# COSEWIC
# Assessment and Status Report

on the

# Eastern Yellow-bellied Racer
*Coluber constrictor flaviventris*

and the

# Western Yellow-bellied Racer
*Coluber constrictor mormon*

**in Canada**

**THREATENED**
**2015**

**COSEWIC**
Committee on the Status
of Endangered Wildlife
in Canada

**COSEPAC**
Comité sur la situation
des espèces en péril
au Canada

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

COSEWIC. 2015. COSEWIC assessment and status report on the Eastern Yellow-bellied Racer *Coluber constrictor flaviventris* and Western Yellow-bellied Racer *Coluber constrictor mormon* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xvii + 64 pp. (http://www.registrelep-sararegistry.gc.ca/default_e.cfm).

Previous report(s):

COSEWIC 2004. COSEWIC assessment and update status report on the Eastern and Western Yellow-bellied Racers, *Coluber constrictor flaviventris* and *Coluber constrictor mormon* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 35 pp. (www.sararegistry.gc.ca/status/status_e.cfm)

Campbell, C.A., and D.W. Perrin 1991. COSEWIC status report on the Racer *Coluber constrictor* in Canada. Committee on the Status of Endangered Wildlife in Canada with additions on the Eastern and Western Yellow-bellied Racers by J.M. Macartney and additions on the Blue Racer by B.D. Porchuk; revised and edited by F. Cook and R.J. Brooks. 36 pp.

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Cover illustration/photo:
Eastern Yellow-bellied Racer (*Coluber constrictor flaviventris*); photo courtesy of Laura Gardiner.


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# COSEWIC
# Assessment Summary

**Assessment Summary – November 2015**

**Common name**
Eastern Yellow-bellied Racer

**Scientific name**
*Coluber constrictor flaviventris*

**Status**
Threatened

**Reason for designation**
The Canadian distribution of this snake is restricted to three river valleys in southwestern Saskatchewan and one in extreme southeastern Alberta. Small population size (< 10,000), together with the use of communal dens for over-wintering, make the population particularly vulnerable to declines from stochastic events such as landslides during the denning period and from road mortality. Habitat loss and degradation in foraging habitat and along migration routes is also a concern.

**Occurrence**
Alberta, Saskatchewan

**Status history**
Designated Special Concern in April 1991. Status re-examined and designated Threatened in November 2004 and November 2015.

**Assessment Summary – November 2015**

**Common name**
Western Yellow-bellied Racer

**Scientific name**
*Coluber constrictor mormon*

**Status**
Threatened

**Reason for designation**
The Canadian distribution of this snake is confined to arid valleys of south-central British Columbia, an area with intensive agricultural development and an expanding human population and tourism industry. While relatively little is known of this elusive snake, it likely faces similar threats as other large snakes with which it shares its habitat (Western Rattlesnake, Great Basin Gophersnake). Migratory behaviour of snakes between overwintering dens on valley slopes and lowland foraging habitats, together with increasing numbers of roads and traffic volumes, make populations particularly sensitive to road mortality and habitat loss and fragmentation. Life history characteristics, such as small clutch size and infrequent reproduction by females, increase vulnerability of populations to disturbance, persecution, and changes in land use.

**Occurrence**
British Columbia

**Status history**
Designated Not at Risk in April 1991. Status re-examined and designated Special Concern in November 2004. Status re-examined and designated Threatened in November 2015.

**COSEWIC**
**Executive Summary**

# Eastern Yellow-bellied Racer
*Coluber constrictor flaviventris*

and the

# Western Yellow-bellied Racer
*Coluber constrictor mormon*

## Wildlife Species Description and Significance

The racer species complex (*Coluber constrictor*) has a broad distribution throughout North America, with three subspecies occurring in Canada: Eastern Yellow-bellied Racer (*Coluber constrictor flaviventris*), Western Yellow-bellied Racer (*C. c. mormon*), and Blue Racer (*C. c. foxii*; addressed in a separate status report). Racers are long, slender snakes with whip-like tails. The Eastern and Western Yellow-bellied Racers are olive-green to blue-grey with cream to bright yellow undersides, from which the name “Yellow-bellied Racer” is derived. Juvenile racers have dark saddle-shaped dorsal markings that fade as the snakes mature. Their sleek body form helps make them extremely fast, while their colouration provides excellent camouflage. In Canada, racers are at the northern extent of their global distribution, where they are of high conservation value as such populations often possess unique ecological adaptations. Racers are non-venomous and harmless to humans. They feed mainly on rodents and insects and are beneficial to local ecological processes.

## Distribution

Racers are broadly distributed across North America, but the Eastern Yellow-bellied Racer and Western Yellow-bellied Racer have more restricted ranges. In Canada, the distribution of the Eastern Yellow-bellied Racer extends into three discrete river valleys in southern Saskatchewan and one in southeastern Alberta. The Western Yellow-bellied Racer is restricted to the arid south-central interior of British Columbia, where it occurs in five discrete river valleys.

## Habitat

In Canada, racers overwinter in communal rock dens. Western Yellow-bellied Racers may also use rodent burrows or other refuges and hibernate singly, as shown for the sympatric Great Basin Gophersnake. Rock dens are often located on south-facing slopes of steep river valleys, and suitable sites appear to be a limited resource within the landscape. During the active season, racers move from their dens into grassland foraging areas in adjacent lowlands. While Eastern Yellow-bellied Racers occur in mixed-grass prairie, Western Yellow-bellied Racers most frequently occur in Ponderosa Pine and Bunchgrass habitats. Both subspecies forage in riparian and valley bottom habitats.

## Biology

In more southern areas of their range in the United States, female racers mature at 2 - 4 years of age and produce one clutch of eggs per year, although, depending on body condition, some may reproduce only every second year. Limited data are available on the age of maturity and survivorship of racers in Canada. The generation time is presumed to be 7 – 8 years. Racers mate after emerging from their winter dens in spring. Females lay a clutch of 3 – 12 eggs, which hatch in approximately 2 months (usually August or September), at which time neonates find their way to a den to hibernate for the winter. Individuals often exhibit strong fidelity to specific hibernacula. The diet of juvenile Eastern and Western Yellow-bellied Racers consists mainly of insects, including crickets and grasshoppers. Adult racers will also take larger prey such as small mammals, reptiles, birds, and amphibians.

## Population Sizes and Trends

Racers are well-camouflaged, fast, wary snakes, which makes it difficult to accurately estimate population sizes or even their presence/absence. Based on recent research conducted in Saskatchewan and Alberta, it is evident that Eastern Yellow-bellied Racers are uncommon on the Canadian prairies, and that population dynamics may be negatively affected by habitat fragmentation. The Canadian population size is most likely less than 10,000 adults, distributed among four discrete major valleys on the prairies. Within the past 10 years, the population has declined as a result of a terrain slumping event in Grasslands National Park that killed and displaced snakes from the largest known den of this subspecies in Canada.

Western Yellow-bellied Racers in British Columbia are also uncommon, and their numbers have likely declined from historical levels as a consequence of habitat loss associated with the expansion of urban and agricultural areas. There are potentially five subpopulations of Western Yellow-bellied Racers in major river valleys in the arid interior of the province. Continued threats from road mortality and habitat loss, deterioration, and fragmentation suggest that the population is declining.

## Threats and Limiting Factors

Both Eastern and Western Yellow-bellied Racers are vulnerable to habitat loss and fragmentation. These snakes exhibit a high degree of fidelity to specific hibernacula, nesting sites, and summer foraging areas, and appear not to tolerate significant disturbance to these habitats. Racers are limited by the availability of suitable den sites and are unlikely to be able to relocate to other areas if dens are destroyed. Large geographic distances or habitat-barriers isolate small subpopulations, further decreasing the probability of individuals dispersing between sites. Both subspecies are regularly killed on roads, but the threat of road mortality varies greatly across their ranges, being considerably greater for the western subspecies. The overall threat impact was rated as “high” for the Western Yellow-bellied Racer and “medium” for the Eastern Yellow-bellied Racer according to the COSEWIC threat calculator.

## Protection, Status, and Ranks

COSEWIC assessed the Eastern Yellow-bellied Racer as Threatened and the Western Yellow-bellied Racer as Special Concern in 2004. Both are listed in Schedule 1 of the *Species at Risk Act*. Provincially, the Saskatchewan *Wildlife Act* and the British Columbia *Wildlife Act* prohibit unauthorized killing or possession of racers, but they have no legal protection in Alberta. NatureServe lists both the Eastern Yellow-bellied Racer and the Western Yellow-bellied Racer as Secure (G5T5) globally, Vulnerable (N3) in Canada, and Vulnerable (S3) provincially, except in Alberta where racers are considered Unrankable (SU) because of a lack of information. The General Status Rank of *C. constrictor* (subspecies are not ranked separately) is considered Sensitive (rank 3) in Canada, Sensitive in British Columbia, and At Risk (rank 1) in Saskatchewan. The IUCN lists *C. constrictor* as a species of Least Concern.

# TECHNICAL SUMMARY – Eastern Yellow-bellied Racer

*Coluber constrictor flaviventris*
Eastern Yellow-bellied Racer Couleuvre agile à ventre jaune de l'Est
Range of occurrence in Canada (province/territory/ocean): Saskatchewan and Alberta

**Demographic Information**

| | |
|---|---|
| Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used) | ~7 – 8 yrs (females) |
| Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? | Yes, observed and inferred decline based on a terrain slumping event at a major den in 2011, and projected decline based on threats calculator results. |
| Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]. | Unknown |
| [Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]. | Unknown |
| [Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations]. | Unknown |
| [Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future. | Unknown |
| Are the causes of the decline a. clearly reversible and b. understood and c. ceased? | a. No<br>b. Partially<br>c. No |
| Are there extreme fluctuations in number of mature individuals? | No |

**Extent and Occupancy Information**

| | |
|---|---|
| Estimated extent of occurrence | 15,491 km² |
| Index of area of occupancy (IAO)<br>(Always report 2x2 grid value). | <100 km² based on communal overwintering den sites |
| Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse? | a. Unknown but probably not<br>b. Yes |

| | |
|---|---|
| Number of "locations"* (use plausible range to reflect uncertainty if appropriate) | 10 – 12, corresponding to the number of den sites and their surroundings, where snakes are subject to separate threats from roadkill, predation, and landslides. Additional unknown den sites may exist, bringing the most plausible number of locations above 10 |
| Is there an [observed, inferred, or projected] decline in extent of occurrence? | Unknown but not in known EO |
| Is there an [observed, inferred, or projected] decline in index of area of occupancy? | Unknown but not in known IAO |
| Is there an [observed, inferred, or projected] decline in number of subpopulations? | No, if each major river valley is considered to support its own subpopulation |
| Is there an [observed, inferred, or projected] decline in number of "locations"*? | No |
| Is there an [observed, inferred, or projected] decline in [area, extent and/or *quality*] of habitat? | Yes; observed, inferred and projected decline in area, extent and quality of habitat |
| Are there extreme fluctuations in number of subpopulations? | No |
| Are there extreme fluctuations in number of "locations"*? | No |
| Are there extreme fluctuations in extent of occurrence? | No |
| Are there extreme fluctuations in index of area of occupancy? | No |

**Number of Mature Individuals (in each subpopulation)**

| **Subpopulations (give plausible ranges)** | **N Mature Individuals [1]** |
|---|---|
| Milk River (Alberta) – 1 known den. It is estimated that there is probably a comparable number of dens (or fewer) than in the Frenchman River population (based on apparently suitable habitat) | Unknown but likely 100-1000 |
| Frenchman River (Saskatchewan) – 7 known active dens. There are likely few unknown dens (based on habitat and surveys) | Unknown but likely 200-1000 |
| Rock Creek (Saskatchewan) – 1 known den area. There are likely few unknown dens (based on habitat and surveys) | Unknown but likely 100-500 |

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

[1] These figures are estimated based on the perception of the report writers from 5 years of field experience. Most dens are only inhabited by a small number of adults (an estimated 20-30 individuals), but one den in the Frenchman River Valley was inhabited by up to 300 individuals. Beyond these rough estimates, there is no way to accurately estimate population size for Eastern Yellow-bellied Racers in Canada.

| | |
|---|---|
| Big Muddy Valley (Saskatchewan) – 1 known den, but there are likely several unknown dens (based on extent of suitable habitat) | Unknown but likely 200-1000 |
| Total | Unknown but likely 600-3500 |

**Quantitative Analysis**

| | |
|---|---|
| Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]. | Not done due to lack of data |

**Threats (actual or imminent, to populations or habitats)**

| |
|---|
| Transportation & service corridors (Roads & railroads) |
| Agriculture (Annual & perennial non-timber crops, livestock farming & ranching) |
| Geological events (Avalanches/landslides) |
| Energy production & mining (Oil & gas drilling) |

**Rescue Effect (immigration from outside Canada)**

| | |
|---|---|
| Status of outside population(s) most likely to provide immigrants to Canada. | Montana: S5 (not at risk) |
| Is immigration known or possible? | Possible from Montana |
| Would immigrants be adapted to survive in Canada? | Probably |
| Is there sufficient habitat for immigrants in Canada? | Unknown |
| Are conditions deteriorating in Canada?[+] | Possibly |
| Are conditions for the source population deteriorating?[+] | Unknown |
| Is the Canadian population considered to be a sink?[+] | No |
| Is rescue from outside populations likely? | Possible but of limited importance and restricted to localized areas around the border |

**Data Sensitive Species**

| | |
|---|---|
| Is this a data sensitive species? | Yes (den sites) |

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

**Current Status**

| |
|---|
| COSEWIC Status: Threatened<br><br>COSEWIC Status History:<br>Designated Special Concern in April 1991. Status re-examined and designated Threatened in November 2004. Last assessment based on an update status report.<br><br>Criteria: Met criteria for Endangered, B1ab(iii)+2ab(iii), but designated Threatened, B1ab(iii)+2ab(iii) because a large part of the subspecies' habitat is in Grasslands National Park, and there is rescue potential from the state of Montana.<br><br>Reason for Designation (2004):<br>"This snake is restricted to two small areas in extreme southern Saskatchewan. It is at risk due to loss of habitat from agriculture, mortality on roads, loss of den sites and perhaps from effects of small population size. There may be a rescue effect from immigration from the United States, but this effect has not been observed". |
| Author of Technical Summary: COSEWIC Amphibians & Reptiles SSC |
| Additional Sources of Information: Parks Canada Agency. 2010. Recovery Strategy for Eastern Yellow-bellied Racer (*Coluber constrictor flaviventris*) in Canada. Species at Risk Act Recovery Strategy Series. Parks Canada Agency. Ottawa, Ontario. vii + 22 pp. |

**Status and Reasons for Designation:**

| **Recommended Status:** | **Alpha-numeric code:** |
|---|---|
| Threatened | C2a(i) |
| **Reasons for designation:**<br>The Canadian distribution of this snake is restricted to three river valleys in southwestern Saskatchewan and one in extreme southeastern Alberta. Small population size (< 10,000), together with the use of communal dens for overwintering, make the population particularly vulnerable to declines from stochastic events such as landslides during the denning period and from road mortality. Habitat loss and degradation in foraging habitat and along migration routes is also a concern. | |

**Applicability of Criteria**

| |
|---|
| Criterion A (Decline in Total Number of Mature Individuals): Does not meet criteria. While there are observed, inferred and projected declines, their magnitude is unknown or below thresholds. |
| Criterion B (Small Distribution Range and Decline or Fluctuation):<br>Does not meet criteria. While the EO and IAO are below thresholds for Threatened or Endangered, respectively, and habitat quality is declining, the number of locations is suspected to be greater than 10, and there is no severe fragmentation or extreme fluctuations. |
| Criterion C (Small and Declining Number of Mature Individuals):<br>Meets Threatened C2a(i) because there are estimated to be fewer than 10,000 mature individuals, there is an observed and inferred decline in population size, and no subpopulation contains more than 1000 mature individuals. |
| Criterion D (Very Small or Restricted Population):<br>Does not meet criteria. The population is not sufficiently small or restricted to meet this criterion. |
| Criterion E (Quantitative Analysis):<br>Not applicable. Not done due to lack of data. |

# TECHNICAL SUMMARY – Western Yellow-bellied Racer

*Coluber constrictor mormon*
Western Yellow-bellied Racer Couleuvre agile à ventre jaune de l'Ouest
Range of occurrence in Canada (province/territory/ocean): British Columbia

**Demographic Information**

| | |
|---|---|
| Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used) | ~7 – 8 yrs (females) |
| Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? | Yes, inferred and projected decline from continued loss of habitat and threats |
| Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations] | Unknown |
| [Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]. | Unknown |
| [Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations]. | Projected and suspected decline of >30% based primarily on road mortality and habitat loss and degradation, supported by population model developed for the sympatric Great Basin Gophersnake with similar life history characteristics and ecology. |
| [Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future. | Inferred and suspected decline of >30% based on threats (past and projected) and habitat loss |
| Are the causes of the decline a. clearly reversible and b. understood and c. ceased? | a. No<br>b. Partially<br>c. No |
| Are there extreme fluctuations in number of mature individuals? | Unknown |

**Extent and Occupancy Information**

| | |
|---|---|
| Estimated extent of occurrence | 48,493 km² |

| | |
|---|---|
| Index of area of occupancy (IAO)<br>(Always report 2x2 grid value). | < 1000 km², based on known and suspected communal overwintering den sites; actual IAO may be larger, as an unknown proportion of racers may hibernate singly away from these sites. |
| Is the population "severely fragmented" ie. is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse? | a. No<br>b. Probably not but the landscape is fragmented |
| Number of "locations"* (use plausible range to reflect uncertainty if appropriate) | Possibly >100, corresponding to the number of known den sites and their surroundings, which are subject to separate threats from roadkill, habitat loss and fragmentation, and other threats |
| Is there an [observed, inferred, or projected] decline in extent of occurrence? | No |
| Is there an [observed, inferred, or projected] decline in index of area of occupancy? | Inferred and projected decline based on threats from roadkill and habitat loss |
| Is there an [observed, inferred, or projected] decline in number of subpopulations? | No, if snakes in each major valley are considered subpopulations |
| Is there an [observed, inferred, or projected] decline in number of "locations"*? | Unknown but possibly an inferred and projected decline based on habitat loss, roadkill and other threats |
| Is there an [observed, inferred, or projected] decline in [area, extent and/or *quality*] of habitat? | Yes, an observed, inferred and projected decline in the area, extent and quality of habitat |
| Are there extreme fluctuations in number of subpopulations? | No |
| Are there extreme fluctuations in number of "locations"*? | No |
| Are there extreme fluctuations in extent of occurrence? | No |
| Are there extreme fluctuations in index of area of occupancy? | No |

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

**Number of Mature Individuals (in each subpopulation)**

| Subpopulation | N Mature Individuals |
|---|---|
| South Columbia watershed (Trail) | Unknown but small |
| Granby watershed (Grand Forks) | Unknown but small |
| Kettle watershed | Unknown but small |
| Okanagan/Similkameen watershed | Unknown but larger |
| Thompson/Fraser watershed | Unknown but larger |
| Total | Unknown but possibly < 10 000<br><br>BC Conservation Data Centre places the number of individuals in the category of 2,500 - 10,000 individuals based on expert opinion, but there are no robust data |

**Quantitative Analysis**

| | |
|---|---|
| Probability of extinction in the wild is at least 20% within 20 years or 5 generations, or 10% within 100 years. | Not done due to lack of data |

**Threats (actual or imminent, to populations or habitats)**

| |
|---|
| Transportation & service corridors; roads & railroads<br><br>Residential & commercial development; housing & urban areas, commercial & industrial areas<br><br>Agriculture & aquaculture; annual & perennial non-timber crops; livestock farming & ranching<br><br>Human intrusions & disturbance; recreational activities |

**Rescue Effect (immigration from outside Canada)**

| | |
|---|---|
| Status of outside population(s)? | Washington: S5 (not at risk) |
| Is immigration known or possible? | Unknown |
| Would immigrants be adapted to survive in Canada? | Probably |
| Is there sufficient habitat for immigrants in Canada? | Unknown |
| Are conditions deteriorating in Canada?[+] | Yes |
| Are conditions for the source population deteriorating?[+] | Unknown |
| Is the Canadian population considered to be a sink?[+] | No |

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

| | |
|---|---|
| Is rescue from outside populations likely? | Possible but restricted to areas around the border and of limited importance |

**Data Sensitive Species**

| | |
|---|---|
| Is this a data sensitive species? | Yes (den sites) |

**Current Status**

COSEWIC: Special Concern

COSEWIC Status History:
Designated Not at Risk in April 1991. Status re-examined and designated Special Concern in November 2004.

Criteria (2004): Not applicable

Reasons for Designation (2004): “This snake occurs in five valleys in south-central British Columbia. It is susceptible to habitat loss and fragmentation from agriculture and urban development, especially as this species is particularly intolerant of urbanization. The ongoing expansion of the road network and traffic volume increases mortality and further fragments the habitat. Pesticide applications in agricultural areas may impact the snakes both directly and via contamination of their insect prey. It is unlikely that there is a significant rescue effect because of extensive loss of habitat contiguous to the United States border”.

Author of Technical Summary: COSEWIC Amphibians & Reptiles SSC

Additional Sources of Information: Racer Management Team Working Group. 2013. Management plan for the Racer (*Coluber constrictor*) in British Columbia. Prepared for the B.C. Ministry of Environment, Victoria, British Columbia. 25 pp.

