Inventory Methods for Pond-breeding Amphibians and Painted Turtle

Standards for Components of British Columbia's Biodiversity No. 37

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Preface

This manual presents standard methods for inventory of pond-breeding amphibians and Painted Turtles 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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All decisions regarding protocols and standards are the responsibility of the Resources Inventory Committee. Background information and protocols presented in this version are based on substantial contributions from Ted Davis with helpful comments from Kristina Ovaska. In addition, Rosamund A. Pojar and David F. Hatler contributed to an earlier unpublished draft, *Standardized Methodologies for the Inventory of Biodiversity in British Columbia: Techniques for Pond-Using Amphibians and the Painted Turtle* which incorporated advice from Fred Schueler and Stan Orchard and an extremely helpful review by Linda Dupuis. In keeping with standard methods in the Pacific Northwest, this manual attempts to follow protocols produced by the Society for Northwest Vertebrate Biology (Olson *et al.*, 1997). Charlotte Corkran and Chris Thoms kindly gave permission to use their protocol for the Basic Pond Survey, referred to as Systematic Pond Survey within this manual. The toe-clipping scheme was devised by Ted Davis.

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

Amphibians and reptiles are a significant component of British Columbia's biodiversity. Although they are represented by only 39 species in this province (Orchard 1990a, b), many are widespread, abundant and exhibit great diversity in life history, morphology, and ecological function (Green and Campbell 1984; Gregory and Campbell 1984; Corkran and Thoms 1996). Because they do not use metabolically generated heat to maintain their body temperatures, they are able to allocate a higher proportion of their ingested energy to producing new biomass than can birds and mammals. This efficiency of biomass production can result in dense populations that are important to other species as either predators or prey (Pough 1980, Burton and Likens 1975a, b).

In contrast with other vertebrates including reptiles, most amphibians have an independent larval stage and a biphasic (from the Greek *amphi* = double, and *bios* = life) life cycle with both terrestrial and aquatic stages. Larval frogs and toads are called 'tadpoles', but salamander larvae are simply called 'larvae'. Amphibians have skins that are permeable to water, so they are sensitive to changes in temperature and moisture, and are vulnerable to a variety of environmental pollutants. Some species are in decline, and because they are high in the food chain and inhabit both terrestrial and aquatic environments, it has been suggested that their decline might be a warning of deeper ecosystem deterioration (Blaustein and Wake 1995). Globally, most declines of amphibian populations are due to habitat modification (Pechmann and Wilbur 1994, Phillips 1994, Blaustein and Wake 1995).

This report presents the standard inventory/monitoring methods applicable for amphibians and reptiles that are necessarily dependent on standing water for at least a part of their life cycle. These "pond-using species" include one reptile, the Painted Turtle (*Chrysemys picta*), and fourteen amphibians, the Tiger Salamander (*Ambystoma tigrinum*), Northwestern Salamander (*Ambystoma gracile*), Long-toed Salamander (*Ambystoma macrodactylum*), Rough-skinned Newt (*Taricha granulosa*), Great Basin Spadefoot Toad (*Scaphiopus intermontanus*), Western Toad (*Bufo boreas*), Pacific Treefrog (*Hyla (=Pseudacris) regilla*), Striped Chorus Frog (*Pseudacris triseriata*), Red-legged Frog (*Rana aurora*), Northern Leopard Frog (*Rana pipiens*), Spotted Frog (*Rana pretiosa*), Wood Frog (*Rana sylvatica*), and two introduced species, American Bullfrog (*Rana catesbeiana*), and Green Frog (*Rana clamitans*). Nomenclature follows Orchard (1990a, b) for all species.

2. INVENTORY GROUP

Assessing the presence or abundance of animals requires some understanding of their likely spatial and temporal distribution in the area(s) of interest. Those patterns vary both among and within species. This section identifies and describes some of the life history and population characteristics that must be taken into consideration when selecting inventory methods for monitoring or surveying members of this group. Table 1 provides a concise summary of some of the natural history for each of the species in the group.

Table 1. Some biological features of the adult stages of fourteen pond-breeding amphibians and the Painted Turtle as related to considerations for inventory methods in British Columbia.

	Movement Patterns			Habitat Preferences		
Species	**Status**	**Daily**	**Seasonal**	**Terrestrial**	**Aquatic**	**Calls**
Tiger Salamander *Ambystoma tigrinum*	Provincial Red List	Nocturnal	Migrates to water April-May	Underground burrows including abandoned rodent burrows or other moist hollows	Small, frequently alkali, lakes and temporary ponds; neotenes in cold lakes	None
Northwestern Salamander *Ambystoma gracile*	Common in B.C.	Nocturnal	Migrates to water to breed	Moist forests	Lakes and streams; also in sub-alpine ponds	None
Long-toed Salamander *Ambystoma macrodactylum*	Common; widespread	Nocturnal	Migrates to water to breed as early as December	Moist microhabitats in forests, pastures; rock rubble	High and low elevation lakes and ponds; in pools along streams	None
Rough-skinned Newt *Taricha granulosa*	Common in B.C.	Diurnal and nocturnal	Migrates to ponds to breed Feb-April	Forests	Vegetated fringes of permanent water bodies and slow-moving streams	None
Great Basin Spadefoot Toad *Scaphiopus intermontanus*	Provincial Blue List	Nocturnal	Migrates to water to breed; Feb-April at low elevations	During dry weather, under the soil in burrows	Temporary or shallow ponds	Choruses large, loud, and insistent

	Movement Patterns			Habitat Preferences		
Species	**Status**	**Daily**	**Seasonal**	**Terrestrial**	**Aquatic**	**Calls**
Western Toad *Bufo boreas*	Locally common, widespread, but patchy; in decline in western U.S.	Primarily nocturnal	Migrates May-June; at high elevations Fall: Sept-Oct	Most forested habitats in all biogeoclimatic zones and ecoregions	Small ponds and pools, temporary or permanent	Bird-like chirps; no mating call reported in B.C.
Pacific Treefrog *Hyla* *(=Pseudacris) regilla*	Common on coast	Diurnal and nocturnal	Migrates to water for breeding Mar-May	Forests; often on trees and shrubs; also common along shores	Shallow ponds with lots of vegetation; not necessary to be permanent	Large, loud choruses; may drown out other species
Striped Chorus Frog *Pseudacris triseriata*	Locally common; NE B.C.	Diurnal and nocturnal	Migrates to water for breeding Mar-June	Meadows, deciduous forests and around marshes	Shallow standing water	Loud, early in spring; all day and night
Red-legged Frog *Rana aurora*	Locally common; SW B.C.	Primarily nocturnal	Mainly aquatic; may move to other small ponds breeds Mar-April	Near small ponds in damp forests	Temporary or permanent ponds and slow-moving streams; Mar-April	Calls under water; feeble, hard to detect
Northern Leopard Frog *Rana pipiens*	Provincial Red List	Active mainly on damp days	Migrates to ponds or swamps Mar-June	Near breeding sites, but may also forage in meadows and fields	Shallow, permanent marshes, ponds and lakes, especially with emergent vegetation	Squeals in distress; mating call low guttural rumble on, or below water
Spotted Frog *Rana pretiosa*	Common, widespread; some populations at risk	May be active near ponds during day	Very aquatic; may move over land in rainy periods Feb-July	At edges of ponds and lakes	Prefer permanent ponds and small lakes in early spring	Low-pitched, with little carrying power; grunt

	Movement Patterns			Habitat Preferences		
Species	**Status**	**Daily**	**Seasonal**	**Terrestrial**	**Aquatic**	**Calls**
Wood Frog *Rana sylvatica*	Scattered; common locally in north B.C.	Mainly diurnal	Moves to water for breeding April-July	Meadows and forest near ponds; alpine tundra, very cold tolerant	Shallow clear ponds for only a few days in north	Duck-like quack; day or night
American Bullfrog *Rana catesbeiana*	Introduced Van. Is. and SW mainland	Crepuscular	Mainly aquatic, breeds May-July	Water edge	Permanent ponds of variable depth; prefers shallow with vegetation	Males call in deep bass snore; loud, carries; bark when frightened
Green Frog *Rana clamitans*	Introduced Van. Is. and SW mainland	Diurnal	Mainly aquatic; breeds May-July	Water edge	Permanent ponds	Mating call a muffled explosion, squawks when frightened
Painted Turtle *Chrysemys picta*	Provincial Blue List	Diurnal	Females migrate to and from nest sites on land in spring and summer	Nest on moist land adjacent to ponds within 50 m or water	Ponds, lakes, streams; slow-moving, permanent	None

2.1 Natural History

For descriptions, distribution, and natural history notes on amphibians, see Green and Campbell (1984), Leonard *et al.* (1993), and Corkran and Thoms (1996). For the Painted turtle, see Gregory and Campbell (1984). Stebbins (1985) is useful for both amphibians and reptiles.

References for each species given in the species accounts below are not exhaustive but provide an introduction to some of the important literature. Most literature published before about 1980 can be found in Campbell *et al.* (1982). Also see the *Catalogue of American Amphibians and Reptiles*.

2.1.1 Tiger Salamander (*Ambystoma tigrinum*)

Description: This is the largest salamander in British Columbia. Adults may reach 327 mm total length, but generally average between 140 mm and 180 mm. These are heavy-bodied animals with prominent costal groves, a broad head, and small protruding eyes. They are distinctively patterned with large blotches of yellow or dirty white on a black, grey or dark brown background. There are two prominent tubercles on each foot, and there are no parotid glands.

Larvae are olive-green and have long feathery gills, tail fins, but unlike the pond-type larvae of other British Columbia salamanders, they lack balancers behind the head. Neotenic individuals may be found in deeper lakes or ponds. In some populations, some larvae are cannibalistic, but cannibalistic larvae have not be reported in British Columbia.

Range: This wide-ranging salamander occurs from Mexico through the central, midwestern and eastern United States, and into southern Canada. In British Columbia, it is found in the Okanagan, as far north as Summerland.

Habitat: These salamanders are found near or in small, frequently alkali, lakes and ponds in the dry southern interior of the province. Loredo *et al.* (1996) found that adult California Tiger Salamander (*Ambystoma californiense*) used ground squirrel burrows as terrestrial habitat up to 129 m from the breeding pond, but may travel much farther.

Reproduction: Breeding occurs in the early spring in permanent or seasonal lakes and ponds. Eggs are laid shortly after mating and hatch in two to three weeks. The larvae grow rapidly and usually transform in three to four months, but some larvae require a second summer to reach metamorphic climax.

Natural History: This salamander is a voracious predator feeding on invertebrates, fish, and amphibians. Movements are poorly understood, but adults may be found several kilometers from standing water (Sarell 1996).

Status: Red list. Threatened by introduced fish and habitat modification. May depend on rodent burrows in the adult stage.

References: Arnold (1976); Sexton and Bizer (1978); Collins (1981); Semlitsch (1983), Pfenning *et al*. (1991, 1994); Sredl and Collins (1991); Zerba and Collins (1992); Collins *et al.* (1993); Pfenning and Collins (1993); Allison *et al.* (1994); Holomuski *et al.* (1994); Maret and Collins (1994); Sadler and Elgar (1994); Werner and McPeek (1994); Whiteman *et al.* (1994); Leonard and Darda (1995); Loredo *et al.* (1996); Sarell (1996).

2.1.2 Northwestern Salamander (*Ambystoma gracile*)

Description: This is a large, robust, dark brown salamander with distinct, lighter coloured parotid glands behind the eyes. Glandular areas are also located along the top of the tail. There are no tubercles on the soles of the feet. Adults may reach 248 mm total length.

Larvae are grey or brown and often mottled. Larvae will transform when they are between 75 mm and 120 mm long, but neotenic larvae can grow to 185 mm.

Range: These salamanders occur along the Pacific coast from extreme southern Alaska to northern California, including Vancouver Island.

Habitat: Adults may be common but hard to find because of their extensive use of underground burrows. They may occasionally be found inside rotting logs. Larvae can be found in small ponds and lakes and in pools formed by slow-moving streams. Neotenic larvae are common in subalpine lakes and ponds.

Reproduction: Breeding takes place in the early spring in permanent or semi-permanent ponds in forests. The gelatinous egg masses are attached to thin branches of shrubs or stems of grasses and other plants. The masses are typically round, firm, about the size of a small grapefruit and contain between 40 and 270 individual embryos. The eggs may be green due to the presence of a symbiotic algae. Hatching occurs in 6 to 8 weeks, and the larvae take at least a year to transform and another two to three years to reach sexual maturity.

Status: Common, but may be affected by logging.

References: Brodie and Gibson (1969); Efford and Mathias (1969); Efford and Tsumura (1973); Henderson (1973); Licht (1973, 1975b, 1992); Sprules (1974); Eagleson (1976); Taylor (1983, 1984); Titus (1990); Bury *et al.* (1991); Blaustein *et al.* (1995).

2.1.3 Long-toed Salamander (*Ambystoma macrodactylum*)

Description: This salamander is about 80 mm to 120 mm in total length, grey or black with an irregular green or yellow stripe down the back. There are numerous white, silver, or blue flecks on the sides and ventral surface. Larvae are brown coloured. Before the front limbs develop, the larvae have a pair of balancers protruding from the sides of the head.

Sexes: Males have slightly longer tails and larger vents than females, but distinguishing between the sexes in the field is difficult.

Range: This salamander is found from southern Alaska to northern California and as far west as Idaho and Montana. In British Columbia it is found throughout the province except for the Queen Charlotte Islands and the far north.

Habitat: Adults may be found in moist forest habitats under coarse woody debris (CWD) or rocks on the ground or within logs or under the bark on logs. Larvae are found in pools and small lakes.

Reproduction: These salamanders lay small eggs (2.5 mm diameter) singly or in small egg masses (6-57 eggs per mass) in temporary pools and small lakes in the early spring. The eggs are attached to underwater vegetation. Development is rapid and hatching occurs in about two weeks if temperatures are favourable. At low elevations larvae may metamorphose by early summer, but at higher elevations metamorphosis may take two or three years.

Status: Yellow list. Apparently, these salamanders are unable to coexist with introduced fish.

References: Storm and Pimentel (1954); Anderson (1967, 1968, 1972); Howard and Wallace (1985); Beneski *et al.* (1986); Walls *et al.* (1993).

2.1.4 Rough-skinned Newt (*Taricha granulosa*)

Description: This salamander has a dry granul above, and bright orange below.

Sexes: Breeding males develop a swollen vent, high tail crest, smooth skin, and cornified, melanized nuptial pads. Nonbreeding males have a granulated skin as do females at all times. Sexes can be distinguished by anatomical details of the cloaca (Stebbins 1954:45), but this is difficult to do in the field.

Range: This species is found in the humid coastal forests from southeast Alaska to northern California, primarily west of the Cascade and Coast Range mountains.

Habitat: This species is found in permanent swamps, ponds, and lakes. Microhabitats in forest habitats have not been studied.

Reproduction: These salamanders lay a series of single eggs in ponds and small lakes in the spring. Larvae develop over the summer and transform by the end of August. At higher altitudes, some larvae may overwinter and transform the following summer. After metamorphosis, the young leave the water until they reach their 4th or 5th year when they become sexually mature and return to the pond to breed. On southern Vancouver Island, Oliver and McCurdy (1974) found that adult males normally remain permanently aquatic, but adult females migrate from breeding ponds to overwinter on land. However, at Marion Lake, B.C., which is on the mainland, Efford and Mathias (1969) reported that males as well as females left the water by mid-October and returned early in the spring. Mass migrations of newts to breeding ponds are limited to females only. Details of the activities and natural history of *T. granulosa* during the terrestrial phase are unknown.

Natural History: The skin of *T. granulosa* contains high concentrations of tetrodotoxin (TTX), a neurotoxin, which functions as a defense against predators. Thus, they are virtually immune to predation by fish, and unlike many other aquatic amphibians, are able to coexist with fresh water salmonids.

Status: Yellow list. Common.

References: Chandler (1918), Storm and Pimentel (1954); Pimentel (1960); Brodie (1968); Efford and Mathias (1969); Efford and Tsumura (1973); Oliver (1974); Oliver and McCurdy (1974); Macartney and Gregory (1981); Taylor (1984); Brodie and Brodie (1990, 1991); Bury *et al.* 1991.

2.1.5 Great Basin Spadefoot Toad (*Scaphiopus intermontanus*)

Description: The Great Basin Spadefoot Toad has a small, compact body with numerous dark brown or reddish tubercles and spots, but it has no warts or parotid glands. It has a raised boss between the eyes, large golden-yellow eyes with vertical pupils, and a single horny black spade at the base of the first toe of each hind foot.

Sexes: Males have dark throat patches and areas of darkened skin (nuptial pads) on the inner three fingers during the breeding season. Females are slightly larger than males.

Range: East of the Cascade and Sierra mountains to Wyoming, from southern Nevada and northwestern Arizona to the Okanagan and Nicola valleys in British Columbia. It ranges as far north as 70 Mile House in the Cariboo region.

Habitat: Arid regions with sandy soils in open woodland, meadow, sage, or bunch grass prairie. It is often found near lakes or permanent ponds, but they can also be found far from permanent water.

Reproduction: Breeding begins with the onset of rain in the spring and early summer in roadside ditches, temporary pools, or shallow lakes. Choruses are large, loud, and insistent. The black eggs are laid in clumps attached to floating sticks and submerged vegetation in shallow water. A female can lay as many as 800 eggs in several small clusters. They have the most rapid rate of embryonic development of any North American frog or toad. Embryos hatch after two or three days of development. The carnivorous tadpoles are voracious, and transform in about six weeks. Tadpoles can reach 70 mm in length. Toadlets are 20 to 25 mm long and reach sexual maturity in two to three years.

Natural History: Great Basin Spadefoot Toads are nocturnal and may be abundant even though not often seen. During the day and dry weather, they will burrow into the soil and remain dormant (hibernation in the winter and aestivation in the summer), for as long as 7 or 8 months. They burrow backwards pushing the soil aside with the spades on their hind feet. They can burrow rapidly and thereby escape predators such as snakes, herons, Burrowing Owls and Coyotes. Their skin poisons are potent and bad tasting. They produce an odour resembling peanuts.

Status: Blue list.

References: Bragg (1965); Hovingh *et al.* (1985); Sadler and Elgar (1994); Hall *et al.* (1995); Waye and Shewchuk (1995).

2.1.6 Western Toad (*Bufo boreas*)

Description: The Western Toad has large oval-shaped parotid glands at the back of the head and reddish warts all over the back and legs. The skin is rough, colour variable, but there is a white or cream-coloured dorsal stripe. The gold-flecked eyes have horizontal pupils. Two enlarged, horny tubercles are present on the sole of each foot, and there is a large wart on each calf. The dorsal stripe can be weak or absent in very young toads. Young toads often have bright yellow foot tubercles.

Sexes: Males have longer arms and narrower heads than females. During the breeding season, males have smoother skin than females and develop black pads (nuptial pads) on their thumbs.

Range: Western North America from southern Alaska to northern Baja, west of the Rocky Mountains. This toad is found throughout British Columbia except for the extreme northeast. It is the only amphibian native to the Queen Charlotte Islands.

Habitat: Western Toads are common near ponds, marshes, and small lakes, but they may roam great distances through meadows, scrub, or forests. Outside of the breeding season they may be found buried in the soil, in burrows of other animals, or under CWD.

Reproduction: Breeding occurs in pools, small ponds, and lakes in the spring and early summer. They prefer shallow water with a sandy bottom. There is no advertisement call, and the sex ratio at breeding sites can be strongly in favour of males.

Eggs are laid in long strings attached to submerged vegetation. A single female can produce more than 12,000 eggs in a clutch which may extend for 10 m. Embryos hatch in three to ten days. Tadpoles develop rapidly and transform in about 6 to 8 weeks, depending on the temperature. Newly transformed toadlets are about 12 mm long. They reach sexual maturity in two to three years.

Natural History: Western toads are nocturnal except during the breeding season. They feed on a large variety of invertebrates and are preyed upon by garter snakes, ravens, crows, and occasionally mammals (Corn 1993; Brothers 1994). Their skin is relatively resistant to desiccation while the thin skin of the pelvic patch allows them to absorb moisture from the ground. When threatened, they may secrete a mild, bitter, white poison, especially from the parotid glands. Tadpoles are highly gregarious and form large schools. They swim along the margins of ponds or lakes feeding on algae and organic detritus.

Status: Yellow list. The Western Toad was very common in the western United States before about 1970, but it has since greatly declined or disappeared from several areas for unknown reasons. The populations in British Columbia have not been monitored. The use of terrestrial habitats is unstudied.

References: Mullally (1952); Lillywhite *et al.* (1973); Smits (1984); Smits and Crawford (1984); Olson (1989); Olson *et al*. (1986); Hews (1988); Carey (1993), Corn (1993), Blaustein *et al.* (1994); Brothers (1994).

2.1.7 Pacific Treefrog (*Hyla* (=*Pseudacris*) *regilla*)

Description: This is the only frog in British Columbia with prominent adhesive toe-pads. The skin is smooth. Skin colour is olive-brown to bright green, and individuals can change colour in a few minutes, but the dark eye stripe extending from the nose through the eye to the shoulder is always present. The belly and chest are creamy white. There is a fold of skin that crosses the breast between the front legs. The pupils are horizontal.

Sexes: Males have dark throat patches; females are often larger than males.

Range: From Baja to central British Columbia as far north as Quesnel. From the Pacific coast, east to western Montana and eastern Nevada, and in British Columbia to the Rocky Mountains. They are native to Vancouver Island, but have been introduced into the Queen Charlotte Islands on Graham Island.

Habitat: Outside of the breeding season they can be quite far from ponds in a variety of terrestrial habitats.

Reproduction: Breeding occurs in shallow ponds, roadside ditches, and wetlands in the spring and early summer. Males call in large, loud choruses, especially at night. Females lay 400 to 750 eggs in a series of small, irregular clusters attached to vegetation in shallow water. Each egg cluster contains 10 to 70 eggs. Embryos hatch in two to three weeks and tadpoles transform two to three months later during the summer. Newly transformed froglets are about 15 mm long and reach sexual maturity in about a year.

Natural History: A very common frog within its range, and coexists well with humans as long as shallow, unpolluted breeding ponds are available. They are good climbers and will sometimes sun themselves on exposed leaves. Individuals can change colour. This colour change is related to temperature and humidity rather than the background colour.

Status: Also known as the Pacific Chorus Frog. Common throughout its range.

References: Storm and Pimentel (1954); Brattsstrom and Warren (1955); Bradford (1989); Reimchen (1991); Weitzel and Panik (1993); Gardner (1995).

2.1.8 Striped Chorus Frog (*Pseudacris triseriata*)

Description: A small frog without toe-pads. Skin colour is variable, but there is a prominent dark stripe that extends from the snout, through the eye, and past the shoulder to the groin. There are usually three stripes on the back, but these are sometimes broken or replaced with spots.

Sexes: Males have dark, greenish-yellow throats and are somewhat smaller than females.

Range: East of the Rocky Mountains from Great Bear Lake to the Gulf of Mexico. In British Columbia, they are found primarily in the Peace River region.

Habitat: Except for the breeding season, adults are usually underground in underground burrows.

Reproduction: Males begin to call very early in the spring, even in ice-covered ponds or ditches. They may call continuously night and day during the breeding season. The eggs are laid in small clumps attached to vegetation. The tadpoles transform in about two months, and the froglets reach sexual maturity the following year.

Status: Yellow list.

References: Whitaker (1971); Smith (1983); Sredl and Collins (1991); Skelly (1995); Smith and van Buskirk (1995).

