BC Environment

STATUS OF THE NORTHERN PACIFIC RATTLESNAKE IN BRITISH COLUMBIA

by
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Wildlife Branch
Ministry of Environment, Lands and Parks

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ABSTRACT

The northern Pacific Rattlesnake, *Crotalus viridis oreganus*, is a venomous snake of the family Viperidae. The range of this species within British Columbia is restricted to the Ponderosa Pine and Bunchgrass biogeoclimatic zones which occur primarily in the Thompson and Okanagan basins, and the Nicola valley. At present we have little information regarding population sizes or overall population trends for *C. v. oreganus* in the province. However, the distribution of this species overlaps to a considerable degree with areas of extensive land development and there has likely been some negative impact on population numbers. The low reproductive rate of *C. v. oreganus* in British Columbia makes it particularly sensitive to large-scale disturbances, as populations may respond slowly to perturbations. In order to protect this species, further research on its basic biology is needed and should include: information on the locations of den sites from a wide range of sites in the province; long-term population monitoring to gain an understanding of population trends; and detailed knowledge of movements and habitat use to allow informed management decisions. Rattlesnakes are afforded the same legal protection as other wildlife in the province under the Wildlife Act (1982). However, the Act allows for animals to be killed if they are a threat to life. Since venomous snakes are perceived as threatening by their very nature, it is likely that the Act provides little real protection from persecution. Public education programs offer an effective opportunity to protect this species. In particular, it is important that the general public be able to see live rattlesnakes and come to realize that, although they are potentially dangerous, they should be respected and not feared. The Wildlife Branch, Ministry of Environment, Lands and Parks, has placed the northern Pacific Rattlesnake on its Blue List (species considered to be vulnerable and at risk.)

TABLE OF CONTENTS

LIST OF FIGURES

GENERAL BIOLOGY

The Northern Pacific Rattlesnake (*Crotalus viridis oreganus*) is a member of the family Viperidae (Subfamily Crotalinae), and is the only venomous snake found in British Columbia (barring the rare, and only nominally venomous, Night Snake, *Hypsiglena torquata*). It is a heavy-bodied snake that can exceed 1 m in length, and is characterized by the presence of a "rattle" (formed from modified scutes) at the end of the tail. Colouration is quite variable, ranging from olive-green to tan, with dark blotches along the back which change to dark bands posteriorly (Gregory and Campbell 1984).

The nominate species, *C. viridis*, has an extensive range covering most of western North America. The range of *C. v. oreganus* extends from southern British Columbia, through central Washington, Oregon, and into central California (Stebbins 1985). Within British Columbia, *C. v. oreganus* is found throughout the Okanagan valley, west along the Thompson Plateau as far as Lillooet and east as far as Grand Forks (Gregory and Campbell 1984).

Although *C. viridis* is one of the most intensively studied snake species in North America (Macartney and Gregory 1988), it has been little studied in British Columbia until recently. Although some limited information is available on *C. v. oreganus* in the south Okanagan (Preston 1964), the majority of the work done in this province has been conducted near Vernon (Macartney 1985, Charland 1987). Specific population and life history data presented in this report are from that location only, unless otherwise specified.

Annual Cycle

Detailed information on the annual cycle of *C. v. oreganus* in British Columbia is available only from the studies conducted near Vernon. The following account of the annual cycle has been taken from Macartney (1985) and Charland (1987). Snakes emerge from communal hibernation sites, located on south and southeast facing rocky ridges, mainly in April. However, in some years, emergence may begin in March. They spend little time in the vicinity of the den before moving off to the summer range to begin feeding. The summer range is typically open grassland where rodents are abundant. However, rattlesnakes can be found in almost any habitat within their range during summer. Mating takes place in late summer and early fall on the summer range, after which the animals start to return to the winter den where they have usually entered hibernation by mid-October. In some years snakes may remain above ground until November.

Females that have mated in the summer have enlarged ovarian follicles at the time they enter hibernation. Sperm is stored during the winter and ovulation and fertilization occur after emergence in the spring. Rattlesnakes are viviparous (live-bearers) and the gravid (pregnant) females generally remain in the vicinity of the den, except for short movements early in the season, for the entire summer as the embryos develop. Birth typically occurs between mid-September and early October, whereupon the females immediately enter hibernation. The newborn young remain at the surface near the den until they have shed their skins for the first time (approximately two weeks), after which they too enter the den to hibernate.

Reproductive Capability

Age at Sexual Maturity — The smallest sexually mature male found at the Vernon study site was 535 mm snout-vent length (SVL) and was likely about three years old (Macartney 1985, Macartney *et al*. 1990). Male *C. v. oreganus* exhibit delayed sexual maturity in northern populations (Macartney *et al*. 1990), even when compared with populations as near as Idaho (Diller and Wallace 1984). Crotaline snakes are well known for male-male combat during the breeding season and large males are presumed to have an advantage in such contests (Shine 1978). In addition, females may not mate with small males. Macartney (1985) never observed males less than 720 mm SVL aggregating with females and suggested that age at first reproduction might be substantially older than age at sexual maturity. However, this has not been studied.

Among female *C. v. oreganus,* the smallest sexually mature individual found at the Vernon study site was 650 mm SVL. However, many females do not reach sexual maturity until they are 700-760 mm SVL (Macartney *et al*. 1990). Long-term mark-recapture studies indicate that first mating can occur at five to seven years old and that first litters can be produced at six to eight years old. However, many females do not produce their first litter until seven to nine years old (Macartney and Gregory 1988). Delayed reproduction appears to be common among viperids (*ibid*.), but the proximate factors that lead to variation in reproductive maturity among individuals are unknown.

