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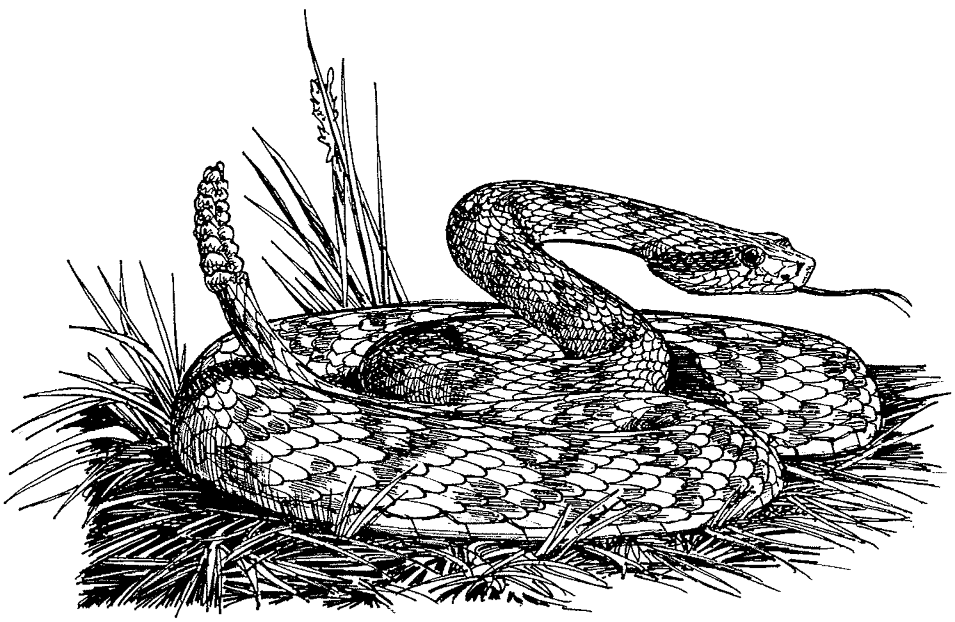
Status of the Prairie Rattlesnake (*Crotalus viridis*) in Alberta:

Update 2012



Alberta Wildlife Status Report No. 6 (Update 2012)

Alberta Conservation Association

Alberta Government

Status of the Prairie Rattlesnake (*Crotalus viridis*) in Alberta:

Update 2012

Prepared for:
Alberta Environment and Sustainable Resource Development (ESRD)
Alberta Conservation Association (ACA)

Update prepared by:
Kelley J. Kissner

Much of the original work contained in the report was prepared by Sheri M. Watson and Anthony P. Russell in 1997.

This report has been reviewed, revised, and edited prior to publication. It is an ESRD/ACA working document that will be revised and updated periodically.

Alberta Wildlife Status Report No. 6 (Update 2012)

December 2012

Published By:

Publication No. T/275
ISBN No. 978-1-4601-0311-1 (On-line Edition)
ISSN: 1206-4912 (Printed Edition)
ISSN: 1499-4682 (On-line Edition)

Series Editors: Sue Peters, Robin Gutsell, and Shevenell Webb
Illustrations: Brian Huffman
Maps: Darren Bender

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This publication may be cited as:

Alberta Environment and Sustainable Resource Development and Alberta Conservation Association. 2012. Status of the Prairie Rattlesnake (*Crotalus viridis*) in Alberta: Update 2012. Alberta Environment and Sustainable Resource Development. Alberta Wildlife Status Report No. 6 (Update 2012). Edmonton, AB. 49 pp.

PREFACE

Every five years, Alberta Environment and Sustainable Resource Development reviews the general status of wildlife species in Alberta. These overviews, which have been conducted in 1991 (*The Status of Alberta Wildlife*), 1996 (*The Status of Alberta Wildlife*), 2000 (*The General Status of Alberta Wild Species 2000*), 2005 (*The General Status of Alberta Wild Species 2005*), and 2010 (*The General Status of Alberta Wild Species 2010*), assign individual species "ranks" that reflect the perceived level of risk to populations that occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily available sources of population data. A key objective of these reviews is to identify species that may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the general status exercise, and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are *At Risk* or *May Be At Risk* in the province, that are of uncertain status (*Undetermined*), or that are considered to be at risk at a national level by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Reports in this series are published and distributed by Alberta Conservation Association and Alberta Environment and Sustainable Resource Development. They are intended to provide detailed and up-to-date information that will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide current information that will assist Alberta's Endangered Species Conservation Committee in identifying species that may be formally designated as *Endangered* or *Threatened* under Alberta's *Wildlife Act*. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

EXECUTIVE SUMMARY

A review of the status of the prairie rattlesnake (*Crotalus viridis*) in 2000 resulted in the species being designated as *Data Deficient* in Alberta. The *General Status of Alberta Wild Species 2010* ranks the species as *May Be At Risk* in the province, given the many threats to the species and its habitat. Since the initial provincial status assessment of this species in 2000, there have been additional surveys and research projects that have increased knowledge about its abundance and distribution in Alberta. This report summarizes historical and recent information on the prairie rattlesnake in Alberta as background information for a reassessment of its status in the province.

The prairie rattlesnake reaches the northern limit of its range in Alberta. It is primarily distributed along major river drainages in the southeastern portion of the province. Historically, the species was found as far north as Trochu, and almost as far west as Calgary. The range of the species appears to have contracted toward the east and south sometime prior to the 1960s, but seems to have remained largely unchanged since that time.

There appears to have been a long-term decline in abundance of this species in the province, likely related to significant historical persecution and habitat loss. However, in some areas of the province (e.g., Dinosaur Provincial Park) there is evidence that the species has rebounded or has remained stable over the last several decades. There is evidence for more recent declines of several overwintering populations, possibly related to increasing industrial development and associated traffic. Most hibernacula in Alberta likely contain fewer than 100 mature snakes.

The species has low reproductive capacity because of late maturity, small litter sizes, biennial or triennial reproduction and low juvenile survival. These factors make the species slow to recover from population declines. The primary factor that has the greatest influence on prairie rattlesnake abundance and distribution is land use: agriculture, urban, energy and road developments result in loss, degradation and/or fragmentation of prairie habitat and expose rattlesnakes to direct and indirect sources of mortality. A number of initiatives underway in the province will continue to enhance knowledge of prairie rattlesnake distribution and abundance, mitigate some effects of development on the species, and help improve public perception of the species.

ACKNOWLEDGEMENTS

For the original 1997 report prepared by Sheri M. Watson and Anthony P. Russell:
A number of individuals made significant contributions to the successful completion of this report. Although all assistance was deeply appreciated, a few individuals deserve special consideration. We are greatly indebted to Larry Powell for his counsel, for generously providing information, and for critically reviewing earlier drafts of this manuscript. We are also grateful to Dave Prescott and Steve Brechtel (Alberta Natural Resources Service), Andy Didiuk (Canadian Wildlife Service), and Dave Scobie (Operation Grassland Community) for reviewing the first draft of the manuscript; their comments and insights were very much appreciated. We also thank Delinda Ryerson (Alberta Natural Resources Service) for editorial assistance, and Jane Horb for drafting the maps. Also, special thanks to Graham MacGregor for his support and constant encouragement. Production of this report was supported by the Wildlife Management Enhancement Fund of Alberta Natural Resources Service and the Alberta Conservation Association.

Information for this report was gathered from a number of sources, and we would like to acknowledge those individuals and agencies who contributed information, both directly or indirectly. Contributors denoted with an asterisk (*) provided records used for determining the current range (see Figure 1). The following individuals are listed alphabetically, but deserve equal consideration: Robert Barclay (University of Calgary), Steve Brechtel (Alberta Natural Resources Service), Doug Collister (URSUS Ecosystem Management Ltd.), Dave Crooks (Dinosaur Provincial Park), Adrien Corbiere (Lethbridge Naturalists' Society), Ann Dalton (Montana Natural Heritage Program), Jane Danis, Andrew Didiuk* (Canadian Wildlife Service), Dale Eslinger* (Alberta Natural Resources Service, Medicine Hat), Express Pipeline Ltd., Pat Fargey (Parks Canada), Laura Friis (B.C. Environment, Wildlife Branch), David Genter (Montana Natural Heritage Program), Joyce Gould (Alberta Natural Resources Service), Wayne Harris (Saskatchewan Fish and Wildlife), Mike Hauser (Express Pipeline Ltd.), Ed Hofman* (Alberta Natural Resources Service, Hanna), Robert Hugill (Dinosaur Provincial Park), Andy Hurley (University of Lethbridge), Janice James* (University of Calgary), Ann Lane* (Royal Tyrrell Museum), Rick Lauzon* (DELTA/AXYS Environmental Management Group Ltd.), Lethbridge Naturalists' Society*, Rob Morrison (Alberta Natural Resources Service, Foremost), National Museum of Canada*, Larry Powell* (University of Calgary), Wayne Roberts* (University of Alberta Museum), Edward Ruff, Reg Russell (Alberta Natural Resources Service, Brooks), Delinda Ryerson* (Alberta Snake Hibernaculum Inventory), Elizabeth Saunders* (Helen Schuler Coulee Centre), Dave Scobie (Operation Grassland Community), Paulette Shields* (Alberta Natural Resources Service, Lethbridge), Simon Shonhofer (Majestic Ranch), Wayne Smith*, Howard Troughton* (Palliser Pipeline Project), Cliff Wallis (Cottonwood Consultants Ltd.), Robert Ward* (Writing on Stone Provincial Park), Earl Wiltse (Saskatchewan Environment and Resource Management), Robert Wolfe (Alberta Environmental Protection), and the University of Calgary Map Department.

For the 2012 update prepared by Kelley J. Kissner:
This report benefited greatly from the contributions of many individuals who provided data and other information for the report, and who engaged in many thoughtful discussions about the species. In alphabetical order, I thank Corey Anderson (Valdosta State University), Wonnita Andrus (University of Lethbridge), Darren Bender (University of Calgary), Lonnie Bilyk

(Alberta Environment and Sustainable Resource Development [ESRD]), Ron Brooks (COSEWIC), Kristen Campbell (Cenovus), Doug Collister (Accipiter Ecological Management), Andrew Didiuk (Canadian Wildlife Service), Robin Digby (Atlas Coal Mine Museum), Brandy Downey (ESRD), Reg Ernst (Lethbridge Rattlesnake Conservation Program), Dale Eslinger (ESRD, Medicine Hat), Pat Fargey (Parks Canada), Dan Fogell (Southeast Community College), Eleanor Gillespie, Robin Gutsell (ESRD), Gavin Hanke (Royal British Columbia Museum), Ed Hofman (ESRD), Dennis Jørgensen (World Wildlife Fund), Kris Kendell (Alberta Conservation Association), Ian Kriston (Royal Alberta Museum), Ross MacCulloch (Royal Ontario Museum), Adam Martinson (AJM Environmental), Bonnie Moffet (Writing-on-Stone Provincial Park), Rob Morrison (ESRD), Joel Nicholson (ESRD), Cynthia Paszkowski (University of Alberta Museum), Jeanette Pepper (Saskatchewan Environment), Sue Peters (Alberta Conservation Association), Ray Poulin (Royal Saskatchewan Museum), Larry Powell (University of Calgary), Coreen Putnam (Helen Schuler Coulee Centre), Tim Schowalter (independent consultant), Brent Smith (Canadian Forces Base Suffield), Michèle Steigerwald (Canadian Museum of Nature), Mark Steinhilber (Royal Alberta Museum), Benjamin Taylor (Canadian Forces Base Suffield), Drajs Vujnovic (Alberta Tourism, Parks and Recreation), and Jonathan Wright (independent consultant).

I also thank Darren Bender, Sue Peters, Robin Gutsell, and three reviewers for providing editorial comments on earlier drafts of this work that greatly improved the final product. I also thank Darren Bender for producing the maps used in this report.

Preparation of this updated report was funded by Alberta Conservation Association and Alberta Environment and Sustainable Resource Development.

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INTRODUCTION

The prairie rattlesnake, *Crotalus viridis*, is one of three extant species of rattlesnakes in Canada and the only species of rattlesnake found in Alberta (Behler and King 1979, Crother 2008, Russell and Bauer 1993). An assessment of this species' status in Alberta in 2000 resulted in a status designation of *Data Deficient**, indicating there was insufficient information on the species to determine its status in the province (Alberta Endangered Species Conservation Committee 2000). However, given many threats to the species and its habitat, it is ranked as *May Be At Risk* in the province according to the *General Status of Alberta Wild Species 2010* (Alberta Sustainable Resource Development 2011). In Canada, the prairie rattlesnake also occurs in Saskatchewan where it is ranked as S3, indicating that it is vulnerable to extirpation (Saskatchewan Conservation Data Centre 2011). The prairie rattlesnake has not been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), but it has been identified as being high priority for assessment (COSEWIC 2011). It is expected that a national status report for this species should be developed within the next two years, after which the species' status will be formally assessed (R. Brooks pers. comm.). Across much of the United States, this species is ranked as S5 (*Secure*) or S4 (*Apparently Secure*), except in Iowa where it is ranked as S1 (*Critically Imperiled*) and is protected as an *Endangered* animal, in Oklahoma where it is ranked as S3 (*Vulnerable*), and in North Dakota where its status has not been determined (Iowa Administrative Code 2011, NatureServe 2010).

Since the initial provincial status assessment of the prairie rattlesnake in 2000, there have been additional surveys and research projects on this species that have increased knowledge about its abundance and distribution in Alberta, including estimates of the size of some overwintering populations and additional investigations into how anthropogenic factors may limit rattlesnake abundance and distribution. This report summarizes historical and recent information on the prairie rattlesnake in Alberta as background information for a reassessment of its status in Alberta.

SPECIES TAXONOMY

In the 1997 edition of this report, the prairie rattlesnake was identified as *C. viridis viridis*, one of eight subspecies of the western rattlesnake (*C. viridis*). Recent molecular studies have led to a revision in the taxonomy of the western rattlesnake and its subspecies, including the prairie rattlesnake (Ashton and de Queiroz 2001, Douglas et al. 2002, Pook et al. 2000). Currently, the prairie rattlesnake is considered to be a distinct species from the western rattlesnake, and the two species are now named *C. viridis* and *C. oreganus*, respectively (Crother 2008). In Canada, *C. oreganus* occurs in British Columbia and was previously considered as *C. viridis oreganus*.

DISTRIBUTION

1. Alberta - The distribution of *C. viridis* is closely associated with major rivers in southern Alberta because these areas provide suitable habitat for hibernation sites (Cottonwood Consultants 1987, Gannon 1978, Pendlebury 1977). The majority of records from Alberta occur along the South Saskatchewan River drainage (including the South Saskatchewan, Red Deer, Bow, and Oldman rivers) and the Missouri River drainage, which includes the Milk River (Gannon 1978). Away from the river valleys, the occurrence and relative abundance of *C. viridis* decrease. The prairie rattlesnake's close association with rivers and coulees limits the ability of this species to expand its range.

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* See Appendix 1 for definitions of selected status designations.

