COSEWIC
Assessment and Status Report

on the

Great Basin Gophersnake
Pituophis catenifer deserticola

in Canada

THREATENED
2013

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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Waye, H., and C. Shewchuk. 2002. COSEWIC status report on the Gophersnake *Pituophis catenifer* in Canada *in* COSEWIC assessment and status report on the Gophersnake *Pituophis catenifer* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-33 pp.

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COSEWIC
Assessment Summary

Assessment Summary – May 2013

Common name
Great Basin Gophersnake

Scientific name
Pituophis catenifer deserticola

Status
Threatened

Reason for designation
This large, non-venomous snake is restricted in Canada to the dry southern interior of British Columbia, where it occurs within landscapes fragmented by roads, orchards, vineyards, and houses. Because of its low reproductive rate and late age at maturity, seasonal migrations, and habit of lingering on warm roads, this snake is especially vulnerable to road mortality. This mortality, together with habitat loss and degradation and intentional and inadvertent killing, are expected to continue and result in population declines over the next 24 years (3 generations).

Occurrence
British Columbia

Status history
Designated Threatened in May 2002. Status re-examined and confirmed in May 2013.

COSEWIC
Executive Summary

Great Basin Gophersnake
Pituophis catenifer deserticola

Wildlife Species Description and Significance

The Great Basin Gophersnake, *Pituophis catenifer deserticola*, is the largest snake native to British Columbia. Adults measure up to 2.4 m in total length. The base body colour is grey, cream or yellowish; the underside is white. There is a dark band between the eyes, and two dark bands extending from above the eye to the upper jaw. The back and sides are marked with a series of regularly spaced dark brown or black rectangular blotches that become stripes on the tail. The Great Basin Gophersnake is one of a suite of species vulnerable to development and degradation of native grasslands.

Distribution

The Great Basin Gophersnake's range extends from southern British Columbia to Washington, Oregon, California, Arizona, Colorado, Nevada, Idaho, Utah, and Wyoming. The Canadian portion consists of parts of the dry interior of British Columbia and includes warm, dry grassland valleys of the Thompson and Okanagan rivers, Fraser River Valley from Lillooet north to Big Bar Creek, Lower Nicola River Valley, Similkameen River Valley, from the international boundary to Hedley, and Kettle River Valley from Rock Creek to Christina Lake. The species occurs at elevations from 200 – 1000 m throughout most of its Canadian range but may occasionally be found at elevations up to 1700 m.

Habitat

To complete their life cycle, gophersnakes require access to foraging, hibernating, and egg-laying habitats that are relatively close together (optimally within approximately 500 m). They forage in a variety of open habitats, including grasslands, dry open forest, edges of cultivated fields, shrubby areas, talus, wetlands, and riparian areas. Gophersnakes shelter in underground burrows, at the base of shrubs, or under rocks, logs or other cover objects. Females lay their eggs in burrows on warm grassy slopes or in fine talus. Gophersnakes hibernate during winter in dens in bedrock crevices, in deep burrows in earth or in road-fill, or in interstitial spaces between rocks in talus slopes. They often share winter dens with other snake species, such as Desert Nightsnakes, Western Rattlesnakes, Western Yellow-bellied Racers, and Terrestrial Gartersnakes.

Biology

Increasing ground temperatures in spring (March – April) cause gophersnakes to rouse from winter dormancy, emerge from their dens, and travel to summer ranges. Mating takes place shortly after the snakes leave their winter dens. Females lay 2 – 8 eggs in June or July in an underground chamber on a warm slope. Most clutches hatch from late August to early October. Gophersnakes travel back to their winter dens in fall, with some individuals returning as early as August. They usually return to the same winter den year after year but will occasionally switch dens.

Females are thought to mature at 3 – 5 years of age, produce 1 small clutch annually or every second year, and may live more than a decade. The generation time is approximately 8 years. Gophersnake populations rely on high adult survivorship for persistence.

Gophersnakes are non-venomous. They feed on small mammals and birds, which they kill by constriction. Predators of gophersnakes and their eggs include badgers, coyotes, foxes, skunks, hawks, owls, and eagles. When threatened, gophersnakes may produce a rattlesnake-like display of tail vibration, hissing and striking. This behaviour probably protects them from some predators but also makes them more likely to be killed by people mistaking this harmless species for a venomous one.

Population Sizes and Trends

Population sizes and trends are poorly known. Gophersnakes are difficult to survey because they spend much of their time underground. Populations are suspected to be declining due to high incidence of road mortality, loss and fragmentation of their grassland habitats by human developments, and other human-caused threats. Declines are also projected for the future due to these factors.

Threats and Limiting Factors

The greatest threat to gophersnakes in Canada is direct mortality, mainly through roadkill but also from construction, mining, forestry and agricultural machinery. Loss and degradation of grassland habitats from urban, industrial and agricultural sources further threaten populations. Strychnine-based poisons used to control Pocket Gophers in orchard and vineyards can result in mortality of snakes that consume contaminated prey. Fire suppression can lead to habitat degradation through forest encroachment onto grasslands. Human persecution is an ongoing threat.

Protection, Status, and Ranks

The Great Basin Gophersnake is on Schedule 1 of the federal *Species at Risk Act*, which prohibits killing or capturing the snakes or destroying their residences on federal lands. The snake is Blue-listed (Special Concern) in British Columbia, with a provincial rank of S2S3 (“imperilled” – “vulnerable”). It is protected under the provincial *Wildlife Act*, which prohibits killing or capturing individuals or keeping them captive except under provincial permit. The Great Basin Gophersnake is listed as Identified Wildlife under the provincial Identified Wildlife Management Strategy, which guides the implementation of management actions for listed species under the provincial *Forest and Range Practices Act*. As of February 2013, 31 known snake den sites have been designated as Wildlife Habitat Areas and receive some degree of protection; 32 additional such areas have been proposed. Overall, approximately 10% of the suitable habitat is located within protected areas.

TECHNICAL SUMMARY

Pituophis catenifer deserticola
Great Basin Gophersnake — Couleuvre à nez mince du Grand Bassin
Range of occurrence in Canada: British Columbia

Demographic Information

Generation time (average age of parents in the population) Calculated based on estimated survival rates in a US population (see **Biology**).	Ca. 8 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? *There is an inferred decline from mortality associated with increasing human activities, mainly from roads, and continued habitat loss*.	Yes
[Observed, estimated, inferred, or suspected] percent of continuing decline in total number of mature individuals within [5 years or 2 generations]: *Inferred and suspected decline from habitat loss and roadkill.*	Unknown
[Observed, estimated, inferred, or suspected] percent reduction in total number of mature individuals over the last [10 years, or 3 generations]: *Inferred and suspected decline from habitat loss and roadkill.*	Unknown
[Observed, estimated, inferred, or suspected] percent reduction in total number of mature individuals over the next [10 years, or 3 generations]: *Suspected decline from a combination of roadkill, habitat loss,, pesticides, and other sources. Gophersnakes are particularly susceptible to roadkill due to their migratory behaviour and habit of lingering on warm road surfaces; 85% of known communal snake dens are within 2 km of paved roads. Results of the threats calculator assessment and population modelling predict a decline > 30% across the species' Canadian range within the next 3 generations, based on sensitivity of the population to excess adult mortality from roadkill and other sources.*	>30%
[Observed, estimated, inferred, or suspected] percent reduction 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. *See above*	>30%
Are the causes of the decline clearly reversible and understood and ceased?	Partially reversible and understood but ongoing
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	34,156 km²

Index of area of occupancy (IAO) (2x2 km grid value) *Discrete IAO with grid cells placed on all known occurrences since 1987*	1,044 km²
Is the total population severely fragmented? *Severe fragmentation is possible at the landscape level due to extensive habitat fragmentation, particularly in the Okanagan – Similkameen, but is undocumented and cannot be substantiated for the entire range of the species.*	Unknown
Number of locations∗ *With road mortality as the greatest threat, there are numerous locations; same applies if habitat loss and degradation from urbanization and agriculture are considered most important threats.*	Unknown; probably >15
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence? *The species continues to persist throughout its known historical EO, but population distribution is not well known*	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy? *Inferred decline based on habitat trends and road mortality.*	Yes, inferred decline
Is there an [observed, inferred, or projected] continuing decline in number of populations? *Populations persist in all 3 large occupied areas. However, within these areas subpopulations may be declining, based on inferences from habitat trends.*	No
Is there an [observed, inferred, or projected] continuing decline in number of locations*? *Inferred and projected decline based on continuing loss and fragmentation of habitat and increase in roads and traffic.*	Yes, inferred and projected decline
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat? *Observed and projected decline in area and quality of habitat*	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations∗?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Portion of range	N Mature Individuals
1. Fraser-Thompson-Nicola	unknown
2. Okanagan-Similkameen	unknown
3. Kettle	unknown

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

Total	Probably <10,000, but no solid data are available

Quantitative Analysis

Probability of extinction in the wild.	Not done due to lack of data

Threats (actual or imminent, to populations or habitats)

Mortality due to roadkill; habitat loss due to human development; mortality from agricultural and industrial activities, including secondary poisoning of snakes that consume prey contaminated with strychnine-based rodenticides; human persecution

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? *The only U.S. state from where immigration is possible is Washington, where the species is considered common and widespread in suitable habitats*	Washington State (not at risk)
Is immigration known or possible?	Possible but unconfirmed
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Not in South Okanagan
Is rescue from outside populations likely?	Possible but effects limited to near the border, and the rate would be slow

Status History

COSEWIC: Designated Threatened in May 2002. Status re-examined and confirmed in May 2013.

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** A3b
Reasons for designation: This large, non-venomous snake is restricted in Canada to the dry southern interior of British Columbia, where it occurs within landscapes fragmented by roads, orchards, vineyards, and houses. Because of its low reproductive rate and late age at maturity, seasonal migrations, and habit of lingering on warm roads, this snake is especially vulnerable to road mortality. This mortality, together with habitat loss and degradation and intentional and inadvertent killing, are expected to continue and result in population declines over the next 24 years (3 generations).	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened A3b because a continuing decline of >30% is projected and suspected over the next 3 generations, based on an index of abundance appropriate to the taxon. Although past declines are inferred and suspected, their magnitude is uncertain and, therefore, A1, A2 and A4 do not apply.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EO is above thresholds and, although IAO is under the threshold for Threatened and there is a continuing decline in the area, extent and/or quality of habitat b(iii) and the number of mature individuals b(v), the species exists at more than 10 locations and severe fragmentation cannot be demonstrated.
Criterion C (Small and Declining Number of Mature Individuals): May meet C1 for Threatened as population size may be <10,000 and there is an estimated continuing decline of >10% within 3 generations. However, there are no robust population estimates for the species in Canada.
Criterion D (Very Small or Restricted Total Population): Not met. Does not meet D because neither the total number of mature individuals nor the index of area of occupancy is very small, and there are more than 5 locations.
Criterion E (Quantitative Analysis): Not done due to lack of information.

PREFACE

The previous COSEWIC status report (Waye and Shewchuk 2002) included 3 subspecies of *P. catenifer: P. c. deserticola* (Great Basin Gophersnake), *P. c. catenifer* (Pacific Gophersnake), and *P. c. sayi* (Bullsnake). This update status report addresses one of these subspecies, *P. c. deserticola*.

New information since the 2002 report includes additional surveys that have increased the numbers of known sites, including hibernacula (Hobbs and Sarell 2000, 2001, 2002, 2002; Hobbs 2001; Sarell and Alcock 2004; Sarell 2005a, 2005b; Hobbs 2011a, 2011b). A master's thesis on gophersnake ecology (White 2008) provided new data on movements, habitat use, and behaviour. A number of conservation planning initiatives have been completed for the gophersnake at the provincial level, including a provincial recovery strategy (Southern Interior Reptile and Amphibian Recovery Team 2008), a conservation assessment (Haney and Sarell 2007), and an effectiveness evaluation of established Wildlife Habitat Areas (WHAs) (Ovaska and Sopuck 2004; Haney and Sarell 2005; Erickson *et al*. 2007). Additional protected areas have been designated, and WHAs have been established to guide management of important gophersnake habitat on provincial Crown lands.