Reproductive Frequency — There is no information available concerning the frequency of reproduction of male *C. v. oreganus*. However, Macartney (1985) found that, following sexual maturity, males had sperm present in the vasa deferentia at all times of the year. This suggests that males are capable of mating annually, and it would be surprising if this were not the case.

Late summer mating and autumn parturition in *C. v. oreganus* from British Columbia constrains females to reproducing only every second year, at the very most. If a female mates in the late summer of a given year, she will be carrying developing embryos the following year and presumably will be unable to mate. In reality, few females are able to reproduce every two years (Macartney and Gregory 1988). Gravid females feed very little, or not at all, while carrying developing embryos, and are extremely emaciated following the birth of the young. These animals enter hibernation immediately and do not have an opportunity to resume feeding until spring, at which point they may have gone as long as one and a half years without feeding. A female presumably must have enough fat reserves to carry her through this period of fasting before mating. Macartney (1985) showed that a female that has given birth the previous fall must double her body weight before she will produce young again. It is apparently difficult to gain this much weight in a single season, so females may require additional summers of foraging before being able to mate. In the north Okanagan, it appears that many females reproduce only every three years or more (Macartney and Gregory 1988). The presence of triennial or longer reproductive cycles has only been confirmed for *C. v. oreganus* in B. C. and for northern populations of *C. horridus* in the eastern U.S. (*ibid.*). However, extended reproductive cycles have been suggested for almost all populations of North American viperids (Seigel and Ford 1987).

Litter Characteristics — The average litter size for *C. v. oreganus* in British Columbia is about five (range two to eight) and the sex ratio of the young does not differ from one male to one female (*ibid.*). Macartney (1985) reported mean SVLs of neonates to be 267.2 mm for females (n=75) and 269.9 mm for males (n=68). The average weight of neonates in his sample was 17.2 g for females and 17.9 g for males. There was no significant difference between the sexes in either SVL or weight. However, Charland (1987), working at the same study site, found longer, but thinner, neonates. The average SVL of females in his sample was 285.1 mm (n=61) while males averaged 284.1 mm (n=54). More interestingly, the average weight of females (14.9 g) was significantly less than that of males (16.0 g). The interpretation of these differences is problematical, but it does appear that there may be annual differences in size and condition of neonates produced within a population. Factors responsible for such variations are unknown at present; nor is it known what the effect of these variations may be on the future survival of the animals.

Population Structure — Before we discuss population structure in detail, it is necessary to comment on the use of winter den (hibernaculum) sites. In general, rattlesnakes den communally in British Columbia and spend approximately 200 days a year in hibernation (Macartney 1985). In addition, *C. v. oreganus* shows considerable den site fidelity, with individuals returning to the same den year after year. Macartney (1985) found that fidelity ranged from 74% to 100%, with most dens having 100% fidelity. Furthermore, most den switching occurred between neighbouring dens and the animals that switched were typically juveniles. As a consequence, any interpretation of population structure must incorporate knowledge of the structure at all dens in a given area.

The overall sex ratio within any size class did not differ significantly from 1:1 in the population studied near Vernon (*ibid.*). However, specific dens were consistently biased towards either males or females.

Age structure varied considerably among dens and from year to year. Because reproduction is not annual, most dens experience pulses of recruitment reflecting years when many females reproduce. This makes it difficult to interpret the importance of the age structure of a den based on short-term data. If recruitment is low for a number of years in a row, all of the juveniles at the den will have grown to adulthood and the age structure of the den will appear to consist mainly of adults. Macartney (1985) found that the size/age class distribution of adults changed relatively little within a den and that changes in population structure took place primarily as a result of changes in the proportion of juveniles. The considerable variation in age structure among dens led Macartney (1985) to conclude that there was no single population structure that could be said to be representative of the rattlesnake population at the Vernon study site. This conclusion can clearly be extended to include the entire British Columbia population of *C. v. oreganus* and underscores the importance of obtaining data from other parts of the species range in the province.

Mortality and Survivorship — Differential mortality of age/sex classes is important in determining the patterns of population structure observed. Overwinter survivorship of adult rattlesnakes appears to be >90%, and may be 100% in many dens (*ibid.*). However, much lower, or more variable, survivorship has been found among neonates. Overwinter survivorship of neonates appeared to be 0% for some dens in some years, but there was considerable variability among years (*ibid.*). A den with 0% survivorship of neonates one year might show modest survivorship the following year. In some dens neonate survivorship was as high as 76.5% (*ibid.*), and a detailed study of overwinter survivorship at two dens near Vernon indicated a minimum survivorship of 55% during the winter of 1985/86 (Charland 1989).

Hibernation by snakes in cold temperate regions is necessary for winter survival. However, there appears to be variation among dens with respect to winter survivorship (Macartney 1985), although the reasons for this are unknown. Winter survival also varies annually for a given den (*ibid.*) and it has been suggested that this may be partly a function of winter snow cover. Cold winters with heavy snow cover may result in lower mortality than warmer winters with light snow, presumably because of the insulative capacity of snow (Gregory

1982). Hibernating snakes may also have strict water requirements which could also be related to winter snow cover. Much of the mass loss by snakes during winter seems to result from water loss rather than fat utilization, and annual variation in winter survivorship may well be attributable to variation in water/humidity conditions within the dens (Costanzo 1985, Charland 1989). It should be stressed that the lack of information concerning internal den characteristics, and factors governing den choice and location make it difficult to do more than identify potential vulnerabilities during hibernation.

