COSEWIC
Assessment and Status Report

on the

Western Rattlesnake
Crotalus oreganus

in Canada

THREATENED
2015

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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COSEWIC
Assessment Summary

Assessment Summary – May 2015

Common name
Western Rattlesnake

Scientific name
Crotalus oreganus

Status
Threatened

Reason for designation
The Canadian distribution of this snake is confined to arid valleys of south-central British Columbia, where its population is suspected to continue declining due to road mortality and persecution. Habitat loss from urbanization and agriculture constitute additional threats. Threats to the species are exacerbated because the snakes congregate at overwintering dens, the persistence of which is critical for the survival of local populations. Life history characteristics that include late maturity, small litters, and infrequent breeding by females hinder recovery after disturbances.

Occurrence
British Columbia

Status history
Designated Threatened in May 2004. Status re-examined and confirmed in May 2015.

COSEWIC
Executive Summary

Western Rattlesnake
Crotalus oreganus

Wildlife Species Description and Significance

The Western Rattlesnake (*Crotalus oreganus*) is the only truly venomous snake species native to British Columbia. The Northern Pacific Rattlesnake (*C. o. oreganus*) is the only subspecies of Western Rattlesnake present in Canada. Adults can reach 1.3 m in total length and are yellow, grey or greenish tan with brown to olive green blotches. Juveniles are brown and have more contrasting colour patterns. The Western Rattlesnake has a triangular head that is noticeably wider than its stout body, and a number of loosely interlocking horny segments at the end of its tail that the snake can vibrate to produce a warning buzz.

Distribution

The Western Rattlesnake ranges from south-central British Columbia south to Baja California and east to Idaho, eastern Utah, and Arizona. In British Columbia, the Northern Pacific subspecies occurs in five areas in the province's interior and has been recorded east along the Canada/USA border to Christina Lake, west to Lillooet, and north to Kamloops and Cache Creek.

Habitat

The Western Rattlesnake uses a home range that typically includes one or more winter dens, a transient area, and a summer range. The snakes overwinter in dens on steep slopes in rock outcrops, along talus slopes, or in earth-covered outcrops. Their habit of congregating at communal dens makes them particularly vulnerable to disturbances. Summer habitats include grassland areas with suitable basking and retreat sites and prey, and riparian areas that are used to escape summer heat. Western Rattlesnakes spend much of their time under or near cover such as rocks and fallen trees, and also readily use boards, concrete structures, and other anthropogenic objects or features.

Biology

Western Rattlesnakes emerge from their dens in March and April, and males and non-gravid females disperse to feed and mate. After mating in late summer or early fall, the snakes return to the den vicinity and enter hibernation in mid-October or early November. Most individuals remain within 1200 m of their dens throughout the active season. Gravid females do not forage or migrate but remain near the den to give birth in mid-September or early October. Western Rattlesnakes feed on a variety of small mammals. Their main predators are mammalian carnivores and large raptors.

Female Western Rattlesnakes mature at 7 – 9 years of age and thereafter give birth to small litters of 2 – 8 live young every 3 – 4 years. The generation time is approximately 15 years. This suite of life history characteristics that includes a low reproductive potential, long lifespan, and reliance on high adult survivorship increases the vulnerability of populations to excess mortality on roads and from human activities.

Population Sizes and Trends

The number of Western Rattlesnakes in British Columbia probably exceeds 10,000 adults, but there is much uncertainty about the population size. Continued habitat loss and other threats, including road mortality, suggest that the population is declining. Rattlesnakes from 12 dens (3% of those known) have been extirpated since the 1980s. Other dens were apparently destroyed by persecution and road and railway construction prior to 1980, but accurate documentation is lacking.

Threats and Limiting Factors

The main threats to the species are road mortality, persecution by people, and habitat loss and fragmentation from urban and agricultural developments. If dens are destroyed, entire subpopulations can collapse. Information on snake population size and structure at dens and the viability of the dens themselves is limited. Lack of knowledge and fear of rattlesnakes have resulted in persecution and killing of snakes.

Protection, Status and Ranks

The Western Rattlesnake is listed as Threatened on Schedule 1 of the federal *Species at Risk Act* and is protected provincially under the British Columbia *Wildlife Act*. The British Columbia Conservation Data Centre ranks the subspecies *Crotalus oreganus oreganus* as S3 (Vulnerable). Its national rank in Canada is N3 (Vulnerable). NatureServe lists the Western Rattlesnake's global rank as G5 (Secure). Twenty-two percent of known rattlesnake dens are on protected land (parks or private land managed for conservation).

TECHNICAL SUMMARY

Crotalus oreganus
Western Rattlesnake — Crotale de l'Ouest
Range of occurrence in Canada: British Columbia

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	~15 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, inferred decline from continued loss of habitat and threats
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown, but suspected to be greater than 30% based on anticipated habitat loss and road mortality
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown but suspected to be greater than 30% based on habitat loss and road mortality
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. No. Habitat loss is likely permanent; road mortality is very difficult to reverse. b. Yes c. No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	26,853 – 28,838 km^2 (This range represents EOO calculated using the minimum convex polygon method for dens only since 1998 (low value) and for all observations of snakes (high value; see Table 2 for details)
Index of area of occupancy (IAO) (Always report 2x2 grid value).	804 – 1424 km^2 (This range represents IAO calculated using only dens since 1988 (low value) or all snake observations (high value; see Table 2 for details)

Is the population "severely fragmented" i.e. is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. Unknown b. Probably not
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	>>10 (based on the most plausible threat, road mortality)
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes (12 snake dens are considered extirpated, including nine in the Okanagan-Similkameen. Extirpation in additional areas is strongly suspected but poorly documented)
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, an observed decline in the area, extent and quality of habitat
Are there extreme fluctuations in number of subpopulations?	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)

Subpopulations (give plausible ranges)	**N Mature Individuals estimated based on expert breakdown of total number from Hobbs (2013)**
Okanagan-Similkameen	Unknown, but likely < 4000
Midway	Unknown, but likely < 500
Grand Forks	Unknown, but likely < 1000
Thompson-Nicola	Unknown, but likely < 3000
Vernon	Unknown, but likely < 1000

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term.

Total	Possibly over 10,000 adults, but widely different estimates are available: • 2,500 - 10,000 individuals, with likely fewer than 5000 adults (BC Conservation Data Centre 2013b) • Less than 10,000 individuals (age unspecified), based on counts at dens (Hobbs (2013) • 31,277 - 56,776 adults, based on habitat modelling (Aquila Conservation & Environment Consulting 2014); this value could be a gross overestimate, as it relies on a number of assumptions and is based on extrapolating from a small high quality area supporting a high snake density to the entire B.C. range of the species.

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Analyses not done due to insufficient data.

Threats (actual or imminent, to populations or habitats)

Road mortality; Killing and collecting snakes; Habitat loss/degradation from urbanization and agriculture; Human intrusion and disturbance; Invasive and problematic species; Fire and fire suppression

Rescue Effect (immigration from outside Canada)

Status of outside population(s)?	Ranked as secure (S5) in Washington and Idaho south of the species' range in British Columbia
Is immigration known or possible?	Unknown but possible along the international boundary between Chopaka and Anarchist Mountain and at Christina Lake (Cascade)
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Probably not
Are conditions deteriorating in Canada?[+]	Yes
Are conditions for the source population deteriorating?[+]	Unknown
Is the Canadian population considered to be a sink?[+]	No
Is rescue from outside populations likely?	Possible but of limited importance

[+] See Guidelines for modifying status assessment based on rescue effect.

Data Sensitive Species

Is this a data sensitive species?	Yes

Status History

COSEWIC: Designated Threatened in May 2004. Status re-examined and confirmed in May 2015.

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric code:** A3cd+4cd
Reasons for designation: The Canadian distribution of this snake is confined to arid valleys of south-central British Columbia, where its population is suspected to continue declining due to road mortality and persecution. Habitat loss from urbanization and agriculture constitute additional threats. Threats to the species are exacerbated because the snakes congregate at overwintering dens, the persistence of which is critical for the survival of local populations. Life history characteristics that include late maturity, small litters, and infrequent breeding by females hinder recovery after disturbances.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet A1, because the magnitude of declines over past 3 generations (~45 years) is uncertain and the threats are not clearly reversible and understood and ceased. Does not meet A2, because the magnitude of declines over past 3 generations (~45 years) is uncertain. Meets Threatened A3cd, because there is a suspected decline of 30% or greater over the next 3-generation period (~45 years), based on loss and decline in quality of habitat and road mortality (c) and levels of persecution (d). Meets Threatened A4bc because there is a suspected decline of 30% or greater over a 3-generation period including both past and future (~45 years), based on loss and decline in quality of habitat and road mortality (c) and levels of persecution (d).
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criteria. EOO is above threshold, and while IAO is below threshold for Threatened, sub-criteria are not fully met because the population is not severely fragmented, does not undergo extreme fluctuation, and there are more than 10 locations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Does not meet criteria because the population may contain more than 10,000 adults; however, there is much uncertainty about the population size.
Criterion D (Very Small or Restricted Population): Not applicable. Does not meet criteria, because the population is not very small or restricted.
Criterion E (Quantitative Analysis): Not applicable. PVA was not performed due to lack of data.

PREFACE

Initiatives for rattlesnake conservation that have occurred in British Columbia since the previous status report include a provincial recovery strategy prepared in 2008 (Southern Interior Reptile and Amphibian Recovery Team 2008) and a provincial population assessment (Hobbs 2013). Five master's theses have been completed since the previous status report, four in British Columbia (Brown 2007; Gomez 2007; Hobbs 2007; Lomas 2013) and one in California (Barbour 2012). A number of field surveys have taken place at various localities in British Columbia to document rattlesnake presence and locate hibernacula (see "**SEARCH EFFORT**"). Aquila Conservation & Environment Consulting (2014) modelled the population size and estimated population parameters based on a 10-year mark-recapture dataset at the Osoyoos First Nations' Reserve in South Okanagan. These efforts have helped better delineate the species' range, identify threats, and provide valuable information on population biology of the species, but many unknowns remain. No systematic surveys across the species' Canadian range have been conducted.

No Aboriginal traditional knowledge was available for this species.