A map of the current and historical distribution of *C. viridis* in Alberta is provided in Figure 1. Examination of records collected since 1980, which correspond to approximately the three most recent generations for this species (for details on generation length, see Conservation Biology section), shows that the current distribution of snakes appears to be largely continuous along the river valleys of southeastern Alberta (Figure 1). Possible exceptions to this continuity are records at Drumheller, which occur approximately 70 km from the next observation of rattlesnakes along the Red Deer River (one observation of two snakes near Hutton) and over 100 km from multiple observations in Dinosaur Provincial Park (DPP). Local residents report rattlesnakes several kilometres upstream of Finnegan, and indicate that the species has been present (but fairly uncommon) around this area at least since the mid-1950s (E. Gillespie pers. comm., E. Hofman pers. comm.). However, residents further north along the river at East Coulee and Dorothy report no encounters with rattlesnakes, and no local knowledge of the species occurring in these areas (R. Digby pers. comm., J. Wright pers. comm.). This apparent remaining gap in distribution between Finnegan and Drumheller makes the origin of snakes at Drumheller puzzling, since the river valley would be the most obvious dispersal route for snakes to reach Drumheller. Habitat around Drumheller appears suitable for rattlesnakes (E. Hofman pers. comm.) and the historical range of the species apparently extended north of Drumheller to Trochu (historical data in Pendlebury 1977), suggesting it is possible that there could be a remnant historical population of snakes at Drumheller that survived the contraction of the species' range. However, no rattlesnake hibernacula have been identified near Drumheller by resource managers and researchers familiar with this area (E. Hofman pers. comm., J. Wright pers. comm.), nor have rattlesnakes been observed at hibernacula near Drumheller used by bullsnakes (*Pituophis catenifer sayi*), which often hibernate communally with rattlesnakes (J. Wright pers. comm.). Local opinion is that rattlesnakes have been accidentally transported to Drumheller (e.g., on vehicles) and that the Drumheller records most likely represent incidental observations from such translocations (E. Hofman pers. comm., T. Schowalter pers. comm., J. Wright pers. comm.). Some local reports at Drumheller also likely involve misidentification of the species, since bullsnakes are more common around Drumheller and are often misidentified as rattlesnakes (J. Wright pers. comm.). Thus, based on local knowledge of the area, there is no evidence for a local (resident) population of rattlesnakes at or near Drumheller, and it appears that the distribution of rattlesnakes along the Red Deer River may not extend much further north than Finnegan. However, additional surveys could be conducted between Finnegan and Drumheller to verify this conclusion.

The historical distribution of *C. viridis* in Alberta is also shown in Figure 1 (triangle symbols denoting records between 1894 and 1979). It is evident from the map that the distribution of prairie rattlesnakes was formerly more extensive in the province. Historically, the distribution of this species apparently extended northwest along the Red Deer River valley to Trochu, as well as along the Bow River drainage almost as far west as Calgary (Pendlebury 1977, Russell and Bauer 1993). Pendlebury (1977) first noted a range contraction for this species in his examination of its historical distribution (prior to 1958) and current distribution at the time (1958–1977). Pendlebury's description of prairie rattlesnake distribution (1958–1977, shown as the dashed boundary in Figure 1) is remarkably similar to the current range of this species in the province (1980–2011). Thus, it appears that the significant decline in the range of this species occurred prior to the 1960s and does not appear to have continued to the present day. It is noteworthy that the turn of the 20th century marked the beginning of significant cultivation

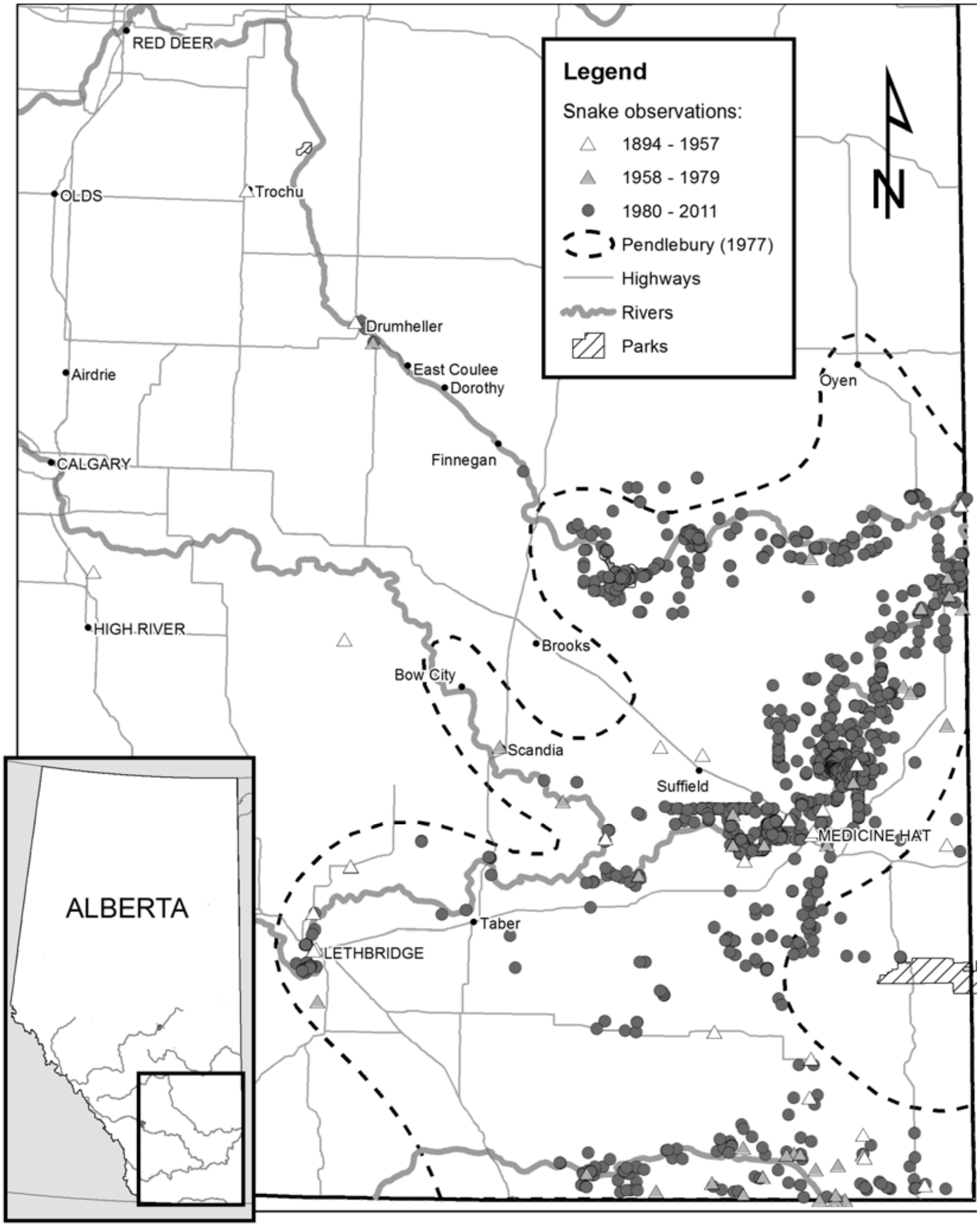

Figure 1. Recent (1980 to 2011) and historical (1894 to 1979) records of prairie rattlesnakes in Alberta. Historical records are divided into two groups (1894 to 1958 and 1959 to 1979) to correspond to the evaluation of the species' range undertaken by Pendlebury (1977). The dashed line denotes the species' range current as of 1977 (based on records between 1959 to 1977, Pendlebury 1977) and is provided to illustrate where contractions of the species' range may have occurred since 1977. Observation data were compiled from researchers, professional biologists, museum records and the provincial Fish and Wildlife Management Information System database.

of the prairies that continued for several decades (Alberta Environmental Protection 1997), which likely contributed to the reduction in the range of rattlesnakes before 1960.

A comparison of Pendlebury's description of prairie rattlesnake distribution (1958–1977, area denoted by dashed line in Figure 1) with the current distribution of snakes (circles denoting records between 1980–2011, Figure 1) indicates several areas where some recent, smaller declines in distribution may have occurred. In particular, there appears to be some contraction of the species' range along the Bow River around Bow City and Scandia, and west of Suffield along Highway 1. The range provided by Pendlebury (1977) also includes observations directly south of Lethbridge along Highway 4 all the way to the Milk River, which are no longer evident in the current distribution. The range provided by Pendlebury (1977) also extends from the Red Deer River valley as far north as Oyen, although no recent observations of this species have been made near Oyen and the study by Pendlebury (1977) includes only one record near Oyen. Given the possibility for accidental translocation or misidentification of the species, caution should be applied in attributing a range contraction at Oyen based on this single observation.

The current extent of occurrence of *C. viridis* in Alberta, measured using a minimum convex polygon that encompasses all observations of rattlesnakes collected between 1980 and 2011, is 46 012 km^2. Habitat used for overwintering (hibernacula) provides the most biologically relevant estimate of the species' area of occupancy, since habitat used for overwintering represents the smallest area of habitat essential to the species during its life history and without this habitat the species could not persist. The index of area of occupancy (IAO) of hibernacula is 496 km^2 based on occupancy in a 2-km x 2-km grid, using locations of 192 hibernacula in the province (see Population Size and Trends section regarding the estimated number of hibernacula). However, most hibernacula are small (much less than 4 km^2 and often much less than 0.25 km^2), so the biological area of occupancy (BAO) for the species would be smaller than a value of 42 km^2 (calculated from occupancy in a 0.5-km x 0.5-km grid). Note that similar calculations could be made for habitat used for birthing sites (rookeries), given that they represent an important habitat feature required for reproduction of the species. However, limited data on the number and location of rookeries in the province precludes calculations of IAO and BAO for rookery habitat at this time. Less than 5% of the global range of *C. viridis* occurs in Alberta.

The structure of the rattlesnake population in Alberta is largely unknown. The distribution of rattlesnakes appears to be largely continuous along the two river drainages in southeastern Alberta (Figure 1). Thus, within each drainage, snakes from neighbouring hibernacula likely interact. Isolation could occur if the distance between neighbouring hibernacula exceeds the migration capability of Alberta rattlesnakes, which is estimated to be 25 km–30 km (Didiuk 1999, 2003). Although it has not been studied, it is also plausible that snakes inhabiting hibernacula along the South Saskatchewan drainage and Missouri River (Milk River) drainage may be interacting, given that there are near continuous observations between the two drainages (the two closest observations are only 19 km apart, Figure 1). It is also likely that some snakes from Alberta interact with snakes from Montana; for example, those along the Milk River.

Potential barriers to gene flow could include the cities of Medicine Hat and Lethbridge and major highways such as the Trans-Canada Highway, although there is little evidence of this to date. One study of two pairs of overwintering populations located on opposite sites of Medicine Hat and the Trans-Canada Highway provided little evidence for genetic differentiation among these groups (Weyer

2009, Weyer et al. in prep., C. Anderson pers. comm.). Overall, genetic diversity was high within and among overwintering populations and was comparable to the level of diversity observed in other rattlesnake species (Weyer et al. in prep., C. Anderson pers. comm.). However, the isolating effects of these developments may have occurred too recently for genetic effects to be detected (C. Anderson pers. comm.). Rattlesnakes do not appear to avoid crossing roads, despite these features being high sources of mortality (see Habitat and Limiting Factors section). Thus, roads are not barriers to gene flow, but they do reduce it through mortality. Rattlesnakes rarely cross rivers (Andrus 2010, Jørgensen 2009), so these features act as partial barriers to movement and gene flow. Occasional crossings do occur, and these crossings may also result in snakes being transported downstream (Andrus 2010, Jørgensen 2009, Jørgensen and Gates 2007). Thus, these infrequent crossings may provide opportunities for interaction.

There is some suggestion that rattlesnakes within the city of Lethbridge are becoming isolated (Ernst and Quinlan 2006). Currently, habitat for snakes in Lethbridge is largely surrounded by residential developments, roads and other human-dominated areas such as golf courses (Andrus 2010, Ernst and Quinlan 2006). Increasing development in and around Lethbridge has largely removed dispersal corridors for snakes that might allow interaction with other local populations along the Oldman River (Ernst and Quinlan 2006). If development continues to encroach on remaining habitat and remove remaining dispersal corridors for snakes in Lethbridge, it is likely that snakes will become isolated and eventually will be extirpated as a result of habitat loss, human-induced mortality and elimination of any chance for local rescue.

2. Other Areas - The range of *C. viridis* in North America (Figure 2) encompasses the area from southeastern Alberta and southwestern Saskatchewan through the central United States including Montana, Idaho, Wyoming, Colorado, Utah, extreme southeastern Arizona, New Mexico, North Dakota, South Dakota, extreme western Iowa, Nebraska, central Kansas, central Oklahoma, and western and central Texas to the northern tip of Mexico (Campbell and Lamar 2004, Conant 1975, Klauber 1956, NatureServe 2010, Stebbins 2003). However, within this area, prairie rattlesnake distribution may be quite fragmented (Russell and Bauer 1993).

In Saskatchewan, the range of the prairie rattlesnake consists of two disjunct areas separated by approximately 150 km (Pendlebury 1977). The southern portion is associated with the lower reaches of the Frenchman River to a point about 14 km north of Val Marie (Pendlebury 1977, A. Didiuk pers. comm., R. Poulin pers. comm.), whereas the northern portion extends from the Alberta-Saskatchewan border along the South Saskatchewan River drainage to a point south of Eatonia (Pendlebury 1977).

HABITAT

In Alberta, prairie rattlesnake distribution overlaps the Grassland Natural Region, primarily the Dry Mixedgrass and Mixedgrass subregions (Natural Regions Committee 2006). The semi-arid climate of the prairie grasslands in southeastern Alberta is characterized by low precipitation, high summer temperatures, a short growing season, and cold winters (Anonymous 1994, Coupland 1961, Natural Regions Committee 2006). Habitat for the prairie rattlesnake is often associated with river and coulee bottoms, badlands, sage flats, and upland prairie grasslands surrounding these features (Halladay 1965, Lewin 1963, Russell and Bauer 1993).

