# Inventory Methods for Snakes

## Standards for Components of British Columbia's Biodiversity No. 38

Prepared by
Ministry of Environment, Lands and Parks
Resources Inventory Branch
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Resources Inventory Committee

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# Preface

This manual presents standard methods for inventory of snakes in British Columbia at three levels of inventory intensity: presence/not detected (possible), relative abundance, and absolute abundance. The manual was compiled by the Elements Working Group of the Terrestrial Ecosystems Task Force, under the auspices of the Resources Inventory Committee (RIC). The objectives of the working group are to develop inventory methods that will lead to the collection of comparable, defensible, and useful inventory and monitoring data for the species component of biodiversity.

This manual is one of the Standards for Components of British Columbia's Biodiversity (CBCB) series which present standard protocols designed specifically for group of species with similar inventory requirements. The series includes an introductory manual (Species Inventory Fundamentals No. 1) which describes the history and objectives of RIC, and outlines the general process of conducting a wildlife inventory according to RIC standards, including selection of inventory intensity, sampling design, sampling techniques, and statistical analysis. The Species Inventory Fundamentals manual provides important background information and should be thoroughly reviewed before commencing with a RIC wildlife inventory. RIC standards are also available for vertebrate taxonomy (No. 2), animal capture and handling (No. 3), and radio-telemetry (No. 5). Field personnel should be thoroughly familiar with these standards before engaging in inventories which involve either of these activities.

Standard data forms are required for all RIC wildlife inventory. Survey-specific data forms accompany most manuals while general wildlife inventory forms are available in the Species Inventory Fundamentals No. 1 [Forms] (previously referred to as the Dataform Appendix). This is important to ensure compatibility with provincial data systems, as all information must eventually be included in the Species Inventory Datasystem (SPI). For more information about SPI and data forms, visit the Species Inventory Homepage at: http://www.env.gov.bc.ca/wld/spi/ric_manuals/

It is recognized that development of standard methods is necessarily an ongoing process. The CBCB manuals are expected to evolve and improve very quickly over their initial years of use. Field testing is a vital component of this process and feedback is essential. Comments and suggestions can be forwarded to the Elements Working Group by contacting:

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The Resources Inventory Committee consists of representatives from various ministries and agencies of the Canadian and the British Columbia governments as well as from First Nations peoples. RIC objectives are to develop a common set of standards and procedures for the provincial resources inventories, as recommended by the Forest Resources Commission in its report "The Future of our Forests".

For further information about the Resources Inventory Committee and its various Task Forces, please contact:

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## Terrestrial Ecosystems Task Force

All decisions regarding protocols are the responsibility of the Resources Inventory Committee. Background information and protocols presented in this version are based on substantial contributions from Christopher H. Shewchuk and Heather L. Waye. In addition, Christopher H. Shewchuk and Patrick T. Gregory contributed to an earlier unpublished draft, *Methods for Sampling Snakes in British Columbia*. An extensive review was provided by Dan Farr with editorial assistance from Ann Eriksson. Taxonomy follows the 1998 draft of a reptile catalogue for British Columbia by Gregory and Gregory (In press).

The Standards for Components of British Columbia's Biodiversity series is currently edited by James Quayle with data form development by Leah Westereng.

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# 1. INTRODUCTION

Because of their secretive habits and cryptic colouration, snakes are often overlooked and considered to be of insignificant ecological value. However, such prejudices are likely the result of poorly informed judgement, as all snakes are predators and it is likely that many play important roles in the dynamics of energy flow through ecosystems. The contribution of snakes to the health of local biological systems should not be underestimated.

In British Columbia, six of the nine snake species have been placed on the provincial Blue-list (vulnerable or sensitive) or Red-list (endangered or threatened) due to loss of habitat and persecution. All nine species that occur in the province represent northern populations of animals that are more widely distributed at southern latitudes (in the United States). A large portion of British Columbia has severe climatic conditions, making it uninhabitable to most species of snakes. For this reason, northern populations may be unique, as they are likely genetically distinct from those in the south. They also exhibit unique ecology, presumably reflecting adaptations to northern extremes (Macartney and Gregory 1988).

Land use planning to conserve snakes in British Columbia requires reliable information about population sizes and viability, species distribution, and temporal trends. Such information is of particular necessity to snakes, as the ecology of most species is poorly known and, in most cases, even the most rudimentary natural history information is lacking. The prime objective of this manual is to recommend methods and protocols which are currently used by experienced herpetologists to sample snakes in the field. Because snakes are poorly studied and unfamiliar to most biologists, we also provide descriptions of the nine species and summarize broadly the known features of their natural history.

# 2. INVENTORY GROUP

The following is a list of the snakes found in British Columbia:

**Family Boidae**

*Charina bottae* (Blainville) [Rubber Boa]

**Family Colubridae**

*Contia tenuis* (Baird & Girard) [Sharptail Snake]

*Coluber constrictor* Linnaeus [Racer]

*C. c. mormon* Baird & Girard [Western Racer]

*Hypsiglena torquata* (Güntler) [Night Snake]

*H.t. deserticola* Tanner [Desert Night Snake]

*Pituophis catenifer* (Blaineville) [Gopher Snake]

*P.c. catenifer* (Blaineville) [Pacific Gopher Snake]

*P.c. deserticola* Stejneger [Great Basin Gopher Snake]

*Thamnophis elegans* (Baird & Girard) [Western Terrestrial Garter Snake]

*T.e. vagrans* (Baird & Girard) [Wandering Garter Snake]

*T.e. nigrescens* Johnson

*Thamnophis ordinoides* (Baird & Girard) [Northwestern Garter Snake]

*Thamnophis sirtalis* (Linnaeus) [Common Garter Snake]

*T.s. fitchi* Fox [Valley Garter Snake]

*T.s. parietalis* (Say) [Red-sided Garter Snake]

*T.s. pickeringi* (Baird & Girard) [Puget Sound Garter Snake]

**Family Viperidae**

*Crotalus viridis* (Rafinesque) [Western Rattlesnake]

*C.v. oreganus* Holbrook [Northwestern Pacific Rattlesnake]

## 2.1 Rubber Boa *Charina bottae*

**Description**

Adult TL: 355-830 mm

Body form: short and stout; blunt, prehensile tail; rounded, blunt head

Colour: dorsal: uniform brown, greyish or yellowish- or greenish-brown; ventral: yellow

Eyes: small with vertical pupil

Head scales: 9-11 upper labials; plates large and irregular; no chin shields

Body scales: small and smooth; usually 44 or fewer dorsal rows at midbody; anal plate single, with small spur in pit on either side (spur more conspicuous in males, may be absent in females); subcaudal scales single

**Range and distribution**

Occurs across southern British Columbia, as far north as Quesnel; range extends south to the San Bernadino Mountains, California, and east to western Montana, western Wyoming, and Utah.

**Life history**

Activity: adapted to burrowing; highly nocturnal; sluggish and inoffensive

Feeding: kills food by constriction: small mammals, occasionally birds and lizards; captive animals eat a wide variety of food, including fish and small snakes

Reproduction: viviparous; 2-8 young, 180-280 mm total length.

**Habitat requirements**

Appears to inhabit humid, mountainous regions; also occurs in drier lowlands and foothills with open vegetation.

**Status**

Provincial Blue List

**Selected references**

Hoyer 1974; Nussbaum and Hoyer 1974; Nussbaum *et al.* 1983; Smith and Brodie 1982; (map from Gregory and Campbell 1984)

## 2.2 Sharptail Snake *Contia tenuis*

**Description**

Adult TL: 205-455 mm

Body form: short, fairly stout; tail short, tapering, ending in sharply pointed scale; head wider than neck, with broad, rounded snout

Colour: dorsal: ground colour greyish, yellowish-brown, or reddish-brown (tending to be reddish on tail), sometimes with fine dots of black or slate and usually with a wide yellowish or reddish stripe along each side; scales below stripe dotted with black or darkened to form a continuous band in young individuals; ventral: whitish, greyish, or yellowish with conspicuous transverse dark bar on anterior edge of each plate; head: top dark brown, chin light

Eyes: small with round pupil

Head scales: 7 upper labials; 7 lower labials

Body scales: smooth; 15 dorsal rows at midbody; anal plate double; subcaudal scales divided

**Range and distribution**

In British Columbia, several scattered records have been made from Vancouver Island and the Gulf Islands, in the Coastal Douglas-fir Biogeoclimatic Zone; one additional record made from McGillivray Lake, in the Engelmann Spruce-Subalpine Fir Biogeoclimatic Zone. Elsewhere, range extends from western Washington and Oregon south to central California.

**Life history**

Activity: possibly nocturnal

Feeding: diet consists mainly of slugs

Reproduction: oviparous; 2-9 eggs per clutch; young about 75 mm long at hatching

**Habitat requirements**

Appears to inhabit woodlands and forests, especially near streams; moist environments.

**Status**

Provincial Red List

**Selected references**

Cook 1960; Nussbaum *et al.* 1983; Spalding 1993; (map from Gregory and Campbell 1984)

## 2.3 Racer *Coluber constrictor*

**Description**

Adult TL: 560-1980 mm

Body form: long and slender with long, whip-like tail; head large and distinct from neck

Colour: dorsal: uniform greyish or olive in adult; young with series of 70-85 brown cross- bands along back and smaller blotches on sides; ventral: yellow

Eyes: large with round pupil

Head scales: lower preocular wedged between upper labials; usually 8 upper labials; 9 lower labials

Body scales: smooth; 17 dorsal rows on fore- and mid-body; 15 dorsal rows on rear body; anal plate divided; subcaudal scales divided

**Range and distribution**

Occurs throughout the interior Dry Belt of British Columbia, especially in the area bounded by the Okanagan, Similkameen, Fraser, and Thompson Valleys. Range extends over most of the United States and adjacent parts of southern Canada.

**Life history**

Activity: fast and agile; aggressive; generally diurnal; climbs vegetation

Feeding: large, active predator: small mammals and insects; also frogs, lizards, snakes, birds

Reproduction: oviparous; 3-9 eggs (24-39 mm x 14-21 mm); young 205-305 mm at hatching

**Habitat requirements**

Inhabits open, sparsely treed country; may overwinter in more forested areas; den communally with rattlesnakes, gopher snakes, garter snakes.

**Status**

The subspecies, *Coluber constrictor mormon,* is on the Provincial Blue List.