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
(2015)

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

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

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

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

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

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

There are five subspecies of Western Rattlesnake, *Crotalus oreganus* (Crother 2012): *C. o. helleri* (Southern Pacific Rattlesnake), *C. o. abyssus* (Grand Canyon Rattlesnake), *C. o. concolor* (Midget Faded Rattlesnake), *C. o. lutosus* (Great Basin Rattlesnake) and *C. o. oreganus* (Northern Pacific Rattlesnake; Holbrook 1840). The Northern Pacific Rattlesnake is the only subspecies present in Canada; therefore, COSEWIC assesses it by the current species name, Western Rattlesnake, *Crotalus oreganus*.

The Western Rattlesnake was formerly classified as a subspecies of *Crotalus viridis* (Crother 2000), but *C. oreganus* was given full species status based on genetic studies (Ashton and de Queiroz 2001). The name *C. viridis* is now applied to the Prairie Rattlesnake (Crother 2012).

Morphological Description

The Western Rattlesnake (Figure 1) is the only truly venomous snake species native to British Columbia (Matsuda *et al.* 2006). When the snake strikes, venom is delivered through two hollow, hinged fangs at the front of the upper jaw. The other venomous snake in the province is the rear-fanged Nightsnake (*Hypsiglena chlorophaea*), which lacks hollow fangs and applies the venom into its prey by a chewing motion. The Western Rattlesnake is thick-bodied with a triangular head. The eyes have a vertical pupil characteristic of nocturnal animals. Thermosensory organs are embedded in oval or pear-shaped facial pits located between the eyes and nostrils on each side of the head (Preston 1964).The tail is relatively short, ending in a series of loosely interlocked horn segments that the snake can vibrate to produce a rattling or buzzing noise (Matsuda *et al.* 2006). A new segment is added to the base of the rattle each time an individual sheds. Preston (1964) reported up to 11 rattle segments on snakes in the south Okanagan.

Distinct markings consist of large blotches on the dorsal surface of the body, ranging from tan to chocolate brown or olive green, bordered by light-coloured scales. No two individuals appear to have the same markings (Sarell pers. obs. 1986-2013). The underside is yellow-white to brown. Juveniles have lighter but more contrasting patterns. The dorsal scales are strongly keeled.

Adults can reach up to 1200 mm SVL (snout-vent length) and 1285 mm in total length, with males usually longer than females (Matsuda *et al.* 2006). The longest of 54 snakes captured during a study on the Osoyoos Indian Reservation was a male measuring 906 mm SVL (Lomas 2013). Neonates average 270 mm SVL at birth (Matsuda *et al.* 2006).

Figure 1. Western Rattlesnake (Oliver, BC; L. Andrusiak photo).

Population Spatial Structure and Variability

The Western Rattlesnake occurs in five distinct areas within British Columbia (Okanagan-Similkameen, Midway, Grand Forks, Thompson-Nicola, and Vernon), separated from each other by unsuitable habitat. Natural movement of individuals between these broad areas are not thought to occur in Canada, but the Okanagan-Similkameen, Midway, and Grand Forks populations may be contiguous south of the international boundary through United States. No studies were available to document possible genetic differentiation among snakes from different areas in Canada.

The spatial distribution of the Western Rattlesnake in British Columbia was assessed using the dataset of occurrences used for the area of occupancy calculation. As rattlesnakes in the province have been documented travelling >3 km from hibernacula, a 6 km separation distance for occurrences in suitable habitat and 1 km in unsuitable habitat were used. The area was divided spatially into points or clusters of points that were separated by >6 km from other points in suitable habitat and 1 km in unsuitable habitat (such as lakes or urbanized areas). Twenty-three isolated clusters were documented among which gene flow could be limited. It is suspected that gene flow between these clusters has diminished as development and increased road traffic continue to isolate subpopulations from one another.

Designatable Units

The Western Rattlesnake occurs within one COSEWIC Terrestrial Amphibians and Reptiles Faunal Province, the Intermountain. The snakes are thought to have dispersed northwards post-glacially from south of the international border. No genetic, morphological, or behavioural differences have been sought or documented that would indicate the presence of more than one designatable unit in Canada.

Special Significance

Rattlesnakes are specialized rodent predators. They consume a number of species that are considered agricultural pests. The Western Rattlesnake is the only species of pit viper native to British Columbia and the only native snake in the province that poses any degree of danger to people. Although fear of rattlesnakes by humans is much greater than the actual hazard, it can be difficult to garner popular support for conservation of a species perceived as dangerous (Howard 2005).

DISTRIBUTION

Global Range

NatureServe (2014) lists *Crotalus oreganus* (all subspecies) as present in Arizona, California, Colorado, Idaho, New Mexico, Navajo Nation, Nevada, Oregon, Utah, Washington, Wyoming, and British Columbia. The species is absent from the Pacific coastal areas of British Columbia and Washington.

The Northern Pacific Rattlesnake subspecies, *C. o. oreganus* (Figure 2), occurs in British Columbia, eastern Washington, north and eastern Oregon, central Idaho, and the northern half of California (Ashton and de Queiroz 2001; Stebbins 2003). It is replaced by the Southern Pacific Rattlesnake (*C. o. helleri*) in southern California and by the Great Basin Rattlesnake (*C. o. lutosis*) in the west-central United States.

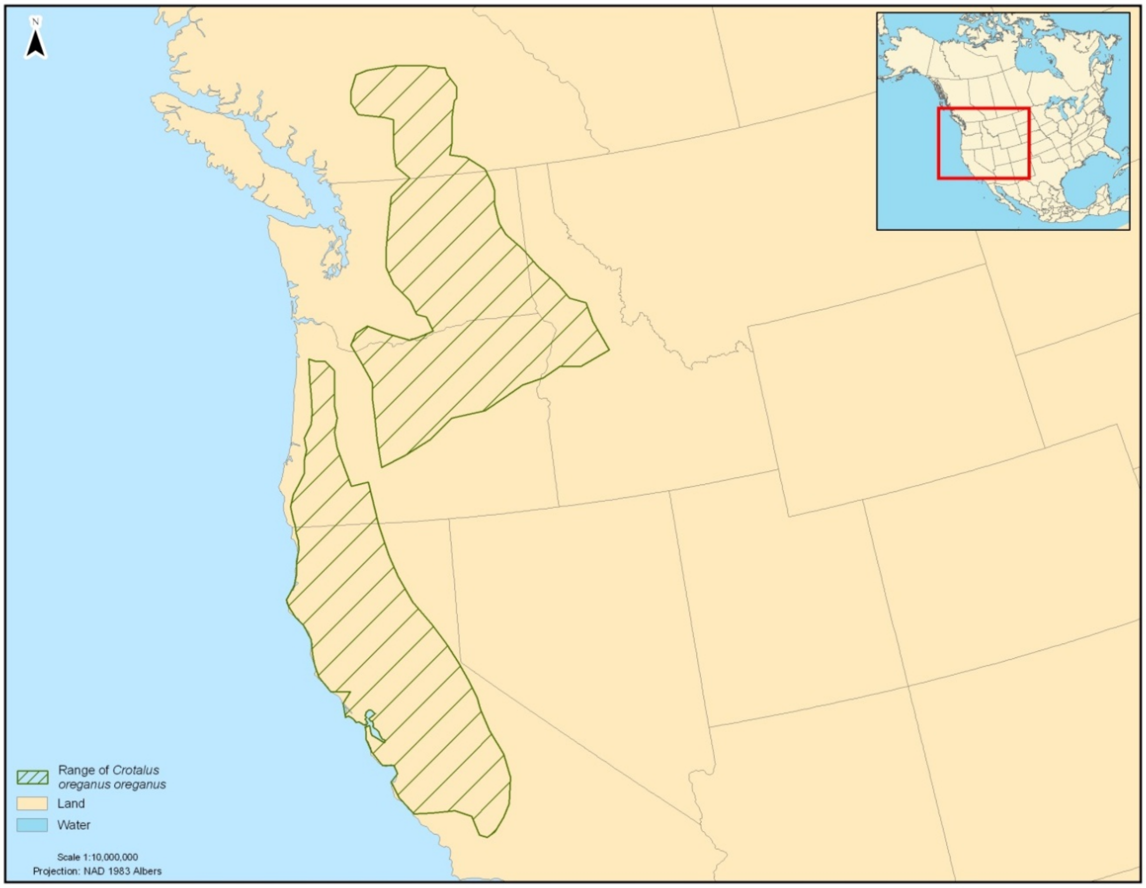

Figure 2. North American distribution of *Crotalus oreganus oreganus* (redrawn from Ashton and de Queiroz 2001).

Canadian Range

The Western Rattlesnake is found within the Thompson-Okanagan interior dry belt of British Columbia (Figure 3) east of the Cascade Mountains. Its range extends through portions of the Similkameen, Okanagan, Kettle, Lower Nicola, Central Fraser and South Thompson valleys (Didiuk *et al*. 2004; Southern Interior Reptile and Amphibian Recovery Team 2008). The species has been documented at elevations up to 1430 m above sea-level (asl) in British Columbia (Gomez pers. comm. *in* Hobbs 2013) with known dens up to 975 m above sea level (asl) (Hobbs 2013).

