COSEWIC
Assessment and Status Report

on the

Coastal Tailed Frog
Ascaphus truei

in Canada

SPECIAL CONCERN
2011

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

COSEWIC. 2011. COSEWIC assessment and status report on the Coastal Tailed Frog *Ascaphus truei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 53 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Previous report(s):

COSEWIC. 2000. COSEWIC assessment and status report on the Rocky Mountain Tailed Frog *Ascaphus montanus* and the Coast Tailed Frog *Ascaphus truei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 30 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Dupuis, L.A. 2000. COSEWIC assessment and status report on the on the Rocky Mountain Tailed Frog *Ascaphus montanus* and the Coast Tailed Frog *Ascaphus truei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-30 pp.

Production note:
COSEWIC would like to acknowledge Linda Dupuis for writing the status report on the Coastal Tailed Frog (*Ascaphus truei*) in Canada, prepared under contract with Environment Canada. This report was overseen and edited by Ronald J. Brooks and Kristiina Ovaska, Co-chairs of the COSEWIC Amphibians and Reptiles Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la Grenouille-à-queue côtière (*Ascaphus truei*) au Canada.

Cover illustration/photo:
Coastal Tailed Frog — Photograph by Jared Hobbs.

Catalogue No. CW69-14/639-2012E-PDF
ISBN 978-1-100-20212-9

Recycled paper

COSEWIC
Assessment Summary

Assessment Summary – November 2011

Common name
Coastal Tailed Frog

Scientific name
Ascaphus truei

Status
Special Concern

Reason for designation
This unusual frog of an ancient lineage has a scattered distribution in western British Columbia, where it occupies cool, clear, fast-flowing mountain streams and adjacent older forest. Habitats continue to be lost and degraded as a result of forestry and other human activities that occur throughout much of its Canadian distribution. Siltation of breeding streams and loss of older forest cover associated with resource use are main threats. Threats identified in the previous assessment in 2000 continue to degrade and fragment habitats, and new threats, such as run-of-river independent hydropower projects, have the potential for rapid and widespread increase throughout the species' Canadian range. Specialized habitat requirements, life history characteristics that include low reproductive potential, and patchy distribution make the frogs particularly vulnerable to human activities and climate change.

Occurrence
British Columbia

Status history
Designated Special Concern in May 2000. Status re-examined and confirmed in November 2011.

COSEWIC
Executive Summary

Coastal Tailed Frog
Ascaphus truei

Wildlife species description and significance

The Coastal Tailed Frog is one of two members of the family Ascaphidae, which represents a distinctive and ancient line of frogs adapted to life in turbulent streams. Distinctive attributes include vertical pupils, no tympana (ear drums), claw-like forefeet, enormous webbed hind feet, a cloacal 'tail' in males, and tadpoles with an adhesive sucker. Coastal Tailed Frog tadpoles are a dominant herbivore in many streams, contributing significantly to stream ecology in the western cordillera. These frogs have become an icon of stream health much as salmon embody river integrity.

Distribution

The Coastal Tailed Frog is endemic to western North America. It occurs throughout the Coast and Cascade mountains from northern California through Oregon and Washington to British Columbia, as far north as the Alaskan panhandle border, from near sea-level to elevations of approximately 2000 m. In Canada, it occurs throughout the Cascade and Coast Ranges in British Columbia. It is absent on most offshore islands and generally does not range into lowlands where streams are warmer and more sluggish. The more continental climate on the periphery of these mountain chains restricts the species' distribution, limiting it to streams with moderately warm water in the summer, and sufficient snow to buffer streams against winter freezing and summer drying.

Habitat

The Coastal Tailed Frog occurs in drainages with catchment areas ranging from 0.3 to 50 km^2; catchments of stream reaches where breeding occurs are typically less than 10 km^2. Creeks draining these smaller catchments usually display cascade or step-pool bedforms. The locked boulders and cobbles of these streams afford foraging sites for tadpoles and refugia for all life stages. Step-pool stream morphologies also provide stability against large channel events such as sediment floods and debris flows. Tadpoles thrive best in basins with moderate levels of ruggedness and relief; very steep (slope >90%) channels are more likely to have unstable substrates, whereas level channels are prone to sediment accumulation. Juveniles and adults require older forests with stable, moist microclimates and enough structural diversity to provide refuge sites and food.

Biology

The Coastal Tailed Frog breeds in streams in the fall. Females lay strings of large eggs under anchored boulders as soon as the water warms up, usually in June in British Columbia. Hatchlings emerge within 4 to 6 weeks but remain in their nurseries, feeding from the yolk sac until their sucker is fully developed. The larval period ranges from 1 to 5 years depending on stream temperature and nutrient regime. Tadpoles scrape diatoms from rocks, drifting up to 70 m in response to food availability and predators. Tadpole survivorship is low, probably due to high risks associated with living in a dynamic environment. Metamorphs (new froglets) also have low survivorship and do not reach reproductive age until 7 – 9 years of age. Juveniles and adults feed mainly on terrestrial arthropods. Breeding adults maintain home ranges next to stream reaches; their daily movements do not seem to exceed about 30 m. Dispersal can be along streams or across slopes between streams, when conditions are cool and moist. Dispersal capabilities of the frogs appear to be low and particularly limited in exposed habitats such as clear-cuts.

Population sizes and trends

Based on limited surveys of tailed frogs in productive forests in southern British Columbia, the density of frogs within riparian zones was approximately 0.02 individuals/m^2, of which 30 to 40% were adults, resulting in 60 – 80 adults/ha. There are no firm data on population sizes or trends, but habitat is declining in both quality and quantity, probably resulting in a declining total population size.

Threats and limiting factors

Tadpoles are vulnerable to local extirpation from massive substrate movements in their creeks. This sensitivity is compounded by road building, logging practices, and run-of-river hydroelectric installations that can alter hydrological regimes and increase fine sediment in channel beds. Increased peak flows can enhance channel instability; lowered base flows can cause channels to dry up in the summer. Fine sediments clog pores among coarse stream bottom substrates, decreasing food availability and eliminating refuges. Numbers of juveniles and adults are reduced in heavily disturbed watersheds. Aforementioned human activities also compromise the quality of forest habitats surrounding stream reaches. Gene flow becomes increasingly limited as the landscape is further fragmented. Over the past few decades, an emerging fungal disease, chytridiomycosis, has resulted in amphibian population declines in many parts of the world and has recently been detected in tailed frogs from the U.S. Rocky Mountains and Coast Mountains. Chytridiomycosis is a potential threat to the Coastal Tailed Frog in British Columbia.

Protection, status, and ranks

In Canada, the Coastal Tailed Frog is federally listed as “Special Concern” and is in Schedule 1 of the *Species at Risk Act* (SARA) Registry. In British Columbia, it is in the provincial Blue-list (Special Concern) of species at risk. Globally, the species is considered apparently secure by NatureServe. Parks protect approximately 15% of the Coastal Tailed Frog’s range in British Columbia; approximately 5% of known occurrences are within protected areas (provincial parks and conservancy areas). Provincial Special Management Areas provide protection to additional areas. A total of 40 Wildlife Habitat Areas, established for species at risk listed under the *Forest and Range Practices Act*, have been approved for the Coastal Tailed Frog and are in various stages of implementation.

TECHNICAL SUMMARY

Ascaphus truei
Coastal Tailed Frog — Grenouille-à-queue côtière
Range: British Columbia Coast and Cascade Ranges

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used) *- Based on average age of adults; age at first reproduction = 7 – 9 years; adult life span 10 – 20 years; no information on annual adult mortality rates, which are probably low (see **Life History and Reproduction**).*	15 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? *- Inferred and projected continuing decline, based on habitat loss and degradation throughout the species' Canadian range.*	Yes
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations] *- Magnitude of decline unknown due to lack of baseline data.*	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]. *- Inferred and suspected decline of unknown magnitude based on habitat trends.*	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations]. *- Projected and suspected decline of unknown magnitude based on habitat trends.*	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future. *- Inferred and suspected decline of unknown magnitude based on habitat trends.*	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Reversible over centuries (e.g., old growth is 250+ years); moderately understood; not ceased
Are there extreme fluctuations in number of mature individuals?	Unknown but probably not

Extent and Occupancy Information

Estimated extent of occurrence *- Calculated using the provincial data query service, Hectares BC.*	64,300 km^2
Index of area of occupancy (IAO) *- 325 2 x 2 km grid cells with confirmed occupancy result in a discrete IAO of 1300 km^2. However, a continuous IAO, which takes into account intervening areas between occurrences, is a more appropriate estimate of IAO, and falls above the threshold of 2000 km^2.*	Greater then 2000 km^2 (continuous IAO)

Is the total population severely fragmented? *- This species has a naturally fragmented range, which is further fragmented by logging and other human activities. Specialized habitat requirements, poor dispersal ability, and occurrence in disturbed landscapes suggests fragmentation of populations, but detailed data on distribution patterns, genetics, and population viability are not available*.	Possibly but unknown
Number of locations *- Locations are deemed to correspond to 50 km^2 watersheds (upper size limit of occupied stream catchments) with suitable habitat and with logging as the main threat. The actual number of such basins occupied by the species is unknown, but there are several hundred basins with potentially suitable habitat within the Canadian range of the species. The size of cutblocks harvested at any one time varies greatly across the species' Canadian range, resulting in further uncertainty in the number of locations.*	Possibly >200
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected], continuing decline in index of area of occupancy? *- Inferred decline possible due to habitat decline, but new sites continue to be found with increasing survey effort, masking actual trends in IAO.*	Possibly, but data are lacking
Is there an [observed, inferred, or projected], continuing decline in number of populations? *- Inferred decline based on habitat trends; abundance in heavily logged watersheds can be low. However, no data on population trends or disappearances are available.*	Unknown but suspected
Is there an [observed, inferred, or projected] continuing decline in number of locations*? *- Inferred and projected decline suspected based on habitat trends.*	Unknown but suspected
Is there an [observed, inferred, or projected] continuing decline in area, extent and quality of habitat?	Yes
Are there extreme fluctuations in number of populations?	Unlikely
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
60 – 80 adults/ha have been estimated based on two pitfall trapping studies in southern B.C. Occupied habitat is a fraction of a given drainage, and population sizes are unknown.	Unknown; probably 1000s/population
Total population size is unknown but probably several million based on wide range and number of potentially suitable headwater basins.	Unknown; probably several million

Quantitative Analysis

Probability of extinction in the wild is at least *No PVA done.*	n/a

*See definition of location.

Threats (actual or imminent, to populations or habitats)

Habitat fragmentation, loss, and degradation from forestry activities, expanding run-of-river independent power projects, and associated road building are threats throughout the Canadian range of the species; proposed oil and gas pipelines are expected to cross hundreds of streams with suitable habitat for the frogs; urban developments threaten populations in localized areas. All the above can lead to siltation of breeding streams, loss of refugia, drier microclimates on the forest floor, and reduced food supplies, and eventually to population isolation. Climate change is expected to exacerbate negative impacts of both natural disturbances, such as landslides, and human disturbances of creek and creek-side habitats. Threat from emerging diseases including chytridiomycosis, which is spreading across North America and has been detected in tailed frogs in the U.S., may increase with climate change and elevated water temperatures. Limiting factors: Extreme habitat specialization (such as rivers with a specific slope and aspect, fast-flowing, clear water, rocky substrates with interstitial spaces) and life history attributes (such as delayed maturity, low reproductive potential, long lifespan) makes these frogs highly susceptible to population declines from habitat loss as a result of human activities, such as siltation from forestry, hydropower projects, and roads.

Rescue Effect (immigration from outside Canada)

Secure globally (G5) and apparently secure nationally (N3N4 in Canada; N4 in the U.S.) but of special concern throughout its range (S3S4 in British Columbia; S3 in Idaho and Oregon; S2S3 in California; S4 in Washington)	
Is immigration known or possible?	Possible but unlikely
Would immigrants be adapted to survive in Canada? *Conditions are similar in south coast B.C.*	Yes
Is there sufficient habitat for immigrants in Canada? *There are parks protecting whole watersheds along the Canada/U.S. border.*	Yes
Is rescue from outside populations likely? *Rescue is limited by poor long-distance dispersal capabilities of the frogs and extensive habitat fragmentation. Rescue is possible through the Cascades but will not benefit populations in the Coast Mountains north and west of Fraser River.*	Possible but localized and likely restricted to the border area

Current Status

COSEWIC: Special Concern, May 2000. Status re-examined and confirmed in November 2011.