**Selected references**

Brown and Parker 1976; (map from Gregory and Campbell 1984)

## 2.4 Night Snake *Hypsiglena torquata*

**Description**

Adult TL: 305-600 mm

Body form: slender; head somewhat flat and slightly triangular

Colour: dorsal: ground colour grey or yellowish-brown; numerous darker grey-brown spots; mid-dorsal row of more or less paired blotches; alternating row of smaller blotches on each side; second row of still smaller spots low on each side; three distinct dark brown blotches on back of neck, middle one widened posteriorly to cover most of nape; much variation in configuration and degree of connection of these blotches. ventral: white or yellowish. head: upper labials whitish; dark brown bar behind eye, running backward and downward; narrower bar running forward in front of eye.

Eyes: pupil vertical

Head scales: 8 or 9 upper labials; 10 lower labials

Body scales: smooth; 21 dorsal rows at mid-body; anal plate divided; subcaudal scales divided

### Range and distribution

In British Columbia, the Night Snake has been recorded 5 times in the southern Okanagan valley; also a single report from the southern Similkameen valley. Range extends through central Washington, eastern Oregon, southern Idaho, Nevada, Utah, and across the southern United States from California to central Texas; south throughout Mexico and Central America to Costa Rica.

### Life history

Activity: nocturnal

Feeding: venomous; rear-fanged (not thought to be dangerous to humans); diet probably lizards, small snakes, frogs

Reproduction: oviparous, 3-9 eggs; hatchlings 150-180 mm total length

### Habitat requirements

Inhabit dry, sandy areas with abundant rock cover.

### Status

Provincial Red List

### Selected references

Diller and Wallace 1981; (map from Gregory and Campbell 1984)

## 2.5 Gopher Snake *Pituophis catenifer*

### Description

Adult TL: 915-1800 mm (in British Columbia)

Body form: long and stout; tail moderately long; head slightly larger than neck; snout narrow and projecting beyond lower jaw

Colour: dorsal: ground colour usually pale yellow or greyish-yellow; keels on scales are dark brown; 45-55 dark brown blotches along back beginning behind head; on upper surface of tail, these become a series of 12-16 dark brown cross-bands; several series of smaller blotches or spots along body sides; ventral: yellow or yellowish-white with brown or black spots; head: dark line across head in front of eyes; dark band from eye to angle of jaw; dark vertical spot below eye

Eyes: large with round pupil

Head scales: 8 (7-10) upper labials; 12-13 lower labials

Body scales: lightly keeled on back; smooth on sides; anal plate single; subcaudal scales divided

**Range and distribution**

Occurs throughout the interior Dry Belt of British Columbia. Single records (of *P.c. catenifer*) from Galiano Island and Sumas, Washington. Range extends over most of the western and southeastern United States and parts of adjacent Canada.

**Life history**

Activity: good climber; aggressive; largely crepuscular

Feeding: large, active, constricting predator: small mammals; birds and eggs

Reproduction: oviparous; 3-24 eggs/clutch; hatchlings 204-455 mm long

**Habitat requirements**

Habitats range from forested areas to open sagebrush; usually den communally with rattlesnakes and other snake species.

**Status**

*P.c. deserticola* (Synonym: *Pituophis melanoleucus deserticola*): Provincial Blue List

*P.c. catenifer* (Synonym: *Pituophis melanoleucus catenifer*): Provincial Red List

**Selected references**

Parker and Brown 1980; Nelson and Gregory (in press); Nussbaum *et al.* 1983; (map from Gregory and Campbell 1984).

## 2.6 Western Terrestrial Garter Snake *Thamnophis elegans*

**Description**

Adult TL: 455-1065 mm

Body form: fairly long and robust; tail moderately long; head large and distinct from neck

Colour: dorsal: ground colour usually grey, black, to dark brown on Vancouver Island, and lighter brown elsewhere in B.C.; prominent yellow to orange mid-dorsal stripe along length of back, usually a wavy line but sometimes straight; yellow lateral lines running length of body (on 2nd and 3rd rows of body scales) less evident than mid-dorsal stripe; two rows of dark brown or black blotches between stripes on each side of body (upper row invades mid-dorsal stripe giving stripe a wavy appearance); blotches particularly obvious in Interior specimens but may not show clearly in coast specimens; series of small dark brown or black spots below lateral stripe (or even invading lateral stripe); rarely, specimens have tinge of red on sides of body; some coast specimens may have a generally bluish appearance with otherwise normal pattern. ventral: usually greyish, sometimes with black markings. head: top black or brownish with black markings in coast specimens, brown in Interior specimens; upper lip white or yellow; chin and throat whitish.

Eyes: moderately large with round pupil

Head scales: usually one preocular on coast, two east of Coast Range; 8 (7-8) upper labials; 10 (9-10) lower labials; posterior upper labials very large relative to other garter snakes

Body scales: strongly keeled; 21 dorsal rows at mid-body; anal plate single; subcaudal scales divided

**Range and distribution**

Occurs throughout the southern part of British Columbia, from Vancouver Island and the adjacent coast to the Alberta border, and as far north as the Peace River district. Range extends east through Alberta and southwestern Saskatchewan, south to central New Mexico and west to central California.

**Life history**

Activity: diurnal; aquatic; very active and aggressive

Feeding: diet highly varied: mainly slugs, small mammals, fish; also amphibians, earthworms, leeches, birds, other snakes; occasionally uses constriction to hold prey

Reproduction: viviparous; 4-19 young, 171-230 mm total length; mating takes place in spring

**Habitat requirements**

Usually found near water, including marine environments; may occupy terrestrial situations (open meadows and estuaries) where small mammals are abundant.

**Status**

Provincial Yellow List

**Selected references**

Gregory 1978, 1984; Gregory and McIntosh 1980; (map from Gregory and Campbell 1984)

## 2.7 Northwestern Garter Snake *Thamnophis ordinoides*

### Description

Adult TL: 320-850 mm

Body form: long and fairly stout; tail moderately long; head small, fairly blunt in snout, not very distinct from neck

Colour: dorsal: extremely variable; typically: ground colour brown; yellow stripe and yellow lateral stripe (on 2nd and 3rd rows of body scales) on each side, running length of body; two rows of small black blotches between stripes; some specimens with dorsal and/or lateral stripes incomplete or lacking; many specimens with considerable red: sides of body may be reddish, dorsal stripe may be red; dark or completely black specimens fairly common; some specimens completely black with bright red dorsal stripe and/or belly; albino specimens are known. ventral: variable; yellowish, olive, brown, bluish, slatey, or black; commonly blotched with red and sometimes with black. head: variable; typically: top brown, upper lip white; chin white.

Eyes: small with round pupil

Head scales: 1-2 preoculars; usually 7 upper labials; 8-9 lower labials

Body scales: strongly keeled; 17 dorsal rows at mid-body; anal plate single; subcaudal scales divided

Note: markings are extremely variable; this species must be identified by scale count.

### Range and distribution

Occurs along the coast of southwestern British Columbia, including the Gulf Islands and all of Vancouver Island, and inland to Manning Park. Elsewhere, ranges through western Washington and Oregon south to extreme northwestern California.

### Life history

Activity: diurnal; highly terrestrial; not aggressive

Feeding: diet includes slugs and earthworms

Reproduction: viviparous; 2-19 young, 145-200 mm total length; mating in fall and spring

### Habitat requirements

Inhabits meadows or ecotones between meadows and woods; sparse forests; found along estuaries and on beaches on the coast.

### Status

Provincial Yellow List

**Selected references**

Gregory 1978; Gregory and McIntosh 1980; (map from Gregory and Campbell 1984)

## 2.8 Common Garter Snake *Thamnophis sirtalis*

**Description**

Adult TL: 460-1300 mm

Body form: long and slender; tail moderately long; head large and distinct from neck

Colour: dorsal: ground colour usually black or dark brown; skin between dorsolateral scales usually red producing series of red vertical bars or blotches on sides of body (red sometimes absent on Vancouver Island specimens); three yellow or greenish-yellow stripes running length of body; mid-dorsal stripe includes middle row of scales and half of row on each side, lateral stripes occupy second scale rows and lower half of the third scale rows. ventral: yellow to black. head: top usually uniform black, brown, or olive-green; upper lip yellow; posterior part of head often marked by considerable red, laterally (less so on Vancouver Island specimens); often red or dark blotch on posterior upper labials; chin and throat usually pale yellow.

Eyes: large with round pupil

Head scales: one preocular; usually 7 upper labials, 10 lower labials

Body scales: strongly keeled; 19 dorsal rows at mid-body; anal plate single; subcaudal scales divided

**Range and distribution**

In British Columbia, *T.s. pickeringi* is restricted to Vancouver Island and the immediately adjacent mainland coast, *T.s. fitchi* occurs across the province south from 300 km north of Prince Rupert, and *T.s. parietalis* occurs along the eastern side of the province, south from the Peace River district. Elsewhere, the Common Garter Snake is transcontinental from Fort Smith, Northwest Territories to the Gulf of Mexico, but is absent from the southwestern United States.

**Life history**

Activity: diurnal

Feeding: diet includes mainly amphibians and earthworms; also intertidal and freshwater fishes, leeches, small birds

Reproduction: viviparous; 2-85 young, about 200 mm total length; usually mates in spring near hibernacula

### Habitat requirements

Inhabits a wide variety of habitats; most abundant near marshes, small lakes, rivers and ponds, fairly humid forests; often overwinters communally in large numbers, especially in northern parts of the range.

### Status

Provincial Yellow List

### Selected references

Gregory 1978; Gregory and McIntosh 1980; (map from Gregory and Campbell 1984)

## 2.9 Western Rattlesnake *Crotalus viridis*

### Description

Adult TL: 600-1575 mm

Body form: long and stout; tail short, ending in a horny rattle or button; head broad (especially at back), triangular, distinct from neck

Colour: dorsal: ground colour brown, tan, olive, or grey, may be somewhat lighter towards tail; series of large dark brown blotches along back; these blotches typically have light-coloured edges and appear as cross-bands on the posterior part of the body and tail; series of smaller blotches on each side of body below large blotches; juveniles usually lighter in colour, with greater contrast of blotches with background. ventral: yellowish-white, sometimes brownish. head: top usually shows ground colour with dark band running from below eye to corner of jaw.

Eyes: moderate in size with vertical pupil; deep pit between eye and snout

Head scales: two preoculars; small on top of head; 15 (10-19) upper labials; 16 (11-20) lower labials

Body scales: strongly keeled (lower 1-3 may be smooth); 23-29 dorsal rows; anal plate single; subcaudal scales single

### Range and distribution

Restricted to the interior Dry Belt in British Columbia, east to the Cascade Mountains, west to Lytton, and north to Kamloops and Cache Creek; a few specimens recorded as far west as Lillooet. Elsewhere, range extends over most of the western half of North America with few gaps.