2.1.9 Red-legged Frog (*Rana aurora*)

Description: The Red-legged Frog is a brown frog with a dark mask and a whitish jaw stripe. The eyes are oriented outward. The back is usually covered by small black flecks and spots. The belly and undersides of the legs are bright red that appears to be coloured under the skin. Dorsolateral folds are present. Usually, there is green mottling in the groin. The hind legs are relatively long, and when adpressed along the body, the heel extends beyond the snout.

Sexes: Sexes are difficult to distinguish, although males have dark thumbs in the breeding season and are smaller than females.

Range: Southwest British Columbia, including Vancouver Island, through western Washington and Oregon to California and Baja.

Habitat: Outside of the breeding season, these frogs are highly terrestrial and can be found in forests far from standing water. They can occasionally be found inside decayed logs.

Reproduction: Breeding takes place early in the spring in shallow water in permanent ponds and swamps. This frog calls underwater and the calls are weak. A female lays 750 to 1300 eggs in a large (20 to 30 cm), loose gelatinous cluster which tends to deteriorate toward the end of embryonic development. Embryos develop and hatch after about four weeks of development, and the tadpoles transform after four or five months. Age to sexual maturity is probably three to four years.

Status: Yellow list.

References: Storm and Pimentel (1954); Licht (1969, 1971); Calef (1973); Hayes and Jennings (1986); Bury *et al.* 1991; Hovingh (1993).

2.1.10 Northern Leopard Frog (*Rana pipiens*)

Description: This is a medium-sized brown to green frog with distinctive spots. The spots are well-defined by light-coloured halos. The belly is white. A white stripe extends along the upper jaw. Distinct light-coloured dorsolateral folds are present from the head to the groin**.**

Sexes: Males have dark swollen thumbs in the breeding season. Females reach up to about 100 mm in length and males to about 80 mm.

Range: Leopard Frogs occur over much of North America but are absent from the southeast. Their distribution is spotty and populations have disappeared over large areas in recent decades.

Habitat: Although associated with ponds, lakes, and riparian areas, the Leopard Frog will forage far from standing or running water. They may be found in meadows or grassy fields, especially on wet days.

Reproduction: Breeding occurs in shallow water in the early spring, often before the ice has fully melted on ponds. Egg masses are oval or round, about 115 mm in diameter. The tadpoles transform in mid-summer into 25 mm long froglets. They take two to three years to reach sexual maturity.

Natural History: These frogs hibernate in the bottom of lakes or ponds, but do not burrow into the mud. They prey on a variety of invertebrates, but also take fish, other amphibians, snakes and birds. They are preyed upon by Bullfrogs, garter snakes, herons, and Raccoons.

Status: Red list.

References: Leclair and Castanet (1987); Werner (1992); Corn and Fogleman (1984); Gilbert *et al.* (1994).

2.1.11 Spotted Frog (*Rana pretiosa*)

Description: The Spotted Frog is a brown frog with upturned eyes and a light-coloured jaw stripe. The back is usually covered by small black flecks and spots. The belly and undersides of the legs are red or orange and appears to be “painted on”. Dorsolateral folds are present. Usually, there is no mottling in the groin. The hind legs are relatively short, and when adpressed along the body, the heel does not reach the snout.

Sexes: Sexes are difficult to distinguish, although males have dark thumbs in the breeding season and are smaller than females.

Range: Extreme southeast Alaska to Oregon, Wyoming and Utah. In British Columbia, between the Rocky Mountains and the Coast range, except for the Peace River region. They have not been reported from Vancouver Island.

Habitat: Almost always found near permanent water.

Reproduction: Breeding occurs in the early spring in permanent ponds and small lakes.

Natural History: Although primarily aquatic, Spotted Frogs sometimes forage in terrestrial habitats. They are active during the day.

Status: Red list on lower mainland, yellow list elsewhere. In the past 50 years, a dramatic reduction has occurred in Oregon, Washington, and other parts of its range.

References: Licht (1969, 1971, 1975a); Hovingh (1993); Cuellar (1994).

2.1.12 Wood Frog *(Rana sylvatica)*

Description: A small, brown or grey frog with a distinct black mask, and white underparts. They may be uniformly-coloured or have dark spots on the back. Some individuals have a bright white strip running down the middle of the back. Dorsolateral folds are present.

Sexes: Males and females are similar in appearance, although females are slightly larger than males.

Range: The Wood Frog is found farther north and is more widespread than any other amphibian in Canada. It is found from the northeastern United States across Canada to the Yukon and Alaska. In British Columbia, it is found east of the Coast Range Mountains.

Habitat: Although adult Wood Frogs are terrestrial and can be found in forests, meadows or muskeg, they are usually not found far from water.

Reproduction: Wood Frogs have a short breeding season in the early spring, often before ice has melted on ponds. Males call day and night during the breeding season. The eggs are laid in globular masses and may be attached to vegetation. The tadpoles transform by mid-summer.

Status: Yellow list.

References: Heatwole (1961); Nyman (1986); Berven (1988); Werner (1992); Layne (1995).

2.1.13 American Bullfrog (*Rana catesbeiana*)

Description: A large, robust, green or olive-brown frog, with white undersides. Dorsolateral folds are absent, but there is a conspicuous fold of skin that bends around the eardrum from the eye to the shoulder. There is a prominent sacral hump.

Tadpoles are green and can reach 153 mm in length.

Sexes: Males have bright yellow throats and large eardrums that exceed the eyes in diameter. In females, the eardrums are smaller than the eyes in diameter. When breeding, males have nuptial pads on the thumbs. Females are larger than males and have been known to attain a length of 200 mm.

Range: Bull frogs are native to eastern North America from Canada to the Gulf of Mexico. They are not native west of the Rocky Mountains, but have been introduced at many locations in the west. In British Columbia, they have been introduced in the Okanagan, Fraser Valley, and on Vancouver Island.

Habitat: Bullfrogs are highly aquatic and rarely leave the vegetated edges of the permanent ponds and lakes in which they breed.

Reproduction: The Bullfrog has a prolonged breeding season that extends through most of the summer. Breeding takes place in ponds and lakes. The call is loud and distinctive. Eggs are laid in large (60 cm diameter), floating masses. The mass eventually sinks to underlying vegetation before hatching. Tadpoles take at least two years to develop, and overwinter in the bottom mud. Newly transformed froglets are about 50 mm long.

Natural History: Adult males are highly territorial. Bull frogs are highly voracious. They usually eat invertebrates, but have been know to take birds, mice, fish, reptiles, and other frogs.

Status: This frog may have been introduced as pets or as stock for frog farms. It is thought that the disappearance of other anurans is at least partly the result of the introduction of Bullfrogs.

References: Hayes and Jennings (1986); Lefcort and Eiger (1993); Shirose *et al.* (1993); Werner (1991, 1994); Werner and McPeek (1994); Anholt and Werner (1995); Shirose and Brooks (1995); Werner *et al.* (1995); Werner and Anholt (1996).

2.1.14 Green Frog *(Rana clamitans)*

Description: This is a medium-sized green to brown frog with a bright green stripe on the upper jaw. The undersides are white. Dark bars are present on the legs. The eardrum is conspicuous. Distinct dorsolateral folds are present, but do not reach the groin**.**

Tadpoles are green and can reach 84 mm in length.

Sexes: Males have bright yellow throats and large eardrums that are twice the size of the eyes in diameter. In females, the eardrums are the same size as the eyes. When breeding, males have nuptial pads on the thumbs. Females are larger than males and have been known to attain a length of 111 mm.

Range: Green Frogs are native to eastern North America from Canada to the Gulf of Mexico. They are not native west of the Rocky Mountains, but have been introduced at several locations in the west. In British Columbia, they have been introduced in the Okanagan, Fraser Valley, and on Vancouver Island.

Habitat: Permanent pond and lakes. The Green Frog is a highly aquatic frog, but will also forage through meadows or grassy fields in wet weather.

Reproduction: Green Frogs have a long breeding season that extends from late spring to early summer. Females lay between 1,000 to 5,000 eggs in loose, floating masses in permanent ponds and lakes. Development is rapid, and tadpoles hatch in less than a week. Tadpoles feed on algae and other vegetation. They take one year to develop, and overwinter in the bottom mud. Newly transformed froglets are about 30 mm long.

Natural History: Males establish breeding territories. Prey is usually insects and other invertebrates, but they will also eat tadpoles and small frogs. They are eaten by a variety of snakes, birds, and mammals.

Status: This frog may have been introduced as pets, fish bait, or as stock for frog farms.

References: Hamilton (1948); Martof (1953,1956); Werner (1991, 1994); Warken (1992); Werner and McPeek (1994); Shirose and Brooks (1995); Werner *et al.* (1995); Werner and Anholt (1996).

2.1.15 Painted Turtle (*Chrysemys picta*)

Description: This freshwater turtle has a low carapace, with olive, yellowish, or red markings. It has yellow lines on the head and limbs, and a red blotch or bar behind the eye. The plastron is red except for a large black central blotch with branches extending along the scute margins.

Sexes: Males have very long claws on forefeet, and a more concave plastron than females. Females are larger than males.

Range: From southern Canada (Atlantic to Pacific) to the Gulf of Mexico. Absent from the southwestern United States, the Great Basin, and the Pacific coast. Found across southern British Columbia, including Vancouver Island. Coastal populations may be the result of introductions.

Habitat: Ponds, lakes and streams with muddy bottoms, slow-moving water, and aquatic plants.

Reproduction: Eggs are laid in terrestrial nests in the early summer. Hatchlings generally overwinter in the nests, although there are reports of fall emergence.

Natural History: Mostly aquatic, but movements of several hundred meters on land are not uncommon. Homing up to three kilometers has been recorded.

Status: Blue list.

References: Macartney and Gregory (1985); Wilbur and Morin (1988); St. Clair (1989); Lindemann (1990); Crawford (1991); Congdon *et al.* (1992); Etchberger *et al.* (1992); Frazer *et al*. (1993); Cagle *et al.* (1994); Janzen (1994); St. Clair *et al.* (1994); Lefevre and Brooks (1995)

2.2 Considerations for Inventory

2.2.1 Movements and behaviour

Some species are more mobile than others. An understanding of the behaviour of the species to be surveyed is essential for a successful survey. Questions that should be asked include: a) at what time of the day is the species most active? Surveys for nocturnal species, for example, are most effective when done from dusk onwards; b) Does the species migrate to and from breeding areas, and if so, how far? The timing and extent of movement will influence the ease of locating and/or trapping certain species, and several different methods may have to be employed at different times of the year. If a species uses the same habitat year round, and for all activities, one method may suffice. Unfortunately, many aspects of the natural history of these species are poorly known.

Most amphibians and reptiles are secretive and therefore difficult to find. They are generally active on the surface only when foraging, or when migrating to and from breeding areas. For the rest of the time, most remain hidden, and some fossorial species may spend days or even months in underground burrows. Suitable survey techniques are designed to find species when they are active and are on or near the surface.

2.2.2 Sensitivity to climatic conditions

Amphibians obtain heat mainly from the external environment (ectothermy) so their daily and seasonal activity levels are constrained by prevailing temperatures. Most adult amphibians depend primarily on the lungs for respiratory gas exchange, but significant gas exchange can also occur across their permeable skins. As a result of this transcutaneous gas exchange, their skins are very permeable to water, making amphibians susceptible to desiccation (Shoemaker *et al.* 1992). Consequently, amphibians on land tend to become more active after a rainfall. In dry environments or dry seasons, activity may temporarily cease altogether. Therefore, weather conditions strongly influence amphibian activity, and dictate when surveys should be carried out most effectively.

Reptiles are also ectotherms, but because they are covered by dry scales that are impervious to water, they are very tolerant of dry conditions. They breathe entirely with lungs and have no larval stage. When conditions are cold and wet, most reptiles are not active and are difficult to locate. The only reptile covered by this manual is the Painted Turtle (*Chrysemys picta*), which can been seen basking on warm sunny days, usually on logs in ponds and lakes, but also on the surface of the water. Again, weather conditions will dictate when surveys should be carried out most effectively.

2.2.3 Complexity of life cycles

A complete understanding of a species' life cycle is essential for an effective survey. The amphibians described in this manual have a biphasic life cycle, and many species require a number of habitats to complete their life cycles successfully. Typically, they require an aquatic habitat for breeding, a foraging ground which is often terrestrial, and a place to hibernate. These amphibians can survive only if all three habitats are available and movement between them is not restricted. Similarly, Painted Turtles require aquatic habitats for foraging and terrestrial habitats for basking and laying eggs.

The timing of metamorphosis varies among, and within amphibian species at different elevations, geographical locations, and from year to year. For many of the species in this inventory group, little is known about how these factors affect their life cycles in British Columbia.

2.2.4 Natural fluctuations

Many amphibians and reptiles exhibit wide natural fluctuations in numbers from year to year. Reports are common of frogs being abundant around a given pond one year, but not seen there again (or only in very low numbers) for many years thereafter. These natural fluctuations are not clearly understood, but tend to be cyclical and may be weather related (Duellman and Trueb 1986). Natural, short-term fluctuations can mask long-term population changes (Pechmann *et al.* 1991, Pechmann and Wilber 1994), so sites should be monitored over a number of years, even if they yield little data in some years. Thus, the concern as to whether or not perceived declines of many species are the result of human-influenced disturbance can only be assessed by long-term monitoring (Pechmann *et al.* 1991; Pechmann and Wilber 1994; Blaustein *et al.* (1994); Blaustein and Wake 1995).

2.2.5 Geographical distribution and habitat

Heavily vegetated habitats in wetter parts of the province are more difficult to search intensively than are drier, more sparsely vegetated areas. Large areas of British Columbia are remote, therefore accessibility of an area of interest is also an important logistical consideration when choosing a monitoring method.

The presently known geographical distributions of the species in this inventory group are only preliminary for most, since they are based more on incidental records than on deliberate systematic searches. Thus, one should not assume that range maps show the full extent of a species' distribution. Also, a continuous distribution does not imply that a species is found throughout its range. For example, the Western Toad occurs throughout British Columbia, yet it is rare or absent at many locations within its' range.

2.2.6 Where to look for amphibians

The following discussion (Corkran and Thoms, 1996) may also be helpful when planning surveys or during sampling:

- "Salamander larvae are often concealed in the mud or debris at the bottom of the pond or they are in aquatic vegetation, during the day in most weather conditions. At night or on overcast days they may be visible on the pond bottom.
- Metamorphosed juvenile and adult salamanders usually remain underground and undetectable. During the breeding season, adults are often in ponds or under logs and debris on land near ponds. At other times of the year when the soil is moist, some juveniles and adults remain near ponds under logs and debris. In late summer, when many temporary ponds are drying, recently metamorphosed juveniles are often found under objects around the edges.
- Frog and toad tadpoles tend to cluster in the warmest available water. During the day this is usually in shallow water, frequently with a southern exposure. Whenever surface water is cooler than deeper water, tadpoles may congregate at the pond bottom or under insulating debris.

- Juvenile and adult frogs are found either on the shoreline, at the water surface, or in moist vegetation on the shore. Frogs bask in the morning sun. When the ambient temperature is cold or when it is windy, frogs may be found at the bottom of the pond. Active temperature range varies with species.
- Western Toads remain underground or in sheltered areas away from ponds. Adults gather briefly in ponds for breeding. In late summer, when many temporary ponds are drying, recently metamorphosed juveniles are often found under objects around the edges. Juvenile toads are also found dispersing in huge numbers through shore vegetation.
- Spadefoots remain underground except during nights after rain."

3. Protocols

The rationale for using standard techniques in inventory and monitoring work is that the results of different studies are much more likely to be comparable (Heyer *et al.* 1994:17). However, simply using the same methods will not guarantee that the data gathered are equivalent. This is partly because the ecological role of individuals and species is context-dependent. Local weather conditions and topography, intrinsic population characteristics, and chance events can cause population fluctuations from year to year. Life history characteristics and the ecological role of a species can vary temporally, geographically, and with the presence or absence of other species with which it interacts. Also, the efficiency of a particular method of sampling can vary with the physical conditions of the site, weather conditions, and the experience of the collectors. Thus, caution should be exercised when attempting to compare results among studies, sites, or through time.

The objectives of the study, the urgency of the management decisions to be made, and cost effectiveness will dictate the methods to be used and the number and type of replicate samples required. Often, several different methods may be needed to address different aspects of a study. As new information is obtained, new questions and hypotheses may be formed, the objectives redefined and the methods modified. Typically, there will be a trade-off between the amount of time and money an investigator can devote to a particular plot or site and the number of replicate plots or sites that it is possible to establish (Hairston 1989).

The first step in any inventory project is to clearly state the objectives of the study. The objectives addressed by the methods presented in this manual include: verification of presence, assessment of species richness, estimation of relative abundance, determination of density, and documentation of habitat use. Because amphibians have both terrestrial and aquatic phases, both habitats sometimes need to be sampled. Cover boards, pitfall traps, and quadrat sampling are suitable for terrestrial habitats, while larval surveys focus on aquatic habitats. Systematic surveys, breeding surveys and auditory surveys are applicable to both habitats. Over the year, repeated surveys of both terrestrial and aquatic habitats may be needed to provide the required data.

Table 2 presents the recommended methodologies on a species by species basis for three levels of inventory: presence/not detected (possible), relative abundance, and absolute abundance.

Table 2. Applicability of described herpetofauna inventory methods to individual species in the inventory group.

Species	**Inventory Methods**		
	Presence/ Not detected (possible)	**Relative Abundance**	**Absolute Abundance**
Tiger Salamander	• Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall and funnel traps	• Mark-recapture
Northwestern Salamander	• Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall and funnel traps	• Mark-recapture
Long-toed Salamander	• Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall and funnel traps	• Mark-recapture
Rough-skinned Newt	• Road survey • Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall and funnel traps	• Mark-recapture
Great Basin Spadefoot Toad	• Auditory survey • Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall traps	• Mark-recapture
Western Toad	• Road survey • Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall and funnel traps	• Mark-recapture
Pacific Treefrog	• Auditory survey • Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall traps	• Mark-recapture
Striped Chorus Frog	• Auditory survey • Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall traps	• Mark-recapture

Species	Inventory Methods		
	Presence/ Not detected (possible)	Relative Abundance	Absolute Abundance
Red-legged Frog	• Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall traps	• Mark-recapture
American Bullfrog	• Auditory survey • Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall traps	• Mark-recapture
Green Frog	• Auditory survey • Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall traps	• Mark-recapture
Northern Leopard Frog	• Auditory survey • Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall traps	• Mark-recapture
Spotted Frog	• Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall traps	• Mark-recapture
Wood Frog	• Auditory survey • Time-constrained search • Systematic survey	• Systematic survey • Larval survey • Pitfall traps	• Mark-recapture
Painted Turtle	• Time-constrained search • Systematic survey	• Systematic survey • Floating pitfall traps	• Mark-recapture

3.1 Sampling Standards

3.1.1 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).*

Although they may be inappropriate to describe fully aquatic habitats, ecosystem field forms may still be used to the describe terrestrial habitats of amphibians and shoreline portions of a pond habitat, such as those delineated by habitat strata in recommended protocols below.

3.1.2 Time of survey

If the results of surveys from different studies are to be comparable, the timing of breeding and daily activity cycles of the target species must be considered. For this inventory group, these are species-specific and vary geographically among populations of the same species. Reference to the primary literature and field guides will provide general guidelines, but details for most species in most areas are unknown.

In general, the best time to survey for amphibians is after a rainfall, during wet weather in the spring or fall. The start of the survey period should be dictated by the probable time of breeding of the species in the area of interest.

3.1.3 Marking and Identification

Anyone who is handling and/or marking amphibians or reptiles should be familiar with provincial protocols outlined in the manual, *Live Animal Capture and Handling Guidelines for Wildlife Mammals, Birds, Amphibians, and Reptiles* (No. 3).

Most species of amphibians in British Columbia do not have colour patterns or other external characteristics that allow individuals to be identified upon recapture, so studies requiring this information must rely on marking. For amphibians, such marking is often problematic due to their small size and smooth, delicate skin. Generally, the most practical method for marking more than a few individuals is toe-clipping, and this has been used in the vast majority of studies in which individual-specific marks were required. However, because toes can regenerate rapidly, the marks are not necessarily permanent. In addition, virtually no work has been done on the effects of toe-clipping on the survival, behaviour and recapture rates of amphibians. Some evidence suggests that adverse effects may be significant (Nishikawa and Service 1988), and Clarke (1972) has shown that toe-clipping can reduce survivorship in Fowler's Toad (*Bufo woodhousei fowleri*). Golay and Durrer (1994) reported that toe-clipping of natterjack toads can lead to infection and necrosis, sometimes involving the entire limb. Nevertheless, toe-clipping is the recommended method for most amphibians.

Many alternative marking schemes are available (Donnelly *et al*. 1994) but are not without serious drawbacks. Tags are time-consuming to attach, may harm the animals, and cannot be used with many of the smaller species. Brands (tattoo, heat, silver nitrate, and freeze) and most marking schemes using fluorescent pigments have similar problems and are not widely used by herpetologists. Methods for marking amphibian larvae include fin-clipping, and staining with dyes or fluorescent pigments. Marking by injection of fluorescent elastomere dyes under the skin is a technique which is currently under development (T. Davis and K. Ovaska, pers. comm.). Pattern mapping, in which colour patterns, scars and other features are used to identify individuals, is appropriate for a few species (e.g., Tiger Salamander), but relatively few individuals can be identified, patterns can change over time, and the method is prone to observer bias. Nevertheless, it may be useful in certain circumstances (see Donnelly *et al*. 1994). Rice and Taylor (1993) describe a waistband to mark anurans for long-distance identification in short-term studies.

PIT tags (passive integrated transponders) are radio-frequency identification tags about the size of a grain of rice. Each tag has a unique code that can be read with a portable scanner. PIT tags are usually implanted in the body cavity with a modified syringe. To avoid damage to the internal organs, Donnelly *et al*. (1994) recommends inserting PIT tags into the dorsal lymph sac rather than intrabdominally. PIT tags are not practical for larvae and smaller amphibians, are expensive, and may be less reliable than generally presumed (Germano and Williams 1993).

Turtles are relatively easy to mark and a variety of methods including the attachment of tags and branding, painting, notching or engraving the carapace (see reviews by Ferner 1979 and Plummer 1979). Shell notching or engraving are most commonly used (Mitchell 1988) and that is the method recommended here.

Ferner (1979) and Jones (1986), review marking amphibians and reptiles, and Donnelly *et al.* (1994) review marking amphibians. Radioactive tagging is reviewed by Ashton (1994).

Toe-clipping

Generally, the most practical method for marking more than a few individuals is toe-clipping. Because it is easy to do, fast, and inexpensive, it is by far the most common method of marking small amphibians. However, little work has been done on the effects of toe-clipping on the survival, behaviour and recapture rates of salamanders. A discussion of toe-clipping and ethical issues appears in the March 1995 issue of FROGLOG.

To mark salamanders , toads, and frogs individually, two to four toes are removed with small, good quality scissors. Generally, no more than three toes are removed, but never more than one toe from each foot. Removing two toes is optimal, because a single toe can be occasionally lost by accident or attempted predation, and a minimum number of toes cut should minimize any adverse effects caused by the procedure. An inexpensive head mounted magnifier (e.g., Magni-focuser®, Edroy Products Co., Inc., Nyack, New York) will make clipping and reading the marks easier. After the toes are clipped, the code should be read back to the data collector to ensure that the mark corresponds to what is recorded on the data sheet. It is easy to become confused as to orientation and order when toe-clipping. After finishing with each individual, the scissors should be dipped in 95% ethanol to reduce the chance of transmitting infections between salamanders, and the toes treated with the antibiotic Bactine® (Martin and Hong 1991; Donnelly *et al.* 1994).

