Den Survey and Population Assessment of the Northern Pacific Rattlesnake in BC

Final Report

Prepared For: BC Ministry of Forests, Lands and Natural Resource Operations

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Prepared: February 23, 2013

Acknowledgements

First and foremost I would like to acknowledge the dedication and commitment of all of the British Columbia Conservation Foundation (BCCF) technicians that worked on this project. Each of the technicians subjected themselves to long, hot and arduous hikes, up steep terrain and in demanding conditions, to find each of the dens reported here. Searching for snake dens is perhaps one of the most physically demanding field tasks to undertake and the following individuals showed commitment to the goal: Dennis Lynch, Mike Dunn, Jess Findlay, Greg Ferguson, Laura Werden, Leah Ballin and Susan Dulc. We would all like to acknowledge Joanne Neilson for tolerating our missed check-ins, erratic schedule and long hours, including weekends, and for providing vital administrative support for the crews during the spring and fall snaking sessions.

I would be remiss not to also thank Mike Sarell for introducing me to his collective knowledge, acquired over 20 years, of this species in BC. In particular Mike has been graciously collaborative in allowing me to access and co-operatively maintain the most extensive database of snake den locations in BC. Working together, we have amassed a considerable body of knowledge on the species denning behaviour and the extent of the species current (and historic) distribution in BC. Thanks also to the landowners, particularly Paul (Ashcroft Ranch) and Dennis (Ashcroft IR) for allowing us access to suitable habitats on their properties.

Finally, thanks to the snakes for alerting us to your presence, for not biting us and for being so much fun to work on; you have our respect.

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Executive Summary

Surveys were conducted in 2012 to detect denning sites for the Northern Pacific Rattlesnake (*Crotalus oreganus oreganus*) in BC. Surveys occurred in three shifts; one shift (10 days) occurred in April 2012. The remaining two shifts (19 days) occurred in September 2012. In total, we conducted 29 days of den surveys (with an average of four observers per field day) for a total of 116 person days of effort. A total of 18 dens were detected. These dens constitute approximately 6% of the 318 confirmed rattlesnake dens recorded in the provincial snake den database today. Each den site is described and images, observations and den coordinates are provided in the appendices.

Although this report is ostensibly intended to summarize the spring and fall den survey results (as described above)a more significant goal, , was to provide a complete synthesis of over a decade of research and inventory on the Northern Pacific Rattlesnake throughout the species' Canadian range. This synthesis also includes an analysis of covariates on a collaborative snake den database that was initiated by Mike Sarell and subsequently (and collaboratively) expanded, refined and maintained by both M. Sarell and J.Hobbs. In addition relevant learning's from my MSc thesis work are included as this research on the species' thermal ecology adds clarity and provides important information regarding our understanding of appropriate survey timing windows for this species in BC. The "Methods" section provides instruction regarding techniques used to find new dens. The "Summary of Existing Information" section provides the first (and only) province wide assessment of various influential covariates including den elevation, distance to road, tenure and provincial distribution (within each of five provincial populations). The "Discussion" and "Management Recommendations" sections provide a context-based perspective with insights on how these covariates are suspected to affect vital rates for rattlesnakes in BC. In addition, the BC snake den database was also used to develop new, more accurate and current range maps for gopher snakes, rattlesnakes and racers in BC. A revised and more accurate range map for rattlesnakes is presented here.

The results presented here suggest there is strong cause for conservation concern regarding the continued persistence of the Western Rattlesnake in BC. The species has been extirpated from several large areas of its former range in both the central portion of the Okanagan population and from large areas along the south side of the Thompson Valley from Chase to Ashcroft. More localized extirpations are also evident in the Midway and Grand Forks populations. Indeed, there are only five meta-populations (see Discussion) in BC that remain relatively un-impacted by negative anthropogenic influences. Stronger and more effective legal protection for this species is likely required to arrest or reverse apparent range wide declines of rattlesnakes in BC.

Table of Contents

Introduction

Species Information

The Northern Pacific Rattlesnake was formerly recognized as one of nine sub-species (formerly: *C. viridis oreganus*) of the widely distributed Prairie Rattlesnake (*C. viridis*). Previous genetic work by Ashton and de Queiroz (2001) split *C. viridis* into two clades (IUCN. 2012). The Eastern clade (*C.viridis*) contains the nominal subspecies *viridis* (and *nuntius*) and includes populations from east and south of the Rockies*;* the western clade (*C.oreganus*) includes all five other former subspecies of *C.viridis* that occur west of the Rocky Mountains, including:

1. Northern Pacific Rattlesnake (*C.o. oreganus*) (nominal species: Holbrook, 1840). From east of the Cascades in BC, continuing on both sides of the Cascades into Washington, Idaho, Oregon and east of the Cascades in California.
2. Grand Canyon Rattlesnake (*C.o.abyssus*). Restricted to the Grand Canyon, Utah.
3. Midget Faded Rattlesnake (*C.o.concolor*). Utah, Colorado, Wyoming east of the Rockies.
4. Southern Pacific Rattlesnake (*C.o.helleri*). Southern California, including Santa Catalina Island.
5. Great Basin Rattlesnake (*C.o.lutosus*). East of the Cascades including Southeastern Oregon, southern Idaho, eastern California, Nevada, Utah and northern Arizona.

This new polytypic species is now referred to by its common name, the Western Rattlesnake (*C. oreganus*), with five recognized subspecies (Rubio. 2010).

In North America, the Western Rattlesnake (*Crotalus oreganus*) is the most northerly distributed species of the Crotalinae sub-family. The nominate subspecies, *C. o. oreganus*, retains its previous common name (the Northern Pacific Rattlesnake) and extends further north than any of the other four sub-species of Western Rattlesnake as it extends north into BC. Within Canada, the Northern Pacific Rattlesnake is the only extant subspecies of the Western Rattlesnake clade[1]. Because Canada is home to only a single sub-species of the Western Rattlesnake (i.e. the Northern Pacific Rattlesnake), this sub-species can be referred to by either the full species name (Western Rattlesnake) or the sub-species name (Northern Pacific Rattlesnake) when discussed in a Canadian context. The remainder of this report is focused on the Northern Pacific Rattlesnake as a sub-species of the polytypic Western Rattlesnake.

In BC, the Northern Pacific Rattlesnake (*Crotalus oreganus oreganus*) occupies portions of the dry southern interior grasslands of BC and is designated as a 'blue listed' species by the BC Conservation Data Centre (BC Conservation Data Centre 2012) and as 'threatened' by the Committee on the Status of Endangered Wildlife In Canada (COSEWIC 2012). Restricted geographic range within BC, threats (habitat loss and persecution), and reported declines in the BC population (due to localized extirpations and habitat loss) make this species a cause for conservation concern (Charland et al. 1993). As such, the Northern Pacific Rattlesnake is also listed on the federal Species at Risk Act (SARA) under Schedule One; its residences (including den (hibernacula) features and mating sites) are legally required to receive both federal and provincial protection under SARA (on federal land) and under the Bilateral Agreement (on provincial crown land and on private land).

1: Two other species of rattlesnake occur in Canada – the Prairie Rattlesnake (*C. viridis viridis*) occurs in Alberta and the Eastern Massasauga Rattlesnake *(Sistrurus catenatus catenatus*) occurs in Ontario.

Distribution

In North America, the Northern Pacific Rattlesnake occurs on the east and west sides of the Cascades from Oregon north to western Washington along the US portion of the Okanogan River Valley with extensions into Canada. In Canada, the northernmost population of the Western Rattlesnake occurs along the Thompson-Nicola (and Fraser) river drainages and is geographically disjunct from the three BC populations that occur along the international border. This northernmost population has likely been disjunct since the hypsithermal periods (~9,000-5,000 ans)[1]. This is suspected to be the northernmost extent of the range of the Crotalus genus in North America[2]. The three southern BC populations include the Grand Forks, Midway and Okanagan-Similkameen Populations. All three southern populations of *C.o.oreganus* are geographically contiguous south of the international border.

In BC, the distribution of the Northern Pacific Rattlesnake is restricted to four discrete extant populations on the east side of the Cascade mountain range as described below:

1. The Thompson-Nicola population likely occurs east to Chase along the South Thompson River (Hobbs. 2007) and north to Westsyde along the North Thompson River. The population continues along Kamloops Lake and the Thompson River to the Thompson River – Fraser River confluence at Lytton. The population also extends for 20 km up Bonaparte Creek to Hart Ridge and along the Nicola River Valley to Skahun Creek (J. Hobbs, pers. obs), although isolated records exist further east along the Nicola Valley to Spirit Creek (B. Davis, pers. com.). Along the Fraser River canyon historic records exist as far south as Boston Bar (COSEWIC 2004). Recent records (Pers obs 2004, 2010 & 2011; F.Iredale. 2011) confirm that the population extends north of Lytton towards Lillooet for ~30 km to McGillivray Creek. There is only one confirmed record on the west side of the Fraser River at Kwoiek Creek (confirmed from photo). It is suspected that this snake drifted across the Fraser after escaping from the fire at Mt. Arthur Seat in 2008. There is no evidence of an established population or den at this site.
2. The Okanagan – Similkameen & Vernon populations extend from the international border at Osoyoos and continue north along the Okanagan valley to Vernon. Connectivity between the extant population in Vernon and the known extant population further south in the Okanagan is compromised by extensive urban development. The species has been extirpated from much of its former habitat in Kelowna and the two populations are now likely disjunct. The southern portion of the population continues south from Okanagan Mountain Park to the international border and east along the Similkameen River through Richter Pass and Yellow Lake Pass, from Chopaka (at the International Border) northwest to Bromley Rock.
3. The Midway population occurs from Rock Creek and continues west along the West Kettle River Valley to Midway. From Midway, this population extends north to Kerr Creek (~4 km northeast of Midway) and continues south of Midway (south of the International Border) along the Kettle River. The Kettle River re-enters BC at Grand Forks, connecting the West Kettle population to the East Kettle population.
4. Grand Forks population occurs from Grand Forks and continues north up the Granby River to Niagara. This population extends east along the East Kettle River where it continues north along the Christina Lake valley. To the south, this population is connected with the population in the United States (south of the International Border) below Christina Creek along the Kettle River Valley to where it joins the Columbia River. (Note: Historical accounts exist for Castlegar but no recent records are available for confirmation. This sub-population is likely extirpated (M. Sarell, pers. com.) but may have once extended along the Columbia River north to Montrose, Trail and Castlegar.)

The total number of dens for each population is summarized in Table 1.

1: The Holocene Climate Optimum (HCO) was a warm period during roughly the interval 9,000 to 5,000 years before present. This event has also been known by many other names, including: Hypsithermal, Altithermal, Climatic Optimum, Holocene Optimum, Holocene Thermal Maximum, and Holocene Megathermal.
2: The population of *C.viridis* in Brooks, Alberta potentially extends further north but current records suggest that the most northerly den in Dinosaur NP is 8.6km further south than BC's most northern den (Abandonment Den) near Cache Creek.

Table 1: Number of confirmed (C1), suspected (C2), probable (C3) and extirpated snake dens (all species) in BC. *(Note: numbers are inclusive of all dens, regardless of confirmation of rattlesnake use; rattlesnakes have been confirmed at 380 of the 459 known dens reported below*.

Population Name	Confirmed (C1) Dens	C2 Dens	C3 Dens	Extirpated Dens
Thompson-Nicola	87	16	1	1
Okanagan-Similkameen & Vernon	251	60	10	10
Midway	12	2	0	0
Grand Forks	18	4	0	1
TOTAL	**355 (318 with rattlesnake)**	**82**	**11**	**12**

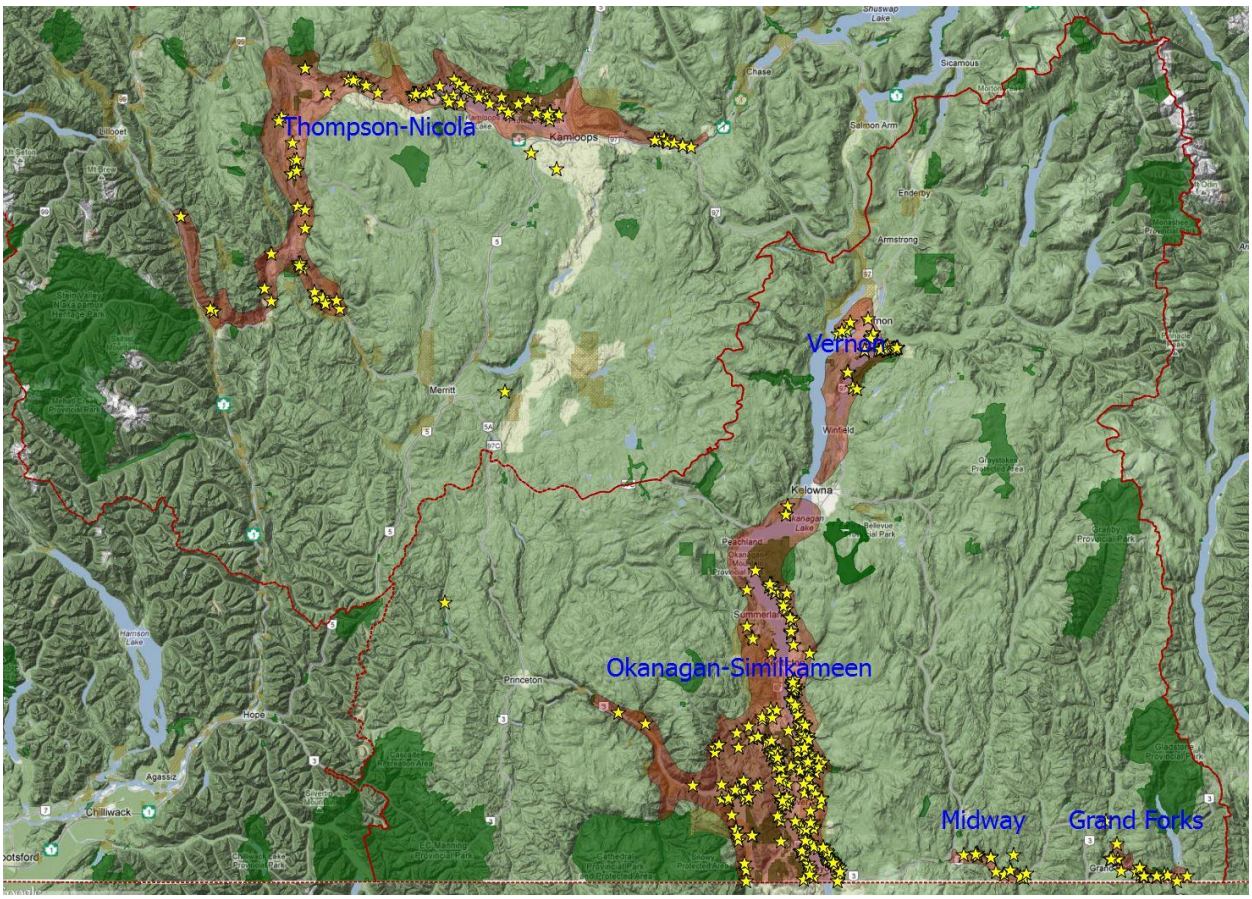


Figure 1: Distribution of the Northern Pacific Rattlesnake in BC showing all four populations. Yellow stars depict dens, red shaded areas represent estimated ranges. The red line indicates MOE regional boundaries.