1. Overwintering Habitat - A critical component of prairie rattlesnake habitat in northern climates relates to the availability of

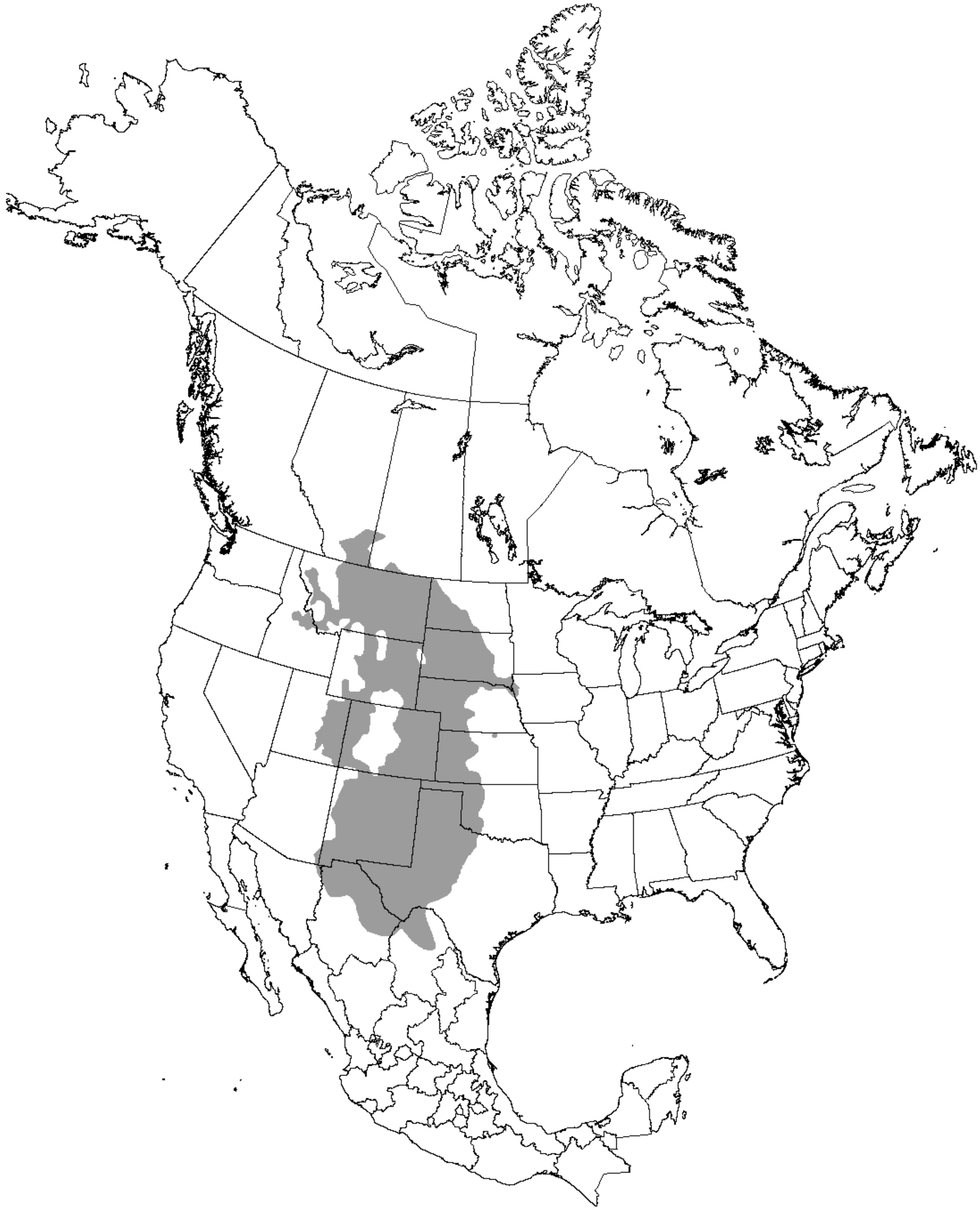

Figure 2. Distribution of the prairie rattlesnake in North America. Modified from NatureServe 2010 (Canada and United States) and Stebbins 2003 (Mexico).

hibernacula that allow the snakes to survive the long, cold winters (Blood 1993, Gannon 1978, Macartney and Weichel 1989). The majority of hibernacula in Alberta occur along major river drainages (South Saskatchewan, Red Deer, Bow, Oldman and Milk rivers) (Gannon 1978), but some hibernacula have been documented along small creek complexes with associated coulees (J. Nicholson pers. comm.). Gannon (1978) surveyed habitat surrounding prairie rattlesnake hibernacula (overwintering dens) in Alberta and Saskatchewan and found that it consistently encompassed both a river valley and the surrounding prairie, although local topography and vegetation varied among sites. Areas of slumped glacial deposits, meander scarps (remnants of water channels), fissures, subterranean water channels (dry), sinkholes, rocky outcrops, and abandoned mammal burrows have all been found to provide suitable conditions for hibernacula in Alberta (Andrus 2010, Cottonwood Consultants 1987, Didiuk 1999, Fast 2003, Gannon 1978, Russell and Bauer 1993). Hibernacula typically occur on slopes with southern or eastern exposures, which provide maximum exposure to the sun and offer protection from prevailing winds (Cottonwood Consultants 1987, Didiuk 1999, Fast 2003, Gannon 1978, Macartney et al. 1990). Hibernacula also may occur on slopes with other aspects, even predominantly northern aspects (Andrus 2010, Cottonwood Consultants 1987, Didiuk 1999), although these sites appear to also include microsites where snakes can bask (Didiuk 1999).

Prairie rattlesnakes den communally, often in large numbers, and hibernacula are generally shared with other species such as bullsnakes and garter snakes (*Thamnophis* spp.) (Cottonwood Consultants 1987, Didiuk 1999, Ernst 2003, 2004, Fast 2003, Russell and Bauer 1993). The typical lifespan of a snake hibernaculum is not known, but it is likely to vary with factors such as slope stability and exposure to environmental factors (Didiuk 1999). Some of the oldest known hibernacula in Alberta were initially reported in the 1940s and 1950s and remain active (Cottonwood Consultants 1987, Kissner 2011, Kissner and Nicholson 2003).

A variety of methods have been used to construct predictive models for identifying areas of suitable habitat for snake hibernacula in Alberta (Didiuk 1999, Fast 2003, Kissner 2004, Nicholson and Rose 2001, Wolfe and Watke 1997). Models exist for areas of the South Saskatchewan River north of Medicine Hat (roughly the east side of the river within the Suffield National Wildlife Area (SNWA) and a similar area on the west side of the river across from Canadian Forces Base Suffield) (Didiuk 1999, Fast 2003, Nicholson and Rose 2001, Wolfe and Watke 1997), as well as the Milk River drainage (Kissner 2004). Field validation of some of these models indicates that they are generally useful for predicting where hibernacula are likely to occur on the landscape (Didiuk 1999, Fast 2003, Nicholson and Rose 2001). However, hibernacula may occasionally occur in areas identified as having low suitability (Didiuk 1999, Nicholson and Rose 2001, Wolfe and Watke 1997), particularly if local conditions allow burrowing mammals to create openings to underground cavities and crevices (Didiuk 1999).

The physical characteristics of hibernacula, such as number of openings to a hibernaculum (single to many) or the area over which these openings occur, can be quite variable (Andrus 2010, Didiuk 1999, Martinson 2009a). The number of openings to hibernacula may be influenced by the amount of activity by burrowing mammals that creates additional openings or modifies natural openings. The size of a hibernaculum, estimated as the area over which openings occur, has not been measured for most sites and is often variable among sites. The size of one of the largest known rattlesnake hibernacula in Alberta located along the Red Deer River has been estimated to be approximately 500 m x 100 m (Proctor et al. 2009). This site has numerous openings (holes) where snakes are regularly observed. At sites like this, which extend over a fairly large area, the hibernaculum is better described as a "den complex." The underground structure of hibernacula (e.g., chamber connectivity) is not known, nor how snakes distribute themselves within hibernacula.

2. Summer Habitat - Rattlesnakes show high fidelity to hibernacula, typically returning to the same site each fall, so habitat used for hunting, basking and mating must be available within a reasonable distance from the hibernaculum (Andrus 2010, Blood 1993, Charland et al. 1993, Didiuk 1999, Jørgensen 2009). Several studies of habitat use by Alberta rattlesnakes demonstrate that a variety of habitat types are used during the summer months (Andrus 2010, Didiuk 1999, Jørgensen 2009, Martinson 2009a).

Didiuk (1999) examined habitat use of prairie rattlesnakes in SNWA by examining the frequency of captures of snakes at 20 drift fences constructed in areas of variable surficial material and vegetative cover. Rattlesnakes were captured in all 20 drift fences, but were most frequently captured in low shrub/sand dune habitat in the Middle Sand Hills, upland grassland habitat, and grassy terraces along the river valley. Martinson (2009a) also used drift fences to evaluate capture frequency of rattlesnakes in various habitats in DPP. He found that capture frequency was highest in badlands (45.8%), followed by prairie habitat (35.7%) and cottonwood habitat (18.5%).

Andrus (2010) examined habitat use of the Lethbridge population of snakes and found that 17 radio-tracked snakes used 8 of 23 habitat types available in her study area, but flood plain/grassland and coulee/grassland habitats accounted for the greatest proportions (41% and 47%, respectively) of her 456 snake locations.

Jørgensen (2009) is the only study to have documented a large proportion of rattlesnakes using non-upland (grassland) habitat features. He radio-tracked the annual movements of 24 non-gravid female prairie rattlesnakes from two hibernacula near Medicine Hat and found that snakes used different types of habitat based on the distance that they moved away from hibernacula during the active season. Snakes that made shorter distance migrations from the hibernacula (generally <2.64 km) used riparian habitat between the river's edge and the transition zone between the river valley and upland grassland habitat (15 of 24 snakes), whereas snakes that made longer distance migrations (between 1.22 km and 9.94 km) used upland grassland habitat (9 of 24 snakes). The foraging ranges of these two groups of rattlesnakes rarely overlapped, and there was no evidence that differences in migration distance and habitat use were influenced by size or age (juvenile vs. adult) of snakes (Jørgensen 2009).

The amount of habitat required by individuals to complete all of their life history requirements has not been well-studied for prairie rattlesnakes in Alberta; however, one Alberta study documented a radio-tracked rattlesnake dispersing 25 km from overwintering habitat during the active season (Didiuk 1999; also see Conservation Biology section). Migrations of up to 30 km from overwintering habitat are likely possible, based on additional observations and analysis of dispersal of snakes from river valley habitat within the SNWA (A. Didiuk pers. comm.). In Alberta, home range sizes of prairie rattlesnakes have been calculated only for prairie rattlesnakes within an urban area. Andrus (2010) calculated home range sizes of radio-tracked rattlesnakes in Lethbridge using the minimum convex polygon (95%) method, which she deemed more reliable than home ranges she estimated using the kernel density method (see discussion in Andrus 2010, W. Andrus pers. comm.). Mean home range size was estimated at 31.51 ha (range 6.9 ha to 52.4 ha, n = 8) for snakes radio-tracked in 2005 and was estimated at 3.72 ha (range 0.09 to 10.31 ha, n = 9) for snakes radio-tracked in 2006.

Note that in the study by Andrus (2010) only one snake was radio-tracked in both years, so these estimates are largely based on movements by two different groups of radio-tracked snakes. Andrus (2010) speculated that much smaller home range sizes in 2006 might have resulted from variation in resource availability between years (untested), or that reduced movements in 2006 might be evidence that snakes are actively modifying their behaviour in response to habitat change (fragmentation) that has occurred within Lethbridge. Although differences in weather among years were not discussed by Andrus (2010), it appears that 2006 was not appreciably cooler or wetter than 2005, which could have accounted for reduced movement in 2006 (Environment Canada 2011). It is unknown whether home range sizes of rattlesnakes observed within Lethbridge are representative of home ranges of rattlesnakes in more natural areas, although studies on other species of snakes indicate that snakes in urban environments use less space and make fewer movements compared to snakes in natural areas (Bonnett et al. 1999, Parent and Weatherhead 2000, Pattishall and Cundall 2008). Clearly, more studies on habitat use and home ranges of prairie rattlesnakes are needed to understand the habitat requirements of this species. Until such data are available, the observation of one radio-tracked snake dispersing 25 km one-way from its overwintering habitat combined with other observations of dispersing snakes presumably moving up to 30 km (A. Didiuk pers. comm.), suggest that a 25 km to 30 km radius be placed around hibernacula and suitable habitat for hibernacula in order to identify and protect potential summer habitat for rattlesnakes (see application in Kissner 2004; A. Didiuk pers. comm.).

3. Habitat Used by Gravid Females - Another habitat requirement of the prairie rattlesnake is the presence of suitable birthing areas or rookeries where gravid (pregnant) females can aggregate until parturition (birth). Rookeries apparently provide optimal thermoregulatory conditions for embyronic development and quick escape from predators (Gannon and Secoy 1985, Graves and Duvall 1993, 1995). Rookery sites identified in Alberta typically occur within about 1 km of known overwintering hibernacula or at the edge of rivers or river valleys (Andrus 2010, Didiuk 1999, Jørgensen and Nicholson 2007, Martinson 2009a). In a study by Jørgensen and Nicholson (2007) near Medicine Hat, all 12 rookeries they located were within 500 m of a known hibernaculum. Hibernacula may sometimes function as rookeries (Andrus 2010, Jørgensen and Nicholson 2007, Martinson 2009a), and could suggest that appropriate rookery habitat around some hibernacula is not available (i.e., never existed or has been lost). Although it is typical to observe multiple females at rookery sites, these sites are sometimes occupied by a single female (Didiuk 1999, Jørgensen and Nicholson 2007, Martinson 2009a). Rookery sites identified in Alberta are typically occupied by gravid females in multiple years, and are commonly associated with somewhat permanent habitat features (e.g., rocky areas, Jørgensen and Nicholson 2007, Martinson 2009a), although use of more transient habitat features (pile of driftwood) has been observed in one study (Didiuk 1999). Use of the rookery sites by multiple females and in multiple years suggest that these sites appropriate for gestation may be limited on the landscape (Andrus 2010, Charland and Gregory 1990, Gannon and Secoy 1985, Jørgensen and Nicholson 2007, Martinson 2009a), and that these sites represent important habitat features that require protection from disturbance.

Common habitat features at rookeries are mammal burrows or large, flat rocks (often overlying mammal burrows) that females appear to use as refugia (Duvall et al. 1985, Gannon and Secoy 1985, Jørgensen and Nicholson 2007, Martinson 2009a, A. Didiuk pers. comm.). Fast (2003) used radio telemetry to examine habitat selection of a single gravid female by comparing the habitat characteristics of the snake's locations (at the scale of 1-m^2 quadrants) to habitat characteristics of 300 random points in the same study area (represented by a semi-circular area along the South Saskatchewan River with a radius of 640 m). She found that the snake was always located within 1 m of a small mammal burrow, and that the habitat used by the snake had less grass and higher proportions of sand and cactus than did random points. Graves and Duvall (1993) also found that gravid prairie rattlesnakes in Wyoming are rarely located further than 1 m from refugia. Anecdotal observations made by other individuals at rookery sites in Alberta suggest that these sites appear to have higher percentages of shrub cover (particularly sagebrush, *Artemesia cana*) than does surrounding habitat (J. Nicholson pers. comm.), but shrub cover did not differ between rookery and random sites in the study by Fast (2003). Although Fast's (2003) study represents the most explicit examination of habitat use by gravid female rattlesnakes in Alberta, it was based only on observations of a single gravid female. More data on habitat selection of gravid prairie rattlesnakes in the province are needed.

4. Habitat Loss and Fragmentation - The Grassland Natural Region, which encompasses the range of prairie rattlesnakes, is highly fragmented from the combined activities of agriculture, energy development, urbanization and associated infrastructure, such as roads (Alberta Environmental Protection 1997, Bradley and Wallis 1996, Saunders et al. 2006). As of 1997, nearly 40% of prairie habitat had been lost to various land uses, including more than 95 000 km (and an estimated area equivalent to ca. 20 townships) of highways, gravel roads, trails, well site accesses, and railways (Alberta Environmental Protection 1997). The remaining prairie habitat has been largely altered, and currently only 26% of grassland in Alberta remains in a relatively unaltered state (Saunders et al. 2006).

The degree to which changes in habitat affect *C. viridis* is not well understood. As discussed earlier (see Distribution section), features such as roads or cultivated fields, which might restrict movements for other species (e.g., Clark et al. 2010, Madsen et al. 1996), do not appear to act as significant barriers to movement of rattlesnakes (Didiuk 2003, Jørgensen 2009). However, crossing these features may expose snakes to significant risk of mortality (see Limiting Factors section). Ultimately, mortality associated with dispersal across these areas could lead to population declines and population fragmentation by limiting interaction and genetic exchange between local populations. This could further reduce rescue and recolonization potential, and eventually could lead to genetic effects such as reduced genetic diversity and differentiation among populations.