**Status and Reasons for Designation:**

| **Recommended Status:** | **Alpha-numeric code:** |
|---|---|
| Threatened | A3cd+4cd |

**Reasons for designation:**
The Canadian distribution of this snake is confined to arid valleys of south-central British Columbia, an area with intensive agricultural development and an expanding human population and tourism industry. While relatively little is known of this elusive snake, it likely faces similar threats as other large snakes with which it shares its habitat (Western Rattlesnake, Great Basin Gophersnake). Migratory behaviour of snakes between overwintering dens on valley slopes and ridges and lowland foraging habitats, together with increasing numbers of roads and traffic volumes, make populations particularly sensitive to road mortality and habitat loss and fragmentation. Life history characteristics, such as small clutch size and infrequent reproduction by females, increase vulnerability of populations to disturbance, persecution, and changes in land use.

**Applicability of Criteria**

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened A3cd, because there is a suspected reduction of 30% or more in the number of mature individuals over the next 3 generations based on declines in the quality of habitat (sub-criterion c), primarily due to increases in road mortality and habitat loss, and potential levels of exploitation (deliberate killing of snakes) (sub-criterion d), Meets Threatened A4cd because in addition to above projected declines, there are inferred past declines from habitat loss and from these and other threats.

| |
|---|
| Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criteria. While the IAO is below the threshold for Threatened and there is a decline in habitat quality, there are >10 locations and the population is not severely fragmented, and there are no extreme fluctuations. |
| Criterion C (Small and Declining Number of Mature Individuals): Possibly meets criteria. Although there are probably less than 10,000 adults, there much uncertainty with this population estimate, and insufficient data regarding subpopulation size and rate of decline to apply the criteria at this time. |
| Criterion D (Very Small or Restricted Population): Does not meet criteria. The population is not very small or restricted. |
| Criterion E (Quantitative Analysis): Not applicable. Not done due to lack of population data. |

## PREFACE

Since the previous status report (COSEWIC 2004), new survey information has helped refine distributions of both the Eastern and Western Yellow-bellied Racers, and several previously unknown den sites have been documented. New molecular work completed on 150 Eastern Yellow-bellied Racers from two river valleys (Frenchman and the Big Muddy river valleys) indicates that there may be several genetically distinct subpopulations in Canada. A major terrain slump event occurred in the spring of 2011 at the largest known den site of the Eastern Yellow-bellied Racer and displaced or killed a potentially significant but unknown proportion of racers at the den. No new information exists on population size and trends of Western Yellow-bellied Racers, but threats have been assessed and remain substantial.

A federal recovery strategy has been prepared for the Eastern Yellow-bellied Racer (Parks Canada 2010), including Critical Habitat description. Critical Habitat currently protected for Eastern Yellow-bellied Racers consists of a 500 m buffer around each of seven known hibernacula within the Frenchman River Valley. While den protection is essential, conservation strategies must also consider movement corridors and summering grounds to ensure long-term persistence. For the Western Yellow-bellied Racer, a provincial management plan was completed in 2013 (Racer Management Team Working Group 2013), and a federal management plan has been proposed (Environment Canada 2014).

## PREFACE

Since the previous status report (COSEWIC 2004), new survey information has helped refine distributions of both the Eastern and Western Yellow-bellied Racers, and several previously unknown den sites have been documented. New molecular work completed on 150 Eastern Yellow-bellied Racers from two river valleys (Frenchman and the Big Muddy river valleys) indicates that there may be several genetically distinct subpopulations in Canada. A major terrain slump event occurred in the spring of 2011 at the largest known den site of the Eastern Yellow-bellied Racer and displaced or killed a potentially significant but unknown proportion of racers at the den. No new information exists on population size and trends of Western Yellow-bellied Racers, but threats have been assessed and remain substantial.

A federal recovery strategy has been prepared for the Eastern Yellow-bellied Racer (Parks Canada 2010), including Critical Habitat description. Critical Habitat currently protected for Eastern Yellow-bellied Racers consists of a 500 m buffer around each of seven known hibernacula within the Frenchman River Valley. While den protection is essential, conservation strategies must also consider movement corridors and summering grounds to ensure long-term persistence. For the Western Yellow-bellied Racer, a provincial management plan was completed in 2013 (Racer Management Team Working Group 2013), and a federal management plan has been proposed (Environment Canada 2014).

## COSEWIC HISTORY

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

## COSEWIC MANDATE

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

## COSEWIC MEMBERSHIP

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

## DEFINITIONS
## (2015)

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

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

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

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

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# COSEWIC Status Report

on the

# Eastern Yellow-bellied Racer
*Coluber constrictor flaviventris*

and the

# Western Yellow-bellied Racer
*Coluber constrictor mormon*

**in Canada**

2015

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## WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

### Name and Classification

Class: Reptilia

Order: Squamata

Suborder: Serpentes

Family: Colubridae

Subfamily: Colubrinae

Species: *Coluber constrictor* Linnaeus 1758

Subspecies in Canada [English and French common names follow Crother (2012) and Green (2012), respectively]:

*C. c. flaviventris* Say 1823 (Eastern Yellow-bellied Racer; Couleuvre agile à ventre jaune de l'Est)

*C. c. mormon* Baird and Girard 1852 (Western Yellow-bellied Racer; Couleuvre agile à ventre jaune de l'Ouest)

*C. c. foxii* Baird and Girard 1853 (Blue Racer; Couleuvre agile bleue)

The Eastern and Western Yellow-bellied Racers are addressed in this report; the Blue Racer was addressed in a separate COSEWIC status report and a status appraisal summary (Wilson and Rouse 2002; COSEWIC 2012).

There are 11 subspecies of the North American Racer, *C. constrictor*, including the three that occur in Canada. The separation of the subspecies has been debated over the past 40 years. Over the years, the taxonomic status of *C. c. flaviventris* has changed, which has led to the accrual of many colloquial names. Fitch *et al.* (1981) elevated *C. c. mormon* to species (*C. mormon*), because of a supposed lack of intergradation with *C. c. flaviventris*. Since then, however, several authorities have provided evidence of intergradations and reinstated the subspecies, *C. c. mormon* (Greene 1984; Corn and Bury 1986). Collins (1991) reinstated *C. c. mormon* to species status; however, allopatry was not suitably demonstrated, and Anderson (1996 *in* Crother 2012) successfully argued that, based on allozyme data, *C. c. mormon* should remain a subspecies.

A fourth subspecies was previously thought to occur in Canada; however, Canadian records for the Northern Black Racer (*C. c. constrictor*) are now discounted. The range of the Northern Black Racer was thought to include areas in the Maritime Provinces (Mills 1948; Logier and Toner 1955, 1961; Bleakney 1958; Conant 1958), based on unverified sightings and anecdotal reports from the 1800s (Bleakney 1958; Cook 1967; Martin 1969; Gorham 1970; Gilhen 1984). These observations were doubted, and Cook (1967) recommended that *C. c. constrictor* be removed from the lists of Canadian subspecies.

## Morphological Description

Yellow-bellied Racers are sleek, medium-sized snakes, resembling large gartersnakes (*Thamnophis* species) in body size and shape. In Canada, adults are usually < 1 m from the snout to the vent, with adult females being slightly larger than males (Matsuda *et al*. 2006; Martino unpubl. data *in* Parks Canada Agency 2010). Eastern Yellow-bellied Racers tend to be somewhat longer and more slender, while Western Yellow-bellied Racers tend to be shorter and stockier (Fitch *et al.* 1981). The head of Yellow-bellied Racers is distinct from the body, the snout is rounded, and the eyes are large with a round pupil. The body scales are smooth (as opposed to keeled) and arranged in 17 rows. The anal plate (ventral scale immediately anterior to the cloaca) is divided. The colouration is variable, and even individuals within the same area may vary greatly.

The name “Yellow-bellied Racer” is derived from the ventral colouration of the underside, which ranges from bright yellow (Eastern Yellow-bellied Racer; Figure 1) to yellowish white (Western Yellow-bellied Racer; Figure 2). From above, Eastern Yellow-bellied Racers tend to be bluish green, bluish or grey, with black inter-scale colouration, while Western Yellow-bellied Racers tend to be green, olive-green, yellowish-brown or occasionally reddish brown in some areas (red individuals have not been observed in British Columbia) (Wilson 1978; Stebbins 1985; Macartney pers. comm. *in* Campbell and Perrin 1991).

Juvenile racers are similar to adults in body form but differ substantially in colouration (Figure 3). Juveniles have lateral blotches and a series of “saddles” or partial cross-bands dorsally, which may be grey, brown or reddish on a light grey background. These bands tend to be boldest on the neck, fading towards the middle of the body (St. John 2002). The bands become less distinct as an individual grows and reaches sexual maturity.

The two subspecies can be distinguished morphologically using a combination of characteristics, including the pattern of scales on the head (Corn and Bury 1986) and the number of dentary and maxillary teeth (Auffenberg 1955). However, the distinctiveness of individual morphological traits has been debated because there is often overlap (Fitch *et al.* 1981; Corn and Bury 1986).

Figure 1. Young Eastern Yellow-bellied Racer. This snake was captured in the spring of 2010 and was the first observation of a live racer recorded in the Big Muddy River Valley since 1976 (Kreba 1978). The background of the photo provides a sense of “typical” racer habitat in Saskatchewan and Alberta. Photo courtesy of C. Somers.


Figure 2. Western Yellow-bellied Racer captured in British Columbia. The background of the photo provides a sense of "typical" racer habitat in British Columbia. Photo courtesy of L. Gardiner.

Figure 3. Neonate Eastern Yellow-bellied Racer from Grasslands National Park in Saskatchewan. Photo courtesy of R. Poulin.

Juvenile Bullsnakes (*Pituophis catenifer sayi*) and Prairie Rattlesnakes (*Crotalus viridis*) may be confused with juvenile Eastern Yellow-bellied Racers, because all three have dorsal cross-bands when young, but the resemblance is superficial. Specifically, Bullsnakes and Rattlesnakes have keeled scales, which differentiate them from the smooth-scaled Racers. Several species of snakes in British Columbia have cross-bands similar to juveniles of the Western Yellow-bellied Racer, including the Night Snake (*Hypsiglena torquata*), young Great Basin Gophersnakes (*Pituophis catenifer deserticola*), and young Western Rattlesnakes (*Crotalus oreganus*). However, the eyes of the Night Snake have a vertical pupil, the Gophersnake has keeled scales, and the Western Rattlesnake has both vertical pupils and keeled scales (St. John 2002).

## Population Spatial Structure and Variability

Little is known about the population structure of either the Eastern or the Western Yellow-bellied Racer in Canada. However, it is clear that there are both geographical and behavioural barriers to movement that likely influence genetic population structure and result in demographic isolation among Canadian subpopulations. Racers are limited by the maximum distance they can travel (up to 5 km observed in Saskatchewan), and there are often large geographic distances between subpopulations. They also exhibit strong fidelity to their hibernacula, returning to the same den site each year. This behaviour furthers their isolation and reduces the likelihood of significant genetic exchange between subpopulations.

The degree of population fragmentation of both Eastern and Western Yellow-bellied Racers is unknown, mainly because subpopulations have not been well surveyed across their ranges (but see below for initial genetic studies). It appears that both subspecies tend to be associated with river valleys, as this type of geographic feature creates a suitable environment for their hibernacula and riparian habitats for summer activities. There may be gene flow between dens that are relatively close together (< 5 km), but at greater distances, populations are likely geographically isolated from one another. In Saskatchewan and Alberta, the closest two occupied river valleys are 35 to 50 km apart and surrounded by agricultural lands, making natural dispersal between these areas nearly impossible. Even if different river valleys are within movement capabilities of the snakes, appropriate habitat must exist for snakes to be able to disperse successfully and survive in the long-term, a requirement that is an issue in regions where racers exist in Canada. Western Yellow-bellied Racer subpopulations are also geographically isolated from one another. Racers occurring in different river valleys are at least 50 km apart in some areas. With increasing levels of urban development in the interior of British Columbia, these areas will likely become more fragmented, leading to further isolation of subpopulations.

A recent study on Eastern Yellow-bellied Racers across Saskatchewan revealed that there are two genetically distinct subpopulations (Martino *et al.* unpubl. data). Eastern Yellow-bellied Racers (n = 150) were sampled from seven sites in the Frenchman River Valley and the Big Muddy River Valley, and individuals were genotyped at ten microsatellite loci. Distances among sampling sites varied greatly: some areas were only a few kilometres apart (within the Frenchman River Valley), whereas the Frenchman River Valley and Big Muddy River Valley were separated by approximately 150 km. Results from $F_{ST}$ analyses indicated that all three subpopulations were genetically differentiated; the two clusters in the Frenchman River Valley had an $F_{ST}$ value of 0.0822, indicating weak, but significant, differentiation; the Big Muddy River Valley and the first Frenchman River Valley populations had an $F_{ST}$ of 0.1275, and the Big Muddy River Valley population and the second Frenchman River Valley population had an $F_{ST}$ of 0.1244, both of which indicate moderate, but significant, differentiation. Currently, no population genetic research has been done on Western Yellow-bellied Racers in British Columbia, but similar genetic variability among geographically isolated subpopulations is likely.

## Designatable Units

COSEWIC guidelines state that populations must be both discrete and significant in order to be considered separate designatable units. The Eastern and the Western Yellow-bellied Racers in Canada are geographically separated from each other, occupy different COSEWIC Amphibians and Reptiles Faunal Provinces (Prairie/Western and Intermountain, respectively), and represent recognized subspecies. Therefore, they meet the criteria for both discreteness and significance.

While the distributions of both subspecies of racers are geographically fragmented and genetic differences have been documented among subpopulations of the Eastern Yellow-bellied Racer, there is currently insufficient information on ecological, morphological, or other characteristics to warrant further division of either subspecies.

## Special Significance

In Canada, both the Eastern and Western Yellow-bellied Racers are at the northern extent of their geographic range (Figure 4), where their populations are small and probably limited by the amount of suitable habitat, particularly hibernation sites. These populations are of high conservation value, as they may be genetically distinct from those in the core of the species' distribution farther south (Lesica and Allendorf 1995). Populations that can persist at northern peripheries of a species' distribution should be considered significant because of differences in reproductive adaptations with respect to the north/south gradient.

Racers are non-venomous and harmless to humans. They feed mainly on rodents and insects and are beneficial to ecological processes.

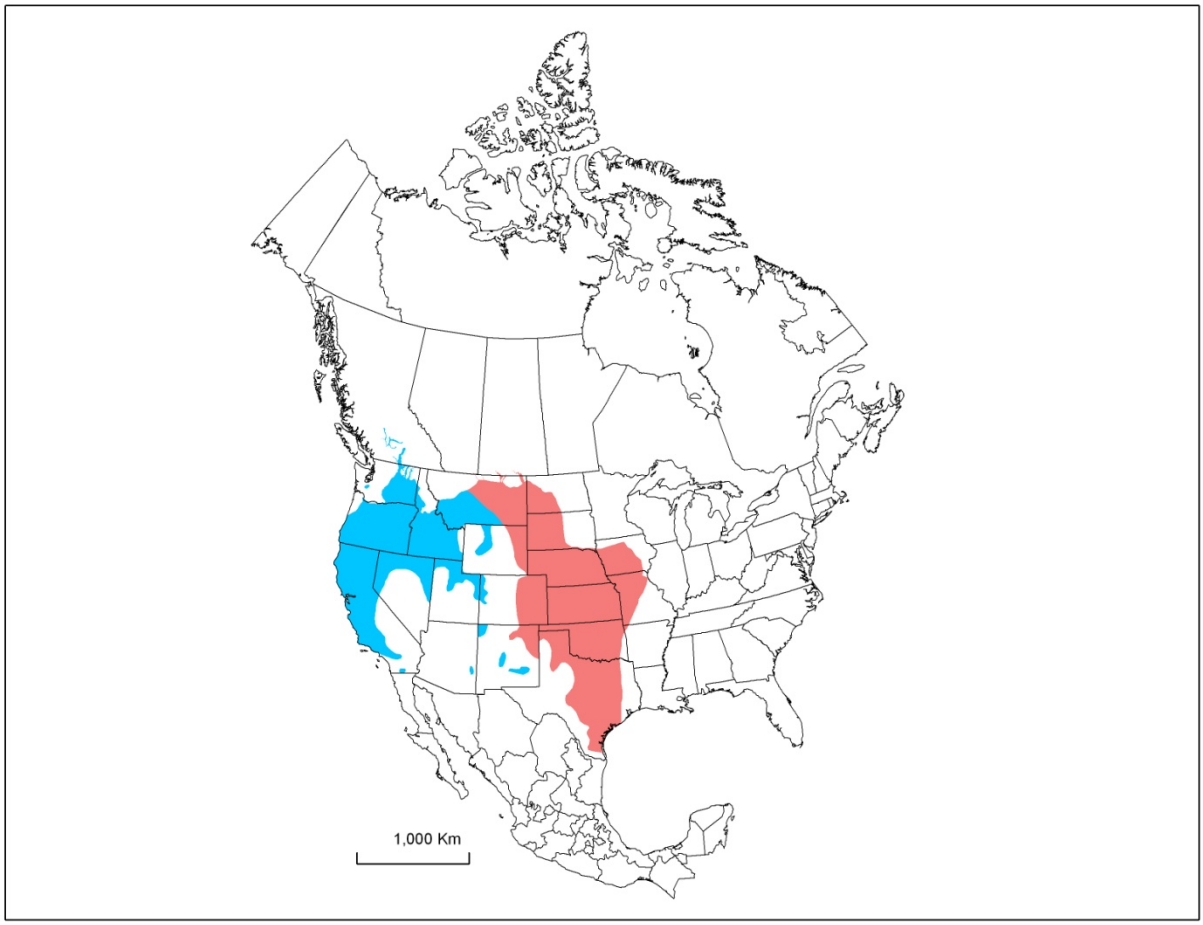


Figure 4. Global distribution of the Eastern Yellow-bellied Racer (in red) and Western Yellow-bellied Racer (in blue). Adapted from Ernst and Ernst 2003, previous COSEWIC report (COSEWIC 2004), and new data on Canadian populations compiled for this report.

## DISTRIBUTION

### Global Range

The North American Racer has a broad distribution across North America, with the majority of the distribution in the United States (Figure 4). The Eastern and Western Yellow-bellied Racers collectively have a narrower range, stretching east from the west coast to Illinois, south to northern Mexico, and extending north into southern British Columbia, Alberta, and Saskatchewan (Figure 4; Stebbins 1985; Ernst and Ernst 2003; Gardiner *et al*. 2011).

## Canadian Range

Eastern Yellow-bellied Racer:

In Canada, the distribution of the Eastern Yellow-bellied Racer is restricted to a few river valleys in southern Saskatchewan and southeastern Alberta (Figure 5; Gardiner *et al*. 2011). There is evidence to document four discrete subpopulations on the Canadian prairies: 1) Frenchman River Valley, 2) Rock Creek, and 3) Big Muddy Valley in Saskatchewan, and 4) Milk River Valley in Alberta. Two of these (Frenchman and Big Muddy river valleys) have been confirmed to be genetically distinct.

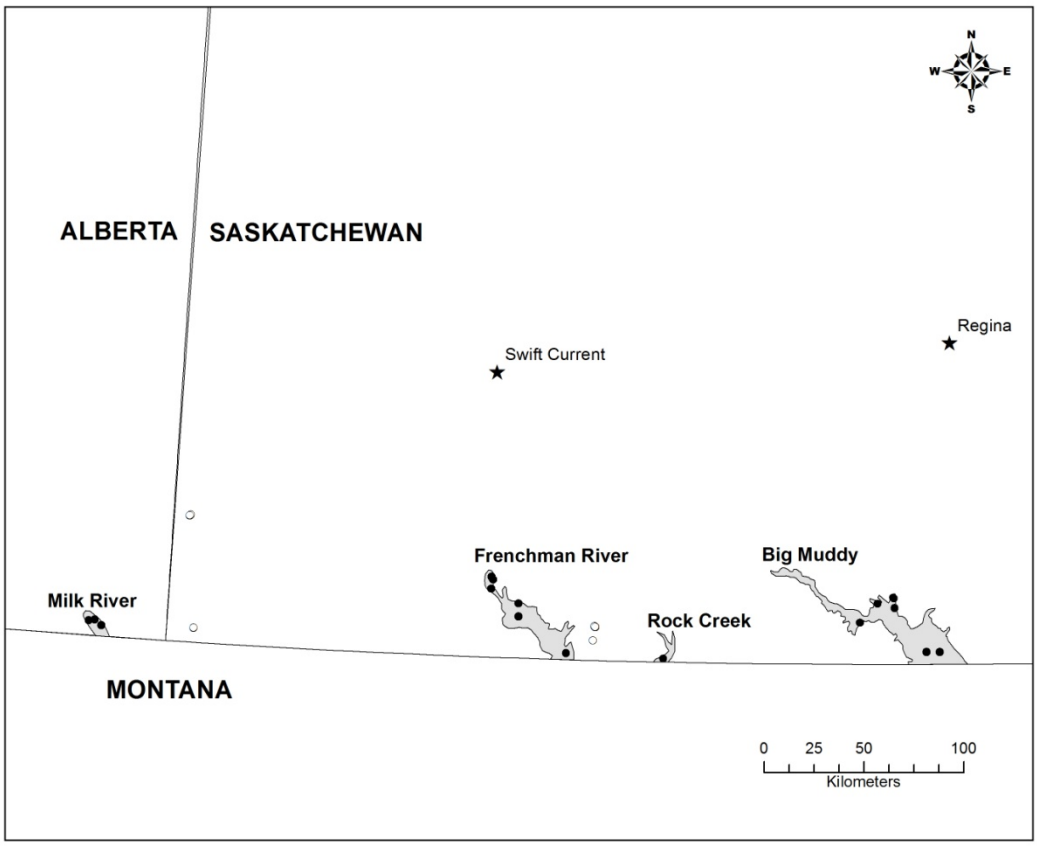


Figure 5. Canadian distribution of the Eastern Yellow-bellied Racer, showing four discrete areas (shaded) in Alberta and Saskatchewan: 1) Big Muddy; 2) Rock Creek; 3) Frenchman River; 4) Milk River. Solid circles represent areas where racers have been confirmed, open circles represent unconfirmed or isolated observations.