Den Ecology: Timing

Each fall, in temperate latitudes, snakes return to den features to avoid lethal surface temperatures. In BC the timing of the fall return movement is somewhat variable as it differs at different elevations and it varies geographically (depending on site specific local conditions (e.g. aspect)). In general, in BC, the fall movement back to the den (ingress) is correlated with the onset of cooler nights when temperatures drop below 9°C. This typically occurs during September through to mid-October although some snakes have been observed traveling back to dens as late as early November in the South Okanagan (M.Sarell. pers com).

In 2006 I attempted to more accurately and precisely define the timing of den return movements by monitoring snake body temperature and snake movement (using concurrent telemetry data contributed by L. Gomez). These results confirmed that, on average, rattlesnakes returned to the den commencing September 17 and that all monitored snakes had returned by October 13th. Median return date was September 22nd (Hobbs 2007). A larger sample size would likely show that ingress, or return movements to the den, generally occur in mid to late September with snakes being reliably seen at dens when evening temperatures in the area fall below 9C° (pers obs). This finding is consistent with prior and subsequent repeated observation and research by the author and others.

Each spring, sometime in early to mid-April, rattlesnakes leave their den sites to return to summer foraging areas. In BC, rattlesnakes have a relatively short emergence, or egress, period. During this period they frequently bask at the den entrance for several days prior to leaving the vicinity of the den to forage for the summer (Hobbs. 2006). In one study in southern BC, over the three-year duration, dispersal from the den occurred between April 23 and May 30 (Shewchuk. 1996).

Similarly, in 2006, I attempted to more accurately and precisely define the timing of the spring den egress (i.e. when snakes leave the den). My research refined earlier estimates for spring egress. Emergence from dens began in late March or early April (dates of first emergence ranged from March 22 to April 4). Upon emergence, snakes remained at, or near, the den entrance exiting to bask on the surface during warm or sunny days when surface temperature exceeded 10°C and air temperatures exceeded 15°C. This period of den emergence typically lasts until mid to late April. All monitored snakes (n=8) left the den between April 20-24th. Some snakes may remain at the den beyond this period but the number of snakes visible (or remaining) dwindles rapidly by late April and, as a consequence, den detectability diminishes rapidly.

Den Ecology: Thermal Considerations

Two studies have been conducted on overwinter thermal ecology of rattlesnake in BC. The first was near Kalamalka Lake (near Vernon, BC) by Macartney (1996). This research suggested a critical body temperature (Tb) (between 4-9°C) must be maintained while the snakes are in the den. More recent studies (Hobbs 2007) on overwintering thermal ecology of rattlesnakes in BC (including dens from the Thompson-Nicola and Okanagan-Similkameen and Vernon populations) showed that mean weekly Tb declined towards the end of the active period (in September) from 23.2°C to 15.9°C immediately before den entry. Once Tb fell below 15°C rattlesnakes would enter the den and most snakes remained inside the den for the duration of the denning period (although at least some snakes showed a tendency to exit the den periodically, throughout the winter denning period, to bask on the surface (see Figure 4)). A graphic example of internal body temperature readings, collected during my research in 2006/7, illustrates these patterns (Figure 4 & 5).

Figure 4: Body temperature readings were collected four times each 24 hour period, from eight snakes, between July 24, 2006 to April 24, 2007. The graph below indicates mid-winter basking, seen as 'spikes' in body temperature that occurred when the snake exited the den to bask on the surface during the winter (Tb exceeded internal den temperature).

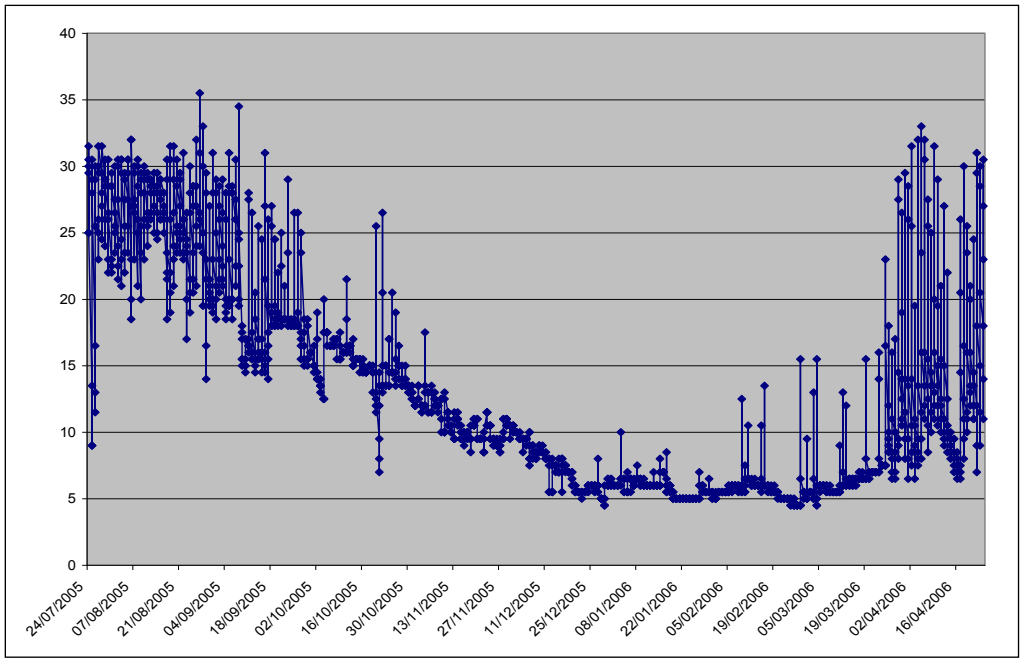
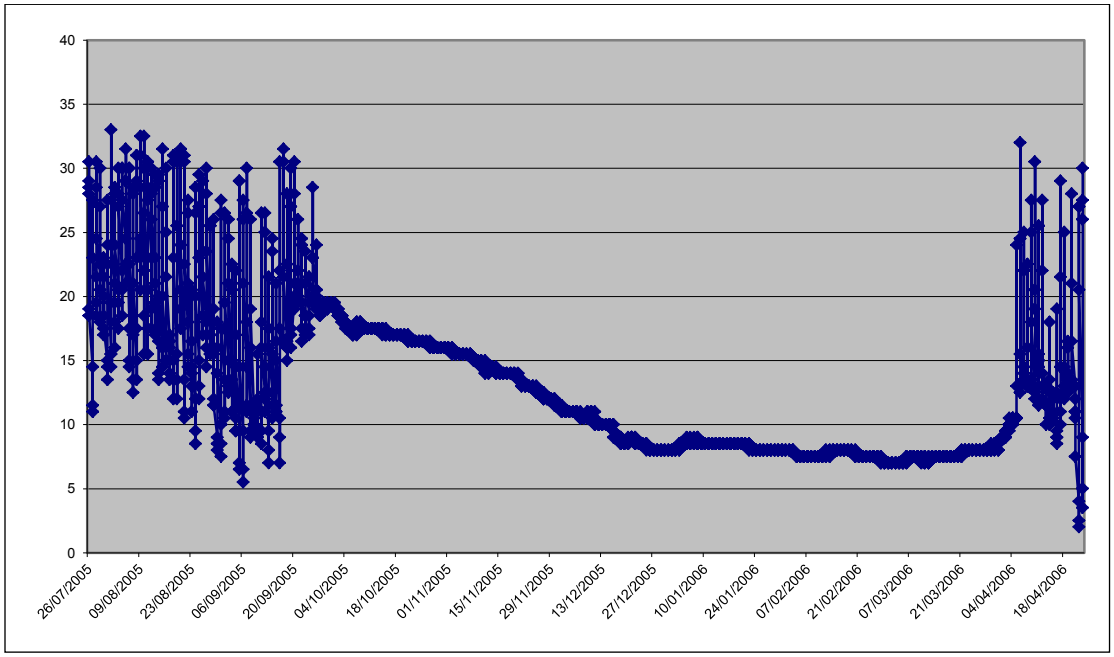


Figure 5: In contrast, there was no evidence of mid-winter basking observed for most dens monitored, as evidenced by the relatively stable (i.e. lacking spikes) body temperature observed for most snakes.



After ingress in September and October 2005, Tb declined at ~0.5°C/week over winter to reach a mean weekly Tb of 6.4°C by February-March before exiting the den again in the spring. During the denning period, mean Tb was 9.6°C (n=8).

Summary of Known Den Information

Ectotherms are unable to generate sufficient warmth internally (for prolonged periods) to maintain body temperatures above ambient surface temperatures. Hence northern latitudes, characterized by prolonged sub-zero winter temperatures, pose a thermo-regulatory challenge to the survival of ectotherms, including snakes. The survival of snakes, during cold periods, depends on the thermal characteristics of their hibernation sites (Brown 1982, Marion and Sexton 1984). Snakes must select sites, for over-winter denning, which maintain temperatures consistently above freezing. In BC, they persist by taking advantage of geo-thermal characteristics that occur naturally, in limited availability, in the landscapes that they occupy. Snakes at northern latitudes, including the Northern Pacific Rattlesnake, gather each fall at communal winter den sites, or hibernacula, to overwinter. Many individuals of several snake species commonly share these dens sites in BC including the Great Basin Gopher Snake (*Pituophis catanifer*), Racer (*Coluber constrictor*), Common Garter Snake (*Thamnophis sirtalis*) and the Western Terrestrial Garter Snake (*T. elegans*) (Klauber 1972, Macartney 1985, Sarell 1993, Hobbs 2001). Snake populations at some of these dens have been estimated at over 500 individuals (Hobbs 2001).

Mike Sarell began building and maintaining a database of snake dens in the early 1990's. In 2001 J.Hobbs and M.Sarell collaboratively compiled all known BC den data to build and maintain a shared database of den location information for BC. Due to the confidential nature of the dens on private land and on IR are not submitted to the BC government however summary level data, as presented here, are available for conservation and planning purposes. The database contains coordinate and information (including species observed, approximate den population size (based on head-counts), land tenure, jurisdiction (MOE region) and basic habitat information (including distance to nearest paved road, BEC, elevation, slope, aspect & eco-section).

Including the results from this project (2012 field season) the BC den database contains:

- **355 Confirmed One (C1) dens:** Multiple snakes observed at or near the den entrance.
- **82 (Suspected) Confirmed Two (C2) dens**: Single snake observed at or near a suspected den entrance with only a single season of observation; further visits are required to confirm denning with absolute certainty.
- **11 (Probable) Confirmed Three (C3) dens:** Evidence of snakes (tracks, sheds, feces) at or near a suspected den entrance)
- **12 Extirpated (E) dens** : The den is suspected to be extirpated based on sign, rumour of intentional persecution or repeated zero counts under ideal conditions).
- **191 Candidate Dens:** No evidence of denning, but denning likely based on geo-physical assessment of the potential den structure).

Conservation and protection of all confirmed (C1 status) dens is required as these sites are used, by multiple snakes over multiple generations, for critical habitat, or shelter, during the winter period. All suspected (C2) and probable (C3) sites should be re-surveyed in an attempt to elevate the status of these 'suspected/probable' dens to confirmed (C1) status. Candidate den sites should be resurveyed, under appropriate denning conditions, if there is any potential threat of change to these habitat features in an area.

Population Size

The BC snake den database can also be used to provide a very approximate estimate of the provincial population size (absolute abundance) based on known counts (summarized into size classes) at each den. When collecting den counts we consistently count snakes based on 'head-counts' only; we then assign it to a size class as follows:

- Size Class 1: 1-9 snakes
- Size Class 2: 10-25 snakes
- Size Class 3: 26-50 snakes
- Size Class 4: 51-75 snakes
- Size Class 5: 75-100 snakes
- Size Class 26: >100 snakes

A cumulative analysis of the "Size Class" of all dens in the BC Snake Den Database (Sarell and Hobbs data-2012) is summarized in Table 2.

Table 2: Cumulative analysis of population size based on confirmed (C1) rattlesnake dens in the BC snake den database.

# of Dens	Size Class	Number of snakes (max count)	Total estimated rattlesnake population	
			Minimum estimated	Maximum estimated
145	1	1-9 Snakes	145	1,305
87	2	10-25 Snakes	870	2,175
35	3	26-50 Snakes	910	1,750
9	4	51-75 Snakes	459	675
10	5	76-100 Snakes	760	1,000
8	6	> 100 Snakes	800	800
24	unknown	No count available	Unknown	Unknown
318			**3,943**	**7,896**

These numbers may be used as a minimum estimate, based on head counts, of the BC population of Northern Pacific Rattlesnakes however caution is required when applying this conservative and approximate absolute abundance estimate of the BC population size. The actual population size is likely larger as den counts will underestimate (by a suggested factor of up to five times) the number of snakes actually using the den. In addition, there are likely many dens that exist but are not documented (i.e. not yet found). Conversely, this suspected underestimate is offset by likely declining trends that are suspected for most (>75%) of the known snake dens remaining in BC. Regardless of the limitations of these estimates they remain the most comprehensive surrogate estimate of the total provincial rattlesnake population available.