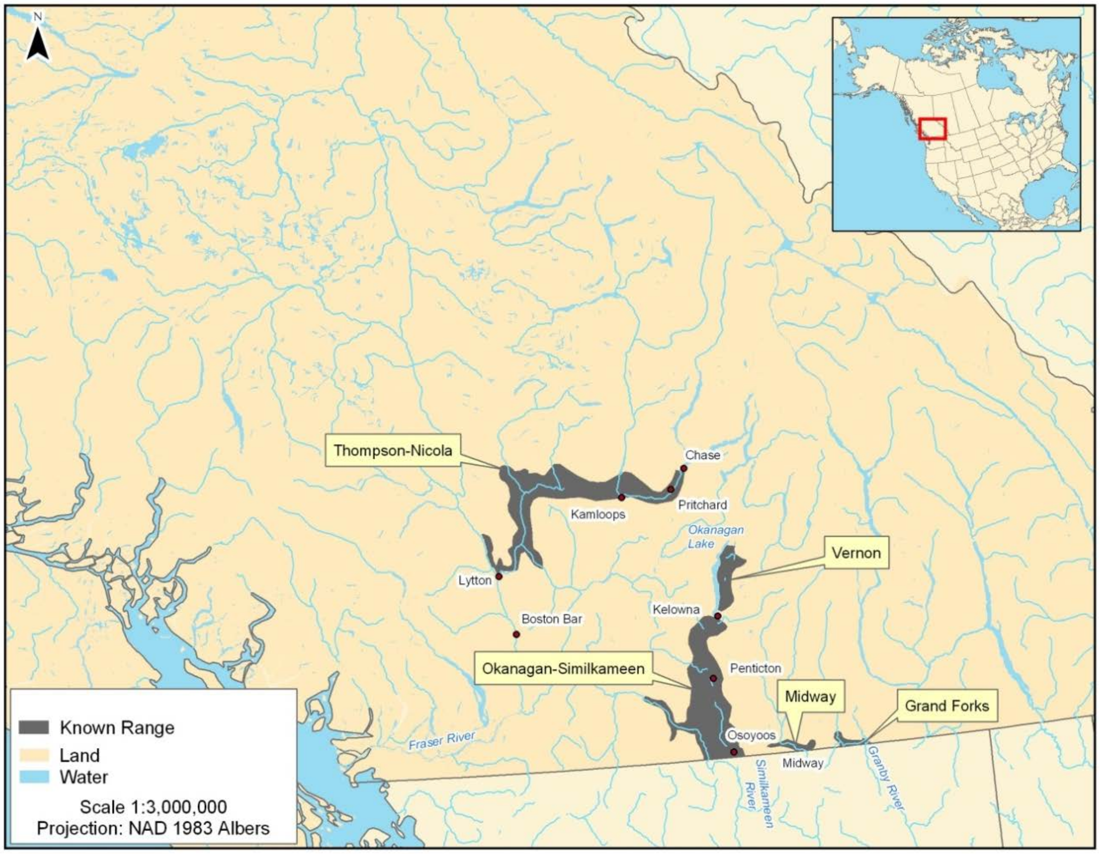

Figure 3. Canadian distribution of *Crotalus oreganus oreganus* (redrawn from Hobbs 2013).

Less than 5% of the global distribution of the Western Rattlesnake is in Canada (Southern Interior Reptile and Amphibian Recovery Team 2008). The Western Rattlesnake is found within the Interior Douglas-fir, Bunchgrass and Ponderosa Pine biogeoclimatic zones in British Columbia (Table 1). The snakes occupy five broad distinct areas (Figure 3) in the southern interior of British Columbia (Didiuk *et al*. 2004; Southern Interior Reptile and Amphibian Recovery Team 2008; Hobbs 2013):

1. Thompson-Nicola:
   - Along the Thompson River valley from Cache Creek east to the community of Pritchard
   - North up the North Thompson valley to the Westsyde neighbourhood of Kamloops
   - Along the Nicola River from its junction with the Thompson River east to Agate Creek
   - Along the drainage of Bonaparte Creek to Hart Ridge
   - Along the Fraser River valley from the village of Lytton south to the town of Boston Bar
   - North of Lytton to McGillivray Creek

2. Okanagan-Similkameen:
   - Along the west side of Okanagan Lake from the south end of West Side Road in the city of West Kelowna south to the international boundary
   - Along the east side of Okanagan Lake from Okanagan Mountain Provincial Park south to the international boundary
   - West of the community of Kaleden including Keremeos Creek, to the Similkameen River
   - Along the Similkameen River valley from the international boundary north and west to Bromley Rock

3. Vernon:
   - The east side of Okanagan Lake from the city of Vernon (Bella Vista) south to the community of Winfield. This population was formerly treated as part of the Okanagan-Similkameen, but it is now disjunct due to urban development through the city of Kelowna (Hobbs 2013; M. Sarell pers. obs.). The range also includes both sides of Kalamalka Lake in the municipality of Coldstream.

4. Midway:
   - Kettle River Valley, from the settlement of Rock Creek east to the village of Midway and south to the international boundary

5. Grand Forks:
   - Kettle River valley from the mouth of the Granby River east to the south end of Christina Lake
   - Granby River valley north to Snowball Creek

Snake populations in the Okanagan-Similkameen, Midway, and Grand Forks areas may be contiguous south of the international boundary (Stebbins 2003), although connectivity has not been demonstrated. The Thompson-Nicola and Vernon areas both are disjunct from any others.

Table 1. Number of known rattlesnake dens by biogeoclimatic unit (M. Sarell, J. Hobbs, unpubl. data).

Biogeoclimatic Subzone Variant	Number of Dens
BGxh1 Thompson Very Dry Hot Bunchgrass	42
BGxh2 Nicola Very Dry Hot Bunchgrass	29
BGxw1 Nicola Very Dry Warm Bunchgrass	1
IDFxh1 Okanagan Very Dry Hot Interior Douglas-fir	41
IDFxh1a Okanagan Very Dry Hot Interior Douglas-fir grassland phase	13
IDFxh2 Thompson Very Dry Hot Interior Douglas-fir	3
IDFxh4 Boundary Very Dry Hot Interior Douglas-fir	8
PPxh1 Okanagan Very Dry Hot Ponderosa Pine	110
PPxh1a Okanagan Very Dry Hot Ponderosa Pine grassland phase	63
PPxh2 Thompson Very Dry Hot Ponderosa Pine	38
PPxh2a Thompson Very Dry Hot Ponderosa Pine grassland phase	15
PPxh3 Kettle Very Dry Hot Ponderosa Pine	17
Grand Total	380

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) and index of area of occupancy (IAO) were calculated by the report writers from a combination of three datasets, which are described below and summarized in Table 2. Including dens only, the EOO is 26,853 – 26,923 km^2. This range of values represents EOO calculated using the minimum convex polygon method for dens only, including den sites observed to be occupied since 1998 (low value) and for all den observations since 1960 (high value). If all observations of snakes, not just den sites, are used, then the EOO is 28,838 km^2, whatever period is used (Table 2).

Table 2. Index of area of occupancy (2 x 2 km grid cells) and extent of occurrence minimum convex polygon (MCP) for Western Rattlesnake using different datasets. Calculations provided by report writers.

Dataset	Date	Index of Area of Occupancy	Extent of Occurrence MCP (ha)	Extent of Occurrence MCP (km^2)
Dens only	All	201 grid cells; 804 km^2	2,692,284	26,923
Observations and Dens	All	356 grid cells; 1,424 km^2	2,883,798	28,838

Dataset	Date	Index of Area of Occupancy	Extent of Occurrence MCP (ha)	Extent of Occurrence MCP (km²)
Dens only	Post-1998	171 grid cells; 684 km²	2,685,288	26,853
Observations and Dens	Post-1998	299 grid cells; 1,196 km²	2,883,798	28,838
Dens only	Post-1988	201 grid cells; 804 km²	2,692,284	26,923
Observations and Dens	Post-1988	356 grid cells; 1,424 km²	2,883,798	28,838

* BG= Bunchgrass biogeoclimatic zone; PP= Ponderosa Pine biogeoclimatic zone;
IDFxh=Interior Douglas-fir very dry, hot biogeoclimatic subzone

The first dataset used was provided by the British Columbia Conservation Data Centre and consisted of 32 records of Western Rattlesnakes dating from 1993 to 2012 (BC Conservation Data Centre 2013a). The second dataset consisted of an additional 576 records (1990 to 2010) obtained from the BC Wildlife Species Inventory (SPI) database and represented observations made during wildlife inventory and research projects, including incidental observations made during projects not targeting rattlesnakes. Some of the incidental records had not yet undergone quality assurance checks. Some reports of the Western Rattlesnake from the public are actually sightings of the Great Basin Gophersnake (*Pituophis catenifer deserticola*), which resembles the Western Rattlesnake both in appearance and behaviour. The incidental records were plotted spatially for review, and five suspicious records well outside (>20 km) the known range of Western Rattlesnake (likely errors in UTM coordinates or species code) were flagged and removed from the database.

The third dataset, privately maintained, is the Provincial Snake Den Database (Sarell and Hobbs unpubl. data 2013). It includes locations of dens used by any snake species [Western Rattlesnake, Northern Rubber Boa (*Charina bottae*), North American Racer (*Coluber constrictor*), Desert Nightsnake (*Hypsiglena chlorophaea*), and Great Basin Gophersnake)], as reported by a number of different observers. This database was filtered to include only records documenting Western Rattlesnake. Duplicate records due to repeated visits at a single site were removed, leaving only a single record based on the most recent date. Currently there are 368 hibernaculum records in the provincial den database, not including 12 dens from which the snakes are believed to be extirpated.

Some of the records (especially dens) were included in more than one of the three datasets. Duplicate den records were easily filtered out using den name. Only the record with the most recent date was retained. Duplicate snake observations were filtered using a combination of location and date.

EOO and IAO have been calculated using three different data selection criteria for date of observation. These included: all records dated 1968 or later (approximately three generations); records dated 1998 or later; and records dated 1988 and later. Within those date criteria, separate calculations were made for observations of dens, and for all observations (sightings of individuals and dens).

Each dataset was used to create an EOO minimum convex polygon (MCP). Suitable habitat (defined as the extent of the Interior Douglas-fir, Bunchgrass and Ponderosa Pine biogeoclimatic zones) within the minimum convex polygon was totalled. A 2x2 km grid was overlain on the map, and the number of grid squares containing at least one observation was totalled to derive values for IAO. A summary of IAO and MCP values calculated using the different datasets is presented in Table 2.

A substantial number of dens have not been visited recently, especially those on private lands and First Nations reservations. Using only the most recent records would severely underestimate the current distribution of the species. Also, using all records rather than just den records was deemed appropriate, because not all dens are known and snakes found away from dens must hibernate somewhere in the vicinity (within a few kilometres).

Historical distribution data for the Western Rattlesnake are not sufficient to quantify population declines or range contractions, which must be inferred based on rates of habitat loss. Snakes from the Vernon area have now been isolated from those in the Okanagan-Similkameen by intervening urban development. Rattlesnakes in 12 dens in the provincial snake den database are believed to have been extirpated or displaced in the past 50 years (3 generations). Additional dens were apparently destroyed in the Vernon area in the early part of the last century based on anecdotal historical information. The BC Conservation Data Centre (2013a) reports the range extent for Western Rattlesnake as 1000 – 5000 km^2, and the area of occupancy as 100 – 500 km^2 based upon a 2x2 km grid and 100 hibernacula locations. The actual values, using more complete datasets, are probably larger with EOO from 26,853 – 28,838 km^2 and IAO from 804 – 1424 km^2 (Table 2).