Currently, the impact of habitat change on *C. viridis* is likely greatest for the Lethbridge population of rattlesnakes. Rattlesnakes in Lethbridge are largely confined to relatively small and largely isolated patches of prairie habitat (Andrus 2010, Ernst and Quinlan 2006). Dispersal routes among patches are increasingly being jeopardized by current or planned developments (see Limiting Factors, Urbanization section). Andrus (2010) suggests that one of the three local populations of prairie rattlesnakes within the city of Lethbridge may be largely isolated, and is at particular risk of extirpation. This local population is separated from the other two local populations by features/areas with high potential for human-snake interactions or impediments to successful dispersal, including residential areas, roads and golf courses. Using a cost analysis, she showed that the habitat separating this one local population from the other two would be particularly costly in terms of its high mortality risk associated with movement. Consistent with her analysis, none of her radio-tracked snakes moved from this area to the other two areas, and vice versa. The other two local populations in Lethbridge occur in adjoining natural areas/parks. Andrus (2010) demonstrated that the cost of movement between them was relatively low, given that no high traffic roads or residential areas separate them. Supporting her prediction, radio-tracked snakes originating (overwintering) in one location made frequent movements into the other area, allowing for interaction among individuals. Further evidence of effects of fragmentation in Lethbridge is Andrus's (2010) data on habitat use of radio-tracked snakes. She found that snakes appeared to avoid residential areas, given that she never located (0 of 456 locations) 17 radio-tracked snakes within these areas despite their high availability. However, rattlesnakes are occasionally encountered within residential areas in Lethbridge, indicating that they attempt to move through these areas, but sometimes unsuccessfully (Ernst 2000, 2002, 2003, 2004, Ernst and Quinlan 2006). Additionally, radio-tracked snakes in Andrus's study showed no evidence of the highly-directed movements that are typical of this species during dispersal away from the dens, which could be indicative of snakes avoiding anthropogenic habitats and being constrained to move within the remaining habitat. Alternatively, these snakes may make shorter distance migrations as has been observed by Jørgensen (2009).

There are no province-wide estimates of the current amount of suitable habitat (overwintering, summer, gravid female) for prairie rattlesnakes in Alberta. Given recent proposals for urban developments, transportation networks, and petroleum development within areas occupied by rattlesnakes (see Limiting Factors section), it is likely that the trend is for greater loss and fragmentation of suitable habitat and likely population declines.

CONSERVATION BIOLOGY

For the prairie rattlesnake, aspects of its reproductive biology, growth, survivorship, thermal ecology, movement and activity patterns are of potential importance for conservation and management decisions.

1. Species Description - *C. viridis* is a heavy-bodied snake with a triangular head that is noticeably wider than its neck (Russell and Bauer 1993). Most individuals are tan in colour with darker bands or blotches along their backs (Russell and Bauer 1993). The prairie rattlesnake's most distinguishing feature is its rattle, but like other pit vipers, it has two heat-sensing pits located on each side of its head and two retractable fangs on its upper jaw used to inject venom into its prey (Russell and Bauer 1993).

2. Reproductive Biology - Mating in *C. viridis* occurs during mid- to late summer and possibly in early fall (Aldridge 1993, Duvall et al. 1985, Russell and Bauer 1993, but see Holycross 1995). Young are born the following year, between late August and mid-October in Canada (Jørgensen and Nicholson 2007, Macartney et al. 1990), with litter size ranging from 4 to 13 (Jørgensen and Nicholson 2007, Kissner et al. 1996, Powell et al. 1998, Russell and Bauer 1993, Trottier and Didiuk 1995). Sexual maturity for male prairie rattlesnakes occurs at three to four years of age (Macartney et al. 1990), whereas females are thought to attain sexual maturity at five to seven years of age (Russell and Bauer 1993, but see Jørgensen and Nicholson 2007). Females produce their first litters at six to eight years of age (Russell and Bauer 1993). Females from northern populations typically follow a biennial or triennial reproductive cycle (Gannon and Secoy 1984, Jørgensen and Nicholson 2007, Macartney et al. 1990, Macartney and Weichel 1993, Russell and Bauer 1993), although in Saskatchewan, four females were found to be pregnant in two consecutive years indicating that annual reproduction can occur (Kissner et al. 1996). The reproductive biology of prairie rattlesnakes, with characteristics such as late reproductive maturity, relatively small litters, and biennial or triennial reproductive cycles, indicates that the reproductive capacity and recruitment levels for this species are extremely low (Jørgensen and Nicholson 2007, Macartney and Weichel 1989).

3. Growth and Survivorship - Rattlesnakes at higher latitudes typically experience slower growth rates and greater overwintering weight loss than individuals from more southern populations (Gannon and Secoy 1984, Macartney et al. 1990). For example, snout-vent lengths of one-, two-, and three-year old western rattlesnakes in central California (Fitch 1949), were found to be approximately equal to three-, four-, and five-year old rattlesnakes in British Columbia (Macartney et al. 1990). Similarly, overwintering weight loss in western rattlesnakes in northern Utah was found to be four to nine percent of body weight (Parker and Brown 1974), whereas overwintering weight loss of rattlesnakes in Saskatchewan ranged from 7.1% to 13.9% of total weight (Gannon and Secoy 1984).

Studies of rattlesnake populations in British Columbia and Saskatchewan demonstrate that overwintering survival in young-of-the-year can be poor (as low as 0% in some years; Charland 1989, Charland et al. 1993, Gannon and Secoy 1984, Macartney and Weichel 1993). Population-level recruitment has only been studied at one hibernaculum in Alberta (the largest known overwintering site in Alberta) (Proctor et al. 2009). Recruitment of snakes was estimated to be 7% and 17% in two consecutive years. Slow growth rate, high overwintering weight loss, and poor juvenile survivorship/low recruitment are indicative of the harsher conditions faced by rattlesnake populations inhabiting higher latitudes.

Overwinter survival of snakes is largely unstudied for Alberta rattlesnakes, but was estimated to be 62% and 55% at one hibernaculum in two consecutive years (Proctor et al. 2009). Russell and Bauer (1993) indicate that the maximum lifespan of adult prairie rattlesnakes is 15 years, although other researchers have indicated it may be as high as 20 years (Klauber 1956, A. Didiuk pers. comm.).

4. Generation Time - Generation time for this species, calculated as the average age of reproductive females in the population, is apparently not reported in the literature. Given that females tend to have their first litters at approximately age seven and may live to approximately 15 years, a reasonable estimate for generation time is approximately 11 years.

5. Thermal Ecology and Seasonal Activity Patterns - Snake populations in cold climates often develop specific behavioural and physiological strategies for dealing with a shortened active season (see Gannon and Secoy 1985). In Alberta, prairie rattlesnake populations reach the northern limit of their distribution (Macartney and Weichel 1989, McCorquedale 1965), and restrictions imposed by the colder climate should be reflected in their thermal ecology. At high latitudes, such as in Alberta and Saskatchewan, the active period for rattlesnakes lasts only five to seven months (from late April to early October; Andrus 2010, Didiuk 1999, Gannon and Secoy 1985, Jørgensen 2009, Macartney et al. 1990), in comparison to 8.5 months for populations in Wyoming (Duvall et al. 1990). In addition, southern populations of *C. viridis* may be active above ground during occasional warm spells in winter, whereas hibernation is continuous for northern rattlesnakes (Macartney et al. 1990). Rattlesnakes at more northern latitudes also appear to experience lower body temperatures during hibernation (Jacob and Painter 1980, Macartney et al. 1989).

Thermal requirements of *C. viridis* may also influence movement and habitat use. As noted earlier, gravid females use rookery sites during gestation that are apparently chosen, at least in part, because they have thermoregulatory characteristics that are favourable for embryonic development (Graves and Duvall 1993). A greater understanding of the thermal ecology of prairie rattlesnakes in Alberta, during both hibernation and the active season, may provide insight into factors restricting distribution in this species (e.g., additional habitat requirements necessary for effective thermoregulation).

6. Movement and Dispersal Patterns - Prairie rattlesnakes make seasonal movements between overwintering hibernacula and summer ranges. Snakes show high fidelity to hibernacula, typically returning to the same site in the fall. Observations of snakes switching hibernacula are rare (only 1 of 21 radio-tracked snakes in one Alberta study; Jørgensen 2009; and was rare for snakes in SNWA, A. Didiuk pers. comm.). Despite the majority of overwintering habitat for *C. viridis* occurring along major rivers valleys within southern Alberta and the species' ability to swim well (Klauber 1956), most rattlesnakes do not cross these rivers and instead disperse to habitat on the same side of the river as their hibernacula (Andrus 2010, Didiuk 1999, Jørgensen 2009). Both Andrus (2010) and Jørgensen (2009) observed infrequent crossing of the Oldman and South Saskatchewan rivers, respectively, by radio-tracked snakes. In Jørgensen's study, only 1 of 21 snakes crossed the South Saskatchewan River, and this snake spent the majority of its active season (mid-May to mid-September) within about 600 m of its hibernaculum located on the opposite site of the river. This snake moved back across the river in the fall and returned to its hibernaculum, despite apparently being displaced 2 km downstream during its return trip across the river (Jørgensen 2009, Jørgensen and Gates 2007).

Migration of male and non-gravid female snakes appears to be primarily associated with the search for suitable foraging areas (Duvall et al. 1985, 1990). The diet of prairie rattlesnakes in Alberta is largely composed of colonial burrowing small mammals such as sagebrush vole (*Lemmiscus curtatus*) and meadow vole (*Microtus pennsylvanicus*) (Hill et al. 2001). Prairie rattlesnakes often make straight-line or fixed-bearing movements away from hibernacula in the spring, which appears to increase efficiency of locating small mammal patches (Didiuk 1999, Duvall et al. 1997, Duvall and Schuett 1997) and possibly locating mates (Didiuk 2003, Duvall et al. 1992). Migration paths back to the hibernaculum are often similar to snakes' outbound paths (Didiuk 1999). Some researchers have found less directed movements of rattlesnakes (Andrus 2010, Jørgensen 2009). Jørgensen (2009) found that snakes from two hibernacula in Alberta that spent the active season in upland habitats were more likely to make linear migrations to these areas compared to snakes that spent the active season in riparian areas. This difference in movement patterns with habitat use could suggest that prey may be differentially distributed in various habitat types and/or strategies to efficiently locate prey differ among these habitat types. Andrus (2010) did not observe fixed-directional movements in her study of rattlesnakes within the city of Lethbridge, but snakes avoided residential and human-impacted areas (e.g., golf courses) that largely surround these sites, suggesting that movement patterns may have been influenced by development. Other studies of snakes in urban environments indicate that they may use less space and make fewer movements compared to conspecifics in natural areas (Bonnett et al. 1999, Parent and Weatherhead 2000, Pattishall and Cundall 2008).

Migration distances appear to vary among individuals, and may be related to several factors such as emergence time from dens, age, reproductive status (Didiuk 1999); they could also be related to resource availability or genetic differences among individuals (Jørgensen 2009). Didiuk (1999) found that one radio-tracked non-gravid female made a straight-line migration of nearly 25 km one-way from its hibernacula, and found that four other snakes made similar straight-line migrations of 12 km, 14.7 km, 15.3 km and 18.7 km one-way. Long migrations may make rattlesnakes more susceptible to mortality, as snakes moving longer distances are likely to cross roads or habitats that may expose them to predation (Didiuk 1999). Other studies have noted both short- and long-distance migrations of rattlesnakes in Alberta (Jørgensen 2009, Powell et al. 1998). Powell et al. (1998) found that migration distances of snakes they radio-tracked in southern Alberta varied between 0.3 km to 12 km. Jørgensen (2009) found that snakes appeared to fall into one of two groups, those that made short-distance migrations and those that made long-distance migrations. Difference in migration distances in his study were associated with differences in habitat use, with shorter-distance migrants occupying riparian habitat and longer-distance migrants occupying upland habitat during the active season.

Gravid females make short-distance migrations from hibernacula (generally < 1 km) to rookery sites (Didiuk 1999, Fast 2003, Jørgensen and Nicholson 2007). Although previous studies have found gravid prairie rattlesnakes to be rather sedentary once at rookeries (Graves and Duvall 1993), gravid females occasionally move between rookeries or make short distance movements within the area around rookeries (Fast 2003, Jørgensen and Nicholson 2007). Following parturition, females and neonates remain together at the rookery for several days before dispersing. These postpartum aggregations may allow neonates to recognize conspecific odours that are later used to help newborns locate overwintering hibernacula (Duvall et al. 1985, Graves et al. 1986).

POPULATION SIZE AND TRENDS

1. Alberta **-** No studies have attempted to estimate the size of the Alberta rattlesnake population, and only a few studies have estimated snake abundance at individual hibernacula in the province. Using anecdotal accounts of snake abundance at hibernacula across Alberta, Cottonwood Consultants (1987) indicated that most hibernacula in Alberta likely support fewer than 100 snakes. Recent studies of snake abundance provide some support for this assumption. Didiuk (1999) recorded 17 to 138 (average = 83) snakes per hibernaculum at six hibernacula in SNWA that were fenced between 1995 and 1997 to allow complete counts of snakes as they emerged in the spring. Similar numbers of snakes were estimated by Jørgensen (2009) at two other hibernacula along the South Saskatchewan River using mark-recapture techniques. He estimated the abundance of female prairie rattlesnakes (juvenile and mature) to be approximately 21 to 35 snakes at one hibernaculum and 20 to 25 snakes at the second hibernaculum. Sex ratios of adult prairie rattlesnake populations tend to be male-biased (1.3:1; Kissner et al. 1996; 1.5:1 Didiuk 2003); even using a ratio of 1.5:1 to extrapolate expected abundance of males, total abundance would be under 100 snakes at both of Jørgensen's sites. Andrus (2010) used mark-recapture techniques to determine abundance of rattlesnakes within the city of Lethbridge, and estimated between 161 and 295 mature snakes occur within the city. Given that there are three main overwintering locations used by snakes within the city, her estimate suggests fewer than 100 snakes in each area. Previous estimates of the number of snakes in Lethbridge by Ernst (2003) and Ernst and Quinlan (2006) suggested lower numbers (< 50 adults), but these were based largely on incidental observations of snake numbers at hibernacula in the spring and fall. A mark-recapture study conducted at the largest known den complex in Alberta (along the Red Deer River) estimated abundance of snakes over one year of age to be 500 to 1000 snakes (± 40%), depending on the estimation method used and the year abundance was estimated (Proctor et al. 2009). Besides this large den complex, only one other particularly large site is known; however, it is believed to be considerably smaller in size compared to this large den complex and it has not been monitored for activity since the early 2000s (E. Hofman pers. comm.).

A crude estimate of the minimum number of prairie rattlesnakes in Alberta can be obtained by multiplying typical abundance per hibernaculum by the number of known hibernacula in the province. As mentioned above, Didiuk (1999) reported an average of 83 snakes per hibernaculum. Similarly, the study by Jørgensen (2009) at two hibernacula suggested fewer than 100 snakes at each site, and the study by Andrus (2010) in Lethbridge suggested 100 or fewer adult snakes at each of three overwintering populations. The Proctor et al. (2009) study reports much higher abundance (500 – 1000 snakes total, excluding snakes < 1 year old), although their study site represents a complex of hibernacula that likely support the highest rattlesnake densities in Alberta (E. Hofman pers. comm., J. Nicholson pers. comm.). Note that all studies, except the one by Andrus (2010), combined abundance of immature and mature snakes. However, it is possible to estimate the number of mature individuals per hibernaculum based on the expected age structure of snakes. A few studies have provided information on the proportion of sexually-mature snakes at individual hibernacula in Alberta or adjacent areas. In Lethbridge, adults compose 79% of the estimated population (Andrus 2010). At four drift fences positioned 200 m from the river valley (overwintering habitat) in the SNWA, 57% of snakes captured were adults (Didiuk 2003). Only 55% of prairie rattlesnakes captured at a den complex near Leader, Saskatchewan were considered to be mature (Gannon and Secoy 1984). Based on these varying results, it seems reasonable to estimate that about two-thirds of snakes at a hibernaculum are sexually mature in a given year. Thus, for the purposes of the Alberta population estimate it was assumed that hibernacula, on average, contain 100 snakes, of which 66 are mature.