Impacts of Roads

In addition, a GIS analysis of den location in proximity to "nearest paved road" was conducted to provide some insight into habitat conditions. Road-related mortality is regarded as a severe stressor on the snake populations (Hubbard and Chalfoun. 2012). A review of road-related mortality, by Andrusiak and Sarell (COSEWIC 2004) found supporting literature that confirms depletion effects. A cited study suggested that snake populations were reduced by >50% within 450m of moderately used roads. Depletion effect was also still evident at distances ≥850m. A second cited study confirmed that the loss of only three adult female Black Ratsnakes (*Elaphe obsoleta*) in Ontario increased the probability of extinction to over 90% over 500 years. The life history of rattlesnakes, like other BC snake species, include traits that make a species' population vulnerable (low fecundity, late maturity, long natural adult survivorship and seasonal migrations). As such, the cumulative effects of population depletion from road mortality may have serious effects on the genetic diversity of snake populations (Jackson and Fahrig 2011).

Every attempt has been made to survey all habitats, with a bias *against* survey of areas near paved roads. This analysis shows the challenge faced in achieving this objective. Despite survey bias to avoid surveys near roads almost all suitable rattlesnake habitats in BC are bisected by roads.

Ideally an analysis of population trend, at known dens or within known snake populations, is warranted however this analysis is severely confounded by detection bias associated with sampling conditions. The data in the provincial snake den database is not robust enough to afford any insight to population trends provincially. An alternative analysis was attempted, to examine the population size (based on den count data) relative to (paved) road proximity to allow relative comparison of population sizes with differing road proximities however this afforded no additional insight. Unfortunately, the den count data in the database does not provide an accurate estimate of *actual* population size and as such population size patterns are 'masked' by variability in the available den counts. In summary, it is only pertinent to provide a summary of paved road proximity for 355 confirmed dens. This summary is provided here (refer to Table 3).

Table 3: Summary of confirmed (C1) rattlesnake dens (n=318) relative to proximity to road.

Proximity to Road (m)	# of C1 Dens	% C1 Dens
0-999	176	49%
1,000-1.999	98	27%
2,000-2,999	25	7%
3,000-3.999	13	4%
4,000-4,999	3	1%
>5,000	3	1%
Total	318	-

Elevation

Finally, an analysis of known confirmed rattlesnake den locations (n=318) in the Kamloops and Okanagan MOE regions was conducted to describe known elevation distribution patterns for rattlesnakes in BC (see Table 4). In summary, snakes show a strong tendency to den at low valley-bottom elevations, where anthropogenic influence is most pronounced, throughout their entire range in BC.

Table 4: Summary of confirmed (C1) rattlesnake dens (n=318), by elevation range, for Region 8 & 3.

Elevation Range	Number of known (C1) rattlesnake dens	
	Region 8 (%)	Region 3 (%)
200-400	9 (4%)	4 (5%)
400-600	126 (52%)	39 (51%)
600-800	82 (34%)	31 (41%)
800-1,000	21 (9%)	2 (3%)
1,000-1,200	3 (1%)	0 (0%)
>1,200	1 (0%)	0 (0%)
Total	242	76

Summary of Legal Protection

In October 1996, the governments of all Canadian provinces and territories, and the Federal Government, signed the national Accord for the Protection of Species at Risk. All signatories committed to establishing complementary legislation to provide effective legal protection for threatened or endangered species, including individuals and their habitats, within Canada. On June 1, 2004 Canada enacted the Species at Risk Act (SARA). SARA prohibits the destruction of residences of listed species and defines residences as, "…a place or area in, or a natural feature of, the habitat of the species at risk that is habitually occupied or used as a dwelling place by one or more individuals of the species at risk, or considered as being necessary for that occupation or use" (BC Ministry of Environment 2007b).

Rattlesnake hibernacula meet these criteria, and as such, the conservation and protection of rattlesnake hibernacula (i.e. residences) and critical habitat are federally mandated, within Canada, by the Species at Risk Act (SARA). In addition, in 2005, the BC provincial government signed a species at risk bi-lateral agreement with the federal government (the Canada-British Columbia Agreement on Species at Risk) (BC Ministry of Environment 2007b). This agreement clarified the roles and responsibilities of British Columbia and Canada as related to species at risk, with the purpose of coordinating federal-provincial efforts for species at risk conservation within BC. Eight years have passed and the development of effective legal protective mechanisms to ensure preservation of snake hibernacula is still required.

An analysis of known rattlesnake den locations (n=318) in the BC den database, by tenure type, was conducted to assess conservation options available under the current regulatory framework in BC (see Table 5).

Table 5: Summary of confirmed (C1) rattlesnake dens (n=318), by region, for each tenure type.

Tenure Type	Known Dens-Rgn 8 (%)	Known Dens-Rgn 3 (%)
Crown Land (WHA)	74 (7) (46%)	61 (24%)
Federal Land	25 (9%)	0 (0%)
Indian Reserve	51 (19%)	4 (5%)
Parks/Protected Areas/WMAs	44 (9%)	9 (12)
Private Land	39 (14%)	5 (6%)
Conservation Land (private)	16 (6%)	0 (0%)
TOTAL	242	76

Current mechanisms to protect rattlesnakes and rattlesnake hibernacula differ according to land tenure and are summarized for each tenure type as follows:

1. Private Land (including lands held privately for conservation purposes): The BC Provincial Wildlife Act affords protection to the individual snake but does not provide any protection to the den feature. The Northern Pacific Rattlesnake is recognized as a "Schedule A" species under the Wildlife Act and as such it is an offence to harass, harm, capture or kill an individual unless the snake poses a direct threat to a person or to property. There is currently no protection afforded to snake hibernacula that occur on privately held lands in BC. Stewardship activities could be encouraged through land-owner contact programs, public outreach and education. Property tax reductions could also be explored as a possible incentive to encourage citizens to establish conservation covenants on privately held lands.
2. Federal Lands (including First Nations Reserves, Federal parks and Federal Wildlife Management Areas): Under SARA, snake hibernacula should be categorized as a "Residences" for three of BC's resident snake species (including the Northern Pacific Rattlesnake). As such, den sites for these species are afforded legal protection by the Act where they occur on federal lands, including both First Nations Reserves and federal conservation areas. It is a punishable offence to destroy a snake den; however continued inventory is required to identify den sites on federal lands in British Columbia. To meet federal objectives for den site conservation a monitoring program should be developed, in co-operation with First Nations, the Canadian Wildlife Service and the BC Ministry of Environment, to ensure managers are informed of snake den locations and to provide guidance and recommendations to land managers to aid in the conservation of these features on federal lands.
3. Parks and Protected Areas: Existing Parks and protected areas have been established to conserve biodiversity values and habitat within portions of the rattlesnake's range in British Columbia, however many potentially detrimental activities are still permitted within some of these parks (i.e. grazing, development of hiking trials etc.). Species specific management guidelines could be developed for den features within parks and protected areas to ensure these activities do not adversely affect resident snake populations. Communication should also be encouraged between park managers and wildlife managers within the BC MOE to ensure park's staff are kept informed of den locations and are provided information to enable effective conservation and management of snakes and snake dens.
4. Crown Land: the Forest and Range Practices Act (FRPA) affords limited protection to rattlesnake dens. Under FRPA, the Identified Wildlife Management Strategy (IWMS) (BC Ministry of Environment 2007a) enables the designation of Wildlife Habitat Areas (WHAs) at known den sites that occur on provincial crown land. Once an area is designated as a WHA, specific attributes of the habitat that could potentially be adversely affected by forest and range management activities are specifically regulated to maintain habitat values for rattlesnakes. Although this mechanism restricts harmful activities that may result from forest and range tenured activities, it cannot regulate recreational activities (i.e. off-road vehicle use), mining activities or transportation infrastructure development (i.e. road building and quarrying activity). The provincial government has not currently provided any other regulation, on Crown Land, to apply similar conservation objectives to these other potentially adverse activities.

Responsible and appropriate conservation and management of this species, and of the landscape features that are critical to the species' long-term survival in Canada, is consistent with federal expectations of the BC Provincial Government, and is consistent with stated Provincial Government commitments under the 1996 national Accord for the Protection of Species at Risk (BC Ministry of Environment 2007b).

Study Area

Within BC, the Northern Pacific Rattlesnake is restricted to grasslands characterized by bluebunch wheatgrass (*Agropyron spicatum*) and big sagebrush (*Artemisia tridentata*); and open parkland forests characterized by Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*). These vegetation types are recognized as the Bunchgrass (BG), Ponderosa Pine (PP) and Interior Douglas-fir (IDF) Biogeoclimatic Zones (BEC) and occur primarily within the Thompson-Okanagan Plateau Eco-region. In BC, the Northern Pacific Rattlesnake has been confirmed at elevations ranging from 152 m to ~1,430 m ASL (L. Gomez. pers.com.), however reports exist for at least two populations (Cathedral Mountain) above 1,750 m (M. Sarell, pers. com.). Elevation of known rattlesnake dens in BC (n=318) is from 292-975m ASL (BC Snake Den Database-2012).

The population of the Northern Pacific Rattlesnake near Kamloops and along the Thompson River, Nicola River and Fraser River canyons is the northern extent of the species' range in North America. This population is unique in BC because, unlike the other BC populations, it is disjunct from the larger US population to the south. Habitat connectivity was likely lost after the Hypsithermal Period (see P.7) approximately ~6,000-9,000 years ago (Cannings and Cannings 1996). As such, continued persistence of this population is completely dependent on survival of snakes within this sub-population. Over the past decade I have focused much of my attention and effort, identifying den sites, within the Thompson-Nicola sub-population of rattlesnakes. This allocation of effort is intentional as I am attempting to address a relative 'gap' in our provincial understanding of the species' ecology. When I began searching for dens in this area there were less than ten known dens sites. Today we have close to 76 documented/confirmed rattlesnake dens in this population as a direct result of these efforts.

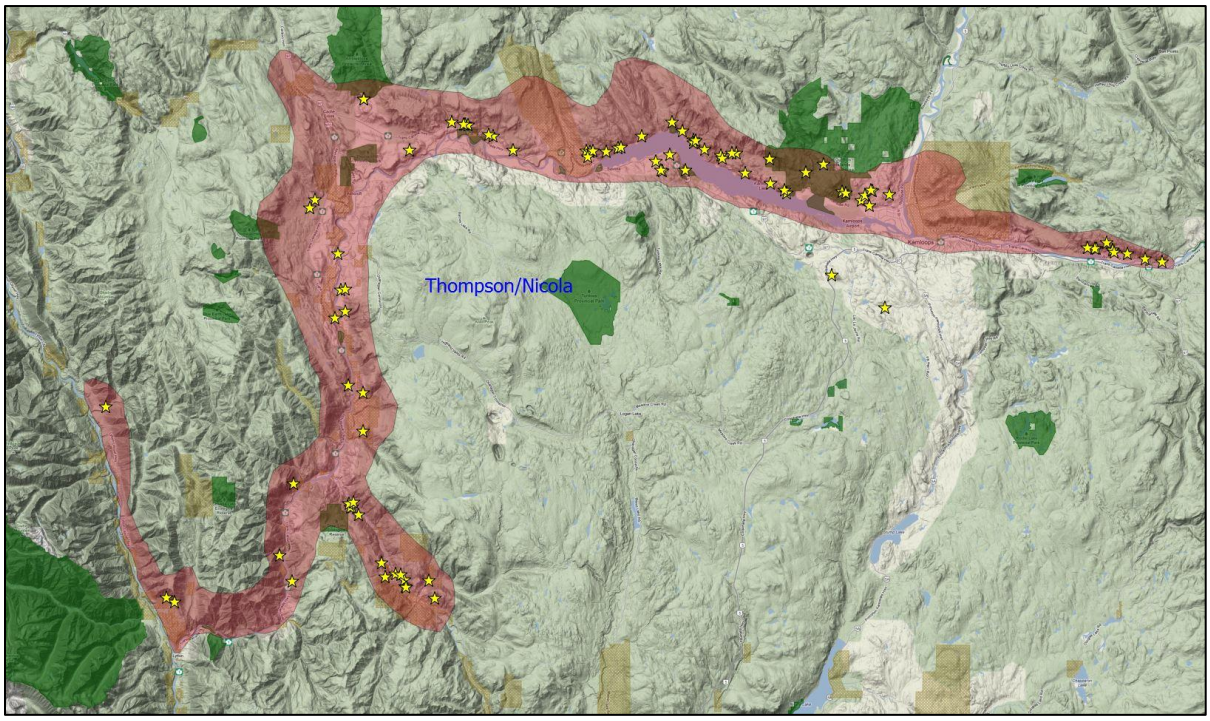


Figure 2: Map depicting all 76 known dens (including 2012 dens) in the Thompson-Nicola population.

The South Okanagan-Similkameen rattlesnake population represents the northern extent of the larger contiguous US range of the Northern Pacific Rattlesnake; no work was conducted in the Vernon, Midway or Grand Forks population (see Fig. 1) in 2012 so those populations are not included in the study area description. Connectivity to southern populations is maintained with this BC population through corridors of suitable habitat along the undeveloped valley slopes that span the International Border. The South Okanagan-Similkameen study area encompasses portions of the Okanagan and Similkameen Valleys. Known dens range in elevation from 356-975m ASL and occur within the BGxh1, PPxh1 and the IDFxh1 BEC variants (Meidinger and Pojar 1991). Dominant vegetation at the den sites is typical of desert and grassland shrub-steppe habitat and includes antelope-brush (*Purshia tridentata*); big sagebrush, rabbit brush (*Chrysothamnus nauseosus*) and Bluebunch wheatgrass plant communities. Den substrates mainly occur within granite and gneiss rock outcrops.

