td> <td>2</td> <td>2</td> </tr> <tr> <td colspan="2">Calculated Overall Threat Impact:</td> <td>Low</td> <td>Low</td> </tr> </tbody> </table>			Threat Impact		Level 1 Threat Impact Counts		high range	low range	A	Very High	0	0	B	High	0	0	C	Medium	0	0	D	Low	2	2	Calculated Overall Threat Impact:		Low	Low
Threat Impact		Level 1 Threat Impact Counts																											
		high range	low range																										
A	Very High	0	0																										
B	High	0	0																										
C	Medium	0	0																										
D	Low	2	2																										
Calculated Overall Threat Impact:		Low	Low																										
Assigned Overall Threat Impact:	D = Low																												
Impact Adjustment Reasons:																													
Overall Threat Comments	Calculator was conducted for Alberta subpopulation only. The Saskatchewan records (Proulx and Proulx 2014) are unconfirmed and there is little known about threats across the distribution of those records.																												

Threat	Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1 Residential & commercial development					
1.1 Housing & urban areas					no
1.2 Commercial & industrial areas					no
1.3 Tourism & recreation areas					no
2 Agriculture & aquaculture	Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	
2.1 Annual & perennial non-timber crops					Not applicable to the Suffield NWA. This would be considered a threat outside of the NWA, but this wasn't considered in the scoring of the threat.
2.2 Wood & pulp plantations					no

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.3	Livestock farming & ranching		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	In the Suffield NWA, about 40% of the site allows livestock grazing; however, the severity is not considered serious (Wilson pers. comm. 2018). Although grazing may alter the species composition of grassland communities, the impact for Western Harvest Mouse is thought to be negligible.
2.4	Marine & freshwater aquaculture						no
3	Energy production & mining						
3.1	Oil & gas drilling						There are existing gas structures in the NWA but there hasn't been any new development; existing wells and infrastructure are maintained but not expanded.
3.2	Mining & quarrying						no
3.3	Renewable energy						no
4	Transportation & service corridors						
4.1	Roads & railroads						Very few roads across the range of the Alberta subpopulation; access roads for oil and gas facilities are not maintained. Given the limited footprint, this is not thought to be an impact for WHM.
4.2	Utility & service lines						no
4.3	Shipping lanes						no
4.4	Flight paths						no
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						no
5.2	Gathering terrestrial plants						no
5.3	Logging & wood harvesting						no
5.4	Fishing & harvesting aquatic resources						no
6	Human intrusions & disturbance						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.1	Recreational activities						Not applicable. The only people in Suffield NWA are researchers or oil and gas personnel, so no public. They have allowed some people to hunt elk during hunting season, but this is by foot.
6.2	War, civil unrest & military exercises		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	The Suffield NWA is adjacent to Canadian Forces Base Suffield resulting in some possibility of military exercises or activity affecting the habitat or resulting in direct mortality of Western Harvest Mouse. However, the threat is negligible.
6.3	Work & other activities						no
7	Natural system modifications	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
7.1	Fire & fire suppression	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Fire can be caused by military activities. Fire suppression does lead to a higher probability of a large fire with greater impacts for the WHM.
7.2	Dams & water management/use						no
7.3	Other ecosystem modifications		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	The impact of invasive plants is not well understood. Fire suppression could alter plant communities with the potential to reduce the area or quality of habitat for the WHM.
8	Invasive & other problematic species & genes						
8.1	Invasive non-native/alien species						No cats have ever been seen at Suffield.
8.2	Problematic native species						no
8.3	Introduced genetic material						no
9	Pollution						
9.1	Household sewage & urban waste water						no
9.2	Industrial & military effluents						No evidence of pollution from military activities.
9.3	Agricultural & forestry effluents						no
9.4	Garbage & solid waste						no
9.5	Air-borne pollutants						no
9.6	Excess energy						no

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10	Geological events						
10.1	Volcanoes						no
10.2	Earthquakes/tsunamis						no
10.3	Avalanches/landslides						no
11	Climate change & severe weather	D	Low	Pervasive (71-100%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs)	
11.1	Habitat shifting & alteration						no
11.2	Droughts	D	Low	Pervasive (71-100%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs)	Droughts will be more frequent and sustained with potential impacts for WHM habitat (Lemmen <i>et al.</i> 2008; Stephens <i>et al.</i> 2018).
11.3	Temperature extremes						no
11.4	Storms & flooding						no
Classification of Threats adopted from IUCN-CMP, Salafsky <i>et al.</i> (2008).							