The choice of a coding system is largely a matter of personal taste and experience, but it is desirable to use a system that is simple and easily recorded. Several coding schemes are presented by Donnelly *et al.* (1994). The coding scheme presented here will be used as the standard coding system. It is a simple symbolic coding scheme and does not require mental addition and uses a single numeric character per foot (Figure 1). Each mark is of the form 0000 where each character place corresponds to a particular foot. Numbers correspond to particular toes. No more than one toe from each foot should be excised. The code is read from the left front foot to the left back foot, to the right front foot and finally to the right back foot. Toes are counted from proximal to distal and a dorsal view is used to reduce struggling. Thus, 0320 represents toes number three on the left hind foot and number 2 on the right forefoot. For most studies, only two and three-toe marks will be needed. To avoid using the same code twice, a sheet containing all the codes should be prepared, and codes checked off as they are used. Additional numbers may be used to indicate unusual marks (e.g., 5 = foot missing; 6 = leg missing; 7 = 2 or more toes missing; 8 = toes fused; 9 = see comments). Toes that may have a function in feeding or mating should not be excised.

Toe-clipping should not be used for the Painted Turtle.

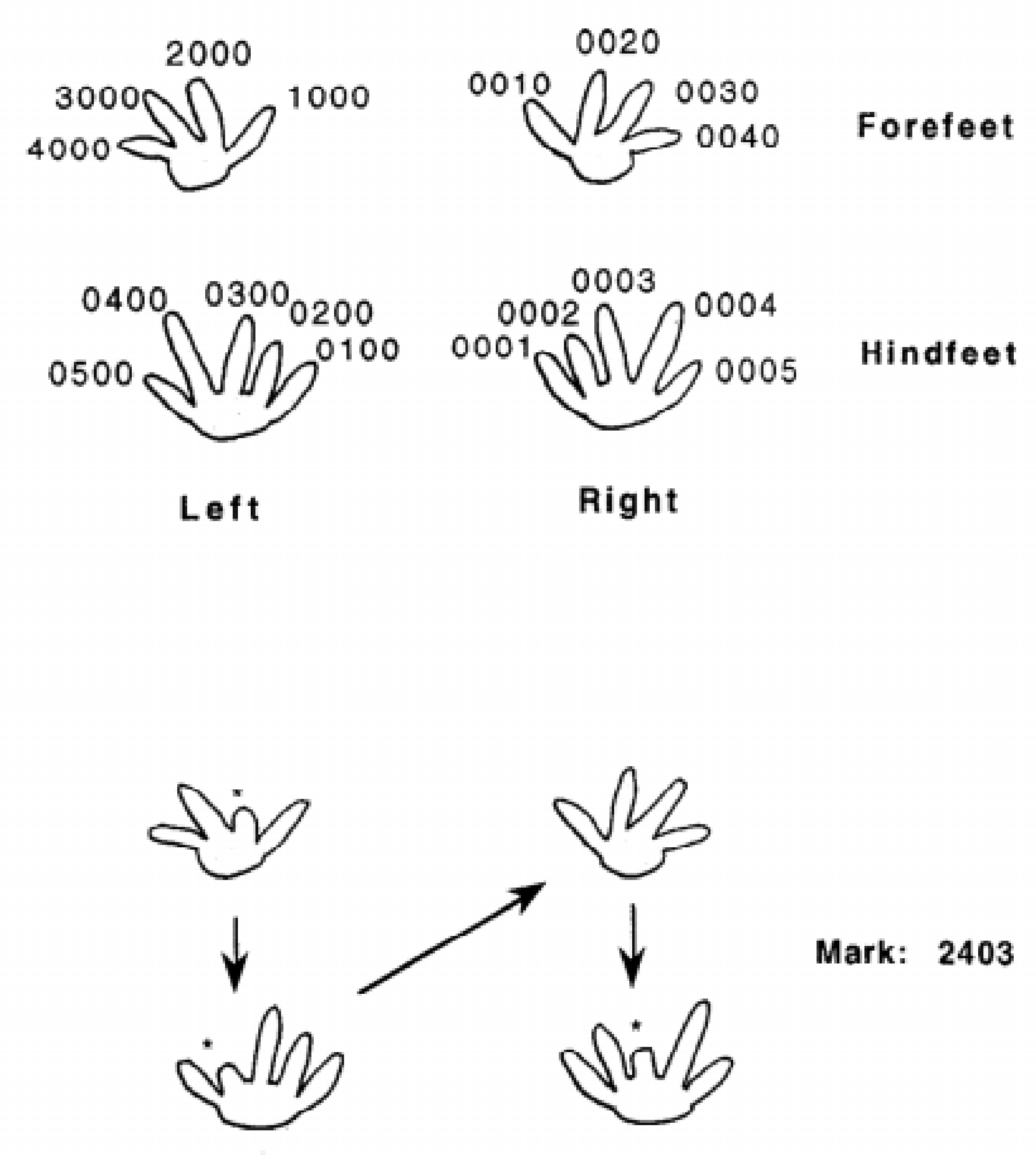

Figure 1. A symbolic coding scheme for toe-clipping.

The code is read from the left front foot to left back foot to right front foot to right back foot. At lower left, an (*) marks toes that have been clipped; this mark reads 2403. The number of toes, and which toes can be clipped, vary among species.

Marking the Painted Turtle

Painted Turtles are marked by filing notches in marginal scutes (St. Clair 1989). This is best done with a small square file. Marks are permanent. The marking code (Figure 2) is from Macartney and Gregory (1985) which was based on the method of Cagle (1939).

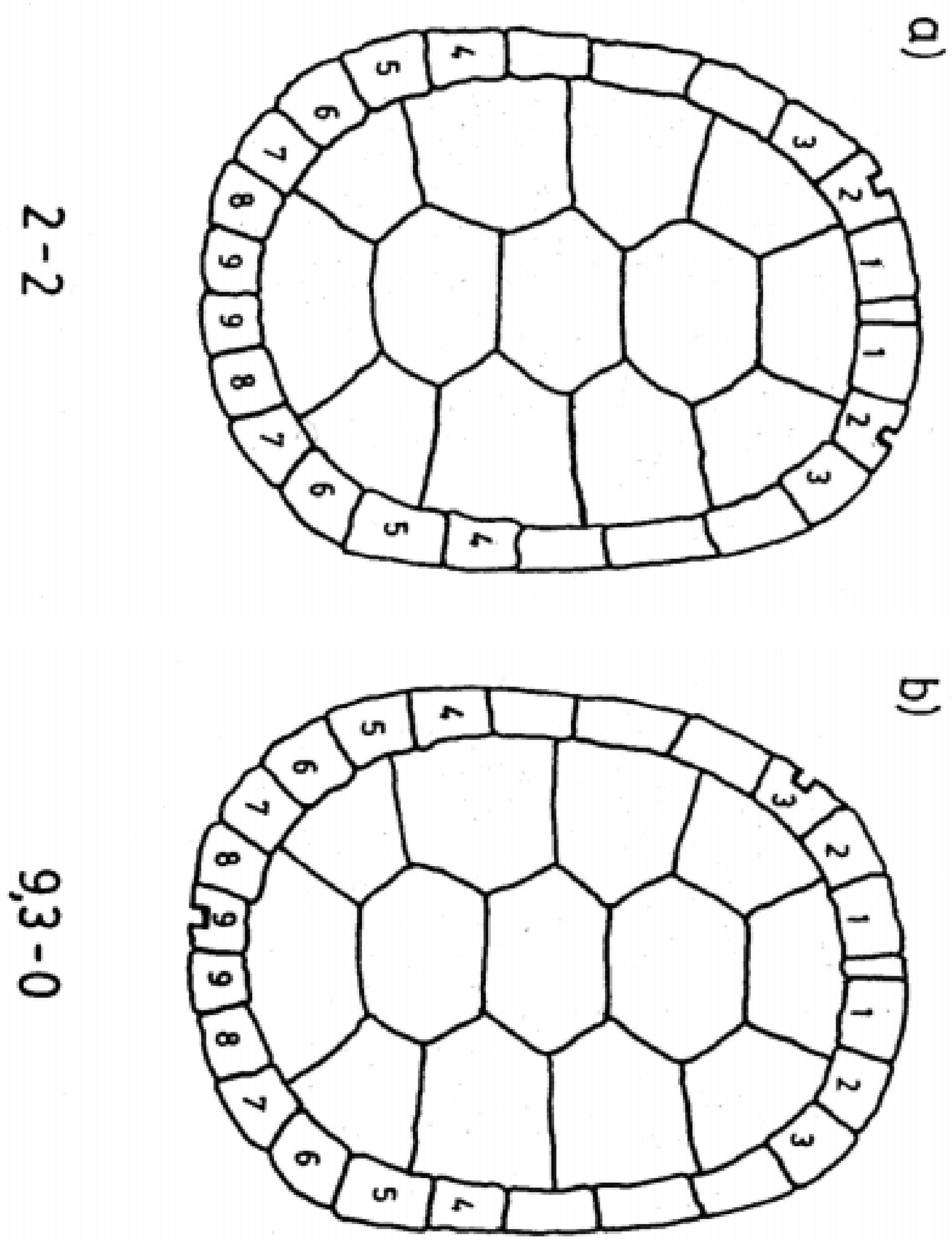

Figure 2. Carapace of a painted turtle showing marking scheme (from Macartney and Gregory 1985).

3.1.4 Measurements

Weight

- Most amphibians may be weighed to the nearest 0.1 g in a plastic bag with a 10 g or 50 g Pesola® spring scale. The scale may be adjusted to zero with the plastic bag empty, but this should be checked frequently. These scales are very accurate in still air, but a wind screen is needed when the air is moving. A clear plastic jar is a convenient wind screen, but the plastic bag should not touch the sides of the jar (Fellers *et al.* 1994). When it is raining, water clings to the bag thereby increasing its weight, so it can be time-consuming and difficult to get an accurate reading.

Length

- For salamanders, snout-vent length (SVL) is generally preferred over total length because tails can be partially missing and are difficult to measure on live animals. Typically, SVL is measured to the nearest 0.1 mm with a vernier caliper. The salamander can be held against the first two fingers of the left hand by the thumb and the caliper can be operated with the right hand. It is important to hold the salamander so that the vertebral column is straight. Too firm a grip will cause the salamander to struggle, and some practice is needed to develop the technique. The salamander will also struggle if turned ventral side up, so the anterior end of the vent is estimated relative to the hind limb. Alternatively, the salamander can be restrained inside a plastic bag or a Plexiglas® and sponge device described by Wise and Buchanan (1992). Some inaccuracies are inevitable as the salamander will attempt to contort its body, and efforts should be made to ensure that the vertebral column is straight. To assess precision, repeated measurements should be made on a series of live specimens, and to assess accuracy these should be checked against measurements taken when the animals are anaesthetized or dead.
- Some species (e.g., Rough-skinned Newt and Northwestern Salamander) can be held against a ruler for the measurement of SVL.
- SVL is measured from the tip of the snout to the anterior end of the vent. Some researchers prefer the posterior end, as it separates body length from tail length, the entire vent region being part of the body (Leonard *et al.* 1993: 163). However, the measurement is frequently interpreted as snout-*to*-vent length, so the measurement is taken to the anterior end of the vent. This can be considered standard (Stebbins 1985:3; Heyer *et al.* 1994:276). However, care must still be taken when comparing SVL measurements from different studies.
- For frogs - the length of a frog is measured most easily using a ruler with a stop at one end, constructed by nailing and gluing a 5x5 cm stop to one end of a 20 cm x 5 cm wooden base (Fellers and Freel 1995). A flat plastic 15 cm ruler is glued to the center of the wooden base with the metric scale beginning at the stop. Attach the ruler with a good, waterproof glue. When measuring the frog, hold its head up against the stop and then gently press down on the vertebral column and pelvic girdle so that the frog's back is parallel with the ruler. Measure the distance from the tip of the nose to the vent (base of the hind legs). Calipers can also be used to take this measurement.

Sex

- The sex of many adult amphibians can readily be determined using standard field guides which describe distinguishing characteristics such as swollen thumbs or dark throats of male frogs (Fellers and Freel 1995).
- Section 2.1 (Natural History) gives methods for determining the sexes of adults of each of the target species.

3.1.5 Collection and Voucher Specimens

Collecting details and preparation of voucher specimens adapted from Nussbaum *et al.* 1983 and Corn and Bury 1990. Anyone collecting voucher specimens in British Columbia with standards for voucher collection, outlined in manual No. 4 in this series.

For Collecting:

NOTE: A permit must be obtained from the local Ministry of Environment office before any collecting can occur. Collecting is discouraged and should only be done to confirm a record, or where a species was found in a new location. Verify rare species or range extensions with photographs, tape recordings of the call, or have at least two other experienced herpetologists identify the specimen.

- A deep, finely sewn, cloth or canvas bags that can be tied at the top is useful for large frogs and reptiles.
- Place moist paper towel, moss or damp leaves in the bottom to keep animals from dehydrating.
- Smaller containers such as bottles with screen-top lids or plastic freezer cartons with holes in the top work well for salamanders and small frogs.
- All specimens should be kept cool (4-18 C).
- Alternatively, plastic bags can be used.
- Label fully with collecting data, full locality, time, date, collector, and reference to data sheet.

Voucher Specimens:

- Prior to study, check with repository as to collecting requirements.
- Kill specimens in a solution of chlorotene, which is a saturated hydrous chlorobutanol in 95% ethanol.
- Dilute the solution - 2 ml chlorotene to 570 ml water.
- After the animal is dead, weigh, measure and attach a tag with collecting number and detailed location information to right hind leg.
- Preserve specimen in 10% formalin buffered with 4 g of baking soda or sodium bicarbonate/400 ml.

Individuals of each species can be deposited in repository (museum or university) if they are collected from a previously unknown site.

3.1.6 Equipment

Dipnet and "Leopard Frog Net" Construction (after Pedlar 1991)

Dipnet construction.

- A handle made of a flexible material, such as a sapling, is much less apt to break than if made of doweling.
- The handle should be proportioned to the height of the user and come up to her/his eye level. A longer handle extends the user's reach when sweeping or picking up frogs or turtles from the water surface. However, a long handle may be unwieldy in brush. A short handle is useful for close-up work.
- The handle is tapered from about 35 mm diameter at the frame to about 25 mm at the other end. The taper puts the greatest strength near the frame where it is needed.
- The net handle may be notched every 10 cm so that it can be used to measure the water depth.
- The net frame is made of 6.5 mm steel rod, 30 cm in diameter, circular in shape, and attached to the handle by a ferrule or two hose clamps.
- The net bag should be of strong, woven, nylon mesh, 45 cm deep, and attached to the frame by a canvas sleeve. Finer meshes capture small animals but are easily clogged by detritus. Coarser meshes move through the water more easily. (See Heyer *et al.* 1994 for suitable net sizes). Smaller net frames may be useful for picking off individuals from vegetation and larger ones for catching swimming animals in clear water.

  Note: The "ace-oval" weave shown in the illustration (following page) is not the strongest weave. The user should check local suppliers for the selection of meshes available.

"Leopard Frog Net"

- A light net, similar to an entomologist's net, with a shorter, more slender, handle.
- The frame is made of a lighter, more flexible, spring steel than for a dipnet.
- The bag is deeper and made of a lighter material than a dipnet.
- The net bag is brought down over the frog on land and the frog jumps into it. The bag must be kept as dry as possible, otherwise the frog cannot jump into it.

Construction of Pitfall Traps, Funnel Traps, and Drift Fences

Pitfall trap construction

For salamanders, a pitfall trap can be made from 4-liter ice cream bucket with a funnel made from a 500 g yogurt tub. The yogurt tub, with the bottom cut off, is inserted into a hole cut in the lid of the ice cream bucket. Terrestrial salamanders are unable to escape from this trap, but can easily climb out if there is no funnel in place, in spite of the horizontal surface formed by the lid of the 4-liter bucket (T. Davis, unpubl. data). To reduce desiccation and provide cover, a small amount of wet moss (or a small sponge) can be placed in the trap, but not so much as to afford a bridge to the funnel or a refuge from the collector. A piece of wood or foam may be placed in the bottom of the trap to act as a raft in the event that the trap collects rain water. When not in use, traps can be covered with the lid from the yogurt tub funnel.

For frogs, deeper buckets are needed and various designs are possible. Tin cans taped together with duck tape have been used for traps (Corn 1994). A trap can also be made from a 2-liter water bottle or an 11.4 liter ice cream bucket. Funnels are generally recommended. Whatever design is used, it should be tested to ensure that the target species cannot escape once they are in the trap.

A wood or bark cover raised above pitfall traps may improve capture rates and may help protect the trapped animals from desiccation and predation by birds. When the traps are checked, the under surface of the lid, the sides of the funnel (if any) and sides of the trap should checked for amphibians.

Funnel trap construction

Funnel traps consist of window screen or hardware cloth tubes with inwardly directed funnel-shaped openings, usually at both ends. Storm and Pimentel (1954) describe a trap made of window screen that was about 14 cm in diameter and 35 cm long. It successfully caught several species of amphibians. Corn (1994) recommends a larger trap made of window screen, 25 cm in diameter and 76 cm long. Other designs are shown in Jones (1986) including simple jar and can funnel traps which are made from a jar or can and a simple cone of window screen. Experimentation is required to determine the optimum size. Funnel traps can be used on land with drift fences, or in combination with pitfall traps and drift fences. They can also be used in aquatic habitats.

In ponds, commercially available minnow traps without bait work well for *A. gracile* larvae if the opening are enlarged (T. Garner, pers. comm.). Bait is unnecessary. Unbaited minnow traps will also capture *R. aurora* and *H. regilla* tadpoles, and adult *T. granulosa* (V. Hawkes, pers. comm.). Minnow traps baited with liver and illuminated with a light stick will capture *A. tigrinum* (S. Orchard, pers. comm.).

“Portable” (spring-loaded) lightweight plastic mesh funnel traps (MT4 Collapsible Minnow Trap) are available from Nylon Net Co. (Tennessee); 1-800-238-7529.

Drift fence construction

Drift fences can be made from a variety of materials including plastic, tar paper and window screen, but the preferred material is 50 cm wide aluminium flashing (Corn 1994). The advantages of aluminium flashing are that it is relatively self-supporting and requires few stakes, is very durable, and has a smooth surface which may discourage climbing. The flashing is placed in a 20 cm-deep trench and soil is used as backfill. The trench can be dug with a shovel or mattock, but large roots can make digging very difficult and an axe may be needed to cut through them. Where roots are a serious problem, 6 or 10 mil plastic sheeting can be used instead of flashing and the lower edge stapled to the roots where necessary (Davis 1996a). Plastic sheeting requires a stake about every two meters. Drift fences are labour-intensive to install and it require one day for 4-6 people to install 3-6 arrays (Corn 1994).

Murphy (1993) describes a more complex fence for treefrogs.

3.1.7 Survey Design Hierarchy

Surveys of pond-breeding amphibians follow a survey design hierarchy which is structured similarly for 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 systematic pond survey of amphibians. Any survey, including others outlined in this manual, which follows this design will lend itself well to standard methods and RIC data forms.

Figure 3. RIC species inventory survey design hierarchy with examples.

3.2 Inventory Surveys

The list and table below outlines the type of surveys that are used for inventorying pond breeding amphibians and the painted turtle for the various survey intensities. Whenever possible survey protocol was modeled after Olson *et al.,* 1997 in order to methods used in British Columbia be consistent with those in other areas of the Pacific Northwest. The survey methods below have been recommended by wildlife biologists and approved by the Resources Inventory Committee.

The following survey method descriptions are given below to provide information on why and when a particular method is used.

Auditory Survey:

- *Species?* Calling species of frogs only
- *Level of Intensity?* Presence/Not detected and Relative Abundance
- *Why?*
    - works well when focal species is most easily detected by call
    - useful in areas that are difficult to search visually
    - useful to determine breeding habitat or microhabitat use
    - useful to determine breeding phenology of species
- *When?* During breeding season
- *Where?* Pond habitat, especially species rich areas and where frogs occupy all strata and many microhabitats
- *Other.* Can be used with Road Survey

Road Survey:

- *Species?* Amphibians only (not suitable for Painted Turtle)
- *Level of Intensity?* Presence/Not detected
- *Why?* Works well in areas where there are migrations of animals after a heavy rainfall toward or away from breeding ponds.
- *When?* Usually in spring to coincide with breeding season because mass migrations are more likely, but can also be done during fall migration.
- *Where?* Roads next to pond habitat
- *Other.* Can be used with Auditory Survey (surveying roadways in between calling stations).

Time-constrained Search:

- *Species?* All amphibians and Painted Turtle.
- *Level of Intensity?* Presence/Not detected
- *Why?*
    - useful when a lot of study areas must be covered
    - often the best way to survey species that are trap shy, or rare
    - useful as a preliminary approach, an informal opportunistic search

- *When?* -
    - usually during breeding season because animals are easier to detect due to increased activity
    - on sunny summer days for Painted Turtles when they are usually basking
- *Where?* Pond (or riparian) habitat
- *Other?* Depending on results, a more intensive Systematic Survey should be performed

Systematic Survey:
- *Species?* Amphibians and Painted Turtle
- *Level of Intensity?* Presence/Not detected and Relative Abundance
- *Why?*
    - very thorough survey because everything seen and heard is recorded.
    - required if a Time Constrained Search produces unsatisfactory results.
- *When?* -
    - usually in spring to coincide with breeding season for amphibians
    - on sunny summer days for Painted Turtles
    - must coincide with previous surveys if the objectives include the need to monitor populations over time
- *Where?* .Pond (or riparian) habitat; most effective at breeding sites since that is where animals are most conspicuous
- *Other?* Performed if Time Constrained Search produces unsatisfactory results.

Larval Survey:
- *Species?* Amphibians only.
- Level of Intensity*? Relative Abundance and Absolute Abundance*
- *Why?*
    - may be easier to detect species when they are conspicuous and discretely distributed during aquatic phase of life cycle
    - used when objectives include an assessment of productivity and/larval population size
- *When?* During the breeding season
- *Where?* Pond habitat

Capture Surveys:
- *Species?* Amphibians and Painted Turtle
- *Level of Intensity?* Relative Abundance
- *Why?*
    - can be used to detect the presence of rare/elusive species
    - yields data on morphometrics and vitality.
- *When?* Does not have to be done in the breeding season
- *Where?* Terrestrial habitat for amphibians; aquatic habitat for Painted Turtle
- *Other?* Pitfall trap and funnel traps in conjunction with drift fences used for amphibians; floating pitfall traps for Painted Turtle

Mark recapture:

- *Species?* Amphibians and Painted Turtle
- *Level of Intensity*? Absolute Abundance
- Why? Used when measure of density or total numbers is required.
- *When?* In spring to coincide with breeding season for amphibians, and on sunny summer days for Painted Turtles
- *Where?* Pond or terrestrial habitat

Table 3. Types of inventory surveys, the data forms needed, and the level of intensity of the survey.