The majority of records of Eastern Yellow-bellied Racers occur within the Frenchman River Valley in southwestern Saskatchewan (Maher and Beck 1964; Cook and van Zyll de Jong 1975; Finley and Jasieniuk 1978; Lynch 1978; Mackay 1987; Macartney and Weichel 1993; Kissner *et al*. 1996), but they have only recently been studied extensively (Martino *et al*. 2012; Gardiner *et al*. 2013). Early records of Eastern Yellow-bellied Racers are mostly from den surveys in the Val Marie and the Grasslands National Park area (Mackay 1987; Macartney and Weichel 1993; Kissner *et al*. 1996). The first record of a racer north of Grasslands National Park was a road-killed racer found in 2006 in the Val Marie Prairie Farm Rehabilitation Agency (PFRA) community pasture (Gardiner *et al*. 2011); more racers in the area were confirmed in 2007 (Poulin and Didiuk 2008). As a result of subsequent search efforts, two dens were located within the PFRA pasture by radio-tracking Bullsnakes (one of these dens has since been destroyed by a predator). These dens extended the known distribution of racers by about 25 km up the river valley. It is currently unknown whether or not the species ranges any farther north. There are currently seven known active racer den sites within the Frenchman River Valley, six of which are located within Grasslands National Park (Gardiner *et al*. 2011).

In the Big Muddy River Valley, only three records of Eastern Yellow-bellied Racers existed prior to 2010, from 1968 (Morrison 1969), 1974 (Cook and van Zyll de Jong 1975), and 1976 (Kreba 1978). In May 2010, a road-killed racer (Royal Saskatchewan Museum #20225) was found approximately 36 km up the valley, northwest from previous observations. In fall 2010, a radio-tracked Bullsnake led to the discovery of a den, the first known Canadian hibernaculum to contain Eastern Yellow-bellied Racers outside the Frenchman River Valley (Gardiner *et al*. 2011). In summer 2013, several more racers were observed 20 km away from the one known den in the Big Muddy Valley, suggesting that another den existed in this area (Poulin pers. obs. 2013). The habitat farther north in the Big Muddy Valley superficially appears to be suitable for racers, and the species may inhabit the Big Muddy Valley from the international border north of St. Victor, Saskatchewan.

In fall 2012, three racers (including a juvenile) were captured at the “Sinking Hill” snake den in the Rock Creek area of Eastblock-Grasslands National Park (Poulin pers. obs. 2012). The extent of racers in this region is unknown as the area is sparsely populated, and there are few roads. Vegetation is very dry grassland, and the Rock Creek racers are probably restricted to the immediate vicinity of the watercourse. The Sinking Hill den is approximately 50 km from the nearest known den in Westblock-Grasslands National Park and approximately 100 km from the den in the Big Muddy Valley. There have been a few unconfirmed reports by landowners of racers observed between the Frenchman River Valley dens and the Sinking Hill den, but based on habitat connectivity the two areas have isolated subpopulations of racers.

Incidental or unconfirmed reports of racers in Saskatchewan have occurred in the southwest part of the province. Racers have also been incidentally observed (twice) in Cypress Hills Provincial Park, Saskatchewan (Schmutz and Picotte 1998; Gardiner *et al*. 2011). Both observations occurred within 1 km of Fort Walsh in the Cypress Hills, 11 years apart (1998 and 2009). These two observations suggest that a potentially undocumented subpopulation of racers may inhabit the Cypress Hills area. In summer 2001, Wayne Harris observed a road-killed racer on Hwy 21 in the vicinity of Lodge Creek (near the town of Govenlock). However, no specimens or photographs were taken at either of the Cypress Hills or Govenlock sites, and the observations remain unconfirmed.

In Alberta, racers have been confirmed near Onefour and Lost River in the Milk River Valley in southeastern Alberta (Werschler and Wallis 2002; Wershler pers. comm. 2013). There were only four confirmed records of the species from the province from 1975 – 2010 (Parks Canada Agency 2010). Surveys in October 2014 resulted in the finding of an active hibernaculum on a ranch near Onefour (Douglas 2015).

Western Yellow-bellied Racer:

In Canada, the distribution of the Western Yellow-bellied Racer is restricted to arid valleys in the south-central interior of British Columbia. The range includes the South Columbia, Granby, Kettle, Okanagan/Similkameen, and Thompson/Fraser watersheds (Figure 6; Hobbs and Sarell 2002; Sarell 2004; Racer Management Working Group 2013), suggesting potentially five discrete subpopulations (Hobbs and Sarell 2002). Four of the five subpopulations are situated along the southern border of British Columbia, and are likely contiguous with regions containing racers in the United States. The southern Okanagan/Similkameen subpopulation and the northern Thompson/Fraser subpopulation are the largest in the province. The Thompson/Fraser subpopulation represents the northernmost extent of the range of Western Yellow-bellied Racers and was probably previously connected to the southern subpopulations during the Hypsithermal Period, 8,000 years before present (Hobbs and Sarell 2002). Historical observations near the south end of Shuswap Lake, north of Vernon, suggested a connection between these two larger known areas, but these sightings could not be confirmed (Campbell *et al*. 1982; Gregory and Campbell 1984). A more detailed account of the collection history is given in the previous COSEWIC (2004) status report. Hobbs (pers. comm. 2013) has located a dozen more individual racers north and south of Lillooet since these previous observations were recorded.

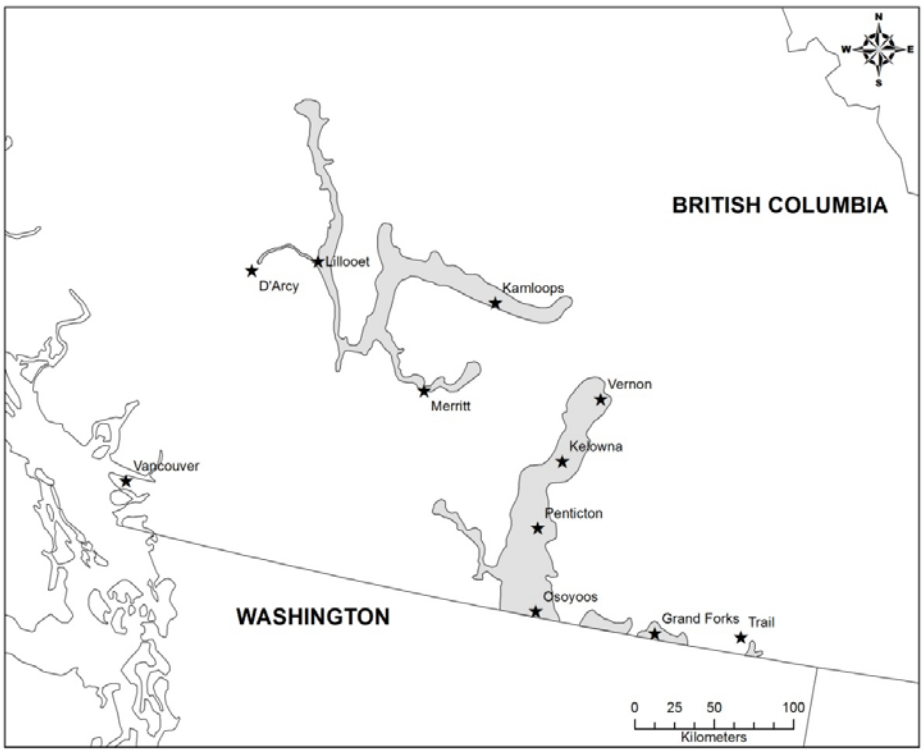


Figure 6. Canadian distribution of the Western Yellow-bellied Racer, showing broad areas (shaded), where the subspecies occurs in British Columbia.

A total of 490 communal snake dens (C1-confirmed, C2-suspected, and C3-probable) have been identified in the arid interior valleys of British Columbia (Hobbs pers. comm. 2015, based on queries of Hobbs and Sarrell privately maintained snake den database[2]). These dens are often used communally by multiple species of snakes, including Western Rattlesnakes, Great Basin Gopher Snake (*Pituophis catanifer*), Western Yellow-bellied Racer, Common Garter Snake (*Thamnophis sirtalis*) and the Western Terrestrial Garter Snake (*T. elegans*) (Hobbs 2013). Racers have been found in 102 of 383 confirmed dens, 40 of 83 suspected dens, and 4 of 24 probable dens. Racers most likely occur in additional dens (Hobbs pers. comm. 2015), but because they spend little time around the hibernacula before and after emergence, their presence is difficult to confirm. The above represent all known den sites, historical and recently documented, and it is unknown whether all are still active. Twelve historical dens are no longer used by snakes (none with confirmed racer records) and are not included in the above counts. In addition to communal rock dens, racers may also use rodent burrows for hibernation as demonstrated for the sympatric Great Basin Gophersnake (Williams *et al.* 2015).

[2] Data are privately maintained and not submitted to the BC government due to the confidential nature of dens on private and First Nations lands, but summaries are available for conservation and planning purposes (Hobbs 2013).

## Extent of Occurrence and Area of Occupancy

The extent of occurrence for Eastern Yellow-bellied Racers is 15,491 $km^2$, which was calculated from a minimum convex polygon around the subpopulation ranges outlined in Figure 5. The area occupied by the four subpopulations in Saskatchewan and Alberta is 1640 $km^2$, based on the areas of the occupied drainages (see Figure 5 and Table 1 for calculations). The index of area of occupancy (IAO) is more appropriately calculated as the number of 2 x 2 km grid cells with den sites, where the snakes congregate for overwintering and which constitute a critical resource for this species. There are 10 known den sites (9 in Saskatchewan and 1 in Alberta), and a few other undocumented sites may exist (see **Canadian Range**). Based on known and potential dens, the IAO is <100 $km^2$.

**Table 1. The estimated area inhabited within each subpopulation of Eastern and Western Yellow-bellied Racer (Figures 5 and 6).**

| Eastern Yellow-bellied Racer | | Western Yellow-bellied Racer | |
|---|---|---|---|
| Subpopulation | Area Inhabited ($km^2$) | Subpopulation | Area Inhabited ($km^2$) |
| Milk River Valley | 86 | Thompson/Fraser watershed | 4112 |
| Frenchman River Valley | 541 | Okanagan/Similkameen watershed | 3811 |
| Rock Creek area | 60 | South Columbia watershed (Trail) | 52 |
| Big Muddy River Valley | 953 | Granby watershed (Grand Forks) | 200 |
| TOTAL | 1640 | Kettle watershed | 246 |
| | | TOTAL | 8421 |

The extent of occurrence for Western Yellow-bellied Racers is 48,493 $km^2$, which was calculated from a minimum convex polygon around the subpopulation ranges outlined in Figure 6. The area occupied by the five putative subpopulations is 8421 $km^2$, based on the areas of the occupied drainages (see Figure 6 for distribution and Table 1 for calculations). As for the eastern subspecies, however, IAO is more appropriately calculated as the number of 2 x 2 km grid cells with occupied den sites. This value is impossible to calculate accurately because (1) the exact localities of all known den sites are not within the public domain, and (2) detectability of racers at dens is low because the snakes quickly disperse to summer ranges after emergence in spring and surveys have not specifically targeted this species. The BC Conservation Data Centre (2015) gives the area of occupancy category as 500 – 1000 $km^2$; all recent observations are not yet in the database and the localities of some known dens on private and First Nations lands have not been released to the BC government, preventing a more precise estimate. It is probable that the IAO is <1000 $km^2$ and probably no greater than that of the Western Rattlesnake (804 $km^2$; COSEWIC 2015).

## Search Effort

Historically, search efforts for both Eastern and Western Yellow-bellied Racers have been sporadic. Searches have typically taken place in spring, in likely denning habitat and close to incidental observations on the periphery of the distribution. Racers have recently been studied in specific regions of their range (e.g., Frenchman River Valley in Saskatchewan; Martino *et al.* 2012; Gardiner *et al.* 2013), but other areas have not received any focused search effort.

In British Columbia, Dulisse (2006) conducted surveys for the Western Yellow-bellied Racer in the Kootenay region over three field seasons in 2004 – 2006. In addition, numerous surveys for snakes have been conducted within the range of this subspecies, although not specifically targeting racers (Macartney 1985; Charland 1987; Sarell 1993; Hobbs and Sarell 2000, 2001; Iredale 2006, 2008; Iredale and Ferguson 2007; Sarell and Alcock 2008; Gill 2010; Gardiner and Song 2013a,b; Hobbs 2011a,b, 2013; Lomas 2013). Many of these surveys included locating communal snake hibernacula.

# HABITAT

## Habitat Requirements

Eastern Yellow-bellied Racer:

Racers hibernate in dens with characteristics that enable survival during harsh Canadian winters. Specific characteristics of overwintering dens are uncertain, but likely involve a combination of substrate and depth to achieve an appropriate buffer against low surface temperatures during winter. In Canada, Eastern Yellow-bellied Racers rely heavily on a limited number of overwintering dens or hibernacula that are typically located in bluffs of river valleys. Unstable slump zones are a common area for dens, and racers are known to exhibit high fidelity to these sites (Brown and Parker 1976; Ernst and Ernst 2003; Gardiner and Sonmor 2011). Landslides, or slumps, along unstable slopes create terraces containing sinkholes, fissures, and loosely packed soil. These factors provide opportunities for snakes to find refuge below the frost line (Gardiner and Sonmor 2011). The dens themselves consist of underground burrow systems of unknown size and structure, created naturally or by burrowing mammals such as Mountain Cottontails (*Sylvilagus nuttallii*) or American Badgers (*Taxidea taxus*). Although these slopes can remain stable for extended periods of time, surface erosion such as loss of large amounts of substrate can still occur in certain conditions, making them potentially unstable (Gardiner and Sonmor 2011). Den sites are often occupied by a variety of snake species simultaneously, which is likely a response to the limited availability of suitable hibernation sites (Gregory 1982). In Canada, Eastern Yellow-bellied Racers are known to share dens with Prairie Rattlesnakes, Bullsnakes, Plains Garter Snakes (*Thamnophis radix*), Terrestrial Garter Snakes, and Western Hognose Snakes (*Heterodon nasicus*). The number of racers varies by site, with at least one site known to contain hundreds of individuals (Gardiner *et al*. 2011), but most other dens are likely occupied by 20 - 30 individuals. Thus, hibernacula may vary in quality, or local subpopulations may simply vary substantially in size.

During the active season, Eastern Yellow-bellied Racers move from their dens on the slopes of river valleys down to riparian zones in the adjacent lowlands (Martino *et al*. 2012; Gardiner *et al*. 2013). This migratory pattern creates a "dumbbell"-shaped area of yearly activity, with two areas of activity (den and summering ground) connected by a movement corridor (Gardiner *et al.* 2013). Retreat sites are an important component of all inhabited areas (Martino *et al*. 2012). Eastern Yellow-bellied Racers select burrows and shrubs as retreat sites within the Canadian extent of their range, which likely provide a prey source, protection from predators, and suitable areas for thermoregulation and breeding. In Saskatchewan, burrows available to racers are commonly created by mammals such as Richardson's Ground Squirrels (*Urocitellus richardsonii*), Mountain Cottontails, American Badgers and Black-tailed Prairie Dogs (*Cynomys ludovicianus*). Racers cannot dig their own burrows, resulting in a dependence on these mammals to create retreat sites. In addition, shrubs available for retreat sites include sagebrush (*Artemisia* species), Winterfat (*Krascheninnikovia lanata*), Black Greasewood (*Sarcobatus vermiculatus*), Wolf-willow (*Elaeagnus commutata*), Thin-leaved Snowberry (*Symphoricarpos albus*), and Creeping Juniper (*Juniperus horizontalis*). Suitable habitat for racers must include suitable wintering dens, a migration corridor, and suitable summering grounds (within 2 km of the den) that include burrows and shrubs within open grassland, and probably within close proximity to a permanent source of water (e.g., creek, river).

Western Yellow-bellied Racer:

Western Yellow-bellied Racers are also reliant on hibernacula that are often shared with other snake species, including Western Rattlesnakes, Gophersnakes, Rubber Boas, Night Snakes, and Common Gartersnakes (Gregory and Campbell 1984; Sarell 1993; Shewchuk 1996; Hobbs and Sarell 2001). Dens are typically located in rocky outcrops, talus slopes, and small rock piles on steep south-facing slopes (Shewchuk and Waye 1995). Deep cracks in the mountain face allow snakes to find refuge below the frost-line, and are typically selected in areas higher up on the mountain where snow cover is present all winter long, presumably providing thermal insulation for the snakes. Hobbs and Sarell (2002) describe four main attributes of suitable denning sites in this area: fracturing, thermal momentum, humidity, and cover. Fracturing allows access to geothermal heat, maintaining temperatures above freezing, and occurs most often in basalt and gneiss rocks. Thermal momentum indicates the ability of the dens to absorb and maintain heat, which is influenced by aspect, slope, mass, position, and surface albedo (Hobbs and Sarell 2002). Humidity is also an important component of suitable hibernacula, as racers are prone to desiccation. Cover is particularly important for thermoregulation at the den entrance, as well as protection from predators during the sensitive period of spring emergence. Cover in the Canadian extent of the snakes' range consists of rock piles, shrubs, and coarse talus, which are important local-level components of movement corridors and summer habitats.

Williams *et al*. (2015) found during a 2-year study in British Columbia that contrary to expectations many Great Basin Gopher Snakes hibernated alone in rodent burrows rather than using communal rock hibernacula. The extent to which Western Yellow-bellied Racers, which are sympatric with the Great Basin Gophersnake use rodent burrows, and under what conditions, remains unknown but raises management issues and emphasizes the importance of protecting active season ranges of the snakes, as well as communal hibernacula.

After emergence from hibernation, Western Yellow-bellied Racers move down-slope from their dens through gullies in the mountainous slopes into adjacent lowland areas (Shewchuk and Waye 1995). Small gullies serve as valuable movement corridors as they provide cover, such as rock piles, shrubs, and trees. Larger gullies are often too steep, and may contain waterfalls, which likely act as a hindrance to snake movement. Western Yellow-bellied Racers typically move through a mosaic of habitats, including talus slopes, pine stands, grassland, and shrub steppe habitat, to gain access to riparian areas (Shewchuk and Waye 1995). Pine stands are sparsely treed with open canopy (Gregory and Campbell 1984) and may contain a combination of Ponderosa Pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), Western Redcedar (*Thuja plicata*), and Western Hemlock (*Tsuga heterophylla*) (Orchard 1984; Cannings *et al*. 1999; Sarell and Alcock 2000; Sarell 2004). Grassland and shrub steppe areas contain mostly Bluebunch Wheatgrass (*Pseudoroegneria spicata*; Orchard 1984), Kentucky Bluegrass (*Poa pratensis*), Needle-and-Thread Grass (*Hesperostipa comata*), Downy Brome (*Bromus tectorum*), Sand Dropseed (*Sporobolus cryptandrus*), Big Sagebrush (*Artemisia tridentata*), Antelope Brush (*Purshia tridentata*), and Rabbitbrush (*Ericameria nauseosus*) (Tisdale 1947; Orchard 1984). Riparian areas, which serve as summering grounds for Western Yellow-bellied Racers, are likely to provide sufficient cover, optimal thermal conditions, and high prey abundance (Shewchuk and Waye 1995). Suitable summer habitat for Western Yellow-bellied Racers therefore includes movement corridors abundant with retreat sites such as rock piles and shrubs, and riparian foraging areas.

**Habitat Trends**

Eastern Yellow-bellied Racer:

On the Northern Great Plains, the loss and alteration of native prairie as a result of agriculture over the past 150 years has been extensive, with a greater than 70% decline in the native mixed-grass prairie (Samson *et al*. 2004). The remaining native grasslands are highly fragmented, resulting in a mosaic of native habitat, crop and hay fields, tame pasture, roads, and human settlements. As racers are known to avoid cropland (Martino *et al*. 2012; Gardiner *et al*. 2013), the agricultural landscape likely impairs any significant dispersal by racers. Some of the native grassland in this area is protected from agricultural and industrial development (e.g., Grasslands National Park), but natural loss of winter den sites is still a threat within the protected areas. Slump zones are suitable sites for hibernacula, but they are, under certain conditions, potentially unstable and dynamic. In spring 2011, the den containing the largest known number of Eastern Yellow-bellied Racers in Canada was seriously damaged by a slump event (Gardiner and Sonmor 2011).