Recommended Status and Reasons for Designation

Recommended Status: Special Concern	**Alpha-numeric code:** Not applicable
Reasons for designation: This unusual frog of an ancient lineage has a scattered distribution in western British Columbia, where it occupies cool, clear, fast-flowing mountain streams and adjacent older forest. Habitats continue to be lost and degraded as a result of forestry and other human activities that occur throughout much of its Canadian distribution. Siltation of breeding streams and loss of older forest cover associated with resource use are main threats. Threats identified in the previous assessment in 2000 continue to degrade and fragment habitats, and new threats, such as run-of river independent hydropower projects, have the potential for rapid and widespread increase throughout the species' Canadian range. Specialized habitat requirements, life history characteristics that include low reproductive potential, and patchy distribution make the frogs particularly vulnerable to human activities and climate change.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Declines in numbers of mature individuals are suspected based on habitat loss and degradation, but their magnitude is unknown.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EO and IAO are above thresholds.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. The estimated number of mature individuals is above critical thresholds.
Criterion D (Very Small or Restricted Total Population): Not applicable. Total population is not small or restricted, and the values are well above critical thresholds.
Criterion E (Quantitative Analysis): Not applicable. Insufficient data exist for population viability analysis.

PREFACE

Since the last COSEWIC assessment of tailed frogs in 2000, genetic research has led to the recognition of the Coastal Tailed Frog (*Ascaphus truei*) as a distinct species from the Rocky Mountain Tailed Frog (*Ascaphus montanus*). Previously, the two Tailed Frogs were considered separate designatable units within a single species (Dupuis 2000). The “Pacific Coast population”, corresponding to the Coastal Tailed Frog, was assessed as Special Concern.

The Canadian distribution of the Coastal Tailed Frog has been further refined since 2000, especially in the Cascade Mountains in the extreme southeastern part of the species’ range in British Columbia but also in the Coast Mountains. Geographical Information System (GIS) queries have enabled more accurate calculation of the species’ range, its area of occupancy, and the level of protection afforded by parks and management initiatives. Much effort has gone into studying the species’ aquatic habitat associations and distribution patterns at the regional, watershed, and local scales. This species is a step-pool specialist breeding in mountain streams with contributing basins of less than 10 km^2. It is found in streams with low to moderate disturbance regimes. Factors governing stream stability involve complex interactions between topography, discharge rates, channel material, and human activities. A limited amount of research on terrestrial habitats indicates that juveniles are the main dispersers in the population. Movement appears to be primarily overland in natural settings, and along riparian corridors where tree stands have been removed. There is no new information on population size, as Coastal Tailed Frog juvenile and adult samples remain low, and fluctuations in tadpole numbers are too extreme to provide insight on population trends.

Protection of some old-growth patches and stable streams is underway and includes the establishment of Wildlife Habitat Areas along streams occupied by this species with guidance from the Identified Wildlife Management Strategy of British Columbia. Once completed, the Wildlife Habitat Areas are expected to protect about 10,000 ha of occupied habitat. However, previously identified threats from logging and road construction have not been attenuated in the vast majority of the area where this species occurs. Independent power projects are a new threat, with run-of-the-river installations being proposed for hundreds of creeks. Climate predictions show that, within the distribution of the species in B.C., climate change will result in more volatile creeks during winter and significant aquatic habitat contraction during the growing season in less than 50 years. These changes are expected to accentuate negative impacts of human activities. New genetic information indicates that removal of forest cover impedes gene flow in Coastal Tailed Frogs. Increased fragmentation and climate change can limit overland dispersal and contribute to population isolation and decline. The recently discovered chytrid fungus that is responsible for the decline of many amphibian populations was detected in Coastal Tailed Frog samples from the United States in 2007 and may be an additional threat in B.C.

No Aboriginal Traditional Knowledge is readily available for the Coastal Tailed Frog at this time

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS
(2011)

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

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

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

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

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and classification

The Coastal Tailed Frog, *Ascaphus truei*, belongs to the family Ascaphidae, an ancient lineage with *Ascaphus,* the only genus in the family. In British Columbia (B.C.), the species is known by the English common name of Pacific Tailed Frog. The French common name is Grenouille-à-queue côtière. Until recently, *Ascaphus* was considered a monotypic genus, with *A. truei* its only species. Nielson *et al.* (2001) found significant genetic divergences between populations from the Coast and the Rocky Mountains. The latter form was promoted to a full species, *A. montanus*, the Rocky Mountain Tailed Frog (Crother 2008). *Ascaphus truei* now refers only to the Coastal Tailed Frog. Nielson *et al.* (2001) and Carstens *et al.* (2005) suggest that the two lineages became isolated in the late Miocene, probably in response to the rise of the Cascade Mountains. Their findings are congruent with the genetic patterns found in other mesic species (species that occupy moist habitats rather than dry or humid ones) during this time period (Carstens *et al.* 2005).

Morphological description

Unlike all other North American frogs, *Ascaphus* is adapted for life in cold, clear, mountain streams and their forested borders (Nussbaum *et al.* 1983). The morphological traits of both adults and tadpoles reflect this specialization for swift water habitats. The body length (snout to urostyle) of adults of the Coastal Tailed Frog is 2.2 – 5.1 cm (Figure 1). They possess a vertical pupil and lack tympana (ear drums), stapes (middle-ear bone), and the ability to vocalize (Jones *et al.* 2005). They have claw-like toes on their forefeet, but their hind feet are webbed with broad, flattened outer toes (Figure 2). The skin is granular and helps them blend in with their surroundings. The colour can vary from tan or brown, to olive green or red; indistinct dark blotches can be seen on paler individuals, and there is often a distinct copper-coloured bar or triangle between the eyes and snout (Jones *et al*. 2005; Corkran and Thoms 2006). The name “tailed frog” is in reference to the males’ short, conical ‘tail’, an extension of the cloaca that functions as a copulatory organ (Figure 2).

Figure 1. Profile of a Coastal Tailed Frog; photo by Jared Hobbs (permission to reproduce).

Figure 2. Dorsal view of a male Coastal Tailed Frog; photo by Jared Hobbs (permission to reproduce).

The tadpoles are up to 6.5 cm in total length including the tail (up to 3 cm in body length), and have a ventrally flattened body and a laterally compressed tail bordered by a low, straight or tapered dorsal fin (Figure 3). A key characteristic of tailed frog tadpoles is their oral disc, a mouth modified into an adhesive sucker that allows them to cling to rocks (Figure 4). Hatchlings are about 11 mm in total length, uniform dark brown, and carry a conspicuous ventral yolk sac. Tadpoles generally remain dark brown in the first year and may turn light brownish-grey with or without lighter flecks as they age. Tadpoles usually have a white dot (ocellus) at the tip of the tail.

Figure 3. Coastal Tailed Frog tadpole adhering to a cobble; photo by Jared Hobbs (permission to reproduce).

Figure 4. Oral disc of a tailed frog; photo by Wayne Lynch (permission to use in educational material).

Population structure and variability

Nielson *et al.* (2006) found that *Ascaphus truei* populations from the Coast to the Cascade Mountains in B.C. were relatively uniform, suggesting relatively recent range expansion or contemporary gene flow. However, genetically distinct groups exist in the United States (Nielson *et al.* 2006). Significant allelic divergence was noted in the north and south Olympic Mountains of Washington, and in the four southernmost populations of southern Oregon and California. These units are probably the result of climate-induced isolation (Nielson *et al.* 2006).

In B.C., frogs inhabiting several tributaries linked by a mainstem with a catchment area of generally about 50 km^2 can be considered populations or subpopulations with varying degrees of connectivity to each other (Dupuis and Friele 2003). There are about 772 such basins within the species' Canadian distribution, but it is uncertain how many of them are occupied. Spear and Storfer (2008) used landscape genetic analysis to assess the effect of fragmentation from large-scale timber removal on Coastal Tailed Frog population connectivity. Their research suggests that the absence of forest is a key restrictor of genetic connectivity and that intact forest patches in the surrounding environment are necessary for continued gene flow. Although individuals could recolonize catchment basins, the risk of isolation from forest fragmentation exists and is on the rise throughout coastal B.C. Dupuis *et al.* (2010) suggested that a disruption of metapopulation dynamics, followed by a rapid decline in Coastal Tailed Frog population size, is likely to occur when more than 50% of inter-connected riparian and old (micro-climatically stable) forests have been removed from the coastal landscape.

Designatable units

There is no evidence of deep phylogenetic divisions or major discontinuities in the range or habitat of the Canadian population of the Coastal Tailed Frog, and the species' range is largely within one Ecoprovince (Coast and Mountains). Therefore, only one designatable unit is identified.

Special significance

Tailed frogs are among the most primitive frogs in the world (Brown 1975); their closest relatives are in New Zealand. Their unique and ancient lineage is reflected in their distinctive morphology and life histories. They are the only frogs in North America adapted to life in cold mountain streams (Cook 1984). They are one of the longest-lived of all North American frogs (Nussbaum *et al.* 1983). These adaptations make them vulnerable to climate change.

Tailed frogs are of some political interest in B.C. because of their uniqueness, habitat specialization, and vulnerability to land development. They have brought attention to headwater creeks, which have historically received little management priority because they generally lack fish. As tailed frogs thrive best in stable, forested creeks, they have become a symbol of mountain stream integrity much as salmon are indicators of river health.

Coastal Tailed Frog tadpoles play an important role as grazers in stream ecosystems. As a dominant grazer, they are an umbrella species; protecting their habitats safeguards other inhabitants of upland streams. The large biomass of tadpoles in many streams implies that they are a significant source of prey for small vertebrates feeding in creeks, such as water shrews (*Sorex* sp.) and American Dippers (*Cinclus mexicanus*).

DISTRIBUTION

Global range

The Coastal Tailed Frog is endemic to the Pacific Northwest of North America (Figure 5). It occurs from near sea level to timberline in mountainous forests of the Coast and Cascade ranges. It is found in British Columbia, Washington, Oregon, and northern California.

Figure 5. Distribution of the Coastal Tailed Frog in North America (from Jones *et al*. 2005).

Canadian range

In Canada, the Coastal Tailed Frog occurs throughout the Cascade and Coast ranges in British Columbia (Figure 6), where its distribution covers approximately 6,430,000 ha. Its distribution largely coincides with the mainland portion of the Coast and Mountains Ecoprovince (Dupuis *et al.* 2000), which extends along the length of the B.C. coastline (Figure 6). In southern B.C., the species also occurs in the leeward ranges of the Coast and Cascade mountains, within the Southern Interior Ecoprovince (Figure 6). The Coast and Mountains Ecoprovince and the western edge of the Southern Interior Ecoprovince are characterized by rugged mountain ranges and a relatively mild climate (B.C. Ministry of Environment 2006). B.C. Biogeoclimatic zones (Meidinger and Pojar 1991) where the Coastal Tailed Frog occurs include the Coastal Western Hemlock (CWH) zone at lower elevations, and the Mountain Hemlock (MH), Engelmann Spruce-Subalpine Fir (ESSF), and Alpine Tundra (AT) zones at higher elevations. Much of the species' range also overlaps with intrusive rocks (Dupuis *et al.* 2000; Gyug 2001; Sutherland *et al.* 2001) of the Coastal Plutonic Complex (Holland 1976; Wheeler *et al.* 1992).