### Life history

Activity: mainly crepuscular, but active at any time of day or night if conditions suitable; active in B.C. between early April and early October

Feeding: venomous; diet mainly small mammals, birds

Reproduction: viviparous; 2-8 young (fully venomous), 240-270 mm TL; mate in late summer and early fall

**Habitat requirements**

Inhabit grassland and grassland-forest ecotone; den communally in talus slopes and rock outcrops

**Status**

Provincial Blue List

**Selected references**

Macartney 1985; Macartney and Gregory 1988; (map from Gregory and Campbell 1984)

## 2.10 Species Identification

Proper species identification is obviously very important. Most British Columbia species are readily identifiable from the key provided here (and in Gregory and Campbell 1984). Note that the identification of species solely on the basis of colour should definitely be avoided as colour can be quite variable between, and even within, populations. Records from localities in which the species has not previously been recorded should be verified by someone qualified to make a proper identification (e.g. at the Royal British Columbia Museum or the University of Victoria).

**Key to the Snakes of British Columbia (modified from Gregory and Campbell 1984)**

1a. Body scales all keeled.................................................................................................2

1b. Some or all body scales smooth...............................................................................5

2a. Pit or cavity between nostril and eye; button or rattle on end of tail
.....................................................................Western Rattlesnake (*Crotalus viridis*)

2b. No pit or rattle...............................................................................................3

3a.17 rows of body scales at mid-body
..............................................Northwestern Garter Snake (*Thamnophis ordinoides*)

3b. More than 17 rows of body scales at mid body.......................................................4

4a.19 rows of body scales at mid-body
..........................................................Common Garter Snake (*Thamnophis sirtalis*)

4b.21 rows of body scales at mid-body
.........................................Western Terrestrial Garter Snake (*Thamnophis elegans*)

5a. Scales on back slightly keeled, all other body scales smooth; 4 prefrontal scales; a series of dark brown blotches down back; dark line across head in front of eyes plus a dark band from eye to angle of jaw
.........................................................................Gopher Snake (*Pituophis catenifer*)

5b. All body scales smooth.....................................................................................6

6a. Head and tip of tail blunt; 44-45 rows of scales at mid-body:; no enlarged chin shields
...........................................................................Rubber Boa (*Charina bottae*)

6b. Fewer than 44 rows of body scales at mid-body......................................................7

7a.21 rows of body scales at mid-body; yellow- brown background with numerous brown blotches, the mid-dorsal row often occurring in pairs; 3 dark brown blotches on back of the neck, pupil of the eye vertically elliptical
............................................................................Night Snake (*Hypsiglena torquata*)

7b. Fewer than 21 rows of body scales at mid-body......................................................8

8a. 15 rows of body scales at mid-body; tail blunt with sharp, pointed scale at tip; usually a yellowish or reddish stripe along each side
...................................................................................Sharptail Snake (*Contia tenuis*)

8b.15-17 rows of body scales at mid-body; head large with large eyes, tail long and whip-like; dorsal colour grey-blue to olive, although small specimens may have a series of large brown blotches down the back
.......................................................................................Racer (*Coluber constrictor*)

# 3. PROTOCOLS

Snakes are often cryptic in colour and behaviour and therefore difficult to find when searching on foot. This fact alone is likely the greatest problem to overcome when setting up a program to sample snake populations. Snakes are also patchy in their distributions, both spatially and temporally. They are often abundant only in certain localities during a particular season, making searching efforts labour-intensive.

Sometimes natural concentrations of snakes are encountered in the field (e.g. communal hibernacula) and these often provide access to large numbers of animals in a short period of time. These natural concentrations of snakes are logistically simple to sample, but have potentially large biases associated with them in terms of age or sex. Samples at dens may misrepresent certain segments of the population (e.g. gravid females may be easiest to find and catch).

The ability to consistently find snakes in the field is a skill that is developed through experience. Experienced researchers know both where to look (habitats, microhabitats) and when to look (season, time of day, weather conditions). Understanding the basic ecology of snakes is important in selecting potential sampling sites. The experienced herpetologist, with a search pattern based on past success and an understanding of the general ecology of the animals, becomes competent at spotting likely locations and conditions for finding snakes.

The most important habitat feature required by snakes is cover or shelter. However, shelter requirements must be fulfilled not only structurally but also in a thermal sense (Huey *et al.* 1989). Snakes, being ectotherms, must select microhabitats that meet their physiological or thermoregulatory requirements, which may vary among species, between sexes, and also diurnally and seasonally. This is a key consideration when searching for snakes. Early in the active season, when temperatures are low (March, April, May), or on cool mornings throughout the active season, snakes of many species bask in an effort to increase their body temperatures. During this time snakes are often in the open and are relatively easy to find. As the active season progresses, nighttime temperatures will gradually increase and this behaviour may be less frequent. The high daytime temperatures and associated intense solar radiation of mid-summer may also influence the activity patterns of snakes (Peterson *et al.* 1993). Air temperatures of 25-30 °C are optimal for activity of most species (Peterson *et al.* 1993); however, with intense sunshine, the ground temperature will likely exceed this, restricting the movement of snakes by forcing them to seek thermally buffered shelters (e.g. under rocks, in tall grass). Thus, snakes may be most active on warm, cloudy days, and consequently these are the ideal summer conditions under which to search for them. Searching success can also be improved by monitoring other weather conditions. Snakes often show increased activity on the first day following several days of inclement weather, especially rain.

Annual timing of searches will vary among species with different diurnal and seasonal activity patterns, once again illustrating the importance of knowledge of the ecology of the animals. Sampling should take place at times when snakes are most active, such as during the spring and fall migrations associated with denning in some populations (e.g. Gregory 1974; Parker and Brown 1980). Similarly, the mating season is also a period of peak activity for mature animals (see species descriptions for mating periods).

Certain land forms tend to concentrate snakes or serve as movement corridors. These will generally be linear landscape features such as ditches, gullies, hedge rows, fence lines or other potential avenues of movement. Collecting along natural barriers such as the base of bluffs or even along the sides of a building may also be productive. Snakes often travel along these barriers for long distances until they can go around them.

Alertness to less secretive species may also lead to the discovery of a snake. Prey species in particular will provide obvious clues to a snake's presence. For example, rodents will issue warning calls as a snake approaches and birds may elicit mobbing behaviours (Fitch 1949). Animals which have been captured and are being consumed by a snake may also be particularly conspicuous in their cries of distress (Fitch 1987).

Several other methods of finding snakes are documented in the literature. Dogs have been trained to detect, trail and point to snakes (Klauber 1956), and foraging domestic turkeys can be effective at finding snakes (Smith 1946). Presence of a particular species at a site may also be indicated by shed skins, but as these are fragile and degrade quickly, their absence is not indicative of an absence of snakes.

This manual recommends a number of methods for the sampling of snakes in B.C. at three levels of inventory intensity (Table 1). Because no one method is uniformly appropriate to sample the full range of snake species in all habitat types, it is recommended that several sampling methods be used in combination.

Survey limitations must be strongly considered when trying to estimate abundance. It is impractical to obtain a valid estimate of snake abundance without repeated, intensive sampling. Although mark-recapture techniques are recommended, these are still subject to population estimates which are biased toward the catchable portion of the population. Relative measures of abundance are similarly biased. Therefore, without the use of formal, long-term and extremely labour-intensive censusing methods, presence/not detected surveys will probably provide the most valid and useful information (although it is important to stress that the inability to detect a snake does not prove absence).

**Table 1. Recommended methods for inventory of snakes in British Columbia at three levels of intensity.**

| Species | Presence/Not Detected | Relative Abundance | Absolute Abundance |
|---|---|---|---|
| **Rubber Boa** | • Hand Collecting<br>• Road Survey | • TCS[1]<br>• Trapping<br>• Quadrats<br>• Transects | • Mark-Recapture |
| **Sharptail Snake** | • Hand Collecting | • | • |
| **Racer** | • Hand Collecting | • TCS<br>• Trapping<br>• Quadrats<br>• Transects | • Mark-Recapture |
| **Gopher Snake** | • Hand Collecting<br>• Road Survey | • TCS<br>• Trapping<br>• Quadrats<br>• Transects | • Mark-Recapture |
| **Common Garter Snake** | • Hand Collecting | • TCS<br>• Trapping<br>• Quadrats<br>• Transects | • Mark-Recapture |
| **Northwestern Garter Snake** | • Hand Collecting | • TCS<br>• Trapping<br>• Quadrats<br>• Transects | • Mark-Recapture |
| **Western Terrestrial Garter Snake** | • Hand Collecting | • TCS<br>• Trapping<br>• Quadrats<br>• Transects | • Mark-Recapture |
| **Night Snake** | • Hand Collecting<br>• Trapping | • * | • * |
| **Western Rattlesnake** | • Hand Collecting<br>• Road Survey | • TCS<br>• Trapping<br>• Quadrats<br>• Transects | • Mark-Recapture |

* so few of these species have been found that abundance measures may not be possible

[1] TCS = Time-constrained Search

## 3.1 Sampling Standards

### 3.1.1 Permits

All native snake species in British Columbia are under the protection of the Wildlife Act (1982) and cannot be collected or disturbed without a permit from the Wildlife Branch, Ministry of Environment, Lands and Parks.

### 3.1.2 Handling snakes

**Capture and handling of herptiles is also discussed in the manual, *Live Animal Capture and Handling Guidelines for Wild Mammals, Birds, Amphibians, and Reptiles,* No. 3 *(1997).* This manual is required reading for anyone who will be capturing or handling live snakes.**

The handling of snakes must be kept to a minimum as some investigators have demonstrated a negative impact on snake populations resulting from their study. If snakes do not need to be handled to meet inventory objectives then they should be left alone. Where it is necessary, non-venomous species are best captured by hand, although a snake hook may be used for the larger animals (i.e., *Pituophis*). When capturing snakes, avoid harmful practices such as pinning the animal down with a snake hook or any other device. Snake tongs should not be used for the capture of non-venomous species nor are they generally recommended for the capture of venomous species. Both tongs and nooses can easily injure snakes if used improperly.