Search Effort

Numerous surveys for snakes have been conducted within the range of the Western Rattlesnake in British Columbia (Macartney 1985; Charland 1987; Sarell 1993; Hobbs and Sarell 2000; Hobbs 2001a, 2001b, 2011a, 2011b; Iredale 2006, 2008; Iredale and Ferguson 2007; Sarell and Alcock 2008; Gill 2010; Lomas *et al.* 2011; Gardiner and Song 2013a,b; Lomas 2013). These surveys were often directed towards locating snake hibernacula in general, but some surveys targeted Western Rattlesnake dens in particular. Targeted surveys generally employed similar methods involving searches of potential hibernation habitat by one or more workers on foot (Reed *et al.* 2012) and/or road cruises from vehicles (Sullivan 2012). It is the consensus of the most active surveyors that approximately 60% of the dens have been located (Hobbs pers. comm. 2013). Appropriate habitats in each of the five broad areas have been surveyed with approximately equivalent search effort (Hobbs pers. comm. 2015).

Most foot surveys employed stratification to identify potentially suitable habitat from spatial data sources or visual assessment of the landscape. Aerial surveys were used to pre-stratify search areas in some cases (Hobbs 2013). Searchers on foot traversed the survey areas while watching and listening for snakes, turning over and replacing cover objects, and paying special attention to habitat features such as rock fissures and crevices. Rattlesnakes have cryptic colouration and spend considerable periods under cover, affecting detection probability. Surveys for dens generally took place in warm, sunny weather during spring emergence or fall retreat to maximize encounters with snakes at den entrances. Western Rattlesnakes are easier to detect than other snake species due to their warning rattle and because they aggregate for long periods near den sites. 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.

During road cruises, observers scanned the road and roadsides for carcasses and live snakes while driving slowly along roads traversing suitable habitat. The success of road cruises is dependent on road densities, traffic loads, carcass persistence, weather and lighting conditions, and surveyor experience (DeGregorio *et al*. 2011; Sullivan 2012).

Several studies (Macartney 1985; Brown 2007; Gomez 2007; Snook and Blaine 2012; Gardiner and Song 2013a,b) used radio-telemetry to track rattlesnakes. Telemetry data were used to calculate movement rates and home range sizes as well as assess habitat use and locate den sites.

Incidental observations have often involved road-killed specimens (Pickard 2009), or observations of live individuals recorded during informal surveys or recorded opportunistically while surveying for other wildlife.

HABITAT

Habitat Requirements

Western Rattlesnakes require overwintering hibernacula and summer foraging habitat, which are suitably connected to allow for seasonal migrations.

<u>Hibernation Habitat:</u>

Hibernation sites are the most specialized habitat used by Western Rattlesnakes. Analysis of 318 confirmed rattlesnake dens in the Okanagan and Kamloops BC Ministry of Environment Regions revealed that most (>80%) of the dens occurred at elevations of 400 – 800 m (Hobbs 2013).

In general, dens occur on relatively steep south (southwest to southeast) facing slopes (Macartney 1985; Sarell 1993; Gienger and Beck 2011; Hobbs 2013). Bertram *et al.* (2001) recorded slopes of 56.6% to 62.3% and aspects of 71.7^{o} to 168.3^{o} (east to south). Hobbs (2001a, 2013) suggested that aspects of 170 to 240^{o} (south to southwest) are most important. Den microsites include cracks and fissures in fractured rock outcrops, along talus slopes, or earth-covered rock outcrops (Macartney 1985; Sarell 1993; Bertram *et al.* 2001; Hobbs 2013). Macartney *et al.* (1989) determined the depth of one den to be greater than 1.3 m.

Requirements for snake hibernacula include temperatures that remain above freezing and relatively high humidity (Hobbs 2013). In southern British Columbia, the core temperature (temperature at lowest depth) of a Western Rattlesnake den used by 50 snakes was 3 – 5^{o}C during the coldest part of the winter, when air temperatures were below freezing (Macartney *et al.* 1989). During another study at 15 hibernacula in southern British Columbia, eight Western Rattlesnakes implanted with temperature loggers had a mean body temperature of 6.4^{o}C during the coldest part of winter (Hobbs 2007). Based on the thermal profiles of 15 snake dens, Hobbs (2007) estimated that den depths of 0.86 to 3.00 m would be adequate to provide refugia during winter. Snow cover reduced the rate of cooling (Macartney *et al.* 1989) and might be important in reducing dehydration of snakes within dens (Gregory 1982). Although there are known external physical characteristics of areas where dens occur (Hobbs and Sarell 2000), Macartney (1985) reported no relationship between den population size and external features.

Individual dens can remain active for many years. Dens identified by Mackie (unpubl. data 1980) and Macnaughton (unpubl. data 1980) in the 1930s were still used by Western Rattlesnakes in the 1990s (Sarell 1993). Some dens may persist for hundreds of years. The physical characteristics of hibernacula may increase their stability and allow them to provide predictable winter shelter (Gienger and Beck 2011). One limitation to the life span of hibernacula used by Timber Rattlesnakes (*Crotalus horridus*) is shading by trees (Brown 1993). Some dens in the Okanagan are located in forested areas, and increased vegetation growth and shading may be a factor limiting the useful life of these dens and of surrounding basking areas. Mass slumping of bedrock may also physically eliminate a den, as has been documented for the Great Basin Gophersnake (COSEWIC 2013).

Travel Corridors and Summer Range:

Male and non-gravid female Western Rattlesnakes move away from hibernacula to their summer ranges along specific migration routes. Gomez (2007) found that some radio-tagged rattlesnakes near Kamloops dispersed from dens in the Bunchgrass zone up to higher-elevation forested habitats, a pattern also documented near Osoyoos (Gardiner and Song 2013a). In the Vernon area, migration routes and summer range were along shallow north-facing slopes that were more homogeneously vegetated by Bluebunch Wheatgrass (*Pseudoroegneria spicata*), Ponderosa Pine (*Pinus ponderosa*), and various native shrubs. Macartney (1985) hypothesized that this habitat may be suitable for prey and provide appropriate microhabitats for foraging and reduce radiative cooling. The same general vegetation types were used by Western Rattlesnakes in the Thompson River Valley (Bertram *et al.* 2001). Areas on the south side of the Thompson River, from where the Western Rattlesnake has been extirpated, are more open and perhaps more susceptible to changes associated with increased human development (Bertram *et al.* 2001). Although rattlesnakes typically forage in grassland and shrub-steppe habitats, they will also hunt in agricultural and urban habitats (Southern Interior Reptile and Amphibian Recovery Team 2008).

The presence of cover is an important microhabitat feature for rattlesnakes (Bertram *et al.* 2001; Gomez 2007; Snook and Blaine 2012). Cover objects include rocks, vegetation (dead trees, dead and live shrubs and bark), and anthropogenic objects, such as concrete berms, plywood, and scrap building materials. In the Kamloops area, Bertram *et al.* (2001) almost always located radio-tagged Western Rattlesnakes under or near cover objects and near rock outcrops, bluffs, or large rocks. Snook and Blaine (2012) reported that radio-tagged rattlesnakes on the Osoyoos Indian Reserve were relocated mainly in rocks (including rock piles and talus), Sagebrush, or Antelope-brush (*Purshia tridentata*) habitat. Brushy rock outcrops and talus may offer opportunities for basking combined with readily available cover and crevices for retreat sites. Cover around den entrances and on travel routes to dens may be particularly important (Hobbs 2013).

Gestation Habitat:

Gravid females do not disperse in spring but remain within a few hundred metres of the hibernaculum (Southern Interior Reptile and Amphibian Recovery Team 2008). Gestation sites are typically areas with good solar exposure and readily available cover, where females can thermoregulate safely and effectively, so hastening the development of the young.

Home Range Size:

Macartney (1985), Bertram *et al.* (2001) and Lomas (2013) employed minimum convex polygon (MCP) methods to estimate sizes of home ranges of Western Rattlesnakes, with variable results. Bertram *et al.* (2001) reported home ranges of 0.12 to 103.5 ha based on radio-telemetry locations from 12 snakes near Kamloops, with the smallest range being that of a gravid female. Macartney (1985) used mark-recapture methods and calculated home ranges of 1.2 to 171.1 ha from 167 individuals at 16 dens near Osoyoos. Lomas (2013) calculated home ranges for 54 males and non-gravid females during the active season on the Osoyoos Indian Reservation. The average home range using the 100% MCP method was 20.0 ± 12.1 (standard deviation) ha, and average home range using the 95% kernel density method was 23.36 ± 14.48 (standard deviation) ha.

Macartney (1985) reported population (=den) home ranges calculated using mark-recapture records of multiple snakes from an individual den. The ‘population home range’ for five dens within one of his study sites at Kalamalka Lake ranged from 82.8-171.1 ha.

Habitat Trends

Aquila Conservation & Environment Consulting (2014) used habitat modelling to identify suitable habitat for rattlesnakes. They estimated 171.3 – 310.9 km^2 of suitable habitat in the province, based on a combination of climate, topography and land cover variables.

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 Western Rattlesnake’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 BC’s southern interior grasslands were lost to human development, 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 continued but at lower rates (1% loss 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 and grassland types. Most land conversion is concentrated in valley bottoms, which also contain habitat that is most suitable for rattlesnakes. Regionally, the highest losses have taken place in the 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 of grassland have also occurred in South Okanagan Highlands (38.6%), South Okanagan Basin (20.5%), and Thompson Basin (20.0%).

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 Western Rattlesnake included Douglas-fir – Pinegrass, 27% lost; Ponderosa Pine – Bluebunch Wheatgrass, 53% lost; Water Birch – Red-osier Dogwood, 92% lost; Idaho Fescue – Bluebunch Wheatgrass, 77% lost; Big Sagebrush shrub-steppe, 33% loss; Antelope-brush – Needle-and-thread Grass, 68% lost; gentle slope grassland and shrub-steppe, 61% lost; Sagebrush – Needle-and-thread shrub-steppe, 70% lost.

Remaining grasslands continue to be affected by human activities. Livestock grazing is widespread. Historically, overgrazing has affected many areas and has facilitated the spread of invasive plants such as Knapweed (*Centaurea* or *Acroptilon* species; Grasslands Conservation Council of British Columbia 2012). Habitats continue to be fragmented by roads and infrastructure associated with increasing human population. The resident human population in the Thompson-Okanagan is projected to increase by an additional 140,000 between 2011 and 2036 (BC Stats 2012).

BIOLOGY

Life Cycle and Reproduction

The annual cycle of the Western Rattlesnake in British Columbia has been described by Macartney (1985) and is summarized below. The snakes move seasonally between overwintering hibernacula (dens) and summer foraging ranges.