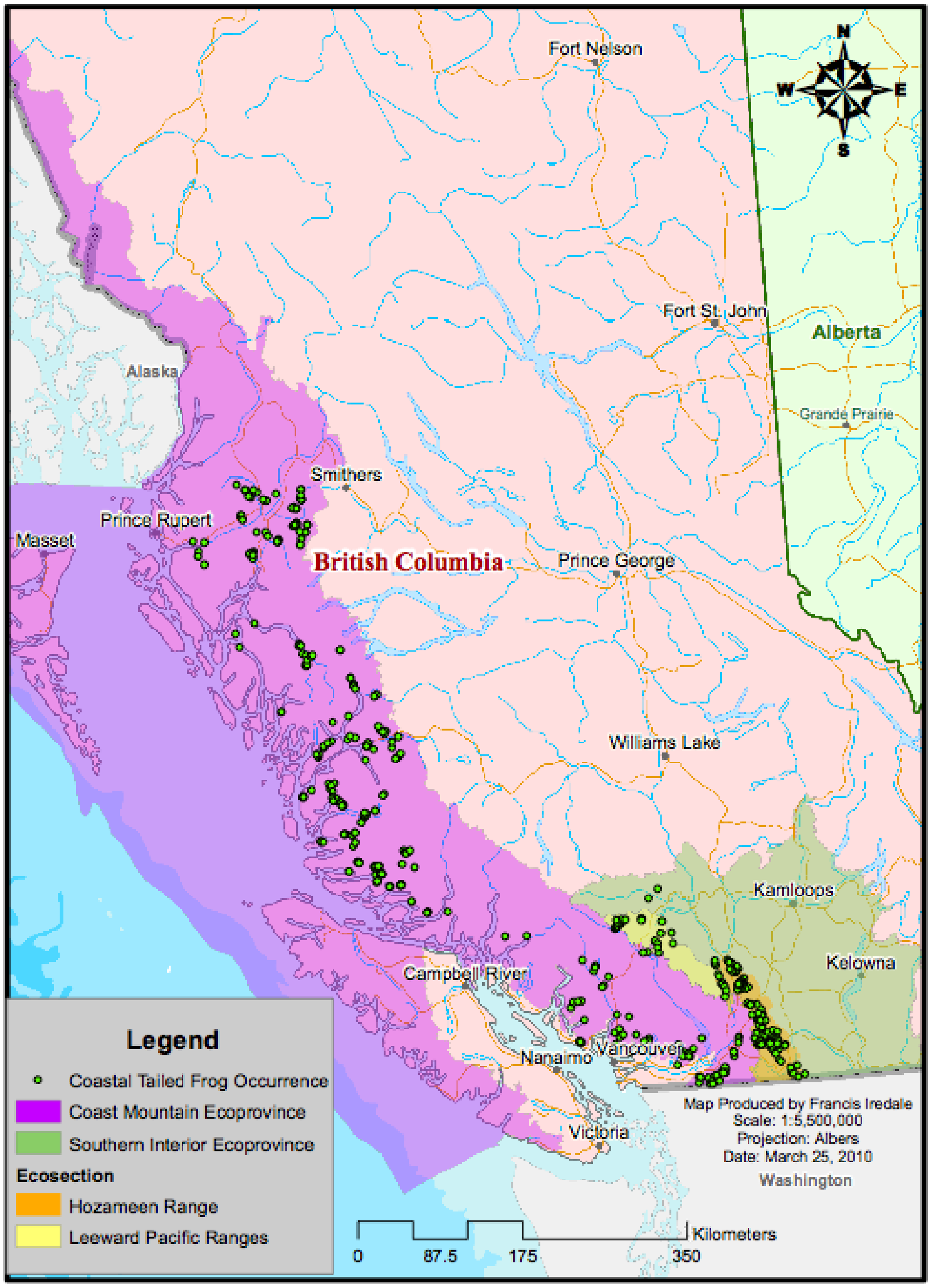

Figure 6. Range of the Coastal Tailed Frog in Canada (prepared by Francis Iredale using data compiled by Linda Dupuis for 1954 – 2010). The Cascade Mountains, including the Hozameen sub-range, are located in the southeastern part of the species' distribution in British Columbia, whereas most of the distribution is within the Coast Mountains.

Portland Canal, which divides B.C. from the Alaska Panhandle, represents the species' northern limit on the windward side of the mountains at approximately 54°15' latitude; scattered populations can be found as far north as 54° 30' on the leeward side (Dupuis *et al.* 2000; Dupuis and Friele 2003). The Coastal Tailed Frog may still be undergoing post-glacial range expansion, or it may be limited from dispersing further north by low temperatures. To the west, the Coastal Tailed Frog does not generally occur in the Hecate Lowlands along the immediate coastline where streams tend to be warmer, more sluggish, and richer in fine sediment. Water barriers have probably prevented the species from becoming established on Vancouver Island and other offshore islands, though it has successfully colonized some near-shore islands such as Gribble and King islands (Dupuis *et al*. 2000).

Since the previous status assessment in 2000, a main focus of Coastal Tailed Frog research in B.C. has been on defining its eastern distributional limits. Results confirm the suggestion by Dupuis *et al*. (2000) that this species' range overlaps with the wet and moist biogeoclimatic zones of the Coast and Mountains Ecoprovince. There appears to be a marked cut-off in occurrence coinciding with the transition to continental ESSF and other Interior biogeoclimatic zones (Gyug 2001; Wind 2009). Occurrences in the ESSF and AT biogeoclimatic zones are likely limited to forests and alpine meadows with sufficiently high summer temperature regimes, and with winter precipitation levels high enough to blanket creeks with snow and prevent them from freezing. Occasional records in the drier Interior Douglas-Fir zone appear to have their headwaters in the ESSF zone (Gyug 2001).

Not all creeks within the species' distribution are suitable, either because they are too cold to support growth and development or because they lack the channel stability necessary for tadpoles to survive their lengthy larval period in the face of seasonal floods and other natural or human-induced bedload movement events (Dupuis and Friele 2003). Larvae occur in 50 to 60% of creeks surveyed in the central portion of their range in B.C. (Michelfelder *et al*. 2008), and 40 to 50% of creeks surveyed further north (Dupuis and Friele 1996) and east (Richardson and Neill 1995; Gyug 2001). At the very edge of its range, the Coastal Tailed Frog occurs in fewer than 20% of creeks (Dupuis *et al*. 2000; Leupin 2000; Wind 2009). The overall frequency of occurrence (based on all combined B.C. datasets) is 40%, and this estimate is biased because steeper reaches are not as accessible to searchers as lower ones. Based on a predictive model for this species, an estimated 22% of creeks actually represent optimal breeding habitat in the prime of its range on the mid-coast (Michelfelder pers. comm. 2010).

Extent of occurrence and index of area of occupancy

The extent of occurrence (EO) was calculated as 64,300 km^2, based on the minimum polygon method. The index of area of occupancy (IAO) was calculated based on the number of 2 km x 2 km grid cells with distribution records of the species up to the year 2010. There were 325 occupied cells, resulting in an IAO of 1,300 km^2 (discrete IAO). If intervening stretches of streams between occurrences are included (continuous IAO), then more than 500 grid cells are intersected by these stream reaches, resulting in an IAO greater than 2000 km^2. The continuous IAO is a more appropriate estimate of IAO for this species. The known area of occupancy has expanded as a result of increased survey effort, but the real trend is unknown and could be declining as a result of habitat degradation (see **Habitat trends**).

Search effort

Over 1360 stream reaches have been surveyed for the Coastal Tailed Frog in B.C. (Table 1). The goal of almost all historical and current surveys has been to refine the species' range limit and further understand its complex habitat associations. Consequently, most inventories (80%) involved time-constrained searches to maximize detection and the area of survey coverage. Surveys were concentrated primarily on the mid- to north coast (56%), and along the eastern edge of the species' known range (39%). Only 8% of the surveys (n = 100) are from the south coast, and most of these are from the Lower Mainland and its vicinity.

Table 1. Summary of Coastal Tailed Frog inventories in B.C.

No. of stream reaches	Year	Survey type*	Primary searcher	Source	Forest district
161	2009	TCS	Volker Michelfelder	Michelfelder *et al.* 2008	Central Coast
23	2009	TCS	Francis Iredale	Unpubl. data; MOE in Kamloops	Cascades
133	2009	TCS	Elke Wind, Pierre Friele	Wind (2009)	Cascades
57	2003	TCS	Leo Frid	Frid *et al.* 2003; report to MWLAP in Nanaimo	Central Coast
35	2002	TCS	P Friele, A Frid, and L Dupuis	Dupuis and Friele 2003; report to MOE Skeena Region	North Coast and Kalum
254	2001	TCS	Les Gyug	Gyug 2001; report to MOE in Kamloops	Cascades
72	2000	TCS	Ernest Leupin	Leupin 2000; report to MOE in Kamloops	Cascades
126	1996	TCS	Linda Dupuis	Dupuis and Steventon 1999; Forest Ecology and Management 124: 35-43	North and Central Coast; Kalum
147	1995	TCS	Linda	Dupuis and Friele 1996; report to	North Coast and

No. of stream reaches	Year	Survey type*	Primary searcher	Source	Forest district
			Dupuis, Pierre Friele	MOE Skeena Region	Kalum
10	1995	TCS, ACS	Tanya Wahbe	Wahbe 1996 (Master's Thesis)	Squamish
74	1994	TCS, ACS	Linda Dupuis	Dupuis and Friele 1996; report to MOE Skeena Region	Kalum
23	1994/95	TCS, ACS	Linda Dupuis	Dupuis and Waterhouse 2001; Extension note for MOF	Lower Mainland, Sunshine Coast
12	1995	TCS	Linda Dupuis	Unpubl. data	Cascades
55	1993	Searches	John Kelson	Unpubl. data; in B.C. Conservation Centre	Kalum
79	1992/93	Unknown	John Richardson	Various research projects	Chilliwack
100	1954-1996	Sightings	Various	Data in B.C. Conservation Centre	Mainly South Coast region

*TCS = Time-constrained search (20 or 30 person-minutes)
ACS = Area-constrained searches (10 to 15 meter reaches)

A total of 735 stream reaches (54%) have been surveyed since the previous status assessment in the year 2000; these surveys have resulted in approximately 290 records of the Coastal Tailed Frog. It is unknown how many of these records represent previously undocumented occupied streams or sub-basins. There are probably in the order of 100 records from new streams, many of which are along the eastern edge of the species' range (e.g., Tulameen and Merritt Forest Districts of the Cascade Mountains; Gyug 2001).

HABITAT

Habitat requirements

Aquatic habitat – Watershed scale

Coastal Tailed Frogs occur in mountain and fjord-side tributaries fed by contributing basin areas of about 0.3 – 50 km^2 or less (Figure 7); breeding and larval-rearing reaches are typically 1 – 10 km^2 (Dupuis and Friele 2003). It is expected that foraging and over-wintering habitat for Coastal Tailed Frogs are also within these small basins, which represent perennial headwaters. Larger basins (10 – 50 km^2) are essentially big tributaries to rivers that link upland streams. Frogs and tadpoles found in these larger watercourses might be dispersers or a result of downstream drift.

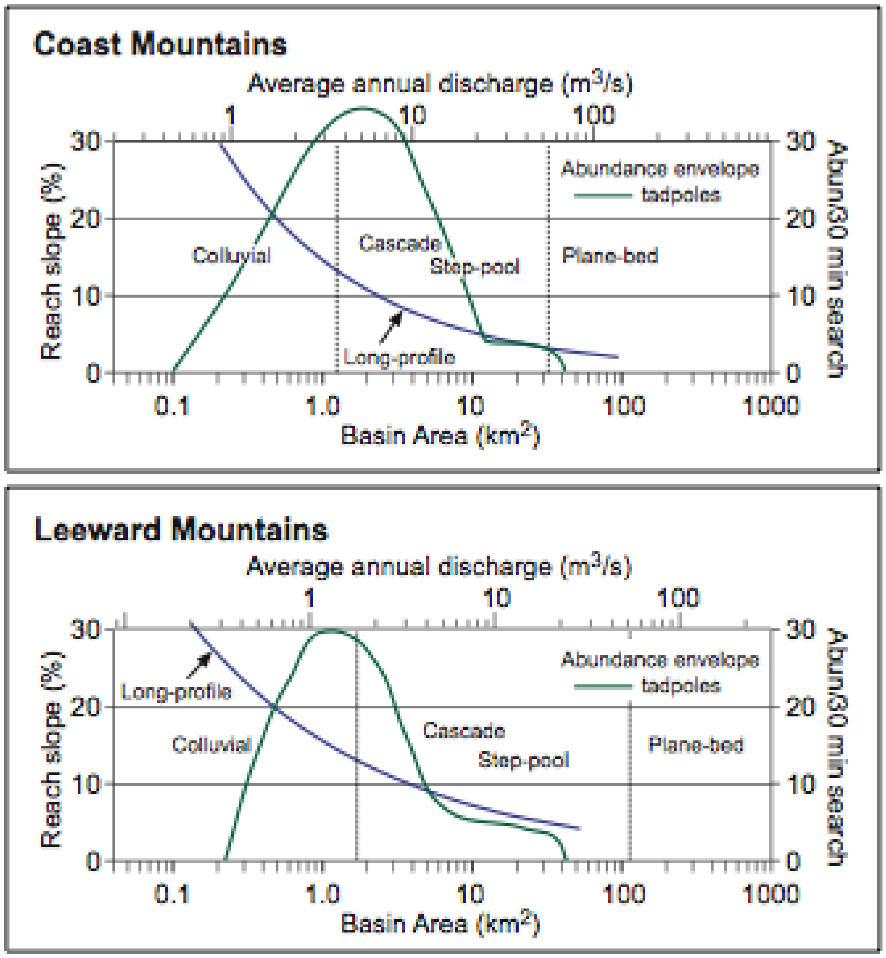

Figure 7. Physiography of streams occupied by the Coastal Tailed Frog in B.C. (Dupuis and Friele 2003), showing tadpole abundance with respect to channel profile (long profile), reach slope, and habitat domains.