Estimates of annual survivorship for *C. v. oreganus* in B.C. have also indicated differences among age/sex classes (Macartney 1985). Not unexpectedly, neonates (to the end of their first year of life) had the lowest annual survivorship (approximately 25%). Juveniles (>1 year old, but not sexually mature) showed higher survivorship than neonates (approximately 50%). Adult males had an annual survivorship in excess of 80%, with the rate typically increasing with size. Annual survivorship estimates for females were broken down according to reproductive state: gravid females, postpartum females (those that had given birth the previous fall), and nonreproductive females. Gravid and nonreproductive females had 90% annual survivorship, while postpartum females had much lower survivorship (78.4%). It appears that postpartum females, because of their generally emaciated condition following birth, experience lower survivorship during the winter and the following summer. These estimates are provided by Macartney (1985) and are for the years 1981 and 1982. There was evidence of annual variation in these estimates, but the number of years on which they are based is small and they should be treated with caution.

Reproductive Rate — Mating by *C. v. oreganus* in B.C. takes place between late July and early September, and occurs on the summer range. Macartney (1985) found no evidence that there were specific mating sites used by individuals. However, he rarely observed reproductive behaviour in the wild and could not rule out the possibility that these sites exist. Males apparently find females, but the mechanism by which they do this is unknown. Pheromones released following skin shedding by females may provide cues that allow males to locate females (Macartney and Gregory 1988). Bisexual aggregations (groups containing at least one male and one female) of as many as eight individuals have been recorded in British Columbia, but the majority of groups were pairs (Macartney 1985).

There is no information available concerning the reproductive success of individual males, and we do not know if a few males mate a disproportionate number of times or if mating is relatively evenly distributed among sexually mature males. As a consequence, we do not know what the effect of reductions in the numbers of sexually mature males would be on the reproductive rate of the population as a whole. The operational sex ratio of a population is the ratio of males and females that are actually reproducing at a given time, and may be different from the overall sex ratio among sexually mature animals. If females will mate only with large males, then sexually competent males would form a smaller subset of the total number of sexually mature males, and therefore affect the operational sex ratio.

The reproductive rate of female *C. v. oreganus* in B.C. has been dealt with in some detail in an earlier section (see Reproductive frequency). Individual females do not appear to be on a fixed reproductive schedule. Instead, females reproduce as often as they can renew their fat reserves sufficiently following parturition. The highest possible frequency of reproduction is every two years, but for many females three or more years pass between successive litters. The facultative nature of female reproduction suggests that there may be years in which many females are producing young, followed by years when there are few. This is certainly true for individual dens. A given den may have very few (or no) females reproducing for a number of years, followed by a year in which virtually all sexually mature females appear to be gravid (M.B. Charland pers. obs.).

The combination of delayed sexual maturity (particularly in females) and infrequent reproduction indicates that the reproductive rate of *C. v. oreganus* in British Columbia is low. Consequently, this species is likely to be very slow in responding to disturbances. Even under managed conditions the speed with which populations increase will be very slow, and small populations will be particularly vulnerable.

Movement Patterns

Winter dens are the focal point for movements by *C. v. oreganus* in that all seasonal movement patterns start and end there. This limits the potential for movement of snakes during the active season, because they must return to the den in the autumn. Dens are generally found on south and southeast facing rocky slopes, and are often near the top of the ridge (Macartney *et al*. 1989). In the Vernon area, rattlesnakes leaving the den typically moved upslope to the top of the ridge and then radiated out to the northeast and northwest (Macartney 1985). In addition, there appeared to be particular corridors that the snakes used to move from the dens to the ridge tops. The physical characteristics of the dens appeared to influence the movement patterns of *C. v. oreganus*. Downslope dispersal from many dens was limited by steep cliffs, but snakes from dens located lower on hillsides may move downslope and radiate in that direction (*ibid.*). Typically, however, the nearest suitable summer habitats were on the other side of the ridges from where the dens were located and that is where the snakes went. Dispersal patterns appear to be a function of den location and few generalizations can be made beyond stressing that rattlesnakes do not appear to disperse randomly from the den sites.

Detailed information on the movement patterns of individuals on the summer range is generally lacking. Macartney (1985) suggested that *C. v. oreganus* in the Vernon area had reached their maximum distance from the den between mid-July and mid-August. The greatest distance from a den was recorded for a juvenile snake found 1575 m from its winter den. However, distances of 1100 -1300 m from the den were not uncommon (*ibid.*).

Gravid females are the most sedentary segment of the population and spend virtually the entire summer in the immediate vicinity of the den. Some gravid females have been found as much as 400 m from the den, but this is invariably early in the active season and they soon return to the den site (Macartney and Gregory 1988). Males appear to move more than nongravid females, as suggested by their apparently larger activity ranges (Macartney 1985, Macartney *et al.* 1988). However, these ranges are based on recapture data rather than from radio-tracking individuals, and should be interpreted cautiously.

Macartney (1985) found some evidence for summer site fidelity by *C. v. oreganus* in that there were particular sites where snakes could be found throughout the active season (*ibid.*). These sites were mainly rock outcrops on the summer range and were used by animals from more than one den. Individual snakes did not necessarily use the same sites year after year, rather these were sites that were constantly in use by snakes throughout the summer.

Specialization And Adaptability

A detailed analysis of the diet of *C. v. oreganus* in the Vernon area indicated that these snakes are primarily rodent eaters (Macartney 1989). When measured as the per cent of the total number of prey items ingested, birds (four species of small passerines) made up 4% of the diet, shrews (*Sorex* spp.) a further 5%, with rodents contributing the remaining 91% (*ibid.*). The main species of rodents taken were voles (*Microtus* spp.) - 46.3% of all prey ingested and Deer Mice (*Peromyscus maniculatus)* - 22.1% of all prey ingested. In comparison with conspecifics in the southern portion of the species range, *C. v. oreganus* in B.C. appear to have a restricted diet. Snakes in the south, particularly neonates and small juveniles, feed principally on small lizards and amphibians (Fitch and Twining 1946, Mackessy 1988). The necessity for small snakes, especially neonates, to rely on mammalian prey in British Columbia may contribute to higher summer mortality and slower growth rates than further south (Charland 1989, Macartney 1989).