Each snake has a unique and somewhat species-specific responses to encounters with people. Racers will typically flee whereas Gopher snakes will present a threatening display; these behaviours make predicting a snake's movement easier and thus increase capture success. Once a snake is captured it should be restrained as little as possible. Some species are quite passive and easy to handle whereas others will thrash and bite. For snakes that need restraint, it is best to hold the snake behind the head with one hand while supporting the body with the other. Often it is best to put frantic or aggressive animals directly into a cloth bag until they calm. Snake bags are very useful when dealing with large aggressive animals and for transporting snakes in the field. They are typically fashioned much the same as pillow cases, however, using an actual pillow case is not recommended as they tend to have inadequate reinforcement and stitching in the corners. Once a snake is placed in the bag, the top must be tied securely. Caution must be taken to make sure the snake's body does not become tied in the knot. The bag in best tied by first twisting the open end and then tying a tight over-hand knot in the twisted material. Snakes are often quite calm once in a bag and can be left for several hours; however, snakes should not be left unattended as they will free themselves from apparently inescapable places. If snakes are to be removed from a site, they will need to be double bagged, or, ideally, placed in bags and then into secure containers.

**Venomous snakes**

A snake hook should be used to capture and handle rattlesnakes, but it should not be used to pin the snake down as this will likely hurt the animal. In rocky areas, it may be necessary to use tongs to get hold of snakes, but extreme caution must be exercised to avoid injury to the animal. Once a rattlesnake is captured, it should quickly be transferred to a heavy canvas bag. It then may be measured and marked by inducing it to crawl into a clear cast acrylic tube. Generally, placing the tube over the head of the snake will cause it to crawl up the tube. The snake can then be immobilized by grasping the posterior half of its body and the tube in one hand. The tube should be of a diameter that prevents the snake from turning around once inside (Murphy 1971). The safest way to measure the mass of a rattlesnake is to weigh it inside the canvas bag and simply subtract the weight of the bag.

### 3.1.3 Measurements

**Length**

The snout-vent length (SVL) of each snake captured should be measured by gently stretching the animal along a meter stick. This is most easily accomplished by grasping the animal at the base of the head with one hand and by grasping the tail of the animal just behind the cloaca with the other hand. The measurement must be taken when the snake relaxes. Care must be taken to avoid injury to the snake from pulling too hard. The distance measured is from the tip of the snout to the posterior edge of the anal plate. Measurements should be recorded to the nearest 5 mm. Consistent measurements of snakes are important but become more difficult to attain when measuring the larger species (e.g. *Pituophis*). Practice measuring snakes is necessary and repeated measurements should be conducted on a series of specimens to assess precision.

The total length of the animals may also be recorded (i.e. from the snout to the tip of the tail); however, this is not as useful of a measure as SVL because many snakes are missing the tips of their tails. Snout-vent length is therefore the standard length measurement and most widely accepted.

**Mass**

The mass of snakes can be recorded using an appropriately sized portable scale (e.g. Pesola spring scale). The mass should be recorded to the nearest gram if possible.

**Sex**

The sex of snakes can be determined using several methods. In most species the base of the tail is noticeably broader in males. This is due to the presence of the retracted hemipenes in this portion of the tail. However, in some individuals this is not readily apparent. These animals should be sexed using a blunt probe of appropriate size (Schaefer 1934). This procedure should be performed only by persons that have some experience with this technique. The probe is inserted caudally, at the lateral margins, into the cloacal opening of the animal. In a male snake, the hemipenal pockets will allow the probe to move caudally for some distance; in a female snake, the probe will not be able to move far. Great care must be taken when using this method as the tissues in this region are easily punctured. Another method used to sex snakes is that of hemipenal eversion. By applying pressure to the base of the tail it is often possible to evert the hemipenes of male snakes. This method is preferred for sexing small snakes and neonates (Gregory 1983) as large males are difficult to evert and excess pressure may cause injury.

The reproductive condition of female snakes should be determined using palpation. By palpating the abdomen of the snake ovarian follicles and uterine eggs can be felt and often counted, although caution must be exercised to avoid injuring the embryos.

### 3.1.4 Marking

Ferner (1979) reviews marking techniques for snakes. Where it is required for long term studies, the recommended method is clipping of ventral or subcaudal scales in a unique pattern for each individual (Blanchard and Finster 1933). Clipping of subcaudal scales is preferable, as there is less risk of injury to the snake from penetration into the abdominal cavity. The entire scale, through the dermis (the underlying muscle should be exposed), should be excised with a small pair of scissors. Similar marks may also be obtained by branding snakes (using a soldering iron) on their subcaudal scales.

Scale #1 is designated as the first scale behind the cloaca to contact its counterpart on the opposite side; this first scale is never clipped. Some combination of scales 2-20 on the (snake's) left and/or right side are clipped, and the pattern recorded. One recording method uses the following descriptor: "(# of clipped scale on left)L (# of clipped scale on right)R". An example clipping pattern is therefore 2L2R; in this case, the second scale has been clipped on both the left and right side. When all possible combinations of one and two clipped scales have been exhausted, the series may be expanded to include three or more clips.

There are some considerations to make when marking by clipping scales is applied. Counting scales to read marks is time consuming, increasingly so as more posterior scales are clipped. Similarly, the probability of making an error in counting also increases with higher counts. Limiting clips to the anterior subcaudals (2-10) should provide a sufficient number of marks for most purposes. Some species, such as racers and garter snakes, frequently lose the tips of their tails; for these snakes, scales should not be clipped past #15. Clipped scales may slowly regenerate, and marks may become hard to read over time; in long-term studies it may become necessary to reclip scales as snakes are recaptured. Finally, it is important to consider that this system is used in several B.C. locations, so consultation between researchers is necessary to avoid confusion through duplicate marks, and researchers working together on the same population must agree on the same marking conventions (e.g. which scale is considered #1).

An alternative, but more expensive method, for marking snakes in long term studies, is the use of passive integrated transponder (PIT) tags. These small (10.0 X 2.1 mm; 0.05 g) tags are injected into the abdominal cavity of the animal with a large-bore modified hypodermic syringe. PIT tags are glass-encased electromagnetic coils and microchips, each encoded with a unique alphanumeric code that is read by generating a low-frequency electromagnetic signal with an external reader. The expected longevity of the tags is 15-20 years. The primary advantage of PIT tags is that they cannot be misread (they fail rarely); the primary disadvantage is price (reader: US$950; tags: US$4.75-6.00 each) (Germano and Williams 1993).

Many studies will be short term and will not require “permanent” marks. An alternative method, used for rattlesnakes, is to mark the basal (most anterior) segment of the rattle with paint or some form of tag (Fitch 1987). Paint may also be used on other species, but these marks are temporary as the paint is shed with the skin. Permanent marks (such as scale clipping and PIT tags) should be used only for studies in which a snake population will be visited over more than one season. This will minimize the impact on animals and avoid confusion among studies.

### 3.1.5 Habitat Data Standards

A minimum amount of habitat data must be collected for each survey type. The type and amount of data collected will depend on the scale of the survey, the nature of the focal species, and the objectives of the inventory. As most, provincially-funded wildlife inventory projects deal with terrestrially-based wildlife, the terrestrial Ecosystem Field Form developed jointly by MOF and MELP (1995) will be used. However, under certain circumstances, this may be inappropriate and other RIC-approved standards for ecosystem description may be used. For a generic but useful description of approaches to habitat data collection in association with wildlife inventory, consult the introductory manual, *Species Inventory Fundamentals* (*No.1).*

### 3.1.6 Finding Snakes

**Den Sites**

The most productive locations for finding large numbers of snakes are den sites. In temperate climates, snakes must hibernate during the winter months (Gregory 1982; Macartney *et al.* 1989). These hibernating sites are often referred to as dens. It is thought that the locations of suitable denning sites is limited in some areas and that snakes consistently aggregate at the few available sites. Both in the spring and fall, large aggregations of snakes may be found near dens, which may also serve as important basking sites for some species. These aggregations of snakes may be made up of several species (e.g. *Coluber constrictor, Pituophis catenifer, Thamnophis sirtalis*, and *Crotalus viridis* in Okanagan valley den sites).

"Chance encounter " is likely the most common way to find den sites. One can greatly increase the chance of encounter by keeping in mind the general characteristics of den sites. Dens are commonly found on south facing rock outcrops. These may be in the form of talus slopes, solid rock faces that contain deep anastomosing fissures or even human-made structures such as road embankments constructed from piled cobbles. Den sites are often overlain by a top layer of soil, but the underlying rock fissures provide access for snakes to depths below the frost line.

Surveyors should be aware that there are detrimental impacts associated with using den sites as sampling areas. It has been suggested that repeat visits to dens by researchers alter the behaviour of snakes in the vicinity of the den (W.S. Brown, pers. comm.). If true, this will undoubtedly affect subsequent samples but, more importantly, repeated visits may disturb the snakes' natural activity patterns and possibly cause a reduction in snake numbers. Repeated visits to denning sites may also damage the site itself through compression of the substrate and shifting of rocks due to human traffic. When visiting den sites natural cover objects should not be disturbed and the researcher should step carefully on solid ground that will not shift underfoot. It is also important to be quiet and may be advantageous to view the den location from a distance. Because of the potential risks to the focal species, repeated sampling at den sites is strongly discouraged.

Several other problems are associated with sampling at dens. Perhaps most fundamental of these is a lack of knowledge as to whether all species of snakes have the same denning requirements or whether only certain species den in aggregations. Also, different groups within a population may utilize different denning habitats. For example, young garter snakes are frequently absent from den samples that contain adults (Gregory 1982, 1984). Known locations of den sites are limited in the province. When den sites are encountered they should be recorded and the details of the location sent to the Conservation Data Centre.

**Nest Sites**

Another location at which to encounter potentially large numbers of snakes is at a nesting site. Several oviparous species are known to be communal nesters and often migrate from their summer range to nesting sites (Parker and Brown 1980). The nesting site not only provides an opportunity to capture gravid female snakes, but also to capture hatchling snakes, a component of the population that is often not adequately sampled once it disperses from the nesting site. Although gravid viviparous species do not have nest sites, they do have behaviours that make them more susceptible to capture. For example, they often bask in specific locations (Macartney 1985). Gravid rattlesnakes do not disperse far from the winter den, but move to basking sites (maternity sites) near the den where they will spend the summer until parturition (Macartney 1985). Known locations of nest sites are limited in the province. When nest sites are encountered they should be recorded and the details of the location sent to the Conservation Data Centre.

**Radiotelemetry**

If a researcher cannot find a snake den or nesting site by searching, a snake may be used to lead the researcher to the den/nest site. Snakes caught in the field can be equipped with miniature transmitters and followed to critical habitats. Anyone undertaking radiotelemetry work should be familiar with the manual, *Wildlife Radio-telemetry, No. 5* (In prep. for RIC committee).