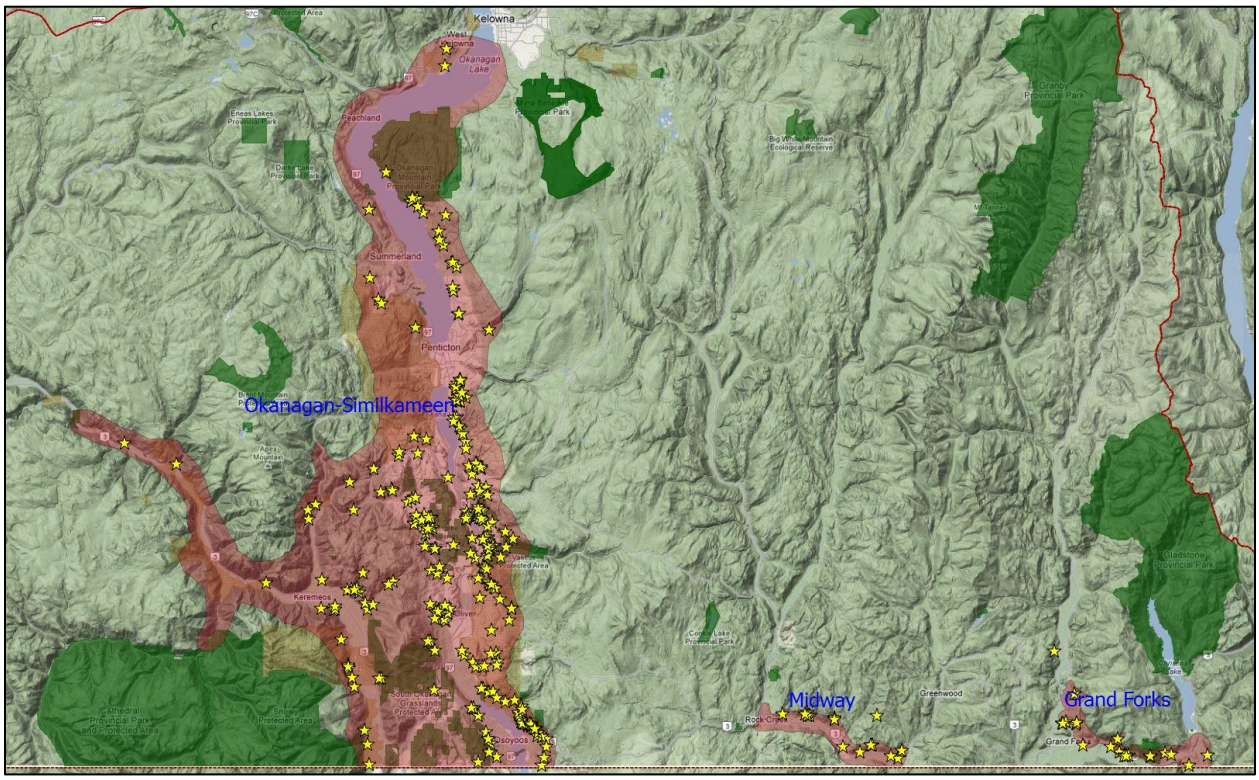


Figure 3: Map depicting all 272 known dens, from previous work, in the three populations in southern BC.

Project Goals and Objectives

Aggregation to survive the hibernation period is perhaps one of the most interesting behavioural attributes of snakes. Information on thermal characteristics of den sites and of over-wintering Northern Pacific Rattlesnakes will improve our understanding of the species' ability to overcome the thermal challenges that it faces at the extreme northern limits of its range. As well, this information will help managers identify important habitats and develop guidelines for the conservation of rattlesnakes in British Columbia. The importance of over-wintering dens (i.e. hibernacula) to the ecology of snakes in temperate regions, coupled with the high fidelity of snakes to these sites (Klauber 1972) suggests that the conservation of these sites is likely required to ensure snakes continue to persist on the local landscape. This study has embraced a long standing objective; to find and conserve snake dens by providing more accurate information to land managers in BC.

Methods

Overview of Geo-physical Attributes of Den Features

Four main components are suspected to influence the suitability of a site for bedrock denning. It is useful to be aware of these attributes when attempting to objectively assess the denning potential at a site. Dens can also occur in fluvial material (Bertram *et al*. 2001) although these "earth dens" are suspected to be rare as significant retreats that penetrate below the frost line are more typically associated with rock material, especially in the Cariboo where there are few burrowing rodents.

1. **FRACTURING:** This component refers to the level of fracturing that is evident in the rock or denning material. Certain types of rock are more prone to severe fracturing than others (e.g. basalt and gneiss). Fractures must be deep enough to penetrate the denning material well below the frost line and access geothermal heat. Internal den temperatures and den probe measurements collected from 15 dens suggest that depths between 0.86-3.00 m may be sufficient to facilitate hibernation by rattlesnakes in BC (Hobbs 2007). Typically, these deep fractures occur in rock bodies between geomorphic layering events (e.g. separate volcanic deposits) or at severe stress points (faults) in the rock face. Deep talus may also provide deep fractures suitable for denning.

2. **HUMIDITY:** Although there is little supporting evidence for this second factor, the humidity in the den may also influence winter survivorship. In BC, there have been no previous attempts to quantitatively measure the effect of relative humidity on survivorship. However, Macartney (1995) suggested that most of the weight loss that occurred in snakes (measured prior to entering the den and upon emergence from the den in the spring) occurred due to water loss (desiccation) and was not due to fat loss (starvation). In the Okanagan, many dens have been found at the base of cliffs. This position is often associated with a higher level of moisture as surface precipitation drains down the impermeable cliff face to reach the toe of the cliff. The relatively higher moisture levels at these sites are often indicated by the presence of plant species typically associated with more mesic sites than the surrounding xeric habitats. Species such as rose (*Rosa spp.*), sumac (*Rhus glabra*), poison ivy (*Toxicodendron rydbergii*) and chokecherry (*Prunus virginiana*) find a niche in these areas because of the higher moisture content present in the "drip zone" of these cliffs. The increased moisture levels associated with these sites may increase the humidity levels within dens located at these sites and may be of benefit to over-wintering snake populations.

3. **COVER:** Upon spring emergence from the den and fall retreat into the den, snakes tend to spend a disproportionate amount of time at or near the den entrance engaged in thermoregulatory activities (i.e. basking). During denning, snakes enter a type of torpor and their body temperature falls significantly (Rubio 1998). During torpor, digestive processes are halted and any food matter remaining in the digestive system may putrefy and cause poisoning (Macartney. 1996). Effective thermoregulation may be particularly important prior to entering the den in the fall to aid completion of any digestive processes that are occurring. Upon emergence in the spring, thermoregulation may also be important in restoring metabolic processes when reviving from torpor. In many species of *Thamnophis,* mating also occurs at the den entrance upon spring emergence. Due to the disproportionate amount of time spent at or near the den entrance engaged in this type of thermoregulatory behaviour, available cover (at or near the den entrance) may have a direct influence on predation levels. Most dens (personal obs) appear to feature components of cover that may influence survivorship. These areas are referred to as solariums and may be provided by vegetative matter or rock material. Coarse talus, bushes, boulders (with

cavities underneath) and other similar objects near the den are all heavily used by snakes as cover objects during the spring and fall emergence and retreat and may be of significant importance.

Cover must also be available along movement corridors near the den. Cover along these movement corridors may be provided by vegetation, which, as discussed previously, often increases in diversity and density along the drip line of significant cliffs. Snake movement corridors are often found in these areas and are evidenced by snakes and snake tracks in the vegetation along the base of cliffs near den sites. Talus is also often used to provide a covered approach along movement corridors between the den and the summer range and may be an important component in poorly vegetated rocky areas. Bands of coarse talus extending below a cliff towards foraging habitat can provide effective security cover (and foraging opportunities) along subterranean movement corridors.

4. **THERMAL MOMENTUM:** The fourth, and perhaps most significant component, is best described as "thermal momentum". This term describes the ability of the den entrance area to absorb and retain sufficient thermal radiation during warm, sunny periods to permit cool-weather basking in early spring and late fall, thereby extending their growing period. There are several factors that may influence the "thermal momentum" of the denning entrance and nearby cover objects, as follows:
   - Aspect: 'warm' aspects (south/southwest aspects between 170º-240º) receive a greater proportion of solar radiation (relative to 'cool' aspects).
   - Slope: slope also influences the amount of incident solar radiation received by an area. Steep slopes, that are oriented perpendicularly to the sun, will receive the most solar radiation.
   - Mass: the mass of a body of rock will influence its capacity to retain absorbed heat. Heat retention will increase as the mass of the absorptive body increases.
   - Position: The position of a den (i.e. Exposure) can have a strong influence on the absorptive capacity of the denning material. Dens positioned on an exposed ridge top will receive more incident thermal radiation than dens positioned in a shaded ravine.
   - Surface Albedo: The amount of radiation that is reflected off a surface rather than being absorbed. Dark surfaces may have an albedo as low as 10% (absorbing most visible light). This absorbed light is converted to thermal energy, so low albedo surfaces tend to emit more heat.

An evaluation of these four broad components may provide insight to the suitability of a site for denning. However, caution should be used when eliminating sites as den candidates as none of these factors works in isolation and several of these factors are difficult to visually estimate. For example, a den may receive a very low rating of thermal momentum (due to poor positioning and/or aspect) but may still provide ideal denning habitat if fracturing is deep enough to extend well below the frost line (Sarell 1993, Hobbs 2001a).

Aerial Candidate Den Assessment

This technique was used, prior to ground based surveys, to assess potential features using low-level aerial helicopter flight. This method was implemented as a pilot project, within the Thompson-Nicola population, to greatly increase efficiency in subsequent den searching.

To conduct this assessment each potential snake den feature was assessed, by helicopter, by approaching the feature as closely as possible. At each rock outcrop (RO), Talus anchor (TA) or extended Cliff Face (LC) a unique number was assigned as a feature identifier. Each feature was assigned a feature type class (RO/TA/LC), a waypoint (UTM-NAD 83), a photo ID number(s) and a score, or rating, for each of two parameters: thermal momentum and fracturing.

- Thermal Momentum: A point score was assigned (max 5 points) to indicate the quality of the features thermal momentum. To score this criteria rock mass, slope position (mid/lower/upper slope), aspect (N/NE/E/SE/S/SW/W/NW) and albedo[1] (refractive property) were assessed.
- Fracturing: A point score was assigned (max 5 points) to indicate the depth and severity of fracturing. From the helicopter each feature was searched for major faults (e.g. vertical 'seams', horizontal fissures created in the rock during a cool period during separate volcanic events, etc.). Fractures must allow snakes to attain den depths >1.5m (usually >3m). In addition, fractures should/must contact the ground (to allow snakes access) and a covered approach (talus or vegetative) and a solarium (cover object that provides security cover for basking, shedding, maternity) was desirable (but not essential).

After each assessment, at each feature, a cumulative score (x/10) was assigned[2]. This score, or rating, provides an estimate of the feature's potential as a den site.

All sites scoring >7/10 (n=119) were identified as "candidate dens" for subsequent 'ground based' assessment, under optimum conditions, during the fall retreat or spring emergence period (note: features that scored <7/10 (n=215) were recorded but ground-based survey was not afforded priority). All candidate (n=119) den features were loaded onto Garmin Map 60Csx GPS units. A shape file was also created and loaded onto each crew members GIS tablet (iPad); crews would use the iPad and GPS to set field priorities to ensure efficient survey of all points assigned an aerial rating of >7/10. Any additional features not identified on the aerial survey but opportunistically encountered while checking aerial candidate features, were also assessed for use by snakes for denning.

Appendix two contains the data for the aerial den candidate assessment.

1: The albedo of an object is a measure of how strongly it reflects light from light sources such as the Sun. It is therefore a more specific form of the term reflectivity.
2: it should be noted that this technique is based on a subjective rating that is biased by search preference for a 'specific' type of den feature and should not be used as an exhaustive measure of potential denning opportunities available to snakes within the area assessed.

Ground Based Den Searches

Areas containing candidate den sites, as identified from: former aerial survey, visual assessment of areas in the field, or consideration of former effort, experience and local knowledge were selected for ground based den searches in 2012.

All aerial "candidate den" features (n=119) that received a rating >7/10, were identified for ground inspection. These features were loaded into field GIS tablets (Apple iPad V.2 64GB) as shape files where they could be reconciled against ortho-imagery and other base-layers (including Indian Reserves, parks, private land boundaries etc.). Candidate den features were strategically grouped into areas for searching and these areas were then assigned to field staff for survey. The iPad proved to be a very effective field tool to maximize efficiency and to ensure all areas were considered adequately.

Upon arrival at each area to be surveyed, field staff would collaboratively (based on visual assessment) discuss each area, prior to survey, in order to estimate the availability of any additional potential suitable denning opportunities requiring assessment. Rock outcrops and cliffs that were fractured, featured associated talus or vegetation along the toe of the cliff and appeared to have sufficient mass to retain heat through the winter were also selected for inspection (in addition to candidate dens already identified by the preceding aerial assessment where available). Features were approached, on foot, and searched systematically and intensively for any evidence of use by snakes; evidence included the presence of snakes, snake tracks, shed snake skin(s) and the presence of snakes faeces (snakes typically defecate prior to fall ingress and their faeces are distinctive and easy to identify).

At the start of the survey of each area sampling conditions and start times were recorded. Conditions noted included; wind (using Beaufort scale), cloud cover (%) and temperature (C). In addition, whenever possible, proximal known snake den(s) (from previous survey work) were visited at the start and end of each day to verify that conditions were appropriate and to calibrate any snake observations (counts) from any new (previously unknown) dens that were encountered. A track log was also collected, by each observer, to record effort (spatial and temporal) at each area that was surveyed.

When a new den was discovered field staff would record a Universal Transverse Mercator (UTM) coordinate (NAD 83) using a Garmin Map60CSX model GPS hand-held receiver. Coordinates were 'averaged' and collected at the entrance of the den to increase precision. Each den site was also photographed (using a Version 3 Apple iPad tablet) and described (slope, slope position, aspect, cover, albedo, mass and fracturing). In addition, the GIS tablet was used as a second GPS (backup) to record the den location; photographs were associated with each den location recorded in the iPad using the program "GPS Kit" (© Garafa Industries). All relevant snake observations (including sign and/or snakes) were recorded in field notes and on the iPad. If no snakes or snake sign was located at a feature identified as a candidate den (based on previous aerial assessment) the site was described and re-classified accordingly.