The specialization of *C. v. oreganus* on rodents in B.C. suggests that they will be affected by any factors that influence rodent numbers. Even natural shifts in the numbers of rodents available during the active season can be expected to be manifested in eventual changes at the population level of the snakes, particularly given the facultative nature of reproduction in females. In addition, the interaction among prey availability, foraging success, and reproduction are poorly understood. High prey availability and potential foraging success may be counteracted by poor summer weather which, by reducing digestive efficiency and rate, could lead to poor weight gain and low probability of reproduction among females (Charland and Gregory 1989).

Rattlesnakes are often persecuted by humans and killed directly, not only to remove a perceived threat to human safety, but also by collectors for trade in skins and other products. However, even when this does not occur, rattlesnakes appear to be sensitive to human disturbance, particularly at the winter dens. The importance of the winter den sites, not only because of their role in winter survival, but also because of their use by gravid females during the summer, makes them a critical concern when considering human disturbance. A number of researchers working on rattlesnakes across North America feel that repeated visits to dens over a number of years (for research purposes, not for collecting or killing snakes) may have a significant impact on the behaviour of these snakes (J.M. Macartney, H. Higgins, W.S. Brown, all pers. comm.). The most obvious effect seems to be a reduction in basking behaviour in the vicinity of the den site. When first visited, there may be numerous basking animals, but over the years the number drops markedly (M.B. Charland, pers. obs.). The dens do not appear to be abandoned because newly shed skins are frequently found and neonates are captured each fall. It is unclear whether there are additional effects of repeated visits to den sites beyond behavioural modification. However, it seems very likely that the snakes do respond even to relatively noninvasive disturbances in the vicinity of these critical sites.

Knowledge of the basic biology of *C. v. oreganus* can be used profitably to reduce the effects of human disturbance. In the fall of 1985, the British Columbia Ministry of Highways revealed plans to straighten, raise, and widen a section of Highway 97 south of Vernon, in the north Okanagan. This particular stretch of roadway was adjacent to a British Columbia Ecological Reserve that contained a rattlesnake den within sight of the highway. Although the den itself was not located within the proposed work area, it was very close to the construction area and there was concern about the effect of blasting operations and general activity on the resident snakes. In addition, a talus slope used by gravid females from this den as a rookery was to be removed in re-sloping the road side. The Ministry of Highways, in consultation with Ecological Reserves and Dr. P.T. Gregory (Univ. of Victoria), agreed to a number of proposals to reduce the impact of the road construction on the snakes.

First, blasting was not started until after 15 June 1986, in order to give the snakes time to emerge from hibernation and to disperse from the vicinity of the den. Second, the den was fenced so that gravid females could be captured as they emerged. These animals were then held for the summer in an outdoor enclosure, at a site away from the road construction. Roadwork was completed by the end of the summer of 1986 and a fine-mesh, snake-proof fence, extending for several hundred meters on either side of the den, was erected along the edge of the new roadway to prevent snakes from moving out onto the road (snakes from this den were known to move upslope generally). The gravid females, removed in the spring, were then released back at the den site, and at least one of these females gave birth that fall (P.T. Gregory, pers. comm.). The last phase of the operation took place in the early spring of 1987 when Highways personnel cleared an area, chosen by P.T. Gregory, to be used as a new rookery by gravid females from the den.

This project appears to have been successful. Neonatal *C. v. oreganus* have been observed at this den each fall since the construction was completed (M.B. Charland, pers. obs., P.T. Gregory, pers. comm.), indicating that the snakes are continuing to reproduce. In addition, the newly cleared rookery site is also being used (M.B. Charland pers. obs.). However, the long term effects of this construction activity have yet to be determined. Population estimates have not been made following construction and so no comparison with preconstruction numbers (found in Macartney 1985) can be made, although the indications are encouraging.

It should be noted that the success of this project hinged largely on a detailed knowledge of population size, emergence patterns, dispersal directions, and behaviour of gravid females at this den, all determined by Macartney's (1985) study. It seems unlikely that future successes of this sort could be accomplished without a similarly solid database on the dens in question. In the absence of such information, the potential to damage *C. v. oreganus* populations, which have low recovery rates, dictates that a thorough knowledge of den sites be developed and the exercise of caution in activities near dens or other critical habitats.

HABITAT

Description

Throughout its range, *C. v. oreganus* occupy a variety of habitats, ranging from sandy deserts to woodlands (Nussbaum *et al.* 1983). Within British Columbia, however, they are restricted to habitats characterized by bluebunch wheatgrass (*Agropyron spicatum*) grasslands and open Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) parklands. These habitats occur primarily in the Okanagan and Thompson river basins. Because these areas are located in the rainshadow of the Coast mountains they are the warmest and driest areas of the province in summer (Campbell *et al.* 1990). Precipitation is low, and the skies are generally clear, particularly in summer. In winter and early spring, inversions in the valleys resulting from outbreaks of cold dense arctic air from the north may result in prolonged periods of cold weather at the middle and low altitudes (*ibid.*). Snakes generally occupy talus slopes or ridges within these habitats. They require hibernacula suitable for overwintering, and summer range that provides adequate food, shelter, and basking sites.

Hibernacula are normally located on south-facing rocky slopes (Nussbaum *et al.* 1983). Most hibernacula located by Macartney (1985) were inside discrete rock outcrops or in localized areas of large continuous rock faces on south, southeast, or southwest facing slopes at elevations of 500 to 625 m. Most hibernacula on the south-facing slopes were located in the upper third of the slope, while 25% were located in the middle or lower regions (Macartney 1985). One hibernaculum in this area was in a large earth-covered mound of broken rock (*ibid.*). The number of apparent entrances to these dens ranged from one to three (*ibid.*). Rattlesnakes were the primary occupants, but small numbers of other species of snakes including Western Racers (*Coluber constrictor*), common Garter Snakes (*Thamnophis sirtalis*), and Gopher Snakes (*Pituophis melanoleucus*) occurred at most dens (*ibid.*).