Hibernation:

Most rattlesnakes in British Columbia retreat to hibernacula in mid-September to mid-October where they remain throughout the winter. Movement back to hibernacula begins in September, and by late October all snakes are in dens (Macartney 1985; Bertram *et al.* 2001). Some individuals may emerge from the den periodically on warm winter days and bask at the den entrance (Hobbs 2007, 2013). Spring emergence from hibernacula occurs in March and April and, except for gravid females, all snakes migrate to the summer range. Emerging snakes may spend 2 – 4 weeks basking at the den entrance before leaving.

The number of snakes using particular dens is variable; Hobbs (2013) reported that eight dens in British Columbia were estimated to be used by >100, 19 dens by 51 – 100, 122 dens by 10 – 50, and 145 dens by <10 individual rattlesnakes. Rattlesnakes frequently share hibernacula with other snake species. A provincial rattlesnake den database containing records of 380 dens (Sarell and Hobbs, unpubl. data 2013) included 17 shared with Desert Nightsnakes, 56 with Great Basin Gophersnakes, 88 with North American Racers, six with Northern Rubber Boas, and seven with gartersnakes (*Thamnophis sirtalis* or *T. elegans*). In total, 122 of the 380 dens with confirmed rattlesnake use also had confirmed use by at least one other snake species.

Reproduction:

Female rattlesnakes, similar to other pit vipers, begin vitellogenesis (or yolk deposition) in summer and then enter hibernation. Vitellogenesis resumes in spring after females emerge from hibernation (Aldridge 2002). There is a bimodal temporal pattern of mating in the Western Rattlesnake: i) females mate in summer or fall during early vitellogenesis and store sperm in the oviduct until fertilization the following year, or ii) females mate after emergence in spring (Aldridge 2002). Hersek *et al.* (1992) observed 'combat dances' (lasting up to 20 minutes) of Western Rattlesnakes in May, July, and August in California, corresponding with the spring and summer mating periods. Mating has been reported in British Columbia in July and early August in small (two to eight individuals) aggregations (Macartney and Gregory 1988; Snook and Blaine 2012).

Gravid females remain near the hibernaculum throughout summer and do not feed (Macartney 1985, 1989). Rattlesnakes are viviparous (give birth to live young). Parturition takes place in September and October in British Columbia (Macartney 1985, 1989), after a gestation period of about 110 days (Diller and Wallace 1984). Small litters (mean 4.6, n = 28, range 2 – 8) of relatively large neonates are born at the den and spend the first winter in the same hibernaculum as their mothers. Post-partum females emerge the following spring in an emaciated condition due to the cumulative weight loss during gestation (6%), parturition (37%), and overwintering (6%) (Macartney and Gregory 1988).

Reproductive cycles of individual females may be biennial, triennial, or quadrennial, with triennial apparently the most common pattern (Macartney and Gregory 1988). The timing of subsequent mating by individual females depends partly on body mass recovery (Macartney and Gregory 1988). Therefore during any active season, a population may include gravid females, post-partum females that may or may not mate, and newly matured females that may or may not mate. Thus, any factor that affects females during a particular stage of their reproductive cycle will have less impact on the population than if all of the females were at a similar reproductive stage each year. However, because females do not reproduce until 7 to 9 years of age, and only every 3 – 4 years thereafter, a critical but unknown number of reproductive females is needed to sustain local populations.

Growth and Development:

The Western Rattlesnake in British Columbia is a relatively small rattlesnake. Large females are typically 850 to 900 mm SVL and large males 950 to 1000 mm SVL (Macartney *et al.* 1990). Males in British Columbia mature at 3 to 5 years (at approximately 535 mm SVL), but only large males (>720 mm SVL) were observed mating (Macartney and Gregory 1988; Macartney *et al.* 1990), perhaps due either to a size advantage in male / male conflicts (Shine 1978) or to female preference. Females mature later than males, at 5 to 7 years in British Columbia (at approximately 650 mm SVL) and have their first litter at 7 to 9 years of age (700 to 760 mm SVL) (Macartney *et al.* 1990). Female Western Rattlesnakes mature earlier in California (at 3 years) and in Idaho (4 to 6 years) (Fitch and Twining 1946; Diller and Wallace 1984).

Growth rates of the Western Rattlesnake in British Columbia differ among age groups, between sexes, and among years (Macartney *et al.* 1990). Neonates are born near the den, and although they shed their skin, they do not eat or gain body mass before entering the hibernaculum 3 to 5 weeks later (Macartney *et al.* 1990). The average size of 258 neonates measured in 1981, 1982 and 1985 was 275 mm SVL (210 to 345 mm SVL). Juveniles have the greatest and most variable growth rates. Macartney *et al.* (1989) attributed differences in annual growth to weather and concomitant differences in productivity and food availability. However, Charland (1989) reported that food availability did not affect weight gain of post-partum females.

Survivorship:

There are limited data on survivorship. Data from the Osoyoos Indian Reservation suggested that the overall annual survival was high (70 – 98 %) between 2002 and 2012 (Bishop *et al.* unpubl. data *in* Lomas 2013). In general, overwinter survival is greater for larger snakes, presumably because of the physiological benefits (higher energy reserves and reduced water loss and dehydration) of large body size (Gregory 1982). Macartney (1985) found that overwinter survivorship increased from neonates (approximately 25%) through juveniles (approximately 50%) to adults (90 to 100%). Of adults, post-partum females had the lowest survivorship. Charland (1989) reported 55% overwinter survivorship of neonates from the same population studied by Macartney (1985) but in a different year, suggesting that survival differs among years. Charland (1989) hypothesized that body size of neonates may be more critical for survival through the first summer, possibly due to limited availability of sufficiently small prey.

Life table data for Western Rattlesnakes are incomplete, largely because of under-sampling of younger age classes (Macartney 1985). Nonetheless, some preliminary estimates have been made. Female rattlesnakes first mate at 6 to 8 years, give birth to small litters (mean = 5 young) more than 1 year later, and mate only every 3 to 4 years. From this information, and using survival rates from study populations near Kalamalka Lake, Macartney (1985) developed a reproductive life table for females. He calculated a net reproductive rate of 0.496, suggesting that North Okanagan populations were in decline, but noted that his two years of survival data were not sufficient to conclude that populations were facing imminent extinction. He estimated that 20% of females would have to live about 20 years to obtain long-term equilibrium. Recruitment rates at a single den depend on the number of adult females using the den, because immigration from other dens is rare.

Snook and Blaine (2012) conducted telemetry studies of rattlesnakes on the Osoyoos Indian Reserve. Roadkills were the largest source of mortality (Table 3), making up 72 to 100% of known mortalities over the three years reported. Seven of 54 snakes monitored died during another study on the Osoyoos Indian Reserve, five from predation, one from roadkill, and one from human persecution (Lomas 2013).

Table 3. Numbers of Western Rattlesnake mortalities and captures recorded on the Osoyoos Indian Reserve (located at the north end of Osoyoos Lake), 2010-2012 (Snook and Blaine 2012).

Year	2010	2011	2012
Roadkill	9	13	8
Natural causes	0	5	2
Unknown	0	0	1
Total mortalities	9	18	11
Total number snakes captured	218	195	172

<u>Generation Time:</u>

Aquila Conservation & Environment Consulting (2014) calculated the generation time based on mark-recapture data for the Western Rattlesnake obtained over 10-year period on the Osoyoos Indian Reserve. The IUCN method of 1/mortality rate + age at maturity was deemed appropriate for this species because there was no evidence of mortality increasing and fecundity decreasing with age. The average generation was calculated as 15.6 years (minimum 7.1 years; maximum 25.8 years).

<u>Diet and Feeding:</u>

Western Rattlesnakes feed on a variety of mainly mammalian prey, but birds and other snakes are also occasionally taken (Table 4). The size of prey items ingested by Western Rattlesnakes has been positively correlated to snake size under field conditions (Macartney 1989). Juvenile snakes feed mainly on small mammals. North American Deermice (*Peromyscus maniculatus)*, voles (*Microtus* spp., *Myodes* spp., *Phenacomys* spp.), and shrews (*Sorex* spp.) formed the majority of prey of both adults and juveniles. Adults also consumed larger prey items, such as squirrels and Bushy-tailed Woodrats (*Neotoma cinerea*) (Macartney 1989; Weaver and Lahti 2005; Sarell, pers. obs. 2013). The snakes feed mostly while on their summer ranges in June – August, with little feeding taking place in spring and fall (Macartney 1989).

Table 4. Species present in British Columbia that are known to be consumed by Western Rattlesnakes.

English Name	Scientific Name	Source
Shrews	*Sorex* spp.	Macartney 1989
North American Deermouse	*Peromyscus maniculatus*	Macartney 1989; Weaver and Lahti 2005
Chipmunks (unspecified)	*Neotamias* spp.	Macartney 1989

English Name	Scientific Name	Source
Northern Pocket Gopher	*Thomomys talpoides*	Macartney 1989; Weaver and Lahti 2005
Voles	*Microtus* spp., *Myodes* spp., *Phenacomys* spp.	Macartney 1989
Bushy-tailed Woodrats	*Neotoma cinerea*	Macartney 1989
Great Basin Pocket Mouse	*Perognathus parvus*	Macartney 1989
Red Squirrel	*Tamiasciurus hudsonicus*	Macartney 1989
Yellow-bellied Marmot	*Marmota flaviventris*	Macartney 1989
Common Muskrat	*Ondatra zibethicus*	Merko 2013
Nuttall's Cottontail	*Sylvilagus nuttalli*	Sarell pers. obs.
North American Racer	*Coluber constrictor*	Sarell, pers. obs.
Birds (unspecified)		Macartney 1989

Western Rattlesnakes are sit-and-wait or ambush predators. They locate feeding sites using a combination of thermo-visual and chemical cues (Barbour 2012). Upon locating a suitable foraging site, a snake assumes a tight 'ambush coil' (Barbour 2012) and remains motionless for long periods of time, waiting for prey to approach within striking distance. The snake may partially uncoil periodically to probe its surroundings.

When suitable prey approaches, the snake strikes and injects venom into the animal's body with twin hollow fangs. Struck prey is usually immediately released, likely to prevent injury to the snake from struggling prey (Kardong and Smith 2002). The snake then follows the prey's trail to locate the body of its victim and swallows it whole.

Physiology and Adaptability

The Western Rattlesnake is ectothermic and at the northern limit of its distribution in British Columbia. Canadian snakes may have physiological adaptations to low temperatures, but comparisons with more southern populations have not been carried out.