No Aboriginal Traditional Knowledge was accessible at the time of the preparation of this report.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS
(2013)

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

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

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

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

Environment Canada / Environnement Canada
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Canada

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

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

The Great Basin Gophersnake *Pituophis catenifer deserticola* (Stejneger 1893) is a member of the family Colubridae, order Squamata, class Reptilia (Crother 2012). There are two other subspecies of gophersnakes native to Canada. The Pacific Gophersnake (*P. catenifer catenifer*) was found on the southern coast of British Columbia (B.C.) and the Gulf Islands but is now considered extirpated (BC Conservation Data Centre 2011a). The Bullsnake (*P. c. sayi*) occurs in Alberta and Saskatchewan. All three were formerly included with pine snakes as subspecies of *Pituophis melanoleucus* but have now been separated as different species based upon mitochondrial and nuclear DNA differences (Rodríguez-Robles and De Jesús-Escobar 2000; Pyron and Burbrink 2009). Rodriguez-Robles and De Jesús-Escobar (2000) conducted genetic analyses of snakes of the *Pituophis* species complex, including *P. c. deserticola* specimens from Utah, Nevada, California, and Colorado. They reported that the *P. c. catenifer* and *P. c. deserticola* subspecies formed a distinct clade, and that there was intergradation between those two taxa.

Morphological Description

The Great Basin Gophersnake (Figures 1, 2) is a large snake, up to 1.2 m in total length in B.C. (Shewchuk 1996). Individuals as long as 1.8 m have been recorded in other areas of the subspecies' range (Bartlett and Bartlett 2009).

Figure 1. Great Basin Gophersnake (with neonate Western Rattlesnakes) (Wade Alcock photo).

Figure 2. Great Basin Gophersnake, showing the head with characteristic dark bands between the eyes and extending from the eye to the upper jaw margin (Wade Alcock photo).

The head of the Great Basin Gophersnake is bullet-shaped, slightly wider than the neck, and the eyes are relatively large with round pupils. Adult males are usually longer in total length than females; they also have proportionately longer tails that are thicker at the base than females' tails (Parker and Brown 1980; Diller and Johnson 1982; Shewchuk 1996).

The base body colour is grey, cream or yellowish on the dorsal surface (Ernst and Ernst 2003), and white on the ventral surface. A dark band extends from above each eye back at an angle down to the base of the upper jaw; a second dark stripe extends down through the eye to the margin of the upper jaw; a third dark stripe extends across the front of the head between the eyes. The throat is white (Stull 1940).

The dorsal surface and sides of the relatively stout body are marked with 57 – 95 regularly spaced dark brown (black anteriorly) rectangular blotches, becoming 12 – 22 alternating stripes on the tail (Stull 1940; Ernst and Ernst 2003). The pattern of blotches is quite variable, especially on the neck where they may be fused to varying degrees. The anterior dorsal light scales have dark-coloured keels, while the lateral scales are smooth. There are usually 4 (range: 2 – 6) prefrontal scales and a single anal plate (Stebbins 2003). The rostral scale is as wide as it is long (Stull 1940). Adult and juvenile gophersnakes may be misidentified as Western Rattlesnakes (*Crotalus oreganus*), and young gophersnakes may be potentially confused with first year Western Yellow-bellied Racers (*Coluber constrictor mormon)* or Terrestrial Gartersnakes (*Thamnophis elegans*), all of which may have superficially similar markings.

Population Spatial Structure and Variability

The Great Basin Gophersnake's distribution in Canada consists of several disjunct or partially disjunct components, each supporting separate subpopulations (Waye and Shewchuk 2002; Haney and Sarell 2007; Southern Interior Reptile and Amphibian Recovery Team 2008). The Kettle and the Okanagan-Similkameen subpopulations are not contiguous with each other in B.C., but are connected through Washington State. The Fraser-Thompson-Nicola subpopulation appears to be disjunct from all other gophersnake populations at present but most likely was historically connected between Kamloops and the north Okanagan (Westwold area) (Haney and Sarell 2007).

Within each subpopulation, habitat fragmentation by human developments and activities is likely to limit movements and constrain gene flow, resulting in further division of populations at the landscape level. Based on an analysis of dispersal distances (up to 1 km), Haney and Sarell (2007) concluded that distances >2 km between hibernacula would effectively prevent natural dispersal and gene flow between subpopulations. Newly available data includes documented movements up to 2.4 km (Williams *et al*. 2012), so minimum width of barriers to dispersal might be up to 3 km. No genetic studies have been undertaken in Canada, although some samples have been collected pending funding for analysis (Russello pers. comm. 2011).

Designatable Units

The Great Basin Gophersnake is treated as a single designatable unit. The Canadian range is within a single national ecological area (Southern Mountains), and the snakes occupy similar arid habitats in each area, although some spatial discontinuities exist among subpopulations. No information is available on genetic, morphological, or behavioural differences among populations that would indicate local adaptations.

Special Significance

The Great Basin Gophersnake is the largest snake in B.C. It is part of a suite of grassland species that are considered at risk in the province due to development and degradation of native grasslands (Leech *et al*. 2006; Southern Interior Reptile and Amphibian Recovery Team 2008). Gophersnakes have environmental, resource management, and educational values to the Secwepemc First Nations (Markey and Ross 2005 cited in Southern Interior Reptile and Amphibian Recovery Team 2008).

Gophersnakes are well-known as predators of rodents (Schmidt and Davis 1941), but the degree to which that predation may affect agricultural pest abundance is unknown. Gophersnakes are easily mistaken for the venomous, sympatric Western Rattlesnake due to similarities in the two species' appearance, habitat use, and defensive behaviour (Kardong 1980; Sweet 1985), and this 'mistaken identity' has led to persecution of gophersnakes Sarell pers. obs.).

DISTRIBUTION

Global Range

The gophersnake has a wide range in western North America, but the range of the subspecies *Pituophis catenifer deserticola* is difficult to map accurately due to recent taxonomy revisions and, in some areas, lack of distributional information at the subspecies level. Stebbins (2003) describes the Great Basin Gophersnake's range as extending from southern B.C. southward through Washington, Oregon, California, Arizona, Colorado, Nevada, New Mexico, Idaho, Utah, and Wyoming. NatureServe (2012) lists its distribution as B.C., Wyoming, Colorado, Arizona and Nevada, with the caveat that distribution data are incomplete for the subspecies. The Gophersnake (subspecies not specified) is listed by NatureServe for 18 US states as well as for B.C., Alberta, and Saskatchewan.

Rodríguez-Robles and De Jesús-Escobar (2000) mapped the subspecies as present through south-central B.C., eastern portions of Washington, Oregon and California, southern Idaho, throughout Utah, northern Arizona, western Colorado and southwestern Wyoming (Figure 3). The range of the Great Basin Gophersnake in the United States is bordered by that of *P. c. catenifer* along the west coast, *P. c. affinis* to the south, and *P. c. annectens* in the southwest in California.

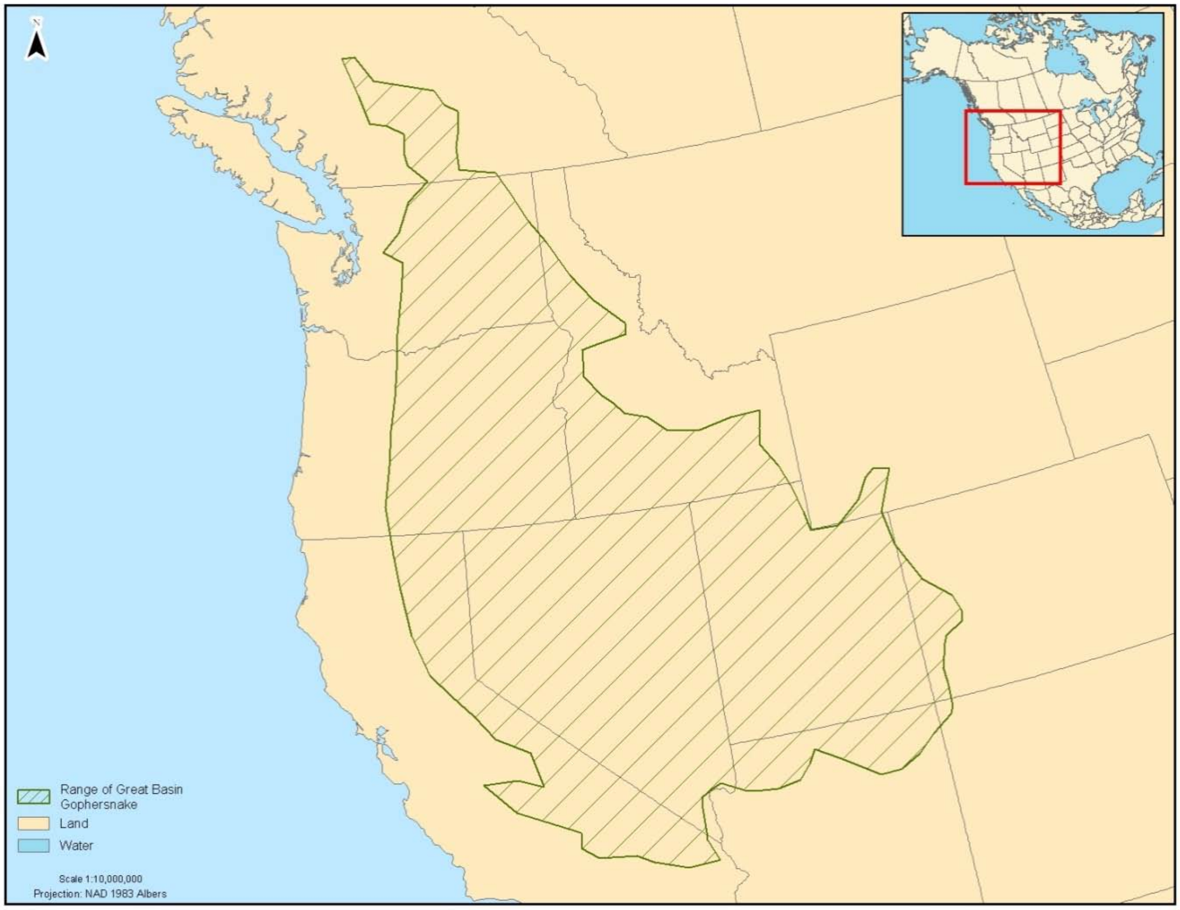

Figure 3. Global range of the Great Basin Gophersnake in western North America.

Canadian Range

In Canada, the Great Basin Gophersnake occurs only in B.C., where it exists at the northern extent of its global range (Figure 4). The province is estimated to support <5% of the global population (Southern Interior Reptile and Amphibian Recovery Team 2008). The snake is restricted to river valleys and slopes in the dry southern interior of the province (White 2008) and occurs in the Bunchgrass, Ponderosa Pine, and Interior Douglas-fir biogeoclimatic zones (Meidinger and Pojar 1993; BC Conservation Data Centre 2011a). It occurs at elevations of 200 to 1000 m above sea level throughout most of its Canadian range but may occur up to 1700 m in some mountainous areas (BC Ministry of Water, Land and Air Protection 2004; Southern Interior Reptile and Amphibian Recovery Team 2008).

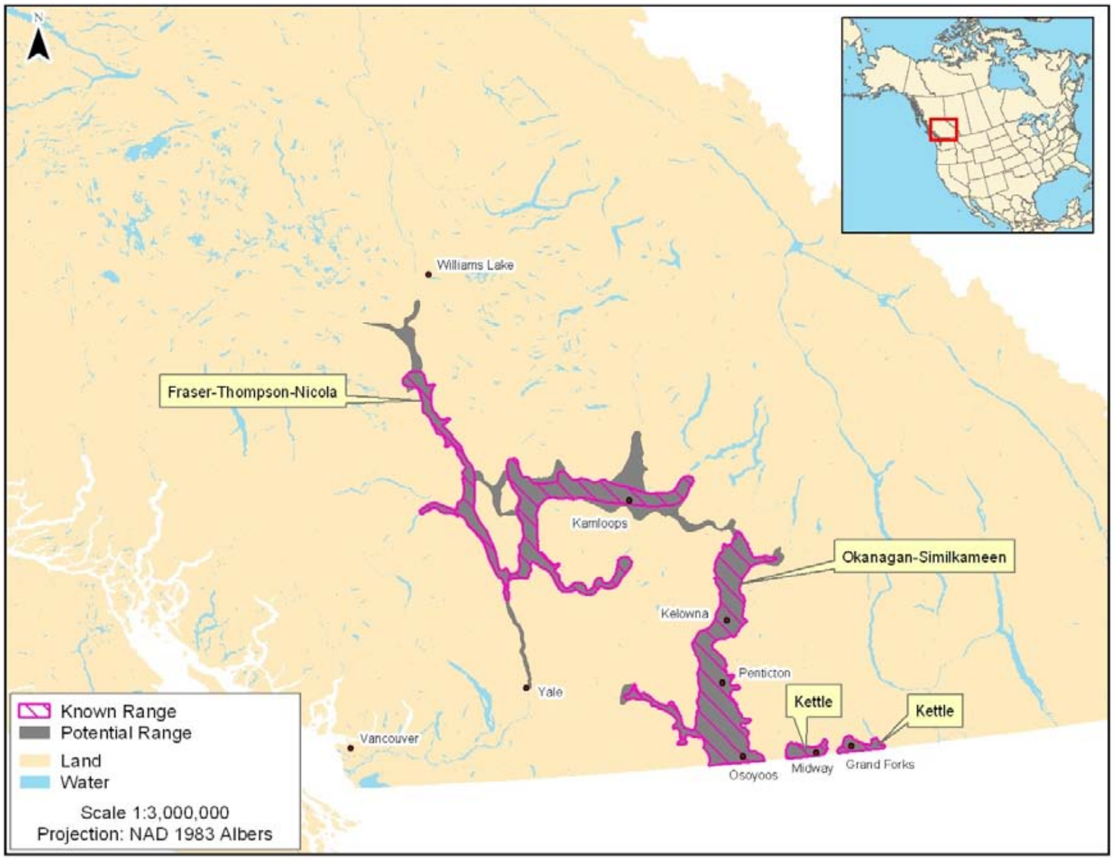

Figure 4. Canadian range of the Great Basin Gophersnake, showing 3 portions of the range. The two areas labelled as Kettle are joined through the United States.