Macartney (1985) located a total of 22 dens in two areas at his study site near Vernon, while two other areas contained only one known den each. In general however, there is no information on the availability of suitable den sites within the range of rattlesnakes. Areas of talus on south-facing slopes were not used by snakes studied by Macartney (1985). An important task therefore is to determine what sites are suitable for and used by snakes. So far, the only feasible way to obtain such information has been to observe the snakes themselves at hibernating sites in fall and spring. Furthermore, as discussed above, rattlesnakes tend to show a high degree of den site fidelity (*ibid.*); thus new sites may not be readily colonized by snakes even if they are available.

As snakes emerge from hibernation in the spring, areas of talus adjacent to dens appear to be important basking sites (*ibid.*). Macartney (1985) found that although suitable summer habitats appeared to be available in all directions from the den, snakes from two sites dispersed along ridge tops and north-facing slopes. Vegetation in these areas was more dense and homogeneous than on south-facing slopes, and is characterized by open ponderosa pine and Douglas-fir forest. Prey availability in these areas may also have been higher. Insolative properties of this vegetation cover may also allow snakes longer periods of time to forage above ground on hot summer days, and to remain active after dusk (*ibid.*). Rock outcrops, which provide shelter and shedding sites, are an important component of the summer range, and Macartney (1985) often found individuals from several different dens using the same rock outcrops in the summer, especially when the availability of these sites was low.

Distribution

Historical — In the Pacific Northwest during the transition from the late Miocene to the early Pliocene (14 to 10 million years ago), uplifting of the Cascade range and the region east of the Cascades created an effective rain shadow. This eliminated temperate forest species from the Great Basin, and desert-adapted species expanded northward into interior basins and valleys. These species subsequently were forced to move south by cool climates resulting from the Pinedale Glaciation (Auffenberg and Milstead 1965). British Columbia was completely covered by continental ice during this last glacial maximum, which occurred 25 000 to 10 000 years ago (Nussbaum *et al.* 1983). The sagebrush deserts of the Great Basin were replaced by ponderosa pine forests and grasslands (*ibid.*). After the retreat of the glaciers, a tongue of the Great Basin desert moved northward into south-central British Columbia, providing an avenue for a small number of desert species to move into the province (*ibid.*).

Present — The distribution of *C. v. oreganus* in British Columbia is currently limited to those areas that represent northward extensions of the Great Basin desert. These areas occur within the Thompson-Okanagan Plateau ecoregion, in the Ponderosa Pine and Bunchgrass biogeoclimatic zones. The distributions of these biogeoclimatic zones occur primarily within the Okanagan and Thompson valley basins, and the Nicola valley in south-central British Columbia, with a small portion occurring along the Fraser River (Campbell *et al.* 1990). In the lowest elevations in these river basins, vegetation consists primarily of grasslands of bluebunch wheatgrass, which is occasionally replaced by sagebrush. Other valleys are characterized by open parklands of mixed ponderosa pine and Douglas-fir and shrub-grassland communities. Saskatoon, big sagebrush, bluebunch wheatgrass, Idaho fescue, pinegrass, needlegrass, and lupines are common plants in these areas (*ibid.*).

Crotalus v. oreganus do not occur within the Southern and Eastern Thompson Upland regions between these two valley basins, resulting in a slightly disjunctive distribution for the species in British Columbia. Vegetation in the upland regions consists of interior Douglas-fir and montane spruce forests, which are generally too dense (and as a result too cold) to provide suitable habitat for *C. v. oreganus*. There are records, however, for *C. v. oreganus* from the Fraser valley near Boston Bar between Lytton and Hope (Gregory and Campbell 1984). This area is in the Interior Douglas-fir biogeoclimatic zone within the Pacific and Cascade Ranges ecoregion (Campbell *et al.* 1990).

Habitat Trends

There has been a considerable amount of land development in the Thompson and Okanagan basins which has likely resulted in a significant reduction in available habitat for *C. v. oreganus*. However, there are no data to indicate the effects of this reduction on rattlesnake populations. Without detailed knowledge of the locations of den sites in the area, and actual patterns of habitat use by snakes at those dens, it is difficult to predict the effects of development on local populations. The amount of potential habitat available to snakes in the vicinity of dens is limited by the maximum distances snakes can move in the active season, and by traditional dispersal routes. Even small developments can have a serious impact on local populations if they disrupt dispersal routes, or if they occur on the only suitable summer habitat available to snakes in the vicinity of a den. Development in the immediate vicinity of den sites also poses a serious threat to rattlesnake populations. Given the degree of den site fidelity shown by this species, it is not known whether snakes will relocate to other sites if dens are destroyed.

In the Pacific Northwest, Herrington (1988) found that many talus slopes, which may serve as important denning and basking sites for snakes, had been altered by either removal of rock from the bottom of the slope for road construction, or removal of trees from the slope itself. Removal of talus may result in increased erosion through movement of talus both on the surface and in deeper layers. This increased erosion may fill in existing hibernacula. An increase in radiation as a result of removal of trees from talus slopes may result in increased moisture loss (Herrington 1988). This may not be a problem in British Columbia, as logging within rattlesnake range is limited because of the slow rate of tree growth caused by the dry climate (Campbell *et al.* 1990).

Development also places snakes in close proximity to human inhabitants, who may be quite intolerant of their presence. *Crotalus v. oreganus* are often exterminated in areas near settlements, and are frequently killed when they are encountered by people (Orchard 1984). Road kills may be another major source of mortality, especially if roads are in close proximity to den sites (*ibid.*), or traverse migration routes.