Relief and basin ruggedness (overall gradient) appear to be important factors influencing tailed frog occurrence and abundance within the 0.3 to 50 km^2 range of basin sizes (Dupuis and Friele 2003), as is also bedrock geology (Diller and Wallace 1999; Wilkins and Peterson 2000; Dupuis and Friele 2003). More specifically, steepness and rock type affect the frequency and severity of geologic processes that small catchments are exposed to, including floods, sediment pulses, debris flows, rock fall, and avalanche activity (Montgomery 1999) (Figure 8). The Coastal Tailed Frog tends to be absent from excessively steep creeks (> 90% overall gradient) because of their frequent channel activity and because they are subject to rapid runoff and extreme peak discharges; these factors are conducive to high bedload transport (de Scalley *et al.* 2001). Occurrence is particularly low in windward basins of hyper-maritime areas because high precipitation associated with incoming storms leads to elevated discharge rates, increased mobility of channels, and thus high mortality rates among tadpoles (Dupuis and Friele 2003). Similarly, Coastal Tailed Frogs are absent from streams governed by colluvial activity because frequent, unpredictable gravity-based rock fall renders these higher elevation headwaters unstable; they are also often ephemeral.

Thus, the Coastal Tailed Frog thrives best in channels with a moderate disturbance regime (Dupuis and Friele 2003, 2006; Frid *et al.* 2003). Table 2 summarizes the range of watershed parameters that contribute to optimal habitat for this species.

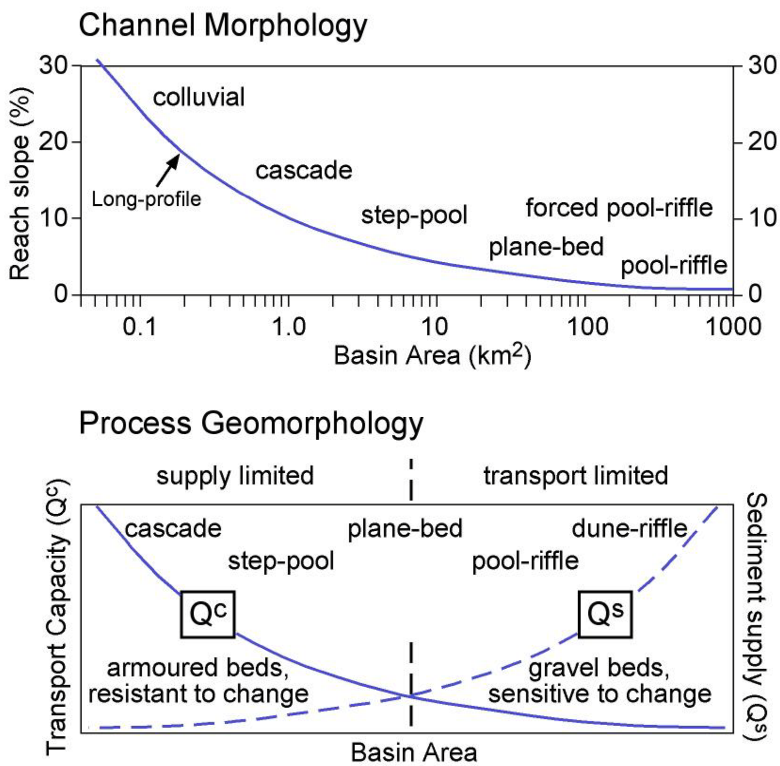

Figure 8. Stream structure and processes affecting habitats of the Coastal Tailed Frog (prepared by P. Friele).

Table 2. Optimal Coastal Tailed Frog habitat (Dupuis and Friele 2003).

Habitat parameter	**Ideal range**
Flow	Perennial
Basin area (km^2)*	0.3 – 10
Watershed steepness (%)*	31 – 70
Reach slope (%)	3 – 40
Disturbance regime	Infrequent debris flows, low sediment transport
Substrate embeddedness	None; or low to moderate (<50% embedded)
Bankfull width (m)	1 – 6.5
Water temp (°C)	8.0 –16

* map-derived variables

Habitat in the tributaries of small basins (0.3 – 50 km^2) normally constitutes a succession of rock steps (anchored cobbles and boulders) with associated downstream pools. These step-pool sequences are relatively stable because they cause flows to tumble, reducing water velocity and lowering the pulling force on the channel bed (Figure 9; Chin 1998; Scheuerlein 1999; Zimmerman and Church 2001). Coastal Tailed Frog tadpoles possess an oral sucker that enables them to move in this step-pool environment with ease, and without risk of displacement. Eggs, yolk-feeding larvae with undeveloped suckers, and metamorphosed frogs take refuge in the interstitial pores of the anchored steps and in the relatively quiet waters of their downstream pools. Although step-pools are subject to collapse at critical flows within 5 to 50-year recurrence intervals (Chin 1998, 2002) depending on local geomorphic conditions, they can accommodate the lengthy (multiple year) aquatic development period of most tadpoles; they allow for one or more successful (catastrophe-free) egg-laying and post-metamorphic recruitment cycles during the lifespan of a breeding adult. Although many individuals are likely killed by bedload movement (channel mobility) in dynamic mountain streams, re-colonization is always possible by tadpoles that survive in the remaining, intact steps.

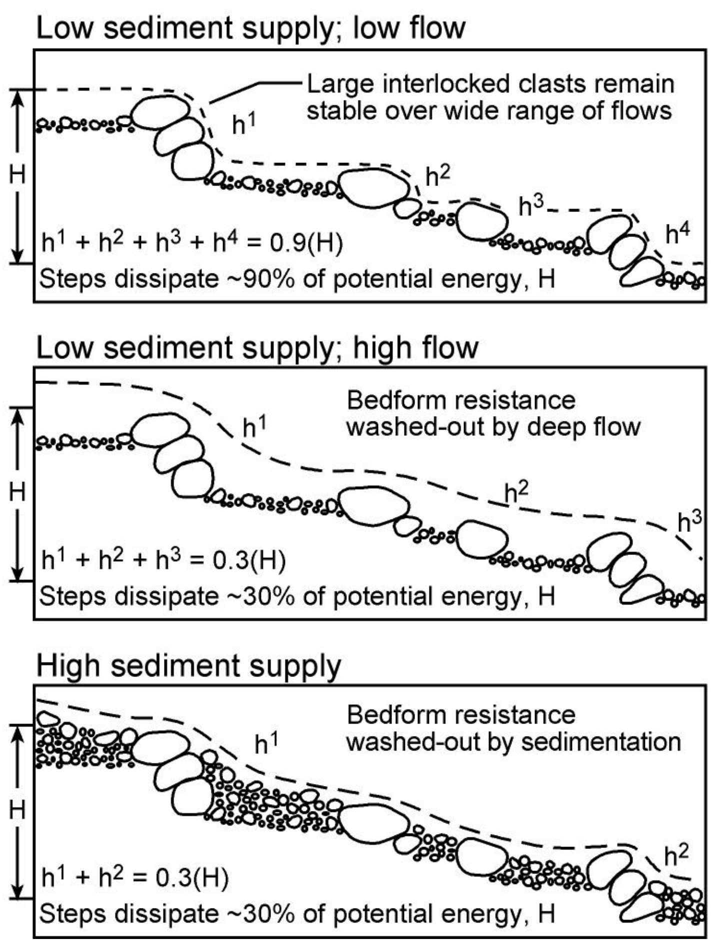

Figure 9. Step-pool habitat of the Coastal Tailed Frog in relation to sediment supply and flow regime (from Dupuis and Friele 2003).

Large watercourses found in the lower portions of a watershed (with contributing basins > 50 km^2) tend to be unsuitable for Coastal Tailed Frogs because they have gentle gradients and high flows. Consequently, they are characterized by large proportions of sand and pebbles, and by plane bed and pool-riffle bedforms. Interstitial microhabitat availability and channel bed stability are reduced in this environment. Eggs and hatchlings in particular lack the ability to resist pulling forces. The presence of tadpoles in rivers is thought to be a product of downstream drift (see Wahbe and Bunnell 2001).

Aquatic habitat – Stream reach scale

Regional and watershed characteristics such as topography, precipitation levels, and basin size all interact to influence site-level parameters such as discharge rate, reach morphology, and substrate composition. These channel features can cause tailed frogs to have a spotty distribution at the site level (Figure 8). There can be as much as a 50-fold difference in tadpole numbers within and among the reaches of a single creek (Dupuis and Friele 2003; Friele 2009).

Distribution of Coastal Tailed Frog tadpoles is particularly influenced by channel substrate texture and degree of embeddedness (Dupuis and Friele 1996; Diller and Wallace 1999; Wilkins and Peterson 2000; Adams and Bury 2002; Stoddard 2002; Dupuis and Friele 2003). By monitoring Coastal Tailed Frog tadpoles for 5 years, Ardea Biological Consulting Ltd. (1999) found that tadpole density was positively correlated with the percentage of cobbles and inversely proportional to the percentage of fines (sand and pebbles) and woody debris. Likewise, Altig and Brodie (1972) found that tadpoles showed a preference for smooth rocks above 55 mm in diameter in a laboratory setting. Hawkins *et al.* (1988) noted the highest densities of tadpoles on 100-300 mm diameter substrates during the day, and substrates >300 mm at night. Fine materials fill the interstitial matrix that tailed frogs specialize in (Metter 1964; Bury and Corn 1988; Dupuis and Friele 1996; Welsh and Ollivier 1998; Diller and Wallace 1999; Wilkins and Peterson 2000), covering food sources and traction surfaces, and eliminating refugia. In areas with more frequent, extreme storm events, population levels are expected to show a stronger relationship with substrate texture, and geological parameters at large (Dupuis and Friele 2003, 2006).

Temperature is also a critical parameter of tailed frog habitat. Although larval populations in B.C. are most frequently found in creeks with low summer stream temperatures associated with deep snow pack and prolonged snow melt, embryonic and tadpole development is not possible in streams under 7°C (Brown 1975; Dupuis and Friele 2003, 2006). In continental areas of the north, Dupuis and Friele (2003) found that Coastal Tailed Frogs were uncommon in north-facing basins, presumably because these were too cold to support the growth and development of tadpoles. A meta-analysis of datasets from B.C. and Washington also showed a higher occurrence rate of Coastal Tailed Frogs in streams with southern or eastern aspects (Sutherland *et al.* 2001). Eggs require temperatures of 5 to 18.5 °C for survival, the narrowest range and lowest maximum of all North American frogs (Brown 1975). Very young tadpoles seem to congregate in pockets of cooler water (approximately 10°C). Maturing tadpoles tolerate relatively high temperatures (Metter 1966) but tend to avoid conditions in excess of 22°C (de Vlaming and Bury 1970). Lethal temperatures for adults range from 21°C to 24.1°C (Metter 1966; Claussen 1973; Adams and Frissell 2001). Franz and Lee (1970) suggested that water chemistry may influence tadpole population distribution; they found Rocky Mountain Tailed Frog tadpoles only in streams with $pH < 7.7$ and dissolved oxygen levels > 8.2 parts per million.

Tadpoles are found in stream gradients ranging from 2 to 93% (Sutherland *et al*. 2001), but they are usually absent in low-gradient streams that drain low-lying lakes and depressions because waterpower in these watercourses is insufficient to flush fine sediment. Due to low flows, their temperature regimes can be quite elevated as well. Both sand and the filamentous algae that colonize warm streams can displace tadpoles.