Excessive amounts of soil saturation caused the sediment to collapse, occluding the den entrances and burying many snakes. The possible loss of such an important site happened within a protected area and accentuates the sensitivity of local racer locations and the value of each overwintering site. It should be emphasized, however, that although slump events can be devastating when they occur, they are also sporadic.

Western Yellow-bellied Racer:

In British Columbia, the loss of valley grassland habitat and south-facing slopes to human disturbance is a threat to Western Yellow-bellied Racer habitat (Shewchuk and Waye 1995). The largest area in which racers are found occurs within the densely populated Okanagan Valley, which has been subject to intense habitat alteration. Historically, as much as 75% of the native grassland has been lost, and the loss of riparian habitat is as high as 93% along the Okanagan River (Lea 2008). Only about 10% of the remaining grassland is under protection (Grasslands Conservation Council of British Columbia 2004). Much of the valley bottom has been converted to orchards and vineyards, with ranches on the adjacent slopes, resulting in loss and alteration of a considerable amount of suitable racer habitat (Shewchuk and Waye 1995). The situation is exacerbated by the fact that tourists and snakes exhibit the same affinity for sunny south-facing slopes, resulting in the destruction of valuable den areas for resort developments. In the Thompson-Fraser area, 10-20% of native grassland has been lost, with less than 7% under protection (Grasslands Conservation Council of British Columbia 2004). Most of the remaining grassland in this area is grazed or harvested as hay.

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

## BIOLOGY

### Life Cycle and Reproduction

More research is needed to gain understanding of the reproductive biology of racers in Canada. Data are lacking because most racers are caught at overwintering dens in the early spring before females have enlarged ovarian follicles. Additionally, breeding behaviour and nest sites have rarely been observed in Canada.

In racers, sexual maturity is often associated with the loss of juvenile markings. Little is known about the specific age of maturity for Eastern Yellow-bellied Racer in Canada, although individuals generally lose their markings at around 30 to 60 cm snout-vent length (Gardiner unpubl. data; Martino unpubl. data). In Utah, Kansas, and Michigan, female Eastern Yellow-bellied Racers mature at 2-3 years of age (Fitch 1963; Rosen 1991). It is unlikely that female Eastern Yellow-bellied Racers in Saskatchewan are sexually mature before their third spring as racers often still possess juvenile markings in their second spring (Poulin pers. obs.). Female Eastern Yellow-bellied Racers in Saskatchewan likely lay their first clutch of eggs in their fourth or fifth spring, when they assume their adult colouration. Juvenile Western Yellow-bellied Racers in British Columbia begin to lose their patterns by 45 to 60 cm in total length (Stebbins 1985), and individuals are believed to become sexually mature at about 3 - 4 years of age, although males may mature at a younger age (Brown and Parker 1984; Macartney, unpubl. observations *in* Campbell and Perrin 1991). Individuals may reproduce either annually or biennially, depending on factors such as body condition (fat reserves) and environmental conditions (Shewchuk and Waye 1995). For example, egg production is reduced during drought years in Western Yellow-bellied Racers in northern Utah (Brown and Parker 1984).

Similar to Eastern Yellow-bellied Racers in Kansas (Fitch 1963), it is likely that racers in Saskatchewan and Alberta mate shortly after emerging from their wintering dens. In Saskatchewan, small groups of racers have been observed near den sites in spring (April-May), and these groups usually involve one female and several males, which may be indicative of mating (Gardiner unpubl. data 2013). Gardiner regularly observed pairs of racers under shrubs in Grasslands National Park throughout the month of May, suggesting possible mating events. In British Columbia, Western Yellow-bellied Racers mate in May after emerging from their winter dens in late March to April (Sarell 2004). Mating generally occurs in the summer range away from the den sites (Shewchuk and Waye 1995).

Racers are oviparous, depositing a clutch of approximately 3 – 20 eggs in a nest. Adults abandon nests after oviposition. Clutch size is dependent on body condition, particularly fat reserves, and also shows geographic variation. Mean clutch sizes of 6 – 15 eggs have been reported in eastern United States (Fitch 1963; Rosen 1991). Little is known about egg production and incubation of Eastern Yellow-bellied Racers in Canada, as no nests have been observed on the Canadian prairies. In British Columbia, Western Yellow-bellied Racers generally lay their eggs in June or July, and depending on temperatures, incubation lasts 40 to 60 days (Nussbaum *et al.* 1983; Sarell 2004). Sarell (2004) reported a range of 3 – 7 eggs per clutch; Macartney (unpubl. data *in* Campbell and Perrin 1991) reported a mean clutch size of 6.3 eggs, range 4 – 12.

Survivorship patterns of racers are poorly known, but early mortality is probably high with survivorship improving after adult body size is reached. Fitch's (1963) extensive studies on Eastern Yellow-bellied Racers in Kansas indicate a mortality rate of 41.5% in the 2-year-old age class, which decreased to 17.8% in the 3-year-old age class. Fitch found very few young racers less than two years old and hence could not estimate early mortality rates, which he suspected to be high (>50%). Studies by Brown and Parker (1984) on the Western Yellow-bellied Racer also indicated that survival probability increases when snakes

reach maturity. Sex ratios in both subspecies appear to be approximately 1:1 (Saskatchewan Gardiner unpubl. data; Martino unpubl. data; British Columbia: Macartney unpubl. data *in* Campbell and Perrin 1991; Shewchuk and Waye 1995; Sarell and Alcock 2000).

In the wild, racers often live to 7 – 8 years, but individuals 10 years and older have been documented (Fitch 1963, 1999). In captivity, racers can live 15 – 30 years. The generation time in Canadian populations is unknown but may be approximately 7 – 8 years for both subspecies, based on the time at first reproduction (3 – 5 years for females) and longevity of 10 or more years.

**Physiology and Adaptability**

Racers are diurnal snakes, with most daily activity occurring in the morning (Ernst and Barbour 1989). Racers have been observed to move across the ground with raised heads, which may aid in visual predator and/or prey detection (Ernst and Ernst 2003). Racers are heat-tolerant and have been observed moving around at >32°C when other snakes are not active (Ernst and Barbour 1989). They are also excellent climbers and are often found basking on the lower branches of bushes (Gregory and Campbell 1984; Ernst and Ernst 2003). Eastern Yellow-bellied Racers in Saskatchewan often remain close to water in summer, selecting riparian foraging areas when they are available (Martino *et al*. 2012). They appear to be susceptible to dehydration and may need access to water during hot dry summer months (Ernst and Ernst 2003).

For both subspecies, fidelity to den sites is generally high, with most individuals returning to the same den site each autumn (Ernst and Ernst 2003; Gardiner unpubl. data; Martino unpubl. data). Racers may hibernate singly or in small groups, or use communal hibernacula shared with a number of snakes, including other species. Communal denning is common in Canadian populations, probably because appropriate den sites are rare features in the landscape in northern environments.

Racers are fast-moving, have good vision, and are quick to escape from approaching humans, making them difficult to observe in their natural environment. Small racers tend to be more aggressive than larger individuals, and defensive behaviour usually includes vibration of the tail, hissing and striking (Campbell and Perrin 1991). Racers are non-venomous and do not pose a threat to humans, although they often act defensively and bite when captured (Ernst and Ernst 2003). In general, racers are difficult to handle and tend not to thrive in captivity; they will often die of exhaustion from stress or starvation (Ernst and Ernst 2003). Racers do not adapt well to urbanization and other human-altered landscapes. In a study of habitat selection by racers in Saskatchewan, Martino *et al.* (2012) found that racers did not use agricultural crop fields even though they were a commonly available habitat type in the study area.

## Dispersal and Migration

Racers in Saskatchewan have been observed to emerge from hibernation as early as April, but date of emergence is temperature-dependent and may be later if the spring is cold (Gardiner unpubl. data; Martino unpubl. data). In British Columbia, racers usually emerge from their dens in April but may emerge in March in warmer years (Shewchuk and Waye 1995). Generally, racers move quickly from hibernacula to their summer ranges (Shewchuk and Waye 1995; Gardiner *et al*. 2013), where they will remain until returning to the hibernacula in September; occasionally they will remain active into October or even as late as November in British Columbia (Shewchuk and Waye 1995; Hobbs and Sarell 2002). The onset of colder nights (temperature ≤ 9 °C) appears to trigger this return to the hibernaculum (Hobbs and Sarell 2002).

Radio-tracked Eastern Yellow-bellied Racers in Saskatchewan moved up to 5 km from their den during the course of the summer (range: 804 – 4994 m; mean: 2551 $\pm$ 272 m) (Martino *et al*. 2012). These maximum migration distances were up to 10 times longer than reported for populations farther south in the United States, probably reflecting the scarcity of suitable hibernation sites in the landscape in the northern extremity of the species' range. Once within their summer ranges, racers made only small daily movements (77 ± 8 m) (Martino *et al*. 2012). Telemetry studies have shown the mean home range size of racers in Saskatchewan to be 145 ha ± 46 ha (n = 14) using minimum convex polygon (MCP) methods, which is greater than at the core of their range (Martino *et al.* 2012). The larger area used by individual snakes in Saskatchewan stems from dumbbell-shaped home ranges consisting of winter and summer habitats linked by a narrow corridor. Actual activity centres within these home ranges are considerably smaller than the MCP methods show (Gardiner *et al*. 2013).

Migration distances from dens are poorly known for the Western Yellow-bellied Racers in British Columbia. In Utah, radio telemetry studies by Brown and Parker (1976) indicate maximum movement distances of 1.6 and 1.8 km from two den sites, respectively, with average displacement distance of shorter than 1 km (781 m for males and 663 m for females). In British Columbia, gravid females may travel more than 500 m to suitable egg-laying sites (Sarell 2004). While on their summer ranges, daily movements are generally relatively short. Shewchuk and Waye (1995) found that daily movements were usually less than 200 m and sometimes followed a circuit returning to a regular overnight roost. Brown and Parker (1976) found that the average daily movements of racers in Utah were only approximately 30 m.

## Interspecific Interactions

Racers are not the constrictors their scientific name suggests (Wilson 1978); rather, they actively seek out their prey and kill it by biting and pinning it. Racers are foraging generalists, but consume mostly insects and small mammals (Fitch 1963). They are also opportunists, with their diets likely reflecting seasonal changes in prey availability. There is little information on the diet of racers in Saskatchewan or Alberta, but limited stomach content analyses suggest a diet of insects (e.g., crickets) and small mammals (e.g., shrews;

Poulin pers. obs. 2013). Orchard (1984) and Shewchuk and Austin (2001) found that arthropods (mostly grasshoppers and crickets) made up the bulk of the diet of Western Yellow-bellied Racers is British Columbia, but they also observed a small percentage of mammals, reptiles and amphibians in the stomach and faecal contents. Diets appeared to vary with the size of the individual, with larger snakes consuming a greater number of vertebrates and a greater variety of prey.

Although racers have excellent camouflage and are fast moving, they are still vulnerable to predation. Aerial predators such as hawks and eagles are major predators, as well as terrestrial animals such as badgers, weasels, foxes, coyotes (*Canis latrans*), skunks, and other snakes (Fitch 1963; Macartney unpubl. data *in* Campbell and Perrin 1991; Ernst and Ernst 2003). Eggs may also be depredated from nests by animals such as ground squirrels.

## POPULATION SIZES AND TRENDS

### Sampling Effort and Methods

There have not been any comprehensive population surveys of either Eastern or Western Yellow-bellied Racers across their Canadian ranges. Racers are elusive compared to other large-bodied snakes, and even experienced researchers may have difficulty detecting racers in their native habitat; racers are secretive and active and do not linger at den sites after emergence in spring. There are many factors that contribute to detectability, such as yearly variation in when individuals emerge from and return to den sites, weather, and search effort. Mark-recapture studies have been conducted in specific regions (e.g., Frenchman River Valley in Saskatchewan); however, other areas known to have racers have been poorly surveyed. Thus, these isolated assessments are insufficient to estimate population sizes accurately across the range of each subspecies.

Estimates of population size have been made using other methods besides surveying, using expert opinion and comparisons with other snakes; however, the accuracy of these estimates is suspect. For example, numbers of Western Yellow-bellied Racers were previously assumed to be similar to those of other snake species that share similar habitat and distribution with them in British Columbia, specifically the Western Rattlesnake and the Great Basin Gophersnake (COSEWIC 2004). However the behaviour of these three species can be quite different, which may influence detectability. In addition, there is no solid *a priori* foundation on which to make the assumption that population sizes of the various species are even correlated, much less similar. Consequently, using either Western Rattlesnakes or Great Basin Gophersnakes as a proxy to determine racer population size is not appropriate.

## Abundance

Neither Eastern nor Western Yellow-bellied Racers were probably ever widespread or abundant in Canada, as the southern regions of British Columbia, Saskatchewan and Alberta are the northern extremes of their geographic distributions.

Eastern Yellow-bellied Racer:

In Saskatchewan, Eastern Yellow-bellied Racers have been surveyed in some areas. During a survey in the Frenchman River Valley conducted in 1990, Macartney (unpubl. data *in* Campbell and Perrin 1991) found racers at 7 of the 9 active snake hibernacula that were known at the time. Several years later, Kissner *et al.* (1996) captured 45 racers in the Frenchman River Valley. As of 2011, there are seven known active Eastern Yellow-bellied Racer den sites in the Frenchman River Valley, mainly within Grasslands National Park. Population size estimates based on three recaptures of 24 marked snakes at the Snake Pit den site in 2010 suggested that over 300 Eastern Yellow-bellied Racers inhabited the largest hibernaculum in Grasslands National Park. Search effort included repeated visits over four years, with daily visits to the den during spring emergence (April - May). Incidental searching occurred for the remainder of the summer in all four years during telemetry studies (Martino *et al.* 2012; Gardiner *et al.* 2013), where racers were tracked daily in the vicinity of Snake Pit, leading to the discovery and capture of other racers (which were highly likely from Snake Pit). However, despite the high amount of search effort at the Snake Pit den, capture rates are still low, and confidence intervals to population estimates are high. Additionally, this work was done prior to the occurrence of a significant slump event at that den site (Gardiner and Sonmor 2011). Although insufficient information is available to estimate the numbers of racers from other dens in Saskatchewan, regular visits to these dens have only ever revealed small numbers of racers (<10) per year, suggesting they are inhabited by significantly fewer racers than the large den in Grasslands National Park. Racers in southeastern Alberta have received little survey effort, so subpopulation sites and sizes are unknown for that area.

Although no robust population estimates are available for the Eastern Yellow-bellied Racer in Canada, it is unlikely that it would exceed 10,000 adults, given the distribution of this subspecies, which is restricted to a few river valleys, the apparent scarcity of suitable den sites in the landscape, and the number of snakes using known dens. It is reasonable to assume that no subpopulations contain more than 1000 adults.

Western Yellow-bellied Racer:

There are insufficient data to accurately estimate population size of the Western Yellow-bellied Racer in British Columbia. Such estimates are hindered by the secretive habits of the snakes and lack of recent mark-recapture studies, and low recapture rates where such studies have been attempted in the past (Macartney unpubl. data *in* Campbell and Perrin 1991). Rough population estimates based on the opinion of local experts suggest that there may be fewer than 10,000 adults: >3000 adults (Cannings *et al.* 1999); 2500 – 10,000 adults (BC Conservation Data Centre 2015), but there are no robust population estimates to support these values.

**Fluctuations and Trends**

It is likely that racer populations of both subspecies have experienced long-term declines across their Canadian distributions, particularly due to habitat loss and fragmentation. However, due to lack of reliable population estimates or indices of abundance over time, it is difficult to quantify trends.

Eastern Yellow-bellied Racer:

In the previous status report, Wayne Harris (pers. comm. *in* COSEWIC 2004) suggested that there have been declines in the Frenchman River Valley because no racers had been seen for several years, and in fall 1990, communal snake dens in the area were devoid not only of racers but also of the Prairie Rattlesnakes. In 2011, a natural slump event at the largest known hibernaculum of this subspecies in Canada seriously impacted the den structure and killed an unknown proportion of the hibernating racers in Frenchman River Valley within Grasslands National Park (Gardiner and Sonmor 2011). While terrain slumping events are natural phenomena and also create denning habitat in addition to destroying it, impacts on small populations concentrated at sites subjected to such events can be devastating. There is uncertainty about how many racers were killed or displaced in the slump event in 2011. Mark-recapture studies in 2010 and 2011 suggest that up to one half of the snakes using the den may have disappeared, but sample sizes are small (Gardiner and Sonmor 2011). A motion-detection camera was set up on the single remaining exit hole for two weeks following the slump (other holes were buried under >2 m of mud and debris), but detected only a single rattlesnake and no racers (Poulin pers. comm. 2015). Monitoring of the den in the weeks and years following this slump event revealed that fewer snakes than usual were emerging. Slumping also occurred to various extents at or near several other known hibernacula within Grasslands National Park during this time. One den with four species of snakes, including racers, in the Frenchman River Valley (outside of park boundaries) was buried/destroyed by a mammal in 2008, and no snakes have been observed at the site since that time (Poulin pers. obs.). In addition to slumping, other types of stochastic environmental events such as harsh winters, drought, and fires may also cause significant declines and fluctuations in population sizes.

In conclusion, there has been an observed and inferred decline from multiple sources within the past three generations (21 – 24 years) but its magnitude remains uncertain. Declines are expected to continue into the future due to threats (overall threat impact calculated as "Medium" based on four low impact threats; see **Threats**).

Western Yellow-bellied Racer:

While it can be inferred from threats and habitat trends that the population has declined, the magnitude of past declines is uncertain. Sarell (pers. comm. *in* COSEWIC 2004) suggested that racers in British Columbia are likely declining because of habitat loss and vehicle mortality on roads throughout the areas where racers have been studied in that region. The BC Conservation Data Centre (2015) estimated a short-term declining trend of 10 – 30% and a moderate-term declining trend of 25 – 50% for this species in the province, based largely on inferences from habitat trends, including urban expansion and agricultural activities, and threats from roadkill mortality. Roadkill was a major contributor to an overall threat impact of "High" (see **Threats**). The calculated threat from all threat categories was assessed as "high", which implies a 10 – 70% decline over the next three generation period.

A population model (Reed 2013) conducted as part of the status assessment for the Great Basin Gophersnake, another large snake occurring in the same general area, predicted a population decline of 30% or more across the species' Canadian range within the next three generations, based on sensitivity of the population to excess adult mortality from roadkill and other sources, such as inadvertent and intentional killing (COSEWIC 2013). The life history parameters used in the model are very similar to those of the Western Yellow-bellied Racer (Table 2), suggesting the results of the model apply for this species as well, which is similarly vulnerable to roadkill. Habitat loss and fragmentation pose additional stresses and contribute to projected declines.

**Table 2. Comparison of life history parameters of the Great Basin Gophersnake, used in model of effects of roadkill (Reed 2013), and the Western Yellow-bellied Racer in British Columbia.**

For data sources for Great Basin Gophersnake see COSEWIC 2013; for Western Yellow-bellied Racer see Biology section in this report.

| Model parameters (females): | Age at maturity | Frequency of breeding | Mean clutch size (low, high) | Juvenile survivorship (Year 1) | Immature survivorship | Adult survivorship | Generation time (yrs) |
|---|---|---|---|---|---|---|---|
| Great Basin Gophersnake | 4 | 0.5 - 0.8 | 4.6-7.4 | 0.2 | 0.71-0.76 | 0.63-0.85 | 8 |
| Western Yellow-bellied Racer | 3-4 | 0.5 - 0.8 | 6.3 | <0.5 | 0.59 | 0.83 | 7-8 |

While there is uncertainty associated with the magnitude of the projected declines, there is no reason to presume that threats are any less for this species than for other sympatric snakes (Western Rattlesnake and Great Basin Gophersnake; both assessed as threatened by COSEWIC based largely on suspected future declines due to increasing threats), which share habitats with racers in the arid interior of British Columbia and are subjected to similar threats.

### Rescue Effect

Whether there is exchange of individuals between Canadian and United States populations of either subspecies is currently unknown. Northern Montana contains extensive areas of grassland habitat, and several drainages may provide opportunities for dispersal of individuals into the Canadian prairies. This area has not been well surveyed, so little is known about population size and distribution (Cabarle pers. comm. 2013). However, additional recent information is available from the Montana Field Guide (undated), indicating records close to border on the United States' side of the border within 5 – 15 years. Some of the recent observations are close to GNP West Block and Rock Creek, East Block sites, where racers occur in Canada. Much of this area is contiguous with similar habitat in southeastern Alberta and southwestern Saskatchewan, so dispersal of individuals northward is possible, although it would probably require many generations. It is possible that rescue could be a factor in localized extirpation events in those areas over a three-generation period. However, currently no population genetic work has been done on racers in Montana and North Dakota (Leclere pers. comm. 2013), so their genetic similarity to Canadian subpopulations is unknown.

The potential for rescue of Western Yellow-bellied Racers from populations in the United States subpopulations is also low. Western Yellow-bellied Racers in the northern regions of the United States are unevenly distributed across the landscape and are rather isolated in specific habitats associated with river valleys. There have been few records of racers in northern Washington; currently, population size, distance between den sites, and the connectivity of subpopulations across the border are completely unknown (Washington State Department of Fish and Wildlife 2013). Given the degree of habitat fragmentation in the southern portion of the species' distribution in British Columbia, rescue from populations in the United States is unlikely.