Although habitat change due to development may be extremely rapid, the natural successional rate of the bunchgrass zone is slow due to frequent summer drought (Campbell *et al*. 1990). Thus while natural succession will not result in any immediate changes in the quality and quantity of habitat available to *C. v. oreganus*, rapid changes as a result of development are a serious concern.

Present Habitat Status

Because suitable habitat for *C. v. oreganus* is located in areas that are ideal for development, very little of this habitat is crown land, government owned, or protected. There are several Ecological Reserves and Provincial Parks which provide suitable habitat for this species, but these are small and limited in number. While wildlife habitat within Ecological Reserves is protected under the Ecological Reserves Act, there are no provisions for protection of rattlesnake habitat within Provincial Park campsites. With the exception of Kalamalka Lake Provincial Park, most parks in the Okanagan are campsites, and heavy use of these areas by tourists may result in high levels of snake mortality as a result of encounters with people. Although rattlesnakes still appear to be common at many locations throughout their range in British Columbia, the level of protection that currently exists may not be adequate to prevent declines in numbers in areas where snakes are in close proximity to humans.

Den sites, where there may be large concentrations of individuals entering hibernation in the fall and emerging from hibernation in the spring may be particularly vulnerable. With the exception of hibernating sites in Ecological Reserves or Provincial Parks, these areas are not currently protected. While there is a market for the meat, leather and venom of this species, it is not currently threatened by commercial exploitation in British Columbia (Orchard 1984). The potential for over-harvesting does exist at these sites, however, as large numbers of individuals (up to several hundred) may be collected at one time. The Wildlife Branch of the British Columbia Ministry of Environment, Lands and Parks has received one application for a permit to harvest 300 to 400 individuals from a den site near Grand Forks (C. Dodd, pers. comm.). The Wildlife Act (1982) protects all wildlife species from this type of wholesale collection or killing, and the permit was refused (*ibid.*).

Protection of critical habitat — One of the main problems in protection of critical habitat lies in identification of these areas, and determination of the degree to which they are limited within the range of *C. v. oreganus*. Once important den sites are located, for example, measures could be taken to protect these sites specifically. If these areas are located on private land, legislation may be necessary to restrict development and/or human disturbance. Alternatively, attempts could be made by the government or private organizations to acquire the land.

Vegetation cover appears to be an important component of the summer range (Macartney 1985), so land-clearing for logging or agricultural purposes should be carefully monitored in areas where the availability of suitable summer habitat may be limited. Areas of standing trees around hibernation sites should also be maintained, to prevent excessive moisture loss from the substrate due to an increase in evaporation rates (Herrington 1988).

DISTRIBUTION

The Western Rattlesnake (*Crotalus viridis*) is one of the most widely distributed rattlesnakes in western North America. The Northern Pacific Rattlesnake (*C. v. oreganus*) is one of eight subspecies (Stebbins 1985) and has a range extending from southern British Columbia to central California (Fig. 1). Within British Columbia the range of *C. v. oreganus* is restricted to the dry interior (Fig. 2).