Radio transmitters are small (2-20 g or larger) devices that broadcast a radio signal on a unique frequency (some transmitters also have components that encode the temperature of the transmitter into the signal). Some workers have force-fed transmitters to animals; these transmitters are often regurgitated or passed through the gut and have been found to modify the behaviour of the animals (Lutterschmidt and Reinert 1990). For this reason, force-feeding is discouraged in favour of surgical implantation. Transmitters are implanted subcutaneously or into the abdominal cavity (Reinert and Cundal 1982). Reinert (1992) provides a useful review of radiotelemetry methods.

Radiotelemetric studies are currently appropriate only for larger snakes; the implanted transmitter should be no more than 5% of the body weight of the animal (e.g. 2 g transmitter in a 40 g snake). Implanted transmitters may affect the behaviour of the animal, including feeding rate, preferred body temperature, activity level, and locomotion (Fitch 1987). The surgery itself may have a significant effect on the health and condition of the animal, and all subjects should be retained for several days to allow the animal to begin to heal. Other drawbacks of radiotelemetric methods include expense (receiver: $1000-1200; transmitters: $150-300) and potential technical problems (bad batteries, penetration of coelomic fluid into transmitters, poor electrical connections, and short reception/transmission distance, especially with small transmitters and snakes that hide underground) (Peterson *et al.* 1993). Thus, radio-telemetry studies should be well planned, thoroughly reviewed, and only commence after careful consideration of other options.

### 3.1.7 Voucher specimens

Voucher specimens serve to document the identity of organisms encountered or used in any study. They are the only method for validating the presence of a species in a study and for making historical comparisons. Voucher specimens can improve the credibility of an inventory or monitoring project and should be collected when appropriate. If the animal can not be collected because it is rare, endangered, or protected by law, for example, then a series of good photographs should be taken. When an animal is sacrificed, the voucher specimen must be preserved properly, documented with the appropriate field data and deposited in a museum or other institution where they are readily accessible. Detailed protocols for collecting voucher specimens of snakes can be found in the manual, *Voucher specimen collection, preparation, identification and storage,* No. 4 (In prep. for Resources Inventory Committee).

If snakes are to be killed, it must be done humanely (see also *Live Animal Capture and Handling Guidelines for Wild Mammals, Birds, Amphibians, and Reptiles,* No. 3). The preferred method is lethal injection with Nembutal (pantobarbital) (Pisani 1973). A 1.0 ml injection of commercial Nembutal (1 g/ml) in the heart of a large reptile should be sufficient to produce rapid death. Use a 1:10 dilution for smaller specimens. Nembutal is a restricted drug and is not used much except by professional collectors. Placing specimens in a freezer is an alternative method, but may cause distortion of cells and tissues.

The preservation of snakes is conducted in two steps. The animals are first preserved in a fixative and later transferred to alcohol for storage. Fixation of snakes is done with a 10% formalin solution. To make this, the commonly available stock solution (37-40% formaldehyde, which is synonymous with 100% formalin) is diluted one part full strength stock solution to nine parts water, resulting in a 10% formalin solution. Care should be taken to avoid inhalation of formalin fumes. The specimen should be injected with a hypodermic syringe every 10 cm along the body so that the entire body cavity is filled with fixative. The tail portion of the animal should also be injected in several locations. Male snakes should be injected at the caudal end of the hemipenal pockets, making the hemipenes evert. If a hypodermic needle is not available then the specimen should have several incisions made in the ventral body wall so that the formalin can readily penetrate the tissue. A waterproof label with the proper collecting information should be tied around the neck of the animal with a square knot. The specimen should be coiled (and possibly tied with string) in a position that facilitates storage. The fixation process will make the specimen rigid, so positioning must be considered carefully. After injection, the specimen should be soaked in a 10% formalin solution for at least a week, but a period of several months is better. Later the specimen can be transferred to a 70 % ethyl alcohol solution for permanent storage, but should first be soaked in water for 24 hours to prevent dehydration (Pisani 1973).

### 3.1.8 Sample Design Hierarchy

Snake surveys follow a sample design hierarchy which is structured similarly to all RIC standards for species inventory. Figure 3 clarifies certain terminology used within this manual (also found in the glossary), and illustrates the appropriate conceptual framework for a presence/not detected survey for snakes. A survey set up following this design will lend itself well to standard methods and RIC data forms.

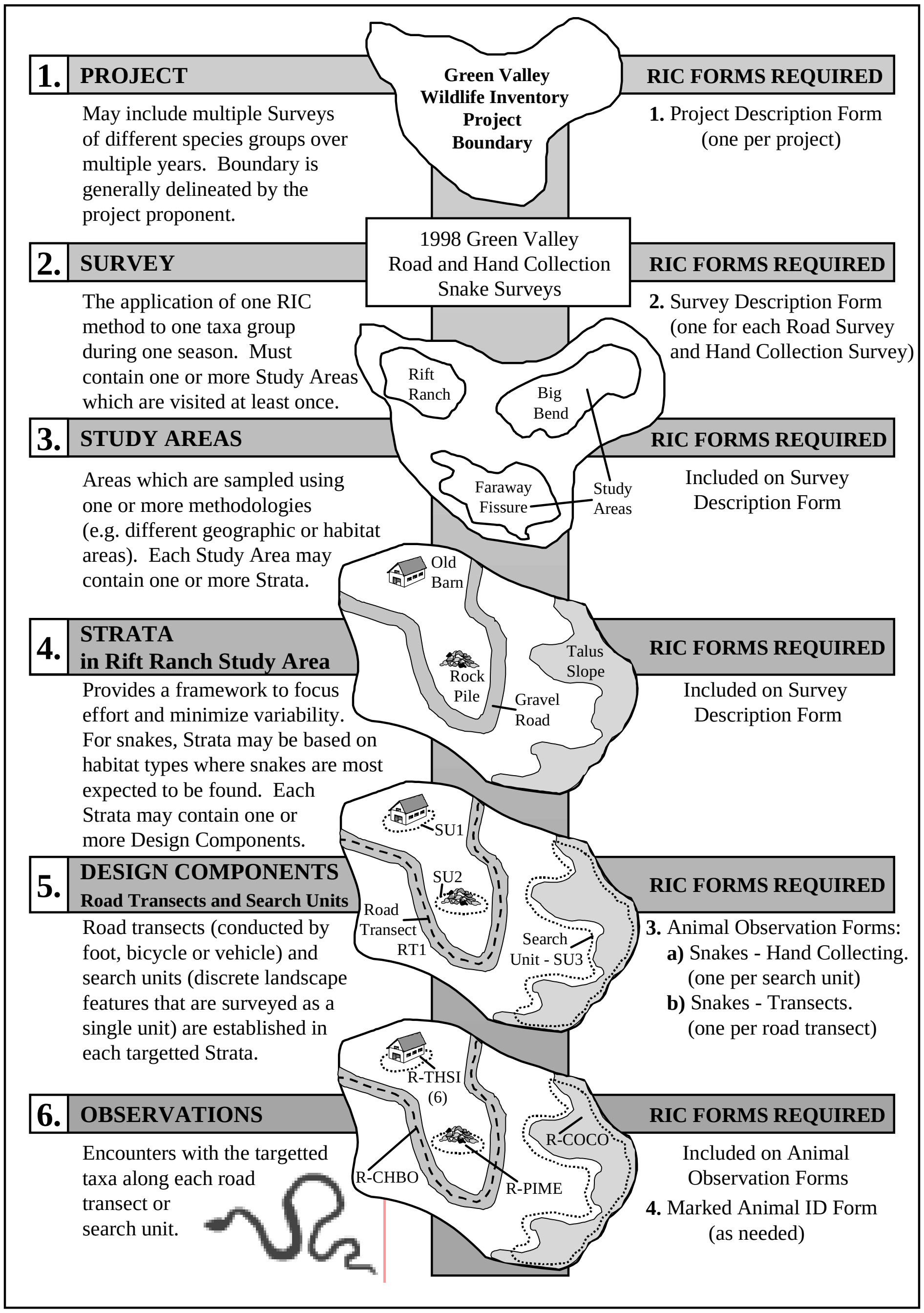


**Figure 1. Survey design hierarchy for snake surveys. Example shows study areas and search units within them.**

### 3.1.9 Standard Protocol for all Survey Types

**Office Procedures**

- Review the introductory manual, *Species Inventory Fundamentals* (*No.1)* for information on sampling design, habitat description, and reporting.
- Determine the Project Area.
- Obtain relevant maps for the Project Area (e.g. 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps). 1:5000 colour air photos are best to evaluate habitat type.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units within the Project Area. Use this information to delineate potential Study Areas from maps.
- Based on the maps and other knowledge (other reports, local resource specialists), stratify each Study Area based on expected occurrence of snakes.
- Note on air photos likely locations to find snakes (e.g. old buildings, rock outcrops, gullies, stream margins, etc.). These Search Units should be delineated on maps, and may be referred to on data forms.
- A preliminary survey using hand collecting methods should be performed to determine the feasibility of an abundance study before any substantial investment in time or materials is made.

**Sampling Standards**

- Time of year: Length of the sampling season depends on latitude and altitude of the Study Area, and on the seasonal activity patterns of the species sought. Sampling from April to October should encompass the peak activity periods of the province’s species, although survey success for different species may vary within this time period.
- Time of day: On a daily basis, sampling times depend on the activity patterns of the species sought and the thermal conditions of the site; times of extreme temperature are likely to be unproductive.
- Weather: Sampling is usually not worthwhile during periods of inclement weather; rain and cold will make sampling unproductive, although a rainy spring or summer morning followed by a sunny afternoon can be quite productive.

**Personnel**

- Crew size depends on the size of area to be sampled and time allotted, and on budget limits.
- A minimum crew size of 2 should be used for safety purposes (in case of a fall, snakebite, etc.) and for setting up drift fences.
- All individuals hired should have experience collecting snakes and be able to identify all species found in British Columbia.
- When working in areas with rattlesnakes, all members should have experience handling venomous snakes and knowledge of first aid for snakebites; nearby hospitals should be notified of the possibility of a snake-related medical emergency so that they are prepared to provide treatment if necessary.

**Equipment**

A core of equipment will generally be required for any survey in which snakes are captured:

- Cloth snake bags
- Field note book
- Data sheets
- Identification key
- Meter stick (folding preferred)
- Spring scale
- Scissors (if marking snakes)
- Snakebite kit
- Snake tongs and/or snake hook (should only be used by experienced personnel)
- Thermometer
- Plastic specimen bags and museum tags

## 3.2 Inventory Surveys

The table below outlines the type of surveys that are used for inventorying snakes for the various survey intensities. These survey methods have been recommended by wildlife biologists and approved by the Resources Inventory Committee.