## THREATS AND LIMITING FACTORS

### Limiting Factors

Racer populations are naturally limited by the fact that individuals are highly reliant on hibernation sites located in very specific areas, and by their limited ability to disperse. Subpopulations are geographically isolated, which coupled with their small size, could increase the risk of extirpation. Potential for recolonization from other areas is low as dens are often great distances from one another with unsuitable habitat in between them, leaving no corridors for movement.

Seasonal migrations between dens and summer range, fidelity to dens, and the aggregating of individuals at dens increase the snakes' vulnerability to roadkill, other threats, and stochastic environmental fluctuations. Relatively low reproductive rate (small clutch size and often biennial reproductive cycle of females, and a late age at maturity) results in a slow rate of recovery from perturbations.

## Threats

The IUCN Threats Calculator (Master *et al*. 2009) was used to assess threats to the Eastern and Western Yellow-bellied Racers in Canada (Tables 2 and 3). Standard threat categories were rated for scope (proportion of the population subjected to the threat within the next 10 years), severity (percentage decline of snakes exposed to the threat over the next three generations), and timing of the threat. These parameters were then used to calculate a threat impact for each category. The results of the assessment and specific threats, in order of their approximate, perceived order of importance, are discussed separately for the two subspecies below.

### Eastern Yellow-bellied Racer

The overall threat impact for this subspecies is "medium", based on four low impact threats (Table 3; see Appendix 1 for the entire threats calculator spreadsheet).

**Table 3. Summary of IUCN threats calculator assessment for the Eastern Yellow-bellied Racer, according to assessment conducted on 25 February 2014. Those threat categories that were not applicable to the species are omitted (hence the numbering of threats has gaps). See Appendix 1 for the full assessment with notes.**

| | | Level 1 Threat Impact Counts | |
|---|---|---|---|
| **Threat Impact** | | **high range** | **low range** |
| A | Very High | 0 | 0 |
| B | High | 0 | 0 |
| C | Medium | 0 | 0 |
| D | Low | 4 | 4 |
| | **Calculated Overall Threat Impact:** | Medium | Medium |

| **Threat** | | **Impact (calculated)** | | **Scope (next 10 Yrs)** | **Severity (10 Yrs or 3 Gen.)** | **Timing** |
|---|---|---|---|---|---|---|
| 1 | Residential & commercial development | | Negligible | Negligible (<1%) | Extreme (71-100%) | High (Continuing) |
| 1.1 | Housing & urban areas | | Negligible | Negligible (<1%) | Extreme (71-100%) | High (Continuing) |
| 2 | Agriculture & aquaculture | D | Low | Small (1-10%) | Serious - Slight (1-70%) | High (Continuing) |
| 2.1 | Annual & perennial non-timber crops | D | Low | Small (1-10%) | Serious - Slight (1-70%) | High (Continuing) |
| 2.3 | Livestock farming & ranching | D | Low | Pervasive (71-100%) | Slight (1-10%) | High (Continuing) |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing |
|---|---|---|---|---|---|---|
| 3 | Energy production & mining | D | Low | Restricted - Small (1-30%) | Slight (1-10%) | High (Continuing) |
| 3.1 | Oil & gas drilling | D | Low | Restricted - Small (1-30%) | Slight (1-10%) | High (Continuing) |
| 3.2 | Mining & quarrying | | Negligible | Negligible (<1%) | Extreme (71-100%) | High (Continuing) |
| 4 | Transportation & service corridors | D | Low | Pervasive (71-100%) | Slight (1-10%) | High (Continuing) |
| 4.1 | Roads & railroads | D | Low | Pervasive (71-100%) | Slight (1-10%) | High (Continuing) |
| 4.2 | Utility & service lines | | Negligible | Negligible (<1%) | Unknown | High (Continuing) |
| 5 | Biological resource use | | Negligible | Negligible (<1%) | Negligible (<1%) | High (Continuing) |
| 5.1 | Hunting & collecting terrestrial animals | | Negligible | Negligible (<1%) | Negligible (<1%) | High (Continuing) |
| 7 | Natural system modifications | | Negligible | Negligible (<1%) | Slight (1-10%) | High (Continuing) |
| 7.1 | Fire & fire suppression | | Negligible | Negligible (<1%) | Slight (1-10%) | High (Continuing) |
| 10 | Geological events | D | Low | Small (1-10%) | Slight (1-10%) | High (Continuing) |
| 10 | Avalanches/landslides | D | Low | Small (1-10%) | Slight (1-10%) | High (Continuing) |
| 11 | Climate change & severe weather | | Unknown | Unknown | Unknown | |
| 11 | Habitat shifting & alteration | | Unknown | Unknown | Unknown | High (Continuing) |
| 11 | Droughts | | Unknown | Unknown | Unknown | High (Continuing) |
| 11 | Temperature extremes | | Unknown | Unknown | Unknown | High (Continuing) |

*Transportation & service corridors (IUCN Threat 4.0* - impact low*)* – Similar to other snakes that undertake seasonal migrations racers are particularly vulnerable to roadkill when travelling between their winter dens and summer foraging areas. Mature females may be at greater risk than other age/size classes during their travels to egg-laying sites, and in snakes road mortality is often higher for these individuals (Bonnet *et al.* 1999). This is significant because the loss of sexually mature females impacts population growth more than the loss of males or immature individuals (Row *et al.* 2007). This situation may be further exacerbated by the late maturation of females in northern populations and the fact that individuals may not reproduce every year (Fitch 1963).

Road mortality is perhaps the greatest threat for Yellow-bellied Racers in the Big Muddy Valley and in the Frenchman River Valley in Saskatchewan. In southern Saskatchewan, there are relatively few roads and traffic volumes are low except on highways. Some new resource road building is expected in association with expanding oil and gas drilling. Information on the distance of racer dens to roads was not available for this report. In Grasslands National Park, Fortney *et al.* (2012) found that most mortality of snakes, including racers, was on paved rather than gravel roads and that proximity to hibernacula was positively correlated with the occurrence of snakes on roads. Telemetry data suggested that the snakes used road surfaces and sides more often than expected based on availability, potentially increasing their risk to roadkill. The severity of the threat on the population is deemed slight (1 – 10% decline expected), because the risk is reduced in areas with sparse roads.

*Agriculture (IUCN Threat 2.0 - impact "low")* – Impacts for snakes result from the conversion of land into annual and perennial non-timber crops and from livestock farming and ranching. Habitat fragmentation from agricultural activities, combined with naturally sparse subpopulations at the northern extreme of their range, is an imminent threat to racers. Martino *et al.* (2012) found that racers in Saskatchewan select for heterogeneous habitats with adequate cover, such as shrubs and burrows; thus, any activity that reduces cover could conceivably threaten individuals. In the southern prairies where the main land use is agriculture, racers use crop-land much less than expected based on its availability, suggesting that crop-land may be unsuitable habitat for these snakes and may act as a barrier to dispersal (Martino *et al.* 2012; Gardiner *et al*. 2013). As most of the suitable land along the border regions of southwestern Saskatchewan and southeastern Alberta has already been converted to crop-land, further loss of habitat from land conversion is expected to be limited in scope. Ranching is another major land use in this region, and racers often share their habitat with livestock. However, in some areas there has been extensive habitat alteration caused by heavy grazing regimes, but the impact of this on racers is currently not well understood.

*Geological events (IUCN Threat 10.0 - impact "low")* – Landslides or terrain slumps can have a significant impact on racers and their habitat, depending on the timing of the event. If the event occurs while the snakes are hibernating, snakes can be trapped in the dens (see **Fluctuations and Trends**). Although considered to be a rare occurrence, it is possible that landslides occur more often than documented and may increase as a result of storms associated with climate change. While landslides and terrain slumping can destroy hibernacula, as documented for two dens in recent years, they can also create new den sites. Destruction of hibernacula through slumping likely affects a small proportion (1 - 10%) of the racer population, resulting in a "slight" severity (1 - 10% decline over a three generation period).

*Energy production & mining (IUCN Threat 3.0 - impact "low")* – Impacts for snakes result mainly from oil and gas drilling activities, but mining and quarrying also contribute to this threat, although presently considered to have negligible impacts. Intensive oil and gas development is prevalent in lands mostly outside the subspecies' range. While presumably no oil and gas drilling will take place within the Grasslands National Park, these activities remain a possibility on private lands. Gold mining prospects in southwestern Saskatchewan have been raised, but at present there are no mining or quarrying activities officially proposed in the Frenchman or Big Muddy River valleys.

*Threat categories with "negligible" impacts* – Although deemed negligible for the Canadian population, three threat categories that could locally impact racers were identified: Housing and urban areas (Threat 1.1), Hunting and collecting of terrestrial animals (Threat 5.1), and Fire & fire suppression (Threat 7.2). Racers may be persecuted indirectly due to their resemblance to rattlesnakes. It has been suggested that annual burning of grasslands might be detrimental to Eastern Yellow-bellied Racers (Wright and Wright 1957); however, fire suppression in grassland habitat in recent years has likely reduced this threat. Grassland fires are now a rare occurrence and when they do occur, the impact is short term (Appendix 1). A large wildfire occurred in Grasslands National Park in 2013, virtually eliminating shrub cover in riparian areas used by the racers for foraging. The impacts are poorly understood but are probably of short duration, as regeneration is expected to be rapid. Over the long term, burning is likely to improve habitat.

*Threat categories with unknown impacts* – Climate change and severe weather (Threat 11.0) could affect the racer population mainly through habitat shifting and alteration, increased droughts, and temperature extremes. Racers could expand their distribution northwards as the climate warms. However, habitat fragmentation and an increase in temperature extremes, especially cold periods in winter, could prevent snakes from taking advantage of overall warmer conditions. In addition, an increased frequency and duration of droughts may reduce riparian foraging areas and prey availability, resulting in an overall negative effect on the snakes, the magnitude of which cannot be predicted at this time.

Western Yellow-bellied Racer

The overall threat impact for this subspecies was assessed as "high", based on one medium and three low impact threats (Table 4; see Appendix 2 for the entire threats calculator spreadsheet).

**Table 4. Summary of IUCN threats calculator assessment for the Western Yellow-bellied Racer, according to assessment conducted on 18 February 2013. Those threat categories that were not applicable to the species are omitted (hence the numbering of threats has gaps). See Appendix 2 for the full assessment with notes.**

| | | Level 1 Threat Impact Counts | |
|---|---|---|---|
| Threat Impact | | high range | low range |
| A | Very High | 0 | 0 |
| B | High | 0 | 0 |

| | | | |
|---|---|---|---|
| C | Medium | 1 | 1 |
| D | Low | 3 | 3 |
| | **Calculated Overall Threat Impact:** | High | High |

| **Threat** | | **Impact (calculated)** | | **Scope (next 10 Yrs)** | **Severity (10 Yrs or 3 Gen.)** | **Timing** |
|---|---|---|---|---|---|---|
| 1 | Residential & commercial development | D | Low | Small (1-10%) | Extreme (71-100%) | High (Continuing) |
| 1.1 | Housing & urban areas | D | Low | Small (1-10%) | Extreme (71-100%) | High (Continuing) |
| 1.2 | Commercial & industrial areas | D | Low | Small (1-10%) | Extreme (71-100%) | High (Continuing) |
| 2 | Agriculture & aquaculture | D | Low | Pervasive (71-100%) | Slight (1-10%) | High (Continuing) |
| 2.1 | Annual & perennial non-timber crops | D | Low | Small (1-10%) | Extreme - Serious (31-100%) | High (Continuing) |
| 2.3 | Livestock farming & ranching | D | Low | Pervasive (71-100%) | Slight (1-10%) | High (Continuing) |
| 4 | Transportation & service corridors | C | Medium | Large (31-70%) | Moderate (11-30%) | High (Continuing) |
| 4.1 | Roads & railroads | C | Medium | Large (31-70%) | Moderate (11-30%) | High (Continuing) |
| 5 | Biological resource use | | Negligible | Negligible (<1%) | Negligible (<1%) | High (Continuing) |
| 5.1 | Hunting & collecting terrestrial animals | | Negligible | Negligible (<1%) | Negligible (<1%) | High (Continuing) |
| 6 | Human intrusions & disturbance | D | Low | Large (31-70%) | Slight (1-10%) | High (Continuing) |
| 6.1 | Recreational activities | D | Low | Large (31-70%) | Slight (1-10%) | High (Continuing) |
| 7 | Natural system modifications | | Negligible | Negligible (<1%) | Unknown | High (Continuing) |
| 7.1 | Fire & fire suppression | | Negligible | Negligible (<1%) | Unknown | High (Continuing) |
| 7.2 | Dams & water management/use | | Negligible | Negligible (<1%) | Negligible (<1%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) |
| 8 | Invasive & other problematic species & genes | | Unknown | Pervasive (71-100%) | Unknown | High (Continuing) |
| 8.1 | Invasive non-native/alien species | | Unknown | Pervasive (71-100%) | Unknown | High (Continuing) |
| 9 | Pollution | | Unknown | Restricted (11-30%) | Unknown | High (Continuing) |
| 9.3 | Agricultural & forestry effluents | | Unknown | Restricted (11-30%) | Unknown | High (Continuing) |
| 11 | Climate change & severe weather | | Unknown | Pervasive (71-100%) | Unknown | High (Continuing) |
| 11 | Habitat shifting & alteration | | Unknown | Pervasive (71-100%) | Unknown | High (Continuing) |
| Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008). | | | | | | |

*Transportation and Service corridors (IUCN Threat 4.0 - impact "medium")* – Road mortality is considered the greatest threat for this subspecies, particularly in the southern portion of its distribution, where racers are most abundant (Racer Management Team Working Group 2013). The main roads follow valleys, where racers are also found, and almost all suitable habitats are intersected by roads. Hobbs (2013) calculated that of confirmed communal snake dens in British Columbia's arid interior 49% were within 1 km, 27% were within 1 – 2 km, and only 24% were farther than 2 km from roads. Throughout the Okanagan region, the average distance of any point to roads (0.7 km; Table 5) is well within the seasonal travel distances of 1 – 2 km by the snakes. The distribution of Racers is concentrated in the river valleys, where major roads are located, including the busy Okanagan Connector that links United States to British Columbia and communities from south to north and east to west. Therefore, even in the northern portion of the subspecies' range where overall road densities are lower (Table 5), a high proportion of racers is potentially subjected to roadkill. The annual volume of traffic on the Okanagan Connector has increased over the past decade (by 5% and 12% at two points for which consistent records exist; Figure 7); this trend is expected to continue into the future as the human population and tourism increase. In the Cariboo Region, within the northern portion of the subspecies' range where racer densities are lower, an increase in vehicle volume is also expected due to resource extraction activities (Steciw pers. comm. 2012 *in* Racer Management Team Working Group 2013).

**Table 5. Road density and average distance to road in four regions of British Columbia where the Western Yellow-bellied Racer is found (Hectares BC 2015).**

| BC Ministry of Environment Region | Total area (ha) | Total road length (km) | Road density (km/ha) | Average distance to road (km) |
|---|---|---|---|---|
| Okanagan | 2,970,000 | 50,200 | 1.7 | 0.7 |
| Thompson | 5,770,000 | 62,000 | 1.1 | 2.2 |
| Kootenay | 7,570,000 | 69,400 | 0.9 | 2.1 |
| Cariboo | 11,300,000 | 90,600 | 0.8 | 4.4 |

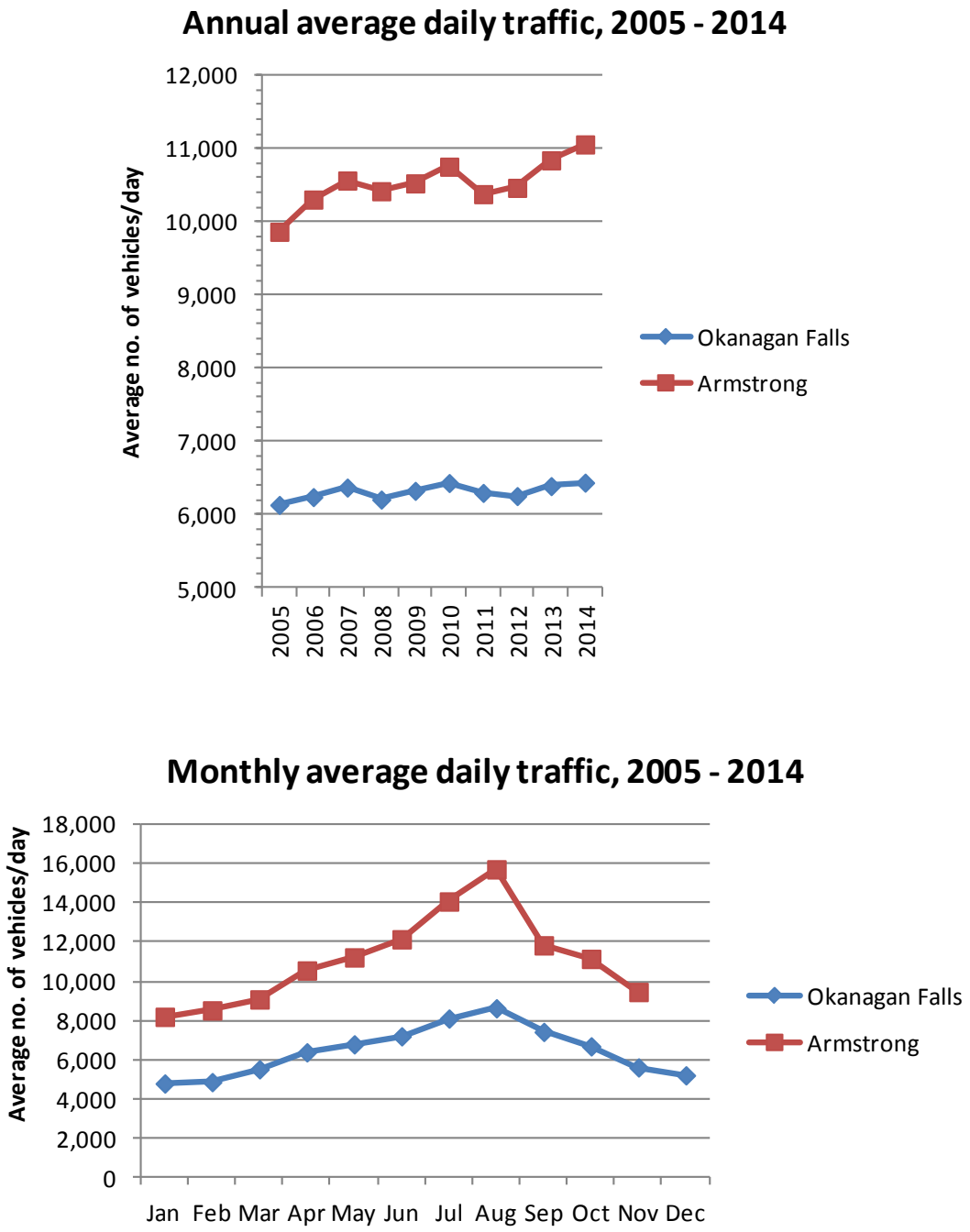


Figure 7. Annual and monthly average daily traffic volumes at two sites in the Okanagan Valley 2005 – 2014 (compiled from data in BC Government 2015).

Roadkill mortality of snakes, including racers, has been documented in many areas of the arid interior of British Columbia (Racer Management Team Working Group 2013 and references therein). Pickard (2009) reviewed snake roadkill records from a 25 km stretch of rural roads south of Penticton in the southern Okanagan Valley collected between 1988 and 2008. Data collection ranged from sporadic and opportunistic to more systematic efforts in the latter years and was collected mainly by one person on a voluntary basis. Of the total of 562 snakes found, 491 were roadkill. Racers comprised 19% (107 observations) of the snakes, following Gophersnakes (45%) and Western Rattlesnakes (31%). Racer observations were associated with distance to den (most observations were within 1 km of a den), seasonally flooded fields, and sparsely vegetated habitat, and most of the observations were of adult snakes rather than juveniles. While lack of search effort data hinders an analysis of trends, the data illustrate that roadkill is a continuing and insidious problem that removes reproductive individuals from the population by attrition with potentially serious effects.

Calculations of predicted increase in road length in the Central Okanagan within the core range of the species (Central Okanagan, Transportation and Mobility 2003) and roadkill rates/km of racers in the study by Picard (2009), resulted in a 17.1 – 22.0% increase in mortality per decade from roadkill alone (Table 6). Note that these calculations do not take into account increased traffic volumes on existing roads and are therefore underestimates.

**Table 6. Estimated increase in roadkill of racers in Central Okanagan based on increase in road length reflecting projected human population growth. The values for the projected population growth and length of roads were derived from Central Okanagan Transportation and Mobility (2003), while the rate of roadkill of racers/km was calculated from Picard (2009). Note that the calculations ignore increase in traffic on existing roads and are therefore underestimates.**

| Year | Human population | Length of public roads & highways | projected roadkill - Central Okanagan | % increase in roadkill (based on length of roads) | % increase in roadkill / decade |
|---|---|---|---|---|---|
| 1999 | 150538 | 1500 | 3210 | | |
| 2025 (1)* | 235000 | 2325 | 4975.5 | 55.0 | 22.0 |
| 2025 (2)* | 235000 | 2140 | 4579.6 | 42.7 | 17.1 |

*1 and 2 represented two projected scenarios

In the West Kootenays, amphibians and reptiles showed a five-fold increase in roadkill mortality when comparing pre-construction (2006 – 2009) and construction (2011) phases of major project development (while traffic rates doubled), with listed snakes including Racer being the most susceptible species (Machmer pers. comm. 2012 *in* Racer Management Team Working Group 2013).