Gophersnakes are found in four disjunct areas within warm, dry grassland valleys in B.C. (Sarell *et al*. 1997, 1998; Hobbs and Sarell 2000, 2001; BC Ministry of Water, Land and Air Protection 2004; Haney and Sarell 2007). The Okanagan/Similkameen portion of the range is the largest and extends from the Canadian border north to Vernon. The Kettle portion is located in the Kettle drainage around Grand Forks to Christina Lake and from Rock Creek to Midway. These two southern subpopulations are interconnected south of the Canadian border. The Fraser-Thompson-Nicola portion is disjunct from all other gophersnake subpopulations. It occupies the Fraser Valley from Lytton north to Churn Creek, the Thompson Valley as far east as Chase, and the Lower Nicola Valley up to Merritt (Hobbs and Sarell 2002; Sarell and Alcock 2004). Its distribution extends at least as far south as Lytton; a road-killed gophersnake was photographed at Yale (Keystone Wildlife Research Ltd. 2008) but was probably a vehicle stowaway (Hilton pers. comm. 2012). There are reports of gophersnake sightings as far north as the Chilcotin River and the Highway 20 bridge over the Fraser River (Steciw pers. comm. 2012), but those sightings are yet to be substantiated. Suitable habitat exists around Trail, but there are no records of the species (Sarell pers. obs.).

The distribution map in Figure 4 was produced from a combination of information sources, including the range map produced by Haney and Sarell (2007), provincial 1:250,000 scale mapping depicting the extent of the Bunchgrass, Ponderosa Pine, and Interior Douglas-fir very dry, hot biogeoclimatic zones, and approximately 1400 gophersnake occurrences obtained from museum collections (Beaty Biodiversity Museum 2011; Canadian Museum of Nature 2011; Royal British Columbia Museum 2011), BC Conservation Data Centre (2011b), and files from individuals (Sarell unpubl. data). Questionable points, including unconfirmed sightings from the Chilcotin River and the Yale roadkill record, were not used to generate the range map but have been included within the depiction of potential range.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EO) was calculated from a minimum convex polygon (IUCN Petitions and Standards Subcommittee) using the occurrence records in Figure 4. The polygon was created using the ‘create minimum convex polygon’ tool in Hawth's Analysis Tools, an extension for ESRI’s ArcGIS. EO was calculated to be 34,156 km^2. It includes large areas of unoccupied and unsuitable habitat that lie between the occupied areas. The area within the minimum convex polygon that also lies within the Bunchgrass, Ponderosa Pine and Interior Douglas-fir biogeoclimatic zones, the zones occupied by the gophersnake, is 20,863 km^2. The BC Conservation Data Centre (2013) estimates a range area of 527,102 km^2 (convex hull method) for the Great Basin Gophersnake (Stipec pers. comm. 2013).

The index of area of occupancy (IAO) is 1,044 km^2, calculated by superimposing a grid with 2 km x 2 km cells over the species’ occupied range and counting cells with at least one occurrence record since 1987 (calculated by the report writers and including sensitive data from private and First Nations lands not in the BC CDC database). Those occurrence records are mainly from small-scale surveys and incidental observations rather than from systematic surveys; hence any comparisons among historical and recent observations should be treated with caution. BC CDC (Stipec pers. comm. 2013) provided an IAO value of 504 km^2 based on 4 km^2 grid cells on occurrences in their database.

Search Effort

Numerous surveys for snakes have been conducted within the range of the Great Basin Gophersnake (Sarell 1993, 2005a, b; Sarell *et al*. 1996, 1997, 1998, 2010; Hobbs and Sarell 2000, 2001, 2002; Hobbs 2001; Sarell and Alcock 2004; Sarell and Shanner 2006; White 2008; Hobbs 2011a, b; Lomas *et al*. 2011). These surveys were most often directed toward locating hibernacula used by any snake species. Several studies (Bertram *et al*. 2001; Brown 2006; White 2008) used radio-telemetry to track gophersnakes. Targeted surveys generally employed similar methods involving examination of potential habitats by one or more searchers on foot (Reed *et al*. 2012) and/or road cruises from vehicles. Most surveys employed stratification to identify potentially suitable habitat from spatial data sources or visual assessment of the landscape. Searchers traversed the survey areas while watching and listening for snakes, turning over and replacing cover objects, and paying special attention to any potential habitat features such as rock fissures and crevices. During road cruises, observers scanned the road and roadsides for carcasses and live snakes while driving slowly along roads traversing suitable habitat. Surveys usually took place during warm, sunny weather in spring and fall when gophersnakes would most likely to be found basking near the entrance to hibernacula, but some surveys relating to snake salvage operations for construction projects took place when construction was imminent.

The effectiveness of foot surveys and road cruises in detecting gophersnakes is difficult to quantify. Gophersnakes spend considerable periods underground or under cover. Bertram *et al*. (2001) found that 3 radio-tagged gophersnakes were visible to the investigator during only 43% of their relocations, and even gophersnakes on the surface could be overlooked due to their cryptic colouration. Dens were rarely revisited by researchers after their use by at least one snake species had been confirmed, as many dens are difficult to access. Western Rattlesnakes are more detectable than gophersnakes due to their warning rattle and because unlike gophersnakes they aggregate for long periods near the den sites. Hence, they may be used as surrogates for other species that den communally with them. The effectiveness of road cruises in detecting snakes is dependent on road densities, traffic loads, carcass persistence, weather and lighting conditions, and surveyor experience (deGregorio 2011; Sullivan 2012).

Incidental observations have often taken the form of road-killed specimens found during informal surveys or opportunistically while surveying for other wildlife (Keystone Wildlife Research Ltd. 2008; Pickard 2009; Canadian Museum of Nature 2011). Museum records provided additional data regarding distribution but had no information on search effort (Canadian Museum of Nature 2011).

HABITAT

Habitat Requirements

Great Basin Gophersnakes occupy arid and semi-arid open and sparsely wooded habitats. Gophersnakes require specific habitats for foraging, hibernation and oviposition, ideally within 500 m of each other (White 2008). Habitats can be broadly described as rock outcrops, grassland and shrub-steppe with rocks and deep sandy, loamy or gravelly soils, a plentiful supply of rodents, and burrows for cover (Ernst and Ernst 2003; White 2008). Gophersnakes are generally absent from dense forests and high elevations (Nussbaum *et al*. 1983). Bertram *et al*. (2001) described habitat of gophersnakes near Kamloops as open Sagebrush - Bunchgrass grasslands dominated by Big Sagebrush (*Artemisia tridentata*) and Bluebunch Wheatgrass (*Pseudoroegneria spicata*).

White (2008) reported that habitat selection of radio-tagged gophersnakes in the Okanagan Valley differed between snakes using different study areas as well as between sexes. Snakes used human-modified sites (roadsides, buildings, debris piles), grassland/meadow, and rock outcrops more than expected based on availability at her 3 study areas in the Okanagan Valley. Microhabitat selection was inconsistent, but in general, snake detections were closer to retreat sites (rocks, burrows, shrubs) and had greater slopes and less soil cover than nearby randomly chosen sites. Three individuals used wetlands to a large extent.

Four females tracked by Brown (2006) near Vaseaux Lake were relocated most frequently in shrub-steppe and rock habitat, but habitat availability was not examined. Lomas *et al*. (2011) also reported that radio-tagged gophersnakes on the Osoyoos Indian Reserve most often used rock (including talus and outcrops) and Antelope Brush (*Purshia tridentata*) habitat. Specific shedding sites are often reused by one or more individuals, and are usually rock features (White 2008).

<u>Foraging Habitats:</u>

There is some evidence from the U.S. that individual snakes use the same summer ranges year after year (Parker and Brown 1980). Foraging habitat is characterized by an abundance of rodent prey and the presence of retreat sites where the snakes can safely digest their prey and thermoregulate. Grasslands and shrub-steppe ecosystems appear to provide the best foraging habitat though open forest, meadows, wetlands and riparian areas are also used. Populations of some prey species may be increased by agriculture, but the lack of cover in cultivated fields restricts gophersnake foraging to field edges (Diller and Johnson 1982).

Gophersnakes spend considerable time underground in rodent burrows, especially during the hottest portion of the summer (Shewchuk 1996). Some snakes in Utah were not detected above ground for 10 – 15 days at a time (Parker and Brown 1980). In the south Okanagan during the active season, gophersnakes rested in enlarged portions of rodent burrows or in dense vegetative cover in riparian areas (Shewchuk and Waye 1995; Shewchuk 1996). Individual snakes often returned multiple times to a specific burrow after bouts of foraging in grasslands and riparian areas, and retreat sites were sometimes used by more than one gophersnake (Shewchuk 1996). Retreat sites may also be shared with other snake species (Bertram *et al*. 2001).

Hibernation Habitats:

Gophersnakes overwinter in underground hibernacula. Hibernacula must be sufficiently deep (such as crevices penetrating below the frost line) for snakes to avoid freezing, yet sufficiently cool so that body fat is not metabolized too quickly causing starvation prior to spring emergence (Parker and Brown 1980). There are two major types of overwintering habitat: sites associated with rock and burrows in deep soils on hillsides or gentler slopes. Rock dens can be either in deep crevices in bedrock or in talus slopes where there is adequate depth of talus to provide thermal cover (Sarell 1993; Sarell *et al*. 1997; Hobbs 2001). These types of dens typically harbour relatively high numbers of individuals, can be used by multiple snake species, and persist for many generations. One rock den in South Okanagan is known to have been used for at least 100 years (Sarell unpubl. data). The longevity of these features and the multiple individuals using them have resulted in much better documentation of rock dens than of burrow dens.

Dens in deep rodent burrows are typically used by only one or a small number of individuals and are likely short-lived. Occasionally gophersnakes have been observed denning in fill material (such as road beds and railway lines) and along building foundations (Bertram *et al*. 2001; Sarell pers. obs.). Hibernacula known to be used by other snake species, such as Western Rattlesnakes, Western Yellow-bellied Racers, and Common Gartersnakes (*Thamnophis sirtalis*), may be also used by gophersnakes (Sarell pers. obs.). Dens with confirmed gophersnake use in Canada range from 300 – 873 m in elevation (Sarell, unpubl. data).

Gophersnakes were found at 26% of 41 snake dens visited in the Okanagan in 1993, most of which (53%) were rock outcrops or talus (Sarell 1993). The majority of those sites were between 400 and 780 m in elevation in the transition area between the Bunchgrass and Ponderosa Pine biogeoclimatic zones. Hobbs and Sarell (2000) investigated 21 snake (all species) den sites in the Okanagan Basin, 14 in the Ponderosa Pine zone and 7 in the Bunchgrass zone. Dens were in cliffs, talus, rock outcrops, and road fill. Gophersnakes (live or dead) or their sign (shed skins) were detected at 5 of the sites. Western Rattlesnakes were detected at 9 dens, including 3 of those where gophersnake presence was confirmed. Hobbs (2001) described 14 snake den sites visited in the Kamloops, Merritt, Vernon, and Penticton forest districts. Gophersnakes were observed at 2 of the dens, both in the Ponderosa Pine biogeoclimatic zone.

Optimal snake den sites within the species' range in B.C. are thought to be large, exposed, dark-coloured rock outcrops on steep, warm aspects, as these sites will absorb the maximum heat from the sun (Sarell 1993; Hobbs 2001). However, hibernaculum characteristics vary somewhat regionally, depending on the local habitat and whether rocky outcrops are available (White 2008). Two of 3 radio-tagged gophersnakes monitored by Bertram *et al*. (2001) near Kamloops, B.C., hibernated singly in small holes in flat, open ground. The third snake denned in the gravel substrate of a railway line.