**Table 2. Types of inventory surveys, the data forms needed, and the level of intensity of the survey.**

| Survey Type | Forms Needed | *Intensity |
|---|---|---|
| **Hand Collecting** | • Wildlife Inventory Project Description Form<br>• Wildlife Inventory Survey Description Form - General<br>• Animal Observation Form - Snakes - Hand Collecting | • PN |
| **Road Survey** | • Wildlife Inventory Project Description Form<br>• Wildlife Inventory Survey Description Form - General<br>• Animal Observation Form - Snakes- Transects | • PN |
| **Trapping** | • Wildlife Inventory Project Description Form<br>• Wildlife Inventory Survey Description Form - General<br>• Capture (Station) Form - Snakes - Capture<br>• Animal Observation Form- Snakes - Capture<br>• Ecosystem Field Form | • PN<br>• RA |
| **Time-constrained Search (TCS)** | • Wildlife Inventory Project Description Form<br>• Wildlife Inventory Survey Description Form - General<br>• Animal Observation Form - Snakes - Hand Collecting | • RA |
| **Quadrat Search** | • Wildlife Inventory Project Description Form<br>• Wildlife Inventory Survey Description Form - General<br>• Animal Observation Form - Snakes - Hand Collecting<br>• Ecosystem Field Form | • RA |
| **Transect Search** | • Wildlife Inventory Project Description Form<br>• Wildlife Inventory Survey Description Form - General<br>• Animal Observation Form - Snakes- Transects | • RA |
| **Mark-Resight** | • Wildlife Inventory Project Description Form<br>• Wildlife Inventory Survey Description Form - General<br>• Capture (Station) Form - Snakes Capture<br>• Animal Observation Form- Snakes Capture<br>• Animal Observation Form- Snakes Recapture | • AA |

* PN = presence/not detected (possible); RA = relative abundance; AA = absolute abundance

## 3.3 Presence/Not detected

**Recommended method(s):** Hand collecting, Road survey, Trapping.

The most direct way to determine the number of species of snakes present in a specific area is to systematically survey the natural habitat cover and appropriate microhabitats when the weather conditions are warm. This is more complicated than it appears, as snakes are cryptic in colour and secretive in nature, making them difficult to find even under the best conditions. Therefore, not finding a particular species at a site, even after extensive searching, does not necessarily mean that the species is absent from that site. However, if the appropriate microhabitats are searched when the weather conditions are favourable and searches are done several times in a season, as the cumulative number of unproductive searches increases, it becomes more unlikely that the species is present. Species may also be detected using repeated road sampling; however, this may be inadequate for certain rare species which may require intense trapping effort.

### 3.3.1 Hand collecting

In most instances, the preferred method for determining presence is hand collecting. This method is labour-intensive, but it is more versatile and likely more productive than other techniques that tend to require much more equipment and set-up time.

Cover for snakes can take many forms. For example, snakes may hide at the bases of clumps of long grass. However, snakes frequently use rocks and logs to hide under, and flipping such cover objects can sometimes be a productive way to find snakes. The cover object must always be carefully replaced the way it was found, to minimize disturbance of the microhabitat under it. Furthermore, the same cover objects should not be flipped repeatedly (e.g. every day), to avoid disturbance of the site and the snakes. It is recommended that a cover object remain undisturbed for a minimum of at least two weeks between examinations. Also, if venomous snakes are in the area, the safety of the field workers should be considered when lifting cover objects (for example, pull the cover object up towards you by grasping the far side of it to keep the object between you and the snake). Hand searching may also turn up the shed skins of snakes. These can be identified to species using scale counts and can lead to the detection of a particular species in an area without having to capture it.

**Sampling design**

- Non-random. Stratify Study Area based on expected occurrence of snakes, focusing search effort where snakes are most likely to occur. It is important to keep track of these Search Units (specific portions of the Study Area on which search effort was focused e.g. meadow, barn, talus slope) to evaluate the effectiveness of a search.

**Sampling effort**

- Search when weather conditions are favourable - several times in a season, at a minimum try to target denning and dispersal times. Place effort where snakes are likely to occur.

**Field procedures**

- Record location and appropriate environmental conditions.
- Identify and search, Search Units within the Study Area. These should be recorded on a map and may be referred to on data forms.
- Record UTM coordinates and appropriate measurements for individual animals (see section 3.1)

### 3.3.2 Road Surveys

Road surveys have been used in many studies to sample snake populations (e.g. Klauber 1939; Fitch 1949). By travelling stretches of roads (by car, bicycle, or on foot), it is possible to record at least the presence of particular species and perhaps a rough index of relative abundance of a species for a particular area over time (if one makes appropriate assumptions about vagility and other habits). Road-cruising for snakes may be quite biased as a sampling technique as studies such as Fitch and Shirer (1971) report that some snakes avoid crossing roads. Because of this, the absence of snakes on roads does not mean that they are not present in the surrounding habitat.

Despite the biases, many of the B.C.'s snakes can be found along roads, basking at the edges during the day (e.g. garter snakes) or on the road itself in the early evening (e.g. gopher snakes, rattlesnakes). When searching roads, it is important to keep in mind the reason why snakes are apparently attracted to the road. The presence of snakes on roads is likely associated with reptilian thermoregulation. Because of this, it is unlikely to find snakes sitting on a road on a hot sunny day, as the road surface will be much too hot. However, pavement generally heats up quickly in the morning, making it potentially attractive to snakes as a basking spot until they reach their optimal temperature. The same is true in the evening as the pavement retains heat relatively well and can provide a warm surface for basking. It should noted that this circadian pattern may vary depending on whether a species is diurnal or nocturnal; sampling for a particular species must be conducted at an appropriate time.

Regularly travelled roads will also yield road-killed snakes. These animals make valuable voucher specimens and may provide information on food habits, reproductive status, parasite loads, etc. The direction of travel by snakes may provide information with respect to habitat use and location of denning sites; however, the efficiency of this approach is unknown.

**Sampling design**

- Nonrandom. Focus effort on roads where snakes are likely to occur.

**Sampling effort**

- Search when weather conditions are favourable, several times in a season.

**Additional Equipment**

- Vehicle or bicycle
- Road map
- Spot light (if at night)

**Field procedures**

- Paved or gravel roads with little vehicle use are best.
- Record distance travelled and appropriate environmental conditions.
- Drive slowly and scan the road for snakes.
- Record locations and measurements for individual animals (see section 3.1).
- Collect road killed specimens as vouchers.

### 3.3.3 Trapping

Funnel traps are recommended. Other trapping methods have been proposed, but their use is limited. Trapping is often a labour-intensive project and is therefore not suitable for casual sampling. As different species are attracted to different habitat features and may have unique movement patterns, traps are likely to give a biased estimate of community composition. For example, racers are readily caught in traps, as they actively forage, while rattlesnakes tend to be more sedentary and are found in traps less often (Shewchuk, unpubl. data). Traps in which animals are restrained can lead to mortality when weather conditions are extreme, when incompatible animals are trapped together (small mammals will kill snakes when they are left in a trap together), or when snake predators encounter a trap.

To effectively trap snakes, natural barriers or drift fences will need to be used in conjunction with traps. Drift fences provide a method of directing the movements of snakes towards a trap. A drift fence is simply a barrier which is set-up where snakes are likely to move. Snakes that encounter a drift fence will likely follow along the obstruction looking for an alternative route around it. Traps are then placed at gaps in the drift fence to capture snakes moving through the openings.

Funnel traps have been used in many different studies, with many different designs (Fitch 1951, 1987; Campbell and Christman 1982). They typically consist of a wire mesh cylinder with a funnel entrance constructed of the same material. They are similar in design to many commercial minnow traps, except that the optimal proportions may vary with respect to the species of snake sought. They can be constructed with a funnel at only one end of the cylinder, but better results are obtained from a double-ended design. As mentioned earlier, traps are best used in conjunction with a barrier, either natural (the base of a cliff) or artificial (the foundation of a building or a drift fence). The funnel trap should be placed tightly against the barrier to prevent the snakes from squeezing between the edge of the trap and the barrier. No baiting is required.

**Office procedures**

- In addition to general office procedures, air photos may be used to locate landforms that may increase trap success.

**Sampling design**

- Non-random. Traps and drift fences are usually grouped into trap arrays which are placed in habitats which are expected to contain snakes. Placement will depend on the topography of the area to be searched. Linear travel corridors and barriers to movement may be particularly productive.
- The number of traps and length of drift fence will depend on the amount of effort to be invested into the survey; length of fences and number of traps must be recorded.

**Sampling effort**

- Multiple trap sessions are better than one. At a minimum, try and have traps open during times of dispersal (generally spring and fall).
- Restraining traps must be checked at least daily, probably more frequently depending on weather conditions and the frequency of by-catch in the trap. If trapping is continuous (i.e. 24 hours a day), it will be necessary to check traps at least every 12 hours.

**Additional Equipment**

- Equipment and materials for constructing and installing traps:
    - Funnel traps - wire mesh, 1/8 inch hardware cloth or window screen
    - Drift Fencing - plywood, hardware cloth, sheet metal, aluminum flashing, or window screen may all be suitable. Some may have certain disadvantages (e.g. wood deteriorates quickly) but this may depend on the project. Digging equipment may be useful for installation.
- GPS (optional)

**Trap Construction**

Optimal trap design depends on the type of snake to be caught. There is no uniform size that will suit all snakes; traps should be tailored to the species or size group of interest. Inward projecting wire points at the apex entrance can be left to discourage escapes or a hinged plastic door can be attached. The entrance hole should be elevated well above the trap floor and only slightly larger than the diameter of the snakes to be trapped. If the entrance hole is too small, some snakes may be excluded from the trap. It is therefore best to err on the large side, but to make certain that the entrance holes are adequately elevated above the trap floor.

To provide some idea of trap size:

- For small species and neonates, traps should be constructed from 1/8 inch hardware cloth or window screen. Funnel traps may also be constructed from quart jars. The funnel portion of the trap can be soldered into the screw-top lid of the jar, but must be made of mesh or a similar material to allow air circulation.
- A suitable trap for snakes such as *Thamnophis spp*. would measure 15 cm in diameter and 35 cm long, with funnels 25 cm at the wide end and a 2.5-3.0 cm diameter hole at the apex.

Shading is imperative with the use of traps. All traps must be shaded from the sun using plywood or some other insulating material that is firmly anchored (to prevent it from being blown off). In some habitats the sun may be so intense that even several layers of plywood will not provide adequate insulation and overheating of snakes will occur very quickly.