Survey Type	**Forms Needed**	***Intensity**
Auditory Surveys (frogs)	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observation Form- Frog Auditory Survey • Ecosystem Field Form Note: Can be conducted at the same time as a Road Survey. However, data must be kept separate on the appropriate forms.	PN RA
Road Surveys (amphibians)	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observation Form - Pond-Breeding Amphibians Road Survey • Note: Can be conducted at the same time as an Auditory Survey. However, data must be kept separate on the appropriate forms.	PN
Time Constrained Search - *Adults / Larvae* (all species)	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • AND • Animal Observation Form- Pond-Breeding Amphibians/ Painted Turtle Search - *Adults* • Ecosystem Field Form • *OR* • Animal Observation Form- Pond-Breeding Amphibians Search - *Larvae*	PN
Systematic Surveys - *Adults / Larvae* (all species)	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • AND • Animal Observation Form- Pond-Breeding Amphibians/ Painted Turtle Search - *Adults* • Ecosystem Field Form • *OR* • Animal Observation Form- Pond-Breeding Amphibians Search - *Larvae*	PN RA
Larval Survey (Dipnetting) (*Larvae* amphibians)	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observation Form - Pond-Breeding Amphibians Larval Survey (Dipnetting)	RA AA
Larval Survey (Traps) (*Larvae* amphibians)	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Capture Form - Pond-Breeding Amphibians/Painted Turtle • Animal Observation Form - Pond-Breeding Amphibians/Painted Turtle Aquatic Traps	RA AA

<table>
<tr><th>Survey Type</th><th>Forms Needed</th><th>*Intensity</th></tr>
<tr><td>Capture Survey - Amphibians

(Pitfall & Funnel traps)</td><td>Wildlife Inventory Project Description Form
Wildlife Inventory Survey Description Form - General
AND at least one of (A) or (B).
A)
Capture Form -Pond-Breeding Amphibians/Painted Turtle
Animal Observation Form - Pond-Breeding Amphibians /Painted Turtle Aquatic Traps
B)
Capture Form -Pond-Breeding Amphibians/Painted Turtle
Animal Observation Form - Pond-Breeding Amphibians Terrestrial Traps
Ecosystem Field Form</td><td>RA</td></tr>
<tr><td>Capture Survey - Painted Turtle

(Aquatic Pitfall traps)</td><td>Wildlife Inventory Project Description Form
Wildlife Inventory Survey Description Form - General
Capture Form - Pond-Breeding Amphibians/Painted Turtle
Animal Observation Form - Pond-Breeding Amphibians /Painted Turtle Aquatic Trap</td><td>RA</td></tr>
<tr><td>Mark-Recapture Surveys

(all species)</td><td>Wildlife Inventory Project Description Form
Wildlife Inventory Survey Description Form - General
Marked Animal Identification Form
AND at least one of (A), (B), or (C).
A)
Animal Observation Form - Pond-Breeding Amphibians/ Painted Turtle Search
B)
Capture Form -Pond-Breeding Amphibians/Painted Turtle
Animal Observation Form - Pond-Breeding Amphibians Terrestrial Traps
Ecosystem Field Form
C)
Capture Form -Pond-Breeding Amphibians/Painted Turtle
Animal Observation Form - Pond-Breeding Amphibians /Painted Turtle Aquatic Traps</td><td>AA</td></tr>
<tr><td>Any Survey Type</td><td>Wildlife Inventory Survey Collection Label -used whenever a voucher specimen is collected.
Marked Animal Identification Form -used whenever an animal is permanently marked.</td><td>PN

RA

AA</td></tr>
</table>

3.3 Presence/Not detected

Recommended methods: For Amphibians- Auditory Survey (calling species only, frogs/toads); Road Survey, Time-Constrained Search (TCS), and Systematic Surveys (for Ponds or Riparian Areas and Wetlands). All of these survey types are recommended during the breeding season (for breeding adults, egg masses, and larvae). For Painted Turtles, TCS and Systematic Survey when Painted Turtles are likely to be basking.

In general, any method that detects a species can be used for determining its presence. However, failure to detect presence does not necessarily confirm absence. The credibility of absence data from a survey depends on a) the expectations based on known, broad geographic ranges and seasonal habitat selection, b) how conspicuous the species is, c) the intensity of the searches, and d) the frequency of the searches. For amphibians, this is best done during the breeding season because egg masses and larvae can be found, and adults are much easier to locate at that time compared to other times of the year. For turtles, summer pond surveys are the most efficient and could be combined with late-season pond surveys for amphibians.

Surveys should focus on breeding ponds and riparian habitats. If road surveys are used, the route should pass by breeding ponds or through wetlands. Roadside ditches should be checked during daylight hours and roadkills may be encountered. Night cruising along roads may be done by motor vehicle, but a bicycle is better. Auditory transects can be combined with road cruising or can be done at breeding ponds. Preliminary, informal, opportunistic searches can often reveal the presence of species; however, such searches must be under a time constraint to give some indication of effort. A more systematic pond survey is necessary for a more thorough, higher intensity search of the area of interest.

3.3.1 Auditory surveys

Listening for the calls of male frogs and toads can be used for presence/not detected (possible) inventories. It is used for volunteer surveys as well as having been adopted by the North American Amphibian Monitoring Program (NAAMP). The method is also known by other names, including "aural site transect", "spring road transect" (Schueler 1992), and "audio strip transect" (Zimmerman 1994).

Auditory surveys can be used at discrete listening sites, or on road transects. A survey conducted by bicycle, or on foot, is quieter than a motor vehicle, and allows the observer to note every chorus along the route. Auditory surveys should work well in B.C. for species with distinct calls or where there are only a few calling species in an area, such as for the Striped Chorus Frog and Wood Frog in northeastern B.C., and for the American Bullfrog and Green Frog where they have been introduced in southwestern British Columbia. This is an excellent way of locating the Great Basin Spadefoot Toad and the Pacific Treefrog. This method can also be used for the Northern Leopard Frog.

Although auditory surveys are useful for sampling frogs and toads during breeding season, and are used widely (especially east of the Rocky Mountains), the method is not without problems. First, not all of the species in the inventory group have calls (Table 1). Second, of those that do call, some species are easier to detect than others. Pacific Treefrog calls may be so loud that they drown out the calls of other species. The Red-legged Frog and Spotted Frog emit soft underwater vocalizations that are difficult to detect. Finally, sampling will be biased toward species which call frequently and over a wide range of climatic conditions.

Note: this method does not apply to salamanders or the Painted Turtle.

Office Procedures

- Review section on Conducting a Wildlife Inventory in the introductory manual, *Species Inventory Fundamentals* (*No.1).*
- Obtain relevant maps for 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).
- Select suitable study area for surveys on air photos and 1:20 000 or 1:50000 maps. Validation of potential study areas on the ground may be necessary.
- If appropriate, stratify and randomize the selection of study areas.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the selected study areas.
- Compile a list of the species potentially present at the selected study areas, based on current knowledge of their distribution and habitat predilections. Current distribution maps should be interpreted cautiously.
- For each species, select an appropriate sampling season. Note that this may vary with prevailing weather conditions, elevation, and latitude. It is important to work on a flexible schedule so that the survey can be done when conditions are favourable.

Sampling Design

- If not all potential sites can be visited, use a stratified, randomized approach.

- For systematic sampling along roads or through wetlands, use fixed listening stations set at regular intervals of 0.5 km.
- The number of detections of new species rapidly falls off after the first minute of listening time (Shirose *et al.* 1995), so the time for an individual survey stop should be three minutes. This protocol is in accordance with current NAAMP guidelines.

Sampling Effort

- Revisit the site as many times as possible during the breeding season. A minimum of 3-5 visits is recommended.

Personnel

- For safety, two people per survey.
- Observers must have good hearing (no hearing impairments) and be able to identify all the frog calls that might be heard.
- Commercially prepared tapes or CD's of amphibian calls should be obtained and studied prior to conducting surveys. *Frog and Toad Calls of the Pacific Coast*, is available as a tape or CD from the Library of Natural Sounds, Cornell Laboratory of Ornithology, 159 Sapsucker Woods Road, Ithaca, NY 14850.
- Observer biases can be minimized by field training and testing of staff prior to the onset of a study. Field training and testing prior to the study is recommended to reduce observer bias and to standardize procedures.
- At least one person should be familiar with the collection of habitat data.

Equipment

- Suitable wet weather clothing with reflective tapes sewn on for safety
- Waterproof footwear
- Appropriate transportation (e.g., bicycle, boat, car) for survey routes
- Flashlights or, preferably, headlamps
- Tapes of calls
- Tape-recorder
- Blank tape for recording unrecognized calls
- Stopwatch
- Thermometer
- Beaufort wind scale
- Waterproof data sheets and pencils.

Field Procedures

- Check the route (transect) shortly before sampling to ensure that there is no interfering noise or major human disturbance.
- Describe distinctive natural or permanent human-made features that will aid future observers in finding the exact location of listening stations. Mark those details on the map.
- Conduct surveys in the spring to coincide with the breeding season of all the calling species that are likely to be in the survey area.

- Carry out surveys around dusk. Start approximately one half hour before dusk, and continue for 2-3 hours or until midnight.
- Surveys are most effective after 1-2 days of rainfall, or during wet weather, but not if the rain is so loud that it will mask calls. Check the weather. If it is raining very hard or if the wind speed is >3 on the Beaufort scale, postpone the survey to another, more suitable, night.
- Travel along the survey route (transect). Travelling by bicycle or on foot is quieter than travelling by motor vehicle, and allows the observer to note every chorus along the route.
- Stop at each pre-determined listening stop every 0.5 km. Listen at each station for 3 minutes. Observers can listen for up to two minutes longer if noise from traffic, etc., interferes with the ability to hear calls. Note: if driving a motor vehicle, turn off the engine and get out of the car. Wait for 1 minute after arriving to reduce the effect of any disturbance caused by the observer’s approach, and then begin the three minute survey.
- Record all species heard, and estimate the direction and distance of the calling frogs.
- Record observations on the accompanying data sheets. Gartshore *et al.* (1992) recommend the following calling index:

  0 = nothing

  1 = individuals can be counted (no overlapping calls).

  2 = calls of individuals are distinguishable, but some calls overlap.

  3 = full chorus, or continuous calls, where individuals cannot be distinguished.

  Note: A chorus can be quieted momentarily by the observer making a loud noise. Some species may be more audible as the calls resume.
- Record weather conditions at each listening station.
- Record all habitat details for each listening station. This can be done at a time other than during the actual survey.
- Periodically do ‘ground-truth’ visits to pinpoint, or confirm, locations of calling males.
- Verify rare species or range extensions with photographs, tape recordings of the call, or have at least two other experienced people hear the call.
- Collect voucher specimens where appropriate.

Data Analysis

Presence/Not Detected

- List all species found at the Study Area, the number of individuals and their status.
- Data may be summarized by species and life history stage (i.e., eggs, larvae, adults).

3.3.2 Road surveys

Road surveys may be thought of as a kind of encounter transect in which the transect is a road (Shaffer and Juterbock 1994). Usually, a motor vehicle is used, but amphibians may be more easily seen from a bicycle. A road survey is useful for detecting the presence of a variety of species. They work especially well in areas where there are migrations of animals after a heavy rainfall toward or away from breeding ponds. A road survey may be combined with an auditory survey, by placing calling survey stations periodically along its length.

Paved roads with little vehicle use are preferred. The best time to start searching is usually just after dark on wet, warm, dark and windless nights. Roads are driven at slow speeds (35-55 km/h), using low headlight beams, flashlights or headlamps to detect road kills and animals moving across or from the road.

Road surveys conducted by bicycle or on foot are often more productive than those done with a motor vehicle. While such surveys may take longer to complete, they have the advantages of allowing the observer to see more, and the potential for crushing animals on the road is reduced. In addition, if an auditory survey is done at the same time, the observer can more easily hear calling frogs and can quietly approach breeding ponds resulting in less disturbance.

Problems with this method revolve around the considerable variation encountered in the timing of the migration of the different species. In addition, the efficiency of the survey will be affected by the weather, time of dusk onset, and the amount of vehicular traffic on the road (Schueler 1992, Seburn 1993). This method is untested with respect to estimating relative abundance, and should be used for presence/not detected intensity levels of inventory only.

Note: this method is not recommended for the Painted Turtle.

Office Procedures

- Review section on Conducting a Wildlife Inventory in the introductory manual, *Species Inventory Fundamentals* (*No.1).*
- 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).
- Select suitable roads for surveys.
- If appropriate, stratify and randomize the areas to be searched.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the selected study areas.
- Compile a list of the species potentially present based on the current knowledge of their distribution. Current distribution maps should be interpreted cautiously.
- For each species, select an appropriate sampling season. Note that this may vary with prevailing weather conditions, elevation, and latitude. It is important to work on a flexible schedule so that the survey can be done when conditions are favourable.

Sampling Design

- If not all potential sites can be visited, use a stratified, randomized approach.

- Surveys are best conducted in the spring to coincide with the breeding season because this is the most likely time to encounter mass migrations.
- Transects along roads should pass through or near suitable habitat, or be placed in an area known for periodic migrations across the road. Choose lightly travelled roads where possible.

Sampling Effort

- Search when weather conditions are favourable (just after dark on wet, warm, and windless nights) several times in a season. As the cumulative number of unproductive searches increases, it becomes increasingly unlikely that the target species is present.
- Each road transect should be visited more than once, preferably weekly, throughout the breeding season and fall migration.
- Road surveys should be done for a set amount of time (person-hours) and distance, if sites are to be compared.
- The length of the transect will be determined by the amount of suitable habitat adjacent to the road that is to be surveyed. In the case of road kills, paved roads yield better results than gravel.

Personnel

- For safety, two people per survey.
- At least one crew member should have previous experience and be competent in field identification of all members of this group, at all stages of their life cycles.
- If road survey is to be combined with an auditory survey:
    1. Observers must have good hearing (no hearing impairments) and be able to identify all the frog calls that might be heard.
    2. Commercially prepared tapes or CD’s of amphibian calls should be obtained and studied prior to conducting surveys. *Frog and Toad Calls of the Pacific Coast*, is available as a tape or CD from the Library of Natural Sounds, Cornell Laboratory of Ornithology, 159 Sapsucker Woods Road, Ithaca, NY 14850.

Equipment

- Motor vehicle or bicycle with headlight
- Spotlight, flashlight, and headlamps
- Thermometer
- Field guides to amphibians (e.g. Nussbaum *et al.* 1983; Green and Campbell 1984; Leonard *et al.* 1993)
- Calipers or ruler
- 10 g and 50 g spring scales
- Plastic bags
- Maps
- Waterproof data sheets and pencils

Field Procedures

- Surveys are best conducted in the spring to coincide with the breeding season because this is the most likely time to encounter mass migrations.
- Carry out surveys around dusk. Start approximately one half hour before dusk, and continue for 2-3 hours or until midnight.
- Before starting, check the weather. If the wind is > 3 force on the Beaufort Scale (gentle breeze), the survey should be postponed to another, more suitable, night. Surveys are most effective after 1-2 days of rainfall, or during wet weather.
- Start searching just after dark on wet, warm, and windless nights.
- Record location, distances and weather conditions at the time of the survey, and during the preceding 48 hours.
- Travel on foot, by bicycle or with a motor vehicle scanning the road surface for amphibians.
- If using a motor vehicle, drive slowly (35-55 km/h) using low headlight beams, to detect road kills and animals moving across or from the road.
- If travelling on foot or by bicycle use flashlights or headlamps to detect road kills and animals moving across or from the road.
- Paved roads with little vehicle use are best.
- Record appropriate measurements for individual animals (see Section 3.1).
- Obtain voucher specimens or dead animals from roads where appropriate (see Section 3.1).

Data Analysis

Presence/Not Detected

- List all species found at the Study Area, the number of individuals and their status.
- Data may be summarized by species and life history stage (i.e., eggs, larvae, adults).

3.3.3 Time-constrained Search (TCS)

As a general preliminary approach, an informal opportunistic search may reveal the presence of the target species, especially if sites are searched during the breeding season. This may be done as a time-constrained search (TCS) which is an equal-effort search as measured by the number of person-hours spent searching (Corn and Bury 1990). This is also known as a visual encounter survey (VES) (Crump and Scott 1994). For presence/not detected surveys, there is no need to formalize the sampling design; simply search areas that are likely to contain the target species. Searches can be done during the day or just after dusk, depending on the season and the target species.

For the Painted Turtle, first search with binoculars for basking turtles. If no turtles are found, favourable areas in a pond can be searched by boat.

These searches should be used as quick surveys and are not a substitute for a more Systematic Surveys, used for ponds or riparian areas and wetlands (see Section 3.3.4). If the target species are not found after 2-person-hours of searching, a Systematic Survey should be conducted.

Office Procedures

- Review section on Conducting a Wildlife Inventory in the introductory manual, *Species Inventory Fundamentals* (*No.1).*
- Obtain relevant maps for 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).
- Select suitable study areas for surveys on air photos and 1:20 000 or 1:50000 maps. Validation of potential study areas on the ground may be necessary.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the selected study areas.
- Compile a list of the species potentially present at the selected study areas, based on current knowledge of their distribution and habitat predilections. Current distribution maps should be interpreted cautiously.
- For each species, select an appropriate sampling season. Note that this may vary with prevailing weather conditions, elevation, and latitude. It is important to work on a flexible schedule so that the search can be done when conditions are favourable.

Sampling Design

- There is no formal sampling design other than a limitation on the time spent searching. Concentrate on areas where the target species are likely to be found (These may correspond with the habitat strata used for more systematic surveys if the TCS is intended as a preliminary step).

Sample Effort

Amphibians

- Search appropriate microhabitats when weather conditions are favourable for 2-person-hours. If the target species are not located, a Systematic Survey (BPS or Riparian / Wetland Systematic Survey) is recommended (Section 3.3.4).

Painted Turtles

- Thoroughly search for basking turtles with binoculars, then search the pond by boat for at least 1-person-hour. If no turtles are located, a Systematic Survey (BPS) is recommended (Section 3.3.4).

Personnel

- For safety, two people per survey.
- At least one crew member should have previous experience and be competent in field identification of all members of this group, at all stages of their life cycles.
- At least one person should be familiar with the collection of habitat data.

Equipment

Amphibians

- Suitable wet weather clothing with reflective tapes sewn on for safety
- Waterproof footwear
- Flashlights or, preferably, headlamps
- Thermometer
- Field guides to amphibians (e.g. Nussbaum *et al.* 1983; Green and Campbell 1984; Leonard *et al.* 1993)
- Maps
- Waterproof data sheets and pencils
- Calipers or ruler
- 10 g and 50 g spring scales
- Plastic bags

Painted Turtle

- Binoculars
- Boat
- Maps
- Waterproof data sheets and pencils
- Ruler
- Thermometer
- Net

Field Procedures

Amphibians

- Check the weather. If it is raining very hard or if the wind speed is >3 on the Beaufort scale, postpone the survey.
- Record appropriate environmental conditions and habitat information.
- Search areas likely to contain the target species for 2-person hours.
- Record appropriate measurements for individual animals (see Section 3.1).

- Obtain voucher specimens where appropriate (see Section 3.1).

Painted Turtle

- Weather should be sunny.
- Record appropriate environmental conditions and habitat information.
- Search the pond thoroughly for basking turtles with binoculars.
- Search areas likely to contain turtles species for 1-person hour using a boat.
- Record appropriate measurements for individual animals (see Section 3.1).

Data Analysis

Presence/Not Detected

- List all species found at the Study Area, the number of individuals and their status.
- Data may be summarized by species and life history stage (i.e., eggs, larvae, adults).
- Indicate effort by recording the time spent searching. Time is calculated as the total time spent searching, multiplied by the number of qualified observers. Time spent processing animals (e.g., weighing, measuring) or hiking around obstacles (e.g., fallen trees, rocky cliffs) is not included in search time.

3.3.4 Systematic Surveys

Amphibians

The majority of pond-dwelling amphibians are most conspicuous at breeding ponds. Therefore surveys conducted at breeding sites are especially effective (Scott and Woodward 1994). Daytime surveys are done at intervals in the appropriate season by wading through shallow water at the edge of breeding ponds, and walking through wetlands. Large areas may have to be stratified and randomly sampled, but smaller discrete areas can be completely searched. All animals seen or heard are recorded, together with habitat information. Egg masses and larvae are also recorded. Surveys of metamorphosed individuals can be conducted by catching animals along the perimeter of ponds as they emerge in the summer.

<u>*Ponds*</u>

The systematic pond survey is a form of spatially-constrained search which utilizes a combination of visual searches and dipnets. It is largely based on the Basic Pond Survey developed by Corkran, Thoms, and Olson for the Society of Northwestern Vertebrate Biology (Chap. 3, Olson *et al.*, 1997). This survey can be used for small sites or for small sections of suitable habitat within large sites. A systematic survey is done along a curvilinear transect which encircles the entire pond. Small areas are searched completely in this systematic fashion. However, depending on the size of the pond, surveyors may not walk the entire perimeter of the pond, but rather may stratify the shoreline by habitat type and use smaller transects to sample selected sections of suitable habitat.

<u>*Wetlands or Riparian Areas*</u>

Line transects are used which parallel the channel for riparian areas, or are spaced to ensure adequate coverage for large wetlands. The same basic approach described for surveying the perimeter of a pond (BPS) should be used. Large areas may have to be stratified and randomly sampled, but smaller discrete areas can be completely searched.

Painted Turtle

The majority of Painted Turtles are most conspicuous at breeding ponds. Therefore surveys conducted at breeding sites are especially effective (Scott and Woodward 1994). Daytime surveys are done at intervals in the appropriate season by wading through shallow water at the edge of breeding ponds, or searching from a boat on a lake. Large areas may have to be stratified and randomly sampled, but smaller discrete areas can be thoroughly searched. All animals seen or heard are recorded, together with habitat information.

For the Painted Turtle, a pond survey involves a systematic search of the entire pond, or randomly selected areas based on a stratified sampling scheme.

Office Procedures:

- Review section on Conducting a Wildlife Inventory in the introductory manual, *Species Inventory Fundamentals* (*No.1).*

- Obtain relevant maps for project area (e.g., 1:50 000 air photo maps, 1:20000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps).
- Select suitable study areas for surveys on air photos and 1:20 000 or 1:50000 maps. Validation of potential study areas on the ground may be necessary.
- If appropriate, stratify and randomize the selection of study areas.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the selected study areas.
- Compile a list of the species potentially present at the selected study areas, based on current knowledge of their distribution and habitat predilections. Current distribution maps should be interpreted cautiously.
- For each species, select an appropriate sampling season. Note that this may vary with prevailing weather conditions, elevation, and latitude. It is important to work on a flexible schedule so that the survey can be done when conditions are favourable.
- If appropriate, stratify the pond perimeter by habitat type, and divide the study areas into Survey zones (shallow water zone, shore zone, shoreline zone).

Sampling Design

- Often the entire site can be searched. For example, small ponds, ephemeral pools, flooded meadows, stream overflow pools, small wetlands, and shallow bays of large lakes can be completely surveyed.
- If not all potential sites can be sampled, use a stratified, randomized approach.

<u>Systematic Pond Survey</u>

- If the study area is small, survey the entire area or pond exhaustively if possible.
- If an entire pond is too large to survey exhaustively, stratify the pond perimeter according to each major habitat type (break up the shoreline and label each major habitat type). Select a random sample of perimeter transects to survey in each stratum. Sample the shallow, shore, and shoreline zones in each of the selected sections (transects) of the pond perimeter.

<u>Systematic Riparian Areas / Large Wetland Survey</u>

- In riparian or large wetland areas, at least three transects should be placed in each major habitat stratum (Scott and Woodward 1994).

Amphibians

- Surveys should be conducted in the spring: February to April in areas with mild winters, or April to June at higher elevations.

Painted Turtle

- Systematic surveys are usually done by boat on clear days, but snorkeling can also be effective (St. Clair 1989). Use transects in large bodies of water (otherwise transects are optional).