Hibernacula near Vernon were underground sites on grassy hillsides, accessed through rodent burrows (White 2008), although within the same study area, gophersnakes were also denning in fractures of exposed bedrock amongst the grassy slopes (Sarell 2005b). Site fidelity to rock hibernacula appears to be high, while that to earthen sites is lower (White 2008).

The presence of thermal and security cover at hibernacula entrances is important as gophersnakes may remain just outside the den for several days after emergence in spring and before entering dens in fall (Parker and Brown 1980). Flat rocks with gaps underneath them ("solariums") near the den absorb the sun's heat and provide warm cover (Sarell 1993). Clumps of vegetation are also used by thermoregulating snakes (Parker and Brown 1980).

Egg-laying Habitats:

Oviposition sites are usually located on grassy or sparsely vegetated slopes with fine-textured sandy soils and a warm aspect (Parker and Brown 1980; Shewchuk 1996; White 2008). Talus slopes of fine colluvium may also be used (Sarell pers. obs.). Female gophersnakes may dig their own nesting burrows in loose soils or, more commonly, enlarge existing rodent burrows (Shewchuk 1996; White 2008). Eggs of 3 females in Utah were deposited at depths of 34 – 42 cm (Parker and Brown 1980). Brown (2006) reported that 2 females near Vaseaux Lake oviposited 81.2 m and 40.2 m from their respective hibernacula. However, females may travel long distances (>2 km) to nest sites, and nest sites may be shared with other snake species such as racers, which suggests that high-quality sites may be limited in availability (Shewchuk 1996; Bertram *et al*. 2001). Fidelity to a specific oviposition site over 2 years was documented for 1 of 5 females equipped with radio-transmitters in the Okanagan Valley (White 2008) but was not observed in an earlier study at the same location (Shewchuk 1996).

Habitat Trends

A general decline in habitat quality and quantity can be inferred from the availability and condition of native grassland and shrub-steppe habitats within the Great Basin Gophersnake's range. Grasslands in the arid interior of British Columbia are among the most threatened ecosystems in Canada (BC Ministry of Environment 2007). Overall, approximately 15% of B.C.'s southern interior grasslands were lost to human developments, mainly agriculture and urbanization, from mid-1800 to 1990 (Grasslands Conservation Council of BC 2004; BC Ministry of Environment 2007). From 1990 to 2005, losses have continued but at low rates (1% lost overall; BC Ministry of Environment 2007, based on Grassland Conservation Council's 2007 update assessment). The total loss of grasslands from mid-1800 to 2005 was estimated as 16.1%, representing 619,874 ha. The above values do not include grassland lost to forest encroachment resulting from fire suppression.

The rate of loss has varied both among areas (Table 1) and grassland types. Most of the development is concentrated in valley bottoms, which also contain the highest suitability habitat for gophersnakes. Regionally, the highest losses have taken place in Northern Okanagan Basin, where over 47.6% of grasslands had been converted to agriculture (vineyards, orchards, other crops, irrigated pasture) or urban/industrial land uses by 2005 (Grasslands Conservation Council of BC 2004; BC Ministry of Environment 2007). High losses have also occurred in South Okanagan Highland (38.6%), South Okanagan Basin (20.5%), and Thompson Basin (20.0%). Less grassland has been lost in other areas within the species' range (Table 1).

Table 1. Percent of historical area of native grassland lost to urbanization and agriculture within the Canadian range of the Great Basin Gophersnake from mid-1800 to 2005 (data from Grasslands Conservation Council of BC 2004; BC Ministry of Environment 2007).

Ecosection(s)	Portion of range affected	Total % of loss from above sources	Grasslands remaining in 2005 (ha)
Southern Thompson Upland	Fraser-Thompson-Nicola	10	132,298
Southern Okanagan Basin	Okanagan-Similkameen	20.5	32,049
Southern Okanagan Highland	Kettle, Okanagan-Similkameen	38.6	12,496
Okanagan Range	Okanagan-Similkameen	11.2	20,664
Northern Okanagan Basin	Okanagan-Similkameen	47.6	38,060
Thompson Basin	Fraser-Thompson-Nicola	20.0	32,049
Pavilion Ranges	Fraser-Thompson-Nicola	8.7	36,685
Fraser River Basin, Cariboo Basin, Central Chilcotin Ranges and Chilcotin Plateau	Fraser-Thompson-Nicola	16.1	206,776

Lea (2008) quantified the extent of replacement of 10 native grassland habitats with human developments in the Okanagan and Similkameen valleys from 1800 to 2005. Losses of ecosystems associated with the Great Basin Gophersnake included Douglas-fir – Pinegrass, 33% lost; Ponderosa Pine – Bluebunch Wheatgrass, 50% lost; Water Birch – Red-osier Dogwood, 92% lost; Idaho Fescue – Bluebunch Wheatgrass, 75% lost; Big Sagebrush shrub-steppe, 33% loss; Antelope-brush – Needle-and-thread Grass, 68% lost; overall gentle slope grassland and shrub-steppe, 61% lost; Big Sagebrush – Needle-and-thread shrub-steppe, 70% lost.

The remaining grasslands continue to be affected by human activities. Livestock grazing is widespread and continues to modify grasslands throughout the gophersnake's range in B.C. Historically, over-grazing has affected many areas and has facilitated the spread of invasive plants such as knapweed (*Centaurea* spp.; Grasslands Conservation Council 2012). Habitats continue to be fragmented by roads and infrastructure associated with increasing human population. For example, the resident human population in the Thompson-Okanagan doubled between 1971 and 2001 and is expected to increase by another 40% by the year 2031 (Hobson and Associates 2006).

BIOLOGY

Several studies have addressed the biology of the Great Basin Gophersnake in British Columbia (Nelson and Gregory 1992; Shewchuk 1996; Bertram *et al*. 2001; Haras 2005; Brown 2006; White 2008). However, these studies provide few data on age at first reproduction, population densities and structure, survival, and dispersal. Where available, that information has been summarized from published literature from the U.S. (Vetas 1951; Parker and Brown 1980; Diller and Johnson 1982, 1988; Eichholz and Koenig 1992).

Diet and Foraging

The Great Basin Gophersnake is non-venomous and kills its prey by constriction. Williams and Bishop (2011) estimated that an average of 270 g of prey is consumed by an individual during the active season. Mammals (91%; especially neonates) and birds (9%) made up the diet of gophersnakes in the Osoyoos area (Shewchuk 1996). Gophersnakes have also been observed consuming juvenile racers and are reputed to eat rattlesnakes (Sarell pers. obs.). Prey items reported in the literature are listed in Table 2.

Table 2. Species present in British Columbia that have been reported as prey of *P. catenifer* (Diller and Johnson 1982; Ernst and Ernst 2003; Sarell, pers. obs.).

Scientific Name	Common Name
Sylvilagus nuttallii	Nuttall's Cottontail
Peromyscus maniculatus	Deermouse
Mus musculus	House Mouse
Rattus norvegicus	Brown Rat
Microtus montanus	Montane Vole
Parognathus parvus	Great Basin Pocket Mouse
Thomomys talpoides	Pocket Gopher
Spermophilus spp.	ground squirrel
Ondontra zibethicus	Common Muskrat
Numenius americanus	Long-billed Curlew
Anas platyrhynchos	Mallard
Anas acuta	Northern Pintail
Gallus gallus	domestic chicken
Columba livia	Rock Pigeon
Zenaida macroura	Mourning Dove
Stelgidoptyeryx serripennis	Northern Rough-winged Swallow

Scientific Name	Common Name
Icterus galbula	Baltimore Oriole
Junco hyemalis	Dark-eyed Junco
Colaptes auratus	Northern Flicker
Tyrannus spp.	flycatchers
Poecile atricapillus	Black-capped Chickadee
Sturnus vulgaris	European Starling
Turdus migratorius	American Robin
Passer domesticus	House Sparrow
Thamnophis elegans	Terrestrial Gartersnake

The most frequent prey of *P. catenifer* (subspecies not given) in California were small mammals, followed in decreasing order of frequency by bird eggs, birds, lizards, snakes, amphibians, frog eggs, reptile eggs, and insects (Rodríguez-Robles 1998, 2002). A wide variety of prey was taken by Great Basin Gophersnakes in southwest Idaho, with no apparent reliance on any single species (Diller and Johnson 1982). Within that study area, gophersnakes were estimated to remove 4% of the available juvenile ground squirrels (*Spermophilus* spp.) and 22 – 43% of juvenile cottontail rabbits (*Sylvilagus* sp.) (Diller and Johnson 1988).

Great Basin Gophersnakes forage actively and detect prey by scent or sight (Ernst and Ernst 2003). They have been documented entering bird nest boxes to prey on eggs and nestlings of passerine birds (Haras 2005) and may be preferentially attracted to trees with nests containing young (Eichholz and Koenig 1992).

Life Cycle and Reproduction

Emergence and Shedding

Gophersnakes in South Okanagan leave hibernacula in April (Shewchuk and Waye 1995), but the timing of emergence is variable depending on the weather. Great Basin Gophersnakes in Utah emerged from winter dens when air temperatures were approximately 15.5 ^{o}C (Vetas 1951), but Parker and Brown (1980) suggested that soil temperature and amount of solar insolation were more important in triggering emergence than air temperature. Males emerged before females in Utah, and emergence duration ranged from 29 to 48 days (Parker and Brown 1980). Gophersnakes tended to disperse downhill away from the den, and topography around den sites may determine the pattern of dispersal after emergence (Shewchuk and Waye 1995).

A peak shedding (ecdysis) period at the end of July was reported by Shewchuk (1996) in the Osoyoos area, though shedding occurred to some extent in all summer months. White (2008) observed 3 ecdysis periods, in June, July and August, in the Okanagan Valley, though most observations were in June. Shedding takes approximately 10 days (Shewchuk 1996).

Reproduction

Limited information suggests that the sex ratio is approximately equal (Shewchuk 1996). The testes of males are regressed when the snakes emerge from hibernation in spring but enlarge during the active season before regressing again in fall (Goldberg and Parker 1975). Parker and Brown (1980) found motile spermatozoa in the vas deferentia of males throughout the year in Utah. Mating takes place in May after snakes leave the vicinity of hibernacula, and females ovulate in June (Shewchuk and Waye 1995; White 2008). ‘Combat dancing’ may take place between males in the vicinity of females (White 2008).

Gophersnakes are oviparous, and in B.C. usually lay eggs from late June to early July; the eggs hatch from late August to early September (Shewchuk and Waye 1995; Shewchuk 1996). Less than 40% of females were gravid during the breeding season during a study in the Osoyoos area, suggesting biannual or less frequent reproductive cycles (Shewchuk 1996). In contrast, ‘the majority’ (number not provided) of females encountered by White (2008) in the Okanagan valley were gravid. Of 5 females tracked in that study over a 2-year period, all oviposited in both years, but 2 of 6 females tracked for a single year did not lay eggs. Diller and Johnson (1982) reported that "virtually all" mature females reproduced in a given year in Idaho. Reproductive frequency of females may depend on the abundance of food and climatic conditions in particular years.

Clutch sizes reported in Canada range from 2 – 8 eggs (Matsuda *et al*. 2006). The mean clutch size of 19 females in the Osoyoos area was 4.6 ± 1.8 eggs (range 2 – 8 eggs) (Shewchuk 1996), with a general trend of an increase in clutch size of 1 egg/75 mm of female body length. Clutch sizes of 9 females in Utah were larger, averaging 7.4 eggs (4 – 10 eggs) (Parker and Brown 1980). Clutches of 21 females in Idaho averaged 6.5 eggs (Diller and Johnson 1982).

Only one of the 16 females tracked by White (2008) in Okanagan Valley laid eggs in a communal nest, the rest ovipositing at individual sites. Incubation duration is dependent on the temperature of the nest location, with higher temperatures leading to earlier hatching (Shewchuk 1996). Average development time reported in the literature is 67 days (Ernst and Ernst 2003). Hatching occurs in the Okanagan in late September – early October (Shewchuk 1996). The eggs must hatch in time for the juveniles to find and enter hibernacula before the onset of winter.

Hibernation

Movement of snakes to hibernacula in fall is generally correlated with the onset of temperatures below 9^{o} C, although males in a study near Osoyoos initiated travel back to hibernacula at the end of July (Shewchuk 1996). Return to dens usually occurs from September to mid-October in B.C., though ingress can occur as late as early November in the Okanagan (Hobbs 2001). Great Basin Gophersnakes in Utah returned to hibernacula over periods spanning 25 to 35 days in 4 consecutive years (Parker and Brown 1980).