Although abiotic factors govern tadpole distribution patterns in the majority of mountain streams, biotic factors likely play an important role in streams with relatively benign disturbance regimes (Creed 2006). Biotic factors include predation, competition, communal egg-laying locations, and nutrient concentrations.

In any given breeding location, Coastal Tailed Frog tadpoles are found across the full spectrum of microhabitats, although young ones seem to be more commonly found in pools, whereas large ones tend to frequent steps (Dupuis pers. obs. 1994-2008). Metamorphosing tadpoles appear to be most strongly associated with large anchored boulders (Dupuis pers. obs. 1994-2008). They are at higher risk in less stable microhabitats, as their larval oral disc transforms into a mouth. Tadpoles take several years to metamorphose (see **Life cycle and reproduction**) and overwinter in breeding streams. Over-wintering habitats of metamorphs are unknown.

Terrestrial habitat

Tailed frogs are terrestrial foragers. They feed in riparian zones but are known to wander more than 100 m from streams when conditions are moist (Wahbe *et al.* 2004). Individuals may overwinter on land as well as in water (Bull and Carter 1996). Although they are strongly tied to moist forests (Bury *et al.* 1991), often with dense herb and fern cover (Welsh 1993; Corn and Bury 1991), they are not associated with any particular plant species or communities (Metter 1964). Many authors have suggested that this species needs an abundance of cool, moist microhabitats for survival (Welsh 1990; Aubry and Hall 1991; Bury *et al.* 1991).

The Coastal Tailed Frog requires moist, older forest habitat. In addition to old-growth forest, maturing forest (> 80 years old) is suitable, at least in the productive mixed-wood forests in the southern part of the species' range in B.C., as shown by a study in the Chilliwack area by Matsuda and Richardson (2005). In California, the Coastal Tailed Frog is more abundant in late seral stages (≥ 200 years) than in young and maturing stands (Welsh and Lind 1991, 2002). A strong association with old forests has also been reported in Oregon, Washington, and B.C. (Corn and Bury 1989, 1991; Aubry and Hall 1991; Richardson and Neil 1995; Aubry 2000; Stoddard 2002; Welsh and Lind 2002; Dupuis and Friele 2003), although some studies have reported similar densities in second-growth stands (Matsuda and Richardson 2005). A meta-analysis by Sutherland *et al.* (2001) showed that, contingent on channel suitability, older forests were more likely to contain Coastal Tailed Frogs than young forests. Older forests are structurally complex and productive (Franklin 1988), providing extensive tree, shrub and ground cover, greater biodiversity, and more complex vertical stratification than younger, closed canopy stands. Microclimates in old forests are also more stable and cool (Chen *et al.* 1992, 1993; Brosofske *et al.* 1997), facilitating movement and dispersal of adult and juvenile frogs (Claussen 1973). According to Hailman (1982), tailed frogs are also not adapted to the high ambient light levels of exposed habitats, such as found in clear-cuts.

The presence of old forest patches within a watershed is positively correlated with larval abundance of the Coastal Tailed Frog (Stoddard 2002; Welsh and Lind 2002). A recent occupancy model taking environmental variables, management effects, and species detection probability into account showed that forest age is positively correlated with tadpole abundance (Kroll *et al.* 2008). Richardson and Neil (1995) reported reduced tadpole density and biomass in 25-year-old managed stands of south-coastal B.C. The closed canopy characteristic of young stands prevents understory establishment (Alaback and Herman 1988; Stewart 1988; Bailey *et al.* 1998; Franklin *et al.* 2002). A relatively uniform stand of dense conifers devoid of understory vegetation may offer little cover and a reduced insect food source. Low tadpole numbers imply a low recruitment to adulthood.

Riparian areas form important habitat for adult frogs and metamorphs. In a logged landscape, the presence of riparian buffers is directly and positively correlated with Tailed Frog tadpole abundance (Dupuis and Steventon 1999; Stoddard 2002). The most important feature in maintaining humid microclimates and mesic to humic soils within a riparian zone is the leaf area index (leaf area per unit ground surface area), which is highest in an old forest (Sridhar *et al.* 2004). Riparian connectivity between headwaters and valley bottoms is equally important, as are linkages between riparian zones, seepages, upslope (non-riparian) old-growth patches, and the forests of passable divides. Such a forest network provides potential dispersal routes and is expected to be an important aspect of metapopulation dynamics of the Coastal Tailed Frog.

Habitat trends

Stream habitats have been significantly degraded by sedimentation from roads and road construction (Beschta 1978; Reid and Dunne 1984). The total length of roads in B.C. has increased by 82% since the late 1980s (B.C. Ministry of Environment 2007). There were 83,056 km of roads in the Coast and Mountains Ecoprovince alone in 2005 (B.C. Ministry of Environment 2007). Similarly, there were 488,674 stream crossings by roads in 2005; an average increase of 13,369 crossings/year over a 5-year period (B.C. Ministry of Environment 2007). Road building, road traffic, road failures, and road-triggered landslides all contribute to deposition of sediments in streams. Extensive networks of logging roads are usually associated with timber harvesting in coastal B.C.

Logging can degrade stream habitat by introducing sediments (such as through bank failures) and removing microclimatic stability. Logging can also degrade and eliminate riparian and upland forest habitat for tailed frogs and cause landscape fragmentation. Across the province, close to 40% of the total land base is forest less than 140 years old (B.C. Ministry of Environment 2007). This conversion of old-growth to younger seral stages is due to a combination of logging, land clearing, and fires. In coastal forests of B.C., an estimated 7% of the total land base is recently disturbed forest (≤20 years old), 12% is younger forest (21 – 140 years old), and 41% is older forest (>140 years old) (Figure 6 *in* B.C. Ministry of Environment 2007). Undisturbed forests include both old growth (250+ years) with its characteristic structural complexity and microclimatic stability, as well as naturally regenerated second-growth forest that represents future old growth recruitment. Most forests greater than 140 years predate European settlement and the advent of large-scale timber removal. Only 8.5% of the land base in the Coast and Mountains Ecoprovince is legally protected through a variety of designations and is ecologically intact (i.e., represents forest patches greater than 2000 ha in size and more than 5 km away from roads; B.C. Ministry of Environment 2007).

Accurate estimates of rates of habitat loss within the Canadian range of the Coastal Tailed Frog are unavailable, but inferences can be made from published data compiled for coastal B.C. as part of habitat assessment for the Marbled Murrelet, *Brachyramphus marmoratus* (Long *et al.* 2010). It should be noted, however, that the range of the Coastal Tailed Frog extends 2 – 3 times farther inland from the coast than the spatial extent covered in that paper (100 – 150 km versus 50 km). Over a 30-year period from 1978 – 2008, the percentage loss of older (140 years and older) forest within 50 km from the shoreline was as follows (Model 3 in Table 3 in Long *et al*. 2010): South Coast excluding Vancouver Island – 17.4% (11.2% with recruitment); Central Coast – 13.1% (11.8% with recruitment); North Coast – 8.3% (6.3% with recruitment). Assuming that these trends continue and using the percentages with recruitment as stands mature, the rate of older forest loss over the next 10 years is projected to be 3.7% on the South Coast, 3.9% on the Central Coast, and 2.1% on the North Coast. The impacts of past and future forest losses on tailed frogs are cumulative because recovery to suitable conditions takes many decades. The current percentage of the coastal forest in B.C. in younger age-classes (59%) largely unsuitable for the frogs reflects cumulative past losses (Figure 6 *in* B.C. Ministry of Environment 2007).

Table 3. Large protected areas that contain suitable habitat or are known to be occupied by the Coastal Tailed Frog.

Location within tailed frog range in B.C.	Name	Size (ha)
South	Garibaldi Provincial Park	194,650
	Skagit Valley Provincial Park	27,948
	E.C. Manning Provincial Park	70,844
	Golden Ears Provincial Park	62,540
	Tantalus Provincial Park	11,351
Central coast	Pinecone Burke Provincial Park	38,000
	Clendinning Provincial Park	30,330
	Fjordland Conservancy (upland)	76,825
	Bishop River (plus portion of Tsylos PP)	Est. 50,000
	Homathko River-Tatlayoko Protected Area	17,575
North	Gitnadoiks River Provincial Park	57,698
	Kitlope Heritage Conservancy	321,120

BIOLOGY

Life cycle and reproduction

Courtship and mating take place in water (Noble and Putnam 1931) and occur in late summer to early fall in the northern portion of the species' range, including B.C. Tailed frogs do not vocalize, and mates appear to attract one another by means of a water-born pheromone (Asay *et al.* 2005; Belanger and Corkum 2009). Fertilization is internal. The "tail" of the male becomes engorged with blood and is inserted into the female's cloaca. Copulation normally lasts 24 to 30 h (Nussbaum *et al.* 1983). Sperm is stored in the female's oviducts until the egg-laying period from mid-June to late August the following year, depending on temperature regime, elevation, and latitude (mean delay = 82 days; Karraker *et al.* 2006). This delay between mating and oviposition in the north is in contrast to California, where temperatures are less restrictive and adults mate in the spring (Burkholder and Diller 2007). Throughout the range of the species, females appear to have a biennial reproductive cycle and do not reproduce every year (Metter 1964; Nussbaum *et al.* 1983; Burkholder and Diller 2007).

Egg-laying may be communal or solitary. Egg-laying sites occur throughout alluvial channels, which are generally mid-slope (Karraker *et al.* 2006). Each female produces a double-strand of colourless, pea-sized eggs. At 4 – 5 mm in diameter (Corkran and Thoms 2006), the eggs of tailed frogs are the largest of all North American frogs (Brown 1975). Clutch size varies from 20 to 96 eggs (mean = 41.9 $\pm$ 16.3 eggs; Karraker *et al.* 2006). The female attaches her egg mass to the underside of a large, well-anchored cobble or boulder, often in a step or pool (Nussbaum *et al.* 1983; Karraker *et al.* 2006). Stream temperatures during oviposition vary from 6 to 13°C in the northern portion of the Coastal Tailed Frog's range (Karraker *et al.* 2006).

The species' lengthy embryonic period varies from 4 weeks (Metter 1964) to 6 weeks (Brown 1975) depending on the stream temperature regime. Embryos hatch from mid-July to mid-September (Karraker *et al.* 2006). Hatchlings remain in breeding/nursing grounds until the suctorial mouth is fully developed and the yolk sac is depleted (Metter 1964; Brown 1990).

The length of the larval period is variable. In southern Oregon and California, tadpoles may metamorphose within 2 years (one over-wintering cohort; Wallace and Diller 1998; Bury and Adams 1999). In the North Cascade Mountains of Washington, metamorphosis occurs in up to 4 years (Brown 1990; Corn and Bury 1991). In B.C., there seem to be two to four cohorts in late summer, suggesting three to five in-stream winters. Variability in growth rate probably also corresponds to the length of the growing season, which can be affected by aspect, gradient, elevation, snow pack, and number of frost-free days (Bury and Adams 1999; Jones *et al.* 2005). Variability in growth rate can also be affected by tadpole density (Kim and Richardson 2000) and a stream's nutrient regime (Kiffney and Richardson 2001).

Metamorphs make up about 1% of the Coastal Tailed Frog tadpole population (Dupuis and Friele 2003; Michelfelder *et al.* 2008; Wind 2009). Tailed frogs (both species) do not reach sexual maturity until the age of seven to nine years from the time of hatching (Daugherty and Sheldon 1982a; Brown 1990). Females take longer to reach maturity than do males (Burkholder and Diller 2007). Adult tailed frogs live 10 to 20 years (Daugherty and Sheldon 1982a; Brown 1990). The survivorship of all life stages is unknown but is expected to be low for tadpoles and metamorphs, as with most frog species, but higher for adults. The generation time is unknown but is probably at least 15 years, based on the age of maturity and longevity.

Physiology and adaptability

Tailed frogs are among the longest-lived frogs in North America, with lengthy embryonic, larval (aquatic) and juvenile (terrestrial) development stages (see **Life cycle and reproduction**). Low stream temperatures likely contribute to their slow growth and low reproductive rate.

Tailed Frogs are among the few frog species worldwide with internal fertilization (Green and Campbell 1984). A female's ability to store sperm over winter (Karraker *et al.* 2006) allows her to oviposit as soon as stream temperatures are warm enough ($\geq$ 7°C) to support growth and development, i.e., after the spring freshet. Maximizing on the length of the growing season is particularly critical in watersheds with low temperature regimes.