Snakes crossing roads may be actively targeted by drivers. Ashley *et al.* (2007) reported that 2.7% of motorists in their study in Long Point in Ontario intentionally hit snakes and other reptiles. Deliberate targeting of snakes by drivers has also been observed in British Columbia (Sarell pers. obs. *in* COSEWIC 2013).

*Residential and commercial development (IUCN Threat 1.0 - impact "low)* –While much suitable Racer habitat has been lost to urban and rural development in the past, particularly in the southern part of the subspecies' range, new development is expected to be limited in scope over the next 10 years (affecting 1 – 10% of the range). New urban developments are expected to focus primarily on densification rather than expansion into new areas; the Agricultural Land Reserve in the Okanagan Valley will also limit urban sprawl (Racer Management Team Working Group 2013). However, when urban and commercial development does occur, it will be extreme in severity resulting in habitat fragmentation and loss. Racers appear to be intolerant of urbanization.

*Agriculture (IUCN Threat 2.0 – impact "low")* – Impacts for snakes result from conversion of land into annual and perennial non-timber crops and from livestock farming and ranching. As in the case of urban development, much of suitable Racer habitat has been lost to agricultural development in the past. While vineyard developments are expected to continue at a lower rate over the next 10 years, conversion of new areas to agricultural uses is expected to affect a small proportion of Racer habitat (scope 1 – 10%). Racers tend to avoid agricultural areas (Martino *et al.* 2012). However, when they do use such areas, they are subject to mortality from farm machinery. Where agricultural developments do occur, the effect on racers is thought to be serious to extreme as a result of loss and degradation of essential habitats that include egg laying and foraging sites.

Free-range cattle are ubiquitous throughout much of this subspecies' range in British Columbia. While racers can coexist with livestock on range lands, intensive grazing results in structural changes to the habitat, including reduction of vegetation cover and soil compaction, which can be detrimental. Over-grazing associated with soil compaction and low stubble heights have been observed in some areas of the subspecies' range (Racer Management Team Working Group 2013). The effects of cattle can be particularly deleterious in riparian foraging areas of the snakes. However, because of varying intensities of grazing across the subspecies' range and uncertainties about causal effects, the overall effect of livestock grazing on the Racer population is considered slight.

*Human intrusions and disturbance (IUCN Threat 6.0 – impact "low)* – Recreational activities occur throughout much of the subspecies' range and range from recreational all-terrain vehicle use to hunting and hiking. Intensive activities, especially when they involve the off-trail use of all-terrain vehicles, have the potential to cause direct mortality, damage habitat including egg-laying sites, and generally disturb snakes. All-terrain vehicle use occurs throughout the active season of the snakes, often outside of designated roads and trails, and appears to be increasing within portions of the range (Racer Management Team Working Group 2013). Where recreational activities occur, their overall severity to the Racer population is considered slight (1 – 10% decline predicted).

*Threat categories with "negligible" impacts* – Although deemed negligible for the entire Canadian population, two threats that could impact racers locally were identified: Hunting & collecting (Threat 5.1) and Dams & water management (Threat 7.2). Similar to other large snakes, racers may be killed by people who are afraid of or dislike them or as a by-product of persecution of rattlesnakes (Campbell and Perrin 1991). While the overall impact of persecution is thought to be negligible, it would be significant if snake dens were illegally targeted. Flooding of riparian habitat in river valleys during dam expansion projects (e.g., Waneta and Brilliant Dam in the Kootenay Region) and reservoirs causes habitat loss, and could be displacing individuals.

*Threat categories with "unknown" impacts* – Four potentially serious threats with unknown impacts were identified: Fire & fire suppression (Threat 7.1), Invasive & other problematic species (Threat 8.1), Agricultural & military effluents (Threat 9.2), and Climate change and severe weather (Threat 11.0). While burning of the habitat is beneficial for racers over the long term by maintaining its open nature (Fitch 1999), intensive fires may have deleterious effects on snakes locally and over the short term through reduction in both habitat and prey (Fischer and Bradley 1987).

Invasive species could affect the prey base of snakes, but the effects are poorly understood at this time. A potential but more serious threat is from the Snake Fungal Disease, an emerging skin disease affecting populations of wild snakes (USGS 2013). In terrestrial snakes, the disease is linked to the fungus *Ophidiomyces ophiodiicola*, which occurs only in snakes (University of Alberta undated). To date, this disease has been found in a number of snake species in eastern and mid-western United States (USGS 2013). Although currently not reported from any wild snake populations in western North America, it is suspected to be more widespread than is currently documented and may affect more species.

Pesticide use in agricultural areas may reduce food availability and contaminate insect and rodent prey base and possibly cause secondary poisoning in the snakes themselves. The use of strychnine to control Northern Pocket Gophers (*Thomomys talpoides*) is of particular concern for snakes that prey on them (Williams and Bishop 2011). As rodents comprise a small portion of the Racer diet, this threat may be limited to larger adults.

As for the Eastern Yellow-bellied Racer, Climate change and severe weather could affect the racer population in several ways. The overall impacts are unknown in light of the complex nature of this threat and lack of adequate information on the potential severity of the impact.

**Number of Locations**

If each den site, including the surrounding habitat supporting the snakes using the den, is considered a separate location subject to a separate set of threats, there are 10 – 12 known locations for the Eastern Yellow-bellied Racer. One confirmed den site is near Onefour, Alberta, and nine are in Saskatchewan: one in the Big Muddy Valley, one near Rock Creek near the Eastblock of Grasslands National Park, and seven in the Frenchman

River Valley (six of which are in Grasslands National Park). Although no dens have been found, there have been observations of racers in Cypress Hills Provincial Park and near Govenlock, Saskatchewan, suggesting two additional locations. Racers inside of Grasslands National Park and Cypress Hills Provincial Park are relatively safe from large-scale habitat loss/fragmentation and road mortalities. However, as has been highlighted with recent events in the Frenchman River Valley, all den sites could be considered at risk from predators (Poulin pers. obs. 2008) and natural slumping events (Gardiner and Sonmor 2011).

While there are known den sites for Western Yellow-bellied Racers, the number of locations cannot be accurately estimated at this time. Racers have been found in 102 confirmed communal snake dens in British Columbia (historically and/or recently) and occur in additional dens (see **Canadian Distribution**); therefore, there are probably over 100 locations. Habitat loss and fragmentation, as well as roadkill mortality for snakes migrating to and from dens, are serious threats to these sites.

## PROTECTION, STATUS AND RANKS

### Legal Protection and Status

The Eastern Yellow-bellied Racer is listed as a Threatened species on Schedule 1 of the *Species at Risk Act,* and seven known hibernacula have been identified in southwestern Saskatchewan as Critical Habitat (Parks Canada Agency 2010). Provincially, the Eastern Yellow-bellied Racer is protected by the Saskatchewan *Wildlife Act,* which prohibits unauthorized killing or possession. The 2000 Alberta *Wildlife Act* does not protect the Eastern Yellow-bellied Racer specifically, but it prohibits willful destruction of snake hibernacula. The *Parks Act* helps protect species listed under the *Species at Risk Act* by supervising recovery efforts and protecting species and their habitats found in national parks and other areas managed by the Parks Agency. The Parks Canada Agency (2010) developed a Recovery Strategy for the Eastern Yellow-bellied Racer in 2010, and one or more Action Plans are expected to be completed by 2015.

The Western Yellow-bellied Racer is listed as a Special Concern species on Schedule 1 of the *Species at Risk Act*. Provincially, the Western Yellow-bellied Racer is protected by the British Columbia *Wildlife Act*, which prohibits killing, collection and harassment of all native vertebrates without a permit. It is also listed as a species at risk under the Identified Wildlife Management Strategy associated with the *Forest and Range Practices Act*, which applies to provincial crown forestry and range lands.

## Non-legal Status and Ranks

Globally, the Eastern Yellow-bellied Racer is considered Secure (rank G5T5; Nature Serve 2013), and is not listed as a subspecies by the International Union for Conservation of Nature (IUCN 2012). The IUCN does list *Coluber constrictor*, however, as a species of Least Concern (IUCN 2012). Nationally, the Eastern Yellow-bellied Racer is considered Secure (rank N5) in the USA, but Vulnerable (rank N3) in Canada due to its restricted range (NatureServe 2013). Within United States, the status of the Eastern Yellow-bellied Racer is considered Secure (S5) in Colorado and Missouri, and Apparently Secure (rank S4) at a fairly low risk of extirpation in Arkansas and Wyoming (NatureServe 2013). Within Canada, the provincial heritage status of Eastern Yellow-bellied Racer in Saskatchewan is S3, indicating that the subspecies is Vulnerable to extirpation or extinction (NatureServe 2013). In Alberta, the provincial heritage status is SU, meaning the subspecies is currently Unrankable in this province due to the lack of information.

The status of Western Yellow-bellied Racer globally is considered Secure (rank G5T5; NatureServe 2013), but it is not listed as a subspecies by the International Union for Conservation of Nature (IUCN 2012). In the USA, the Western Yellow-bellied Racer is designated as Secure (rank N5), but Vulnerable (rank N3) in Canada due to its restricted range (NatureServe 2013). Within the United States, the Western Yellow-bellied Racer is considered Secure (N5) in Nevada, Vulnerable (N3) in Colorado, and Critically Imperiled (N1) in Texas and Arizona due to its restricted range (NatureServe 2013). Within Canada, the provincial heritage status rank of the Western Yellow-bellied Racer in British Columbia is S3, meaning the subspecies is Vulnerable to extirpation (NatureServe 2013). The Western Yellow-bellied Racer is Blue-listed in British Columbia, because the dry grassland habitat it selects for is currently under threat.

## Habitat Protection and Ownership

Critical Habitat, currently protected for the Eastern Yellow-bellied Racer, consists of a 500 m radius buffer around each of seven known hibernacula within the Frenchman River Valley (Parks Canada Agency 2010). The majority of Eastern Yellow-bellied Racer habitat in this area was protected by the Grasslands National Park (49,000 ha) and a federal community pasture (41,000 ha). In 2012, the federal government initiated a process of relinquishing control of the community pasture (Val Marie PFRA pasture) to the province of Saskatchewan, ending the Community Pasture Program and essentially eliminating federal protection of 46% of the range of the Eastern Yellow-bellied Racer in the Frenchman River Valley. When reverted to provincial ownership, lands may be sold or leased for ranching purposes (Arbuthnott and Schmutz 2013); however, any land use decisions impacting this sensitive area are likely to be under intense scrutiny due to its high profile (Didiuk pers. comm.). Outside of the Frenchman River Valley, the only other known dens exist on privately owned land with no formal protection for the Eastern Yellow-bellied Racer. Den protection alone, however, is inadequate for long-term protection of the subspecies. Conservation strategies must include den areas, movement corridors, and summering grounds as well to ensure long-term persistence of Eastern Yellow-bellied Racers (Gardiner *et al*. 2013).

Several protected areas of suitable habitat exist for the Western Yellow-bellied Racer in British Columbia, but they are all generally small within fragmented landscapes. These areas include Okanagan Mountain Provincial Park, Throne Ecological Reserve, White Lake Protected Area, Kobau Provincial Park, Churn Creek Protected Area, and Nature Trust areas (Sarell 2004). A small amount of habitat is also protected within Ecological Reserves under the provincial *Wildlife Act*. Almost none of these areas contain both suitable winter and summer habitat. The overwhelming majority of Western Yellow-bellied Racer suitable habitat occurs on unprotected lands with development potential, such as valley bottoms.

As part of protecting habitat for species at risk through the provincial Identified Wildlife Strategy associated with the BC Forest *and Range Practices Act*, the province of British Columbia has established 31 Wildlife Habitat Areas around communal snake dens, collectively totalling 5,971 ha, for the purposes of protecting habitat for the Western Rattlesnake, Great Basin Gopher Snake, and Yellow-bellied Racer (Woods pers. comm. 2015). Wildlife Habitat Areas are meant to protect important habitat areas or features that are managed according to specific General Wildlife Measures outlined in accounts for identified wildlife species (Yellow-bellied Racer: Sarell 2004). However, while these efforts have secured a number of important den sites, neither urban development nor other resource-based industries (such as mining) are subject to the provisions of the Identified Wildlife Management Strategy, nor does the presence of a Wildlife Habitat Area prevent the sale of provincial crown land.

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## INFORMATION SOURCES


Anderson, R.E. 1996. Biochemical and hemipenial systematics of *Coluber constrictor* (Reptilia: Serpentes) MSc thesis, Southeastern Louisiana University**.** xiii, 178 pp.

Arbuthnott, K., and J.K. Schmutz. 2013. PFRA community pastures: history and drama of a prairie commons. Saskatchewan Notes, Canadian Centre for Policy Alternatives. 8 pp. Web site: https://www.policyalternatives.ca/sites/default/files/uploads/publications/Saskatchewan%20Office/2013/04/SKnotes_PFRA_0.pdf [accessed July 2015].

Auffenberg, W. 1955. A reconsideration of the racer, *Coluber constrictor*, in the eastern United States. Tulane Studies in Zoology 2(6):89-155.

BC Conservation Data Centre. 2015. Conservation status report. *Coluber constrictor*, North American Racer. http://a100.gov.bc.ca/pub/eswp/esr.do?id=17118 [accessed July 2015].

BC Government. 2015. BC Traffic Data Program, GIS application. Application version 3.0.0. Web site: https://prdoas3.pub-apps.th.gov.bc.ca/tsg/ [accessed July 2015].

BC Stats. 2012. Thompson-Okanagan Development Region Quarterly Regional Statistics, Second Quarter 2012. Web site: http://www.bcstats.gov.bc.ca/Files/9083dab9-580b-4c60-9c3a-5b1dcf77046b/QuarterlyRegionalStatistics-ThompsonOkanaganDR.pdf [accessed October 12, 2013].

Bleakney, J.S. 1958. A zoogeographical study of the amphibians and reptiles of eastern Canada. National Museum of Canada Bulletin No. 155.

Bonnet, X., G. Naulleau, and R. Shine. 1999. The dangers of leaving home: dispersal and mortality in snakes. Biological Conservation 89:39-50.

Brown, W.S., and W.S. Parker. 1976. Movement ecology of *Coluber constrictor* near communal hibernacula. Copeia 1976:225-242.

Brown, W.S., and W.S. Parker. 1984. Growth, reproduction and demography of the racer, *Coluber constrictor mormon*, in northern Utah. pp. 13–40 *in* R. A. Seigel, L. E. Hunt, J. L.Knight, L. Malaret, and N. L. Zuschlag (eds.).Contributions to Vertebrate Ecology and Systematics: A Tribute to Henry S. Fitch. Spec . Publ. 10 Museum Natural History, University Kansas.

Cabarle, K., pers. comm. 2013. *Email correspondence to report writers*. June 2013. Professor, Fish and Wildlife Program Advisor, Department of Science, Dakota College at Bottineau, Bottineau, North Dakota.

Campbell, C.A., and D.W. Perrin. 1991. COSEWIC status report on the Blue Racer *Coluber constrictor foxii* in Canada. [With additions on the Eastern and Western Yellow-bellied Racers by J.M. Macartney and additions on the Blue Racer by B.D. Porchuk; revised and edited by F. Cook and the Subcommittee on Amphibians and Reptiles of COSEWIC for the 1991 meeting; and by R.J. Brooks in 1997]. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario 36 pp.

Campbell, W.R., M.G. Shepard, B.M. Van Der Raay, and P.T. Gregory. 1982. A bibliography of Pacific Northwest herpetology. Heritage Rec. 14, B.C. Prov. Museum, Victoria, British Columbia. 151 pp.

Central Okanagan Transportation and Mobility. 2003. Regional growth strategy, planning for the future. Web site: https://www.regionaldistrict.com/media/20455/pl_trans.pdf [accessed November 2015].

Charland, M.B. 1987. An examination of factors influencing first-year recruitment in the Northern Pacific Rattlesnake, *Crotalus viridis oreganus*, in British Columbia. M.Sc. Thesis, University of Victoria, Victoria, British Columbia. 143 pp.

Cannings, S.G., L.R. Ramsay, D.F. Fraser, and M.A. Fraker. 1999. Rare amphibians, reptiles, and mammals of British Columbia. Wildlife Branch and Resource Inventory Branch, B.C. Ministry of the Environment, Lands, and Parks. Victoria, British Columbia.

Collins, J.T. 1991. A new taxonomic arrangement for some North American amphibians and reptiles. Herpetological Review 22:42-43.

Conant, R. 1958. A Field Guide to Reptiles and Amphibians of the United States and Canada East of the 100th Meridian. Houghton Mifflin Company, Boston, Massachusetts.

Cook, F.R. 1967. An analysis of the herpetofauna of Prince Edward Island. National Museum of Canada Bulletin 212.

Cook, F.R., and C.G. van Zyll de Jong. 1975. Eastern Yellow-bellied Racer in central southern Saskatchewan. The Canadian Field-Naturalist 89:174-175.

Corn, P.S., and R.B. Bury. 1986. Morphological variation and zoogeography of racers (*Coluber constrictor*) in the central Rocky Mountains. Herpetologica 42:258-264.

COSEWIC. 2004. COSEWIC assessment and update status report on the Eastern and Western Yellow-bellied Racers, *Coluber constrictor flaviventris* and *Coluber constrictor mormon* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. vii + 35 pp.

COSEWIC. 2012. COSEWIC status appraisal summary on the Blue Racer *Coluber constrictor foxii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. xvii pp

COSEWIC. 2013. COSEWIC assessment and status report on the Great Basin Gophersnake *Pituophis catenifer deserticola* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. xii + 53 pp.

COSEWIC. 2015. COSEWIC status report on the Eastern and Western Rattlesnake, *Crotalus oreganus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. x + 56 pp.

Crother, B. I. (ed.). 2012. Scientific and standard English names of amphibians and reptiles of North America North of Mexico, with comments regarding confidence in our understanding. 7th Edition. Herpetological Circulars. Society for the Study of Amphibians and Reptiles, St. Louis, Missouri.

Didiuk, A., pers.comm. 2015. *Email correspondence to K. Ovaska.* November 2015. Wildlife Biologist, Canadian Wildlife Service (Prairie and Northern Region), Saskatoon, Saskatchewan.

Douglas, N. 2015. Alberta's species-at-risk Yellow-bellied Racer. 2015. Wildland Advocate 23:22-23.

Dulisse, J. 2006. Western Yellow-bellied Racer (*Coluber constrictor mormon*) inventory in southeastern British Columbia. Columbia Basin Fish and Wildlife, Nelson, British Columbia.

Environment Canada. 2014. Management plan for the Western Yellow-bellied Racer (*Coluber constrictor mormon*) in Canada [Proposed]. *Species at Risk Act* Management Plan Series. Environment Canada, Ottawa, Ontario.

Ernst, C.H., and R.W. Barbour. 1989. Snakes of Eastern North America. George Mason University Press, Fairfax, Virginia.

Ernst, C.H., and E.M. Ernst. 2003. Snakes of the United States and Canada. Smithsonian Books, Washington D.C.

Finley K.J., and M.A. Jasieniuk. 1978. The Eastern Yellow-bellied Racer in Canada. Blue Jay 36:88-91.

Fischer, W.C., and A.F. Bradley. 1987. Fire ecology of western Montana forest habitat types. General Technical Report, US Forest Service - Department of Agriculture, Ogden, Utah. 96 pp.

Fitch, H.S. 1963. Natural history of the racer *Coluber constrictor*. University of Kansas Museum of Natural History Publications 15(8):351-468.

Fitch, H.S. 1999. A Kansas Snake Community: Composition and Changes Over 50 Years. Krieger Publishing Co., Malabar, Florida. 165 pp.

Fitch, H.S., W.S. Brown, and W.S. Parker. 1981. *Coluber mormon*, a species distinct from *C. constrictor*. Transactions of the Kansas Academy of Science 84:196-203.

Fortney, A.N., R.G. Poulin, J.A. Martino, D.L. Parker, and C.M. Somers. 2012. Proximity to hibernacula and road type influence potential road mortality of snakes in southwestern Saskatchewan. Canadian Field-Naturalist 126:194-203.

Gardiner, L.E., unpubl. data. Former graduate student (lab of C.M. Somers), Department of Biology, University of Regina, Saskatchewan.

Gardiner, L.E., and K.W. Sonmor. 2011. Major slump event at Grasslands National Park Snake Pit in southwestern Saskatchewan. Blue Jay 69:120-124.

Gardiner, L.E., J.A. Martino, R.G. Poulin, and C.M. Somers. 2011. Eastern Yellow-bellied Racer populations on the Canadian Prairies. Blue Jay 69:70-74.

Gardiner, L.E., C.M. Somers, J.A. Martino, D.L. Parker, and R.G. Poulin. 2013. Balancing the dumbbell: Summer habitats need protection in addition to winter dens for northern snake communities. Journal of Wildlife Management 77:975-982.