Shewchuk (1996) reported that after a grass fire, radio-tagged snakes still returned to den sites in straight, directional movements, suggesting that olfactory cues (scent trails) were not necessary to enable snakes to navigate. Parker and Brown (1980) reported that Great Basin Gophersnakes at their study site in northern Utah retreated underground as soon as they arrived at dens. No snakes were captured more than once at a den in fall. However, some individuals tracked in Okanagan Valley returned to the vicinity of their hibernacula during late summer and remained underground within 10 – 30 m of the den prior to entering hibernation in fall (White 2008). Gophersnakes have also been observed basking near their dens in late fall during warm weather, suggesting that they may briefly re-emerge during warm periods (Sarell and Alcock 2011).

Snakes may hibernate singly or communally with conspecifics or snakes of other species (Sarell 1993; White 2008). Hibernation site fidelity is common, although individuals may also switch sites between years (Parker and Brown 1980; White 2008; Lomas *et al*. 2011). Four of 10 Great Basin Gophersnakes in Utah that were moved up to 300 m from their den site in fall returned to the den to hibernate that year (Parker and Brown 1980). Four others used alternate dens and the remaining 2 were not relocated. Overall, the rate of annual shifts between dens was 9.5%, and snakes remained in hibernation an average of 219 ± 3.4 days.

Some hatchlings overwinter in rodent burrows close to their nest site but switch to a communal hibernaculum for their second winter (Shewchuk 1996). Juveniles likely do not have an opportunity to feed during their first year of life (Shewchuk and Waye 1995). Parker and Brown (1980) reported that juveniles in Utah generally arrived at communal hibernacula later than adults and suggested that juveniles that travel to communal hibernacula may be more vulnerable to predation than those that hibernate close to their natal site. The availability of nest sites with suitable thermal properties near hibernacula is thought to be critical for gophersnakes (Hobbs and Sarell 2000).

Growth and Longevity

Limited information exists on the age at sexual maturity of gophersnakes in Canada. The smallest female with enlarged follicles from the Osoyoos area was 695 mm in snout-vent length (SVL), which was also the size of the smallest male found with a female during the courtship period (Shewchuk 1996). Larger males may have an advantage over smaller ones in competition for females, thus for males the age of sexual maturity may not be equivalent to the age at first reproduction (Shewchuk and Waye 1995). Parker and Brown (1980) reported that males in Utah matured at 1 – 2 years of age, and females laid their first clutches at ages of 3 – 5 years. Most females in Idaho first reproduced in their 4^{th} summer, at about 80 cm in SVL (inferred from reproductive condition of roadkills) (Diller and Johnson 1982). Most males had sperm in efferent ducts by the fall of their 3^{rd} summer, at about 72 cm in SVL. Gophersnakes in Canada may not reproduce until at least 4 years of age, due to slower growth rates at the northern limits of their range. Growth rates in Idaho were estimated at 14.7 cm/yr for yearlings, 20 cm/yr for 2-year-olds, and 14.3 cm/yr for 3-year-olds (Diller and Johnson 1982).

Gophersnakes may live a decade or more. Shewchuk (1996) sectioned a tail vertebra from an ‘exceptionally large’ road-killed gophersnake in B.C. and reported that the layers suggested that the individual was 14 years old. A wild-caught Great Basin Gophersnake lived 33 years 10 months in captivity (Snider and Bowler 1992 cited in Ernst and Ernst 2003). Parker and Brown (1980) estimated that their largest female captured (110 cm) in Utah may have been 12 – 15 years of age, and the largest male (120 cm) may have been 18 – 20 years old, based on observed growth rates.

No B.C. data are available on juvenile survivorship. Diller and Johnson (1982) reported that Great Basin Gophersnakes in Idaho were relatively long-lived, with the highest mortality in the younger age classes and low adult mortality. However, inferred high mortality rates of juvenile reptiles may be due to sampling biases (Pike *et al*. 2008).

Parker and Brown (1980) reported annual survivorship of 20% for juveniles within the first year of their life, leveling off to an average of 76% for snakes between 1 – 4 years old, based on mark-recapture data from several dens in northern Utah. Maximum lifespan was estimated as 18 – 20 years. The life history strategy employed by gophersnakes was characterized as including late maturity, large size, small clutches, and high adult survivorship. A life table produced for female Great Basin Gophersnakes in Utah indicated an R_0 (total net reproductive rate) of 0.899.

White (2008) found that most mortality of 39 radio-tagged adult snakes in an Okanagan Valley study site was due to terrestrial or avian predators, which killed 6 and 7 snakes, respectively; 3 individuals were road-killed and 5 died from unknown causes. Monthly (April-September) survival of radio-tagged adult gophersnakes ranged between 86% and 100% for both sexes over 2 years (annual survival rates were not provided). In total, 17 mortalities were recorded of the 39 gophersnakes that were radio-tagged over the 2-year study. An additional tagged gophersnake was found dead on a road the year after the study (Sarell unpubl. data).

<u>Generation Time</u>

Generation time is estimated to be approximately 8 years, based mainly on parameters reported for a population of the Great Basin Gophersnake in northern Utah (Parker and Brown 1980). The generation time using the harmonic average survival is 8.3 years, calculated as follows: age of maturity + (1/annual mortality rate), where age at maturity is 5 years, and annual mortality rate is 0.30, which is an average of value for younger ($\leq$6 years) and older (>6 years) adults from a life table for the species in Parker and Brown (1980). Survivorship might be substantially lower in urbanized areas or along major transportation corridors in British Columbia.

Physiology and Adaptability

The Great Basin Gophersnake is at the northern edge of its global range in B.C., and its populations are likely limited by cool conditions (Waye and Shewchuk 2002). The time required for gophersnake eggs to develop depends on the temperature of the surrounding substrate (see **Life Cycle and Reproduction**), and hatching success and/or hatchling survival may be lowered if the weather is cool in late summer – early fall.

Activity of the Great Basin Gophersnake is correlated with air temperature (Grothe 1992). Snakes are active at a mean body temperature of 21.5 – 30^{o}C, with a thermal maximum of 34^{o}C (Parker and Brown 1980; Diller and Johnson 1982; Shewchuk 1996). The lower threshold body temperature for normal movement of captive juveniles is 18^{o}C; the minimum core temperature was 3.0^{o}C and the maximum 40.5^{o}C (Brattstrom 1965 cited in Ernst and Ernst 2003).

Gophersnakes use direct and indirect insolation to raise their body temperature after emergence from hibernation, often exposing only the head (Ernst and Ernst 2003), or simply take advantage of insolating cover rocks. Basking snakes tend to remain in at least partial concealment, usually at the base of a shrub, and immobile even when closely approached. During the active season, gophersnakes maintain a relatively stable body temperature by moving between sun and shade and retreating under rocks (Parker and Brown 1980). They are usually inactive during the hottest and coolest portions of the day. Diller and Johnson (1982) reported a unimodal pattern of peak activity between 10:00 h and 13:00 h in spring, and a strongly bimodal pattern of activity peaking around mid-morning and again around dusk in summer.

The cryptic colouration and defensive behaviour of the Great Basin Gophersnake closely resemble that of the syntopic Western Rattlesnake. Some authors have suggested that the gophersnake is a Batesian mimic of the rattlesnake (Kardong 1980), but others (Sweet 1985) interpret such similarities as resulting from convergent evolution of the two species in shared broad habitats. Some individual gophersnakes are relatively docile when handled, while others may produce a rattlesnake-like threat display of tail vibration, hissing and striking when disturbed (Shewchuk 1996; Ernst and Ernst 2003). Large gophersnakes are capable of inflicting a painful bite (Sarell pers. obs.), though the species poses no danger to humans.

Dispersal and Migration

Movements to and from hibernacula are direct and short in duration and are usually among the longest distances travelled by individuals (Parker and Brown 1980; Shewchuk 1996). Average movement distances of 350 m – 500 m have been reported from B.C. (Kamloops: average maximum of 453 m Bertram *et al*. 2001; Osoyoos: 934 ± 185 m, Shewchuk 1996; South Okanagan: 357 m, Williams and Bishop 2011; 520 ± 25 m, Williams *et al*. 2012), but occasional longer distances up to 2360 m have been documented (Williams *et al.* 2012). In Utah, the average maximum distance reported by Parker and Brown (1980) was 510 m. The configuration of habitat around hibernacula likely affects the distances dispersed by snakes in a given area (Waye and Shewchuk 2002).

The longest single season movements made by gophersnakes (>2 km) are generally those by females travelling to oviposition sites in summer and fall (Shewchuk 1996; Bertram *et al*. 2001). White (2008) observed that males in her study in the Okanagan Valley moved farther than females in spring (perhaps searching for mates), while females moved farther than males in summer and fall.

After reaching their summer ranges, movements of snakes in Osoyoos were relatively short (average 153 ± 96.2 m/day for females and 124.8 ± 23.7 m/day for males) and were centred on a particular retreat site (Shewchuk 1996). There was no significant difference in home range size between males (average 5.3 ha) and females (average 13.9 ha) due to the large variance among individuals. White (2008) also reported no apparent difference in home range shape or pattern between sexes or years in the Okanagan Valley. Home ranges of individuals may overlap extensively (Shewchuk 1996). Home ranges of 1.14 – 33.47 ha have been documented in B.C. (Bertram *et al*. 2001; Brown 2006; White 2008). The maximum home range of gophersnakes was 3.3 ha in Utah (Parker and Brown 1980). Grassland snakes at the northern edges of their distribution may have larger home ranges than individuals in more southerly locales due to climate constraints (Martino *et al*. 2012).

Haney and Sarell (2007) considered that barriers of unsuitable habitat >2 km would effectively prevent gene flow between gophersnake populations. Although gophersnakes have been recorded moving up to 2.4 km from hibernacula, average maximum movements were approximately 500 m (see above). Gophersnakes in B.C. are distributed along both sides of large river valleys, but the frequency of river crossings by gophersnakes is not known. While it is theoretically possible that dispersal could occur passively by natural means (such as with floating debris) or anthropogenic means (such as vehicle stowaways), passive dispersal by gophersnakes has not been documented.

Interspecific Interactions

Gophersnakes may share hibernacula and sometimes retreat sites with Western Rattlesnakes, Northern Rubber Boas (*Charina bottae*), Desert Nightsnakes (*Hypsiglena chlorophaea*), Common Gartersnakes, and Western Yellow-bellied Racers. Egg-laying sites may also be shared with racers (Shewchuk 1996).

Predators of gophersnakes and/or their eggs include Red-tailed Hawks (*Buteo jamaicensis*), Swainson's Hawks (*Buteo swainsonii*), Golden Eagles (*Aquila chrysaetos*), Great Horned Owls (*Bubo virginianus*), American Badgers (*Taxidea taxus*), Striped Skunks (*Mephitis mephitis*), Red Foxes (*Vulpes vulpes*), and Coyotes (*Canis latrans*) (Olendorff 1976; Orchard 1984; Grothe 1992; Shewchuk and Waye 1995; Shewchuk 1996; Ernst and Ernst 2003; White 2008). Juvenile snakes may be killed by domestic cats (Sarell pers. obs.). There are anecdotal reports of deer (*Odocoileus* spp.) deliberately killing gophersnakes and rattlesnakes by trampling (Klauber 1997).

Several wildlife species known to be prey of gophersnakes are listed as species at risk in British Columbia. These include Long-billed Curlew (*Numenius americanus* - eggs), Nuttall's Cottontail (*Sylvilagus nuttallii)*, and Great Basin Pocket Mouse (*Perognathus parvus*).

Parasitic sarcocystis protozoa were found in Great Basin Gophersnakes and in Deermice (*Peromyscus maniculatus*) captured in Idaho, though experimentally infected gophersnakes rarely showed symptoms of illness (Bledsoe 2007). A salmonellosis outbreak in a Domestic Turkey (*Meleagris gallopavo*) flock in the United States was traced to a Great Basin Gophersnake that preyed on turkey poults (Hinshaw and McNeill 1944 cited in Mitchell and Shane 2001). Captive snakes and other reptiles frequently harbour salmonella, which may result in mortality (Mitchell and Shane 2001).