Drift fences should be a minimum of 50 cm high and 15 m in length. They should be flush with the ground so that snakes cannot get underneath them, or, ideally, each fence should be dug at least 2 cm into the ground.

**Field procedures**

- Set up arrays of fences and traps (see above). Funnel traps should be set along drift fences to catch snakes directed into them.
- Record trap and drift fence locations on a map.
- Clearly label all traps with your name, phone number, and a cautionary message (for rattlesnakes).
- Check traps on a regular and recorded schedule (at least every 12 hours). Note: In some situations, it may be necessary to check traps more frequently. Traps which frequently trap incidental species may require extra monitoring to minimize injuries from aggression between captive animals. As well, in certain habitats, captive animals will quickly overheat despite efforts to provide shade; these traps should only be operated in the morning and

evening when the sun's rays are less intense. Under these circumstances, the use of traps that are easily disabled (such as removable funnels) should be considered. Traps should never be operated when there is the potential of exposing snakes to freezing temperatures.

- Once a snake is trapped, it can be handled, measured, and marked (if required) as described previously (see section 3.1).
- Each snake should be released a few meters away from the trap in the direction it was suspected to be travelling when it was captured.

## 3.4 Relative Abundance

**Recommended method(s):** Trapping, Time-Constrained Searches (TCS), Quadrat Searches, or Transect Searches.

The success of a fixed collecting effort (e.g. trap-days or searcher-hours) in different habitats may give some indication of relative abundance. Relative measures of abundance among species are biased, however, as different species of snakes have different susceptibilities to different collecting techniques (Fitch 1992). However, it is possible to compare among habitats within species. As in mark-recapture methods, variation in activity with respect to sex and age introduces further bias. In addition, great care must be taken to ensure that environmental variables (such as time of day, time of season, weather, etc.) remain constant, as these will strongly influence snake activity. Relative abundance surveys for snakes are of little value unless large numbers of replicate measurements are taken.

Due to the many habitat-related biases associated with sampling snakes to determine abundance, this type of data may be more appropriate to follow relative changes in a population over time, rather than relative numbers between habitats. However, attempting to evaluate population trend over time will require consideration of statistical power and tests for significant difference. These should be considered **before** beginning such an inventory. Discussion and references are available in the manual, Introduction to RIC Wildlife Species Inventory.

### 3.4.1 Trapping

Trapping is used for presence/not detected surveys. Essentially the same method is used but with a more rigorous sampling design than that described for presence/not detected surveys. A more rigid sampling design is used so that survey effort can be fixed, allowing surveys to be comparable and to give some indication of relative abundance over time at a given trap or trap array.

Only differences in protocol from the presence/not detected survey are listed here. For details on how to conduct this type of survey see section 3.3.3.

**Sampling Design**

- Determining relative numbers of snakes on a site may not require random placement of traps, provided that the same locations and configurations can be used between years, and an assumption is made that other environmental variables (e.g. succession, weather) have a constant influence on snake abundance.
- Determining relative numbers of snakes in different Study Areas is very difficult. Ideally, the position of the traps within each site should be chosen at random. This may best be accomplished by dividing the Study Area into grid cells, randomly selecting a number of these, and then establishing traps at positions within each cell where snakes are likely to be encountered. Linear travel corridors and barriers to movement may be particularly productive.
- Effort is measured in terms of time: the number of days a trap array is set up and active.
- There must be a similar total length of driftfence per trap among sites or years, but the number of traps (and thus driftfences) can vary, as the number of snakes is calculated as a function of the number of traps and number of days of operation. It is recommended that the traps be installed at each site over the same time period to minimize differences due to weather and time of year.

**Sampling Effort**

- Multiple samples should be taken throughout the field season, as capture success will vary seasonally. Trapping may be most successful during times of dispersal.

**Data Analysis**

- An indication of relative abundance over time within a given site may be made (assuming sampling was done in similar seasons) by calculating the number of snakes per trap (or trap array) as a function of trap days.
  - Calculate the number of snakes per trap as a function of the number of days a specific trap was in operation:

$$\frac{\text{total \# snakes found at a specific trap}}{\text{total \# trap days for that trap}}$$

where: a trap day equals one trap that is operable for one day.

  - Calculate the number of snakes per array as a function of the number of days the traps of the array were in operation:

$$\frac{\text{total \# snakes found at a specific array}}{\text{total \# trap days for that array}}$$

where: a trap day equals one trap that is operable for one day. Thus, total # trap days is calculated by summing the number of trap days of each individual trap within the array.

- Remember that snake trapping success may not necessarily be indicative of relative numbers, particularly when different habitats may serve different purposes (e.g. denning vs. dispersal) in the life of a snake. Thus, comparisons are generally only made over time within a site and on a species by species basis.

### 3.4.2 Time-constrained Search

A time-constrained search is simply hand collecting over a specific amount of time. By fixing survey effort, this technique attempts to facilitate comparison between surveys to provide some indication of relative abundance.

This same basic technique is also used for presence/not detected surveys. Only differences in protocol from the presence/not detected survey for hand collecting are listed here. For details on how to conduct this type of survey see section 3.3.1.

**Sampling Design**

- Searches take place in Study Areas within the Project Area. Depending on the size and nature of each Study Area, it may also be important to keep track of Search Units (specific portions of the Study Area on which search effort was focused e.g. meadow, barn, talus slope) to evaluate the effectiveness of a search.
- Effort is measured in terms of time: the number of hours a Study Area is searched.
- For hand collecting over a specific amount of time, it is recommended that the same person sample each site, as catch efficiency will vary with observer.
- The search is conducted in a non-random fashion; however, if the objective is to compare abundance or diversity between habitats, a stratified random sample may be appropriate (ideally using replication within different habitat strata).

**Sampling Effort**

- Multiple samples should be taken throughout the field season, as capture success will vary seasonally.
- Search when weather conditions are favourable - several times in a season. Ideally, include denning and dispersal periods.

**Field Procedures**

- Record location and appropriate environmental conditions.
- Crew members should spread out to cover the Study Area, but remain in sight of one another, for safety and to avoid searching the same locations twice.
- Cover the territory as thoroughly as possible, investigating as many types of cover as possible. This may be in the bases of clumps of long grass, under rocks, or under logs (see introduction to section 3 for hints on finding snakes). Flip cover objects over to increase chances of finding snakes. Always replace the cover object carefully to the way it was found, to minimize disturbance of the microhabitat under it.
- Do not flip the same cover objects repeatedly (e.g. every day), this helps to avoid disturbance to the site and the snakes. It is recommended that a cover object remain undisturbed for a minimum of at least two weeks between examinations.
- If venomous snakes are in the area, the safety of the field workers should be considered when lifting cover objects (for example, pull the cover object up towards you by grasping the far side of it to keep the object between you and the snake).
- Do not linger in what appears to be an unproductive area. However, it maybe worth returning to it at another time or under different conditions. Field notes are very useful to keep track of what areas were sampled under what conditions. For large areas of diverse habitat, crew

members should keep track of Search Units on maps. These will show exactly which areas were searched within the Study Area and may be referenced on data forms.

- When a snake is captured, record appropriate measurements for individual animals (see section 3.1 for handling protocol and how to take measurements). Do not include processing time as part of total search time.
- If snake skins are found, try to identify it to species using scale counts.

**Data Analysis**

- Calculate the number of snakes as a function of the number of person-minutes searched (not including handling time to take measurements etc.):

$$\text{Relative Abundance measurement} = \frac{\text{Total \# snakes}}{\text{Total person-minutes searched}}$$

where: total person-minutes searched is calculated by summing together the time (min.) each person spent searching.

### 3.4.3 Quadrat Searches

This section includes sampling by areas using quadrats. Quadrats are squares of fixed area which are placed within the Study Area at random. The number of snakes within each quadrat is then determined by hand collecting.

This method will provide a measure of the relative number of snakes in the Study Area as a function of the amount of area surveyed. The quadrats must be placed randomly within the Study Area to be sampled, using start points and compass bearings chosen at random and plotted on air photos or maps beforehand.

**Sampling Design**

- Random. Quadrats must be placed randomly within the Study Area to be sampled, using start points and compass bearings chosen at random and plotted on air photos or maps beforehand.

**Sampling Effort**

- The number of quadrats sampled within a Study Area depends on the desired intensity of sampling, the accuracy of relative abundance estimates and the overall size of the Study Area.
- Multiple samples should be taken throughout the field season, as capture success will vary seasonally.

**Equipment**

Additional equipment includes:

- Measuring tape/chain for establishing quadrats
- Compass
- GPS (optional)

**Field Procedures**

- Place quadrats randomly within the Study Area to be sampled, using start points and compass bearings chosen at random and plotted on air photos or maps beforehand. Quadrat size for sampling snakes must be appropriate for the size of the snake and the extent of its movements (e.g. 50 m x 50 m quadrat for garter snakes, or less for smaller snakes).
- Record location of each quadrat and appropriate environmental conditions.
- Crew members should spread out, but remain in sight of one another, for safety and to avoid searching the same locations twice.
- Search quadrats by hand as thoroughly as possible, investigating as many types of cover as possible. This may be in the bases of clumps of long grass, under rocks, or under logs (see introduction to section 3 for hints on finding snakes). Flip cover objects over to increase chances of finding snakes. Always replace the cover object carefully to the way it was found, to minimize disturbance of the microhabitat under it.
- Do not flip the same cover objects repeatedly (e.g. every day), this helps to avoid disturbance to the site and the snakes. It is recommended that a cover object remain undisturbed for a minimum of at least two weeks between examinations.

- If venomous snakes are in the area, the safety of the field workers should be considered when lifting cover objects (for example, pull the cover object up towards you by grasping the far side of it to keep the object between you and the snake).
- Do not linger in what appears to be an unproductive area. However, it maybe worth returning to it at another time or under different conditions (field notes are very useful to keep track of what areas were sampled under what conditions).
- When a snake is captured, record appropriate measurements for individual animals (see section 3.1 for handling protocol and how to take measurements).
- If snake skins are found, try to identify it to species using scale counts.

**Data Analysis**

- Calculate the number of snakes per unit area:

  snakes per unit area = # snakes per quadrat (e.g. # snakes/50m$^2$)

### 3.4.4 Transect Searches

This section includes sampling using a linear sample unit of set length and width. Transect sampling consists of walking in a straight line for a specific distance and recording all the snakes that you can detect within a set distance on either side of the line. The width of the transect may vary depending on the habitat it passes through, but it should be set at the start of each survey, based on the expected detectability of a snake within the sampled habitat.