Tadpoles can survive in streams with high velocity flows due to their ability to feed and move short distances without losing contact with the channel substrate. When stream discharge rates are excessive (during the fall rainy season and the spring freshet), tadpoles can burrow their flattened heads deep into the substrate.

Interspecific interactions

The diet of Coastal Tailed Frog tadpoles consists largely of diatoms, which are scraped from submerged rocks (Metter 1964; Franz 1970). Food availability is positively associated with levels of incoming light (Kiffney *et al.* 2004). In productive streams tadpoles can reach high densities and growth rates, and thereby significantly affect algae and periphyton production (Mallory and Richardson (2005). As top-grazers, Coastal Tailed Frog larvae can thus influence the complex dynamics of stream ecosystems.

Juveniles and adults feed nocturnally primarily on terrestrial arthropods (Metter 1964), particularly spiders (Held 1985). They will also prey on snails, ticks, mites, collembolans (snow fleas), flies, moths, ants, mayflies, crickets, and lacewings (Metter 1964). Unlike most frogs, their tongues are not attached at the anterior end of the mouth; they lack the ability to flip it out to catch prey (Green and Campbell 1984). As a function of their comparatively small size and their low metabolic rate, amphibians such as the Coastal Tailed Frog can play an important role in forest food webs by converting items of low food value into biomass that is available to larger animals (Pough 1983).

Larvae and immature frogs are preyed on by American Dippers (Morrissey and Olenick 2004), garter snakes (Karraker 2001), trout (Feminella and Hawkins 1994), Western Toads (*Anaxyrus boreas*; Dupuis pers. obs. 1995), and water shrews (Lund *et al.* 2008). Jones and Raphael (1998) observed depredation of a tailed frog metamorph by a hellgrammite (Megaloptera). Near the U.S. border, tailed frogs co-inhabit with Pacific Giant Salamanders (*Dicamptodon tenebrosus)*; tadpoles are a significant component of this species' diet (Jones *et al.* 2005).

Tailed frog tadpoles tend to forage nocturnally and reduce their activity in the presence of salamander and trout predators (Feminella and Hawkins 1994). Tailed frog tadpoles were unable to detect sculpins based on non-visual cues, and predation by sculpins may explain why the tadpoles are seldom found in the low gradient streams where these fish are often abundant (Feminella and Hawkins 1994). The white spot on the tail tip of a tadpole's otherwise cryptically coloured body, is thought to distract predators (Altig and Channing 1993; Blair and Wassersug 2000). Tadpoles wag their tails vertically when positioned on channel substrate surfaces.

Local movement

Tailed frogs have one of the lowest desiccation tolerances among anurans (Clausen 1973). Often hidden under rocks in streams during hot days, adults confine their foraging to stream banks (Metter 1964, 1967). Movements away from water appear to be limited to times of high humidity (Nussbaum *et al.* 1983). Adults in coastal forests have been reported several hundred metres from streams during wet weather (Welsh and Reynolds 1986; Bury and Corn 1988; Corn and Bury 1989; Gomez and Anthony 1996; Dupuis and Waterhouse 2001; Wahbe *et al.* 2004). Even in the moist, moderate climate of the coast, sheltered habitats are more conducive to movements than exposed ones. Maxcy (2000) observed greater movements of the Coastal Tailed Frog in undisturbed habitats than in recently logged areas. Both juveniles and adults moved parallel to streams in clear-cuts, but also across slopes (between streams) in old growth (Matsuda and Richardson 2005). Tailed Frogs were less likely to move away from streams in clear-cuts than in mature forests (> 80 years); the highest capture rates were within 5 m, and the lowest were within 65 m of streams in both habitats (Matsuda and Richardson 2005).

Wahbe *et al.* (2004) documented mean daily distances on land of 23.3 m ± 7.8 m for females and 16.8 m ± 3.9 m for males in the B.C.'s south coast region. Burkholder and Diller (2007) studied in-stream movements of Coastal Tailed Frogs in California, where the matrix environment (upland habitat between stream riparian zones) is hot and dry and frogs are easily encountered in the water. They documented movements of 0 to 112 m in a 24-h period, but the mean movement up or downstream was 13.6 m. These studies insinuate that Coastal Tailed Frogs exhibit high site fidelity, although movements throughout the growing season can be greater in moist areas or when conditions are wet.

Wahbe and Bunnell (2001) observed downstream movements of tadpoles up to 65 m and suggest that dispersal distances are significantly higher in undisturbed reaches than in clear-cut reaches that are free of obstructions (logging debris). Downstream movements by larvae may be the result of passive drift, or tadpoles could be actively moving to better food sources or to avoid predators (Wahbe and Bunnell 2001). Gyug (2001) observed widespread recolonization of a stream by tadpoles two years after it largely dried up, which seems to indicate that tadpoles have an ability to disperse greater distances under some conditions.

Dispersal and migration

As with local movement, dispersal is probably governed by microclimatic and topographic conditions. Spear and Storfer (2008) found that gene flow for the Coastal Tailed Frog was primarily overland in moist environments of the Olympic Peninsula, Washington State. In contrast, gene flow in the Rocky Mountain Tailed Frog, which lives in a drier environment, appears to be almost exclusively along riparian corridors (Spear and Storfer 2010).

Matsuda and Richardson (2005) found pre-reproductive Coastal Tailed Frogs to be the main dispersers in a study on the south coast of B.C. Bury and Corn (1988) captured many recently metamorphosed Coastal Tailed Frogs $\geq$ 75 m from natal stream reaches during the fall in Washington. Daugherty and Sheldon (1982b) observed a greater proportion of juveniles dispersing in the related Rocky Mountain Tailed Frog.

Matsuda and Richardson (2005) found that juveniles were more common in clear-cuts than in old-growth forests. Similarly, Wahbe *et al.* (2004) found juveniles to be 2.9 times more common than adults in clear-cuts, and adults to be 2.3 times more abundant than juveniles in old growth. Vagility in Tailed Frogs decreases with age, with movement decreasing at the onset of maturity (Daugherty and Sheldon 1982b).

Seasonal migration by adults has been suggested as a possible explanation for low summer captures (Metter 1964). Upstream aggregations of tailed frogs have been noted by many during late summer (Landreth and Ferguson 1967; Brown 1975; Kelsey 1995; Adams and Frissell 2001; Dupuis and Friele 2002; Hayes *et al.* 2006). Some believe that upstream aggregations represent mating migrations (Kelsey 1995; Stoddard 2002; Wahbe *et al.* 2004; Hayes *et al.* 2006). Others have postulated that adults move upstream to compensate for downstream drift by tadpoles (Müller 1974; Wahbe and Bunnell 2001). Adams and Frissell (2001) proposed that Tailed Frog migration was linked to seasonal patterns in habitat use. Dupuis and Friele (2002) suggested that the species may accumulate in headwaters where drainage density is high, when attempting to colonize adjacent watersheds. All four hypotheses are plausible.

POPULATION SIZES AND TRENDS

Sampling intensity

Approximately 80% of Coastal Tailed Frog research in B.C. has involved aquatic time-constrained searches (TCS) of 20 or 30 person-minutes (Table 1). The remaining 20% involved aquatic area-constrained searches (ACS), which are time-consuming and invasive and ideally limited to detailed research situations. TCS give an index of relative abundance for tadpoles (number per minute), whereas ACS information can be used to obtain tadpole densities (numbers/m^2).

Adults make extensive use of the terrestrial environment in the cool maritime climate of B.C and are infrequently caught during stream searches. Juveniles and adults typically make up $\leq$1% of encounters on the coast (Dupuis and Friele 2003; Michelfelder *et al.* 2008) and approximately 5% in southwestern B.C. (Gyug 2001; Richardson 2000, unpubl. data). Few studies have focused on the terrestrial phase of the Coastal Tailed Frog (but see Wahbe *et al.* 2004; Matsuda and Richardson 2005); these have involved laborious studies using pitfall arrays. Relative abundance estimates for frogs are thus based on trap capture rates.

Abundance

Very limited work has been done on estimating population size and densities of the Coastal Tailed Frog in B.C. In California, where the frogs are more aquatic and more detectable, Burkholder and Diller (2006) estimated an average of 1.82 and 1.25 adult females per 1 m of stream along productive and stable reaches of two streams. Limited information from B.C. suggests that densities might be much lower. Matsuda and Richardson (2005) sampled 7536 m^2 of clear-cut and mature second-growth (>80 years old) forests during one growing season in Chilliwack, southern B.C. (384 pitfall arrays open during roughly 182 trapping nights). This intensive effort yielded 0.02 juvenile and adult frogs/m^2 (recaptures omitted), 30% of which were adults, resulting in 60 adults/ha. Similarly, Wahbe *et al.* (2004) obtained a density of approximately 0.02 frogs/m^2 in Squamish based on trapping with 48 pitfalls with 240 m of drift fencing to enhance capture success. Arrays sampled a roughly 8000-m^2 area encompassing old-growth (>250 year old) forests and clear-cuts, for three seasons. Adults made up 42% of captures, resulting in 84 adults/ha; 29% of adults were females (n = 254).

Based on 212 area-constrained searches in B.C. in 1994 and 1995, the mean density of tadpoles is 1.9 individuals/m^2 (Dupuis and Wahbe, unpubl. data). Tadpoles are often clustered, and their densities can range from 0.1 to 10 individuals/m^2 within a single stream (Dupuis and Steventon 1999).

Fluctuations, trends, and fragmentation

There is no information on population fluctuations or trends for the Coastal Tailed Frog in B.C. Friele (2009) found that tadpole numbers can fluctuate by as much as 600% from year to year, based on 4 years of monitoring of the related Rocky Mountain Tailed Frog. Diller (pers. comm. 2010) monitored creeks in California for 12 years and obtained similar results (variations in tadpole numbers of several hundred-fold) for the Coastal Tailed Frog. Extreme fluctuations in larval abundance and in natural channel habitat conditions make tadpoles poor indicators of population trends. There are no known terrestrial monitoring studies of breeding adults.

This species has a patchy and naturally fragmented distribution in headwater streams within older forest stands in rugged landscapes (see **Habitat requirements**). Logging and other human activities are further fragmenting habitats and increasing isolation of populations. Whether the total population is severely fragmented *sensu* COSEWIC definition is difficult to assess because of lack of details on the pattern of occupancy and information on population viability. Severe fragmentation is possible based on relatively low dispersal capabilities of the frogs, their specialized habitat requirements, and their occurrence within fragmented landscapes.

Rescue effect

Dupuis and Friele (2006) suggested that headwaters are a probable frontier zone for genetic exchange, i.e., dispersal between channels of a basin, or between catchment basins if watershed divides are surmountable. Connectivity to source populations in the United States is possible through Manning Park, which protects significant proportions of the Skagit, Skaist, and Similkameen River systems. The likelihood of significant cross-border dispersal is low, however, as Tailed Frogs evidently have a low rate of dispersal based on genetic evidence of a high degree of isolation between populations (Nevo and Beiles 1991; Ritland *et al.* 2000). The Fraser River likely represents a significant barrier to further northward dispersal.

THREATS AND LIMITING FACTORS

Stream sedimentation

Declines in tadpole abundance following timber harvesting and road construction have been well documented and are primarily driven by sedimentation effects (Gaige 1920; Noble and Putnam 1931; Metter 1964; Murphy *et al*. 1981; Bury 1983; Corn and Bury 1989; Aubry and Hall 1991; Bull and Carter 1996; Dupuis and Friele 1996; Welsh and Ollivier 1998; Ardea Biological Consulting Ltd. 1999; Maxcy 2000; Adams and Bury 2000; Welsh and Lind 2002; Biek *et al.* 2002). Sediment makes its way into streams from roads due to inadequate channel crossings (Ardea Biological Consulting Ltd. 1999; Dupuis and Friele 2003), improper surface runoff management, bank failures (Beschta 1978), and post-logging landslides (Rollerson *et al.* 2001, 2002). Roads are often a chronic source of sedimentation even when abandoned, although when heavily used, these roads can produce up to 130 times more sediment than abandoned ones (Reid and Dunne 1984). The road density in coastal forests is 0.5 km/km^2 and continues to rise at a rate of 0.06 km/km^2 every year (B.C. Ministry of Environment 2007).