POPULATION SIZES AND TRENDS

Abundance

Few data are available on abundance or population trends. Gophersnakes are difficult to census due to their cryptic nature and fossorial habits, their wide but scattered distribution in British Columbia, and their frequent misidentification by members of the public (Bertram *et al*. 2001; Southern Interior Reptile and Amphibian Recovery Team 2008). Lomas *et al*. (2011) marked gophersnakes for 3 years (2009 – 2011) on the Osoyoos Indian Reserve, but recapture rates were low. Forty-one snakes were captured in 2009, 17 in 2010 (including one individual marked in 2009), and 47 in 2011 (including 4 marked individuals). Williams and Bishop (2011) used telemetry data from White (2008) to estimate population densities of 0.3 - 1 gophersnake/ha in high-quality habitat in South Okanagan. Diller and Johnson (1988) estimated densities of 0.1 – 1.9 gophersnake/ha in southern Idaho, depending on habitat type. Densities from these studies cannot be extrapolated to the total B.C. population given high local variation in abundance and patchiness in distribution and habitat quality. The BC Conservation Data Centre (2012) gives a speculative estimate of the population size of gophersnakes in B.C. at 2,500 to 10,000 individuals, but no robust population estimates are available.

Fluctuations and Trends

Few data are available on population trends and fluctuations (Southern Interior Reptile and Amphibian Recovery Team 2008). Habitat loss to agricultural conversion and urbanization, as well as road density and traffic, are increasing (Bertram *et al*. 2001; Southern Interior Reptile and Amphibian Recovery Team 2008), suggesting continued population declines. The BC Conservation Data Centre (2012) suggests a trend of 'rapidly declining to declining (decline of 10 – 50%)' for the Great Basin Gophersnake and reports that there are "no occurrences with known good viability". Viability was inferred based on threats at known sites, including proximity to roads.

Although some data on mortality are available, there is no information on population recruitment rates in B.C. White (2008) reported mortality of 17 of 39 radio-tagged adult gophersnakes over a two-year period in the South Okanagan, resulting in an annual mortality of 22%. Some of the tagged individuals were not monitored over the full two years, suggesting that the true annual mortality rate might be even higher. Three of the 39 tagged gophersnakes experienced unnatural deaths, all from roadkill, resulting in an annual excess adult mortality rate of 3.8%.

High rates of decline are likely in the vicinity of Kamloops and throughout most of the Okanagan, as well as areas close to major transportation corridors. Snake researchers have noted local extirpations or precipitous declines of large snakes (rattlesnakes and gophersnakes) in the vicinity of Highway 1 from Chase to Ashcroft and in the vicinity of Highway 97 from Summerland to Peachland (Hobbs pers. comm. 2013). Declines may be of lesser magnitude in the Kettle, Similkameen, Nicola, Fraser, and Thompson (except Kamloops area) watersheds where human populations and associated road traffic are less compared to more urbanized areas (MacGillivray 2005). Gophersnake populations in the Upper Fraser area may be more stable, because much of this area is still remote and has less development and fewer roads. However, gophersnakes exist at the northern limits of their distribution in this region, and densities may be relatively low and more subject to climate extremes.

Results from the IUCN threats calculator assessment (see Appendix 1) by a group that included recovery team members, species experts, and B.C. government representatives likewise predict a continuing decline. Based on available data on road mortality and its effects on snake populations (see **THREATS AND LIMITING FACTORS**), there was a consensus that roadkill poses a serious threat to the population and is likely to impact its viability. Results of the threats calculator assessment and population modelling conducted as part of this status assessment predict a population decline of 30% or more across the species' Canadian range within the next 3 generations (24 years), based on sensitivity of the population to excess adult mortality from roadkill and other sources, such as inadvertent and intentional killing. Habitat loss and degradation pose additional stresses to the population. An age-based population projection matrix model for female gophersnakes showed that (a) adult mortality has by far the greatest influence on population growth rate and (b) excess mortality from roadkill has a large predicted impact on population size, with 40 – 50% reduction predicted over 3 generations (Reed 2013). The parameters for the model were compiled from several studies in different areas (Shewchuk 1996; Parker and Brown 1980; Diller and Johnson 1982; White 2008), and do not realistically portray the B.C. population of gophersnakes. Baseline and road mortality rates of adults were calculated from a radiotelemetry study in the Okanagan White (2008), but juvenile survivorship values were from a life table prepared for gophersnakes in Utah (Parker and Brown 1980). However, the model allowed us to draw inferences about the relative influence of different parameters on population growth and effects of additional sources of mortality.

Population Fragmentation

Gophersnakes are threatened by habitat fragmentation as well as by direct habitat loss. Natural distribution of grasslands is fragmented, but urban and agricultural developments and roads exacerbate this fragmentation. Urbanization is the greatest factor in fragmenting gophersnake subpopulations. The cities of Kelowna and Vernon have severely disrupted habitat connectivity and presumably virtually severed north-south gene flow in the Okanagan. The growth of the city of Kamloops has similarly disrupted habitat connectivity and has probably almost severed east-west gene flow in the Thompson-Fraser-Nicola area.

Whether the total population is severely fragmented in the COSEWIC definition of the term is unknown. While habitat fragmentation can be considered severe in parts of the species' range, including the South Okanagan, it is unknown whether 50% or more of the total population is in habitat patches smaller than required to support a viable population, and what indeed the minimum size of such a habitat patch would be.

Rescue Effect

The Fraser-Thompson-Nicola subpopulation appears to be isolated from all other gophersnake populations and would not be subject to rescue from other areas. The remaining portions of the range in the Kettle and the Okanagan-Similkameen valleys are contiguous with the species' range in Washington State, where there are records from the immediate vicinity of the Canadian – U.S. border (Washington Department of Fish and Wildlife 1997; Hallock and McAllister 2005). Gophersnakes are considered common and widespread in the eastern portion of the state but likely extirpated in the western portion (Hallock and McAllister 2005). Rescue is possible but is expected to be slow and confined to the vicinity of the border.

THREATS AND LIMITING FACTORS

The IUCN Threats Calculator was applied to the species by the report writers and was subsequently reviewed and adjusted by a group of experts including recovery team members and B.C. provincial government representatives (Appendix 1). The overall threat impact was calculated as "high" with 1 high impact threat (Roads and Railways) and 6 low impact threats, which cumulatively affect populations. The threats are discussed below, in an approximate order of their importance.

Transportation and Service Corridors

Road mortality is thought to be a major threat to the species (Hobbs and Sarell 2000, 2001; Hobbs 2001; Waye and Shewchuk 2002; Southern Interior Reptile and Amphibian Recovery Team 2008; BC Ministry of Environment 2010; BC Conservation Data Centre 2011a). The snakes are vulnerable to road mortality due to their high mobility and seasonal migrations across landscapes criss-crossed with roads and their habit of lingering or moving slowly across road surfaces.

Road mortality affects gophersnakes throughout their Canadian range but is probably highest in the Okanagan and lowest in the Fraser-Thompson-Nicola area. Mortality due to roadkill can be locally high (Campbell 2007) and is often highest during the periods when the animals are the most mobile and migrating to and from hibernacula (Pickard *et al*. 2009). Gophersnakes reside in the valley bottoms and hillsides within southern interior watersheds, terrain that commonly supports roads, including major transportation corridors. For example, Highways 3, 97, and 8 bisect prime gophersnake habitat, and biologists have noted declines in the vicinity of highways (see **Fluctuations and Trends**).

Gophersnakes appear to be attracted to and may linger on the warmth of paved road surfaces (Waye and Shewchuk 2002), increasing susceptibility to roadkill. They use rectilinear movement in open areas (such as roads) instead of sinusoidal movement (Sarell pers. obs.), possibly to avoid detection by avian predators. Rectilinear movement is slow, and it may take more than 2 minutes for a snake to travel across a 2-lane road (Sarell pers. obs.). Snakes crossing roads may be targeted by drivers. Ashley *et al*. (2007) reported that 2.7% of motorists in their study in Long Point in Ontario intentionally hit snakes and other reptiles on the road. Deliberate targeting of snakes by drivers has also been observed in B.C. (Sarell pers. obs.).

Much of the Gophersnake’s range contains networks of roads, and where roads intersect travel routes, snakes must cross roads at least twice during the active season. A spatial analysis of the database of 318 communal snake dens in the southern interior of B.C. revealed that 86% of the dens are within 2 km of paved roads (49% within 1 km; 27% within 1 – 2 km) (Hobbs 2013). The analysis was conducted for Western Rattlesnakes, but it also pertains to Gophersnakes, which are known from a number of these dens. This distribution is not due to survey bias, as every effort was made to survey potentially suitable habitat away from roads (Hobbs 2013). Only about 15% of the range of the Great Basin Gophersnake is not intersected by roads or has a low road density (Hobbs pers. comm. 2013).

The Great Basin Gophersnake was the most common snake species found as roadkill in the Oliver area in South Okanagan, and juveniles and adults were found in approximately equal numbers (Pickard *et al*. 2009). Also in the South Okanagan, White (2008) reported a high mortality of radio-tagged Gophersnakes; 3 of 39 adult snakes were killed on roads over a 2-year period. In the Vernon area, Davis (2010) compiled 144 observations of roadkill snakes or live snakes that were moved from roads over a 10-year period; 74 of them were Great Basin Gophersnakes. More than a third of the gophersnake observations from Canada assessed for this report (n=1400) were roadkills. An example of the severity of road mortality is a 25 km-stretch of road south of Penticton that was irregularly monitored for 12 years and yielded 255 gophersnake observations, of which about 85% were roadkills (Pickard 2009). The rate of removal of the carcasses by scavengers was not documented but has been found to be high in other studies, greatly underestimating observed roadkill rates (DeGregorio *et al*. 2011; Slater 2002).

Roadkill reduces population size (depletion effects) and changes the demographics (Jackson and Fahrig 2011). Rudolph *et al*. (1999) sampled snake populations at various distances from roads in Texas. Their results suggested that populations of large snakes were reduced by more than 50% within 450 m of moderately used roads and that populations continued to be depressed within distances of at least 850 m from roads. Row *et al*. (2007) studied the effects of roads on Black Ratsnakes (*Elaphe obsoleta*) in Ontario. Although the calculated mortality rate was only 0.026 deaths/crossing, it was sufficient to increase the probability of extinction of the study population from 7.3% to 99% over 500 years. The loss of more than 3 adult females annually due to roadkills increased the probability of extinction of the study area population (estimated at 400 adults) to over 90% over 500 years. Gophersnake life history includes traits that make populations particularly vulnerable to road mortality, including late maturity, low reproductive rate, high natural adult survivorship, and seasonal migrations (Jochimsen 2005). The additive effects of continued losses from road mortality may have serious effects on the genetic diversity of populations (Jackson and Fahrig 2011). Pickard (2009) reviewed roadkill records from an area near Oliver between 1988 and 2008. There were slightly significant decreasing trends in the proportion of sexually mature adult gophersnakes, possibly indicating a shift in age structure in the populations monitored.

Creation and maintenance of service corridors can affect all gophersnakes throughout their range in B.C. (Southern Interior Reptile and Amphibian Recovery Team 2008). Grubbing, clearing and trenching for pipelines constitute the most severe stress associated with service corridors as these destroy habitat and cause accidental mortalities, and individuals can become trapped while the ditch is open (Sarell 2000a). Right-of-ways are typically revegetated at the end of construction, and habitat can be enhanced with rock piles left on the ground surface. These are readily used by gophersnakes for cover, shedding and foraging (Sarell 2006).

Both snakes and their hibernacula have been destroyed (sometimes deliberately) by earth-moving equipment during road construction (Sarell pers. obs.). Salvage operations conducted before and during construction can relocate at least some snakes that would otherwise be at risk of injury or death due to construction machinery (Sarell *et al*. 2010).

Residential and Commercial Development

Residential and commercial development is an important threat for gophersnakes in a portion of their range (Southern Interior Reptile and Amphibian Recovery Team 2008; BC Conservation Data Centre 2011a). Impacts from residential and commercial developments are most severe in the Okanagan Valley and in the Kamloops area, where human populations continue to grow. Development of the areas on or around hibernacula, or removal of talus from them, can eliminate or modify habitat, including changing thermal characteristics of the den. Destruction or alteration of hibernacula can have severe impacts on local populations disproportionate to the area of land affected.

Agriculture

Grazing is pervasive across the Gophersnake's range. Grazing can degrade habitat, reduce small mammal numbers and diversity, reduce cover, increase erosion and soil compaction, and change species' composition (reviewed in Fleischner 1994). Overgrazing by livestock can remove vegetative cover important for predator avoidance for snakes as well as cover for their mammalian and avian prey (Bock *et al*. 1984; Hobbs and Sarell 2000; Ovaska and Sopuck 2004; Rickel 2005; BC Forest Practices Board 2007). Grazing may also result in the spread of non-native plants that change the character of native grasslands (Gayton 2004). The spread of non-native invasive plants, such as Cheatgrass (*Bromus tectorum*), has been linked to declines in gophersnake abundance in some areas (Hall *et al*. 2009). Cheatgrass was one of the earliest exotic weeds in B.C.'s interior and is now 'widespread and common' in the Okanagan (Lea 2008). The impacts of specific grazing regimes on gophersnakes are unknown (Southern Interior Reptile and Amphibian Recovery Team 2008). Gophersnake populations can persist in grazed environments (Reynolds and Trost 1980; Diller and Johnson 1988), so the stress of this threat is likely low unless stocking densities are high.