Two of the rattlesnake's most characteristic physical adaptations are its venom, used in both prey capture and in defence (Mackessy 1991), and its ability to vibrate its tail to produce a rattling sound as a warning to potential predators. Rattlesnake venom is a complex glandular secretion composed of enzymes, proteins and peptides. The composition of rattlesnake venom varies by species, geographic distribution, and age of the individual, but generally includes components that cause hemorrhage, myonecrosis, prey immobilization, and loss of blood pressure (Mackessy 1988, 2008).

Rattlesnakes will readily take advantage of anthropogenic features as cover and for thermoregulation. Bertram *et al.* (2001) radio-tracked 10 Western Rattlesnakes and noted snake use of concrete berms close to highways, as well as old buildings and garbage. Wood debris and metal roofing are also often used as cover objects to attract snakes (Sarell pers. obs.).

Short-distance translocation of snakes away from people and pets has been used as a mitigation measure in conflicts with people (Iredale 2008). Brown *et al.* (2009) translocated 14 radio-tagged rattlesnakes near Osoyoos and found that 12 returned to the general area from which they were removed. There was no evidence that the short-distance translocation had negative effects on survival, behaviour, or body condition.

Rattlesnake life history includes traits that make populations particularly vulnerable to disturbances, including late maturity, low reproductive rate, high natural adult survivorship, and seasonal migrations (Jochimsen 2005). Additive mortality from human causes, such as roadkill and deliberate killing of snakes, is hence especially significant for this species.

Movements and Dispersal

Western Rattlesnakes move seasonally between overwintering dens and summer foraging ranges. Winter dens are the focal point of movements (Charland *et al*. 1993). Migration/dispersal begins soon after emergence.

The migration distance between summer foraging areas and overwintering dens varies depending on habitat, and distances of 290 – 3500 m have been reported in British Columbia. Gravid females do not migrate but remain within 400 m of the hibernacula, frequently at group basking areas termed rookeries (Macartney 1985; Bertram *et al.* 2001). The linear distance moved by ten adults (non-gravid females and males) from five dens near Kamloops varied from 290 to 3000 m (Bertram *et al.* 2001). Western Rattlesnakes from a den in the Okanagan Valley moved variable distances to the same summer range (Macartney 1985). One juvenile was found 1575 m from its den, but most individuals remained within 1200 m of their dens. The maximum migration distance of a mature male was 3568 m (Gomez 2007), but most males remained within 1400 m of the den (Macartney 1985; Bertram *et al.* 2001; Gomez 2007; Lomas 2013).

Migration from dens in the north Okanagan occurs along specific corridors to north and northwest facing slopes (Macartney 1985). Preston (1964) also reported specific migration corridors for a population of Western Rattlesnakes in the south Okanagan. Macartney (1985) found that over 80% of the males and non-gravid females moved in the same direction over at least two consecutive years, but only 56% moved to the same sites on the summer range. Snakes from different hibernacula mixed on the summer range but generally returned to their original dens in fall.

Interspecific Interactions

A number of predators of the Western Rattlesnake have been reported (Table 5), but few data are available regarding the role of predation in limiting populations. Predators known to take rattlesnakes in British Columbia include Desert Nightsnake (Lacey *et al.* 1996), Badger (*Taxidea taxus*, Bertram *et al.* 2001), Black Bear (*Ursus americanus*), and Striped Skunk (*Mephitis mephitis*) (Macartney 1985). Macartney (1985) observed skunk tracks at excavations near several hibernacula and basking areas, suggesting that skunks actively pursue rattlesnakes. Cattle, deer, hogs and horses have been observed to deliberately trample snakes (Klauber 1997).

Table 5. Species present in British Columbia that are known to be predators of Western Rattlesnakes.

English Name	Scientific Name	Source
American Bullfrog	*Lithobates catesbeianus*	Ernst and Ernst 2011
Desert Nightsnake	*Hypsiglena chlorophaea*	Lacey *et al.* 1996
Great Basin Gophersnake	*Pituophis catenifer deserticola*	Ernst and Ernst 2011
Golden Eagle	*Aquila chrysaetos*	Ernst and Ernst 2011
Bald Eagle	*Haliaeetus leucocephalus*	Ernst and Ernst 2011
Red-tailed Hawk	*Buteo jamaicensis*	Ernst and Ernst 2011
Ferruginous Hawk	*Buteo regalis*	Ernst and Ernst 2011
Great Horned Owl	*Bubo virginianus*	Ernst and Ernst 2011
Yellow-bellied Marmot	*Marmota flaviventris*	Ernst and Ernst 2011
Bushy-tailed Woodrat	*Neotoma cinerea*	Ernst and Ernst 2011
Coyote	*Canis latrans*	Ernst and Ernst 2011
Red Fox	*Vulpes vulpes*	Ernst and Ernst 2011
Bobcat	*Lynx rufus*	Ernst and Ernst 2011
Black Bear	*Ursus americanus*	Macartney 1985
Badger	*Taxidea taxus*	Macartney 1985
Striped Skunk	*Mephitis mephitis*	Macartney 1985

Diseases of wild rattlesnakes are not well documented (see THREATS: *Invasive and Other Problematic Species* for Snake Fungal Disease).

If threatened or harassed, rattlesnakes can deliver a debilitating and potentially fatal bite to people or pets (Zielinski 2013). Human deaths due to rattlesnake bites in Canada are extremely rare. Data on the numbers of rattlesnake bites in British Columbia were not available (Aiken pers. comm. 2013), but one death due to rattlesnake bite was reported from the Inkameep Reserve near Osoyoos in 1981 (Anonymous 1981). Approximately 20% of Northern Pacific Rattlesnake bites treated in California are 'dry' bites in which no venom is delivered (Kaiser Permanente Medical Toxicology 2007).

Bites to pets are also rare but off-leash dogs that accompany their owners hiking in rattlesnake habitat may be especially at risk. One veterinary clinic in Westbank reported treating only two cases of snakebite between 1988 and 2013 (Westbank Animal Care Clinic pers. comm. 2013).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Sizes and trends of Western Rattlesnake populations in British Columbia have been estimated using mark-recapture methods and den counts. Most mark-recapture studies (Macartney 1985; Lacey in Sarell 1993; Bertram *et al.* 2001; Snook and Blaine 2012; Gardiner and Song 2013a) have been undertaken in limited areas of the Okanagan.

Abundance

The British Columbia Conservation Data Centre estimated a population size of 2500 – 10,000 individuals, likely fewer than 5000 adults (BC Conservation Data Centre 2013b). Hobbs (2013) estimated a provincial population size of 3,943 to 7,896 individuals, based on counts at dens. The total population estimated by Hobbs (2013) was broken down into approximate maximum numbers for each area, based on professional judgment: 4000 at the Okanagan-Similkameen, 500 at the Midway, 1000 at the Grand Forks, 3000 at the Thompson-Nicola, and 1000 adult snakes at the Vernon area. Den count-derived estimates of snake populations underestimate the population size, as only a fraction of the den population will be seen above ground at any particular time (Martin *et al.* 1990 *in* Brown 1993). Lacey (*in* Sarell 1993) found one den that was estimated to contain 250 individuals (adults and juveniles) from mark-recapture data. There was a maximum of about 50 snakes seen outside the den at any one time. In addition, there may be additional dens that have not been located (Hobbs 2013).

Aquila Conservation & Environment Consulting (2014) estimated the provincial population through a habitat modelling exercise based on the density of snakes recorded on the Osoyoos Indian Reserve over a ten-year period. The data were derived largely from an ongoing program to study Western Rattlesnakes at the Nk'Mip Desert Cultural Centre (Gardiner and Song 2013b). From 2002 – 2013, a total of 1044 rattlesnakes had been marked at this approximately 350 ha site; 639 of the marked snakes were adults. Their analyses suggested a population of 31,277 – 56,776 adults in the province, as extrapolated from data from this site and habitat suitability mapping that was developed for the province as part of the project. The population estimate may be a gross overestimate, as it is based on extrapolating from a relatively small area of high quality habitat to the entire range of the species in British Columbia. The authors note that the models require further validation and field testing.

Several research projects have attempted to quantify rattlesnake populations in discrete areas of the province. Macartney (1985) marked rattlesnakes from 24 dens at four sites in the North Okanagan. The number of dens at each site varied from one to 15, and the estimated number of individuals per den ranged from eight to 133. Two of the areas had more than one den. The rattlesnakes from dens at both of these areas were present together on the summer range and were found together in mating aggregations, indicating that the areas rather than the individual dens represented subpopulations. Macartney (1985) marked 659 and 826 individuals from these two areas. The densities of these snakes on their summer range were 1.6 and 2.5 rattlesnakes/ha, respectively. Although snake numbers varied widely between areas and among dens at the same area, the size and the composition of single dens were stable. These results illustrate the problem of extrapolating information about populations from data on population size and structure obtained from only one den or a small area.

Fluctuations and Trends

The BC Conservation Data Centre (2013a) describes the short-term population trend for Western Rattlesnake as ‘rapidly declining (decline of 30 - 50%)’ and the long-term trend as ‘substantial decline (decline of 50 - 75%)’. Hobbs (2013) attempted to analyse population trends for the Western Rattlesnake in British Columbia but concluded that analyses are severely confounded by detection biases associated with sampling conditions. He stated that ‘it is suspected that declining trends are ongoing within >75% of the snake populations within the species’ range in BC’. Rattlesnakes from 12 dens in the provincial den database, which extends back to about 1980, are considered extirpated. Nine are in the Okanagan-Similkameen population and one each in Vernon, Thompson-Nicola and Grand Forks populations (Hobbs 2013). The Western Rattlesnake has apparently been extirpated from the Vernon Military Camp, where it has not been sighted since 1999 (Nernberg pers. comm. 2013). Additional areas of extirpation include most of Kelowna and a historical population near Castlegar (Hobbs 2013), and population declines have been noted by snake researchers near highways (see **THREATS AND LIMITING FACTORS)**. Anecdotal accounts of disappearances of snakes from other dens associated with persecution and road and railway construction exist prior to 1980, but data are lacking.

Based on habitat trends and continuing threats to populations (Table 6), a decline of 30% or more is plausible over the next three generations (45 years). A population model (Reed 2013) conducted as part of the status assessment for the Great Basin Gophersnake, another large snake occurring in the same general area, predicted a population decline of 30% or more across the species' Canadian range within the next three generations, based on sensitivity of the population to excess adult mortality from roadkill and other sources, such as inadvertent and intentional killing (COSEWIC 2013). The predictions are at least as severe for the Western Rattlesnake, which is similarly vulnerable to roadkill and has a longer generation time than the Great Basin Gophersnake (~15 versus 8 years). Habitat loss and degradation pose additional stresses.