Sampling Effort

Amphibians

- Schedule several surveys based on the time of breeding of all potentially occurring species at the study area. A minimum of three surveys should be scheduled during the breeding and larval periods of all species that may be present. Finding egg masses and hatchlings is the most efficient way to establish presence/not detected for many amphibian species. As the cumulative number of unproductive searches increases, it becomes increasing unlikely that the species is present.
- Initially, individuals should be captured for positive identification, but after that, individuals are counted without being captured.

Painted Turtles

- At least three surveys should be done per year. If no turtles are found with that amount of effort, they are probably not present.

Personnel

- At least two people per survey.
- At least one crew member should have previous experience and be competent in field identification of all members of this group, at all stages of their life cycles.
- At least one person should be familiar with the collection of habitat data.

Equipment

Amphibians

- Suitable wet weather clothing; waterproof footwear
- Hip-waders for shallow water, boat if sampling in deeper water
- Adequately constructed dipnet(s) for aquatic searches
- ‘Leopard frog net’ for capturing frogs on land
- Collecting bags for voucher specimens
- Field guides to amphibians (e.g. Nussbaum *et al.* 1983; Green and Campbell 1984; Leonard *et al.* 1993)
- Maps
- Calipers or ruler
- Thermometer
- 10 g and 50 g spring scales
- Plastic zip-lock bags (collecting bags for voucher specimens)
- Camera and film
- Waterproof data sheets and pencils

Equipment

Painted Turtle

- Hip-waders
- Snorkeling equipment
- Binoculars
- Boat
- Maps
- Waterproof data sheets and pencils
- Ruler
- Thermometer
- Long-handled dipnet

Note: For Dipnet and Leopard Frog Net Construction see 'Equipment' in section 3.1.

Field Procedures -Amphibians

Preliminary Field Procedures

- Conduct a field reconnaissance to acquaint surveyors with the study area and to determine habitats to be studied.

<u>*Systematic Pond Survey*</u>

- Determine Survey Zones (Figure 3) which include the **shoreline** (the physical line at which water and land meet at the time of the survey), the **shallow water** (all water from the shoreline to a depth that can be safely waded - <1m), and the **shore** (the land bordering the pond within 3 meters of the shoreline). Survey Zones are determined by physical parameters (depth and distance form the shoreline) and may include many habitat strata.
- If the pond is too large to survey exhaustively, survey portions of the pond perimeter (transects) from sections of the pond's perimeter which are randomly selected from different habitat strata. Sample the shallow, shore, and shoreline zones for each selected section of transect.

<u>*Riparian Areas / Wetlands*</u>

- A small homogeneous wetland, lacking shoreline or distinct open water, is not divided into survey zones, but is surveyed as a whole unit.
- For large wetland or riparian areas randomly select at least 3 transects in each habitat stratum.

Conducting the Survey - General

- On the day of the survey, adjust the procedures if warranted by weather, water level or other conditions that may influence the survey. This flexibility takes advantage of unanticipated conditions at the site.
- Heavy rains, high winds, or very dark overcast conditions that reduce visibility should be avoided.

<u>Visual Counts</u>

- Visual counts, often with the aid of binoculars, can be taken of many species without disturbing the animals, or can be done in conjunction with captures of select individuals. Visual "head counts" of breeding aggregations of frogs or toads at the water surface are often more accurate than capture counts. This is possible in the Pacific Northwest because there are only a few sympatric species, which may be distinguished spatially, temporally, by call, or by body size.

<u>Capture (if required for identification or measurement)</u>

- Not all animals seen need to be captured, but identification must be positive. Capture animals if necessary for positive identification or measurement.
- Determine procedures for handling and managing amphibians caught (i.e., examined, identified, and released immediately, or held in plastic bags until each pond section has been surveyed). To minimize stress to the animals, immediate release is recommended in very hot weather or during breeding. If amphibians are held in bags, it is important to keep them from overheating. The bags should be kept in a cooler, in the shade, or in the water (make sure they do not float away). Because pond amphibians may have microhabitat specificity, captured animals should be released at the site of capture.
- Ensure there is no insect repellent or suntan lotion on your hands before capturing or handling amphibians. Keep your hands wet when handling them. Do not hold tadpoles or larval salamanders out of the water; examine them in bags or other containers in a small amount of water that is replaced frequently (particularly in hot weather). Close-up photographs showing diagnostic features can be used for later identification and for vouchers, and may decrease the amount of time spent examining animals.

<u>Capture Techniques (if required for identification or measurement)</u>

Frogs / Toads

- Capture frogs and toads by hand. If they have been disturbed, stand still for at least 10 seconds before trying again. Very slowly approach a frog in a straight line and gradually stoop down. In slow motion, reach out one hand low and in front of the frog, the other hand above and behind it, and do not grab until both hands are within 30 centimeters of the frog. Most people develop their own personal techniques for hand capturing frogs.
- While a toad usually can be chased and captured by hand or net either on land or in the water, a frog usually is faster than the surveyor. If a frog is observed on land or in shallow water, use a hand capture technique. In deeper water use a dipnet. For a frog on the surface, slowly push the net out under the frog and sweep forwards and upwards. If you can see a frog on the bottom, or you saw it bury itself in the mud, slowly reach the net out beyond the frog and quickly pull it back toward you. If you miss, wait for the sediment to settle. The frog may still be visible and you can try again.

Larval Salamander

- A larval salamander observed on top of the mud bottom will often turn and swim out to deeper water or under a log if it detects the surveyor approaching. By working slowly in the shallows and scanning ahead, the surveyor can approach a larva without disturbing it. Because larvae are most likely to escape to deeper water, slowly ease the dipnet out beyond the larva and quickly scoop down, back, and up. Alternatively, reach the dipnet out near the larva and quickly scoop down, forward, and up under it. If you miss, the larva may take off suddenly, kicking up a “smoke screen” of mud, and swim a short distance before hiding in the mud. If its hiding spot in the mud can be seen, try to scoop the top 2 or 3 centimeters of mud with the larva.

Metamorphosed Salamander

- If a metamorphosed salamander is hiding under a rock, usually it will remain immobile, permitting easy capture by hand, if it is noticed.

Tadpole of a Frog/Toad

- A tadpole of a frog or toad often deploys the same escape strategies as a larval salamander by swimming to deeper water, so the same capture techniques should be used, and many tadpoles are slow enough to be chased and scooped up with a dipnet. Some tadpoles may hide in dense vegetation instead of mud, where a small net is often less awkward than a large dipnet.

Release

- Release amphibians at their capture sites.

Counts and Estimates

- Making accurate counts of amphibians and egg masses is a difficult but important part of the survey. The team leader must ensure that each species and developmental stage is fully counted, but not counted twice. If there is a recorder in addition to the surveyors, he or she can keep simultaneous tallies as data are called out by the surveyors. Otherwise, each team member is responsible for counting all animals in his or her zone. For large numbers, it may be easier to count clearly defined portions of a zone.
- Often it is not possible to count dense concentrations of egg masses or vast schools of tadpoles, however the surveyor can make reliable estimates, as follows:
    - Before trying to count salamander or frog egg masses that are clustered together, find areas with few or separated masses. Examine these egg masses, measuring several masses at least visually. Once you have a good idea of the size of an average egg mass, go back to the dense concentration, visually break it up into average egg masses, and count these. Care must be taken not to overestimate the number of egg masses.
    - Toad egg masses often cannot be separated for counting because each female lays eggs in two long strings that may be intertwined and clustered with those of other females. If separate strings can be found, use the same technique as above, counting and measuring one string and then visually breaking the concentration into average strings. Frequently all toad eggs are in huge concentrations and may be necessary to estimate number of eggs rather than of strings. Count 10 eggs, then count by tens to 100 eggs, then count by hundreds to 1,000 eggs, then count the concentration by thousands. It may be helpful to visually divide the concentration of egg strings into quadrants or sections, or to estimate the surface layer and then multiply by the number of layers deep the eggs are clustered. A third method is to measure the length and width of the total concentration of egg masses, or photograph the entire concentration with something for scale, and photograph a potion close-up with a ruler for scale.
    - Making estimates of large numbers of tadpoles is difficult because they move around. There are two options: 1) the tadpoles can be counted by tens, hundreds, etc.,

as described above, or 2) visually estimate one square meter of area and count the number of tadpoles in it, count the number of squares with that density of tadpoles, and multiply the number of squares by the number of tadpoles per square. Areas with differing concentrations of tadpoles should be estimated in the same way, and these separate counts summed to give the grand total.

Record

- Record the time, date, surveyors, habitat conditions, and weather (refer to accompanying dataforms).

Habitat Sensitivity

- Wash nets, boots and containers and remove bits of vegetation carefully before going to another site to prevent transfer of diseases. At the end of the day, field gear should be examined closely for weeds and should be scrubbed with soap and water.

Clean-up

- Retrieve gear, using checklist.

Conducting the Survey -A) Systematic Pond Survey

Systematic Pond Survey -Surveying the different zones (Figure 3)

- **Shallow water zone** (<1m deep). The Surveyor wades slowly, stopping every 5 meters (or beyond the area where sediment is still in suspension from the previous stop). While walking, and at each stop, scan the water surface, the pond bottom, and submerged debris for adults, larvae, and eggs. At each stop, the surveyor should visually search a sample of emergent vegetation for individual eggs, or small egg clusters by closely examining stems and gently lifting leaves.
- While surveying the shallow water zone, and at each stop (every 5 meters) the surveyor should use the dipnet, taking 1 scoop in front and 1 to each side of the direction of walking. Each scoop should include the upper 2 to 3 centimeters of the bottom from a 1 meter long swath. After each scoop, water and fine sediment should be strained from the net by gently sloshing it back and forth in the surface water. Examine the contents carefully because some small larvae will go limp and be easily overlooked. Turn the net inside out to return contents to approximately the original location. The dipnet can be used to catch amphibian larvae and adults if needed for identification or measurement.
- A small aquarium net, 4 to 5 inches, can be used to catch larvae and small frogs. It is particularly useful in small pools and dense vegetation where a dipnet is awkward.
- **Shore zone** (land within 3 m of the shoreline). The surveyor on shore should walk a zigzag course parallel to the shoreline and within 3 meters of it. If the vegetation is very low or sparse, the surveyor should walk slowly, scanning ahead with binoculars for frogs or toads. If shore vegetation is tall or dense, a surveyor should walk more rapidly so that amphibians will move to shallow water where the other team member has a better chance of catching them.
- Look under objects on the shore within 3 meters of the shoreline. Only investigate debris on soil that is moist (either permanently or from rain or receding water level of the pond). If there are huge numbers of objects, not all need to be searched. Objects should be lifted or tipped up and replaced in their original positions before replacing

amphibians. Looking under objects is particularly important in early spring when adult amphibians are gathered near breeding ponds, and again in mid-to late summer when juveniles are dispersing from ponds.

- **Shoreline** (physical line between land and water). One surveyor working alone should walk slowly, stopping every 5 meters and scanning ahead both along the shore and shoreline. The dipnet should be used to catch animals that have been disturbed. If there is a narrow overhanging edge, the surveyor should explore underneath it with a hand or small net for larval or adult amphibians (frogs may hop into the water and immediately turn back to hide under this overhanging edge).

Systematic Pond Survey - Search patterns (Figure 4)

- **A.** Where the shallow water zone is narrow, one member of the team surveys the shoreline and scans the vegetation on the shore within 3 meters of the pond, and the second member surveys the shallow water, and stays two meters behind the first. This provides the second surveyor a chance to catch amphibians that enter the pond after being disturbed. After completing the shoreline and shallow water zone searches, the shore should be surveyed by both members working independently.
- **B.** Where the shallow water is extensive, both members of the team work in tandem in the shallow water. The team member nearest the shoreline is responsible for both the shoreline and shallow water zones. The other team member stays two meters behind the first and is responsible for the shallow water zone. The team walks a zigzag course parallel to the shoreline and covers the entire shallow water zone. After completing the shoreline and shallow water zone searches, the shore should be surveyed by both members working independently.
- **C.** If one surveyor must work alone, the shoreline should be surveyed first, followed by the shallow water, and finally the shore.

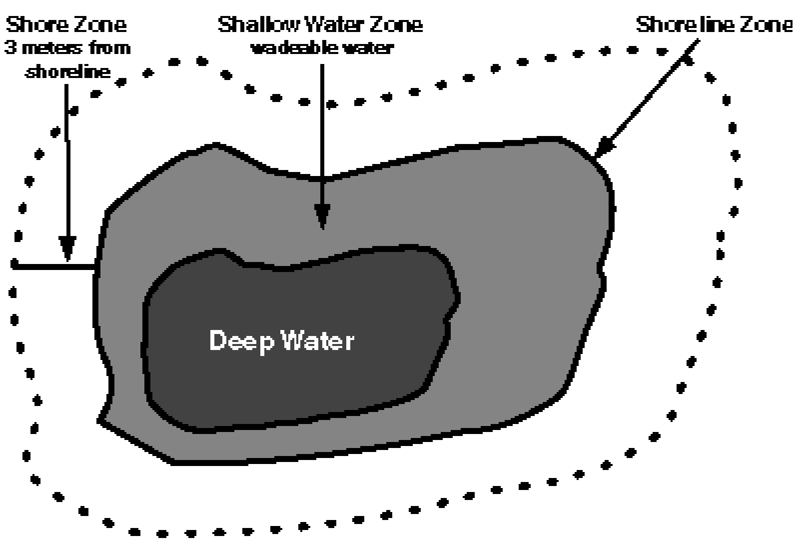

Figure 4. Survey zones for the systematic (basic) pond survey (after Thoms and Corkran in Olson et al., 1997).

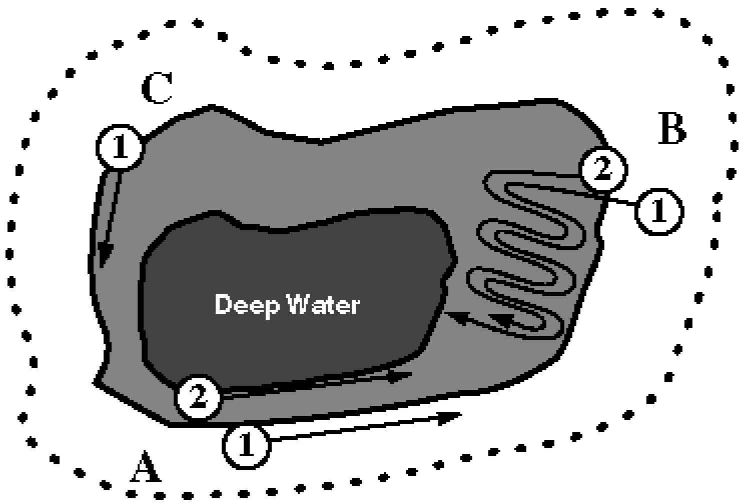

Figure 5. Search patterns for the systematic (basic) pond survey (after Thoms and Corkran, draft 1996).

Conducting the Survey - B) Riparian Areas / Wetlands

- Note: The same basic approach described for surveying the perimeter of a pond should be used along straight-line transects (i.e. riparian areas or large wetlands). Refer to the appropriate sections for details. In general, along straight-line transects, one member of the team walks about two meters behind and two meters to either side of the path taken by the other member.

Field Procedures -Painted Turtle

- Search on sunny days in the summer when turtles are likely to be basking.
- Walk the around the pond on the shore or shoreline watching for turtles. About every 20 m, stop, and using binoculars, search for turtles basking on the shore, on logs, or on the surface on the pond.
- Where the shallow water is extensive, walk a zigzag course parallel to the shoreline and cover the entire shallow water zone looking for turtles.
- Using a boat, systematically survey the pond, checking the surface and underwater. This may be done with or without transects, depending on the sampling design. Clear days are preferable as overcast skies make seeing underwater difficult.
- A long-handled dipnet may be used to capture turtles, if necessary.

Data Analysis

Presence/Not Detected

- List all species found at the Study Area, the number of individuals and their status.
- Data may be summarized by species and life history stage (i.e., eggs, larvae, adults).
- Indicate the size of area (or distance) searched.
  Note:
  1. Data for meadows are generally evaluated on an area basis while streams and rivers are evaluated linearly.

2. Data for amphibians which are found primarily around the edge of lakes can be considered linear, though data for smaller lakes and ponds should be evaluated on an area basis.
3. The area to be searched can be defined prior to the survey or determined in the field.

3.4 Relative Abundance

Recommended method(s): For amphibians: Auditory Surveys (calling species only); Systematic Surveys (Pond and/or Riparian Area/Wetland survey) during the breeding season (for breeding adults, egg masses, and larvae); Larval Surveys; and Capture Surveys - Amphibians (Funnel and Pitfall trapping). For Painted Turtles: Systematic Pond Surveys when the turtles are likely to be basking; and Capture Surveys - Painted Turtles (Aquatic Pitfall trapping).

In general, it is much easier to locate pond breeding amphibians in aquatic habitats than in terrestrial habitats. In ponds, egg masses, larvae, and adults can be counted, but in terrestrial habitats away from ponds, only metamorphosed animals are available. Egg masses are relatively easy to see and count because they are stationary, and the number of egg masses is a direct indication of the number of breeding females in that particular year. Similarly, the abundance of larvae, which far exceed the number of adults, lend themselves to quantification. During the breeding season, adult amphibians are concentrated in breeding ponds, relatively easy to find, and depending on the species, highly vocal. In contrast, when in terrestrial environments, these same amphibians are cryptic, may use underground burrows, and are generally difficult to find. Given these facts, it is far more efficient to assess relative abundance in and around ponds compared to surveys in strictly terrestrial environments.

Nevertheless, terrestrial habitats are essential for the survival of these species. For many amphibians, juveniles and adults leave the immediate vicinity of the pond after the breeding season and forage in terrestrial habitats. Their movements, what microhabitats are important to them, and how much area outside the pond is essential for the survival of the population, is virtually unstudied. Pitfall and funnel traps with drift fences should effectively sample many of these species, but, except for artificial cover boards for the Rough-skinned Newt (Davis 1996a, b), no other proven methods exist for sampling members of this inventory group in strictly terrestrial habitats.

However, there are a variety of very good methods for assessing relative abundance in and around ponds. For species that call, auditory surveys can be used to assess relative abundance. Systematic surveys can be used for quantifying the abundance of egg masses, larvae, and adults. Larval surveys, using throw traps, minnow traps, and nets of different sizes, can yield relative abundance data. Finally, drift fences with pitfall traps may be placed around ponds to capture terrestrial animals during migrations. However, it is important to recognize that each of these methods has inherent biases which need to be considered in terms of the natural history of the target species, the objectives of the study, and local conditions. A variety of methods giving similar results will be more convincing than a single measure of relative abundance.

For the Painted Turtle, systematic pond surveys from the shore and by boat, with or without snorkeling, are recommended. Floating pitfall traps may also be used.

3.4.1 Auditory survey

Counts of calling males or aggregations of calling males can be used to provide a first approximation of the relative abundance of breeding frogs (Zimmerman 1994). This is a standard method adopted by the NAAMP. Auditory surveys can be used at discrete listening sites, or on road transects, surveyed either by motor vehicle, bicycle, or on foot. The basic method is to listen for calling males at predetermined locations or transects, and count individuals or choruses. If equal effort is used among areas or years, the number of calling frogs or choruses can be used as a measure of relative abundance.

Although auditory surveys are simple in concept and relatively easy to do, the method is not without problems. First, not all of the species in the inventory group have calls (Table 1). Second, auditory surveys of frogs and toads are useful during the breeding season only, and must be timed to correspond with the breeding periods of the target species. Third, some species are easier to detect than others. Pacific Treefrog calls may be so loud that they drown out the calls of other species. The Red-legged Frog and Spotted Frog emit soft underwater vocalizations that are difficult to detect. Fourth, sampling will be biased toward species which call frequently and over a wide range of climatic conditions. If too many individuals are calling simultaneously, it will not possible to determine how many individuals in total are calling. Fifth, different individuals may be heard on different visits because some males will move into or out of a breeding area within a few days. Also, not all adult males will call on any given night. Finally, the proportion of males calling can depend on environmental conditions and/or the social environment.

In spite of these difficulties, counting individual frogs or choruses of frogs is possible, and statistically defensible comparisons can be made among sites, regions, and years.

Note: this method does not apply to the Painted Turtle.

Procedures

This technique is also used for Presence/Not Detected surveys. Only differences between the Relative Abundance and the Presence/Not Detected Auditory Survey protocol are listed here. For details on how to conduct this type of survey, see section 3.3.1

Sampling Design / Field Procedures

- It is important that the sampling design remain constant during Relative Abundance surveys.
    1. Ensure that interstation distance is consistent (every 0.5 km).
    2. Spend the same amount of time at each station (wait 1 minute, then record observations for 3 minutes only).
    3. Record only observations/calls heard at stations.

Data Analysis

Relative Abundance

- Record as the number of individuals / calls per station.
- Data may be summarized by species, pond, and habitat type.

3.4.2 Systematic Surveys

Procedures

This technique is also used for Presence/Not Detected surveys. Only differences between the Relative Abundance and the Presence/Not Detected Systematic Survey protocol are listed here. For details on how to conduct this type of survey see section 3.3.4

Sampling Design / Field Procedures

- It is important that the sampling design remain constant during Relative Abundance surveys. Only important points are highlighted here (see section 3.3.4 for more details).

Amphibians

1. When surveying the shallow water zone stop every 5 m. At each stop take 1 scoop in front and 1 to each side of the direction of walking with the net. Each scoop should be taken the same way each time and be 1m in length.
2. When surveying the shore zone, walk a zigzag parallel to the shoreline and within 3 m of it, looking under objects only within the 3 m from the shoreline.
3. When surveying the shoreline, stop every 5 m and scan ahead both along the shore and shoreline.

Painted Turtles

1. When using a boat, systematically survey the pond using transects to ensure complete coverage.

Data Analysis

Relative Abundance

- Record as the number of individuals per unit area (or distance) searched.
- Data may be summarized by species and life history stage (i.e., eggs, larvae, adults).
- Note:
  1. Data for meadows are generally evaluated on an area basis while streams and rivers are evaluated linearly.
  2. Data for amphibians which are found primarily around the edge of lakes can be considered linear, though data for smaller lakes and ponds should be evaluated on an area basis.
  3. The area to be searched can be defined prior to the survey or determined in the field.

3.4.3 Larval surveys

There are a variety of methods that have been developed for sampling amphibian larvae (Shaffer *et al.* 1994). The methods recommended here for the estimation of relative abundance include capturing larvae in nets or traps. The data will consist of numbers of individuals captured per sampling unit. The sampling unit can be either the sweep of a net, or an individual trap (over a specified time interval).

Note: this method does not apply to the Painted Turtle.

Nets

In small bodies of water, including sinkholes, puddles, and roadside ditches, the absolute number of larvae can often be counted. A dipnet or small seine is used to remove larvae from the water, and the number of larvae are counted for each sweep. Larvae are placed in a bucket until at least 10 consecutive sweeps fail to catch any new animals. The larvae can then be returned to the water (Shaffer *et al.* 1994).

In larger bodies of water, nets may be used to take random samples from each major habitat type along transects of fixed length. Transects in each stratum should be of equal length, and an equal number of samples should be taken from each stratum on each trip. Typically, transects are set up parallel to the shoreline.

Nets are of two types: seine nets and dipnets. Seine nets are about 1.5 m wide and 3 to 4 m long. Dipnets are generally less than 30 cm wide and may be fitted with a long handle. Sweeps are standardized for a particular study, and each sweep can be counted as a sampling unit.