Agriculture occurs on most low benchlands in every watershed within the species' range and in floodplains where creeks and rivers have been diked. Factors that affect survival and reproductive success include modification/loss of foraging, nesting or hibernating habitat and/or interruption of dispersal corridors connecting those habitats, accidental mortality due to farm machinery (Bertram *et al*. 2001) and possibly secondary poisoning from pest-control activities (Williams and Bishop 2011).

Formerly, agriculture in the southern interior of B.C. consisted of hayfields, orchards and vegetable crops. The recent trend to vineyard development began in the South Okanagan but has expanded to the Central Okanagan, Kettle, Similkameen, and Nicola valleys. The potential for lucrative yields has prompted a rapid conversion of agricultural fields and native habitats into vineyards. Vineyard operations often strip the topsoil and contour subsoil, which directly affects gophersnakes taking refuge in rodent burrows. Habitat suitability is severely reduced in vineyards as there are virtually no burrows and rodent populations are smaller.

Agricultural activities such as haying or crop harvesting are known to kill snakes (Bertram *et al*. 2001). One rancher in the Fraser canyon reported that ‘many’ dead gophersnakes had been found inside hay bales on his ranch (Sarell pers. obs.).

Energy Production and Mining

Mining and quarrying occur throughout the B.C. range of the species and may have local impacts (Southern Interior Reptile and Amphibian Recovery Team 2008). This threat is derived from direct mortality during earthworks and destruction of habitat. Even small-scale operations can have profound effects, if hibernacula are destroyed.

Biological Resource Use

Persecution occurs in agricultural areas, service corridors, and in residential areas. Aggregations of snakes at hibernacula may be particularly vulnerable to persecution (Hobbs 2001; Gregory 2007), and the presence of rattlesnakes at communal dens may increase risks to gophersnakes. None of over 80 communal snake dens visited across the range of the gophersnake (Hobbs and Sarell 2000, 2001; Hobbs 2001) were completely free of anthropogenic disturbance. Anthropogenic cover objects may also draw snakes into areas close to human residences (Bertram *et al*. 2001), where they may be subject to persecution or accidental mortality.

Sometimes gophersnakes are mistaken for rattlesnakes, but some people simply kill all snakes encountered. Outreach programs occurring in South Okanagan and Lower Similkameen are designed to make the public aware of the differences between gophersnakes and rattlesnakes, the value of snakes in the ecosystem, and the benefits they provide to agriculture by controlling pests (Sarell 2000b; Bertram *et al*. 2001; Lomas *et al*. 2011).

Gophersnakes are collected from the wild and kept as pets in the U.S. Impacts from collecting in B.C. have not been quantified but are believed to be negligible. Keeping other *Pituophis* species (e.g., Pine Snake, *P. melanoleucus*) in captivity in B.C. is apparently legal, although whether released Pine Snakes or other related species could become naturalized here and possibly hybridize with native gophersnakes is not known.

Timber harvesting affects all populations, especially in light of recent increases in salvage harvest of areas of insect outbreaks. Accidental mortality may occur during harvesting (including road construction), and habitat is degraded. However, some low elevation harvesting may actually improve habitat, providing there is no silviculture and the area remains as grassland or parkland.

Human Intrusion and Disturbance

Much of the gophersnake's range is subject to heavy use by off-road vehicle recreation. The impact of off-road vehicles on gophersnakes in Canada has not been quantified, but has been shown to significantly affect reproductive success in other *Pituophis* species, possibly due to mortality of gravid females and young, or disturbance of nests by off-road vehicles (Burger *et al*. 2007).

Threats result from accidental mortality from vehicles (including ATVs; Sarell pers. obs.) and potential collapse of burrows from off-road traffic. Mountain bike traffic has been observed to kill snakes (Sarell pers. obs.). Trails made by off-road vehicle users damage native vegetation and may also facilitate the spread of invasive weeds (Munger *et al*. 1999).

Invasive and Other Problematic Species

Direct mortality occurs from predation by native and non-native predators, and from disease (Bertram *et al*. 2001). The degree of this threat is unknown. Predation by domestic animals (primarily cats) on young snakes may occur in rural areas. Loss *et al.* (2013) quantified cat predation on birds and mammals from several studies and found it to be a significant source of mortality. Based on newer studies, they estimated that 258 – 822 million reptiles could be killed annually by cats in the United States but concluded that effects on populations are unclear and in need of documentation.

Natural System Modification

Fire suppression contributes to tree ingrowth on native grasslands and lowers habitat suitability for gophersnakes (Waye and Shewchuk 2002; Southern Interior Reptile and Amphibian Recovery Team 2008), especially in the Interior Douglas-fir and Ponderosa Pine biogeoclimatic zones. Conversely, fire may cause direct mortality, but the fossorial nature of gophersnakes likely protects them from low-intensity fires.

Pollution

Pocket Gophers (*Thomomys talpoides*) create burrow systems and are food for gophersnakes (Sarell pers. obs.), but they are also a problem for farmers. Gophersnakes may be at risk from secondary poisoning from rodenticides used to control agricultural pests. Williams and Bishop (2011) conducted a modelling exercise to evaluate the risk to gophersnakes of 'gopher-getter' strychnine baits used in orchards and vineyards in South Okanagan. They concluded that 72 – 1113 snakes could be poisoned annually. No field investigation of the potential poisoning hazard has been done, and no gophersnake deaths due to poisoning have been documented.

Number of Locations

The number of IUCN or threat-based locations is difficult to apply to the Great Basin Gophersnake, as the most plausible threat is road traffic. Roads affect most areas within the species' range, but impacts are least severe in the upper Fraser where there are fewer roads and less traffic. If each road (and a 2 km buffer zone along it) is considered a separate location, then there is an unknown but a large number of locations. If known and potential den sites, or combinations of den sites under the same management or land status, are considered to be affected by road mortality, then the number of locations would still be large and exceed 10.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

The Great Basin Gophersnake is included as threatened on Schedule 1 of the federal *Species at Risk Act* (SARA), which prohibits killing or capturing the snakes or destroying their residences. Critical habitat has not been defined for this species as of December 2012.

<u>Provincial Status and Protection:</u>

'*Pituophis catenifer'* is protected under the BC *Wildlife Act*, which prohibits killing or capturing individuals or keeping them captive except under provincial permit. This wording of the Act also extends the same protection to all *P. catenifer* subspecies, including those not native to British Columbia.

<u>Provincial Recovery Actions:</u>

A provincial inventory strategy for the Great Basin Gophersnake was prepared in 2003 (Sarell and Haney 2003). The scope of the strategy was to inventory snakes to identify areas of suitable habitat for conservation initiatives, to monitor populations to assess the effectiveness of habitat conservation, and to develop adaptive management techniques.

A provincial recovery strategy for the Great Basin Gophersnake has been completed (Southern Interior Reptile and Amphibian Recovery Team 2008). That strategy considered four subpopulations described as ‘Fraser-Thompson, including the Nicola Valley; Okanagan-Similkameen; Kettle (Rock Creek to Midway); and Granby.’ The goal of the recovery strategy is to “*maintain self-sustaining populations of the Gophersnake, deserticola subspecies throughout its range within each of four population areas in British Columbia in protected habitats that include access to suitable hibernacula, foraging, mating, and nesting sites*”. The strategy concluded that recovery of the Great Basin Gophersnake was feasible if required habitat features and their connectivity were maintained and anthropogenic mortality was reduced significantly.

Non-Legal Status and Ranks

The Great Basin Gophersnake is Blue-listed (Special Concern) in B.C., with a provincial rank of S2S3 (“imperilled” – “vulnerable”; BC Conservation Data Centre 2011a). The highest priority assigned to the Great Basin Gophersnake under the BC Conservation Framework is 2, under Priority Goal 3 (Maintain the diversity of native species and ecosystems) (BC Ministry of Environment 2010). Global, national and subnational statuses assigned to the *deserticola* subspecies are summarized in Table 3 (NatureServe 2012).

Table 3. Global, national, and subnational ranks for Great Basin Gophersnake. Refer to NatureServe website for details and definitions (NatureServe 2012).

Jurisdiction	Level	Status
Global	Global	G5T5
Canada	National	N2N3
USA	National	N5
BC	Subnational	S2S3
AZ, CO	Subnational	S4
Navajo Nation, NV	Subnational	S5
WY	Subnational	S3
OR, CA, NM, UT	Subnational	Unranked

Habitat Protection and Ownership

Haney and Sarell (2007) completed a detailed analysis of land status within the gophersnake's range in B.C. Suitability modelling was used to identify suitable habitat within each large portion of the species' range, and land ownership and protection status were assessed. Only 10% of the suitable habitat for the Great Basin Gophersnake in B.C. is located within protected areas (provincial parks/ecological reserves, National Wildlife Areas, Wildlife Management Areas, private conservation holdings); most of the remainder was unprotected provincial Crown land (Table 4). The majority of suitable habitat was >1 km from protected lands. High and moderately suitability habitat was fairly well distributed and contiguous throughout the range of most populations, with the exceptions of the Kelowna, Vernon and Kamloops areas (Haney and Sarell 2007). Protected areas include habitats within provincial parks (such as Okanagan Mountain, Kalamalka, and Skaha Bluffs), ecological reserves (such as Tranquille and Trout Creek), other protected areas (such as White Lake, Churn Creek, and South Okanagan Grasslands), Canadian Wildlife Service properties (such as Vaseaux-Bighorn National Wildlife Area), and Nature Trust properties (Sarell *et al.* 1996; Sarell and Alcock 2004; BC Ministry of Environment 2011; Hobbs 2011a). Many protected areas within the gophersnake's range are too small to include different seasonal habitats required by this species (BC Conservation Data Centre 2012).

Table 4. Land status within suitable gophersnake habitat (from Haney and Sarell 2007).

Area	Analysis Unit	Total ha suitable habitat (high, moderate and low)	% Crown land	% Private land	% Indian reserve	% Protected land
Okanagan-Similkameen		284012	50	25-30	16	12
Fraser-Thompson-Nicola	Fraser	138780	50	25-30	10	16
	Thompson-Nicola	310778	50	25-30	10	6
Kettle		32415	50	>50	0	<2
Provincial total		765985				10

Approximately half of the suitable habitat is on unprotected Crown land, and a further 25 – 30% is on private land. Little of the suitable habitat within two potential linkage areas connecting the Fraser-Thompson-Nicola and Okanagan-Similkameen areas is protected (0% and 2%, respectively; Haney and Sarell 2007).

Some high suitability habitat on Crown land (Hobbs 2011b) has been proposed for protection for some time but this has not yet occurred. Sarell and Alcock (2011) identified dens on Crown lands in South Okanagan that could be subject to private sale, pending government negotiations.

A significant proportion of suitable habitat (10% of the Fraser-Thompson and 16% of the Okanagan-Similkameen portion of the range) lies within First Nations' reserves (Sarell 2005a; Haney and Sarell 2007). First Nations' reserves are considered federal lands (*Species at Risk Act* S.C. 2002, c. 29, 2(1)), so SARA prohibitions regarding capture, killing or destruction of critical habitat of gophersnakes would apply to these areas.

As gophersnakes are often found denning with other snakes (Table 5), dens used by other species may be considered suitable habitat. In total, since 1990, 430 snake dens (52 with confirmed gophersnake use) have been documented in B.C. The current status and availability of the majority of dens is unknown as few are monitored. Of the known sites, 148 (32 with confirmed gophersnake use) have some degree of protection. The remaining dens are on private lands, unprotected Crown lands, or First Nations' lands, or where the land status is unknown (Sarell, unpubl. data). Data on dens on First Nations' lands have not been reported as no data sharing agreement is in place.

Table 5. Frequency of gophersnake use of hibernacula that are also used by other snake species in British Columbia (M. Sarell, unpubl. data).

Species	Total number dens known to be used by species	Number of dens also with confirmed gophersnake use
Northern Rubber Boa	18	1
Western Rattlesnake	297	58
Western Yellow-bellied Racer	65	43
Desert Nightsnake	11	2

An Identified Wildlife Management account has been prepared for the Great Basin Gophersnake under the B.C. Identified Wildlife Management Strategy (BC Ministry of Water, Land and Air Protection 2004). Measures undertaken for protection include the establishment of Wildlife Habitat Areas to protect important habitat areas, such as snake dens. Wildlife Habitat Areas are managed according to specified General Wildlife Measures for forestry and range practices.