Table 6. Summary of Threats Calculator prepared for Western Rattlesnake, conducted by conference call on 7 February 2013 by species experts and BC Ministry of Environment personnel.

		Level 1 Threat Impact Counts	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	1	1
C	Medium	1	0
D	Low	5	6
Calculated Overall Threat Impact:		High	High

	Threat	**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Generations)**	**Timing**
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)
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)
2	Agriculture & aquaculture	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)
2.1	Annual & perennial non-timber crops	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)
2.3	Livestock farming & ranching	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)
3	Energy production & mining		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
3.3	Renewable energy		Negligible	Negligible (<1%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)
4	Transportation & service corridors	B	High	Pervasive (71-100%)	Serious (31-70%)	High (Continuing)
4.1	Roads & railroads	B	High	Pervasive (71-100%)	Serious (31-70%)	High (Continuing)

	Threat	Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Generations)	Timing
4.2	Utility & service lines		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)
5	Biological resource use	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)
5.1	Hunting & collecting terrestrial animals	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)
5.3	Logging & wood harvesting		Unknown	Small (1-10%)	Unknown	High (Continuing)
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)
6.2	War, civil unrest & military exercises		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)
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)
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)
8.2	Problematic native species		Unknown	Restricted (11-30%)	Unknown	High (Continuing)
9	Pollution		Unknown	Restricted - Small (1-30%)	Unknown	High (Continuing)
9.3	Agricultural & forestry effluents		Unknown	Restricted - Small (1-30%)	Unknown	High (Continuing)
10	Geological events		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
10.3	Avalanches/landslides		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)

Rescue Effect

Rescue is highly unlikely for the snakes inhabiting the Thompson-Nicola and Vernon areas because unsuitable habitat separates them from the rest of the species' range in the United States. Rescue of snake populations in the Midway, Okanagan-Similkameen, and Grand Forks areas via immigration of individuals from Washington State is possible, but its likelihood is unknown. Snakes from Washington would be adapted to survive in Canada and suitable habitat is present along the international boundary, but it is not known if that habitat is occupied or if there is currently gene flow across the boundary. There are rattlesnake records dating from 1992 – 2012 from Okanogan and Ferry counties in Washington, bordering British Columbia (Washington Herp Atlas 2013). Rattlesnakes are not legally protected in Washington State and are actively persecuted (Fitkin pers. comm. 2008).

THREATS AND LIMITING FACTORS

Limiting Factors

Limiting factors for the Western Rattlesnake include its need for different habitats (overwintering dens and summer foraging) connected by suitable migration habitat. Seasonal migrations between dens and summer range, fidelity to dens, and the aggregating of individuals at dens increase the snakes' vulnerability to roadkill and, by increasing encounter rates, persecution by people (Southern Interior Reptile and Amphibian Recovery Team 2008). Small litter size, triennial reproductive cycle, and a late age at maturity result in slow rates of population recovery from perturbations.

Threats

The IUCN Threats Calculator (Master *et al*. 2009) was used to assess threats to the Western Rattlesnake in Canada. Standard threat categories were rated for scope (proportion of the population subjected to the threat within the next 10 years), severity (percentage decline of snakes exposed to the threat over the next three generations), and timing of the threat. These parameters were then used to calculate a threat impact for each category. The overall cumulative threat impact was rated as "high" with one high impact, 0 – 1 medium impact, and 5 – 6 low impact threats (Table 6). Specific threats are discussed below in order of rank from highest to lowest.

<u>Road Mortality (impact "high")</u>

Road mortality, especially in the vicinity of dens, is a significant threat to Western Rattlesnake populations (Fortney *et al*. 2013). Roadkill reduces population size (depletion effects) and changes the demographics of a population (Jackson and Fahrig 2011). Hobbs (2013) stated that the effects of roads are suspected of 'resulting in unsustainable population depletion within most areas of the species' range in BC'. Almost all suitable rattlesnake habitats in British Columbia are bisected by roads (Hobbs 2013). Snook and Blaine (2012) reported that roadkills were the greatest cause of mortality of rattlesnakes on the Osoyoos Indian Reserve (Table 3), making up 72% to 100% of known mortalities over the 3-year period reported.

Eighty-six percent of 368 confirmed rattlesnake dens in British Columbia were within 2 km of a road (Hobbs 2013). Fifty percent of 106 dens in British Columbia where some data on impacts were obtained were subject to regular mortality from roadkill or to damage from road construction (Sarell 1993). Standardized sampling (May to mid-July: 2010 – 2013) on Highway 97 between the border and Okanagan Falls has not resulted in the detection of any rattlesnakes (Ashpole pers. comm. 2014), suggesting that the heavy road traffic is incompatible with rattlesnake presence. The highway had a mean annual traffic rate of 8111 vehicles/day as measured 7.7 km south of Kaleden Junction (south of Okanagan Falls)(BC Ministry of Transportation 2014).

Rudolph *et al.* (1999) sampled Louisiana Pine Snake (*Pituophis ruthveni*) and Timber Rattlesnake 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 (<100 vehicles/day) and that populations continued to be depressed within at least 850 m of 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 population from 7.3% to 99% over 500 years. The loss of more than three adult female Black Ratsnakes annually due to roadkills increased the probability of extinction of the study area population (estimated at 400 adults) to over 90% over 500 years, illustrating the effects of low chronic mortality.

The additive effects of continued losses from road mortality may also have serious effects on the genetic diversity (Jackson and Fahrig 2011). Clark *et al.* (2010) found that genetic diversity of Timber Rattlesnakes in hibernacula isolated by roads was lower than that of individuals from hibernacula in contiguous habitat. Mating between individuals from different hibernacula was much less likely where there was a major road separating them. One isolated population suffered from morphological abnormalities and low survivorship, and was susceptible to often-fatal infection with fungal pathogens (Clark *et al.* 2011).

Snakes crossing roads may be actively 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. Deliberate targeting of snakes by drivers has also been observed in British Columbia (Sarell pers. obs.).

Pickard (2009) reviewed snake roadkill records from a 25 km road segment near Oliver between 1988 and 2008. The frequency of roadkilled Western Rattlesnakes was negatively correlated with the distance to the nearest den, to the presence of water, and to the distance to the nearest gully. The highest number of roadkills by month occurred during September, when the snakes were returning to hibernacula. A weakly significant decreasing trend in the number of mature adults was noted for the last six years of the study, possibly indicating a loss of breeding individuals that may have had population impacts. The rate of removal of the carcasses by scavengers was not documented but has been found to be high in other studies, greatly underestimating roadkill rates (Slater 2002; DeGregorio *et al.* 2011).

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 have been used to relocate at least some snakes that would otherwise have been at risk of injury or death due to construction machinery (Sarell *et al.* 2010).

Biological Resource Use (impact "medium – low")

Increased development and its intrusion onto the summer habitat of the Western Rattlesnake will increase the frequency of encounters of people and pets with snakes and most probably increase mortality rates of snakes. People kill rattlesnakes for a variety of reasons, ranging from fear to dislike. Persecution occurs in agricultural areas, service corridors, and residential areas. Rattlesnakes found in proximity to human residences are most likely to be killed by those who view rattlesnakes as threats to the safety of people and pets (Coleshill 2014). Bertram *et al.* (2001) assessed various means of increasing public education and awareness about rattlesnakes in the Kamloops area. They distributed information pamphlets, prepared news items for the media (radio, television, and newspapers), and set up a snake hotline. They found that public indifference was largely due to lack of knowledge about rattlesnakes. The immediate response to increasing public awareness seemed positive. However, Gomez (2007) found that improved attitudes towards rattlesnakes quickly dissipated over several months for Grade 2 students.

Education and outreach materials pertaining to rattlesnakes have been produced by the South Okanagan - Similkameen Conservation Program (Sarell 2004, 2005a,b, 2006; Okanagan - Similkameen Conservation Alliance 2012). Rattlesnake awareness programs have been presented to most vineyard staff in the South Okanagan. However, rattlesnakes continue to be killed at a largely unknown rate.

Aggregations of snakes at hibernacula may be particularly vulnerable to persecution (Gregory 2007; Hobbs 2001a). Of over 80 communal snake dens visited across the range of the species (Hobbs and Sarell 2000; Hobbs 2001a,b), none 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 subjected to persecution or accidental mortality.

Outreach programs in the South Okanagan and Lower Similkameen valleys are designed to make the public aware of the value of snakes in the ecosystem and of the benefits they provide to agriculture by controlling pests (Sarell 2000b; Bertram *et al.* 2001; Lomas *et al.* 2011). Outreach has had some success in changing people's behaviour, but persecution continues.

Exclusion fences can prevent or greatly restrict access of rattlesnakes to areas frequented by people (Ovaska *et al.* 2004; Sarell 2005b) and have been used successfully around resorts and summer camps to prevent human – snake interactions (Brown 1993; Snook and Blaine 2012; Gardiner and Song 2013a). A combination of fencing and short-distance translocation of snakes found in situations that put people at particular risk may effectively reduce human-caused snake mortality (Snook and Blaine 2012). The effectiveness of translocation is dependent on the availability of trained snake handlers as well as suitable habitat in close proximity to the snake's original location.

Rattlesnakes are attractive as pets to hobbyists and may be collected from the wild (Blais 2011). The magnitude of this problem in British Columbia is unknown.

The impact of timber harvesting on rattlesnakes is poorly known (Table 6).Timber harvesting may affect some populations, especially in light of recent increases in salvage harvest of areas of insect outbreaks. Timber harvesting and the associated road construction may destroy suitable habitat, and may result in direct mortality of snakes. However, some low-elevation harvesting may actually improve habitat, providing that the area remains as grassland or parkland.

Residential and Commercial Development (impact "low")

In general, the compatibility of Western Rattlesnakes with human development is low (Ovaska *et al.* 2004). Residential and commercial development can have extreme impacts locally through habitat loss, degradation, and fragmentation. Most rattlesnake dens are found at low elevations in interior river valleys, the areas that also support the most intensive human activity (Hobbs 2013). Development of the areas on or around hibernacula, or removal of talus from them, can eliminate or degrade habitat, including altering thermal characteristics of the den. Destruction or alteration of hibernacula can have severe impacts on local populations disproportionate to the size of the area affected. Impacts from residential and commercial developments are most severe in the Okanagan Valley and in the Kamloops area, where human populations continue to expand.