Results

A total of 29 days of den surveys, over three sessions, were conducted in 2012. The first session was conducted between April 11-23. The second and third session were both conducted in the fall, between Sept 17 and October 10, 2012. During all sessions there was an average of four observers per field day representing a total of 116 person days of effort. When working in the Thompson-Nicola population we used the aerial assessment of candidate dens to increase efficiency and focus search efforts. When working in the Okanagan-Similkameen populations we were un-aided by preceding aerial inventory and instead used visual assessment of areas (on the day of actual survey) to refine search priorities. In total we found 20 new confirmed (C1) dens, 10 suspected (C2) dens and four probable (C3) dens.

Aerial Candidate Den Assessment

The egress and ingress periods (each spring and fall, respectively) present a relatively narrow window of opportunity to effectively conduct surveys to search for new dens. To increase efficiency of den search efforts during each of these temporally narrow conditions, aerial assessment of potential denning opportunities was conducted in March, 2010. This method was used to assess potential features using low-level aerial helicopter flight at an extremely rapid pace (relative to ground based surveys) and was implemented to greatly increase efficiency in subsequent den searching. To illustrate the effectiveness of this approach: a single day of flight was required to assess almost all of the snake habitat in the Kamloops region (to cover the equivalent area using ground-based surveys would take many years) (see Figure 4). This single day of effort resulted in the identification, and classification, of 334 potential (candidate) den features.

All aerial candidate den features were assigned a field rating based on an aerial assessment of mass, slope position, slope, aspect and fracturing. All potential/candidate features that were assigned an aerial field rating >7/10 were identified as a priority feature for subsequent ground-based assessment during the 2012 (and/or subsequent) field season. This approach served to narrow, refine and focus subsequent ground based survey efforts and was a very effective method to greatly increase efficiency of subsequent ground-based assessments. Table 6 presents the results of this assessment.

Table 6: Summary of aerial candidates (n=334) for each assigned aerial rating (1-10)

Rating	Number of Candidates Assigned
1-6	215
7	29
8	27
9	47
10	16

The aerial assessment of potential denning opportunities, conducted in 2010, resulted in the identification of 119 candidate den sites in the Kamloops MOE region (i.e. 119 features were considered 'likely' (>70% probability) snake den features). Of these, 78 of these sites were assessed, using ground based methods, in the spring and fall of 2012 (refer to Appendix three for 2012 survey data of aerial candidate dens) (Figure 4).

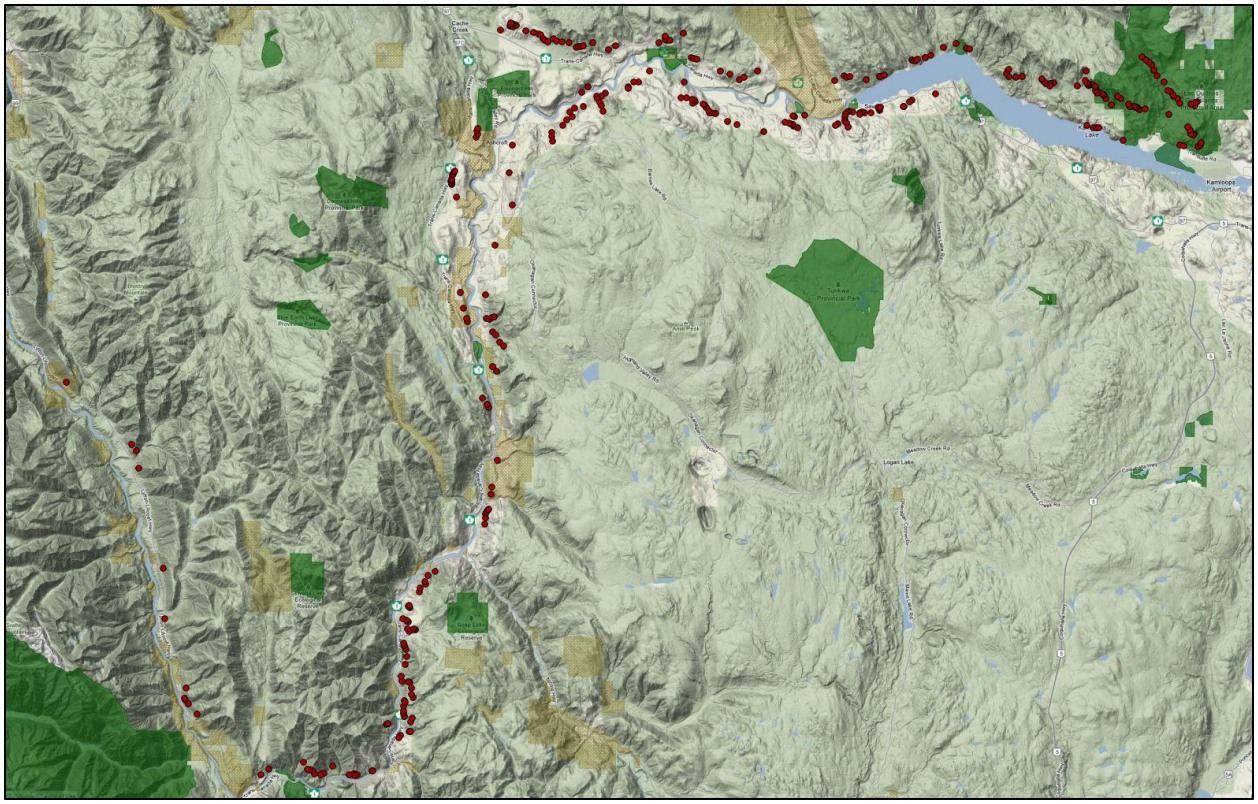


Figure 4: Map depicting all 119 candidate den sites from the aerial assessment (conducted in 2010) for the Thompson-Nicola population in BC.

Ground Based Den Searches

Candidate dens, identified and classified as described above, were identified for subsequent ground assessment in the spring and fall of 2012 (and ongoing). In addition, surveyors opportunistically assessed any additional figures that were encountered.

Spring Surveys

Spring den surveys were conducted between April 13th and April 23rd, 2012. The number of observers and total observer search time, for each day, is presented in Table 7. Den coordinates and images are presented in Appendix 3 and 4.

In total, we found eight new C1 dens, three new C2 dens and one C3 den in the spring of 2012. All dens, with the exception of two C1 dens (Raven's Ledge and Dead Wood) were re-visited in the fall 2012 survey session to collect additional information on den population size. UTM coordinates, survey data and images (where available) are presented in Appendix 3 and 4, respectively. One of the dens (Bump Up) was particularly noteworthy as a minimum of 74 adult and 13 juvenile rattlesnakes were observed at the den. In addition, this den was at the exact location predicted by the aerial den survey; it was identified as a candidate den, requiring future survey, with a score of 10/10.

Table 7: Survey areas, observers and total search time spent at each area during the spring surveys.

Survey Area	Date	# Obs	Search Time (minutes)	Result (Den name and status)
Mormon Hill	13-Apr-12	4	300	Thunderbolt Den-C2
Cedar Creek	15-Apr-12	4	270	No new dens found
Dewdrop	17-Apr-12	5	360	Milkshake Den-C3
Savona	18-Apr-12	5	420	No dens found
Lafarge	19-Apr-12	5	360	Don't Jump (C1), COCO Puffs (C1)
Savona	20-Apr-12	5	360	Bump Up (C1), Heliya (C2)
Savona South	21-Apr-12	2	360	No new dens found
Savona North	21-Apr-12	3	360	Raven's Ledge (C1), Dead Wood (C1)
Cache Creek	22-Apr-12	5	480	Leap of Faith (C2)
Ashcroft Ranch	23-Apr-12	5	330	Cowboy Coffee (C1), Paul's Boutique (C1), Tunnel Vision (C1)
			60 hours	5 C1 dens: 7 C2 dens: 1 C3 Den

Figure5: All dens (C1, C2 & C3) found in the spring survey. (Note: Thunderbolt C2 den not shown)

A brief summary, by date, of observations for each den detected in the spring 2012 survey session is presented below (actual and average (expected) counts at calibration dens are also noted):

Okanagan-Similkameen Population

- **Thunderbolt (C2)**: Detected April 13, 2012. Conditions were overcast and cool (10°C) – calibration at Vince's Den resulted in the detection of only 12 adult rattlesnakes, one racer and one gopher snake (typical count: ~80) suggesting survey conditions were poor. During the subsequent survey a single juvenile rattlesnake was observed at a new den entrance (Thunderbolt Den: horizontal crack at base of small North aspect rock outcrop). Because only a single snake was observed Thunderbolt Den is classified as C2 but it should be re-visited under more optimal conditions in future years. The site was revisited in the fall (2012) and no snakes were observed. As such, the status of this suspected den remains as C2.

Thompson-Nicola Population

- **Milkshake (C3)**: Detected April 17, 2012. Conditions were warm (20°C) and sunny and seemed ideal for basking. Calibration at Cherry (average count: 24) yielded only 10 rattlesnakes and G-man (average count: 8) yielded six rattlesnakes and one racer. Calibration results suggest that conditions were optimal for den surveys however no snakes were seen at this potential C3 feature. Instead, a total of six rattlesnake sheds were found along the base of a talus anchor and along the main cliff face. This site was re-visited in the fall of 2012 and once again no snakes were observed however given the abundance of snake sign at this C3 (potential) den it should be revisited in future years.
- **Don't Jump (C1) & Coco Puffs (C1)**: Both of these dens were found on April 19th, 2012. Conditions were again warm and sunny (~20°C) and seemingly ideal for basking snakes however only three rattlesnakes were seen at the known nearby calibration den (Old Friends – average count ~8). At Coco Puffs a single racer was observed at the entrance of a vertical crack at the base of a medium sized (40m) rock outcrop. At Don't Jump two rattlesnakes were observed near a potential entrance below a small rock outcrop (South aspect). Both features were resurveyed in the fall and although no snakes were subsequently observed at Don't Jump a single neonate rattlesnake was found at the entrance at Coco Puffs. Based solely on the spring observations (2 rattlesnake), Don't Jump is classified as a C1. Based on the spring *and* fall observations Coco Puffs was also elevated to C1 status as snakes were observed repeatedly at the entrance during the two independent denning periods. Given the proximity of both dens to urban development, and the resultant high potential for persecution, it is suspected that both features are currently used by only a small number of snakes.
- **Bump Up (C1) and Heliya (C2)**: Both of these dens were found on April 20th, 2012. Conditions were again warm (~25°C) and sunny and seemingly ideal for basking snakes. A calibration check at nearby Ghost Den yielded seven snakes (average count is eight) so conditions were ideal for survey. Both of these new dens sites were 'predicted' as high potential den sites from the aerial surveys conducted in 2010 (see previous section). A total of 74 adult and 13 juvenile rattlesnakes were observed at Bump Up making this the largest C1 den on record within the Kamloops MOE Region. Bump Up was located at the base of a large (>100m vertical) cliff face. There were multiple entrances in the large course boulder talus slope below the cliff. At a second nearby new C2 (suspected) den, named Heliya, only a single rattlesnake was observed. Heliya was also located in deep talus approximately 400m east of Bump Up but it was not associated with any large vertical rock mass.

- **Raven's Ledge (C1) and Dead Wood (C1)**: Both of these confirmed dens were found on April 21st, 2012. Conditions were warm and sunny (~25°C) and ideal for basking snakes. Calibration counts were collected at two nearby dens; Skookum and Nova Den. Twenty-one rattlesnakes were found at Skookum (previous count was <10). Ten rattlesnakes were found at Nova Den (previous count was <10). Subsequent surveys in the area resulted in two new dens, described as follows: Dead Wood is likely a gopher snake and racer den only as the feature is too small, in mass, to be used by rattlesnakes however it is classified as a C1 gopher/racer den based on the presence of the two snakes that were observed. Future visits should be conducted to determine if rattlesnakes are also using this den. It is located on the summit of a small hill above and~400m west of Nova den. The second den, named Raven's Ledge, was detected at the end of the day, as the sun (and warmth) were diminishing. As such, it is suspected that the observed number of snakes (n=5) is an underestimate of the size of the snake population at this den. The den is located within a course talus slope at the base of a large (>50m) vertical rock face (with a pair of ravens nesting on the ledge above). Two rattlesnakes, two racers and a single gopher snake were observed at this site. Future survey of this den may elicit a higher count; it is suspected that this den may be larger than the 2012 count indicates.
- **Leap of Faith (C2)**: Conditions were clear, sunny and warm (~29°C) during the site visit however no snakes were found at the nearby calibration den (TNT den. It should be noted that TNT Den may be extirpated; historically I have counted up to six rattlesnakes at this site however no more snakes have been observed at this site for many years despite repeated visits). During surveys we revisited a suspected (C2) den previously found by F. Iredale - Daybreak is a suspected den located ~300m upslope from TNT; denning has not been confirmed and no snakes were observed during our visit in 2012 (spring or fall). One new C2 (suspected) den, named Leap of Faith, was found (single rattlesnake in crack on rock) immediately east of Daybreak however the site was resurveyed in the fall and no additional snakes were found. There are abundant potential denning features, including deep course talus and severe horizontal fissuring, throughout the rock face above at this site. It is likely that snakes are dispersed throughout the area; denning in multiple features. Two more rattlesnakes were found nearby but not associated with any features; emigration from the den had likely occurred at this point in the season making detection of the actual den entrance difficult.
- **Tunnel Vision (C1), Cowboy Coffee (C1) and Paul's Boutique (C1)**: The area of private land near Ashcroft Manor was searched (with permission from the owner) on April 23, 2012. Conditions were cool (~16°C), overcast and sub-optimal for den surveys in the morning but conditions improved steadily as the day progressed. Three new C1 dens were found on April 23 however snakes were only observed, during subsequent re-visits, at one of the three new dens (Tunnel Vision) when this area was re-checked in the fall. Tunnel Vision is located at the pump-house near the tunnel on the Thompson River; five rattlesnakes were observed here in the spring and three rattlesnakes and a single western terrestrial garter snake were observed here in the fall. The ranch owner is aware, and marginally tolerant, of the snakes at this site. "Cowboy Coffee" was located in an east aspect rock outcrop near the summit of a small hill. The den feature appears to have been blasted in the recent past; the ranch owner admitted that dens were historically blasted in this area by ranch staff. Only two rattlesnakes were observed here in the spring and no snakes were observed here in the fall. Finally, two rattlesnakes were found at a very promising looking den feature named Paul's Boutique. This feature is located in the talus below a large Southeast aspect limestone rock face immediately across the highway across the old Ashcroft Manor house and restaurant. Despite repeated survey in the fall no more snakes

were found at this site; persecution and road associated mortality have likely had a heavy toll on the population of rattlesnakes using this den feature.