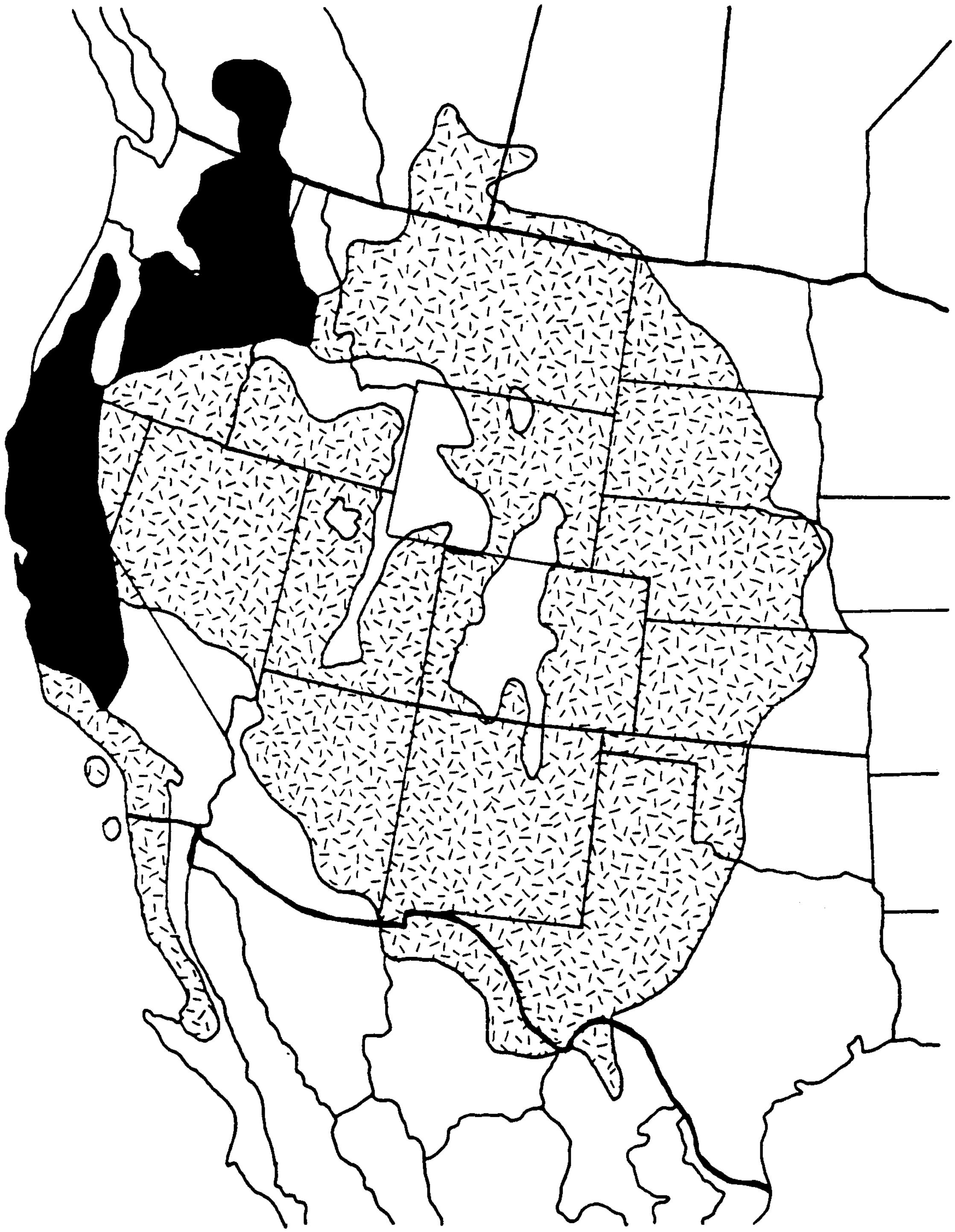

Figure 1. The distribution of *Crotalus viridis* in North America, showing the range of *C. v. oreganus* and all other subspecies combined (stippled area). Map after Stebbins (1985).

Figure 2. Dot localities for *C. v. oreganus* in British Columbia (redrawn from Orchard 1984).

POPULATION SIZE AND TRENDS

At the present time we lack the information necessary to estimate actual numbers of individuals of this species in the province. Given the relatively restricted distribution of *C. viridis* in British Columbia, and the amount of development that has taken place within its range, there has likely been considerable reduction from former numbers. Overall population trends, however, are unknown.

Macartney (1985) found that the number of adults at winter dens in the Vernon area was fairly constant, suggesting stable populations. However, when he constructed a life table for *C. v. oreganus* it suggested that the population was in decline. The discrepancy is likely due to the difficulty of obtaining accurate measurements of survivorship of very young snakes. These problems in determining population trends for a single intensively studied population of *C. v. oreganus* highlight the difficulties associated with making any type of generalization for this species in British Columbia. Local populations throughout the species' range in British Columbia must be studied over several years to determine long-term population trends.

LEGAL PROTECTION

Rattlesnakes are currently designated as wildlife in British Columbia, and as such come under protection of the Wildlife Act (1982). This Act prohibits the collection or killing of wildlife, except where they are a menace. However, Section 27(2) of the Wildlife Act allows wildlife to be killed for the protection of life or property. For many people, the mere proximity of a venomous snake may be perceived as a threat to life. Consequently, there appears to be little hope of effective enforcement of the Act with respect to rattlesnakes, because any dead snake can be claimed to have been a threat. This situation is likely a common one. People encountering rattlesnakes on paths will often kill them because of the perceived threat, even when they could easily have walked around the animal (M.B. Charland, pers. obs.). Rattlesnakes receive the same protection as any other form of wildlife in the province. However, the public perception of the threat posed by a venomous snake, combined with the provisions of Section 27(2) of the Wildlife Act, suggest that rattlesnakes will suffer from continued persecution, although not on the scale previously reported.

LIMITING FACTORS

The limited range of *C. v. oreganus* coincides to a considerable degree with some of the fastest developing agricultural and residential areas in the province (see section **Habitat - Habitat Trends**). It seems likely that this overlap will lead to a decrease in rattlesnake numbers, at least near the valley floors, but we have no data on the degree of impact. Although development itself may still leave potentially suitable habitat for *C. v. oreganus*, the associated increase in encounters with humans is likely to have a negative impact (see sections **General Biology - Specialization and Adaptability**, and **Legal Protection**). Factors that limit or regulate sizes of populations of *C. v. oreganus* are not known. In general, the relative importance of population-limiting factors cannot be judged without additional data on population levels and their trends. Detailed information of this sort is not available for any one population of *C. v. oreganus* in British Columbia.

SPECIAL SIGNIFICANCE OF THE SPECIES

Rattlesnakes in British Columbia are not currently exploited for commercial purposes. However, because they prey on rodents, they may have a significant role in influencing rodent populations. Consequently, they may be important in agricultural areas where the potential for rodent damage to crops is high, but this has not been studied. Elsewhere in North America, rattlesnakes are used commercially in a number of ways. Probably the most important commercial product of rattlesnakes is their venom. Rattlesnake venom is composed of a large number of compounds, each with a specific biological action. These compounds can be separated out and employed in a number of medical and research procedures. Because rattlesnakes are expensive to keep and the yield of venom declines rapidly with repeated "milking", the commercial production of rattlesnake venom relies on a steady supply of animals from the wild (Klauber 1972).

Rattlesnakes are also hunted commercially for their skins, which are used for making boots, belts, hat bands, and other largely ornamental items. However, the market for rattlesnake leather has never been a large one because of the relatively small size of the animals and the fragility of the skin (*ibid.*). Also associated with the commercial hunt is a small market for rattlesnake meat, primarily for use in specialty restaurants.

Public interest in rattlesnakes is considerable in areas where they occur. This interest is common both to people who are fascinated by snakes and to those who dislike them. The first group is driven by curiosity, while the second group seeks to know something about the animal in order to avoid encounters. Most people have heard of rattlesnakes, but relatively few have actually seen them in the wild. People do not generally go out of their way to look for rattlesnakes, but if they see one it is an exciting experience. As a consequence, *C. v. oreganus* may represent a "spectacular" species from a public relations perspective. It may be possible, through education, to change the perception that an encounter with a rattlesnake is a negative experience and instead make it a positive opportunity.