Gardiner, L., and J. Song. 2013a. Movement and habitat use by Western Rattlesnakes and Great Basin Gophersnakes at Mission Hill Vineyard: Unpubl. final Report on 2013 Field Work. Nk'Mip Desert Cultural Centre, Osoyoos, British Columbia. 13 pp.

Gardiner, L., and J. Song. 2013b. Habitat conservation management for Western Rattlesnakes and Great Basin Gophersnakes on the Osoyoos Indian Reserve: Final Report on 2013 Fieldwork. Nk'Mip Desert Cultural Centre, Osoyoos, British Columbia. 12 pp.

Gilhen, J. 1984. The Amphibians and Reptiles of Nova Scotia. Nova Scotia Museum, Halifax, Nova Scotia. 162 pp.

Gill, C. 2010. 2009 Esh-kn-am CRM Species at Risk Project: Western Screech-owl inventory survey & Western Rattlesnake den searches on selected Coldwater, Siska, & Cooks Ferry Reserves. 14 pp.

Gorham, S.W. 1970. The Amphibians and Reptiles of New Brunswick. The New Brunswick Museum. Monographic Series No. 6. St. John, New Brunswick. ix + 30 pp.

Grasslands Conservation Council of British Columbia. 2004. BC Grasslands mapping project: a conservation risk assessment. Unpubl. final report. 116 pp.

Grasslands Conservation Council of BC. 2012. Website: http://www.bcgrasslands.org/grasslandsofbc.htm [accessed May 2012].

Green, D.M. (ed.). 2012. Noms français standardisés des amphibiens et des reptilesd'Amérique du Nord au nord du Méxique. SSAR Herpetological Circulars 40. 63 pp.

Greene, H.W. 1984. Taxonomic status of the western racer, *Coluber constrictor mormon.* Journal of Herpetology 18:210-211.

Gregory, P.T. 1982. Reptilian hibernation. Pp 53 - 154 *in* Biology of the Reptilia Vol 13. C. Gans and F.H.Y Pough (eds.). Academic Press, London. 345 pp.

Gregory, P.T., and R.W. Campbell. 1984. The Reptiles of British Columbia. British Columbia Museum Handbook 44. 102 pp.

Harding, J.H. 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor, Michigan. 378 pp.

Hectares BC. 2015. Web site: http://www.hectaresbc.org/app/habc/HaBC.html [accessed July 2015].

Hobbs, J. 2011a. Oliver Mountain snake den assessment - 2010. Unpubl. report prepared for BC Ministry of Environment and Okanagan Region Wildlife Heritage Fund Society, Penticton, British Columbia. 10 pp.

Hobbs, J. 2011b. Kalamalka Park Snake Dens - 2010. Unpubl. report prepared for BC Ministry of Environment, Victoria, British Columbia. 23 pp.

Hobbs, J. 2013. Den survey and population assessment of the Northern Pacific Rattlesnake in BC: Final Report. Unpubl. report prep. for BC Ministry of Forests, Lands and Natural Resource Operations, Victoria, British Columbia. 85 pp.

Hobbs, J. pers. comm. 2013. *Email correspondence to report writers.* June 2013. Wildlife Biologist, Ministry of Environment, Victoria, British Columbia.

Hobbs, J. pers. comm. 2015. *Email and phone correspondence to K. Ovaska.* July 2015. Biologist, Hemmera, Vancouver, British Columbia.

Hobbs, J.R., and M. Sarell. 2000. Gopher Snakes (and cohorts): An assessment of selected den sites in the South Okanagan. Unpubl. report prepared for BC Ministry of Environment, Lands and Parks, Kamloops, British Columbia. 31 pp.

Hobbs, J., and M. Sarell. 2001. Gopher snakes (and cohorts): An assessment of selected den sites in the Penticton, Vernon, Merritt and Boundary Forest Districts. Report prepared for B.C. Environment, Kamloops, British Columbia.

Hobbs, J., and M. Sarell. 2002. An assessment of racer and gopher snake habitat in the Williams Lake and 100-Mile Forest Districts. Unpubl. report prepared for B.C. Environment, Williams Lake, British Columbia.

Iredale, F. 2006. Fall inventory for Northern Pacific Rattlesnake, Racer, and Gopher Snakes 2006: MOE Regions 3 and 8. Unpubl. report prepared for BC Conservation Foundation and BC Ministry of Environment, Kamloops, British Columbia. 14 pp.

Iredale, F. 2008. Spring/fall inventory for Western Rattlesnake MOE Region 3. Unpubl. report prepared for BC Ministry of Environment, Kamloops, British Columbia. 13 pp.

Iredale, F., and G. Ferguson. 2007. Spring/fall inventory for Northern Pacific Rattlesnake, Racer, and Gopher Snakes 2007 MOE Region 3. Draft. Unpubl. report prepared for BC Conservation Foundation and BC Ministry of Environment, Kamloops, British Columbia. 13 pp.

IUCN. 2012. IUCN Red List of Threatened Species. Version 2012.2. Web site: www.iucnredlist.org [accessed 26 June 2013].

Kissner, K.J., D.M. Secoy, and M.R. Forbes. 1996. Assessing population size and den use of Prairie Rattlesnakes (*Crotalus viridis viridis*) in southern Saskatchewan. Grasslands National Park, Annual Report Vol. 1. 34 pp.

Kreba, R. 1978. Observations of an Eastern Yellow-bellied Racer in captivity. Blue Jay 36:94-98.

Lea, T. 2008. Historical (pre-settlement) ecosystems of the Okanagan Valley and Lower Similkameen Valley of British Columbia - pre-European contact to the present. Davidsonia 19:3-36.

LeClere, J., pers. comm. 2013. *Email and telephone correspondence to report writers*. June 2013. Amphibian and Reptile Specialist, Minnesota Department of Natural Resources, St. Paul, Minnesota.

Lesica, P., and F.W. Allendorf. 1995. When are peripheral populations valuable for conservation? Conservation Biology 9:753-760.

Logier, E.B.S., and G.C. Toner. 1955. Check-list of the amphibians and reptiles of Canada and Alaska. Royal Ontario Museum of Zoology and Palaeontology Contributions 41.

Logier, E.B.S., and G.C. Toner. 1961. Check list of the amphibians and reptiles of Canada and Alaska. Royal Ontario Museum, Life Sciences Division Contribution 53.

Lomas, E. 2013. Effects of disturbance on the Northern Pacific Rattlesnake (*Crotalus oreganus oreganus*) in British Columbia. M.Sc. Thesis. Thompson Rivers University, Kamloops, British Columbia. 107 pp.

Lynch, W. 1978. Death-feigning in the Eastern Yellow-bellied Racer. Blue Jay 36:92-93.

Macartney, J.M. 1985. The ecology of the Northern Pacific Rattlesnake, *Crotalus viridis oreganus*, in British Columbia. M.Sc. Thesis, University of Victoria, Victoria, British Columbia. 289 pp.

Macartney, M., and B. Weichel. 1993. Population status and biology of the Prairie rattlesnake and other reptile species in southwest Saskatchewan 1990-1991. Johnson and Weichel Resource Management Consultants, Saskatoon, Saskatchewan.

Mackay, R. 1987. A survey of snake hibernacula in the Val Marie area. Unpubl. report for the Saskatchewan Natural History Society, Saskatoon, Saskatchewan. 14 pp. + appendices.

Maher, W.J., and W.H. Beck. 1964. Two records of the yellow-bellied racer in Saskatchewan. Blue Jay 22:174.

Martin, J.L. 1969. The Amphibians and Reptiles of Nova Scotia. Nova Scotia Museum, Halifax, Nova Scotia. 17 pp.

Martino, J.A, unpubl. data. Former graduate student (lab of C.M. Somers), Department of Biology, University of Regina, Saskatchewan.

Martino, J.A., R.G. Poulin, D.L. Parker, and C.M. Somers. 2012. Habitat selection by grassland snakes at northern range limits: Implications for conservation. Journal of Wildlife Management 76:759-767.

Martino, J.A., R.G. Poulin, D.L. Parker, and C.M. Somers. Unpubl. data. Genetic research on the Eastern Yellow-bellied Racer, in progress. University of Regina, Regina, Saskatchewan. Web site: http://www.somersbiology.ca/genetics.html [accessed July 2015].

Master, L., D. Faber-Langendoen, R. Bittman, G.A. Hammerson, B. Heidel, J. Nichols, L. Ramsay, and A. Tomaino. 2009. NatureServe conservation status assessments: factors for assessing extinction risk. NatureServe, Arlington, Virginia. 57 pp.

Matsuda, B., D. Green, and P. Gregory. 2006. Amphibians & Reptiles of British Columbia. Illustrated Edition. Royal British Columbia Museum, Victoria, British Columbia. 272 pp.

Mills, E.C. 1948. A check list of the amphibians and reptiles of Canada. Herpetologica 4 (supplement 2).

Montana Field Guide. Undated. North American Racer — *Coluber constrictor*. Montana Field Guide. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Web site: http://FieldGuide.mt.gov/speciesDetail.aspx?elcode=ARADB07010 [accessed November 2015].

Morrison, H. 1969. A preliminary botanical survey of the Big Muddy Valley in southern Saskatchewan. Blue Jay 27:42-53.

NatureServe. 2013. NatureServe Explorer: An online encyclopedia of life (web application) Version 7.1. NatureServe Web site: http://www.natureserve.org/explorer [accessed June 2013].

Nussbaum, R.A., E.D. Brodie, Jr., and R.M. Storm. 1983. Amphibians and Reptiles of the Pacific Northwest. The Northwest Press of Idaho, a Division of the Idaho Research Foundation, Moscow, Idaho. 332 pp.

Orchard, S.A. 1984. Amphibians and reptiles of B.C.: An Ecological Review. Ministry of Forests, Province of British Columbia. 268 pp.

Parks Canada Agency. 2010. Recovery Strategy for Eastern Yellow-bellied Racer (*Coluber constrictor flaviventris*) in Canada. Species at Risk Act Recovery Strategy Series. Parks Canada Agency. Ottawa, Ontario. vii + 22 pp.

Pickard, D. 2009. Snakes on a lane: Analysis of snake observations on a rural road in southern British Columbia. Unpubl. report prepared for Ecosystems Branch, BC Ministry of Environment, Victoria, British Columbia. 36 pp. Web site: https://www.for.gov.bc.ca/hfp/frep/values/wildlife/Analysis-snake-observations-Southern-BC.pdf [accessed July 2015].

Poulin, R.G., pers. obs. and unpubl. data, 2008 – 2013. Head of Research and Collections, Royal Saskatchewan Museum, Regina, Saskatchewan.

Poulin, R.G., and A. Didiuk. 2008. Survey for Eastern Yellow-bellied Racers on AAFC-PFRA Pastures. A 2007 project for Agriculture and Agri-Food Canada - PFRA and supported by the Interdepartmental Recovery Fund. 40 pp.

Poulin R.G., pers. comm. 2015. *Email correspondence to K. Ovaska.* November 2015. Head of Research and Collections, Royal Saskatchewan Museum, Regina, Saskatchewan.

Racer Management Team Working Group. 2013. Management plan for the Racer (*Coluber constrictor*) in British Columbia. Prepared for the B.C. Ministry of Environment, Victoria, British Columbia. 25 pp.

Reed, E.T. 2013. Population model for female Great Basin Gophersnake. Unpubl. report prepared in support of COSEWIC status assessment. Canadian Wildlife Service, Ottawa [available from COSEWIC Secretariat, Ottawa, Ontario].

Rosen, P.C. 1991. Comparative ecology and life history of the racer (*Coluber constrictor*) in Michigan. Copeia 1991:897-909.

Row, J.R., G. Blouin-Demers, and P.J. Weatherhead. 2007. Demographic effects of road mortality in black ratsnakes (*Elaphe obsoleta*). Biological Conservation 137:117-124.

Samson, F.B., F.L. Knopf, and W.R. Ostlie. 2004. Great Plains ecosystems: past, present, and future. Wildlife Society Bulletin 32:6-15.

Sarell, M.J. 1993. Snake hibernacula in the South Okanagan. Unpubl. report prepared for B.C. Ministry of Environment, Lands, and Parks. Penticton, British Columbia.

Sarell, M.J. 2004. Racer. Pp 1 – 7 *in* Accounts and Measures for Managing Identified Wildlife. BC Ministry of Environment, Victoria, British Columbia. Web site: http://www.env.gov.bc.ca/wld/frpa/iwms/documents/Reptiles/r_racer.pdf [accessed July 2015]

Sarell, M.J., and W. Alcock. 2000. Beaver Creek Provincial Park: Wildlife Mitigation Project Report for the Southern Crossing Pipeline Project. Unpubl. report prepared for Westland Resource Group Inc., Victoria, and B.C. Gas Utility Ltd., Vancouver, British Columbia.

Sarell, M., and W. Alcock. 2008. Shackan rattlesnake project. Unpubl. report prepared for Urban Systems Ltd., Kamloops, British Columbia. 8 pp.

Schmutz, J.K., and J. Picotte. 1998. Observations of reptiles and amphibians, and thoughts on conservation in prairie Canada. Blue Jay 56:169-182.

Shewchuk, C.H. 1996. The natural history of reproduction and movement patterns in the gopher snake (*Pituophis melanoleucus*) in Southern British Columbia. MSc thesis, Dept. of Biology, University of Victoria, Victoria, British Columbia.

Shewchuk, C.H., and J.D. Austin. 2001. Food habits of the racer (*Coluber constrictor mormon*) in the northern part of its range. Herpetological Journal 11:151-155.

Shewchuk, C.H., and H.L. Waye 1995. Status of the Western Yellow-bellied Racer in British Columbia. Unpubl. report prepared for Ministry of Water, Land and Air Protection, Lands and Parks. Victoria, British Columbia. 16 pp.

St. John, A. 2002. Reptiles of the Northwest: British Columbia to California. Lone Pine: Renton, Washington. 272 pp.

Stebbins, R.C. 1985. A Field Guide to Western Reptiles and Amphibians. Second edition. Houghton Mifflin Company, Boston, Massachusetts. 336 pp.

University of Alberta. Undated. Faculty of Agricultural, Life & Environmental Sciences. Fungus Collection and Herbarium. Web site: http://www.uamh.devonian.ualberta.ca/Research.aspx [accessed April 2015].

USGS. 2013. Snake fungal disease in the United States. National Wildlife Health Center, Wildlife Health Bulletin 2013-02. Web site: https://www.nwhc.usgs.gov/publications/wildlife_health_bulletins/WHB_2013-02_Snake_Fungal_Disease.pdf [accessed April 2015].

Tisdale, E.W. 1947. The grasslands of the southern interior of British Columbia. Ecology 28:346-382.

Washington State Department of Fish and Wildlife. 2013. Vertebrate distributions: reptiles & amphibians. Web site: http://wdfw.wa.gov/conservation/gap/herps.html [accessed June 2013].

Wershler, C. pers. comm. 2013*. Email correspondence to report writers.* March 2013. Private Environmental Consultant, Sweetgrass Consultants Ltd., Calgary, Alberta.

Werschler, C., and C. Wallis. 2002. Mountain plover habitat and population surveys in Alberta, 2001. Alberta Sustainable Resource Development, Alberta Species at Risk Report No. 37. Edmonton, Alberta.

Wild Species. 2013. Wild Species: The General Status of Species in Canada. Last updated 2012/03/20. Web site: www.wildspecies.ca [accessed June 2013].

Williams, K.E., and C.A. Bishop. 2011. Impact assessment of Gopher Getter, a rodenticide containing strychnine, on Great Basin Gopher Snakes (*Pituophis catenifer deserticola*) in British Columbia's Okanagan Valley. Presented at 21st Annual Meeting of CARCNET. Lakehead University, Thunder Bay, Ontario.

Williams, K.E, K. Hodges, and C.A Bishop. 2015. Hibernation and oviposition sites of Great Basin Gophersnakes (*Pituophis catenifer deserticola*) near their northern range limit. J. Herpetol. 49: 207-216.

Wilson, L.D. 1978. *Coluber constrictor*. Catalogue of American Amphibians and Reptiles. Society for the Study of Amphibians and Reptiles 218:1-4.

Wilson, R.J., and J.D. Rouse. 2002. Update COSEWIC status report on the blue racer *Coluber constrictor foxii* in Canada, in COSEWIC assessment and update status report on the blue racer *Coluber constrictor foxii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 1-17 pp.

Woods, B., pers. comm. 2015. *Email correspondence to K. Ovaska.* July 2015., British Columbia. GIS Technician, Ecosystem Information Section, BC Ministry of Environment, Victoria, British Columbia.

Wright, A.H., and A.A. Wright. 1957 Handbook of Snakes of the United States and Canada. Volumes 1 and 2. Comstock Publishing Associates, Cornell University Press, Ithaca, New York.

## BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Ray Poulin is currently the Head of Research and Collections at the Royal Saskatchewan Museum and adjunct professor at the University of Regina. He has been studying species at risk in Saskatchewan since 1997. In 2007, he teamed up with Chris Somers to begin a research program focused on the ecology of snakes on the Canadian prairies.

Chris Somers is currently an Associate Professor and Canada Research Chair in Genes and the Environment at the University of Regina. His program focuses on interactions between humans and wildlife, encompassing both conservation biology and wildlife management. Much of his research combines field biology with population genetic markers and stable isotopes chemistry.

Laura Gardiner completed her Master's thesis (2012) on the ecology of Bullsnakes, Prairie Rattlesnakes and Eastern Yellow-bellied Racers in Saskatchewan. Laura was supervised by Ray Poulin and Chris Somers from the University of Regina. After completing her M.Sc., she worked for the Canadian Wildlife Service in Regina on a Multi-Species At Risk Action Plan including the Eastern Yellow-bellied Racer. She later moved to Osoyoos, British Columbia, where she conducted snake research on various snake species in the South Okanagan Valley, including the Western Yellow-bellied Racer.

Jessica Martino completed her Master's thesis (2010) on the ecology of Bullsnakes and Eastern Yellow-bellied Racers in Saskatchewan. Jessica was supervised by Ray Poulin and Chris Somers from the University of Regina. Since completing her thesis, Jessica has been working in the Wildlife Ecology and Population Genetics lab at the University of Regina, conducting research into the population structure of Eastern Yellow-bellied Racers in the Canadian Prairies. She also contributed to the 2010 Recovery Strategy for Eastern Yellow-bellied Racers compiled by the Parks Canada Agency.