To determine the number of snake hibernacula in Alberta, the provincial Fish and Wildlife Management Information System (FWMIS) database was queried for hibernaculum records, and contact was made with researchers, resource managers, and professional biologists for additional hibernaculum records that may not have been submitted to the provincial database (Kissner 2011). To obtain an accurate estimate of the number of known hibernacula in Alberta, it was necessary to associate or group records representing repeat observations at the same hibernaculum. For example, the provincial database provided 486 records for rattlesnake hibernacula (recorded between 1972 and 2010); however, many of these records were at the same hibernaculum made by different observers over several decades. Counting the actual number of individual hibernacula was often complicated by the fact that the quality of location information varied among records (e.g., coarse ATS locations vs. precise GPS coordinates). As a first step, all hibernacula locations and their associated precision were plotted in a geographic information system (ArcGIS 10, ESRI, Redlands, CA), and high precision (< 50 m) records within 50 m proximity of each other were automatically grouped together as a single site. However, in cases where grouping records (or considering them separate) was not as obvious (e.g., because of overlapping precision), three scenarios were considered: a cautious and a liberal grouping, plus a best estimate grouping. The cautious approach considered sites to be separate unless there was evidence in the record to link them or if personal knowledge of the site or discussion with other researchers/ resource managers linked the sites together. In the liberal approach, two sites with overlapping precision were grouped together as a single site unless there was evidence to separate them. Finally, the best case approach represented a subjective evaluation of any available evidence to estimate the most likely grouping of hibernacula observations. Using these three approaches, a “best” estimate of the number of hibernacula in the province was produced, along with estimates for the minimum and maximum number of hibernacula in the province.

This approach estimated that there are 192 hibernacula in the province, but there may be as many as 242 and as few as 183. Multiplying 192 hibernacula times an estimated 66 mature snakes per hibernacula yields an estimate of 12 672 mature prairie rattlesnakes in Alberta, although the population may be as high as 15 972 or as low as 12 078 snakes, given the range of possible numbers of hibernacula in the province. Note that the actual number of mature rattlesnakes in the province could be higher depending on how many hibernacula remain undetected in Alberta. It is also expected that a portion of the hibernacula identified in this evaluation may be inactive or destroyed, which is difficult to verify given that many sites have not been recently surveyed for snake activity. One researcher coarsely estimated that the population size of rattlesnakes within the SNWA could be as high as 6500 snakes based on data he collected along a 12-km section of the South Saskatchewan River within the SNWA and then extrapolated across the balance of snake habitat within the Wildlife Area (A. Didiuk pers. comm.). Although this would appear to account for a large proportion of the total estimated population size (above), the SNWA likely represents some of the highest quality habitat within Alberta for this and other prairie species and thus is expected to account for a large proportion of the rattlesnake population within Alberta (J. Nicholson pers. comm.).

Kissner and Nicholson (2003) previously compiled data on the abundance of prairie rattlesnake hibernacula in Alberta and identified 107 sites in the province, which is substantially lower than the estimate of 192 hibernacula estimated for this report. The difference in estimated number of hibernacula should not be interpreted as an apparent increase in the population over the last eight years. Rather, it merely reflects increased survey effort and reporting to the provincial FWMIS database for snake data collected from a variety of sources, such as recent research by the University of Lethbridge and University of Calgary (Andrus 2010, Fast 2003, Jørgensen 2009, Martinson 2009b), hibernacula monitoring studies undertaken by the provincial and federal governments, provincial conservation projects (A Multi-Species Conservation Strategy for Species at Risk in the Grassland Natural Region of Alberta [MULTISAR] and the Alberta Volunteer Amphibian Monitoring Program that included reptile monitoring beginning in 2003), and pre-development surveys for industrial developments.

The limited historical information about prairie rattlesnake populations in Alberta makes it difficult to assess population changes, but what is available suggests there has been a long-term decline since European settlers arrived in western Canada (Macartney and Weichel 1989). In the late 1980s, Cottonwood Consultants (1987) surveyed landholders across the range of prairie rattlesnakes in Alberta to obtain locations of snake hibernacula in the province, and recorded anecdotal information on historical and current numbers of snakes at these sites. At many prairie rattlesnake hibernacula, landholders noted historical numbers of snakes as "scores," "tens," "hundreds" or "thousands" of snakes, but reported apparent large declines in numbers at many of these sites in the intervening years, sometimes even indicating that the site appeared inactive or was intentionally destroyed. Kissner and Nicholson (2003) evaluated the relative differences between historical accounts of numbers of rattlesnakes at hibernacula (including several hibernacula in the report from Cottonwood Consultants 1987) with incidental counts of snakes made at those same hibernacula in the mid-1990s or in early 2000s during hibernacula monitoring surveys. At 14 hibernacula where historical information was available and where subsequent, incidental monitoring was conducted, four dens (29%) appeared completely inactive, five (36%)

showed evidence of declines, and only three (21%) appeared relatively stable and two (14%) appeared to increase. These anecdotal and incidental observations suggest that populations have experienced significant long-term decline across the species' range.

There is also some evidence of recent declines in abundance at several hibernacula in Alberta. Didiuk (2003) reported that rattlesnake numbers at the six overwintering populations monitored between 1995 and 1997 in SNWA (see above) had declined by 2001, but he did not report the degree of this decline. Similarly, Proctor et al. (2009) recorded an apparent 50% decline in population size over only a three-year period at the large den complex along the Red Deer River, based on an estimated reduction in population size from approximately 1000 snakes in 2003 to about 500 snakes in 2006. However, population estimates in the study by Proctor et al. (2009) were coarse (often with overlapping confidence intervals across sampling periods) and the decline was only statistically significant in one of three alternative population models. In both studies the reasons for the declines were unknown, but the researchers noted that possible factors could include natural fluctuations or natural mortality (e.g., overwinter mortality), environmental factors, changes in hibernaculum suitability, hibernaculum switching, investigator disturbance, random sampling/capture bias, or mortality from human activity (e.g., road mortality) during dispersal of snakes (Didiuk 2003, Government of Canada 2008, Proctor et al. 2009). Proctor et al. (2009) suggest the apparent 50% decline in population size they witnessed across three years is unlikely to result from a natural population fluctuation given the steepness and rapidity of the decline. Long-lived, slow-reproducing species, like *C. viridis*, typically do not experience this type of natural fluctuation given their limited capacity to rebound (Proctor et al. 2009, Ricklefs 1990). Proctor et al. (2009) also note that switching of hibernacula is unlikely to explain their declines since rattlesnakes show high fidelity to hibernacula. Similarly, changes in the suitability of hibernacula would seem unlikely to explain these declines since many snakes apparently continued to use the hibernaculum in the study by Proctor et al. (2009), and Didiuk (2003) did not report complete abandonment or disuse of any of the hibernacula he monitored. Although factors such as investigator disturbance cannot be ruled out, both Proctor et al. (2009) and Didiuk (2003) reported marked increases in petroleum development in their study areas, which may have resulted in increased road mortality from increased traffic volume and/or road development. Didiuk (2003) also noted a decline in large, sexually mature snakes in 2001. Given that the largest adults tend to make the longest migrations (Didiuk 2001, 2003), this result is consistent with the idea that declines were due to road mortality, since these individuals may encounter more roads during their long migrations (Didiuk 2003).

Dinosaur Provincial Park (DPP; established in 1955) appears to be one area of the province that experienced a historical decline in rattlesnake numbers, but has rebounded over the last 30–40 years. Rattlesnakes were apparently common in the area in the early 1900s and were still present in the area during the 1930s and 1940s, but by the late 1960s to mid-1970s they were apparently uncommon (Pendlebury 1977; T. Schowalter pers. comm.). In fact, in the mid-1970s, DPP was reportedly advertising that it was rattlesnake-free (Pendlebury 1977), although at that time the public was largely restricted from the badland areas where human-snake encounters would likely be high (J. Danis pers. comm.). Beginning around the late 1970s, reports of rattlesnakes in DPP began to increase and snakes continued to be reported thereafter (Cottonwood Consultants 1987, Pendlebury 1977). Increased effort to survey and monitor the snakes in DPP, beginning in the late 1990s, has revealed a fairly large number of snakes in the park and several hibernacula (e.g., Martinson 2009a). An ongoing mark-recapture study, initiated in 2008, has marked 260 rattlesnakes as of spring 2011 with the intent to produce a rattlesnake population estimate for DPP within the next several years (Martinson 2009a, A. Martinson pers. comm.). In Writing-on-Stone Provincial Park (WOSPP) there were some anecdotal reports of declining snake numbers (only across two years) in the late 1990s (R. Ward pers. comm. to Watson and Russell 1997); however, recent information suggests that snake numbers (although not large) have remained stable over the last decade (B. Moffet pers. comm.). Given that both parks incorporate snake education into their interpretive programs and that snakes may receive some level of protection from their occurrence within parks, it is expected that snake abundance in both parks will at least continue to remain stable.

2. Other Areas - There have been no recent estimates of the size of the Saskatchewan rattlesnake population. Kissner et al. (1996) used mark-recapture techniques at the two largest known hibernacula in Saskatchewan (both in Grasslands National Park) in 1994 and 1995 during the spring and/or fall when snakes were congregated at hibernacula. The number of snakes using these two complexes was estimated to be 455 snakes (confidence intervals = 286 to 1180) using one population estimation method and 313 (confidence intervals = 183 to 453) snakes using a second method. In the spring of 2011, one of these large hibernacula collapsed before snakes emerged from hibernation, apparently as a result of high soil moisture from heavy snowmelt and spring rainfall. Surveys at this site following its collapse revealed that some snakes emerged after the collapse (a few to a dozen seen on separate occasions), but it is suspected that most snakes perished in the collapse and that the site will no longer be suitable for hibernation (P. Fargey pers. comm., R. Poulin pers. comm.). Although the impact to the Saskatchewan population from loss of this site is not known, it could be significant. During the mark-recapture study at the two large hibernacula, researchers also marked snakes at four other hibernacula they visited regularly (every 2 to 5 days) and six other sites they visited incidentally (2 to 3 times during the study). Snakes marked at these additional ten sites accounted for only 27% of all snakes marked during the study, indicating the relative influence of the two largest sites on snake numbers in the area. Thus, the loss of one of these large hibernacula may have severely reduced snake abundance in the province.

Prairie rattlesnake populations in most areas of the United States are apparently stable, including in Montana where the species is widely distributed and apparently abundant (Montana Government 2011, NatureServe 2010, Reichel and Flath 1995). In Iowa, a single remaining population of *C. viridis* occurs in the Loess Hills of northwestern Iowa on land owned by The Nature Conservancy (The Nature Conservancy 2011). It is estimated that the population currently comprises fewer than 250 adults (D. Fogell pers. comm.). Although the species is protected in the state as an *Endangered* animal and exists on protected land, the species is still vulnerable to extirpation from stochastic events and from its isolation (48 km) from other populations in South Dakota (The Nature Conservancy 2011). In Oklahoma, rattlesnakes occur in the western portion of the state; despite their ranking as S3 (*Vulnerable*) (NatureServe 2010), they are still hunted during annual rattlesnake "round-ups" (e.g., Association of South Central Oklahoma Governments 2010).

LIMITING FACTORS

Prairie rattlesnake populations in Alberta appear to be limited in distribution and number by several factors, including the presence of suitable hibernacula (Cook 1984, Cottonwood Consultants 1986, 1987, Gannon 1978, Macartney and Weichel 1989, Pendlebury 1977) and the availability of summer foraging areas or birthing rookeries. These habitat requirements, in conjunction with climate and slow population growth, are "natural" limiting factors, and may be exacerbated by the impact of human-related influences on prairie rattlesnake populations (e.g., see Brooks et al. 1991 and Congdon et al. 1994). Once rattlesnake populations are in decline, factors such as slow growth, delayed sexual maturation, biennial or triennial reproduction, small litter sizes and low survivorship of young will make recovery from decline difficult (e.g., Blouin-Demers et al. 2002).

Factors that have the greatest influence on prairie rattlesnake abundance and distribution include land uses such as agriculture, as well as urban, energy and road developments; these result in loss, degradation and/or fragmentation of prairie habitat, and additionally expose rattlesnakes to direct and indirect sources of mortality.

1. Roads - As noted earlier, more than 95 000 km of roads cover the Grassland Natural Region, which encompasses the range of rattlesnakes (Alberta Environmental Protection 1997). Roads typically do not pose a significant barrier to movement of rattlesnakes, but may ultimately fragment populations given that they may limit dispersal and exchange through direct mortality of snakes (see Habitat, Habitat Loss and Fragmentation section).

Martinson (2009b) found that prairie rattlesnakes had higher rates of mortality compared to bullsnakes or garter snakes in his study of road mortality within DPP. Prairie rattlesnakes have a number of characteristics that make them particularly susceptible to road mortality. Their often long migrations result in them having a higher probability of encountering roads and being killed by a vehicle (Bonnet et al. 1999, Didiuk 1999). Additionally, their behaviour to travel similar paths during their migrations away from and back to overwintering hibernacula (e.g., Didiuk 1999), means that any roads encountered on their outbound migrations are likely encountered again during their inbound migrations. Their large size may make them more likely to be accidentally struck by unsuspecting drivers or more conspicuous "targets" on the road to drivers intent on harming snakes (Martinson 2009b). Their tan colouration may also make them difficult for drivers to detect and avoid on gravel roads (particularly for smaller individuals) (K. Kissner pers. obs.). Rattlesnakes may also be slower moving than other snake species potentially increasing their risk of road mortality compared to other species (Martinson 2009b). Furthermore, the behaviours of prairie rattlesnakes to bask on roads and to remain motionless or to coil and rattle when faced with a threat, rather than flee like other species, may greatly increase their risk of road mortality (Didiuk 2003, Martinson 2009b), even on low-traffic roads. Use of roads by prairie rattlesnakes for opportunistic basking likely represents an ecological trap (Battin 2004) whereby the roads could be considered "attractive sinks" that are associated with very high levels of mortality (Delibes et al. 2001).

Between 1994 and 1996, Didiuk (1999) observed that 66% of all prairie rattlesnakes encountered on a high-traffic road south of CFB Suffield were dead. Within various portions of the CFB Suffield SNWA, the proportion of snakes on roads that were dead was between 22% and 26%. Although these statistics could be inflated since dead snakes remain on roads, it is also likely that these values could be under-estimated because a proportion of road-killed snakes undoubtedly go undetected because they are removed by scavengers (Didiuk 1999) or because some snakes struck by vehicles move off roads before they eventually perish (e.g., Row et al. 2007).

Martinson (2009b) estimated that the probability of a rattlesnake being killed during *a single* crossing of a road in DPP ranged from 0.06 to 0.30 depending on traffic density and snake crossing velocities. Using data on observed numbers of rattlesnakes killed on a 364-m section of road in DPP in relation to those assumed to have crossed (and were captured in drift fences), he estimated mortality to be 18% given an average traffic density of 352. 2 vehicles per day on this section of road (the maximum traffic density on this road was 669 vehicles per day). Another study in southern Alberta estimated the probability of road mortality along two roads outside of Medicine Hat frequented by commuter traffic and traffic related to industrial activity (Jørgensen 2004, D. Jørgensen pers. comm.). The two roads varied in average traffic density; Highway 523 (Holsom Road) averaged 2566 vehicles per day (July 2004) and Bowmanton Road averaged 488 vehicles per day (August–October 2004). At various crossing velocities of snakes (1 m per min–6.3 m per min), the probability of mortality associated with a single crossing of Bowmanton Road varied between 0.11 and 0.51. For Holsom Road, which had a much higher traffic density, the probability of mortality associated with a single crossing varied between 0.45 and 0.98 (Jørgensen 2004). Thus, ignoring cases where snakes may remain motionless on roads to bask, snakes moving across Holsom Road at a low speed have nearly a 100% chance of being killed by a vehicle. Given long migrations by rattlesnakes and their likelihood of encountering numerous roads on their migrations to and from hibernacula, the cumulative risk of mortality of dispersing individuals over the course of their active season appears to be extremely high.