Agricultural Development (impact "low")

Agriculture occurs on most low bench-lands 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 or loss of foraging or hibernating habitat and/or interruption of migration corridors connecting those habitats, as well as accidental mortality due to farm machinery (Bertram *et al.* 2001; Gardiner and Song 2013b). Formerly, agriculture in the southern interior of British Columbia 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. Habitat suitability is severely reduced in vineyards, as there is little cover and rodent prey populations are reduced.

In general, there is little evidence that grazing has a negative impact on rattlesnakes. Clearly, this land use is less detrimental than agricultural uses such as cereal cropping or vineyards. However, high intensity grazing pressure may compact soils and damage or block access to hibernacula, or cause damage to cover indirectly by soil erosion and dislodging cover objects down slopes. As a result, snakes may become more exposed to predation. These threats have not been studied in detail.

Human Intrusion and Disturbance (impact “low”)

Much of the Western Rattlesnake’s range is subject to recreational use, especially hiking, camping, rock climbing, and off-road vehicle recreation. Threats result from accidental mortality from vehicles (including ATVs; Sarell, pers. obs.). Mountain bike traffic has been observed to kill snakes on occasions (Sarell, pers. obs.).

Lomas (2013) reported that radio-tagged Western Rattlesnakes in disturbed sites in the Osoyoos Indian Reserve were smaller and in poorer condition than those in less-disturbed sites, but did not observe any behavioural differences such as increased use of cover or decreased activity. Lower prey densities were suggested as a possible reason for the lower body condition of rattlesnakes in disturbed areas.

Disturbance may also have behavioural effects. A telemetry study of the Eastern Massasauga Rattlesnake (*Sistrurus catenatus catenatus*) in Killbear Provincial Park in Ontario found that snakes closer to human disturbance (roads, trails or campsites) moved significantly less than did individuals that were in less-disturbed areas, but human disturbance did not affect the condition or the growth rates of snakes (Parent and Weatherhead 2000).

Natural System Modification (impact “low”)

Fire suppression contributes to tree ingrowth on native grasslands, which reduces habitat suitability for rattlesnakes. Macartney (pers. comm. *in* Didiuk *et al.* 2004) and Larsen (pers. comm. *in* Didiuk *et al.* 2004) independently revisited their north Okanagan study area in 2002, 20 years after their original studies (Macartney 1985; Macartney *et al.* 1989). They noted a substantial increase in the grassland understory and shading of former basking areas by shrubs.

Conversely, short-term effects of high-intensity fire may result in direct mortality of rattlesnakes and may temporarily make habitat less suitable by removing cover provided by tall vegetation, but there are no data. Means and Campbell (1981) marked 68 Eastern Diamondback Rattlesnakes (*Crotalus adamanteus*) in Florida on a 600 ha site that was then treated by incremental prescribed burning. Only three of the marked rattlesnakes (all individuals in ecdysis) were killed.

Invasive & Other Problematic Species (impact "low")

The impacts of invasive species are thought to be low. Dogs and cats will occasionally kill rattlesnakes (Klauber 1997). A potential but more serious threat is from the Snake Fungal Disease, an emerging skin disease affecting populations of wild snakes (USGS 2013). In terrestrial snakes, the disease is linked to the fungus *Ophidiomyces ophiodiicola*, which occurs only in snakes (University of Alberta undated). To date, this disease has been found in a number of snake species in eastern and mid-western United States (USGS 2013). The disease has been documented from the Timber Rattlesnake in the eastern United States (Sleeman 2013), and rattlesnakes seem to be particularly susceptible. Although not reported in Western Rattlesnakes, or any wild populations in western North America, it is suspected to be more widespread than is currently documented and may affect more species.

Energy Production and Mining (impact "low")

Mining and quarrying occur throughout the range of the species and may have severe local impacts. This threat is derived from direct mortality during earthworks and destruction of habitat. Even small-scale operations, such as sand and gravel extraction for road building, can have profound effects, if hibernacula are destroyed. Energy production (hydro, wind, geothermal) is not thought to threaten rattlesnake populations at present.

Pollution (impact "unknown")

The impacts of pollution on rattlesnakes are unknown (Table 6). Strychnine-based rodenticides are commonly used in orchards and vineyards within the Western Rattlesnake's range to control Northern Pocket Gophers (*Thomomys talpoides*). Williams and Bishop (2011) modelled the potential impacts of rodenticides on the Great Basin Gophersnake, another predator of rodents in BC's southern interior. They projected that if 15% of the snake population was killed by rodenticides annually, only 17% of the population would remain after 25 years. There are no data on potential effects of rodenticides on the Western Rattlesnake, nor any documented strychnine poisoning of rattlesnakes in the province.

Climate Change and Severe Weather (impact "negligible")

Threats posed by climate change and geological events are thought to be negligible over the next ten-year period (Table 6), but impacts are possible over the longer term. Rattlesnakes are not readily able to disperse long distances and will probably respond slowly to climate change. Over the long term, they are likely to experience range contractions, reduced abundances, and changes in distribution patterns as climate change proceeds (Compass Resource Management 2007).

Number of Locations

The number of locations is unknown but given that roadkill is thought to be the most severe plausible threat, and the number of locations is much greater than 10, perhaps in the 100s.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

The Western Rattlesnake is listed as Threatened on Schedule 1 of the federal *Species at Risk Act* (SARA). The act prohibits killing or capturing the snakes or destroying their residences and provides protection for critical habitat, once it has been described and approved. SARA prohibitions for the Western Rattlesnake currently apply only to federal land. Critical habitat has not been defined for this species as of February 2015.

The Western Rattlesnake is protected provincially under the British Columbia *Wildlife Act*, which prohibits killing or capturing individuals or keeping them captive except under provincial permit. A provincial recovery plan has been prepared for the species (Southern Interior Reptile and Amphibian Recovery Team 2008), but the conservation initiatives it describes are still in progress.

Non-Legal Status and Ranks

The subspecies *Crotalus oreganus oreganus* is provincially ranked as S3 (Vulnerable) (BC Conservation Data Centre 2013a). The S3 ranking is applied due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation. Its national rank in Canada is N3 (same definition as S3 above). Canada is the only jurisdiction that ranks the *C. o. oreganus* subspecies.

NatureServe (2014) lists the Western Rattlesnake's global rank as G5 (Secure). The Western Rattlesnake (with no subspecies designations) is listed as either as G5 or not ranked in all states across its US range except in Wyoming, where its rank is S1 (critically imperilled) (NatureServe 2014).

Habitat Protection and Ownership

The Western Rattlesnake is found in several large provincial parks, including Kalamalka Lake Park, Okanagan Mountain Park, White Lake Provincial Park, and Lac Du Bois Grasslands Park. It is also found in Vaseux Bighorn National Wildlife Area, ecological reserves, and on land owned by the Nature Trust of British Columbia and the Nature Conservancy of Canada and managed for conservation. These areas are protected from development, but increased use by people for recreational purposes may be detrimental to rattlesnake populations. Small protected areas frequently lose species through stochastic events (Shaffer 1981), as well as through variation in vital rates (e.g., fecundity, survival) of populations associated with small patch sizes (Hokit and Branch 2003).

Wildlife taxa and plant communities that have been determined to require special management of forestry and range practices are designated as Identified Wildlife under the Identified Wildlife Management Strategy associated with the BC Forest *and Range Practices Act* (BC Ministry of Water, Land and Air Protection 2004; Erickson *et al.* 2007). The Western Rattlesnake is provincially listed as Identified Wildlife. Measures undertaken for protection of Identified Wildlife include the establishment of Wildlife Habitat Areas to protect important habitat areas or features that are managed according to specific General Wildlife Measures. However, neither urban development nor other resource-based industries (such as mining) are subject to the provisions of the Identified Wildlife Management Strategy, nor does the presence of a Wildlife Habitat Area prevent the sale of Crown land. Wildlife Habitat Areas for the Western Rattlesnake provide limited protection. Currently there are 31 established and 20 proposed such areas for the Western Rattlesnake (Table 7).

Table 7. Numbers of Western Rattlesnake Wildlife Habitat Areas in British Columbia.

Region	Number Approved (area in ha)	Number Proposed (area in ha)	Total (area in ha)
Okanagan Shuswap and Arrow Boundary	13 (2,350)	7 (1,721)	20 (4,071)
Merritt and Kamloops	18 (3,622)	13 (3,569)	31 (7,191)
TOTAL	31 (5,972)	20 (5,290)	51 (11,262)

Records within the provincial den database (Sarell and Hobbs, unpubl. data 2013) were summarized by land ownership. Eighty of 368 (22%) extant (i.e., not including 12 dens from which snakes are believed to be extirpated) rattlesnake dens are on protected land (provincial or federal parks or private land managed for conservation) (Table 8). Forty dens (11%) are on private lands. The remainder are on Crown provincial land (107 – 29%) and federal land (35 – 10%)/ First Nations Reservations (66 – 18%).

Table 8. Summary of numbers of confirmed and extant rattlesnake dens (n=368), by population, for each tenure type (from Sarell and Hobbs, unpubl. data).

Tenure Type	**Grand Forks**	**Midway**	**Okanagan-Similkameen**	**Thompson-Nicola**	**Vernon**	**% of total dens**
Crown Land	10	8	63	68	6	42.1
Federal Land	0	0	24	0	1	6.8
Indian Reserve	0	0	62	4	0	17.9
Parks/Protected Areas/Wildlife Management Areas	0		39	10	15	17.4
Private Land	3	2	26	3	6	10.9
Conservation Land (private)	0	1	17	0	0	4.9
TOTAL	13	11	231	85	28	100

Hobbs (Hobbs 2001a,1b) and Hobbs and Sarell (2000) identified potential concerns for long-term survival of den populations based on proximity to roads, adjacent land use (e.g., grazing, vineyards), and encroachment of housing developments. Although many dens themselves are on protected lands, snakes that use those dens often must cross roads as they migrate to summer ranges, exposing them to road mortality (Williams *et al.* 2012; BC Conservation Data Centre 2013b).

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Mike Sarell is a Registered Professional Biologist in BC. 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 BC 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*) and co-authored the draft update status report for Great Basin Gophersnake (*Pituophis catenifer deserticola*).

COLLECTIONS EXAMINED

Not applicable.