In summary, the window of opportunity for den searching in the spring is very short and the exact timing of appropriate conditions is difficult to predict. Daily calibrations are required to have any confidence in search efficacy however surveys still resulted in the successful detection of eight C1 dens, three C2 dens and one C3 den during this very narrow timing window in the spring of 2012.

Fall Surveys

In the fall of 2012 we conducted 19 days of den surveys in two separate shifts; September 17-28 and October 2-10. The majority of our effort was focused in the Kamloops/Thompson population (14 days total); the remaining five days of survey (October 5-10) were conducted in the Okanagan/Similkameen population. Overall, temperatures were unseasonably warm in the fall and, as such, it is likely that den return movements were delayed. This likely influenced the number of snakes observed at dens during the fall survey period.

In the fall shift each surveyor used the track feature on their GPS to record a track log of the survey route they followed. This more detailed quantification of effort allows a more accurate estimate of search time and provides additional details on the exact areas (micro-habitats (i.e. rock features) searched for snakes. The number of observers and total observer search time, for each area, is presented in Table 8; track logs are on file with MFLNRO staff (J.Hobbs).

The fall survey effort included a total of 33 survey areas (in two separate shifts) with a total search time of 167 hours, with between 2-5 observers per hour, allocated to these areas. We found a total of 12 confirmed (C1) dens, seven suspected (C2) dens and three potential (C3) dens. UTM coordinates, survey data and images (where available) are presented in Appendix 3 and 4, respectively.

A brief summary of observations for each confirmed (C1) den detected in the fall 2012 survey session is presented below (actual and average (expected) counts at calibration dens are also noted and C2 (suspected) dens are described if they are thought to have high conservation significance):

Thompson-Nicola Population

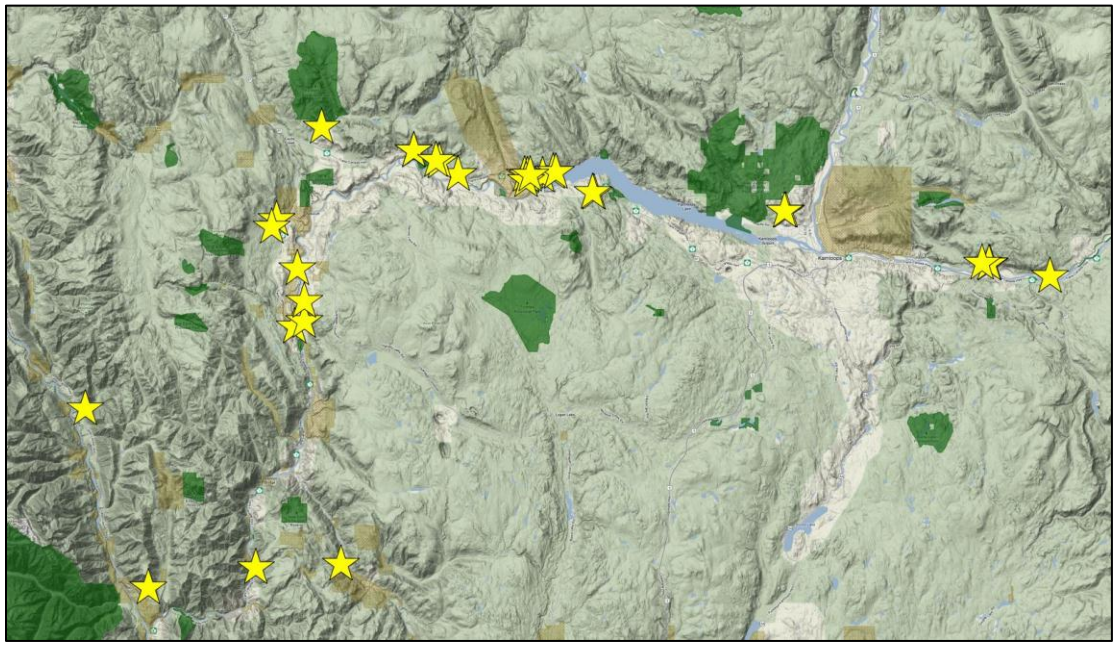
- **Krakatoa (C2)**: We surveyed the rock outcrops at Lions Head Mountain, west of Chase, on September 18, 2012. Conditions were sunny and hot (30°C). There were no nearby dens for calibration. During our search of Lions Head hill a single adult rattlesnake was heard rattling from a concealed crack at the base of a large cliff. This den was re-checked on September 22, under more ideal conditions, however no snakes were observed at this site during this later visit. More work will be required to identify the exact location of the den entrance at this site. This C2 den is at the eastern limit of the Thompson-Nicola population.
  (Note: a large adult rattlesnake was observed, in July, ~2km further east of Lions Head.)
- **Sharp Shooter (C1) and Paralyzer Dens (C1)**: Both of these C1 dens were detected on September 19, 2012. Conditions were sunny and warm (22°C) and appropriate for snake den surveys. Sharp Shooter den was located beneath a large boulder in a south aspect talus slope. Only a single adult and single neonate rattlesnake were observed at the den entrance; as such the den was assigned a status of C1 however it may be a maternity site rather than an actual den feature. Future survey is required to confirm over-winter denning by snakes at this feature. Paralyzer Den: a total of 19 rattlesnakes were observed at this feature. Two adult rattlesnakes were detected approximately 100m below the den; 13 adult and four neonate rattlesnakes were

detected at the den entrance. The den is located in a vertical fissure at the base of a 4m high south aspect rock outcrop. A second entrance was detected in a vertical fissure on the east face of the rock outcrop. Other suitable denning opportunities appeared limited in the local area; it is suspected that this is a significant den feature for the snakes using the area above the highway near Deadman creek.

- **Triumph Den (C1)**: This den feature was detected on September 22, 2012. Conditions were sunny, clear and hot (25°C). A calibration den (Pizza Box) was checked and no snakes were observed despite the fact that this den has a recorded high count of 84 rattlesnakes. Triumph Den was detected on a south aspect face of a rolling hill above the Thompson River. Two well-used maternity sites were detected and one is suspected to be the actual den entrance but future survey is required to confirm this assumption. One of the maternity features at this site had evidence of use (eight adult sheds and ≥30 neonate sheds) and the second site was occupied by an adult female (suspected to be post-parturition based on body condition) and ≥8 neonate rattlesnakes. Three sub-adult rattlesnakes were found 10m downslope of the suspected den entrance. Finally, two more adult rattlesnakes were found in a talus slope in a steep ravine (with an associated cliff face) approximately 50m south of the suspected entrance) however no potential entrances were evident in the immediate area. This area should be surveyed under more ideal conditions in future years to determine the exact location of the entrance within this rock feature.
  (Note: during the survey of the area near Triumph Den we attempted to find and confirm a nearby anecdotally reported den named Basque. We concluded that the reported location (from Mitch Firmin) is incorrect as mapped as there is no rock feature within 300m of this site.)
  (Note: we detected another C3 (candidate) den named Bethedger – this C3 den is reported in the database and is very likely to contain snakes; conditions were too hot during the survey so this site must be rechecked in future).
- **Skeleton Den (C1)**: The area searched along the south side of the Nicola River likely harbours near historic populations of rattlesnakes. This is one of less than five areas remaining within the BC range of rattlesnakes that is relatively pristine: there are no roads and no current evidence of grazing use from Skahun Creek downstream to Rattlesnake Bridge (along the south side of the Nicola valley) along this section of the valley. Much of this area presents very limited denning opportunities as the entire area is north east in aspect; there are available outcroppings of fractured rock but most are characterized by very low solar exposure. In this area all of the known dens occur along the top of the valley ridge or along the edge of incising ravines that have east aspect slopes. As the valley climbs the outcrops along the ridge-top receive relatively more solar exposure; all of the known dens occur within these relatively more exposed features. As such, dens in this area tend to be more significant as they provide shelter for a larger number of snakes (i.e.; where features are limited denning aggregations tend to be larger (pers. obs)). Accessing this area is challenging and requires swimming across the Nicola River; water levels are only low enough to allow access in the fall so I have been searching this area systematically each fall for several years.
  On September 24, 2012 we searched one of the last remaining unprotected and unsurveyed crown land areas in this area of the Nicola Valley. Skeleton Den was located on an exposed east aspect rock feature at the top of the valley. Conditions were variable overcast, cool and sub-optimal for snake surveys; no candidate dens were available (locally) for calibration as all of the known dens are very difficult to access. Despite these unfavourable sampling conditions a total of nine live rattlesnakes, three desiccated (dead) large adult rattlesnakes and 19 rattlesnake sheds were found. It is suspected that this den harbours a very large number of rattlesnakes.

- **No More Tears (C1) and Tears for Fears (C2)**: Until relatively recently rattlesnakes were thought to have been extirpated along the south side of the Thompson Valley from Chase to Ashcroft (K.Larsen. pers.com). In 1995, I found a single adult rattlesnake at Six-Mile hill near the rock-climbing area. Subsequently, in 2006 a new den was discovered and reported, at Six-Mile Hill, by Ralph Heinrich. Further searching in the area has resulted in the detection of three more rattlesnake dens in the area along the north side of Highway 1 (Real Tears (found 2010 by J.Hobbs), Tears for Fears (C2) and No More Tears). All three dens are located in small rock outcrops, in a horizontal fissure that seems to occur consistently at ~650m ASL in this area of the valley. A total of 12 neonate rattlesnakes were observed, with four adult rattlesnakes, at No More Tears. A single adult rattlesnake was observed at a second nearby suspected (C2) den (Tears for Fears) however further survey is required to determine if this second feature is actually used as a winter den. A calibration count was collected from Real Tears at the end of the day; a total of six rattlesnakes were counted here (this is an average count for this den). Road mortality, from nearby Highway 1, is suspected to be a source of high mortality for snakes in this area.
- **Buzzer Beater (C1)**: This den is located along the west side of the Thompson River Canyon, between Spences Bridge and Lytton west of Highway 1. Prior to 2012, there had been no formal surveys for snake dens conducted in this area although it is suspected that the range of the species along the west side of the Thompson River extends at least as far south as the Nicoamen River based on habitat suitability and anecdotal observations (as reported to J. Surgenor and J.Hobbs). This area was surveyed on September 26, 2012; conditions were optimal with partly overcast skies and a daytime high recorded temperature of 24°C. A single Den (Buzzer Beater) was found at the end of the day. The den was located on the mid-slope of the west aspect valley wall, in a 5m high rock outcrop with a severe horizontal fissure (fault was likely a result of previous geologically separate volcanic events). Seven rattlesnakes and two Racers (*Coluber constrictor*) were observed at, or near, the den entrance.
- **Over It (C1)**: The area on the bench, west of Deadman Creek, was surveyed on September 27, 2012. Conditions were sunny and clear however the temperature (25°C) was likely too hot for snake surveys. No snakes were observed at the calibration den (Paralyzer) despite the fact that 19 snakes had been observed at Paralyzer Den on September 19, 2012. As such, it is suspected that the number of snakes observed at Over It on this visit was not representative of the population size at this den. The den feature was located in a Southwest aspect rock outcrop. One adult, one neonate and one sub-adult rattlesnake were observed at the den entrance. The den entrance is located within a horizontal fissure at the base of the outcrop and is partially obscured by dead Rabbit Brush (*Chrysothamnus nauseosus*).
- **Bask Ranch Den (C1)**: An historical record existed, for a den named Bask Ranch (as reported by M.Firman), prior to 2012 surveys (note: another anecdotally reported den, named Basque, is located directly across the Thompson River but the location is incorrect as mapped: see section on Triumph Den). This site (located on First Nations Reserve ID: Oregon Jack Creek #5) was first surveyed for snakes on September 23, 2012 but conditions were sunny and hot (>25C) and sub-optimal for snake surveys. During this first visit we detected only a single adult rattlesnake ~30m from the existing reported den location (see appendix 2). The area was resurveyed again on October 5, 2012 under more optimal sampling conditions. Conditions were clear but cool with a reported daytime high temperature of only 18°C. The October 5 visit, to the same area, resulted in the detection of three adult rattlesnakes at a west aspect den entrance below a minor rock feature (~3m height).

Figure 6: New dens detected in 2012, and all calibration dens visited during area surveys, are depicted as stars.



Okanagan-Similkameen

- **Sweet Scree and Spine (C2)**: Both of these suspected (C2) den features were detected on October 6, 2012. Conditions were ideal, with clear skies and temperatures of ~20°C. As such, it is unclear why more snakes were not found at both sites; future surveys are recommended to determine the actual den entrance. A single adult rattlesnake, and a single rattlesnake shed, was found at Sweet Scree. The feature was detected within a course talus slope at the base of a southwest aspect rock face. The feature was located mid slope in the valley, with light vegetation (bunchgrass) and talus at the suspected feature. Spine Den was detected ~400m east, and upslope from Sweet Scree Den; only a single adult was found at this site (despite ideal sampling conditions).
  Note: the UTM for Spine Den was estimated (based on an orthophotos) as GPS malfunction prevented collection of a more accurate UTM in the field.
- **Mormon Den (C1) and Thunderbolt Den (C2)**: This den feature has proven challenging; several days have been spent, over several years, searching for this feature. I found a single adult rattlesnake, during the denning period, in the spring and fall of 2006 but couldn`t confirm simultaneous use by multiple individuals at this site in 2006. On October 7, 2012 six rattlesnake sheds, two adult rattlesnakes and one adult racer were detected at this site; all were basking in partially concealed positions is a course talus slope. I suspect this is a multi-entrance talus den.
  Note: In the spring of 2012 a single sub-adult rattlesnake was also found nearby in a suspected (C2) separate feature (entered in the database as Thunderbolt Den) approximately 400m west of Mormon Den: this site should be resurveyed (based on the age class of the single snake I strongly suspect Thunderbolt Den is a valid (C1) den feature but confirmation is required).
- **Apple Den (C1)**: This den was detected on October 8, 2012 at the base of a significant southwest aspect rock feature on the ridge above Cedar Creek. The den entrance was located at the base of a rock anchor in a small talus slope. Ten rattlesnakes, several sheds and a snake track were observed during the single visit at this site. Conditions were optimal, albeit a little cool. Calibration counts at two nearby Dens (Sweaty Crack (single rattlesnake) and Buzzer Bunker

(two racers and 19 rattlesnakes) so it is suspected that future survey of snakes at Apple Den may result in ``counts`` of up to 40 snakes.