RECOMMENDATIONS / MANAGEMENT OPTIONS

Virtually all of the information we have on *C. v. oreganus* in British Columbia comes from two studies conducted near Vernon (Macartney 1985, Charland 1987). We need additional detailed studies of all aspects of the biology of this species from other parts of its range in the province. However, from a management perspective one of the most critical concerns should be to identify hibernacula in as many areas as possible. Most aspects of the life history of *C. v. oreganus* center around the winter den site and any management initiatives should start there. In addition, long term population monitoring should be conducted at as many dens as possible, in as many parts of the range in British Columbia as possible, in order to gain an understanding of overall population trends. The fact that *C. v. oreganus* dens communally and is concentrated at the den site in the spring and fall affords an opportunity to collect population data relatively easily. This can be accomplished through brief (i.e. one week) visits to the den during the spring and fall to mark and enumerate snakes. **However, care should be taken to minimize the impact of visits to these dens and it will be important that the actual locations of the dens not become widely known (in order to protect an inquisitive but sometimes careless public but also to protect the animals from exploitation.)**

In addition to locating winter den sites, it is important to obtain detailed information on the patterns of habitat use by *C. v. oreganus*. Critical components of the habitat (i.e. good basking sites, shelter rocks) need to be identified so that the impact of habitat changes can be assessed more accurately. The most efficient way to collect this type of information is through radiotelemetry studies, where individual snakes can be located repeatedly throughout the active season. These locations can be used as habitat sampling points to collect information on habitat use (Reinert 1984a, 1984b; Weatherhead and Charland 1985). Capture data alone may provide a biased picture of habitat use, as snakes will be found primarily in areas that are readily accessible, or where they are most visible (Weatherhead and Charland 1985). Data on habitat preference are incomplete without corresponding information on the patterns of movement that underlie them. Radiotelemetry also affords an opportunity to quantify movement patterns of individuals. This type of information will be important in making informed management decisions by identifying both the habitat requirements and the spatial scale over which these resources are spread.

Although further research on many aspects of the biology of *C. v. oreganus* in B.C. is required, another vital component of a management plan for this species will have to be public education. Snakes rank very low in the esteem of the general public and the situation is even less favourable for venomous species. Despite this, there is evidence that an investment in public education can promote tolerance, if not affection. Research on the biology of *C. v. oreganus* was conducted by Macartney (1985) and Charland (1987) on Coldstream Ranch near Vernon, B.C. As a result of this work, employees of the ranch became quite interested in the rattlesnakes that lived there, frequently asking questions about the histories of particular individuals that they may have caught or seen (M.B. Charland, pers. obs.). A similar situation occurred with the highways crew doing road construction in the vicinity of a winter den site (see section **General Biology - Specialization and Adaptability**). These individuals would report sightings of snakes in the vicinity and express a genuine interest in the animals (M.B. Charland, pers. obs.). To a large extent, this can be attributed to demystifying the rattlesnake for these people. After being exposed to rattlesnakes through talks and demonstrations in which they can see snakes being handled competently and safely, people come to realize that rattlesnakes are not terrifying and unreasonably dangerous. Rather they begin to see them as interesting, but relatively small, members of the local wildlife which although potentially dangerous, should be respected and not feared.

In summary, our major recommendations are:

1) identify as many hibernacula as possible throughout the range of *C. v. oreganus* in British Columbia;
2) conduct long-term population monitoring at as many of these dens as possible, from as many parts of the range in British Columbia as possible;
3) obtain detailed information on habitat use and movement patterns of individuals; and
4) implement public education programs.

EVALUATION

At present, we are unable to give any estimate of *C. v. oreganus* population size or trends in British Columbia. There have been only two detailed studies of this species in the province and both were conducted at the same site. It is clear from these studies, however, that there is considerable variation in life history parameters among denning populations and among years, suggesting that studies from other sites within the range of the species range in British Columbia are required before generalities emerge. Considerable intersite variation in ecology and life history has been observed for other snakes in British Columbia (P.T. Gregory, pers. comm.).

The range of *C. v. oreganus* in British Columbia corresponds, in large part, with areas that are undergoing rapid development and increased human activity. It seems likely that this situation cannot help but have a negative impact on rattlesnake populations, if such is not already the case. Rattlesnakes are vulnerable to this kind of pressure for a number of reasons. Winter dens are discrete sites used by the same individuals over their entire lifetimes, with very little tendency to switch dens. These dens appear to be traditional sites that have been in constant use for many generations. In addition, all summer movements are restricted by the need to return to the original den site in fall. Hence, the potential habitat available to snakes from a given den is limited by both the maximum distance moved from the den and by traditional routes of dispersal. Disruptions of the limited habitat actually available to snakes, or of dispersal routes, may render a den unusable in spite of apparently suitable habitat in the area. Rattlesnake populations in British Columbia are additionally vulnerable because of slow growth rates of individuals, delayed sexual maturity, and infrequent reproduction by females.

Despite the rattlesnake's poor public image, it appears that public education offers a real management opportunity. The general public needs to be shown that rattlesnakes are simply small predators, rather than mythic monsters, and should be viewed as interesting members of the local wildlife. This can be accomplished through public presentations and published material. However, it is important that the public have an opportunity to see live rattlesnakes under controlled conditions and realize that they are rather retiring animals that only pose a danger when threatened or accidentally disturbed.

Rattlesnakes are a relatively high profile species where they occur in British Columbia and it appears likely that they will be increasingly required to share their restricted range with people. As a consequence, it is very important to know more about this species simply to be able to determine whether populations are increasing, decreasing, or are relatively stable. Without this basic information it will be impossible to construct useable management plans that will both maintain populations and reduce potentially dangerous interactions with people.

The northern Pacific Rattlesnake should be considered vulnerable and retained on the Blue List.

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