General Wildlife Measures for gophersnakes were designed to minimize disturbance and mortality, maintain important habitat features, and maintain foraging areas. However, grazing leases are not subject to the grazing component of these measures. Provisions of the Identified Wildlife Management Strategy are stand-level measures only and do not address habitat supply, habitat connectivity or population viability, nor do they apply to urban, agricultural or private land (BC Ministry of Environment 2011). The existence of a Wildlife Habitat Area does not prevent the sale of Crown land.

As of February 2013, 31 Wildlife Habitat Areas have been established around snake dens, totalling over 5971 ha (Woods pers. comm. 2013). A further 32 such areas have been proposed and are under review. An additional 7 snake dens are protected in Wildlife Habitat Areas established for other wildlife. The average size of WHAs around snake dens is 193 ha; this may not be sufficiently large to provide protection for the snake population using a hibernaculum at its centre (Williams *et al*. 2012).

A strategy prepared for monitoring effectiveness of Wildlife Habitat Areas for gophersnakes described various population and habitat monitoring measures (Erickson *et al*. 2007). That strategy included assessing the continued presence of gophersnakes and evaluating their viability and mortality risks. Field surveys were also recommended for ensuring that the habitats within Wildlife Habitat Areas remain suitable, documenting and evaluating threats to gophersnake populations within and around Wildlife Habitat Areas, and assessing accessibility of habitats and habitat features outside these areas.

A routine spatial effectiveness evaluation was completed in 2005 (Haney and Sarell 2005) that compared 5 indicators (road density, land ownership and protection status, land use, fire potential and fire history) within 6 Wildlife Habitat Areas with benchmark areas. The authors concluded that all of the sites assessed were effective for at least one of the indicators, but only one site was judged effective for all indicators evaluated.

Snake management strategies have been developed in a few areas, including the Vernon Military Camp (Sarell 2005b), the Pacific Agri-food Research Centre in Penticton (Sarell and Shanner 2006), and the Osoyoos Indian Reserve (Lomas *et al*. 2011). Mitigation and protection measures often include documentation of hibernaculum locations, maintaining habitat connectivity, installation of snake-proof fencing to prevent snakes from accessing heavily trafficked roads and residential areas, installation of warning signs to drivers, salvage of snakes before development, and outreach programs to improve public awareness.

The South Okanagan – Lower Similkameen Stewardship Program has been promoting voluntary stewardship of important natural lands, including snake habitats, through land owner contacts and outreach events for more than 10 years. The B.C. government has released best management practices (Ovaska *et al*. 2004), intended to provide guidance for developers on minimizing impacts to local reptiles and amphibians. Best management practices are recommendations only and are not legislated requirements.

Local governments (regional districts and municipalities) also may contribute to the protection of gophersnake habitat on private lands within their jurisdictions. One effective means of protecting gophersnake habitat is through the establishment of Environmentally Sensitive Development Permit Areas (ESDPA) as part of official community plans or neighbourhood land use plans. Appendix 2 lists governments within the range of the Great Basin Gophersnake and whether local bylaws effectively guide development in gophersnake habitat.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

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Mike Sarell is a Registered Professional Biologist in B.C. He earned a B.Sc. from the University of Victoria. Mike worked for the Ministry of Environment in Penticton before starting his own small consulting firm, Ophiuchus Consulting. Mike has participated in many snake inventory and research projects in B.C. over the last 25 years. He also is involved in the Southern Interior Reptile and Amphibian Recovery Team and prepared the COSEWIC update status report for Pygmy Short-horned Lizard (*Phrynosoma douglassi*).

COLLECTIONS EXAMINED

No collections were examined, but occurrence records were obtained from the following collections: Royal British Columbia Museum; Amphibian and Reptile Collection, Vertebrate Section, Canadian Museum of Nature; Beaty Biodiversity Museum, University of British Columbia.

Appendix 1. IUCN threats calculator results for the Great Basin Gophersnake. Only those threats that affect the species and were scored are shown.

THREATS ASSESSMENT WORKSHEET			
Species or Ecosystem Scientific Name	*Pituophis catenifer deserticola*		
Element ID	16245	**Elcode**	R-PICA-DE
Date	7/2/2013		
Assessor(s):	Mike Sarell and Lorraine Andrusiak completed the first draft, 10 Nov-2011. On Feb 7 2013, group review via conference call was conducted by Kristiina Ovaska, Dave Fraser, Mike Sarell, Jared Hobbs, Orville Dyer, Julie Steciw, and Purnima Govindarajulu. Notes edited by K. Ovaska, and pollution rating adjusted in consultation with C. Bishop in April 2013.		
References:	Southern Interior Reptile and Amphibian Recovery Team. 2008. Recovery strategy for the Gophersnake, *deserticola* subspecies (*Pituophis catenifer deserticola*) in British Columbia. Prepared for the BC Ministry of Environment, Victoria, BC. 20 pp.		

Overall Threat Impact Calculation Help:

Threat Impact		Level 1 Threat Impact Counts: high range	low range
A	Very High	0	0
B	High	1	1
C	Medium	0	0
D	Low	7	7
Calculated Overall Threat Impact:		High	High

Assigned Overall Threat Impact:	**B = High**
Overall Threat Comments	The greatest threat to gophersnake populations is from road traffic. Roads are prevalent throughout much of the species' range and even populations in protected areas are vulnerable to traffic mortality. Residential development is the second greatest threat.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	Most severe in the Okanagan and Kamloops areas. Assumes that some residential developments will be either large lots or acreages and still provide habitat. Threats are from direct mortality during development, loss of habitat causing reductions in population extent, and isolation of local populations. Does not account for threats from new traffic.
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Most severe in the Okanagan and Kamloops areas. Threats are as for Housing & urban areas. The severity is higher because a commercial/industrial development can be more destructive.
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	Occurs in parts of all three primary gophersnake population areas, Thompson-Fraser-Nicola, Okanagan-Similkameen, and Kettle (Midway-Grand Forks). Golf courses would have more impact than camp grounds. No examples were available.
2	Agriculture & aquaculture	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Assumes that the conversion of habitat to crops is permanent and severely decreases habitat suitability, whereas grazed habitat still maintains some habitat functionality.
2.1	Annual & perennial non-timber crops	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	Formerly most severe in South Okanagan but becoming more of a threat to all portions of the range. Vineyards often strip topsoil and contour subsoil, both of which have considerable impacts to snake populations. Habitat suitability is severely reduced. Does not account for killing of snakes associated with agricultural activities.
2.3	Livestock farming & ranching	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Grazing is pervasive in all areas. Grazing degrades habitat and reduces prey and cover to protect from predators, and causes soil compaction that can lead to collapse of burrows.
3	Energy production & mining		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Rock quarries and gravel pits occur in restricted parts of all three primary gophersnake population areas. Threat is from direct mortality during earthworks and from destruction of habitat. There may be some suitable habitat when the area is reclaimed. The group discussed a large new mine near Kamloops, but there are only historical gophersnake records from this area.
3.3	Renewable energy		Negligible	Negligible (<1%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Some IPPs (independent power projects) occur west of the Fraser; no wind farm developments are known.
4	Transportation & service corridors	B	High	Pervasive (71-100%)	Serious (31-70%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.1	Roads & railroads	B	High	Pervasive (71-100%)	Serious (31-70%)	High (Continuing)	Affects all three large portions of the species' range, but is less severe for the Fraser. Most protected areas are too small to ensure that snake populations are safe from road mortality. Threat is from accidental mortality and habitat destruction from new roads, and ongoing mortality from traffic on existing roads. This reduces population size and can isolate populations. GIS analysis indicates that of known snake dens (rattlesnake and gophersnake) in the area, 49% occur within 1 km and an additional 27% within 2 km of paved roads (Hobbs 2013); this would increase if dirt roads were included. Only about 15% of gophersnake's range in BC is either without roads or has a low road density and still may have historical population levels of snakes. Gophersnakes are highly vulnerable to road mortality (more so than rattlesnakes) because of their high mobility and slow, rectilinear movements across open spaces that increase their exposure. High road mortality has been documented in B.C. (study near Oliver, Pickard *et al*. 2009; radio-telemetry study by White 2008).
4.2	Utility & service lines		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Trenching for pipelines is the most severe stress as it destroys habitat, there are accidental mortalities, and individuals can become trapped while the ditch is open. Habitat can be created with rock debris and revegetation.
5	Biological resource use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Killing of snakes occurs illegally in agricultural areas, during service corridor construction, and in residential areas. Sometimes gophersnakes are mistaken for rattlesnakes and some people kill all snakes encountered. Ashley *et al*. (2007) found that 2.7% of drivers intentionally hit herpetofauna in Ontario; snake researchers have made similar observations in B.C.
5.3	Logging & wood harvesting	D	Unknown	Small (1-10%)	Unknown	High (Continuing)	Affects all three large portions of the species' range, especially with recent increases in conifer mortalities from pests. Threat is from accidental mortality during logging activities (including road construction) and from habitat degradation. Some low elevation harvesting may actually improve habitat, provided there is no silviculture so that the area remains as a grassland or parkland.
6	Human intrusions & disturbance	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Affects all three large portions of the species' range. Threat is from accidental mortality and collapse of burrows from off-road traffic. We know that such mortality does occur but do not know how often; the group agreed that it is probably > 1%.
6.2	War, civil unrest & military exercises		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Military base near Vernon—the base might be actually protecting habitat from development.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
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 suppression leads to degradation of habitat by forest encroachment on grasslands and ingress of parklands. Suppression also directly kills gophersnakes from the construction of fire guards. Suppression leads to severe fire events, which may cause mortalities. Post-fire habitat conditions are often better than prior to fire.
8	Invasive & other problematic species & genes	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	
8.1	Invasive non-native/alien species	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	Affects all three large portions of the species' range. Threat from predation by domestic animals (primarily cats) and mostly to younger snakes. Loss *et al.* (2013) highlights the impacts of feral and domestic cats on wildlife, including reptiles, in United States.
8.2	Problematic native species		Negligible	Restricted (11-30%)	Unknown	High (Continuing)	Primarily in the Okanagan. Racoons have expanded their range, but their impact on snakes is unknown. Ravens appear to have increased from historical levels, and there are anecdotal observations of predation events on snakes, but the effects are largely unknown and undocumented.
8.3	Introduced genetic material		Unknown	Unknown	Unknown	Unknown	Pine snakes and other subspecies of gophersnakes are available for sale as pets. There is a potential for hybridization if they are released into the wild, at present there is no evidence of such occurrences.
9	Pollution		Low	Restricted - Small (1-30%)	Moderate	High (Continuing)	
9.3	Agricultural & forestry effluents		Low	Restricted - Small (1-30%)	Moderate	High (Continuing)	Rodenticides are used for pocket gopher control in vineyards and orchards, and there is overlap with the range of the gophersnake (Williams and Bishop 2011). Consuming poisoned gophers may put gophersnakes at risk.
10	Geological Events		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
10.3	Avalanches/landslides			Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Mass slope failures can cause direct mortality and loss of important habitat features, such as hibernacula. There was a slide in Grassland National Park in 2011(entire hillside slumped), causing very high mortality of hibernating snakes (up to 90%) that were trapped in the hibernacula. Slumping has been noted in two areas within the gophersnake's range in B.C. (Green Lake road, unstable hillside; Vaseaux Lake, torrential downpour), but no data on mortality of snakes are available. This threat may not happen often, but when it happens, the impact may be severe, and effects could be exacerbated by increased frequency or intensity of storm events under Climate Change (but not counted below to avoid double counting).
11	Climate Change & Severe Weather			Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
11.4	Storms & flooding			Negligible (<1%)	Extreme (71-100%)	High (Continuing)	

Appendix 2. Local governments within the Great Basin Gophersnake's range in B.C. that require Environmentally Sensitive Lands Development Permits.

Local Government	Permit required?
Town of Osoyoos	Yes
Town of Oliver	Yes
City of Penticton	Yes
Regional District of Okanagan – Similkameen	In some areas
District of Summerland	Yes
District of West Kelowna	Yes
City of Kelowna	Yes
District of Lake Country	No
Regional District of North Okanagan	No (inferred but not implemented)
City of Vernon	No
Thompson – Nicola Regional District	No
City of Kamloops	Yes (although not reflected in older neighbourhood land use plans),
City of Merritt	No as ESDPA only addresses riparian areas
City of Greenwood	No, although intent is to protect forested slopes around city.
Village of Midway	Unknown
City of Grand Forks	No
Kootenay – Boundary Regional Districts	No
Village of Lytton	No
Squamish Lillooet Regional District	No
District of Lillooet	No
Village of Ashcroft	Yes
Village of Cache Creek	No
Cariboo Regional District	No plans for the Fraser