Step-pool streams are said to be sediment supply limited, meaning that fine materials (sand and pebbles) are transported rapidly through the system, leaving coarse, anchored substrates in the channel bed (Grant *et al*. 1990). Intensive or extensive sedimentation reduces aquatic habitat quality for the Coastal Tailed Frog by filling the interstitial space between larger rocks and washing out these stable step-pool bedforms (Figure 9; Dupuis and Friele 2006). High sediment loads during floods can also kill frogs directly if they should get trapped or struck by rocks. It is not possible to generalize about the longevity of such impacts, but susceptibility seems to be based on a stream's geological make-up and waterpower. Dupuis *et al.* (2000) suggested that sedimentation impacts on the species are most extensive in high risk areas such as channels incised in incompetent, erosion-prone rock types or thick glacial sediments, greatest in creeks with high water power, such as those with steep relief and high discharge rate, and longest-lived in small creeks (first to third order) with low water transport potential. Forested riparian buffers help to prevent sediment input into streams from logging activities, and protect tadpoles from direct physical damage. Watershed restoration activities such as road deactivation and landslide bioremediation are expected to benefit the species as well. These management and remediation activities have occurred in many of B.C.'s watersheds (Polster *et al*. 2010).

Hydrology

Large-scale forest removal and road construction can change a watershed's hydrologic regime (Jones and Grant 1996). In particular, roads intercept shallow groundwater and convert it to surface flow in ditch lines. Surface flow is much more rapid than groundwater flow. Thus, road networks can increase the drainage efficacy in the landscape, potentially resulting in the loss of stream- or microhabitat features, such as step pools or refuges favoured by Coastal Tailed Frog tadpoles. Increased maximum discharge rates can lead to a greater amount of scour and sediment transport, and to decreased channel stability. Reduced base flows could lead to stream impermanence and/or a general reduction in aquatic habitat availability for tadpoles.

Forest loss

Older forests that contain or are next to creeks and their riparian zones provide important foraging and dispersal habitats for the Coastal Tailed Frog. The literature overwhelmingly indicates that the loss of riparian canopy cover and adjacent old-growth or mature second-growth forest is harmful to juveniles and adults of the Coastal Tailed Frog (Welsh 1990; Corn and Bury 1991; Richardson and Neil 1995; Bull and Carter 1996; Dupuis and Steventon 1999; Aubry 2000; Stoddard 2002). Tailed frogs have a higher need for moisture, and a lower ability to absorb water than do other forest frogs (Claussen 1973). Old forests in coastal B.C. are generally moist, cool, and micro-climatically stable. In addition to their high productivity and structural complexity (Robinson 1988; Maser 1990), they afford ample refuge from predators and inclement weather, and good foraging opportunities.

There are few data on densities of the Coastal Tailed Frog in second-growth forests (but see Wahbe *et al*. 2004; Matsuda and Richardson 2005). Although larval numbers may be temporarily high in sediment-free streams running through clear-cuts as a result of increased solar radiation and productivity, forests go through lengthy successional stages (140+ years) in which productivity at the ground level is low. After second and third rotations, forests can have nutrient-poor soils, and they often lose structural diversity as well (large logs, porous soils), making it harder for small animals to forage and seek cover. Also, clear-cuts and young stands have less stable microclimates than old growth (Chen *et al*. 1992, 1993), as is reflected in the significantly stronger stream affinity of Coastal Tailed Frogs in these managed stands (Wahbe *et al.* 2004; Matsuda and Richardson 2005). Due the quantity and quality of the wood in large trees, the availability of productive old growth and riparian habitats will continue to decline as a result of timber harvesting.

Corn and Bury (1989), Richardson and Neil (1995), and Dupuis and Friele (unpubl. data) have all documented higher frequencies of Coastal Tailed Frog occurrences in undisturbed watersheds than in young forests. Wahbe *et al.* (2005) used RAPD molecular markers to explore the effect of forestry-related fragmentation on the genetic make-up of Coastal Tailed Frogs. Although their sample size was too small to make inferences on the effects of fragmentation, patterns of gene flow were significantly different between clear-cuts and old growth. Their data suggest that populations in logged areas go through a bottleneck/founding event but also exhibit greater dispersal. The frogs were perhaps searching for new habitat (which would lower isolation by distance) and suffering mortality (which would decrease diversity). In conducting landscape genetic analyses on the Coastal Tailed Frog, Spear and Storfer (2008) found that closed forests and low solar radiation were correlated with increased gene flow. They also found evidence of a temporal lag in the correlation of decreased gene flow with harvest, suggesting that the full genetic impact of landscape fragmentation may not appear for several generations. Forest fragmentation is extensive in B.C. and continues to rise largely as a result of timber harvesting (see **Habitat trends**).

Independent power projects

Independent power projects (IPP) are becoming increasingly prevalent in the B.C. landscape, exacerbating threats to important habitats for breeding, feeding, and dispersal by the Coastal Tailed Frog. Run-of-river installations direct a portion of a stream's discharge through a penstock to generate power when flows are moderate to high. Up to 90% of stream flow may be diverted this way (Sierra Club B.C. 2010). Reduced flows during the growing season can cause a decrease in a channel's wetted channel width and water depth, and thereby reduce the stream's carrying capacity for Coastal Tailed Frog tadpoles. Moreover, run-of-river projects require that access roads be built from downstream turbines to upstream intake structures. Access roads are generally situated through the length of a riparian zone. They are not built to the same standards as forestry roads and can become chronic sources of sediment; the fine material wends its way into the adjacent stream during heavy rains (Dupuis pers. obs. 1994-2008; Friele pers. comm. 2010). About 8200 creeks and rivers in B.C. have been identified for possible run-of-river installations (Sierra Club B.C. 2010). As of October 2011, there were 70 Electricity Purchase Agreements with IPPs currently delivering power to B.C. Hydro and 48 projects under development (Clark Wilson LLP 2011). Approximately half of these are within the range of the Coastal Tailed Frog. Each project may involve a cluster of streams. The proportion of the approved and proposed projects that will actually be developed is uncertain and largely depends on the political climate. The B.C. government is in the process of preparing an online tracking system for IPPs throughout the province (Malt pers. comm. 2011).

This rise in hydro IPP can cause significant aquatic habitat degradation through sediment pollution, cumulative loss of aquatic habitat, and disruption of dispersal avenues through downstream movements and drift, but impact studies are lacking. It will also lead to a loss of terrestrial habitat because the transmission corridors required to connect run-of-the-river installations to existing power grids can be extensive.

Wind farms are a threat if they are established in watersheds containing Coastal Tailed Frogs, because roads are built to interconnect all the turbines. The larger the wind farm, the bigger the road network and the greater the possibility of altering the hydrological regime of the subject basin. Although wind farms tend to be situated in open areas, the transmission corridors linking them to existing power stations involve the loss of forest habitat. For example, one large wind farm is proposed on Banks Island in Hecate Strait (Katabatic Power 2010). The transmission line for this project would tie in somewhere south of the Skeena River, possibly as far as Terrace, B.C., involving up to 130 km of forest habitat loss on the mainland within the Coastal Tailed Frog's habitats (Dupuis, pers. obs. 2007, 2008). No process is in place to assess the cumulative impact of IPP in the landscape.

Oil and gas pipelines

Several major pipeline developments are proposed for northern B.C. within the range of the Coastal Tailed Frog (Campbell 2006). These projects include the Enbridge Pipeline from the Alberta tar sands to Kitimat, which is presently on hold but could be resurrected. This pipeline would cross thousands of streams and would traverse through large stretches of Coastal Tailed Frog habitat. A proposed natural gas pipeline in the Kitimat area would also cross numerous streams in Coastal Tailed Frog habitat. Adverse effects of pipelines on the frogs would accrue from sedimentation associated with pipeline and road construction and maintenance activities and from leakages and accidental fuel spills. The scope of this threat has the potential to increase greatly over the next 15 or 45 years (1 – 3 generations), as demands for energy increase. The large number of stream crossings necessitated by these and other similar projects is of particular concern.

Climate change

The Intergovernmental Panel on Climate Change has concluded that the global atmosphere is warming (Gayton 2008). Climate models project that excess greenhouse gases that are already in the atmosphere will continue to drive climate change and its impacts for centuries to come. Atmospheric warming is expected to increase by 1.4 to 5.8°C by 2100 in B.C., a rate unprecedented in the past 10,000 years (Gayton 2008).

Warming trends will cause changes to hydrology, particularly as a result of declining snowpack, increased winter rain (and flows), earlier spring freshet, increased flood risk, greater water turbulence and related scouring, declining summer flows, and summer drought-associated low flows (Gayton 2008). For example, Hamlet and Lettenmaier (2000) predicted that climate change will result in significantly greater winter runoff, earlier spring peak flows, and reduced runoff volumes from September to April, in less than 50 years in B.C.'s Columbia River basin. All of these factors will reduce the availability of aquatic habitat and increase the risk of mortality to tadpoles from bedload movement, competition, and predation.

In terrestrial habitats, climate change will reduce forest health and productivity; riparian zones in particular will likely have decreased summer soil moisture (Gayton 2008). Warm and dry conditions will impede movements and dispersal by the Coastal Tailed Frogs thereby further reducing connectivity between populations. Increased isolation will put populations at greater risk of extirpation from environmental pressures and stochastic events.

It is possible that warmer predicted conditions will facilitate northward range expansion of the Coastal Tailed Frog and make some new habitats available that are currently too cold to support populations. However, negative effects from increased peak flows and reduced base flows are likely to overweigh such positive effects. Warmer conditions may also increase threat from chytridiomycosis, an emerging amphibian disease, by providing conditions more suitable for the spread of the fungus responsible for the disease.

Disease

The chytrid fungus, *Batrachochytrium dendrobatidis* (Bd), causes a disease known as chytridiomycosis. It has been linked to population declines of amphibians worldwide (Lips *et al.* 2006; Kriger and Hero 2007; Pessier 2010; Voordouw *et al.* 2010). Chytrid fungus has been detected from a number of species of amphibians from B.C., including the Western Toad, *Anaxyrus boreas* (Deguise and Richardson 2009) and Northern Leopard Frog, *Rana pipiens* (Voordouw *et al.* 2010). The chytrid fungus has not yet been detected in tailed frogs in B.C. (Govindarajulu pers. comm. 2010), but it was recently found in 12% of tailed frog tissue samples (both Coastal and Rocky Mountain Tailed Frogs) from California, Idaho, Montana, and Oregon (True 2009). In contrast, Hossack *et al*. (2010) found a low prevalence (<1%) of Bd in stream-dwelling amphibians (2 species of tailed frogs and 7 species of salamanders of families Dicamptodontidae and Plethodontidae) in 304 headwater streams sampled across the U.S. These results differed from those on other continents, such as Central America and Australia, where stream-dwelling, montane amphibians in general have a high prevalence of Bd, often associated with population declines. The results also differed from wetland-associated amphibians from the same areas that were sampled, which according to other studies had a much higher prevalence of Bd. The authors suggested that low water temperatures in headwater streams may be partially responsible for the low prevalence of Bd in tailed frogs and stream-dwelling salamanders in the areas sampled. Factors affecting the prevalence, spread, and pathogenicity of Bd are poorly understood, and chytridiomycosis remains a potential threat to the Coastal Tailed Frog in B.C., especially if water temperatures increase as a result of climate change.

Overall assessment of threats

Stream sedimentation, changes to hydrology, and loss of terrestrial forest habitat resulting from logging, road building, and independent power projects are widespread observed and continuing primary threats to Coastal Tailed Frog populations in B.C. Negative impacts of climate change on Coastal Tailed Frogs are expected to be pervasive, but the effects may vary across the species' range and are uncertain.

The IUCN Threats Calculator (Master *et al.* 2009) was applied as part of the B.C. management plan for the Coastal Tailed Frog by a group consisting of species experts and provincial government personnel familiar with human activities and projects within the species' range (Appendix 1) (Govindarajulu pers. comm. 2011). The overall threat impact was rated as "very high – high" (indicating high to low range) (Appendix 1). The assessment rated the threat from *Biological Resource Use* as "high – medium" with *Logging and Wood Harvesting* as the only contributor. Threats from *Pollution* were also rated as "high – medium", largely reflecting sedimentation of breeding streams from resource roads. The threat from *Transportation and Service Corridors* was rated as "medium", based primarily on alteration to hydrology, including both surface and stream flows, by roads and stream crossings. The impact of *Climate Change and Severe Weather* was rated as "high – low" in light of the sensitivity of the Coastal Tailed Frog to predicted changes in hydrology, temperature and moisture regimes and extreme events but reflecting uncertainty associated with the magnitude, scope, and speed of the changes. The effects from this threat are expected to increase over the long term (over a 45-year period, corresponding to three generations).