This method will provide a measure of the relative number of snakes in the Study Area as a function of the amount of area surveyed. The transects must be placed randomly within the area to be sampled, using start points and compass bearings chosen at random and plotted on air photos or maps beforehand.

**Sampling Design**

- The transects must be placed randomly within the area to be sampled, using start points and compass bearings chosen at random and plotted on air photos or maps beforehand.

**Sampling Effort**

- The number of transects will depend on the desired intensity of sampling and accuracy of relative abundance estimates.
- Multiple samples should be taken throughout the field season, as capture success will vary seasonally.
- For comparison of abundance between habitats, observers should sample equal area in each habitat class.

**Additional Equipment**

- Compass
- GPS (optional)

**Field Procedures**

- Place transects randomly within the area to be sampled, using start points and compass bearings chosen at random and plotted on air photos or maps beforehand.
- Record location of each transect and appropriate environmental conditions.
- Crew members should spread out on different transects, but remain in sight of one another, for safety.
- Walk the straight line transects for the predetermined distance. Record all snakes occur within the set transect width.
- Search transects by hand as thoroughly as possible, investigating as many types of cover as possible (within the specified width). This may be in the bases of clumps of long grass, under rocks, or under logs (see introduction to section 3 for hints on finding snakes). Flip cover objects over to increase chances of finding snakes. Always replace the cover object carefully to the way it was found, to minimize disturbance of the microhabitat under it.
- Do not flip the same cover objects repeatedly (e.g. every day), this helps to avoid disturbance to the site and the snakes. It is recommended that a cover object remain undisturbed for a minimum of at least two weeks between examinations.

- If venomous snakes are in the area, the safety of the field workers should be considered when lifting cover objects (for example, pull the cover object up towards you by grasping the far side of it to keep the object between you and the snake).
- Do not linger in what appears to be an unproductive area. However, it maybe worth returning to it at another time or under different conditions (field notes are very useful to keep track of what areas were sampled under what conditions).
- When a snake is captured, record appropriate measurements for individual animals (see section 3.1 for handling protocol and how to take measurements).
- If snake skins are found, try to identify it to species using scale counts.

**Data Analysis**

1. Calculate the number of snakes per distance:
   - # snakes per km of transect
2. Calculate the number of snakes per unit area:
   - # snakes per fixed-width transect (length x fixed-width of transect)

## 3.5 Absolute Abundance

**Recommended method(s):** Generally not possible. The description of the method below is only included for those **rare** circumstances where absolute abundance information is required.

It is impractical, but not impossible to find and count every snake in a large area (Lillywhite 1982). The application of formal, long-term and extremely labour-intensive censusing techniques is necessary, and even then the estimate of population size will be biased and likely only an indicator of the catchable portion of the population, with groups like juveniles being vastly underrepresented. Methods that have been proposed include mark-recapture techniques; however, relative abundance inventories are recommended over absolute measures in almost all cases.

### 3.5.1 Mark-Recapture

One way to estimate the size of a population is to capture and mark individuals, release them, and then resample to determine what proportion of individuals had been previously captured. A variety of mathematical formulae are available, depending on the characteristics of the population (see the introductory manual, *Species Inventory Fundamentals*, No. 1). Each of these estimators is a mathematical model that relies on certain, often testable assumptions. It is extremely important to adhere closely to the assumptions of a particular model. If assumptions are violated, estimates of population size may be highly inaccurate, even despite narrow confidence limits (i.e. high precision). In many cases, it simply will not be possible to find a model that is suitable for a particular snake inventory.

Mark-recapture methods provide information on absolute abundance, but require a considerable investment of time and effort. The frequency and type of activity exhibited by an individual snake depends greatly on the time of year, and on the age, sex, and reproductive condition of the snake (Gibbons and Semlitsch 1987). Parameters for each age and sex group should be estimated separately to reduce the effect of variation on the population estimate; however, subdividing a population this way may also reduce sample size to a point at which estimates are no longer reliable. In addition, population fluctuations from immigration, emigration, reproduction, and mortality are likely to introduce error within the time it takes to perform adequate sampling of snakes. Mass captures of animals at denning areas may reduce this (Fitch 1987), but will only provide an estimate of the number of animals at a particular den. This may have little relationship to the number of snakes using a particular summer range; sampling at both the dens and summer areas would provide a more accurate count.

For den sites, it may be possible to surround the location with a drift fence and capture a large proportion of the population as it emerges from hibernation. Unfortunately, this scenario rarely presents itself as denning locations are seldom one discrete opening in the ground, but are more often characterized by many entrances spread over a large area and thus make installing an impassable fence very difficult. However, a large proportion of the population may be caught by placing fences near the den, especially if the direction of the snake migration is known and the fences can be placed to intercept the majority of the snakes (see section 3.1.6).

**Office procedures**

- In addition to general office procedures, plan to locate dens in a first season (by radiotelemetry if feasible) and sample them in subsequent seasons.

**Sampling design**

- The assumptions of the model to be used must be met; if these are violated, it must be recognized that the population estimation could be inaccurate.
- The design depends on the habitat to be surveyed; if trapping or fencing a den will be the method of capture then it also depends on the topography of the area.
- As each capture method has inherent bias, it is recommended that more than one method is used.

**Sampling effort**

- The frequency of resampling the population, once the initial capture and marking is completed, will depend in part on the analysis to be used; for example, a model that assumes a closed population requires that no births or deaths occur within the sampling period.

**Sampling standards**

- In addition to general sampling standards, multiple samples will be needed for mark-recapture (abundance) studies.

**Field procedures**

- Search by hand and use rock flipping (see introduction to section 3. for hints on finding snakes).
- Crew should cover territory as thoroughly as possible, investigating as many types of cover as possible.
- Crew members should spread out, but remain in sight of one another, for safety and to avoid searching the same locations twice.
- Do not linger in what appears to be an unproductive area. However, it maybe worth returning to it at another time or under different conditions (field notes are very useful to keep track of what areas were sampled under what conditions).
- Set traps and drift fences (see section 3.3.3). Note trap, capture, and survey area locations on a map. Take particular care to note the locations of any den sites encountered.
- Clearly label all traps with your name, phone number, and a cautionary message (for rattlesnakes).
- Process and mark snakes (see section 3.1).

# Glossary

**ABSOLUTE ABUNDANCE**: The total number of organisms in an area. Usually reported as absolute density: the number of organisms per unit area or volume.

**ANAL PLATE:** The large scale immediately anterior to the cloacal opening.

**ANTERIOR:** Pertaining to the head end.

**BIODIVERSITY**: Jargon for biological diversity: the variety of life forms, the ecological roles they perform, and the genetic diversity they contain (Wilcox 1984 cited in Murphy 1988).

**BLUE LIST:** Includes any indigenous species or subspecies (taxa) considered to be Vulnerable in British Columbia. Vulnerable taxa are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Blue-listed taxa are at risk, but are not extirpated, endangered or threatened.

**CHIN SHIELDS:** Relatively large, plate-like scales on the chin.

**CLOACA:** The single chamber through which the contents of the digestive, excretory, and reproductive systems pass. Opens to the outside at the vent (cloacal opening).

**CREPUSCULAR:** Active at twilight.

**DIURNAL:** Active during the daytime.

**DORSAL:** Pertaining to the back (dorsum).

**ECTOTHERMIC:** Body temperature controlled by environment; no internal regulation.

**GRAVID:** Pregnant; bearing eggs or developing young internally.

**HEMIPENES:** Paired, eversible copulatory organs in male snakes and lizards.

**HIBERNACULUM:** A den; a site where animals aggregate to hibernate overwinter.

**HIBERNATE:** To enter an inactive or dormant state for the winter.

**KEELED:** Bearing a longitudinal medial ridge.

**LABIALS:** Scales on the lip.

**LATERAL:** Pertaining to the side.

**MELANISTIC:** Colour pattern obliterated by excessive number of melanophores causing the animal to appear very dark or uniformly black.

**MICROCLIMATE:** Small-scale variation in the environment (macrohabitat); an animal's immediate surroundings.

**NOCTURNAL:** Active at night.

**OVIPAROUS:** Eggs deposited; embryonic development outside the female's body.

**PIT:** A pit-shaped sensory structure between the eye and nostril of a rattlesnake.

**POSTERIOR:** Pertaining to the rear portion of the body.

**PREFRONTALS:** Scales of the head, located anterior of the frontals.

**PREOCULARS:** Scales immediately in front of the eye.

**PRESENCE/NOT DETECTED (POSSIBLE):** A survey intensity that verifies that a species is present in an area or states that it was not detected (thus not likely to be in the area, but still a possibility).

**PROJECT AREA:** An area, usually politically or economically determined, for which an inventory project is initiated. A project boundary may be shared by multiple types of resource and/or species inventory. Sampling generally takes place within smaller study areas within this project area.

**RANDOM SAMPLE**: A sample that has been selected by a random process, generally by reference to a table of random numbers.

**RED LIST:** Includes any indigenous species or subspecies (taxa) considered to be Extirpated, Endangered, or Threatened in British Columbia. Extirpated taxa no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed. Red-listed taxa include those that have been, or are being, evaluated for these designations.

**RELATIVE ABUNDANCE**: The number of organisms at one location or time relative to the number of organisms at another location or time. Generally reported as an index of abundance.

**SEARCH UNITS:** specific portions of the Study Area on which search effort was focused e.g. meadow, barn, talus slope.

**STRATIFICATION:** The separation of a sample population into non-overlapping groups based on a habitat or population characteristic that can be divided into multiple levels. Groups are homogeneous within, but distinct from, other strata.

**STUDY AREA:** A discrete area within a project boundary in which sampling actually takes place. Study areas should be delineated to logically group samples together, generally based on habitat or population stratification and/or logistical concerns.

**SUBCAUDAL:** Ventral scales on the tail.

**SURVEY:** The application of one RIC method to one taxonomic group for one season.

**SVL:** Snout-vent length, measured from tip of snout to anterior margin of vent.

**SYSTEMATIC SAMPLE:** a sample obtained by randomly selecting a point to start, and then repeating sampling at a set distance or time thereafter.

**TL:** Total length, measured from tip of snout to tip of tail.

**VENTRAL:** Pertaining to the underside, or venter; ventral scales (ventrals) are those on the underside of the body.

**VIVIPAROUS:** Females give birth to young and provide nutrients to developing embryos.

**YELLOW-LIST:** Includes any native species which is not red- or blue-listed.

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