This method is simple in concept but problems can arise. Larvae can escape by swimming away from a moving net or hiding on the bottom. If vegetation is on the bottom of the pond, or if the bottom is irregular, sampling can be difficult. Many amphibian larvae are habitat specialists and the primary habitat may not be recognized by the surveyors. Some habitats may be more difficult to sample than other habitats. Catchability can be influenced by the size of the larvae, the presence of vegetation, and the presence of aquatic predators. Finally, how the net is passed through the water or vegetation will vary among investigators, and this can affect sampling effectiveness. Thus, one person or team should do all the sampling in any particular study (Shaffer *et al.* 1994).

Traps

Minnow traps also may be used to catch larvae. This is an especially good method for *Ambystoma gracile* and might be attempted with other species. No bait is required, and traps should be set out in a stratified and randomized manner. The data will consist of the number of larvae per trap for a specified interval. The interval may be an hour, several hours, or a day, depending on the species, its activity cycle, and the numbers caught. Experimentation will be required to determine the appropriate protocol.

Office Procedures

- Review section on Conducting a Wildlife Inventory in the introductory manual*, Species Inventory Fundamentals* (*No.1).*
- 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).
- Select suitable study areas for surveys on air photos and 1:20 000 or 1:50000 maps. Validation of potential study areas on the ground may be necessary.
- If appropriate, stratify and randomize the selection of study areas.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the selected study areas.
- Compile a list of the species potentially present at the selected study areas, based on current knowledge of their distribution and habitat predilections. Current distribution maps should be interpreted cautiously.
- For each species, select an appropriate sampling season. Note that this may vary with prevailing weather conditions, elevation, and latitude. It is important to work on a flexible schedule so that the survey can be done when conditions are favourable.
- If appropriate, divide the study area into Habitat Units. If using transects, map the location of transects at each site.

Sampling Design

- If not all potential sites can be sampled, use a stratified, randomized approach.

Nets

- Heavy rains, high winds, or very dark overcast conditions that reduce visibility and should be avoided.
- This procedure can be used during daylight hours for frog and toad tadpoles, because they often congregate in warmer, shallow water during the day. Salamander larvae may be easier to catch at night.

<u>*Exhaustive Searches of Entire Site - for Smaller Study Areas*</u>
<u>*(also used for Absolute Abundance Surveys)*</u>

- Often the entire pool can be searched. For example, small ponds, ephemeral pools, and roadside ditches can be completely surveyed.
- Use a dipnet or small seine to remove larvae from the water, counting the number of larvae for each sweep.
- Place larvae in a bucket until at least 10 consecutive sweeps fail to catch any new animals.
- Return larvae to the water.

<u>*Sample Searches in each Habitat Type - for Larger Study Areas*</u>

- If an entire site or pond is too large to survey exhaustively, stratify the area or pond perimeter according to each major habitat type.
- Sampling should be along randomly placed transects parallel to the shoreline in each habitat strata..
- Transects can follow the pond perimeter and need not be straight.

- Within each stratum, the length of transect (thus the number of samples taken) is proportional to the length of the shoreline habitat.
- Take the first sample 3 m in from the starting point of the transect, and then at 3-m intervals until the end of the transect.
- Number sweeps in ascending order from the starting point of the transect.
- Each sample consists of a 1-m long sweep with a net. The samples (sweeps) will alternate with respect to the distance from shore: first is taken from shore (land/water interface) and out to 1 m in the water; the next 1 m from shore extending to 2 m out in the water; then repeat (Olson *et al.* 1997).
- An equal number of sweeps should be done along each transect, the location of sweeps determined randomly, and the sweeps at least 5 m apart.

Traps

- Traps should be placed randomly.
- If minnow or collapsible traps are used, 2 traps for a 25 m^2 of stratified habitat is recommended, adding 1 trap each time the area doubles (Olson *et al.* 1997).

Sampling Effort

- Schedule several surveys based on the time of breeding of all potentially occurring species. A minimum of three surveys should be scheduled.
- Repeated sampling should be done to determine the variation among sampling periods. If the standard deviation is high, a different stratification, different size samples, or use of other methods may be warranted.

Nets

- An equal number of sweeps should be made in each habitat stratum.

Traps

- An equal number of traps should be place in each habitat stratum.

Personnel

- For safety, at least two people per survey. Delegate one to search and the other to record observations.
- At least one crew member should have previous experience and be competent in field identification of all members of this group, at all stages of their life cycles.
- Field training and testing prior to the study is recommended to reduce observer bias and to standardize procedures.
- At least one person should be familiar with the collection of habitat data.

Equipment

- Suitable wet weather clothing; waterproof footwear
- Hip-waders for shallow water; boat if sampling in deeper water
- Thermometer
- Calipers or ruler

- Field guides to amphibians (e.g. Nussbaum *et al.* 1983; Green and Campbell 1984; Leonard *et al.* 1993)
- 10 g and 50g spring scales
- Maps
- Waterproof data sheets and pencils
- Camera and film
- Collecting bags (plastic zip-lock) for voucher specimens

Nets

- A seine with a mesh size of 1.5 to 7 mm is recommended, depending on the species to be sampled. The seine should be 1 to 1.5 m wide and 3 to 4 m long, but may be larger or smaller depending on the size and depth of the ponds to be sampled. Seines should have floats on the top and lead weights along the bottom. Seine poles (2.5 cm diameter wood dowels) are used to drag the seine.
- Wire-mesh sieves (kitchen strainers) work very well in some circumstances. A handle should be attached.
- Adequately constructed dipnet(s). Various sizes of dipnets with strong handles can be used. Use a net size and mesh appropriate for the target species and pond to be sampled.

Traps

- A variety of other capture devices such as minnow traps and throw traps (Carlson and Berry 1990) can be used.

Field Procedures

- For relative abundance among strata, use the same procedure and equipment in all strata.
- Sample when weather conditions are favourable (i.e. when visibility is good).
- Replicate sampling should be done so that conditions of wind, time of day, and human activity levels are similar among replicates.
- Collect specimens as necessary.

Nets

- Use a standard length of sweep when netting.

Exhaustive Searches of Entire Site - for smaller Study Areas
(also used for Absolute Abundance Surveys)

- Often the entire pool can be searched. For example, small ponds, ephemeral pools, and roadside ditches can be completely surveyed.
- Use a dipnet or small seine to remove larvae from the water, counting the number of larvae for each sweep.
- Place larvae in a bucket until at least 10 consecutive sweeps fail to catch any new animals.
- Return larvae to the water.

Sample Searches in each Habitat Stratum for Larger Study Areas

- Each sweep must be at least 5 m apart; otherwise samples are not independent.
- Take the first sample 3 m in from the starting point of the transect, and then at 3-m intervals until the end of the transect.
- Number sweeps in ascending order from the starting point of the transect.
- Each sample consists of a 1-m long sweep with a net. The samples (sweeps) will alternate with respect to the distance from shore: first is taken from shore (land/water interface) and out to 1 m in the water; the next 1 m from shore extending to 2 m out in the water; then repeat (Olson *et al.* 1997).
- Record the number of larvae per sweep.

Traps

- Place traps at water depths ranging from the minimum depth necessary to allow amphibians to swim into the opening of the trap to a maximum of 1m.
- Traps should be left out overnight when trap rates appear highest.
- Check at regular time intervals. The amount of time traps are left in the water without being checked should range from 8-12 hours, and never exceed 24 hours (Olson *et al.* 1997).
- Record the number of larvae per trap.
- Also see Field Procedures in section 3.4.4 ‘Pitfall traps, funnel traps, and drift fence/trap arrays’.

Data Analysis

Relative Abundance

- Record the number of individuals captured per sample unit.
- A sample unit can either be a sweep of a net, or an individual trap (over a specified time interval).
- Data may be summarized by species and life history stage (i.e., eggs, larvae, adults)

3.4.4 Capture - Amphibians (Pitfall traps, Funnel Traps, and Drift Fence/Trap Arrays)

Pitfall and funnel traps with drift fences are widely used for trapping amphibians and reptiles (Jones 1986; Corn and Bury 1990; Corn 1994; Dodd and Scott 1994) and this is the only method recommended for this inventory group in terrestrial habitats. Artificial cover boards have been used to assess relative abundance among sites for the Rough-skinned Newt (Davis 1996a, b), but the effectiveness of this technique and the use of species-specific artificial microhabitats has not been developed for the other species. Quadrat and transect searches of terrestrial habitats might be used if the animals are on the surface, but the effectiveness of such searches has not been demonstrated for these species.

Pitfall traps are generally round or square containers (cans or plastic buckets) of varying sizes, that are placed in the ground with the tops flush with the surface of the soil. Drift fences serve to divert the animals into the traps. Although floating pitfall traps have been used to capture aquatic turtles (Lagler 1943; Jones 1986), pitfall trapping has mainly been used to survey animals in terrestrial habitats or to capture amphibians migrating toward or away from ponds (Corn 1994; Dodd and Scott 1994). Funnel traps consist of window screen or hardware cloth tubes with inwardly directed funnel-shaped openings, usually at both ends.

For amphibians in the terrestrial phase, pitfall traps can be arranged systematically in grids within the habitat to be sampled (Corn and Bury 1990), in combination with drift fences (Gibbons and Semlitsch 1981), or in arrays with both drift fences and funnel traps (Campbell and Christman 1982). Alternatively, drift fences and funnel traps can be used without pitfall traps (Storm and Pimentel 1954). The drift fences are aligned in a manner designed to intercept the animals as they move, and to divert them into the traps. The choice of design and configuration of pitfall trap/drift fence arrays will be determined by the objectives of the study and the species of interest. "Standard arrays" consist of pitfall traps placed at both ends of a 5 m drift fence, with funnel traps placed in the center of the fence, and with those arrays placed in triads throughout the study area (Corn 1994). Traps and fences have been placed to totally or partially encircle breeding ponds and small lakes, to sample amphibians moving to and from breeding areas (e.g., Storm and Pimental 1954; Bennett *et al.* 1980; Gibbons and Semlitsch 1981; Dodd 1991; Pechmann *et al.* 1991; also see Dodd and Scott 1994), but this is not recommended here for an assessment of relative abundance. It is more efficient to assess relative abundance among ponds with systematic and larval surveys.

Fences have been made from a variety of materials such as boards, hardware cloth, tarpaper, plastic, and aluminium flashing, but Vogt and Hine (1982) found aluminium flashing worked the best. The length of the fence used may vary. Vogt and Hine (1982) found fences between 15-30 cm in length were better than shorter or longer ones. However, Jones (1981) reported fences of 7.6 m to be very effective. The conflicting results may be a reflection of the type of habitat sampled. Mengak and Guynn (1987) found that sampling success did not differ between fences of two different heights.

Corn and Bury (1990) compared the effectiveness of pitfall grids versus arrays in old-growth forests and found that arrays caught more animals than grids. Arrays can provide large sample sizes in a short space of time, but grids remove fewer animals from the population and may be more suitable for long-term monitoring (Corn and Bury 1990). Grids arranged systematically and standardized per unit effort have been used to compare the relative abundance of certain species in two or more habitats during the same season (Bury and Raphael 1983). Results are often expressed as the number of animals captured per 100 or 1000 trap-nights (Friend 1984; Bury and Corn 1988; Corn and Bury 1990), where a trap-night is one pitfall open for one night. Alternatively, results may be expressed as number of captures per trap-array (Campbell and Christman 1982; Enge and Marion 1986; Jones 1988), or per array-day (Dalrymple 1988).

The sampling duration, timing, and effectiveness of pitfall grids or arrays, depend on climatic features of the area. In drier regions, several short sample periods throughout the season (especially after rainfall) will yield the most accurate estimates of amphibian relative abundance (Vogt and Hine 1982). However, in large parts of B.C. the widespread presence of moist, cool habitats means that amphibians may have a more protracted activity period and pitfall installations in many areas may be operated for longer periods of time. Raphael and Rosenberg (1983) demonstrated that abundance rates stabilized by the time traps had been run for 15 months.

The impact of this method on local populations may be severe if mortality in traps is high due to either dehydration in dry areas, or drowning in wet ones. Wood covers supported over pitfalls help to prevent dehydration, act as rain covers, and may serve to attract animals. A small amount of water in the bottom helps to prevent dehydration and make it harder for some frogs to jump out (Pedlar 1991), but too much water will drown some amphibians and small mammals. Where the water table fluctuates, traps may be flooded from below if drainage holes are drilled in the bottom. Checking traps frequently (e.g., every 2-3 days) and bailing water out where necessary reduces mortality.

Not all species are trapped with equal efficiency (Gibbons and Semlitsch 1981; Campbell and Christman 1982; Bury and Corn 1987) and some can climb out of the traps (Welsh 1987). Some species may be able to circumvent the drift fences by climbing over them (treefrogs), or, especially in looser soils, by burrowing underneath them (Dodd 1991). Consequently, care must be taken in the interpretation of relative abundance data. Biases in the sampling may be due to variations in the morphology, ecology, and behaviour of the different species. Experimentation will be needed to determine the effectiveness of pitfall trapping for members of this inventory group.

Although initially expensive and time-consuming to install, this method is considered cost-effective for frequent sampling over time in some habitats (Welsh 1987; McDiarmid 1992). The only expenses incurred after installation are for travel and checking the traps. Checking the traps does not require experienced personnel if the specimens are to be identified later in the laboratory.

For a detailed description of the design, installation and operation of pitfall trap/drift fence arrays, the reader is referred to Corn and Bury (1990) or Corn (1994). Array designs that might be appropriate for use around breeding ponds or small lakes, or in wetlands, are described in Gibbons and Semlitsch (1981), Jones (1986), Corn and Bury (1990), Corn (1994), and Dodd and Scott (1994). Figure 5 provides an example of some of the possible designs. Storm and Pimentel (1954) describe the use of drift fences and funnel traps. The choice of sampling array will depend on the objectives and location of the study, and the time and funding available.

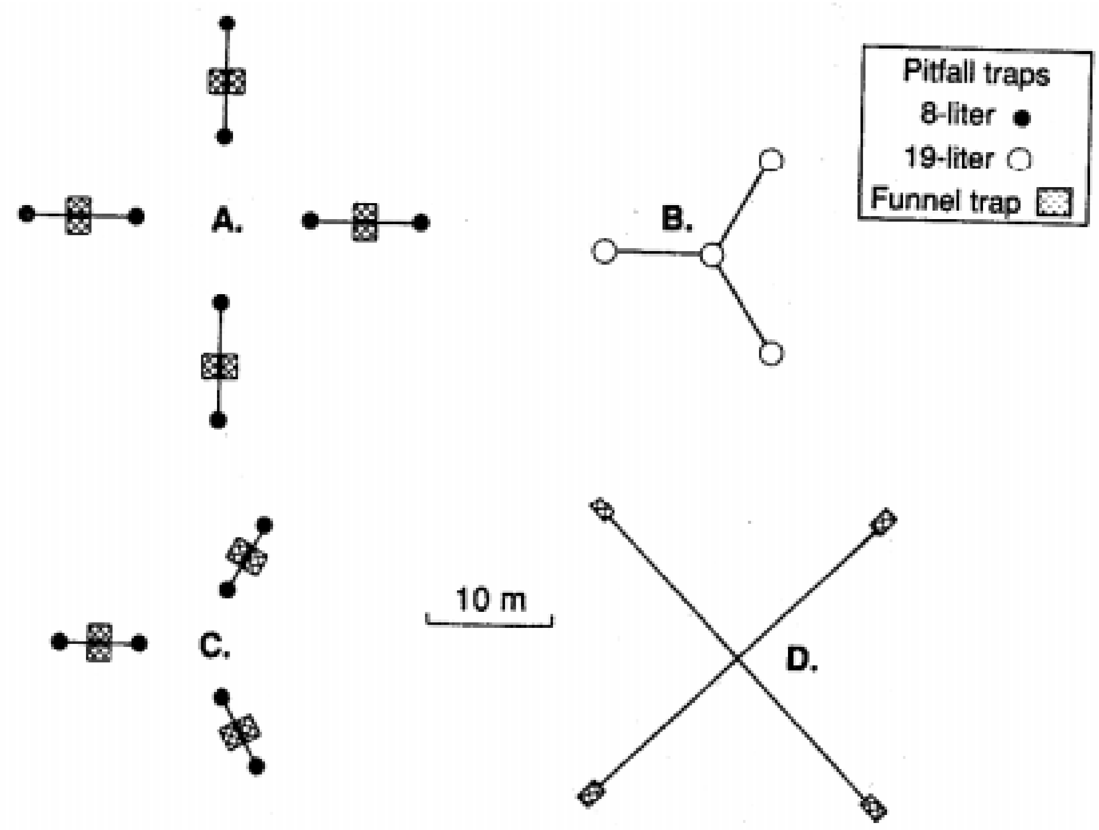

Figure 6. Diagrams of some possible pitfall/drift fence array designs: A) after Campbell and Christman (1982); B) after Jones (1981); C) after Bury and Corn (1990); D) after Dalrymple (1988).

Office Procedures

- Review section on Conducting a Wildlife Inventory in the introductory manual, *Species Inventory Fundamentals* (*No.1).*
- Obtain relevant maps for 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).
- Select suitable study areas for surveys on air photos and 1:20 000 or 1:50 000 map.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for study areas.
- Stratify habitats if appropriate.

Sampling Design

- Single pitfall traps can be considered independent sampling units if randomly located within the terrestrial site. However, to increase the number of amphibians per sample, grids or arrays are recommended. Each grid or array should be considered a single sampling unit, and for comparison among habitats, replication of the sampling units is required. The location of grids or arrays should be random and may be stratified where appropriate. The grid or array design will depend on the goals of the study and the questions being asked. Figure 5 shows a 3-fence array that will intercept animals moving in any direction and uses less material than other configurations (Corn 1994).

- For aquatic funnel traps, the pond should be stratified if possible, and traps set out randomly. For example, traps under overhanging branches and deeper water may be more productive than traps in exposed and shallow water. Details of the sampling design will require experimentation.

Sampling Effort

- If relative abundance among sites is the objective, then traps can be checked when conditions are mild and wet. This will increase the number of animals per sample. If one is interested in variation in numbers through time, traps can be checked daily or weekly. In some studies, traps have been operated continuously for months to years (Bury and Corn 1987; Raphael 1988; Corn and Bury 1991; for a summary see Corn 1994).

Personnel

- At least two people per survey.
- At least one crew member should have previous experience in marking the target species.
- At least one person should be familiar with the collection of habitat data.

Equipment

- Materials for pitfall traps, funnel traps, and drift fences (e.g., 4 litre ice cream bucket, 500 g yogurt tub, 50 cm wide aluminium flashing, 6 or 10 ml plastic sheeting, stakes)
- Shovel, pick, mattock and similar tools for installing traps and fences on land
- Field guides to amphibians (e.g. Nussbaum *et al.* 1983; Green and Campbell 1984; Leonard *et al.* 1993)
- Maps
- Calipers or ruler
- Thermometer
- 10 g and 50g spring scales
- Collecting bags (plastic zip-lock) for voucher specimens
- Camera and film
- Waterproof data sheets and pencils

Note: For construction of pitfall traps, funnel traps, and drift fences see 'Equipment' in section 3.1.

Field Procedures

- Pitfall traps may be set out individually, but are usually used in combination with drift fences.
- Pitfall traps should be tested under controlled conditions to be sure that the target species cannot escape.
- Pitfall traps may be used with or without funnel traps.
- Traps should not be left open and unchecked for more than 24 hours.
- Because salamanders and frogs can be excellent climbers, all interior surfaces of the trap should be thoroughly checked.
- Once the traps are in place, they should be checked in the same order that they are opened.

- Record appropriate measurements for individual animals.

Aquatic Funnel Traps

- Leave an air space at the top of aquatic funnel traps for newts and adult frogs.
- Tie aquatic funnel traps to a log or object on shore as traps can be blown out into the middle of lakes.

Data Analysis

Relative Abundance

Objective

- If relative abundance among sites is the objective, then traps can be checked when conditions are mild and wet. This will increase the number of animals per sample.
- If one is interested in variation in numbers through time, traps can be checked daily or weekly.

Single pitfall traps

- Single pitfall traps can be considered independent sampling units if randomly located within the terrestrial site.
- Record as the number of animals captured per trap-night, where a trap-night is one pitfall trap open for one night.

Grids / Arrays

- Grids / arrays increase the number of amphibians per sample.
- Each grid / array should be considered a single sampling unit.
- For comparison among habitats, replication of the sampling units is required.
- The location of grids or arrays should be random and may be stratified where appropriate. The grid or array design will depend on the goals of the study.
- Record as:
    1. The number of animals captured per grid/array trap-day, where one grid/array trap-day is all traps at one grid/array open for one night.
    2. The number of animals captured per captures per grid/array
    3. The number of animals captured per 100 or 1000 trap-nights, where a trap-night is one pitfall trap open for one night.

3.4.5 Capture - Painted Turtle (Floating Pitfall Traps)

A floating pitfall trap can be used for turtles (Jones 1986). This consists of a floating wooden frame with a submerged trap. Flashing can be used on the wooded frame so that turtles cannot climb out of the trap. Lagler (1943) describes a similar design made with chicken wire.

Office Procedures

- Review section on Conducting a Wildlife Inventory in the introductory manual, *Species Inventory Fundamentals* (*No.1).*
- Obtain relevant maps for 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).
- Select suitable ponds for surveys on air photos and 1:20 000 or 1:50 000 map.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for study area.
- Stratify pond habitats if appropriate.

Sampling Design

- Single pitfall traps can be considered independent sampling units if randomly located.
- If appropriate, the pond should be stratified and traps placed randomly within each stratum.

Sampling Effort

- Traps should be checked until the required sample size is obtained.

Personnel

- At least two people per survey.
- At least one crew member should have previous experience in marking the target species.
- At least one person should be familiar with the collection of habitat data.

Equipment

- Materials for pitfall traps
- Boat
- Maps
- Ruler
- Thermometer
- Collecting bags for voucher specimens
- Camera and film
- Waterproof data sheets and pencils

Field procedures

- Pitfall traps should be tested under controlled conditions to be sure that the Turtles cannot escape.
- Baited traps work best.

- Traps should not be left open and unchecked for more than 12 hours.
- Record appropriate measurements for individual animals.

Data Analysis

Relative Abundance

- Single pitfall traps can be considered independent sampling units if randomly located. If appropriate, the pond should be stratified and traps placed randomly within each stratum.
- Record the number of animals captured per trap-night, where a trap-night is one floating pitfall trap open for one night.

3.5 Absolute Abundance

Recommended method(s): Larval Survey (Total census of amphibian larvae); and Mark-Recapture (all species).

Determining the absolute density of amphibians is time-consuming, costly, and should not be attempted if relative abundance is all that is actually needed. For small populations in small bodies of water, including sinkholes, puddles, and roadside ditches, the larvae can often be counted as they are removed with a dipnet. After all the larvae are counted, they can be returned to their pool. In other cases, removal sampling (a class of analytic sampling methods) is possible (Hayek 1994), but for larger populations and adult amphibians, a mark-recapture estimator is often necessary. The absolute abundance of Painted Turtles can be estimated with mark-recapture techniques.

Mark-recapture can be used with any of the previous inventory methods which involve opportunities for capture. Some of these methods have been used in conjunction with mark-recapture techniques to study population demographics, density, movement, and activity of selected species. Marking is discussed in Section 3.1.

Other techniques for estimating absolute abundance based on density could be devised. For example, Carlson and Berry (1990) calculated the density of larval Tiger Salamanders in prairie potholes by using square throwtraps. Similarly, the number of larvae or tadpoles per unit volume of water could be calculated by repeatedly sampling the population by trapping animals inside an enclosure of a known volume (e.g., box sampler). A variety of such techniques are discussed by Shaffer *et al*. (1994).