Using computer simulations, Martinson (2009b) predicted that mortality of rattlesnakes should increase significantly with road or traffic density and increase moderately with vehicle speed. However, driver awareness was predicted to have little effect on reducing road mortality of rattlesnakes (Martinson 2009b). Didiuk (1999) also found that the orientation of roads in relation to prairie rattlesnake overwintering habitat and direction of snake dispersal/movement influenced the probability of rattlesnake mortality. Within the SNWA, rattlesnake overwintering habitat occurs adjacent to a north-south (N-S) portion of the South Saskatchewan River. Snakes were most frequently encountered on N-S roads in the SNWA because of their tendency to migrate westward from the river (Didiuk 2001, 2003). As expected, mortality of snakes was greatest on N-S roads, particularly on N-S roads closest to the river (Didiuk 2003). Based on these findings and expected increases in road mortality associated with energy developments within the SNWA, several traffic control measures were implemented in 2000 within the SNWA to reduce snake mortality. These included restricting access/entrance points to the SNWA, directing traffic to N-S roads further away from the river and accessing areas close to the river using mainly E-W roads, reducing maximum traffic speeds to 50 km/h, installing snake signage to increase driver awareness, and providing users of the area with educational materials on rattlesnakes and their susceptibility to road mortality. A monitoring program was conducted for two years following implementation of these mitigation measures, and it suggested that these measures helped reduce road mortality of snakes (Didiuk 2003). However, any increase in development within the SNWA could have the potential to increase road mortality of snakes in the area (e.g., Government of Canada 2008).

Improvements to roadways, such as widening or asphalt paving, may also increase risk of road mortality for rattlesnakes in Alberta by promoting higher traffic volumes and vehicle speeds, as well as by facilitating detection of rattlesnakes on pavement for those intent on killing snakes (Didiuk 2003). Several proposed highway developments and upgrades within the range of rattlesnakes in Alberta have the potential to negatively affect prairie rattlesnakes and other prairie species through habitat loss and alteration, road mortality of snakes, and possible population fragmentation associated with road mortality. A new 43-km, four- to eight-lane highway has been proposed that will bypass Medicine Hat to link Highways 1 and 3 (Alberta Transportation 2011). The plan also includes the development of a new bridge crossing on the South Saskatchewan River, which is proposed to be constructed on a section of the river valley with active rattlesnake hibernacula. Planning is still underway and, pending final approval, would begin in approximately 20 years, but the project plan has been endorsed by the City of Medicine Hat, Town of Redcliff, and Cypress County. Similarly, there is a planned linkage for Highways 3 and 4 around the city of Lethbridge (Alberta Transportation 2011). This highway would bypass Lethbridge and may not directly affect the population of snakes within the city (B. Downey pers. comm.), but could affect other populations of snakes along the Oldman River (Ernst and Quinlan 2006). An upgrade has been proposed for Highway 41 to expand the highway to four lanes and extend the highway north all the way to Fort McMurray, such that it provides a direct route between the oil sands and the U.S. border (Hildebrand 2008). The proposed expansion is intended to be used for commercial transport of heavy equipment to the oil sands, and thus the number of large vehicles using the highway and the volume of traffic is expected to increase substantially if this development occurs (Hildebrand 2008). Prairie rattlesnakes are often found killed on Highway 41 (particularly along the portion between Medicine Hat and Empress) because of its proximity to snake overwintering habitat along the South Saskatchewan River, and road mortality is anticipated to increase if the highway expansion proceeds.

2. Energy Sector Development - Energy development occurs throughout the range of rattlesnakes in Alberta and poses a significant threat to rattlesnakes, given its combined effects on habitat (loss, alteration) and mortality. As an example of the mortality risk associated with development, approximately half of the road/trail development (ca. 45 000 km of the >90 000 km as of 1997) within the Grassland Natural Region provides access to wellsites (Alberta Environmental Protection 1997), and these developments result in associated increases in traffic along all roads in the development area. In the past, there may have been mortality of snakes that fell into pipeline trenches and were not removed (E. Ruff pers. comm. to Watson and Russell 1997). Alberta Environment and Sustainable Resource Development currently requires proponents to monitor pipeline trenches and remove snakes in compliance with the *Wildlife Act*. Within CFB Suffield Military Base, where active military training exercises are conducted, wellheads and associated facilities are buried below ground and enclosed in caissons to allow above-ground military activities. Caissons attract snakes because they harbour small mammals (prey items) and square tubing framing the caissons provides secure hiding sites (Accipiter Ecological Management 2011). Unfortunately, snakes may fall into the below-ground wells and may die if they cannot climb out (Didiuk 1999). Although mortality associated with caissons appears to be low (Accipiter Ecological Management 2011), increased energy development within CFB Suffield could increase the number of caissons and their potential importance as a threat to rattlesnakes (e.g., Government of Canada 2008). Industrial development also has been suspected to be associated with some degree of human persecution of snakes (e.g., Proctor et al. 2009). Fortunately, many companies provide their workers with educational materials on rattlesnakes that help to improve attitudes toward the species and help protect workers when working in rattlesnake habitat (D. Jørgensen pers. comm., A. Martinson pers. comm.).

On public land, the Alberta government requires that wildlife surveys be conducted in proposed development areas to identify wildlife habitat that might be impacted during development, and recommends that pre-development wildlife surveys be conducted on private land (Alberta Sustainable Resource Development 2010, Government of Alberta 2011a). There are also provincial guidelines on timing and location (e.g., setback distances) of developments around identified wildlife habitat (Government of Alberta 2011b). For rattlesnake hibernacula, setback guidelines apply year-round and are 500 m from a hibernaculum for high-level disturbances and 200 m from a hibernaculum for low- and medium-level disturbances. The setback distance for low to high-level disturbances around rookeries is 200 m between 15 March to 31 October (roughly the active season for snakes), but declines to 50 m between 1 November to 14 March when snakes are hibernating. In some cases these guidelines may be relaxed on public land, and their application on private land depends on good wildlife habitat stewardship practices by developers and landholders. On public land, failure to adhere to timing and setback distances (or alternative agreed upon mitigation practices) may result in penalties under the *Public Lands Act* (B. Downey pers. comm.). It is also significant to note that in 2010, Alberta Sustainable Resource Development (now Environment and Sustainable Resource Development, ESRD) implemented a new method (Enhanced Approval Process, EAP) for industrial clients to use to make surface land use applications to ESRD, such as application for wellsites and pipelines (Government of Alberta 2011c). As part of this new process, the provincial guidelines for timing and restrictions of development related to wildlife were reviewed and some significant changes were made. In particular, some types of industrial developments were downgraded to lower disturbance categories. Thus, for example, minimum disturbance wellsites, which were in the highest disturbance category in the previous guidelines given that a permanent structure is created and required a setback of 200 m, have now been downgraded to a medium-level disturbance. As such, they are not eligible for the highest setback distance under the new guidelines of 500 m, and still require a setback distance of 200 m (Government of Alberta 2011b).

Energy development continues to expand throughout southeastern Alberta. Even if no new roads are planned as part of any new development, it is expected that road improvements are often necessary and that road traffic would increase (particularly large vehicles) during construction and afterwards (e.g., during wellsite monitoring). Additionally, there could be impacts to snake dens or to suitable overwintering habitat if drilling of wells along river valleys occurs in the future (e.g., Government of Canada 2008).

Some types of mitigation measures used to reduce environmental impacts of development could actually harm snakes. A number of studies have documented the hazard to snakes of using mesh or nets to minimize soil erosion, control runoff or to stabilise revegetated slopes during or after development (Barton and Kinkead 2005, Kapfer and Paloski 2011, Walley et al. 2005). Snakes may try to move through the mesh and become entangled, and then may not be able to free themselves. Once entangled, snakes will perish from environmental exposure or starvation, or possibly from predation during their entrapment. In Alberta, there have been several observations of rattlesnakes and other snake species entrapped (and sometimes dead) in erosion control matting (Martinson 2009a, K. Kendell pers. comm.). In areas where snake populations occur, the use of mesh should be avoided and alternative solutions used, such as broadcasting a layer of mulch over the development area (Kapfer and Paloski 2011).

3. Agricultural Activities - Habitat reduction and disturbance through agricultural activities likely played a significant role in the apparent long-term decrease in prairie rattlesnake numbers in Canada (Cottonwood Consultants 1986, Macartney and Weichel

1989, Pendlebury 1977, Russell and Bauer 1993). The intensification of agriculture within the range of the prairie rattlesnake also may be reducing the availability or quality of foraging habitat. It is not known how prey availability differs between cultivated and native/grazed habitats; however, even if prey availability is higher in cultivated habitats, the potential risks associated with occupying these habitats (see below) may result in these areas becoming attractive population "sinks" for snakes. Additionally, the quality of intact native grasslands might have been impacted by rodent-control programs that have reduced prey abundance (e.g., by poisoning) or could poison snakes indirectly (Campbell 1953).

Mortality risk may be higher in cultivated lands or tame pasture compared to native prairie habitat. Jørgensen (2009) examined movements of snakes from two hibernacula, one of which was surrounded by a significant amount of cultivation and the other was largely surrounded by native prairie grassland habitat. All of his radio-tracked snakes from the hibernaculum surrounded by cultivation that migrated to upland prairie grassland habitat made highly linear movements that are typical of this species, and in doing so, traversed or occupied cultivated fields at some point during their migrations. Two of six mortalities of radio-tracked snakes in his study were due to direct mortality by agricultural implements (swathers) in cultivated fields. Although none of the radio-tracked snakes were preyed upon in cultivated habitats, one snake attempted to cross a field (a minimum 800-m journey) that had been recently tilled and was completely devoid of vegetation or other apparent cover, which undoubtedly increased its risk of detection and predation. Despite these observed mortalities or activities that increased risk of predation, Jørgensen (2009) did not find that cultivation posed a higher risk of mortality than other causes of mortality observed during his study, although sample sizes for this comparison may have been too small to detect an effect (K. Kissner pers. obs.).

Andrus (2010) also observed that 17 radio-tracked prairie rattlesnakes in Lethbridge occasionally used agricultural habitats. However, she found that use of these habitats was significantly lower than expected based on their occurrence in her study area, which suggests some degree of avoidance of these areas. Despite these results, Andrus (2010) argued that in Lethbridge, where urban development poses a particular risk, the maintenance of upland/agricultural habitats in and around the city may be beneficial because such habitats provide some resource opportunities, a degree of protective cover, and movement corridors that are not found in other surrounding anthropogenic habitats (residential areas, golf courses, etc.). Thus, the potential benefits of maintaining agricultural habitats may outweigh their potential costs for the City of Lethbridge, but this is a unique situation and agricultural development in other areas of southeastern Alberta is not likely to outweigh its costs.

4. Urban Development - Urban centres that occur along river valleys, such as Medicine Hat and Lethbridge, continue to expand and potentially threaten rattlesnakes as a result of associated increases in human-snake interactions (e.g., persecution), road mortality, and loss and fragmentation of habitat. For example, between the early 1990s and 2006, 75% of rattlesnake habitat in the southwest portion of Lethbridge was lost to urban development (Ernst and Quinlan 2006). Such development in and around Lethbridge continues to encroach on remaining rattlesnake habitat and limit dispersal routes for snakes (Ernst and Quinlan 2006; B. Downey pers. comm.). Since the early 1990s, public education initiatives, snake/wildlife signage, and a formal management plan and conservation program for Lethbridge rattlesnakes have helped mitigate some of the effects of urbanization (snake-human interactions, road mortality), but ever-increasing development within the city may eventually limit the sustainability of this rattlesnake population (Andrus 2010, Ernst 2000, 2002, 2003, 2004, Ernst and Quinlan 2006).

Currently, at least two of the three local rattlesnake populations in Lethbridge are under threat of commercial or residential development. Hibernacula associated with one population occur on privately owned land. This landowner intends to develop this site into a recreational vehicle campground, and has approached ESRD to remove the snakes and relocate the hibernacula, which ESRD has declined to do (B. Downey pers. comm.). Given that hibernacula and snakes are protected by Alberta's *Wildlife Act*, the landowner cannot legally destroy or remove the hibernacula and/or snakes. Similarly, land immediately north of Popson Park that had been under agricultural use was recently sold and approved for residential development by the City of Lethbridge. Unfortunately, the approval process for residential and commercial developments by the City of Lethbridge currently precludes consultation with ESRD regarding wildlife concerns (B. Downey pers. comm.). Only after the proposed development had been approved was ESRD made aware that the southern edge of the development (approximately 140 ha) would occur within 30 m–40 m of a known rattlesnake hibernaculum in Popson Park. At this late stage, ESRD had limited options for input and was only able to suggest mitigation measures for this development (detailed in AECOM Canada Ltd. 2009, B. Downey pers. comm.). Lack of consultation with ESRD in municipal land use planning decisions will undoubtedly continue to expose the Lethbridge rattlesnake population to future impacts of development.

5. Intentional Persecution - Of any group of animals, snakes tend to be the most feared and persecuted by humans (Seburn and Seburn 2000). In particular, rattlesnakes and other venomous species tend to be viewed most negatively by the public (Campbell 2011, Halladay 1965). Some people find the mere presence of a rattlesnake threatening (Didiuk et al. 2004), and people often overestimate the degree of aggression shown by snakes and misinterpret defensive behaviours as attacks (Whitaker and Shine 2000). Unfortunately, fear and dislike of snakes often results in intentional killing of snakes (Langely et al. 1989, Seburn and Seburn 2000). For example, drivers that observe a snake on the road may be more likely to hit it than if it went undetected (Langely et al. 1989).

Anecdotal historical accounts of human persecution of timber rattlesnakes (*C. horridus*) suggest that intentional killing of snakes played a role in their extirpation in Canada (Ontario) (COSEWIC 2001, Seburn and Seburn 2000). Historical intentional persecution and damage/destruction of hibernacula have likely played a role in the long-term decline of prairie rattlesnakes in Alberta (Cottonwood Consultants 1987, Watson and Russell 1997; see Distribution section), and there is evidence that intentional persecution and vandalism at hibernacula still occur in the province (Campbell 2011, Ernst 2002, W. Andrus pers. comm., R. Ernst pers. comm.). It is common to observe shotgun shells at prairie rattlesnake hibernacula in Alberta, presumably an indicator of intentional killing of snakes at these sites (K. Kissner pers. obs.), or to hear reports of gasoline poured down snake hibernacula and the sites burned (Campbell 2011). It is also common to find road-killed snakes with missing tails/rattles on Alberta roads, suggesting that they may have been run over intentionally and the tails/rattles removed for their trophy or novelty value (Didiuk 2003; K. Kissner pers. obs.).

Rattlesnakes may be particularly vulnerable to malicious acts by humans because they often make themselves conspicuous (Parker and Brown 1974). Individual snakes often announce their presence to a perceived threat, such as an approaching human, by rattling with their tail. In addition, rattlesnakes aggregate seasonally, sometimes in very large numbers, at hibernacula (and rookeries) making them conspicuous and very easy to locate in the spring or fall. Vandalism at hibernacula is of special concern because many rattlesnakes may be killed at once, and damage to hibernacula may result in high mortality if rattlesnakes fail to find alternate overwintering locations (Duvall et al. 1985, Kissner et al. 1996). Suitable hibernation sites may be limited even in areas with superficial appearance of abundance. Macartney et al. (1989) studied thermal dynamics of *C. viridis oreganus* (now *C. oreganus*) hibernacula in British Columbia and found that the core temperature of an occupied hibernaculum was 3°C to 5°C during the coldest part of the winter, whereas an unoccupied site that appeared to be similar experienced subzero temperatures, which would have been lethal to rattlesnakes. Alberta's *Wildlife Act* and Wildlife Regulations protect the dens (but not rookeries) of prairie rattlesnakes throughout the year, and the species is considered a *non-game animal* and may not be killed, possessed, bought or sold (Government of Alberta 2011d).