- **Carla's (C1), Pair o' Dice (C1) and Kings Throne (C1)**: All three of these confirmed (C1) dens were detected on our last day of snake den surveys in 2012 (October 10, 2012). Conditions were mild, clear and sunny. Carla`s den was anecdotally reported by the landowner (Carla); it was located in rip-rap below the decommissioned Kettle Valley Railway (KVR) near Naramata. Three adult rattlesnakes were observed at the entrance; up to eight rattlesnakes have apparently been observed at this site before (Note: Gawne Den (a known historic den located approximately 200m north along the same tracks) was also visited that day; seven rattlesnakes were observed. Pictures and coordinates are contained in the appendices).
  A pair of rattlesnakes were detected at Pair o`Dice Den was located within a horizontal fissure near the top of a small southwest aspect rock face in Okanagan Mountain Park above Paradise Vineyards (Naramata). A second (satellite) entrance was found ~20m north (single rattlesnake). Despite ideal sampling conditions on two sub-adult rattlesnakes and one adult rattlesnake were found at this den. Future survey is required to better assess the number of snakes that are using this feature.
  King`s Throne was detected at the end of the day, as we were returning to the vehicle. This den was located in a major horizontal fissure within a large rock mass immediately east of the vineyard fence. Four rattlesnakes were observed at the entrance and a single rattlesnake was observed at a solarium approximately 15m below the den (in talus). The temperature was dropping quickly; it is suspected that a repeated survey, under more optimal conditions, would result in the detection of a much higher number of snakes at this den site.
  Note: House 4 Wren`t is a C2 den that was also found on October 10. A single adult rattlesnake was observed at the entrance of a severe feature. This site should be resurveyed in future as it is very likely being used as a den.

Figure 6: New dens detected in 2012 and calibration dens visited during area surveys (yellow stars).

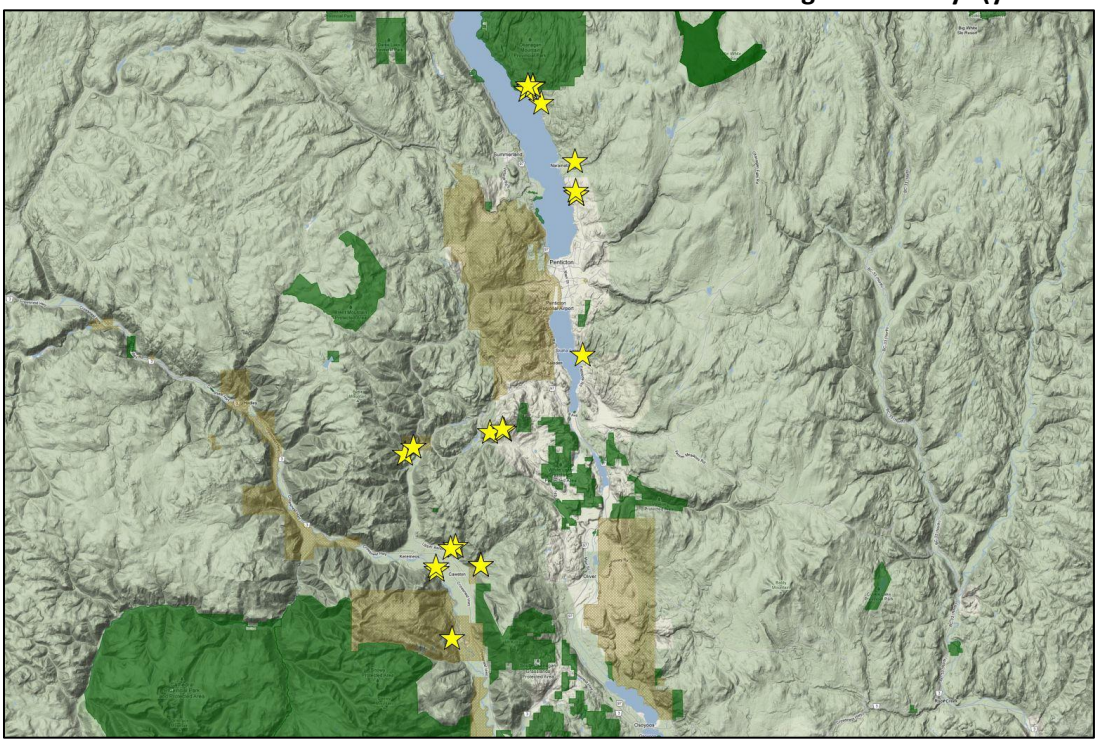


Table 8: Survey areas, observers and total search time spent at each area during the fall surveys.

Survey Area	Date	# Obs	Search Time (minutes)	Result
Savona	17-Sep-12	5	420	No dens found.
Krakatoa	18-Sep-12	5	270	Krakatoa (C2)
Juniper Hill East	19-Sep-12	3	380	Sharpshooter (C1), Paralyzer (C1)
South Walhachin	19-Sep-12	2	295	Walhachin (C3)
Juniper Hill West	20-Sep-12	2	440	No new dens found.
North Walhachin, Back Valley Road	20-Sep-12	2	425	No new dens found.
Ashcroft Ranch	21-Sep-12	2	500	No new dens found.
South Walhachin, Barnes Lake	21-Sep-12	2	480	No new dens found.
Cache Creek, Arrowstone, Triumph	22-Sep-12	3	144	Triumph (C1)
Cache Creek	22-Sep-12	2	120	No new dens found.
Ashcroft Ranch, Basque Ranch	23-Sep-12	2	470	No new dens found.
Ashcroft Ranch, Basque Ranch	23-Sep-12	2	480	No new dens found.
Nicola South Side	24-Sep-12	5	450	Skeleton Den (C1)
Six Mile	25-Sep-12	5	450	No More Tears (C1) and Tears For Fears (C1)
Lytton	26-Sep-12	3	152	No new dens found.
Nicomen Bench	26-Sep-12	2	300	Buzzer Beater (C1)
Battle Creek	27-Sep-12	1	168	No dens found.
Juniper Hill East Deadman Bench	27-Sep-12	1	54	Over it (C1)
Ashcroft Ranch	27-Sep-12	2	360	No new dens found.
Lafarge	28-Sep-12	2	260	No new dens found.
Lac du Bois	October 03-10	3	152	No new dens found.
Nicomen Bench	October 03-10	3	360	Bethedger (C3)
Ashcroft, Triumph	October 03-10	3	60	No new dens found.
Race Track, Basque Ranch	October 03-10	2	480	No new dens found.
Cawston, Keremeos East, Mormon Bench	October 03-10	3	240	No new dens found.
Barcello Bench	October 03-10	2	262	Sweet Scree (C2) and Spine Den (C2)
Kaleden	October 03-10	3	336	No new dens found.
Mormon, Barcello Bench	October 03-10	2	356	Mormon talus den (C1)
Cedar Creek	October 03-10	5	330	Apple (C1)
Oliver	October 03-10	1	232	No new dens found.
White Lake Road	October 03-10	5	348	No new dens found.
Okanagan Mountain Park	October 03-10	5	284	Carla's (C1), Flat Rock (C2), Pair o' Dice (C1), King's Throne (C1), House for Wrent (C2)
			167hrs: 40m	

Discussion

This report is ostensibly intended to summarize the spring and fall den survey results as presented here however a more significant goal, in authoring this report, was to provide a complete synthesis of over a decade of research and inventory on the Northern Pacific Rattlesnake throughout the species' Canadian range. This synthesis also includes an analysis of covariates on a collaborative snake den database that was initiated by Mike Sarell and subsequently (and collaboratively) expanded, refined and maintained by both M. Sarell and J.Hobbs. In addition relevant learning's from Hobbs' MSc thesis work are included as this research on the species' thermal ecology adds clarity and provides important information regarding our understanding of appropriate survey timing windows for this species in BC.

To put our current understanding in context; in 2012, 29 days of den surveys (with an average of four observers per field day) resulted in a total of 20 new C1 dens. This represents 116 person days of effort. The 20 dens found in 2012 constitute less than 6% of the 318 confirmed rattlesnake dens recorded in the provincial snake den database today. As evidenced, this compilation of 318 known dens represents a massive undertaking, by multiple experienced individuals, in amassing such a comprehensive understanding of rattlesnakes in BC. For this report I analyzed all confirmed (known) extant rattlesnake dens in BC to assess several key covariates, including: distance to road, den (population) size, den elevational distribution, known den distribution and abundance within each meta-population and land tenure (of den sites). The results of this analysis are presented in the section "Summary of Known Den Information" in this report. Some key conclusions can be drawn from this analysis, as follows:

1) Impacts of roads: Road-related mortality is regarded as a severe stressor on the snake populations (Hubbard and Chalfoun. 2012). A review of road-related mortality, by Andrusiak and Sarell (COSEWIC 2005) found supporting literature that confirms depletion effects. A cited study suggested that snake populations were reduced by >50% within 450m of moderately used roads. Depletion effect was also still evident at distances ≥850m. A second cited study confirmed that the loss of only three adult female Black Ratsnakes (*Elaphe obsoleta*) per year increased the probability of extinction to over 90% over 500 years. The life history of rattlesnakes, like other BC snake species, include traits that make a species' population vulnerable (low fecundity, late maturity, long natural adult survivorship and seasonal migrations). As such, the cumulative effects of population depletion from road mortality may have serious effects on the genetic diversity of snake populations (Jackson and Fahrig 2011). To estimate the potential impact of road mortality on rattlesnakes, within BC, I analyzed our BC database to assess "proximity to road" data for all 318 confirmed (C1) rattlesnake dens. In this analysis I only included paved road surfaces; the inclusion of gravel (non-paved) roads would be even more alarming. Table 3 (see section "Summary of Known Information") illustrates that 86% of known rattlesnake dens occur within <1km of a paved road surface. Alarmingly, my den search efforts are biased *against* finding dens that are proximal to roads. I have intentionally under-sampled snake habitats within 1km of roads as my primary objective has consistently been to find dens that harbor large populations of rattlesnakes in order to maximize conservation gain that may result from den-focused management and protection. In summary, this statistic has alarming implications that are consistent with my experience with rattlesnakes in BC. It suggests that a very high proportion of our snake population is currently being severely impacted by roads. It is strongly suspected that this single source of mortality is resulting in unsustainable population depletion within most areas of the species range in BC; this opinion is widely held by many herpetologists in the BC scientific community and supported by the fact that rattlesnakes have been eliminated from several large areas of their historic range in BC (e.g. along the south side of the Thompson River Valley, from Chase to Savona).

2) Elevational Distribution: Rattlesnakes are known to forage, in BC, at elevations up to 1,434m ASL (L. Gomez. pers comm 2006) however, thermal requirements are thought to constrain denning to lower elevations within all known BC populations. In BC rattlesnakes tend to aggregate (often with other snake species) for the denning period; this ecological trait makes this species extremely vulnerable to mortality sources, at or near dens, as these have a particularly pronounced effect on the entire range of the population of individuals using the den. Considering that adult male rattlesnakes have been documented foraging (during the active season) as far as 8km from their den site in BC (L. Gomez (2006) & J. Gosling (2010). pers comm) point source mortality has a far reaching potential influence. For example, if a snake population is influenced by point-source mortality (i.e. roadkill, persecution) at a den site the resultant effect is a reduction in population density that may be felt up to 8km away from the den. An analysis of the distribution of known rattlesnake dens (n=318) illustrated that 56% of known rattlesnake dens occur below 600m ASL; 91% occur below 800m ASL. In summary the majority of our known BC population of rattlesnakes aggregate, each winter, in valley bottoms where human activity (e.g. agriculture, recreation, urban development) and road density are at their highest. This statistic has obvious and profound conservation significance.

3) Population Size: There have been no previous attempts to provide an accurate quantitative estimate of BC's resident extant snake population; as such, I attempted to address this using the provincial snake den database. To do this I assigned all known rattlesnake dens (n=318) to a size class based on the highest number of snakes observed at each den (see section on "Population Size"). In some cases these "den counts" were based on multiple visits however in many cases the value was collected during a single visit. Each size class encapsulated a range of values for the "number of snakes observed" (see section "Summary of Known Information"). A simple calculation of the number of dens within each size class yielded a range-value for the current BC population (based on den counts) of rattlesnakes at known dens. The estimated known population (based on den counts) ranged from a minimum of ~3,900 individuals to a maximum of ~8,000 individuals. These numbers may be used as a minimum estimate only as they are based on observed rattlesnake den counts. As such, caution is required when applying this conservative and approximate absolute abundance estimate of the BC population size. The actual population size is likely larger as den counts will underestimate (by a suggested factor of up to five times) the number of snakes actually using the den. In addition, there are likely many dens that exist but are not documented (i.e. not yet found). Conversely, this suspected underestimate is offset by likely declining trends that are suspected for most (>75%) of the known snake dens remaining in BC. Regardless of the limitations of these estimates they remain the most comprehensive surrogate estimate of the total provincial rattlesnake population available for BC.

Any attempt to derive more information from den counts was confounded by multiple variables. Ideally we need to improve our understanding of the rate of population change, and population size, for each sub-population in BC. If population size information was available a comparative assessment could be made to more accurately quantify an already widely held supposition: "population size and density is negatively dependent on proximity to roads". I attempted to do this using "den size" (based on maximum number of snakes observed/recorded at each den) as a surrogate indicator of snake population size however I could not discern any evident pattern with this approach. The supposition is undoubtedly accurate but this approach to analysis is confounded because den counts are a meaningless indication of population size for the following reasons:

- Den counts are highly influenced by timing relative to emergence and retreat "start/end" dates
- Den counts are highly influenced by sampling conditions, not just on the day of the count but also by several days preceding the count. As such, standardization of sampling conditions is virtually impossible.