3.5.1 Larval Survey

For small populations in small bodies of water, including sinkholes, puddles, and roadside ditches, the larvae can often be counted as they are removed with a dipnet. After all the larvae are counted, they can be returned to their pool. In other cases, removal sampling (a class of analytic sampling methods) is possible (Hayek 1994).

Procedures

This technique is also used for Presence/Not Detected surveys. Only differences between the Relative Abundance and the Presence/Not Detected Larval Survey protocol is listed here. For details on how to conduct this type of survey see section 3.4.3.

Sampling Design / Field Procedures

Exhaustive Searches of Entire Site - for smaller Study Areas

- Often the entire pool can be searched. For example, small ponds, ephemeral pools, and roadside ditches can be completely surveyed.
- Use a dipnet or small seine to remove larvae from the water, counting the number of larvae for each sweep.
- Place larvae in a bucket until at least 10 consecutive sweeps fail to catch any new animals.
- Return larvae to the water.

Data Analysis

Relative Abundance

- Record as total number of individuals (by species) per unit area.
- Data may be summarized by species and life history stage (i.e., eggs, larvae, adults).

3.5.2 Mark Recapture

Mark-recapture can be used with any of the previous inventory methods which involve opportunities for capture. Some of these methods have been used in conjunction with mark-recapture techniques to study population demographics, density, movement, and activity of selected species. Marking is discussed in Section 3.1.

There is a large literature on mark-recapture methods (e.g., Begon 1979; Seber 1982; Krebs 1989; Donnelly and Guyer 1994), but the details are beyond the scope of this manual. Some estimators require two samples, others require three samples, and some require several samples. Each estimator has particular assumptions regarding gains or losses in the population, sampling intensity and survivorship. In addition, all mark-recapture methods are subject to four stringent assumptions which should not be violated. Following Donnelly and Guyer (1994), these assumptions are: (1) the initial sample is representative of the entire population and not biased by age or sex; (2) the marks are permanent and recorded correctly; (3) the marked animals are released and disperse randomly in the population; and (4) marking does not affect the probability of recapture or survival (assumption of equal catchability).

As well as being subject to these assumptions, mark-recapture techniques are labour-intensive. Mark-recapture techniques are generally too time-consuming and expensive for routine monitoring of amphibians. Hence, they are only recommended when clearly required for management needs.

Mark-recapture is practical for estimating the abundance of Painted Turtles. Lindemann (1990) tested some Painted Turtle population data with several models, and concluded that the Jolly-Seber estimator returned the best results. He noted that an additional useful feature of the Jolly-Seber method is that it provides for estimation of rates of both population losses and gains, which would be important parameters for long-term monitoring.

Office Procedures

- Review section on Conducting a Wildlife Inventory in the introductory manual, *Species Inventory Fundamentals* (*No.1).*
- Obtain relevant maps for 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).
- Select suitable study areas for surveys on air photos and 1:20 000 or 1:50 000 maps. Validation of potential sites on the ground may be necessary.
- If appropriate, stratify and randomize the selection of study areas.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the selected study areas.
- For each species, select an appropriate sampling season. Note that this may vary with prevailing weather conditions, elevation, and latitude. It is important to work on a flexible schedule so that the survey can be done when conditions are favourable.
- If appropriate, divide the site into survey zones and/or habitat strata. If using transects, map the location of transects at each site.
- Determine the appropriate sampling design and estimators.

Sampling Design

- Determine the estimator to be used depending on the objectives of the study and whether the population is closed (population size does not change during the study period) or open (population changes in size and composition form births, deaths, and movements). Krebs (1989) and Donnelly and Guyer (1994) provide lucid discussions of estimators. The Peterson method (or one of its variants) should be used for closed populations where there is a single marking event only. If there are multiple markings, then the Schnabel method may be used. For open populations and multiple samples, the Jolly-Seber is recommended.
- If possible, use a stratified, randomized approach.
- If an entire site or pond is too large to survey exhaustively, stratify habitats and select a random sample of each major habitat type to sample.

Amphibians

- Sampling should be conducted in the spring, February to April in areas with mild winters, or April to June at higher elevations.

Painted Turtles

- Sample on sunny days in the summer when turtles are easier to find. Sampling can be done with a long-handled dipnet from a boat on clear days, but snorkeling can also be effective (St. Clair 1989).

Sampling Effort

- The schedule should be based on the time of breeding of the target species.
- Sampling effort is dictated by the estimators chosen, the accuracy of the estimate required, the size of the population, and the ease with which animals may be captured.

Personnel

- At least two people per survey.
- At least one crew member should have previous experience in marking the target species.
- At least one person should be familiar with the collection of habitat data.

Equipment

Amphibians

- Suitable wet weather clothing; waterproof footwear
- Hip-waders for shallow water; boat if sampling in deeper water
- Adequately constructed dipnet(s) for aquatic searches (see Section 3.3.4).
- ‘Leopard frog net’ for capturing frogs on land (see Section 3.3.4).
- Maps
- Calipers or ruler
- Thermometer
- 10 g and 50g spring scales
- Collecting bags (plastic zip-lock) for voucher specimens
- Camera and film

- Waterproof data sheets and pencils
- Marking equipment as required (See Section 3.1)

Painted Turtle

- Hip-waders for shallow water; boat if sampling in deeper water
- Binoculars
- Maps
- Waterproof data sheets and pencils
- Ruler
- Thermometer
- Long-handled dipnet
- Snorkeling equipment
- File for marking (See Section 3.1)

Field Procedures

- Sample for Painted Turtles on sunny days in the summer when they are easier to find.
- Heavy rains, high winds, or very dark overcast conditions that reduce visibility and should be avoided.
- Any of the previous inventory methods may be used to capture the animals.
- For every animal that is captured, record the capture date, time, habitat features at the capture point, age, sex, body length, mass, mark, etc..
- All animals captured are marked and released.
- Mark animals as indicated by the estimator to be used. For example, for Peterson mark-recapture estimators, mark all animals in the first sample, but record the number of marked and unmarked individuals in the second sample. For Jolly-Seber mark-recapture estimators, all unmarked individuals captured on each repeat sample are marked and then released.

Data Analysis

- Depending on the number of capture sessions and the characteristics of the focal species, the choice of estimator will vary. Heyer *et al.*, 1994 provide some general advice as to mark-recapture estimators for amphibians. If only two capture sessions are completed, then a Petersen estimate or a derivative thereof, is appropriate. This assumes that the population of interest is closed, but is apparently robust to some violation of this assumption. As an alternative, a Jolly-Seber stochastic estimator is best for more intensive trapping programs (greater than three sessions). It may be the most biologically realistic as it does not assume a closed population and allows variable survival rates.
- The Jolly-Seber estimator is recommended for estimating the abundance of Painted Turtles. This requires greater than three capture sessions.
- Although calculations for the population estimators can be made using hand calculators, it is recommended that for extensive mark-recapture data (e.g., for Jolly-Seber estimator), the data be analyzed with a computer. The Internet is a good place to locate mark-recapture software (e.g. http://www.biol.sfu.ca/cmr/).

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.

ACCURACY: A measure of how close a measurement is to the true value.

AMPHIBIAN: Any member of Class Amphibia (salamanders, newts, frogs, toads, and caecilians). Quadrupedal, ectothermal, vertebrates without scales, feathers or fur.

ANURAN: Frogs and toads.

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).

BIOMASS: The weight (expressed as mass) of living organisms.

CARAPACE: The dorsal part of the shell of a turtle or tortoise.

CREPUSCULAR: Active at twilight

DIURNAL: Active during the daytime

ECTOTHERMY: The condition in which heat is obtained mainly from the external environment.

EXOTHERMIC: Dependent on external sources for raising the body temperature.

FOSSORIAL: Having burrowing habits and living underground.

HERPETOLOGY: The scientific study of amphibians and reptiles.

INVENTORY: In this context, a list of the species found in an area.

LARVA: The early stage in the development of an amphibian after hatching from an egg. Frog and toad larvae are called tadpoles.

LIFE HISTORY: An organism's life-time pattern of growth and reproduction. Includes, among other things, fecundity, survivorship, mode of reproduction, age at reproduction, parental care, body size, and life span.

MARK-RECAPTURE METHODS: Methods used for estimating abundance that involve capturing, marking, releasing, and then recapturing again one or more times.

MICROHABITAT: At a fine scale, the portion of a habitat defined with respect to particular elements (e.g., under bark on logs).

MONITOR: To follow a population (usually numbers of individuals) through time.

NEOTENY: Attaining reproductive maturity while in the larval state by delayed somatic development. The larva fails to metamorphose into an adult form, resulting in a permanent, sexually mature larva (neotene).

NOCTURNAL: Active at night

POPULATION: A group of organisms of the same species occupying a particular space at a particular time.

PRECISION: A measurement of how close repeated measures are to one another.

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.

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 *relative density*: the density of one population relative to the density of another population.

SALAMANDER: Any member of Class Amphibia: Order Caudata (tailed amphibians including salamanders and newts).

SNOUT-VENT LENGTH (SVL): The length of an animal measured from the tip of the snout to the anterior end of the cloacal vent.

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.

SURVEY ZONES: Shore, shoreline, and shallow water zones which are sampled during a systematic survey.

SURVIVORSHIP: The probability of a new-born individual surviving to a specified age.

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.

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

SYSTEMATIC SAMPLE: Samples are selected at a predetermined interval or frequency (e.g., every 10 m along a transect). Contrasted with *random sample* (q.v.).

TADPOLE: A larval frog or toad.

TRANSECT: A survey method in which the observer traverses a linear route (which may or may not be straight) of fixed length, counting the number of animals seen on either side of the line.

Literature Cited

Allison, L. J., P. E. Brunkow, and J. P. Collins. 1994. Opportunistic breeding after summer rains by Arizona tiger salamanders. Great Basin Nat. 54:376-379.

Anderson, J. D. 1967. A comparison of the life histories of coastal and montane populations of *Ambystoma macrodactylum* in California. Am. Midl. Nat. 77:323-355.

Anderson, J. D. 1968. A comparison of the food habits of *Ambystoma macrodactylum sigillatum*, *Ambystoma macrodactylum croceum*, and *Ambystoma tigrinum californiense*. Herpetologica 24:273-284.

Anderson, J. D. 1972. Behavior of three subspecies of *Ambystoma macrodactylum* in a soil moisture gradient. J. Herpetol. 6:191-194.

Anholt, B. R., and E. E. Werner. 1995. Interaction between food availability and predation mortality mediated by adaptive behavior. Ecology 76:2230-2234.

Arnold, S. J. 1976. Sexual behavior, sexual interference and sexual defense in the salamanders *Ambystoma maculatum*, *Ambystoma tigrinum* and *Plethodon jordani*. Zeitschrift fur Tierpsychologie 42:247-300.

Ashton, R. E., Jr. 1994. Tracking with radioactive tags. Pp. 158-163. *In* W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L.-A. C. Hayek, and M. S. Foster (Eds.), Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.

Begon, M. 1979. Investigating animal abundance: capture recapture for biologists. Edward Arnold, London, England.

Beneski, J. T., Jr., E. J. Zalisko, and J. H. Larsen, Jr. 1986. Demography and migratory patterns of the Eastern Long-toed Salamander, *Ambystoma macrodactylum columbianum*. Copeia 1986:398-408.

Bennett, S.H., J. Glanville, and J.W. Gibbons. 1980. Terrestrial activity, abundance and diversity of amphibians in differently managed forest types. Amer. Midland Nat. 103:412-416.

Berven, K. A. 1988. Factors affecting variation in reproductive traits within a population of wood frogs (*Rana sylvatica*). Copeia 1988:605-615.

Blaustein, A. R., and D. B. Wake. 1995. The puzzle of declining amphibian populations. Sci. Am. 52-57.

Blaustein, A. R., B. Edmond, J. M. Kiesecker, J. J. Beatty, and D. G. Hokit. 1995. Ambient ultraviolet radiation causes mortality in salamander eggs. Ecol. Appl. 5:740-743.

Blaustein, A. R., D. B. Wake, and W. P. Sousa. 1994a. Amphibian declines: judging stability, persistence, and susceptibility of populations to local and global extinctions. Conser. Biol. 8:60-71.

Blaustein, A. R., P. D. Hoffman, D. G. Hokit, J. M. Kiesecker, S. C. Walls, and J. B. Hays. 1994b. UV repair and resistance to UV-B in amphibian eggs: a link to population declines? Proc. Natl. Acad. Sci. USA 91:1791-1795.

Blaustein, A.R. and D.B. Wake. 1995. The puzzle of declining amphibian populations. Sci. Am. 52-57.

Bradford, D. F. 1989. Allotopic distribution of native frogs and introduced fishes in high Sierra Nevada lakes of California: implication of the negative effect of fish introduction. Copeia 1989:775-778.

Bragg, A. N. 1965. Gnomes of the night: the spadefoot toads. University of Pennsylvania Press, Philadelphia.

Brattsstrom, B. H., and J. W. Warren. 1955. Observations on the ecology and behavior of the Pacific treefrog, *Hyla regilla*. Copeia 1955:181-191.

Brodie, E. D., Jr. 1968. Investigations on the skin toxin of the adult Rough-skinned Newt, *Taricha granulosa*. Copeia 1968:307-313.

Brodie, E. D., Jr., and L. S. Gibson. 1969. Defensive behavior and skin glands of the Northwestern salamander, *Ambystoma gracile*. Herpetologica 25:187-194.

Brodie, E.D., III, and E.D. Brodie, Jr. 1990. Tetrodotoxin resistance in garter snakes: an evolutionary response of predators to dangerous prey. Evolution 44:651-659.

Brodie, E.D., III, and E.D. Brodie, Jr. 1991. Evolutionary response of predators to dangerous prey: reduction of toxicity of newts and resistance of garter snakes in island populations. Evolution 45: 221-224.

Brothers, D. R. 1994. *Bufo boreas* (Western Toad). Predation. Herpetol. Rev. 25:117.

Burton, T. M., and G. E. Likens. 1975a. Salamander populations and biomass in the Hubbard Brook Experimental Forest, New Hampshire. Copeia 1975:541-546.

Burton, T. M., and G. E. Likens. 1975b. Energy flow and nutrient cycling in salamander populations in the Hubbard Brook Experimental Forest, New Hampshire. Ecology 56:1068-1080.

Bury, B.R., and M.G. Raphael. 1983. Inventory methods for amphibians and reptiles. Pages 416-419 *In* J.F. Bell and T. Atterbury (eds). Renewable resource inventories for monitoring changes and trends: Proc. of an Internat. Conf., Corvallis, OR, 15-19 August 1983, Soc. Amer. Foresters.

Bury, B.R., and P.S. Corn. 1987. Evaluation of pitfall trapping in north-western forests: trap arrays with drift fences. J. Wildl. Manage. 52:112-119.

Bury, B.R., and P.S. Corn. 1988. Douglas-fir forests in the Oregon and Washington Cascades: relation of the herpetofauna to stand age and moisture. Pages 11-22 *In* R.C. Szaro, K.E. Severson, and D.R. Patton (eds). Management of amphibians, reptiles and small mammals in North America. Gen. Tech. Rep. RM-166, USDA For. Serv., Rocky Mtn. For. Range Exper. Sta., Fort Collins, Colo.

Bury, R. B., P. S. Corn, and K. B. Aubry. 1991. Regional patterns of terrestrial amphibian communities in Oregon and Washington. Pp. 341-350. *In* L. F. Ruggiero, K. B. Aubry, A. B. Carey, and M. H. Huff (Eds.), Wildlife and vegetation of unmanaged Douglas-fir forests. General Tech. Report PNW-GTR-285. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Cagle, F. R. 1939. A system for marking turtles for future identification. Copeia 1939:170-173.

Cagle, K. D., G. C. Packard, K. Miller, and M. J. Packard. 1994. Effects of the microclimate in natural nests on development of embryonic painted turtles, *Chrysemys picta*. Functional Ecology 7:653-660.

Calef, G. W. 1973. Natural mortality of tadpoles in a population of *Rana aurora*. Ecology 54:741-758.

Campbell, H.W., and S.P. Christman. 1982. Field techniques for herpetofaunal community analysis. Pages 193-200 *In* N.J. Scott, Jr. (ed). Herpetological communities. Wildlife Res. Rep. No. 13, U.S. Dept. Interior, Fish and Wildl. Serv., Washington D.C. (cited in Jones 1986, Corn and Bury 1990).

Carey, C. 1993. Hypothesis concerning the causes of the disappearance of boreal toads from the mountains of Colorado. Conser. Biol. 7:355-362.

Carlson, B.N., and C.R. Berry. 1990. Population size and economic value of aquatic bait species in palustrine wetlands in eastern South Dakota. Prairie Nat. 22:119-128.

Chandler, A.C. 1918. The Western Newt or Water Dog (*Notophthalmus torosus*): a natural enemy of mosquitoes. Bulletin of the Oregon Agricultural College Experiment Station, Station Bulletin 152.

Clarke, R. D. 1972. The effect of toe clipping on survival in Fowler's toad (*Bufo woodhousei fowleri*). Copeia 1972:182-185.

Collins, J. P. 1981. Distribution, habitats and life history variation in the tiger salamander, *Ambystoma tigrinum*, in east-central and southeast Arizona. Copeia 1981:666-675.

Collins, J. P., K. E. Zebra, and M. J. Sredl. 1993. Shaping intraspecific variation: development, ecology and the evolution of morphology and life history variation in tiger salamanders. Genetica 89:163-183.

Congdon, J. D., S. W. Gotte, and R. W. McDiarmid. 1992. Ontogenetic changes in habitat use by juvenile turtles, *Chelydra serpentina* and *Chrysemys picta*. Can. Field Nat. 106:241-248.

Corkran, C.C. and C. Thoms. 1996. Amphibians: A complete field identification guide for Oregon, Washington, and British Columbia, Lone Pine Publishing, Redmond, Washington.

Corn, P. S. 1993. *Bufo boreas* (boreal toad): Predation. Herpetol. Rev. 24:57.

Corn, P. S. 1994. Straight-line drift fences and pitfall traps. Pp. 109-117. *In* W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster (Eds.), Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.

Corn, P. S., and J. C. Fogleman. 1984. Extinction of montane populations of the Northern leopard frog (*Rana pipiens*) in Colorado. J. Herpetol. 18:147-152.

Corn, P.S., and R.B. Bury. 1990. Sampling methods for terrestrial amphibians and reptiles. Gen. Tech. Rep. No. PNW-GTR-256. U.S. Dept. Agri., For. Serv., Pacific Northwest Res. Sta., Portland. 34pp.

Corn, P.S., and R.B. Bury. 1991. Terrestrial amphibian communities in the Oregon coast range. Pages 305-317 *In* L.F. Ruggiero, K.B. Aubry, A.B. Carey, and M.H. Huff (eds). Wildlife and vegetation of unmanaged Douglas-fir forests. Gen. Tech. Rep. No. PNW-GTR-285, U.S. Dept. Agric., For. Serv., Pacific Northwest Res. Sta., Portland.

Crawford, K. M. 1991. The winter environment of painted turtles, Chrysemys picta: temperature, dissolved oxygen, and potential cues for emergence. Can. J. Zool. 69:2493-2498.

Crump, M.L. and N.J. Scott, Jr. 1994. Visual Encounter Surveys. Pages 84-92 *In* Measuring and monitoring biological diversity: standard methods for amphibians. W.R. Heyer, M.A. Donnelly, R.W. McDiarmid, L.C. Hayek and M.S. Foster, editors. WR 242.

Cuellar, O. 1994. Ecological observations on *Rana pretiosa* in western Utah. Alytes 12:109-121.

Dalrymple, G.H. 1988. The herpetofauna of Long Pine Key, Everglades National Park, in relation to vegetation and hydrology. Pages 72-86 *In* R.C. Szaro, K.E. Severson, and D.R. Patton (eds). Management of amphibians, reptiles and small mammals in North America. Gen. Tech. Rep. RM-166, USDA For. Serv., Rocky Mtn. For. Range Exper. Sta., Fort Collins, Colo.

Davis, T.M. 1996a. Distribution, abundance, microhabitat use and interspecific relationships among terrestrial salamanders on Vancouver Island, British Columbia. Ph.D. Dissertation, University of Victoria, Victoria, British Columbia, Canada.

Davis, T. M. 1996b. Non-disruptive monitoring of terrestrial salamanders with artificial cover objects on southern Vancouver Island, British Columbia. Pp. *In* D. Green (Ed.), Herpetological Conservation. SSAR and Canadian Association of Herpetologists,

Dodd, C.K. 1991. Drift fence-associated sampling bias of amphibians at a Florida sandhills temporary pond. J. Herpetol. 25:296-301.

Dodd, C.K., Jr. and D.E. Scott. 1994. Drift fences encircling breeding sites. Chapter 6. *In* W.R. Heyer, M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster, eds. Measuring and monitoring biological diversity. Standard methods for amphibians. Smithsonian Institution Press, Washington. 364 pp.

Donnelly, M. A., and C. Guyer. 1994. Mark-recapture. Pp. 183-200. *In* W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L.-A. C. Hayek, and M. S. Foster (Eds.), Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.

Donnelly, M. A., C. Guyer, E. Juterbock, and R. A. Alford. 1994. Appendix 2: techniques for marking amphibians. Pp. 277-284. *In* W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster (Eds.), Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.

Duellman, W. E., and L. Trueb. 1986. Biology of Amphibians. McGraw-Hill, New York.

Eagleson, G. W. 1976. A comparison of the life histories and growth patterns of populations of the salamander *Ambystoma gracile* (Baird) from permanent low-altitude and montane lakes. Can. J. Zool. 54:2098-2111.

Efford, I. E., and J. A. Mathias. 1969. A comparison of two salamander populations in Marion Lake, British Columbia. Copeia 1969:723-736.

Efford, I. E., and K. Tsumura. 1973. A comparison of the food of salamanders and fish in Marion Lake, British Columbia. Transactions of the American Fisheries Society 1973:

Enge, K.M., and W.R. Marion. 1986. Effects of clearcutting and site preparation on herpetofauna of a north Florida flatwoods. Forest Ecol. and Management 14:177-192.

Etchberger, C. R., M. A. Ewert, B. A. Raper, and C. E. Nelson. 1992. Do low incubation temperatures yield females in painted turtles? Can. J. Zool. 70:391-394.

Fellers, G. M., C. A. Drost, and W. R. Heyer. 1994. Appendix 1: handling live amphibians. Pp. 275-276. *In* W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster (Eds.), Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.

Fellers, G.M. and K.L. Freel. 1995. A standardized protocol for surveying aquatic amphibians. United States Department of the Interior National Park Service, and Western Region National Biological Service Cooperative Park Studies Unit, Technical Report NPS/WRUC/NRTR-95-01. University of California, Davis, California. 117pp.

Ferner, J.W. 1979. A review of marking techniques for amphibians and reptiles. Society for the Study of Amphibians and Reptiles, Herpetological Circular No.9.

Frazer, N. B., J. L. Greene, and J. W. Gibbons. 1993. Temporal variation in growth rate and age at maturity of male painted turtles, *Chrysemys picta*. Am. Midl. Nat. 130:314-324.

Friend, G.R. 1984. Relative efficiency of two pitfall-drift fence systems for sampling small vertebrates. Austral. Zool. 21:423-433.

Gardner, J. D. 1995. *Pseudacris regilla* (Pacific Chorus Frog). Reproduction. Herpetol. Rev. 26:32.