The results of several recent surveys regarding perceptions of snakes and rattlesnakes provide mixed results. Payne (2010) found that, of 2021 respondents across Canada surveyed regarding their perception of snakes, relatively few people indicated they would kill or harm a snake (any species) in comparison to those who would choose to avoid it or have someone else deal with it. However, respondents who were male or from rural areas were more likely to indicate that they would kill or harm a snake. As a follow up to the national study, Campbell (2011) conducted a survey in southern Alberta that focused on why people intentionally harm or kill rattlesnakes. Only males and people located in rural communities that had not been targets of any specific rattlesnake education or conservation programs (Aden, Foremost, Manyberries, Seven Persons, and surrounding areas) were surveyed. Of 13 respondents, only one indicated that he could not kill a rattlesnake under any circumstance, and 10 admitted to having killed a rattlesnake in the past, often citing the presence of children as justification. Upon further questioning, participants indicated they would be willing to harm or kill a rattlesnake if they feared for the safety of children (13/13), their own safety (10/13) or the safety of pets or livestock (11/13). All respondents were willing to kill a snake on their own property, but few would do so on someone else's property or on public property. One participant indicated that he would be willing to kill a rattlesnake anywhere, even in the presence of an Alberta Fish and Wildlife conservation officer. The concept of sport killing was not specifically targeted in the survey; however, one individual admitted to killing rattlesnakes intentionally, often aiming for them when encountered on a highway. Most respondents were aware of the ecological value of snakes for regulating local rodent (pest) populations, but this knowledge increased their feelings of protectiveness towards rattlesnakes for only two respondents. Other reports have indicated that some ranchers in Alberta and Saskatchewan are very protective of prairie rattlesnakes and their dens because of their perceived role in rodent control (Cottonwood Consultants 1987, Didiuk 1999, B. Moffet pers. comm.).

In 2009, a survey was conducted in Lethbridge to assess local residents' awareness about rattlesnakes and gauge public opinion and values around this species (Helen Schuler Coulee Centre 2009). Lethbridge has been the target of ongoing public education initiatives since 1997, and a formal conservation program has been in place since 2001 (Ernst 2000, 2002, 2003, 2004, Ernst and Quinlan 2006). Respondents (n = 182) were generally aware of the rattlesnake population and its potential sensitivity and risk of decline, and 83% indicated it is important to sustain the population through careful land management and conservation efforts. One-third of respondents believed that rattlesnakes are an extreme danger to people and pets, 37% believed that rattlesnakes are aggressive and territorial, and less than 10% indicated a strong negative response to living in a city with rattlesnakes.

Overall, the results of these three surveys indicate that highly negative feelings toward snakes/rattlesnakes persist in Alberta and that intentional persecution is likely to continue to threaten rattlesnakes in the province. However, the results of the Lethbridge survey suggest that this effect could be minimized through the implementation of long-term public education programs and conservation initiatives that help limit snake-human interactions, and through continued enforcement of regulations protecting snakes and their hibernation sites. Legal protection could also be considered at rookery sites since they are currently not protected under Alberta's *Wildlife Act*, despite the fact that persecution of gravid females or destruction of rookery habitat could severely negatively impact population growth and limit the ability of local populations to rebound from declines.

6. Disease - A fungal infection (*Chrysosporium* sp.) was identified in free-ranging eastern Massasauga rattlesnakes (*Sistrurus catenatus catenatus*) in Illinois in 2008 and was observed again in 2010 (Allender et al. 2011). Infected rattlesnakes exhibited severe facial swelling and disfiguration, and three of four infected individuals subsequently died (Allender et al. 2011). Since this initial report, there have been other reports of apparently similar infections in another species of rattlesnake (timber rattlesnake) in New Hampshire and Massachusetts (Yates 2012). The origin of the fungus and its transmission are yet understood, but it could have serious impacts on snake populations and their conservation. Fungal infections have been associated with declines of other wildlife populations, notably frog (Daszak et al. 1999) and bat (Fenton 2012, Frick et al. 2010) populations. Resource managers and researchers should be made aware of this pathogen in order to detect potential infections in Alberta rattlesnakes or other species as early as possible and to reduce the potential for transmission among snakes or hibernacula.

STATUS DESIGNATIONS*

1. Alberta - One of the first unofficial status designations for the prairie rattlesnake in Alberta was assigned by the Alberta Committee on Rare and Endangered Species, which described this species as "locally abundant in southeastern Alberta" (Anonymous 1984). In 1991, the prairie rattlesnake was designated as a "Blue-listed" species in Alberta (Alberta Forestry, Lands and Wildlife 1991), indicating that the species may be at risk as a result of its potential vulnerability to habitat loss, population decline, or reductions in provincial distribution (Alberta Environmental Protection 1996). The species retained this status during a revision of the provincial colour lists in 1996 (Alberta Environmental Protection 1996) and was still considered a Blue-listed species when the original edition of this report was completed in 1997. Following the preparation of the original edition of this status report, *C. viridis* underwent a provincial status assessment by the Alberta Endangered Species Conservation Committee in 2000 and was assigned a status of *Data Deficient*, indicating there was insufficient information on the species to determine its status in the province (Alberta Endangered Species Conservation Committee 2000). In particular, the committee indicated that although there was information to suggest a long-term decline in population size and occurrence in the province, the rate of population decline could not be determined; furthermore, there was information to suggest that its extent of occurrence had remained

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* See Appendix 1 for definitions of selected status designations.

stable during the preceding 20 years. Also in 2000, the provincial general status ranks were reviewed, and prairie rattlesnake was assigned a provincial status designation of *May Be At Risk* (equivalent to its 1991 and 1996 "Blue-listed" designation) of extirpation, given there existed multiple threats to the species and its habitat (Alberta Sustainable Resource Development 2001). It retained this general status rank of *May Be at Risk* during assessments in 2005 and most recently in 2010 (Alberta Sustainable Resource Development 2007, 2011). *C. viridis* is also ranked as S2S3 in the province indicating that it is potentially at risk because of some factor of its biology or because of large scale disturbances (Alberta Conservation Information Management System 2007).

The prairie rattlesnake is listed as a *non-game animal* under Alberta's *Wildlife Act*, making it illegal to kill, possess, buy or sell rattlesnakes in Alberta without a permit (Government of Alberta 2011d). In addition, the *Wildlife Act* protects prairie rattlesnake hibernacula from disturbance throughout the year (Government of Alberta 2011d).

The location of some dens within provincial parks, natural areas, and ecological reserves may afford snakes and hibernacula some level of protection (A. Martinson pers. comm., B. Moffet pers. comm.), although this likely varies among areas and may be dependent on numerous factors (e.g., land use within these areas, traffic volume, etc.). Prairie rattlesnake populations exist within WOSPP, DPP, and the Kennedy Creek/Milk River Canyon Ecological Reserve (Cottonwood Consultants 1986, 1987). In addition, populations exist within Canadian Forces Base Suffield SNWA and on the federally owned Onefour Experimental Farm. Pending the results of a federal status review of this species, *C. viridis* may be afforded additional protection on federal lands in Alberta under the *Species at Risk Act*.

2. Other Areas - To date, the status of the prairie rattlesnake has not been evaluated by the Committee on the Status of Endangered Wildlife in Canada; however, it has been identified as high priority for evaluation (COSEWIC 2011). A report is expected to be completed by 2014, after which its status in Canada will be formally evaluated (R. Brooks pers. comm.). Currently, *C. viridis* is ranked as N3N4 in Canada, indicating the species may be vulnerable to extirpation or uncommon (but not rare) in Canada, and of some conservation concern (NatureServe 2010).

C. viridis is considered *Vulnerable* (S3) in Saskatchewan (Saskatchewan Conservation Data Centre 2011); however, unofficial reports suggest that it may be under considerably more risk in that province (Macartney and Weichel 1993, Secoy 1987). Saskatchewan's *Wildlife Act* prohibits unauthorized killing and possession of rattlesnakes, and unauthorized destruction of their hibernacula (J. Pepper pers. comm.). A number of hibernacula in Saskatchewan are situated such that they are protected under the *Wildlife Habitat Protection Act*, or are within the boundaries of Grasslands National Park (Macartney and Weichel 1989, 1993). Industrial activity (e.g., oil and gas development) restriction guidelines for Saskatchewan also limit the timing and distance development may occur around hibernacula or rookery sites (Saskatchewan Conservation Data Centre 2003; J. Pepper pers. comm.).

Across much of the United States this species is considered *Secure* (S5) or *Apparently Secure* (S4), except in Iowa where it is protected as an *Endangered* animal, Oklahoma where it is considered *Vulnerable* (S3), and in North Dakota where its status has not been determined (NatureServe 2010). In Montana, this species is considered to be widely distributed and abundant (Reichel and Flath 1995) and is classified as a *non-game species*; but, unlike in Alberta, this status does not offer any protection. Seven states still support yearly "rattlesnake roundups" where thousands of rattlesnakes (various species) are captured and/or slaughtered, often to support commercial trade of skins, organs (e.g., gall bladders), meat and other products (Adams et al. 1994, Franke 2000, Warwick et al. 1991).

RECENT MANAGEMENT AND RESEARCH IN ALBERTA

A number of initiatives in the province are addressing management issues, or are collecting and disseminating information that should lead to improved management of prairie rattlesnakes in the province.

1. Dinosaur Provincial Park - With over 80 000 visitors to the park each year, there is significant potential for human-snake encounters; therefore, public safety and the protection of rattlesnake populations have become primary management concerns. A mark-recapture study has been ongoing since 2008 that will provide an estimate of rattlesnake population size in the park within the next several years (A. Martinson pers. comm.). In addition, several rattlesnake conservation and management recommendations made by Martinson (2009a) are being considered or are in various stages of implementation in the park. These recommendations are targeted at reducing human-rattlesnake encounters, reducing road mortality and other sources of mortality for rattlesnakes, increasing public education about the species, and increasing data collection/knowledge about rattlesnake population numbers and distribution in the park and surrounding area.

2. Suffield National Wildlife Area - Traffic management plans implemented within the SNWA in 2000 to reduce snake road mortality in relation to industrial activity are largely still in place, including traffic routing, speed reductions, access limitations, and the provision to industrial workers of education or training materials (e.g., videos) related to snakes (A. Didiuk pers. comm., B. Taylor pers. comm.).

3. Medicine Hat and Brooks Areas - In the early 2000s, the provincial government was undertaking annual surveys of hibernacula in the Medicine Hat and Brooks areas. However, in recent years, this work has generally been conducted only opportunistically, given limitations in provincial resources available to undertake this work (J. Nicholson pers. comm.).

In 2009, a large den complex in Alberta (Kennedy Coulee) was given additional protection through the application of a protective notation (PNT) on the site in the Alberta Public Lands registry system. This PNT covers 388.5 hectares of public land and restricts industrial surface dispositions (developments) within this area, but allows for land uses such as grazing. Current industrial land use guidelines in Alberta indicate that development should not occur within 200 m–500 m of a hibernaculum depending on the level of disturbance; however, these guidelines may be relaxed on public land and their application on private land depends on good habitat stewardship practices by the landholders and developers. Thus, placement of PNTs on hibernacula located on public land better protects them from potential effects of development.

Recently, a project was undertaken to assign numbers to rattlesnake hibernacula across the province (Kissner 2011). This will help track the number of hibernacula in the province, link observations made at individual hibernacula together in the provincial database, and help track trends in relative numbers of snakes at individual hibernacula. This work will be implemented through the Medicine Hat Fish and Wildlife office (J. Nicholson pers. comm.).

4. Lethbridge Area - The Lethbridge Rattlesnake Conservation Program (initiated in 2001) continues to be implemented within the city. No formal monitoring of the Lethbridge rattlesnake population has been undertaken since 2006. The current focus of the program is on public education and reducing human-snake encounters, including translocating snakes observed in residential areas to the closest hibernation site within the city (B. Downey pers. comm.).

5. Milk River - Since 2001, the MULTISAR program has focused on multi-species conservation in the Milk River Drainage. This project is a collaborative effort between Alberta Conservation Association, ESRD, Prairie Conservation Forum and landholders that promote stewardship through voluntary participation on public and private lands. As part of this work, species-at-risk surveys are undertaken to identify sensitive wildlife and their habitats, and range surveys are undertaken to evaluate the overall health of the lands under consideration. Once surveys are completed, habitat management plans are developed that identify habitat enhancements that can be implemented to benefit both the landholder and wildlife. Surveys for snake hibernacula are regularly completed as part of this program, and best management practices aimed at conserving snake habitat are incorporated into habitat management plans and best management practice guidelines (e.g., Rangeland Conservation Service Ltd. 2004). In addition, a habitat model was used to identify suitable habitat for rattlesnakes within the drainage (Kissner 2004).

6. Alberta Conservation Association - Alberta Conservation Association (ACA) delivers two programs that collect data on Alberta's snake and reptile populations. The Alberta Snake Hibernaculum Inventory, initiated in 1996, solicits information from landowners and naturalists on the location of snake hibernacula in Alberta. The Alberta Volunteer Amphibian Monitoring Program, which initially targeted data collection on amphibian populations only, began encouraging volunteers to submit incidental observations of Alberta reptiles and their hibernacula in 2003. Data collected through these programs are submitted to the provincial Fish and Wildlife Management Information System (FWMIS) database. Both programs help increase understanding of rattlesnake distribution and abundance within the province, and information on the location of snake hibernacula helps resource managers protect these sites from potential effects of land use. Additionally, these programs help increase public awareness about rattlesnakes that hopefully improves public support for their conservation.

Alberta Conservation Association has also developed or helped deliver (with ESRD) several educational materials about Alberta's snakes and reptiles. This material includes a teaching guide, *Alberta's Reptiles: lending a helping hand (or two or three) – Teacher's Guide for Grade 7 Science Curriculum*, that provides information and activities that encourage students to explore their attitudes about reptiles and learn about Alberta's reptiles, an educational brochure, *Reptiles of Alberta*, and a poster, *Snakes of Alberta*.

Alberta Conservation Association also administers several programs that focus on the acquisition, administration, and stewardship of lands that have high habitat value in terms of their importance to wildlife (see below). These programs often involve many other partners with similar interests in conserving and stewarding Alberta's wild spaces and species.

7. Land Acquisitions by Non-profit Conservation Groups - In recent years, there have been increasing efforts by non-profit conservation and wildlife groups to work alone or in partnership to undertake land acquisition projects with the focus of stewarding these lands for the benefit of wildlife. In particular, groups such as ACA, The Nature Conservancy of Canada, Alberta Fish & Game Association and Pheasants Forever are working to identify, acquire and steward lands with high habitat value for a variety of wildlife species. Several land acquisitions have occurred within the Grassland Natural Region that have resulted in the conservation of native grassland habitat (J. Nicholson pers. comm.). Prairie rattlesnake hibernacula have been identified on the acquired lands in at least two of these projects, providing enhanced protection of these features and the snakes inhabiting these lands (J. Nicholson pers. comm.).