- Den counts are highly influenced by availability of suitable denning structures. If the local landscape has a high relative availability of denning options then the population of snakes using each den option will be diminished (i.e. the resident snake population (as limited by summer foraging habitat supply) will be more dispersed during the denning period).
- Den counts are highly influenced by observability (e.g. at talus dens snakes have more concealment cover and, as such, are more difficult to see relative to dens with earth (closed surface) areas at the den entrance.
- Den counts are highly influenced by observer skill. Snakes are notoriously difficult to see as they use concealment cover. In addition, inexperienced observers often fail to move discretely when counting snakes; as such, many snakes will retreat, unobserved, resulting in lower 'counts' relative to the actual number of snakes that were present.

As a result of this, there is no apparent significant correlation between distance to road and “den count”. This unclear result is due to the fact that den counts do not provide an accurate estimate of the size of the population of snakes actually using the den. I suspect that there is likely a very strong correlation between distance to road relative to actual population size, actual rate of population change and actual population density within a given meta-population.

In the absence of more accurate quantitative information on population size, density and rate of change, perhaps the most obvious indication of the threats, and the concomitant perceived resulting decline in BC's resident snake population, is an anecdotal (experience based) assessment of meta-population health. Our accuracy and understanding of the species' current provincial range has improved dramatically in the last decade. This species has been the focal taxa of six masters’ research projects in BC (including M. McCartney, J. Brown, L. Gomez, J.Hobbs, J. Gosling and E. Lomas). In addition, there is now over two decades of inventory information, collected by several key researchers (M. Sarell, J.Hobbs, W. Alcock & F.Iredale), over the entire BC range of this species. This improved collective understanding provides consistent and alarming insights regarding the 'health' (or suspected rate of population change) of each meta-population in BC. Concerns regarding anthropogenic influences on the long-term persistence of this species have been iterated by each of these individuals.

I have been fortunate, in my work on this species, to have arguably the geographically broadest field-based perspective for this species in BC as I have, uniquely, had the liberty of conducting inventory for snake dens with absolutely no restrictions on my geographic area of focus for well over a decade. Since I began searching for snake dens in 1998 I have spent countless days hiking great distances, in arduous terrain, in search of snake dens. Between 2006 & 2012 these efforts were amplified as I trained and led dozens of technicians in search of snake dens throughout the species range in BC. Based on this experience I suspect declining trends are occurring within >75% of the snake populations within the species range in BC. There are currently only five areas that remain relatively un-impacted by roads (or other anthropogenic activity) in BC. Four of these areas (described below) are in the Thompson-Nicola population; one is located in the Okanagan-Similkameen population and there are no un-impacted areas remaining in the Vernon, Midway or Grand Forks populations. Descriptions of each area are provided below.

1. Nicola South Side: The valley and shrub-steppe habitat along the south side of the Nicola River likely harbors near historic populations of rattlesnakes. There are no roads and no current evidence of grazing use from Skahun Creek downstream to Rattlesnake Bridge (along the south side of the Nicola valley) along this section of the valley. Much of this area presents very limited denning opportunities as the entire area is north east in aspect; there are available outcroppings of fractured rock but most are characterized by very low solar exposure. In this area all of the known dens occur along the top of the valley ridge or along the edge of incising ravines that

have east aspect slopes. As the valley climbs the outcrops along the ridge-top receive relatively more solar exposure; all of the known dens occur within these relatively more exposed features. As such, dens in this area tend to be more significant as they provide shelter for a larger number of snakes (i.e. where features are limited denning aggregations tend to be larger (pers. obs)).

2. North Shore of Kamloops Lake (including the Dewdrop): This area includes the shrub-steppe habitat (including grassland and forested ecosystems in the BG, PP and IDF ecosystems along the north shore of Kamloops Lake, between Tranquille Creek and Savona. Denning opportunities are abundant and road access is limited; this is likely some of the highest population density rattlesnake habitat remaining in BC. There is a rail-road running along the lake shore along the entire extent of this area, and I have observed associated mortality (adult rattlesnake trapped in exposed grease at a 'lube station' on the tracks), however impacts are suspected to be relatively low compared to mortality associated with paved roads. There are many known dens, including two of the largest dens in the Thompson population (n=>80), within this area of relatively pristine snake habitat.
3. Thompson (West side) from Spence's Bridge to Lytton: This area of the Thompson River canyon is rugged and steep; the grassland habitat climbs quickly into forested (foraging) habitat in this area. As such, denning opportunities are relatively restricted so dens in this area are likely to harbor large populations of rattlesnakes. Indeed, although only a single day of den searching has been conducted in this area (J.Hobbs and F.Iredale) a very large population of snakes (n=>80) was observed during a single visit at the only den (Epic Den) found that day. This ~50km linear section of snake habitat is impacted by a rail-road running along the entire extent of the canyon and I have observed associated mortality (adult rattlesnake trapped in exposed grease at a 'lube station' on the tracks), however impacts are suspected to be relatively low compared to mortality associated with paved roads. No den surveys have ever been conducted further downstream than Epic Den (approximately 25km downriver from Spence's Bridge). It should be noted that there is no (or very limited) snake habitat along the canyon past this point as the canyon wall from ~35km South of Spence's Bridge and continuing to Lytton are comprised of tall sheer limestone cliffs.
4. Thompson (East side) from Sundance Ranch to the Nicola River: The portion of the Thompson River canyon, from Sundance Range (~10km south of Ashcroft) continuing downstream (south) to the Nicola River (near Spence's Bridge) contains highly suitable snake habitat. The gentle valley slopes transition gradually into forested hillsides that contain high quality snake foraging habitat; denning opportunities along the southwest (prime) aspect valley side are numerous. I have surveyed this area, on several occasions, and have located several very large dens (e.g.; Pizza Box) but there are undoubtedly more dens waiting to be discovered in this area. Most of this area is contained within IR tenure; permission is required to access this portion of excellent snake habitat. There is a single dirt track running the length of the canyon along this section of the Thompson River valley however vehicle use is very light; I have never observed a vehicle on this section of the road in over a decade of working in this area.
5. Okanagan Mountain Park: This is a relatively small area but warrants mention as it is the only area of snake habitat remaining in the entire Okanagan-Similkameen population that is not impacted by roads. Immediately north of the park the low elevation (valley bottom) snake habitat is so severely impacted, along both sides of the Okanagan Valley, that rattlesnakes have largely been eliminated (with the exception of a single very isolated (and likely declining) population at Mt. Boucherie). The majority of this area has never been surveyed for snakes. In 2012, I led surveys (with four very capable technicians) into the southern edge of this area and two dens were detected. Most of this area is inaccessible by road, creating ideal conditions for

snakes, and denning opportunities are abundant. The area was severely impacted by fire in 2006 but the impact on the health of the resident snake population in the area is unclear.

Unfortunately all remaining areas of snake habitat, in the BG, PP and IDF BEC zones, within the range of all five currently disjunct BC populations are impacted, to varying extents, by anthropogenic influence. Throughout all remaining snake habitat in BC roads, urban development, intensive agriculture, railway right-of-ways and intensive recreational use continue to have a strong negative influence on the quality of snake habitat with a concomitant negative effect on adult survivorship of snakes (including racer, gopher snake, rubber boa, night snake and even garter snakes (*T.sirtalis* and *T.elegans*). The resultant influence on the current snake populations within many of these impacted areas (~75% of the species' BC range) is typically quite severe. Despite difficulties associated with accurate quantification extensive field observation suggests that snake populations have (and will continue to), declined sharply within these areas. This supposition is strongly supported by the fact that the species has already been eliminated from several large areas of its former range.

In summary, as a direct result of these collective efforts we have improved our understanding of the species current distribution, current and historic range, timing of seasonal movements, population size and population health in BC. We have also gained important inferential (anecdotal) insights into vital rates including survival, fecundity and rate of population change. Although these observations are not statistically robust, they are still valid and important as they represent the best available range-wide information for this species in Canada. This collective understanding, gained from over a decade of inventory and research on this species by multiple individuals, indicates strongly that there is obvious cause for concern regarding the likelihood of the continued persistence of rattlesnakes in BC.

Management Recommendations

Communal denning behaviour increases snake populations vulnerability. Point source mortality, especially when concentrated near snake hibernacula, results in population depletion that affects the local population at a broader landscape level for snakes with large territories (including racer, gopher snake and perhaps even garter snakes (*T.sirtalis* and *T.elegans*). Sources that exacerbate point source mortality for snakes (all species) include urban development, intensive agriculture, railway right-of-ways and intensive recreational use. These factors are estimated to negatively influence snakes in BC within approximately 75% of the species' current BC range and the influence is generally thought to be quite severe despite difficulties associated with quantification. In addition, loss, through intentional or accidental destruction of snake hibernacula has occurred (and will likely continue to occur) in BC (pers obs). Den destruction also results in the elimination of many individuals and possibly entire populations of snakes from an area (Klauber 1972).

Naturally occurring features that facilitate over-winter survival in BC are limited in availability on the landscape. The importance of over-wintering denning sites (hibernacula) to the ecology of snakes in temperate regions, coupled with the high fidelity of snakes to these sites (Klauber 1972), suggests that the conservation of both den sites and habitat surrounding den sites is likely required to ensure snakes continue to persist. For these reasons, conservation of snake hibernacula is viewed as critically important for the conservation of entire snake populations in BC.

In BC, the only current conservation mechanism available for the management of snake populations is the Identified Wildlife Management Strategy (IWMS) under the Forest and Range Management Practices Act. In order to conserve habitat for identified species (as listed on the Category of Species at Risk)

Wildlife Habitat Areas (WHAs) can be established at known den sites on provincial crown land. Measures are applied within established WHAs to ensure that the den site and the surrounding habitat are protected from potentially detrimental forestry or range practices. Although rattlesnakes, racers and gopher snakes have been designated as Identified Wildlife this enactment affords very limited effective protection to snake populations as the most intensive threats (road mortality and urban/agricultural development) are not addressed under this legislation. In addition, WHAs can only be designated on provincial crown lands. An analysis of all known rattlesnake dens demonstrates that only 42% of the known rattlesnake den sites (n=318) in BC occur on crown land and application of this conservation mechanism is thus restricted to less than half of the known dens in the province. Although IWMS is a positive start for addressing snake conservation in BC this mechanism alone is insufficient for conservation of rattlesnakes at the landscape scale.

In 2004, the federal Species at Risk Act (SARA) was assented and in 2006 the provincial government publicly committed (in a federal-provincial bilateral agreement) to develop legislation that would afford SARA listed species equivalent protection to ensure parody with SARA. As of 2013, this commitment still has not been met by the province, despite the bilateral agreement, for application on provincial crown land. Where SARA does currently apply (i.e. on federal lands) protection is still inadequate as a formal residence description (e.g. snake dens and maternity sites) have still not been accepted and critical habitat has not been defined. More effective and comprehensive legal protection is obviously still required to ensure that rattlesnakes, gopher snakes and racers have a reasonable chance of persistence in BC.

In the interim, continued survey for snake dens is recommended to build upon our collective understanding of species distribution and important habitats. The use of aerial assessment methods has proven to be an extremely cost effective method to refine and focus search efforts. The application of this method (as described in this report and in Hobbs. 2010) should be expanded to other areas. In addition, the use of infra-red aerial assessment methods should be explored, beginning with a pilot project in the Kamloops Region, to improve predictive aerial assessment methods even further.

Finally, a long-term monitoring project should be initiated at several known den sites. Baseline data already exists for Kalamalka Provincial Park so all 21 dens in this area are logical candidates for a longer term demographic study (to assess vital rates including fecundity, survivorship and rate of population changes). If a successful (i.e. non-detrimental and effective) method for population monitoring can be developed this method should be selectively applied in other portions, and at other dens, within the range of the species in BC.

Literature Cited

BC Conservation Framework. 2009. http://www.env.gov.bc.ca/conservationframework /index.html (accessed June 18, 2010).

BC Ministry of Water, Land and Air Protection. 2004a. Appendix 5 in Accounts and Measures for Managing Identified Wildlife – Accounts V. 2004. B.C. Ministry of Water, Land and Air Protection, Victoria, B.C. Available: http://www.env.gov.bc.ca/wld/frpa/iwms/ procedures.html (accessed April 15, 2010).

COSEWIC 2004. COSEWIC assessment and status report on the western rattlesnake Crotalus oreganus in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 26 p. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC 2013 (draft). COSEWIC status report on Great Basin Gophersnake in Canada. Prepared for the Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 69 p.

Gomez, L. 2008. Personal communication

Gosling, J.2012. Personal communication

Hobbs, J. 2007. Thermal Factors in Relation to the Denning Ecology of Northern Pacific Rattlesnakes in British Columbia. Thesis. SFU/RRU. 107 p.

Hubbard, Kaylan and Chalfoun, Anna. 2012. An experimental evaluation of Potential scavenger effects on snake road mortality detections. Herpetologoical Conservation and Biology 7(2). September 2012.

IUCN Taxonomy Tool: http://www.iucnredlist.org/details/64326/0

Jackson, N., and L. Fahrig. 2011. Relative effects of road mortality and decreased connectivity on population genetic diversity. Biological Conservation 144:3143–3148.

Klauber, L. M. 1972. Rattlesnakes: their habits, life histories and influence on mankind. Reprint of second edition. University of California Press, Berkeley, CA.

Lomas, E. 2013. Personal communication

Macartney, J. M. 1985. The ecology of the northern Pacific rattlesnake, Crotalus viridis oreganus, in British Columbia. M. Sc. thesis, University of Victoria, Victoria, B.C.

Macartney, J. M., K. W. Larsen, and P. T. Gregory. 1987. Body temperatures and movements of hibernating snakes (Crotalus and Thamnophis) and thermal gradients of natural hibernacula. Canadian Journal of Zoology 67:108-114.

Meidinger, D., and J. Pojar (eds.). 1993. Ecosystems of British Columbia. Special Report Series 6. BC Ministry of Forests, Victoria, British Columbia.

Sarell, M. 2013. Personal communication.

Rubio, Manny. Rattlesnakes of the United States and Canada. ECO Herpetological Publishing and Distriubtion. 2010.

Appendices

Appendix 1: Confidential Folio of Den locations for BC

Available separately (MS Excel)

Appendix 2: Aerial Candidate Den Data

Available separately (MS Excel)

Appendix 3: Ground Den-Survey Data

Available separately (MS Excel)

Appendix 4: Den Pictures

Available from MFLNRO staff.