Gartshore, M.E., Oldham, M.J., van der Ham, R. and F.W. Schueler. 1992. Participant's manual. Amphibian road call counts. Ontario Task Force on Declining Amphibian Populations. Ont. Field Herpetologists 29pp.

Germano, D. J., and D. F. Williams. 1993. Field evaluation of using passive integrated transponder (PIT) tags to permanently mark lizards. Herpetol. Rev. 24:54-56.

Gibbons, J.W., and R.D. Semlitsch. 1981. Terrestrial drift fences with pitfall traps: An effective technique for quantitative sampling of animal populations. Brimleyana 7:1-16.

Gilbert, M., R. Leclair, Jr., and R. Fortin. 1994. Reproduction of the northern leopard frog (*Rana pipiens*) in floodplain habitat in the Richelieu River, P. Quebec, Canada. J. Herpetol. 28:465-470.

Golay, N., and H. Durrer. 1994. Inflammation due to toe-clipping in natterjack toads (*Bufo calamita*). Amphibia-Reptilia 15:81-83.

Green, D.M., and R.W. Campbell. 1984. The amphibians of British Columbia. Handbook No. 45, Royal British Columbia Museum, Victoria. 101pp.

Gregory, P.T., and R.W. Campbell. 1984. The reptiles of British Columbia. Handbook No. 44, Royal British Columbia Museum, Victoria. 103pp.

Habitat Monitoring Committee. 1990. Procedures for environmental monitoring in range and wildlife habitat management. British Columbia Ministries of Environment and Forests, Victoria.

Hairston, N. G., Sr. 1989b. Hard choices in ecological experimentation. Herpetologica 45:119-122.

Hall, J. A., J. H. Larsen, D. E. Miller, and R. E. Fitzner. 1995. Discrimination of kin- and diet-based cues by larval spadefoot toads, *Scaphiopus intermontanus* (Anura: Pelobatidae), under laboratory conditions. J. Herpetol. 29:233-243.

Hamilton, W. J. 1948. The food and feeding behavior of the green frog, Rana clamitans Latreille, in New York state. Copeia 1948:203-207.

Hayek, L.-A. C. 1994. Removal sampling. Pp. 201-205. *In* W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L.-A. C. Hayek, and M. S. Foster (Eds.), Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.

Hayes, M. P., and M. R. Jennings. 1986. Decline of ranid frog species in western North America: are bullfrogs (*Rana catesbeiana*) responsible? J. Herpetol. 20:490-509.

Heatwole, H. 1961. Habitat selection and activity of the wood frog, *Rana sylvatica* LeConte. Am. Midl. Nat. 66:301-313.

Henderson, B. A. 1973. The specialized feeding behavior of *Ambystoma gracile* in Marion Lake, British Columbia. Canadian Field-Naturalist 87:151-154.

Hews, D. K. 1988. Alarm response in larval western toads, *Bufo boreas*: release of larval chemicals by a natural predator and its effect on predator capture efficiency. Anim. Behav. 36:125-133.

Heyer, W.R., Donnelly, M.A., McDiarmid, R.W., Hayek, L.C. and M.S. Foster (eds). 1994. Measuring and monitoring biological diversity. Standard methods for amphibians. Smithsonian Institution Press, Washington. 364 pp.

Holomuski, J. R., J. J. Collins, and P. E. Brunkow. 1994. Trophic control of fishless ponds by tiger salamander larvae. Oikos 71:55-64.

Hovingh, P. 1993. Aquatic habitats, life history observations, and zoographic considerations of the spotted frog (*Rana pretiosa*) in Tule Valley, Utah. Great Basin Nat. 53:168-179.

Hovingh, P., B. Benton, and D. Bornholdt. 1985. Aquatic parameters and life history observations of the Great Basin spadefoot toad in Utah. Great Basin Nat. 45:22-30.

Howard, J. H., and R. L. Wallace. 1985. Life history characteristics of populations of the Long-toed salamander (*Ambystoma macrodactylum*) from different altitudes. The American Midland Naturalist 113:361-373.

Janzen, F. J. 1994. Vegetational cover predicts the sex ratio of hatchling turtles in natural nests. Ecology 75:1593-1599.

Jones, K.B. 1981. Effects of grazing on lizard abundance and diversity in western Arizona. Southwest Nat. 26:107-115 (cited in Jones 1986).

Jones, K.B. 1986. Amphibians and reptiles. Pages 267-290 *In* A.Y. Cooperrider, R.J. Boyd, and H.R. Stuart (eds). Inventory and monitoring of wildlife habitat. U.S. Dept. Interior, Bur. Land Management, Denver, CO.

Jones, K.B. 1988. Comparison of herpetofaunas of a natural and altered riparian ecosystem. Pages 222-227 *In* R.C. Szaro, K.E. Severson, and D.R. Patton (eds). Management of amphibians, reptiles and small mammals in North America. Gen. Tech. Rep. RM-166, USDA For. Serv., Rocky Mtn. For. Range Exper. Sta., Fort Collins, Colorado.

Krebs, C. J. 1989. Ecological methodology. Harper & Row, New York.

Lagler, K. F. 1943. Methods of collecting freshwater turtles. Copeia 1943:21-25.

Layne, J. R., Jr. 1995. Seasonal variation in the cryobiology of *Rana sylvatica* from Pennsylvania. J. Therm. Biol. 20:349-353.

Leclair, R., Jr., and J. Castanet. 1987. A skeletochronological assessment of age and growth in the frog *Rana pipiens* Schreber (Amphibia, Anura) from southwestern Quebec. Copeia 1987:361-369.

Lefcort, H., and S. M. Eiger. 1993. Antipredatory behaviour of feverish tadpoles: implications for pathogen transmission. Behaviour 126:13-27.

Lefevre, K., and R. J. Brooks. 1995. Effects of sex and body size on basking behavior in a northern population of the painted turtle, *Chrysemys picta*. Herpetologica 51:217-224.

Leonard, W. P., and D. M. Darda. 1995. Ambystoma tigrinum (tiger salamander). Reproduction. Herpetol. Rev. 26:29-30.

Leonard, W. P., H. A. Brown, L. L. C. Jones, and R. M. Storm. 1993. Amphibians of Washington and Oregon. Seattle Audubon Society, Seattle, Washington.

Licht, L. E. 1969. Comparative breeding behavior of the red-legged frog (*Rana aurora aurora*) and the western spotted frog (*Rana pretiosa pretiosa*) in southwestern British Columbia. Can. J. Zool. 47:1287-1299.

Licht, L. E. 1971. Breeding habits and embryonic thermal requirements of the frogs (*Rana aurora aurora*) and (*Rana pretiosa pretiosa*), in the Pacific Northwest. Ecology 52:116-124.

Licht, L. E. 1973. Behavior and sound production by the Northwestern salamander *Ambystoma gracile*. Can. J. Zool. 51:1055-1056.

Licht, L. E. 1975a. Comparative life history features of the western spotted frog, *Rana pretiosa*, from low- and high-elevation populations. Can. J. Zool. 53:1254-1257.

Licht, L. E. 1975b. Growth and food of larval *Ambystoma gracile* from a lowland population in southwestern British Columbia. Can. J. Zool. 53:1716-1722.

Licht, L. E. 1992. The effect of food level on growth rate and frequency of metamorphosis and paedomorphosis in *Ambystoma gracile*. Can. J. Zool. 70:97-93.

Lillywhite, H. B., P. Licht, and P. Chelgren. 1973. The role of behavioral thermoregulation in the growth energetics of the toad, *Bufo boreas*. Ecology 54:375-383.

Lindemann, P.V. 1990. Closed and open model estimates of abundance and tests of model assumptions for two populations of the turtle, *Chrysemys picta*. J. Herpetol. 24:78-81.

Loredo, I., D. Van Varen and M.L. Morrison. 1996. Habitat use and migration behaviour of the California tiger salamander. J. Herpetol. 30(2):282-285.

Macartney, J.M., and P. T. Gregory. 1981. Differential susceptibility of sympatric garter snake species to amphibian skin secretions. American Midland Naturalist 106:271-281.

Macartney, M., and P. T. Gregory. 1985. The western painted turtle in Kikomun Creek Provincial Park. Unpublished report, submitted to Parks Branch, British Columbia.

Maret, T. J., and J. J. Collins. 1994. Individual responses to population size structure: the role of size variation in controlling expression of a trophic polyphenism. Oecologia 100:279-285.

Martin, D., and H. Hong. 1991. The use of Bactine® in the treatment of open wounds and other lesions in captive anurans. Herpetol. Rev. 22:21.

Martof, B. 1956. Growth and development of the green frog (*Rana clamitans*) under natural conditions. Am. Midl. Nat. 55:101-117.

Martof, B. S. 1953. Territoriality in the green frog, *Rana clamitans*. Ecology 34:165-174.

McDiarmid, R.W. 1992. Standard methods for measuring biological diversity of amphibians. Pages 80-82 *In* C.A. Bishop and K.E. Pettit (eds). Declines in Canadian amphibian populations: designing a national monitoring strategy. Proc. Workshop, Burlington, Ontario, 5-6 Oct. 1991. Can. Wildl. Serv. Occas. Pap. No. 76.

Mengak, M.T., and D.C. Guynn, Jr. 1987. Pitfalls and snap traps for sampling small mammals and herpetofauna. Amer. Midland Nat. 118:284-288.

Mitchell, J.C. 1988. Population ecology and life histories of the freshwater turtles *Chrysemys picta* and *Sternotherus odoratus* in an urban lake. Herpetol. Monogr. 2:40-61.

Mullally, D. P. 1952. Habits and minimum temperatures of the toad *Bufo boreas halophilus*. Copeia 1952:274-275.

Murphy, C. G. 1993. A modified drift fence for capturing treefrogs. Herpetol. Rev. 24:143-145.

Nishikawa, K. C., and P. M. Service. 1988. A fluorescent marking technique for individual recognition of terrestrial salamanders. J. Herpetol. 22:351-353.

Nussbaum, R.A., E.D. Brodie Jr., and R.M. Storm. 1983. Amphibians and reptiles of the Pacific Northwest. Univ. Idaho Press, Moscow. 332pp.

Nyman, S. 1986. Mass mortality in larval *Rana sylvatica* attributable to the bacterium, *Aeromonas hydrophila*. J. Herpetol. 20:196-201.

Oliver, W.H. 1974. Wildlife problems asociated with reservoirs used for electrical power generation (with special emphasis on wells hydroelectric project wildlife study). Proc. Annu. Conf. West. Assoc. State Game Fish Comm. 54:146-155. WR 162.

Oliver, M.G., and H.M. McCurdy. 1974. Migration, overwintering, and reproductive patterns of *Taricha granulosa* on southern Vancouver Island. Canadian Journal of Zoology 52:541-545.

Olson, D. H. 1989. Predation on breeding western toads (*Bufo boreas*). Copeia 1989:391-397.

Olson, D. H., A. R. Blaustein, and R. K. O'Hara. 1986. Mating pattern variability among western toad (*Bufo boreas*) populations. Oecologia 70:351-356.

Olson, D. H., W. P. Leonard, and R. B. Bury (eds.). 1997. Sampling amphibians in lentic habitats. Society for Northwest Vertebrate Biology. Olympia, Washington. 134 pp.

Orchard, S.A. 1990a. Amphibians. Pages 23-24 *In* R.A. Cannings and A.P. Harcombe (eds). The vertebrates of British Columbia: scientific and English names. Royal B.C. Mus., Heritage Record No. 20; Wildl. Rep. No. R24, Ministry of Municipal Affairs, Recreation and Culture and Ministry of Environment. Victoria, B.C. 116pp.

Orchard, S.A. 1990b. Reptiles. Pages 25-26 *In* R.A. Cannings and A.P. Harcombe (eds). The vertebrates of British Columbia: scientific and English names. Royal B.C. Mus., Heritage Record No. 20; Wildl. Rep. No. R24, Ministry of Municipal Affairs, Recreation and Culture and Ministry of Environment. Victoria, B.C. 116pp.

Pechmann, J. H. K., and H. M. Wilbur. 1994. Putting declining amphibian populations in perspective: natural fluctuations and human impacts. Herpetologica 50:65-84.

Pechmann, J.H.K., D.R. Scott, R.D. Semlitsch, J.P. Caldwell, L.J. Vitt, and J.W. Gibbons. 1991. Declining amphibian populations: the problem of separating human impacts from natural fluctuations. Science 253:892-985.

Pedlar, J. 1991. A review of herpetofaunal sampling techniques applicable to Grey and Bruce counties. Ontario Ministry of Nat. Resour., Owen Sound Distr. Office. 32pp.

Pfenning, D. W., and J. P. Collins. 1993. Kinship affects morphogenesis in cannibalistic salamanders. Nature 362:836-838.

Pfenning, D. W., M. L. G. Loeb, and J. P. Collins. 1991. Pathogens as a factor limiting the spread of cannibalism in tiger salamanders. Oecologia 88:161-166.

Pfenning, D. W., P. W. Sherman, and J. P. Collins. 1994. Kin recognition and cannibalism in polyphenic salamanders. Behav. Ecol. 5:225-232.

Phillips, K. 1994. Tracking the vanishing frogs. Penguin, New York.

Pimentel, R.A. 1960. Inter- and intrahabitat movements of the Rough-skinned newt, *Taricha torosa granulosa* (Skilton). The American Midland Naturalist 63:470-496.

Plummer, M.V. 1979. Collecting and marking. Pages 45-60 *In* M. Harless and H. Morlock (eds). Turtles: perspectives and research. John Wiley and Sons, Inc.

Pough, F. H. 1980. The advantages of ectothermy for tetrapods. Am. Nat. 115:92-112.

Raphael, M. G. 1988. Long-term trends in abundance of amphibians, reptiles, and mammals in Douglas-fir forests of northwestern California. Pp. 23-31. *In:* Management of amphibians, reptiles, and small mammals in North America. R. C. Szaro, K. E. Severson, and D. R. Patton, Tech. coordinators. General Technical Report RM-166. USDA, Forest service, Fort Collins, Colorado.

Raphael, M.G., and K.V. Rosenberg. 1983. An integrated approach to wildlife inventories in forested habitats. Pages 219-222 *In* J.F. Bell and T. Atterbury (eds). Renewable resource inventories for monitoring changes and trends. Proc. Internat. Conf., 15-19 August 1983, Corvallis, OR. Society of American Foresters.

Reimchen, T. E. 1991. Introduction and dispersal of the Pacific treefrog, *Hyla regilla*, on the Queen Charlotte Islands, British Columbia. Can. Field Nat. 105:288-290.

Rice, T. M., and D. H. Taylor. 1993. A new method for making waistbands to mark anurans. Herpetol. Rev. 24:141-142.

Sadler, L. M., and M. A. Elgar. 1994. Cannibalism among amphibian larvae. Trends Ecol. Evol. 9:5-6.

Sarell, M. J. 1996. Status of the tiger salamander (*Ambystoma tigrinum*) in British Columbia. Wildlife Branch, Ministry of Environment, Lands and Parks, Victoria, B. C.

Schueler, F.W. 1992. An amphibian monitoring programmes for Ontario. Unpubl. Rep. for Ministry of Natural Resources, Ontario. 39pp.

Scott, N. J., and B. D. Woodward. 1994. Surveys at breeding ponds. Pp. 118-125. *In* W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L.-A. C. Hayek, and M. S. Foster (Eds.), Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.

Seber, G. A. F. 1982. The Estimation of Animal Abundance and Related Parameters. 2nd ed. Griffin, London.

Seburn, D. 1993. Handbook for monitoring the amphibians of Alberta. Dept. Environmental Protection, Fish and Wildl. Services, Govt. of Alberta. 64pp.

Semlitsch, R. D. 1983. Structure and dynamics of two breeding populations of the eastern tiger salamander, *Ambystoma tigrinum*. Copeia 1983:608-616.

Sexton, O. J., and J. R. Bizer. 1978. Life history patterns of *Ambystoma tigrinum* in montane Colorado. Am. Midl. Nat. 99:101-117.

Shaffer, H. B., and J. E. Juterbock. 1994. Night driving. Pp. 163-166. *In* W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L.-A. C. Hayek, and M. S. Foster (Eds.), Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.

Shaffer, H.B., R.A. Alford, B.D. Woodward, S.J. Richards, R.G. Altig, and C. Gascon. 1994. Standard techniques in inventory and monitoring. 10. Quantitative sampling of amphibian larvae. *In* W.R. Heyer, M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster, eds. Measuring and monitoring biological diversity. Standard methods for amphibians. Smithsonian Institution Press, Washington. 364 pp.

Shirose, L. J., and R. J. Brooks. 1995. Age structure, mortality, and longevity in syntopic populations of three species of ranid frogs in central Ontario. Can. J. Zool. 73:1878-1886.

Shirose, L. J., C. A. Bishop, D. M. Green, C. J. MacDonald, R. J. Brooks, and N. J. Helferty. 1995. Validation study of a calling amphibian survey in Ontario. Abstract of paper presented at the Second NAAMP conference, Toronto, Ontario:

Shirose, L. J., R. J. Brooks, J. R. Barta, and S. S. Desser. 1993. Intersexual differences in growth, mortality, and size at maturity in bullfrogs in central Ontario. Can. J. Zool. 71:2363-2369.

Shoemaker, V.H., S.S. Hillman, S.D. Hillyard, D.C.Jackson, L.L. McClanahan, P.C. Withers, and M.L. Wygoda. 1992. Exchange of water, ions, and respiratory gases in terrestrial amphibians. Pp. 125-150. In M.E. Feder, and W.W. Burggren (Eds.), Environmental physiology of the amphibians. University of Chicago Press, Chicago.

Skelly, D. K. 1995. A behavioral trade-off and its consequences for the distribution of *Pseudacris* treefrog larvae. Ecology 76:150-164.

Smith, D. C. 1983. Factors controlling tadpole populations of the chorus frog (*Pseudacris triseriata*) on Isle Royale, Michigan. Ecology 64:501-510.

Smith, D. C., and J. van Buskirk. 1995. Phenotypic design, plasticity, and ecological performance in two tadpole species. Am. Nat. 1995:2.

Smits, A. W. 1984. Activity patterns and thermal biology of the toad *Bufo boreas halophilus*. Copeia 1984:689-696.

Smits, A. W., and D. L. Crawford. 1984. Emergence of toads to activity: a statistical analysis of contributing cues. Copeia 1984:696-701.

Sprules, W. G. 1974. Environmental factors and the incidence of neoteny in *Ambystoma gracile* (Baird) (Amphibia: Caudata). Can. J. Zool. 52:1545-1552.

Sredl, M. J., and J. P. Collins. 1991. The effect of ontogeny on interspecific interactions in larval amphibians. Ecology 72:2232-2239.

St. Clair, R. C. 1989. The natural history of a northern turtle, *Chrysemys picta bellii* (Gray). Masters thesis, University of Victoria, Victoria, B. C.

St. Clair, R., P. T. Gregory, and J. M. Macartney. 1994. How do differences in growth and maturation interact to determine size in northern and southern painted turtles? Can. J. Zool. 72:1436-1443.

Stebbins, R. C. 1985. A field guide to western reptiles and amphibians. 2nd. ed. Houghton Mifflin, Boston.

Storm, R.M., and R.A. Pimental. 1954. A method of studying amphibian breeding populations. Herpetologica 10:161-165.

Taylor, J. 1983. Size-specific associations of larval and neotenic Northwestern salamanders, *Ambystoma gracile*. J. Herpetol. 17:203-209.

Taylor, J. 1984. Comparative evidence for competition between the salamanders *Ambystoma gracile* and *Taricha granulosa*. Copeia 1984:672-683.

Thoms, C. and C.C. Corkran. February 1996 draft. Survey methods: Basic pond survey. Society of Northwestern Vertebrate Biology.

Titus, T. A. 1990. Genetic variation in two subspecies of *Ambystoma gracile* (Caudata: Ambystomatidae). J. Herpetol. 24:107-111.

Vogt, R.C., and R.L. Hine. 1982. Evaluation of techniques for assessment of amphibian and reptile populations in Wisconsin. Pages 201-217 *In* N.J. Scott, Jr. (ed). Herpetological Communities. U.S. Dept. Interior, Fish and Wildl. Serv. Wildl. Res. Rep. No. 13. (cited in Jones 1986).

Walls, S. C., J. J. Beatty, B. N. Tissof, D. G. Hokit, and A. R. Blaustein. 1993. Morphological variation and cannibalism in a larval salamander (*Ambystoma macrodactylum columbianum*). Can. J. Zool. 71:1543-1551.

Warken, K. M. 1992. Microhabitat use and feeding rate variation in green frog tadpoles (*Rana clamitans*). Copeia 1992:731-740.

Waye, H. L., and C. H. Shewchuk. 1995. *Scaphiopus intermontanus* (Great Basin Spadefoot). Production of odor. Herpetol. Rev. 26:98-99.

Weitzel, N. H., and H. R. Panik. 1993. Long-term fluctuations of an isolated population of the Pacific chorus frog (*Pseudacris regilla*) in northwestern Nevada. Great Basin Nat. 53:379-384.

Welsh, H.W. 1987. Monitoring herpetofauna in woodland habitats of northwestern California and southwestern Oregon: A comprehensive strategy. Pages 203-213 I*n* Gen. Tech. Rep. PSW-100, Pacific Southwest For. Range Exper. Sta., For. Serv., U.S. Dept. Agric., Berkeley, CA.

Werner, E. E. 1991. Nonlethal effects of a predator on competitive interactions between two anuran larvae. Ecology 72:1709-1720.

Werner, E. E. 1992. Competitive interactions between wood frog and northern leopard frog larvae: the influence of size and activity. Copeia 1992:26-35.

Werner, E. E. 1994. Ontogenetic scaling of competitive relations: size-dependent effects and responses in two anuran larvae. Ecology 75:197-213.

Werner, E. E., and B. R. Anholt. 1996. Predator-induced behavioral indirect effects: consequences to competitive interactions in anuran larvae. Ecology 77:157-169.

Werner, E. E., and M. A. McPeek. 1994. Direct and indirect effects of predators on two anuran species along an environmental gradient. Ecology 75:1368-1382.

Werner, E. E., G. A. Wellborn, and M. A. McPeek. 1995. Diet composition in postmetamorphic bullfrogs and green frogs: implications for interspecific predation and competition. J. Herpetol. 29:600-607.

Whitaker, J. O., Jr. 1971. A study of the western chorus frog, *Pseudacris triseriata, in Vigo County, Indiana*. J. Herpetol. 5:127-150.

Whiteman, H. H., S. A. Wissinger, and A. J. Bohonak. 1994. Seasonal movement patterns in a subalpine population of the tiger salamander, Ambystoma tigrinum nebulosum. Can. J. Zool. 72:1780-1787.

Wilbur, H. M., and P. J. Morin. 1988. Life history evolution in turtles. Pp. 387-435. *In* C. Gans, and R. B. Huey (Eds.), Biology of the reptilia. Vol. 16. Alan R. Liss, Inc., New York.

Wise, S. E., and B. W. Buchanan. 1992. An efficient method for measuring salamanders. Herptol. Rev. 23:56-57.

Zerba, K. E., and J. P. Collins. 1992. Spatial heterogeneity and individual variation in diet of an aquatic top predator. Ecology 73:268-279.

Zimmerman, B.L. 1994. Standard techniques in inventory and monitoring 3. Audio strip surveys. *In* W.R. Heyer, M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster, eds. Measuring and monitoring biological diversity. Standard methods for amphibians. Smithsonian Institution Press, Washington. 364 pp.