SYNTHESIS

The Alberta prairie rattlesnake population is primarily distributed along the South Saskatchewan River and Missouri River drainages in southeastern Alberta because these drainages provide suitable habitat for overwintering. Away from the river valleys, the occurrence and relative abundance of *C. viridis* decrease. In the spring, snakes emerge from hibernation and make migrations of varying distances away from overwintering hibernacula to forage and mate. Although various habitat types may be occupied during the summer months, snakes tend to be found in riparian habitats along the river valley or in upland prairie grassland habitat. Gravid female snakes make only short migrations away from hibernacula, and spend their summer months at rookery sites that typically occur within 1 km of overwintering hibernacula. These sites apparently have features that provide optimal conditions for gestation or escape from predators.

The Alberta rattlesnake population appears to have undergone a long-term decline in abundance and distribution since the first European settlers came to the province. Possible factors in their historical decline include habitat loss from agricultural, industrial and urban development and intentional human persecution of snakes. Although the species' range has been relatively stable over the last 50 years, there is evidence of recent declines in abundance at the few hibernacula in Alberta that have been studied since 1990. If similar declines in abundance are occurring range-wide, there is considerable cause for concern, as the low recruitment and reproductive capacity of this species make it slow to recover from population declines.

Increasing agricultural, urban, road, and energy development in Alberta pose continued risk for the rattlesnake population in the province, because these activities are associated with loss, degradation and/or fragmentation of prairie habitat, and they additionally expose rattlesnakes to direct and indirect sources of mortality. The species also has several physical and behavioural characteristics that make it particularly vulnerable to these sources of mortality and to intentional persecution, which is still occurring within the province.

There are approximately 192 known hibernacula in the province, but there may be as many as 242 or as few as 183. Based on estimates of 66 mature snakes per hibernaculum, the size of the Alberta populations is estimated to be 12 672 mature prairie rattlesnakes, although the population may be as high as 15 972 or as low as 12 078 snakes.

There are several gaps in current knowledge about this species in Alberta that should be the focus for future study. Although there have been some recent studies that have helped increase knowledge of population trends, additional (and standardized) data on abundance of snakes would allow for a better assessment of whether population declines are continuing. Ongoing and future declines will only be detected through the implementation of a standardized, long-term population monitoring program at various locations across the species' range, particularly at locations where previous population studies have been undertaken. This work would be intensive in nature and it is expected that significant resources would be required.

A more precise estimate of the total number of rattlesnake hibernacula in the province is needed and could be established by first surveying hibernacula sites summarized in this report to verify their current activity. Additional surveys for previously undetected hibernacula along sections of river valley that have not been adequately surveyed in the past are also needed, particularly along the Bow River where the range of rattlesnakes has apparently contracted in recent years and along the Red Deer River upstream of Finnegan. Surveys could also be undertaken along the Oldman River where few recent observations of snakes and hibernacula have been noted, presumably because of reduced survey effort along this river over the last 30 years.

Another research priority should be to determine the habitat characteristics of rookeries as a means to identify the location of habitat used by gravid females. Only a small number of rookeries have been identified in the province (<40), yet all hibernacula should have an associated rookery(s) that exists either within the immediate area around the hibernacula or within approximately 1 km of the site. These areas represent a habitat component critical to the reproductive success of the species and gravid females show fidelity to individual rookery sites, indicating that these sites are important features on the landscape required annually by snakes; therefore, it will be important to identify them. Rookeries currently have little protection in the province as there is no legal protection of these sites under Alberta's *Wildlife Act*. Although there are guidelines for land use that restrict development around rookeries (Government of Alberta 2012), these guidelines allow some potentially harmful activities to occur very close to rookeries when snakes are in hibernation.

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Appendix 1. Definitions of status ranks and legal designations.

A. The General Status of Alberta Wild Species 2010 (after Alberta Sustainable Resource Development 2011)

2010/2005 Rank	**1996 Rank**	**Definitions**
At Risk	Red	Any species known to be *At Risk* after formal detailed status assessment and designation as *Endangered* or *Threatened* in Alberta.
May Be At Risk	Blue	Any species that may be at risk of extinction or extirpation, and is therefore a candidate for detailed risk assessment.
Sensitive	Yellow	Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.
Secure	Green	Any species that is not *At Risk, May Be At Risk* or *Sensitive*.
Undetermined	Status Undetermined	Any species for which insufficient information, knowledge or data is available to reliably evaluate its general status.
Not Assessed	n/a	Any species that has not been examined during this exercise.
Exotic/Alien	n/a	Any species that has been introduced as a result of human activities.
Extirpated/Extinct	n/a	Any species no longer thought to be present in Alberta (Extirpated) or no longer believed to be present anywhere in the world (Extinct).
Accidental/Vagrant	n/a	Any species occurring infrequently and unpredictably in Alberta, i.e., outside its usual range.

B. Alberta Species at Risk Formal Status Designations
Species designated as *Endangered* under Alberta's *Wildlife Act* include those listed as *Endangered* or *Threatened* in the Wildlife Regulation (in bold).

Endangered	**A species facing imminent extirpation or extinction.**
Threatened	**A species likely to become endangered if limiting factors are not reversed.**
Species of Special Concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Data Deficient	A species for which there is insufficient scientific information to support status designation.

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 2010)

Extinct	A species that no longer exists.
Extirpated	A species that no longer exists in the wild in Canada, but occurs elsewhere.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.
Special Concern	A species that may become threatened or endangered because of a combination of biological characteristics and identified threats.
Not at Risk	A species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient	A category that applies when the available information is insufficient to (a) resolve a wildlife species' eligibility for assessment, or (b) permit an assessment of the wildlife species' risk of extinction.

Appendix 1 continued:

D. Heritage Status Ranks: Global (G), National (N), Subnational (S) (after Alberta Conservation Information Management System [formerly Alberta Natural Heritage Information Centre] 2007, NatureServe 2010)

G1/N1/S1	5 or fewer occurrences or only a few remaining individuals. May be especially vulnerable to extirpation because of some factor of its biology.
G2/N2/S2	6 to 20 or fewer occurrences or with many individuals in fewer locations. May be especially vulnerable to extirpation because of some factor of its biology.
G3/N3/S3	21 to 100 occurrences; may be rare and local throughout its range, or in a restricted range (may be abundant in some locations). May be susceptible to extirpation because of large-scale disturbances.
G4/N4/S4	Typically > 100 occurrences. Apparently secure.
G5/N5/S5	Typically > 100 occurrences. Demonstrably secure.
GX/NX/SX	Believed to be extinct or extirpated; historical records only.
GH/NH/SH	Historically known; may be relocated in the future.
G?/N?/S?	Not yet ranked, or rank tentatively assigned.

E. United States Endangered Species Act (after National Research Council 1995)

Endangered	Any species that is in danger of extinction throughout all or a significant portion of its range.
Threatened	Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Appendix 2. Technical Summary

A summary of information contained within this report, and used by the Scientific Subcommittee of Alberta's Endangered Species Conservation Committee for the purpose of status assessment based on International Union for the Conservation of Nature criteria. For definitions of terms used in this technical summary, go to: http://www.iucnredlist.org/technical-documents/categories-and-criteria and http://www.cosepac.gc.ca/eng/sct2/sct2_6_e.cfm

Genus species: Crotalus viridis
Common name: Prairie Rattlesnake
Range of occurrence in Alberta: Grassland Natural Region mostly in the Mixedgrass and Dry Mixedgrass sub-regions; distribution closely associated with the major river valleys (Oldman, Bow, Red Deer, South Saskatchewan and Milk rivers).

Demographic Information

Generation time (usually average age of parents in the population) See Conservation Biology, p. 12. Females have 1st litters at ca. 7 years and may live to approx 15 years, so estimated at 11 years.	Not known. Estimated at 11 years.
Is there an observed, inferred, or projected continuing decline in number of mature individuals? See Population Size and Trends in Alberta, pp. 14–18. No population trend data are available for the species.	Anecdotal data support range-wide historical decline; limited evidence of more recent short-term decline in 2 locations (across several dens).
Estimated percent of continuing decline in total number of mature individuals within 5 years or 2 generations. See Population Size and Trends in Alberta, pp. 14–18	Insufficient data to estimate.
Observed, estimated, inferred, or suspected percent reduction in total number of mature individuals over the last 10 years, or 3 generations. See Population Size and Trends in Alberta, pp. 14–18. Data insufficient to estimate magnitude of range-wide decline.	Observed past decline at one site and inferred at a second location.

Appendix 2 continued:

Projected or suspected percent reduction in total number of mature individuals over the next 10 years, or 3 generations. See Population Size and Trends in Alberta, pp. 14–18, and Limiting Factors, pp. 18–26. There is insufficient data to estimate the magnitude of this reduction.	A decline is possible, given the potential for loss of snakes associated with development or human persecution (and possibly future disease).
Suspected percent reduction in total number of mature individuals over a 10 year or 3 generation period, over a time period including both the past and the future. See Population Size and Trends in Alberta, pp. 14–18. There is insufficient data to estimate the magnitude of this reduction.	A decline is possible, given the potential for loss of snakes associated with development or human persecution (and possibly future disease).
Are the causes of the decline clearly reversible and understood and ceased? See Limiting Factors, pp. 18–26, and Habitat Loss and Fragmentation, pp. 10–11	No
Are there extreme fluctuations in number of mature individuals? See Population Size and Trends in Alberta, pp. 14–18. Insufficient data to estimate.	Unlikely, given biology of species.

Extent and Occupancy Information

Estimated extent of occurrence See Distribution in Alberta, p. 4	46 012 km^2
Area of occupancy (AO) (Always report 2km x 2km grid value; other values may also be listed if they are clearly indicated). See Distribution in Alberta, p. 4. IAO of hibernacula only is based on 192 hibernacula. Biological area of occupancy (BAO) is much smaller, because the size of most hibernacula is much less than 4 km^2 and often much less than 500 m^2).	Index of area of occupancy (IAO) of hibernacula only is 496 km^2 (2-km x 2-km grid). BAO is < 42 km^2 (0.5-km x 0.5-km grid).

Appendix 2 continued:

Is the total population severely fragmented? See Distribution in Alberta, pp. 4–5, and Habitat Loss and Fragmentation, pp. 10–11	No
Number of locations See Population Size and Trends in Alberta, pp. 15–16	Estimated # of hibernacula: maximum = 242 minimum = 183 probable = 192
Is there an observed continuing decline in extent of occurrence? See Distribution in Alberta, pp. 1–5	Possibly, but small
Is there an inferred or projected continuing decline in index of area of occupancy? See Distribution in Alberta, pp. 1–5. Anecdotal evidence supports past loss of hibernacula from factors such as human persecution and development (particularly prior to legislation protecting these features). There is insufficient information to assess the magnitude of losses. Existing protection of hibernacula (legislation, land use guidelines) should help reduce loss of sites currently and in the future. Loss of rookery sites during periods when these features are not protected by legislation could contribute to a loss in area of occupancy.	Past decline in area of occupancy associated with range contraction. A continuing decline is possible.
Is there a projected continuing decline in number of subpopulations? See Distribution in Alberta, pp. 1–5. Declines could result from factors associated with development or human persecution (and possibly future disease).	A projected decline is likely if subpopulations (and/or hibernacula or rookeries) are reduced
Is there a projected continuing decline in number of locations? See Distribution in Alberta, pp. 1–5, and Population Size and Trends in Alberta, pp. 14–18. Continuing loss of hibernacula will likely be minimized via existing protection (legislation, land use guidelines, etc.). Loss of rookeries during periods when these sites are not protected from development is a possibility.	Possibly

Appendix 2 continued:

Is there an inferred or projected continuing decline in quality of habitat? See Habitat Loss and Fragmentation, pp. 10–11, and Limiting Factors, pp. 18–26. Habitat modifications from agriculture, urban, energy, and road development reduce habitat quality.	Yes
Are there extreme fluctuations in number of subpopulations? See Distribution in Alberta, pp. 1–5, and Population Size and Trends in Alberta, pp. 14–18	No
Are there extreme fluctuations in number of locations? See Distribution in Alberta, pp. 1–5, and Population Size and Trends in Alberta, pp. 14–18	No
Are there extreme fluctuations in extent of occurrence? See Distribution in Alberta, pp. 1–5	No
Are there extreme fluctuations in index of area of occupancy? See Distribution in Alberta, pp. 1–5	No

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Estimated at 66 mature individuals per hibernaculum x 192 hibernacula (estimated range = 183 to 242 hibernacula). Population Size and Trends in Alberta, pp. 14–18	12 672 (estimated range = 12 078 to 15 972)

Quantitative Analysis

Probability of extinction in the wild	Unknown

Threats (actual or imminent, to populations or habitats)

agriculture, urban, energy and road development, intentional persecution See Limiting Factors, pp. 18–26, and Habitat Loss and Fragmentation, pp. 10–11

Appendix 2 continued:

Rescue Effect (immigration from outside Alberta)

Status of outside population(s)? Populations in Saskatchewan and Montana present. Size and status largely unknown. Recent loss of one of the largest known hibernacula in SK (natural collapse) may have significantly reduced snake numbers in SK. Recent population estimates are not available. See Distribution in Other Areas, p. 5, and Population Size and Trends in Other Areas, p. 18	
Is immigration known or possible?	Not known, but possible from Montana and Saskatchewan.
Would immigrants be adapted to survive in Alberta?	Yes
Is there sufficient habitat for immigrants in Alberta?	Yes
Is rescue from outside populations likely? See Distribution in Other Areas, p. 5, and Population Size and Trends in Other Areas, p.18	Unknown

Current Status

Provincial: Data Deficient, May Be at Risk, S2S3 National: N3N4; Not assessed by COSEWIC (federal status expected to be prepared by 2014) Elsewhere: Arizona (S5), Colorado (S5), Idaho (S5), Iowa (S1), Kansas (S5), Montana (S4), Nebraska (S4), New Mexico (S5), North Dakota (SNR), Oklahoma (S3), South Dakota (S5), Texas (S5), Utah (S5), Wyoming (S5)

Author of Technical Summary: Kelley Kissner

Additional Sources of Information:

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(as of December 2012)

No. 1 Status of the Piping Plover (*Charadrius melodus*) in Alberta, by David R. C. Prescott. 19 pp. (1997)

No. 2 Status of the Wolverine (*Gulo gulo*) in Alberta, by Stephen Petersen. 17 pp. (1997)

No. 3 Status of the Northern Long-eared Bat (*Myotis septentrionalis*) in Alberta, by M. Carolina Caceres and M. J. Pybus. 19 pp. (1997)

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No. 4 Status of the Ord's Kangaroo Rat (*Dipodomys ordii*) in Alberta, by David L. Gummer. 16 pp. (1997)

No. 5 Status of the Eastern Short-horned Lizard (*Phrynosoma douglassii brevirostre*) in Alberta, by Janice D. James, Anthony P. Russell and G. Lawrence Powell. 20 pp. (1997)

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No. 6 Status of the Prairie Rattlesnake (*Crotalus viridis viridis*) in Alberta, by Sheri M. Watson and Anthony P. Russell. 26 pp. (1997)

No. 6 Update 2012. Status of the Prairie Rattlesnake (*Crotalus viridis*) in Alberta. Alberta Environment and Sustainable Resource Development and Alberta Conservation Association. 49 pp. (2012)

No. 7 Status of the Swift Fox (*Vulpes velox*) in Alberta, by Susan E. Cotterill. 17 pp. (1997)

No. 8 Status of the Peregrine Falcon (*Falco peregrinus anatum*) in Alberta, by Petra Rowell and David P. Stepnisky. 23 pp. (1997)

No. 9 Status of the Northern Leopard Frog (*Rana pipiens*) in Alberta, by Greg Wagner. 46 pp. (1997)

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