## Appendix 1. Threats Assessment Worksheet for the Eastern Yellow-bellied Racer.

**THREATS ASSESSMENT WORKSHEET**

| | |
|---|---|
| **Species or Ecosystem Scientific Name** | Eastern Yellow-bellied Racer |
| **Element ID** | **Elcode** |
| **Date (Ctrl + ";" for today's date):** | 25/02/2014 |
| **Assessor(s):** | Dave Fraser (Moderator), Jim Bogart (co-chair), Ray Poulin (co-author), Chris Somers (co-author), Laura Gardiner (co-author), Jessica Martino (co-author), Kris Kendell (AB Conservation Association), Andy Didiuk (CWS), Ruben Boles (CWS), Marie-France Noel (CWS) |
| **References:** | |

**Overall Threat Impact Calculation Help:**

| | | Level 1 Threat Impact Counts | |
|---|---|---|---|
| **Threat Impact** | | **high range** | **low range** |
| A | Very High | 0 | 0 |
| B | High | 0 | 0 |
| C | Medium | 0 | 0 |
| D | Low | 4 | 4 |
| **Calculated Overall Threat Impact:** | | Medium | Medium |

| | |
|---|---|
| **Assigned Overall Threat Impact:** | **Medium** |
| **Impact Adjustment Reasons:** | |
| **Overall Threat Comments** | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 1 | Residential & commercial development | | Negligible | Negligible (<1%) | Extreme (71-100%) | High (Continuing) | |
| 1.1 | Housing & urban areas | | Negligible | Negligible (<1%) | Extreme (71-100%) | High (Continuing) | |
| 1.2 | Commercial & industrial areas | | | | | | |
| 1.3 | Tourism & recreation areas | | | | | | Not scored as a threat at present. A new campground in Grasslands National Park is possible but unlikely. |
| 2 | Agriculture & aquaculture | D | Low | Small (1-10%) | Serious - Slight (1-70%) | High (Continuing) | |
| 2.1 | Annual & perennial non-timber crops | D | Low | Small (1-10%) | Serious - Slight (1-70%) | High (Continuing) | Agricultural lands are embedded in the natural grasslands, and the proportion of range that might be subject to new agricultural uses is small. Racers seem to be avoiding going through crop fields and instead going around them with unknown consequences. In some situations, land use change might have no effect, but in other cases, it will be significant. |
| 2.2 | Wood & pulp plantations | | | | | | |
| 2.3 | Livestock farming & ranching | D | Low | Pervasive (71- | Slight (1-10%) | High (Continui | There is no concrete evidence on the effects of grazing on the Racer population, |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| | | | | 100%) | | ng) | but the impact is probably slight. |
| 2.4 | Marine & freshwater aquaculture | | | | | | |
| 3 | Energy production & mining | D | Low | Restricted - Small (1-30%) | Slight (1-10%) | High (Continuing) | |
| 3.1 | Oil & gas drilling | D | Low | Restricted - Small (1-30%) | Slight (1-10%) | High (Continuing) | Extensive oil and gas development is taking place but mostly in lands that are outside the species known range. While we can assume that Grasslands National Park will not be affected, these activities could potentially occur on other lands. The roads/corridors associated oil & gas development have been addressed in section 4. |
| 3.2 | Mining & quarrying | | Negligible | Negligible (<1%) | Extreme (71-100%) | High (Continuing) | There has been some discussion about gold mining possibilities. Writers of the status report contacted the Saskatchewan Ministry of Environment, who were unaware of any proposed mining or quarrying activities in the natural range of this species, specifically in the Frenchman and Big Muddy River valleys. |
| 3.3 | Renewable energy | | | | | | |
| 4 | Transportation & service corridors | D | Low | Pervasive (71-100%) | Slight (1-10%) | High (Continuing) | |
| 4.1 | Roads & railroads | D | Low | Pervasive (71-100%) | Slight (1-10%) | High (Continuing) | Based on road mortality data, racers are mostly found in low traffic areas; Big Muddy River area is an exception with a higher level of road mortality. We don't know the proximity of dens from the road. Oil and gas drilling will have road corridors built to accommodate them. |
| 4.2 | Utility & service lines | | Negligible | Negligible (<1%) | Unknown | High (Continuing) | Except for pipelines and service lines, scope is very minor. These could potentially benefit the species by creating additional habitat by disturbing soil. |
| 4.3 | Shipping lanes | | | | | | |
| 4.4 | Flight paths | | | | | | |
| 5 | Biological resource use | | Negligible | Negligible (<1%) | Negligible (<1%) | High (Continuing) | |
| 5.1 | Hunting & collecting terrestrial animals | | Negligible | Negligible (<1%) | Negligible (<1%) | High (Continuing) | Racers may be persecuted due to their resemblance to rattlesnakes. |
| 5.2 | Gathering terrestrial plants | | | | | | |
| 5.3 | Logging & wood harvesting | | | | | | |
| 5.4 | Fishing & harvesting aquatic resources | | | | | | |
| 6 | Human intrusions & disturbance | | | | | | |
| 6.1 | Recreational activities | | | | | | Not scored as a threat at present. While the Grasslands National Park may create additional opportunities for viewing of snake dens for educational purposes, this activity would probably be well managed. ATV use in the area is negligible. |
| 6.2 | War, civil unrest & military exercises | | | | | | |
| 6.3 | Work & other activities | | | | | | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 7 | Natural system modifications | | Negligible | Negligible (<1%) | Slight (1-10%) | High (Continuing) | |
| 7.1 | Fire & fire suppression | | Negligible | Negligible (<1%) | Slight (1-10%) | High (Continuing) | Due to a large fire in Grasslands National Park last year (in 2013), many or most of the shrubs/trees that the snakes were using in the riparian area have disappeared. We don't know what the impact on racers will be. It is a rare occurrence, and regeneration of partially burnt areas is fairly quick, so impacts are short term. Time of year will greatly influence impacts. |
| 7.2 | Dams & water management/use | | | | | | |
| 7.3 | Other ecosystem modifications | | | | | | |
| 8 | Invasive & other problematic species & genes | | | | | | |
| 8.1 | Invasive non-native/alien species | | | | | | |
| 8.2 | Problematic native species | | | | | | |
| 8.3 | Introduced genetic material | | | | | | |
| 9 | Pollution | | | | | | |
| 9.1 | Household sewage & urban waste water | | | | | | |
| 9.2 | Industrial & military effluents | | | | | | |
| 9.3 | Agricultural & forestry effluents | | | | | | |
| 9.4 | Garbage & solid waste | | | | | | |
| 9.5 | Air-borne pollutants | | | | | | |
| 9.6 | Excess energy | | | | | | |
| 10 | Geological events | D | Low | Small (1-10%) | Slight (1-10%) | High (Continuing) | |
| 10 | Volcanoes | | | | | | |
| 10 | Earthquakes/tsunamis | | | | | | |
| 10 | Avalanches/landslides | D | Low | Small (1-10%) | Slight (1-10%) | High (Continuing) | Landslides or terrain slumps can have a significant impact on racer populations, depending on the timing. Although a rare occurrence, these events probably happen more often than documented. While impacts on local populations can be severe, based on two dens that have encountered a landslide in recent years (see **Fluctuations and Trends** section), overall the impact is probably slight on the Canadian population. |
| 11 | Climate change & severe weather | | Unknown | Unknown | Unknown | | |
| 11 | Habitat shifting & alteration | | Unknown | Unknown | Unknown | High (Continuing) | If climate warms up as predicted, it might provide suitable conditions for racers to extend their range northward. However, if droughts become more frequent and prolonged, then there may be fewer riparian zones for the snakes to use for foraging and cover. Habitat alterations due to landslides/slumps have been dealt with in Section 10.3. |
| 11 | Droughts | | Unknown | Unknown | Unknown | High (Continuing) | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 11 | Temperature extremes | | Unknown | Unknown | Unknown | High (Continuing) | Colder spells in winter could threaten hibernation, but there are no supporting data. Also, reduced precipitation could result in reduced snow pack, which could be an issue for snakes. |
| 11 | Storms & flooding | | | | | | |

Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008).

## Appendix 2. Threats Assessment Worksheet for the Western Yellow-bellied Racer. The assessment was completed as part of the preparation of the provincial Recovery Strategy for the species by the BC Conservation Data Centre.

**THREATS ASSESSMENT WORKSHEET**

| | |
|---|---|
| **Species or Ecosystem Scientific Name** | Western Yellow-bellied Racer (Initially completed in 2012 by BC for their Management Plan and then updated by same people in 2013). |
| **Element ID** | **Elcode** |
| **Date (Ctrl + ";" for today's date):** | 18/02/2013 |
| **Assessor(s):** | 2012-08-01: Purnima G; Jared Hobbs; Orville Dyer; Francis Iredale; John Surgenor; updated to match final management plan 18Feb2013 |
| **References:** | |

**Overall Threat Impact Calculation Help:**

| Threat Impact | | Level 1 Threat Impact Counts: high range | low range |
|---|---|---|---|
| A | Very High | 0 | 0 |
| B | High | 0 | 0 |
| C | Medium | 1 | 1 |
| D | Low | 3 | 3 |
| | **Calculated Overall Threat Impact:** | High | High |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments* |
|---|---|---|---|---|---|---|---|
| 1 | Residential & commercial development | D | Low | Small (1-10%) | Extreme (71-100%) | High (Continuing) | A significant amount of suitable Racer habitat has been lost to urban and rural development, especially in the Okanagan Valley, where the core population is located (COSEWIC 2004). However, upon assessment of the Racer's current range in British Columbia and overlapping municipal boundaries and corresponding future development, the impact of development upon local Racer populations was considered low. Urbanization will primarily focus on densification due to rising infrastructure, presence of unsuitable steep terrain, and environmental costs associated with development (City of Kamloops 2004; City of Vernon 2008). The presence of the Agricultural Land Reserve, of which 20% of Penticton's land base is within, will also dampen urban sprawl (City of Penticton 2002). Further, under the Local Government Act municipalities are using development permit areas and establishing Environmentally Sensitive Areas (Environmental Law Centre 2007). When urban and commercial development does occur, it will be localized although extreme in severity resulting in habitat fragmentation and alienation with a loss of Racer habitat and individuals. |
| 1.1 | Housing & urban areas | D | Low | Small (1-10%) | Extreme (71-100%) | High (Continuing) | |
| 1.2 | Commercial & industrial areas | D | Low | Small (1-10%) | Extreme (71-100%) | High (Continuing) | |
| 1.3 | Tourism & recreation areas | | | | | | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments* |
|---|---|---|---|---|---|---|---|
| 2 | Agriculture & aquaculture | D | Low | Pervasive (71-100%) | Slight (1-10%) | High (Continuing) | |
| 2.1 | Annual & perennial non-timber crops | D | Low | Small (1-10%) | Extreme - Serious (31-100%) | High (Continuing) | The majority of suitable habitat for Racers is not protected from agricultural activities (COSEWIC 2004). A significant amount of suitable Racer habitat has been lost to agricultural development, particularly in the Okanagan Valley due to the increased number of recent vineyard developments (COSEWIC 2004). Ongoing vineyard development is expected to continue within private lands and First Nation reserves within the Okanagan along with small vineyard ventures being established in Lillooet (City of Penticton 2002; F. Iredale, pers. observation 2011). Intensive agriculture practices likely result in the loss of essential habitats that include egg laying and foraging sites. Further, Racers often forage in agricultural habitats and are frequently killed by farm machinery including mowers and hay balers (COSEWIC 2004). Mechanized farming activities have the potential to reduce populations by removing breeding adults. |
| 2.2 | Wood & pulp plantations | | | | | | |
| 2.3 | Livestock farming & ranching | D | Low | Pervasive (71-100%) | Slight (1-10%) | High (Continuing) | Livestock grazing has a rich history in British Columbia and is a ubiquitous land use practice within the Racer's current range. Grazing can exert a great impact on animal populations, usually due to indirect effects on habitat structure and prey availability (Szaro *et al*. 1985). Intensive livestock grazing reduces vegetation cover and can compact the soil; control of woody regrowth and grazing intensity is an important component of maintaining suitable thermal attributes of habitat for reptiles Michael *et al*. 2008). For example, high soil compaction and below target grass stubble heights were significant within the Okanagan-Shuswap Forest District during the 2004 Range Effectiveness Evaluations conducted by range agrologists (Fraser 2005). Loss of residual grass cover and habitat alteration may have direct fitness costs on Racers, trampling and reduced movements during critical foraging periods, but the effect of livestock grazing on the Racer population is currently considered slight due to lack of causational information (COSEWIC 2004; MWLAP 2004a). |
| 2.4 | Marine & freshwater aquaculture | | | | | | |
| 3 | Energy production & mining | | | | | | |
| 3.1 | Oil & gas drilling | | | | | | |
| 3.2 | Mining & quarrying | | | | | | |
| 3.3 | Renewable energy | | | | | | |
| 4 | Transportation & service corridors | C | Medium | Large (31-70%) | Moderate (11-30%) | High (Continuing) | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments* |
|---|---|---|---|---|---|---|---|
| 4.1 | Roads & railroads | C | Medium | Large (31-70%) | Moderate (11-30%) | High (Continuing) | The ongoing expansion of the road network and traffic volumes within the southern interior of British Columbia alters both the demographic and gene flow among reptile populations through direct mortality and by creating a barrier to movement and dispersal (COSEWIC 2004; Row *et al.* 2007). As ectotherms, snakes used road surfaces for thermoregulation, and are highly vulnerable targets for collision because their long bodies span across much of the road surface (Parks Canada Agency 2010). Recruitment of the Racer may be limited by road mortality, which most strongly affects dispersing juveniles and reproducing females during egg-laying migrations (Bonnet *et al*.1999). Reptile roadkill has been documented in many areas (Hobbs and Sarell 2002; Dulisse 2006a, 2006b; Davis and Wise, unpublished data, 1990–2009; Machmer, unpublished data, 2006-2011; M. Machmer, pers. comm. 2012). Amphibian and reptile road mortality data from the West Kootenay support the value assigned to severity for this threat. Amphibians and reptiles showed a five-fold increase in roadkill mortality when comparing pre-construction (2006–2009) and construction (2011) phases of major project development (while traffic rates doubled), with listed snakes including Racer being the most susceptible species (M. Machmer, pers. comm., 2012). Overall, roads and volume of traffic have increased over the last few years in the south Okanagan and this trend is expected to continue (MWLAP 2004a). Further, road traffic along the Fraser River within the Cariboo portion of the Racer's range is experiencing an increase in vehicle volume due to mining and logging; no baseline information is currently available to determine associated snake mortality (J. Steciw, pers. comm., 2012). This threat may have significant impacts on local populations and is widespread and increasing. |
| 4.2 | Utility & service lines | | | | | | |
| 4.3 | Shipping lanes | | | | | | |
| 4.4 | Flight paths | | | | | | |
| 5 | Biological resource use | | Negligible | Negligible (<1%) | Negligible (<1%) | High (Continuing) | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments* |
|---|---|---|---|---|---|---|---|
| 5.1 | Hunting & collecting terrestrial animals | | Negligible | Negligible (<1%) | Negligible (<1%) | High (Continuing) | Under the B.C. *Wildlife Act*, native snakes are protected from capture and killing without a sundry permit. However, human persecution of snakes is particularly noted towards Western Rattlesnakes (SIRART 2008b). Juvenile Racers resemble Western Rattlesnakes in colour and defensive behaviour and could theoretically be misidentified and killed (COSEWIC 2004). Persecution has the potential to reduce populations by removing juveniles and adults and is likely localized in areas of high human density. For example, at Batchelor Heights residential complex within the City of Kamloops, direct persecution of Western Rattlesnakes, Racers and Gopher Snakes was a concern so snake fencing was installed along the exterior of the complex to mitigate this threat (F. Iredale, pers. comm. 2012). Overall, the extent and severity of this localized threat are unknown but are estimated to be negligible in both scope and severity. The use of expert opinion to estimate causal certainty indicates that this threat has a negligible impact. |
| 5.2 | Gathering terrestrial plants | | | | | | |
| 5.3 | Logging & wood harvesting | | | | | | |
| 5.4 | Fishing & harvesting aquatic resources | | | | | | |
| 6 | Human intrusions & disturbance | D | Low | Large (31-70%) | Slight (1-10%) | High (Continuing) | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments* |
|---|---|---|---|---|---|---|---|
| 6.1 | Recreational activities | D | Low | Large (31-70%) | Slight (1-10%) | High (Continuing) | Intensive recreational activities, including the use of all-terrain vehicles, have the potential to cause direct mortality, damage habitat, and disturb snakes (SIRART 2008a, 2008b). A study on Pine Snake (*Pituophis melanoleucus*), an oviparous species, noted direct impact on reproduction as a result of off-road vehicles (ORV) driving over sensitive egg-laying sites (Burger *et al*. 2007). However, considering the Racer's range in British Columbia, this impact is likely dampened, but further research in regard to impacts near egg-laying sites is warranted. The southern interior is experiencing a rapid increase of public participation in regard to ORV use (F. Iredale, pers. observation 2012). ORV use generally starts in early April and runs through the spring and into late fall in the hunting season. This correlates with spring emergence and egression towards summer foraging and egg-laying sites and fall ingression towards communal hibernacula. Vulnerability and exposure of Racers to ORV may depend on individual dispersal abilities and movement patterns. Regulated ORV use within the Tunkwa-Duffy Management Project will be restricted to existing trail networks away from sensitive grasslands and wetlands. ORV use continues to exploit open grassland areas outside of designated roads and trails. However, these activities are limited near identified communal Western Rattlesnake and Gopher Snake hibernacula, which are often shared with Racers (MWLAP 2004a). The large extent and slight severity of this threat currently present a low impact to the Racer. |
| 6.2 | War, civil unrest & military exercises | | | | | | |
| 6.3 | Work & other activities | | | | | | |
| 7 | Natural system modifications | | Negligible | Negligible (<1%) | Unknown | High (Continuing) | |
| 7.1 | Fire & fire suppression | | Negligible | Negligible (<1%) | Unknown | High (Continuing) | High intensity forest fires may have detrimental effects on Racers, but these effects have never been documented (COSEWIC 2004). Fire suppression alters habitat, promotes tree encroachment into grasslands, and increases the likelihood of high-intensity fires that are thought to be detrimental to snake populations (Smith *et al.* 2001). In the 100 Mile House Forest District, open grasslands are being lost to forest encroachment, thus restricting grazing pressure on remaining grasslands leading to overgrazing, short stubble heights, and early-seral plant communities (Fraser 2005). Removal of artificially high fuel loads to reduce the intensity of fires may help reduce snake mortality (Smith *et al*. 2001). Prescribed fires reduce vegetation cover, which could increase predation rates on Racers in the short term. There were significantly more predation attempts on artificial snakes in recently burned grassland systems than in unburned grasslands (Wilgers and Horne 2007). However, given the negligible extent and unknown severity of this plausible threat, it is considered to have a negligible impact. |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments* |
|---|---|---|---|---|---|---|---|
| 7.2 | Dams & water management/use | | Negligible | Negligible (<1%) | Negligible (<1%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Dam projects such as the Waneta Dam and Brilliant Dam in the Kootenay Region may have direct impacts on habitat availability. Dam projects have impacted occupied sites of Western Skinks, a species with a similar range to the Racer in the Kootenays (Dulisse 2006c). The development of the Waneta Dam will result in the loss of suitable Racer habitat (J. Dulisse, pers. comm. 2012). Dam footprint may alienate suitable foraging, egg laying, and hibernation sites, but overall is thought to have a negligible impact on Racers at this time. |
| 7.3 | Other ecosystem modifications | | | | | | |
| 8 | Invasive & other problematic species & genes | | Unknown | Pervasive (71-100%) | Unknown | High (Continuing) | |
| 8.1 | Invasive non-native/alien species | | Unknown | Pervasive (71-100%) | Unknown | High (Continuing) | The impact of invasive species with respect to Racer populations in British Columbia is not clearly understood at this time. The introduction of non-native forbs and grasses, such as spotted knapweed (*Centaurea maculosa*), Dalmatian toadflax (*Linaria dalmatic*), and brome grass (*Bromus* spp.), has displaced native vegetation but the severity of this threat at the population level remains unclear. It can only be hypothesized that changes to vegetation at the stand scale may alter prey base, such as insects, an important component of the Racer's diet. We suspect pets, especially cats, may predate upon Racers, in particular near urban and rural centres. However, this threat may be partially mitigated due to the Racer's excellent vision, speed, large size of the adult, and blotched colouration of the young (COSEWIC 2004). The severity of this threat is unknown, but may be insignificant. |
| 8.2 | Problematic native species | | | | | | |
| 8.3 | Introduced genetic material | | | | | | |
| 9 | Pollution | | Unknown | Restricted (11-30%) | Unknown | High (Continuing) | |
| 9.1 | Household sewage & urban waste water | | | | | | |
| 9.2 | Industrial & military effluents | | | | | | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments* |
|---|---|---|---|---|---|---|---|
| 9.3 | Agricultural & forestry effluents | | Unknown | Restricted (11-30%) | Unknown | High (Continuing) | The use of strychnine within agriculture areas merits special attention and could pose a threat to the Racer population. Pesticide use in agricultural areas may reduce food availability and contaminate insect and rodents; yet, the effects on populations of ingesting pesticide via contaminated prey have never been assessed for the Racer (COSEWIC 2004). Agriculture areas primarily consist of vineyards and orchards within the Okanagan basin. The application of strychnine is commonly used to control Northern Pocket Gophers (*Thomomys talpoides*) (White 2009), thus protecting important grape vines and trees from associated damage caused by gophers as they eat young roots and tree bark. Strychnine does not bio-accumulate, and biodegrades in the environment, thus non-target exposure of strychnine to Racer snakes is accomplished through secondary exposure of ingested poisoned Northern Pocket Gophers in which strychnine was stored in the Northern Pocket Gophers intestine following consumption (White 2009). As rodents comprise a small portion of the Racer diet, this threat may be limited to larger adults capable of ingesting larger prey items. Since all snakes are secondary, tertiary, and top predators, they are susceptible to the bioaccumulation of environmental contaminants (Campbell and Campbell 2001). Uptake of toxic substances through soft-shelled reptile eggs is known to occur and impact embryo survival in other reptiles (Marco *et al*. 2004). The use of expert opinion to estimate causal certainty suggests that the impact of this threat is unknown and represents an important knowledge gap. |
| 9.4 | Garbage & solid waste | | | | | | |
| 9.5 | Air-borne pollutants | | | | | | |
| 9.6 | Excess energy | | | | | | |
| 10 | Geological events | | | | | | |
| 10 | Volcanoes | | | | | | |
| 10 | Earthquakes/tsunamis | | | | | | |
| 10 | Avalanches/landslides | | | | | | |
| 11 | Climate change & severe weather | | Unknown | Pervasive (71-100%) | Unknown | High (Continuing) | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments* |
|---|---|---|---|---|---|---|---|
| 11 | Habitat shifting & alteration | | Unknown | Pervasive (71-100%) | Unknown | High (Continuing) | It is difficult to predict with certainty the long-term forecast for climate change that encompasses the Racer's current range in British Columbia. We acknowledge endemic species that feature restricted ranges, such as the Racer, will likely be impacted; however, to what extent is currently unknown. As the Racer is an ectotherm, it is plausible that changes in solar patterns may interrupt key thermoregulatory requirements that could inhibit foraging ability (Inkley *et al*. 2004). As insects comprise the majority of their diet, long-term droughts may result in lower insect abundance and thus reduce the fitness of Racers, possibly impeding reproduction. Further, geographic ranges of species will shift northward and upward in altitude, although many species will be unable to shift their range at that rate, including prey species (Hannah *et al*. 2005). Overall, given the complex nature of this threat and lack of adequate evidence in regard to severity and impact, it is currently not possible to accurately predict the effects of long-term climate change on the Racer in British Columbia. |
| 11 | Droughts | | | | | | |
| 11 | Temperature extremes | | | | | | |
| 11 | Storms & flooding | | | | | | |
| Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008). | | | | | | | |

*Note: The comments are from the respective narrative sections in the provincial management plan (Racer Management Team Working Group 2013), where the references can also be found.