Number of IUCN locations

IUCN locations, based on a single threat that can rapidly affect individuals within a given area, are deemed to correspond to 50 km^2 watersheds (upper size limit of occupied stream catchments) containing suitable habitat for the Tailed Frog with logging as the main threat. Frogs inhabiting these basins are also considered populations. There are approximately 772 such basins within the Canadian range of the species, of which 232 are in old-growth forest (see **Abundance**). It is unknown, however, how many of the suitable basins are occupied by the species. The size of cutblocks harvested at any one time varies greatly across the species' Canadian range, resulting in further uncertainty in the number of locations. Hundreds of locations are possible based on the logging threat. If climate change and associated degradation of stream habitats is considered the main threat, the number of locations could be much smaller. However, much uncertainty is associated with the spatial extent and severity of climate-change impacts.

PROTECTION, STATUS, AND RANKS

Legal protection and status

The Coastal Tailed Frog was listed as Special Concern by COSEWIC in 2000 and is currently in Schedule 1 of the *Species at Risk Act* (Environment Canada 2010). Consequently, considerations for this species must be taken into account by stakeholders during environmental assessments for projects that may impact it. Eventually, environmental assessment considerations are to be guided by Management Plans, which are required for all species of Special Concern. A draft Management Plan exists for the Coastal Tailed Frog in B.C., which outlines means of protecting small order, tailed frog-bearing streams and their bordering riparian zones in light of human activities. This plan is expected to be finalized in the 2011-2012 fiscal year. The species is protected under British Columbia's *Wildlife Act* (1982), which dictates that wildlife cannot be killed, collected or held in captivity without permit. The Coastal Tailed Frog is listed under the *Forest and Range Protection Act* as a species at risk.

Non-legal status and ranks

The Coastal Tailed Frog is provincially Blue-listed (Special Concern) because of its specialized habitat requirements, its sensitivity to aquatic and terrestrial disturbances, and its poor dispersal capabilities. The B.C. Conservation Data Centre has assigned an S3S4 rank to the Coastal Tailed Frog (Special Concern/Secure), because it is moderately widespread and locally common in coastal mountains but is probably declining as a result of habitat degradation (Cannings *et al.* 1999).

The Coastal Tailed Frog is not considered at risk globally either by the International Union for Conservation of Nature (IUCN 2010) or NatureServe (G4; NatureServe 2010). It is deemed moderately common and locally widespread in the United States (N4) and Canada (N3N4; NatureServe 2010). However, it is considered Vulnerable in Oregon (S3; Oregon Biodiversity Information Center 2010) and California (S2S3; California Natural Diversity Database 2010); endangerment is not imminent and can be avoided through expanded protection measures. The Coastal Tailed Frog is a Species of Concern ("State Monitored") in Washington (S4) for similar reasons (Washington Department of Fish and Wildlife 2011).

Habitat protection and ownership

None of Canada's national parks occur within the Coastal Tailed Frog's range, but there are a number of large provincial parks that protect this species (Table 3). In the southern portion of the species' range, five large Provincial Parks encompass close to 370,000 ha of habitat, some of which is occupied by the species. Similarly, five protected areas on the mid-coast provide 212,730 ha of habitat, including tailed-frog-bearing creeks. In the north, Gitnadoix Provincial Park and the Kitlope Heritage Conservancy conserve approximately 379,000 ha of mountain slopes. There are smaller parks (roughly 20 provincial ones, ranging from 20 ha to 8000 ha), recreational areas, and wildlife reserves scattered in B.C., particularly along the south coast; these afford some local but isolated protection. Overall, protected parks overlap with 15% of the Coastal Tailed Frog's distribution within the Coast Mountains and Southern Interior Ecoprovinces, which is estimated to cover 6,430,000 ha (Hectares BC 2010). Of known occurrences, 2.5% are in provincial parks and 3.0% in conservancy areas; no records exist from eco-reserves or wildlife management areas (Iredale pers. comm. 2011).

The Identified Wildlife Management Strategy (IWMS) guides the implementation of management actions for those species listed as Species at Risk under the FRPA, including the designation of Wildlife Habitat Areas and General Wildlife Measures for these areas. The IWMS species account for recommendations for the Coastal Tailed Frog Wildlife Habitat Areas includes specific guidance for their design; it recommends 30-m "no-timber-harvesting" zones on either side of a given stream, bordered by additional 20-m "special management" zones. As of July 2011, there are 40 approved Coastal Tailed Frog Wildlife Habitat Areas at various stages of establishment (38 in B.C. Ministry of Environment 2010a; update by Psyllakis pers. comm. 2011). An additional 80 potential WHA have been proposed (Michelfelder *et al.* 2008; Iredale pers. comm. 2010). Once all currently approved Coastal Tailed Frog Wildlife Habitat Areas are established, they will protect in the order of 10,000 ha of habitat, which constitutes less than 0.2% of the distribution of the Coastal Tailed Frog in B.C. Wildlife Habitat Areas for other Identified Wildlife in B.C., including those for Grizzly Bears (*Ursus arctos*), Northern Goshawks (*Accipiter gentilis*), and Marbled Murrelets (*Brachyramphus marmoratus*), currently protect an additional 7% of this species' range (Hectares BC 2010). Ungulate winter ranges under the FRPA and Old Growth Management areas under the *Land Act* may also benefit this species.

Land use objectives are legally established by the B.C. government under the Land Use Objectives Regulation of the *Land Act* within the Central and North Coast. The two relevant orders, commonly referred to as the Coast Land Use Decision, lay out the framework for an Ecosystem Based Management (EBM) approach. Objectives relevant to protecting the Coastal Tailed Frog include: (1) preservation of a certain percentage of old-growth ($\geq$ 250 years) forest in all large-scale biogeoclimatic ecosystem units of the coast; (2) 15% retention of old-growth trees within cutblocks; and (3) riparian buffers along hillslope channels with 70% tree retention (B.C. Ministry of Natural Resources Operations 2010). Implementation of the objective specific to old-growth retention requires that planning includes consideration for co-locating multiple values, including habitat for designated focal species. The list of five focal species includes the Coastal Tailed Frog. To achieve this co-location principle, government agencies, non-government agencies, First Nations, ecologists, and environmental groups are working together to devise a Strategic Landscape Reserve Design (Horn *et al.* 2009; Michelfelder pers. comm. 2010). It is expected that several Wildlife Habitat Areas will be proposed for legal designation as a result of this process.

The Coast Land Use Decision does have several shortcomings with respect to protecting Coastal Tailed Frogs. Firstly, there are no constraints on road building, which is a significant source of stream sedimentation. The 15% minimum retention of old trees within a cutblock affords little shelter; a range from 15 to 70% retention would more accurately mimic natural disturbance regimes, with greater retention in watersheds that have been significantly harvested or in ecosystems that are at risk (Kremsater *et al*. 2008). The 20% equivalent clear-cut area in the Order appears to be ineffective at maintaining the hydrological regime of a watershed (McCrory 2009). As such, the detrimental effect of increased peak flows (potential channel instability) and decreased base flows (summer aquatic habitat) may continue to be a threat to the Coastal Tailed Frog, especially in light of climate change.

The *Fisheries Act* prohibits riparian habitat alteration, disruption or destruction along streams affecting fish values (Department of Fisheries and Oceans 2010). The *Riparian Areas Regulation* enacted under the *Fish Protection Act* in July 2004 calls on local governments to protect riparian areas during residential, commercial, and industrial development by ensuring that proposed activities are subject to a science-based assessment conducted by a Qualified Environmental Professional (B.C. Ministry of Environment 2010b). The purpose of the Regulation is to protect the riparian features, functions and conditions that are vital in the natural maintenance of healthy and productive fish-bearing waters. Neither the *Fisheries Act* nor the *Riparian Areas Regulation* extends to the smaller stream orders that Coastal Tailed Frogs are typically associated with.

ACKNOWLEDGEMENTS

The status report writer would like to extend a big thanks to Francis Iredale for helping with maps and GIS queries. Volker Michelfelder and Len Vanderstar gave valuable input on protection measures for the Coastal Tailed Frog in B.C. Large data sets were provided by Linda Dupuis, Pierre Friele, Leo Frid, Les Gyug, Francis Iredale, Volker Michelfelder, John Richardson, and Elke Wind. Without these critical databases, it would have been hard to define the boundaries of the Coastal Tailed Frog’s range, and to assess abundance and distribution patterns.

This report greatly benefited from review comments provided by the Canadian Wildlife Service (CWS), B.C. provincial government representatives, and members of the COSEWIC Amphibians & Reptiles Specialists Subcommittee. Comments by Ruben Boles and Marie-France Noel (CWS) and by Dave Fraser, Jennifer Psyllakis, and anonymous reviewers (B.C. government) were particularly helpful. Purnima Govindarajulu provided useful information on threats.

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DATA SOURCES

Linda Dupuis, Pierre Friele – Skeena Region (compiled by G. Sutherland)

Leo Frid – Cariboo Region (compiled by G. Sutherland)

Volker Michelfelder – Cariboo Region

Francis Iredale – Thompson/Nichola Region

Elke Wind, Pierre Friele – Thompson-Nicola Region

Ernest Leupin – Thompson-Nicola Region

Les Gyug – Okanogan Region

John Richardson, UBC – Lower Mainland Region

Linda Dupuis and Elke Wind – Sunshine Coast

Linda Dupuis and Tanya Wahbe – Squamish

Conservation Data Centre – miscellaneous reportings

B.C. Natural History Museum (BCNHM) – mainly Lower Mainland Region

BIOGRAPHICAL SUMMARY OF REPORT WRITER

Linda Dupuis did her master's degree on the effect of logging practices on amphibian communities on Vancouver Island. She then worked as a research associate at the University of British Columbia's Centre for Applied Conservation Biology for five years. For the past 12 years, Ms. Dupuis has been working as a consultant. Her focus is on the riparian management needs of amphibians in altered habitats and landscapes. She has dedicated more than a decade to research on the tailed frog, delineating the species' range in British Columbia, evaluating the effects of logging, exploring habitat associations and distribution patterns, outlining monitoring and recovery strategies, and conducting a conservation analysis. Ms. Dupuis also conducts impact assessments, and provides management prescriptions to stakeholders and government agencies for wildlife at large. Passerines are her other big passion.

Appendix 1. Threats calculator results for the Coastal Tailed Frog, *Ascaphus truei*, completed as part of the B.C. management plan for this species by a group of species experts and government personnel (draft, initially completed on 28 July 2011, revised on 4 November 2011). Cells left blank indicate threats that are non-applicable for this species.

		Level 1 Threat Impact Counts	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	3	0
C	Medium	1	3
D	Low	3	4
	Calculated Overall Threat Impact:	Very High	High

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**
1	Residential & commercial development		Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	High (Continuing)
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	High (Continuing)
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)
3	Energy production & mining	D	Low	Small (1-10%)	Extreme - Serious (31-100%)	High (Continuing)
3.3	Renewable energy	D	Low	Small (1-10%)	Extreme - Serious (31-100%)	High (Continuing)
4	Transportation & service corridors	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)
4.1	Roads & railroads	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)
4.2	Utility & service lines	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)
5	Biological resource use	BC	High - Medium	Large (31-70%)	Serious - Moderate (11-70%)	High (Continuing)
5.3	Logging & wood harvesting	BC	High - Medium	Large (31-70%)	Serious - Moderate (11-70%)	High (Continuing)
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Unknown	High (Continuing)
6.1	Recreational activities		Negligible	Negligible (<1%)	Unknown	High (Continuing)
6.3	Work & other activities		Negligible	Negligible (<1%)	Unknown	High (Continuing)
8	Invasive & other problematic species & genes	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)
8.1	Invasive non-native/alien species	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)
8.2	Problematic native species		Negligible	Negligible (<1%)	Unknown	High (Continuing)
9	Pollution	BC	High - Medium	Large (31-70%)	Serious - Moderate (11-70%)	High (Continuing)

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing
9.1	Household sewage & urban waste water		Negligible	Negligible (<1%)	Moderate - Slight (1-30%)	High (Continuing)
9.2	Industrial & military effluents	BC	High - Medium	Large (31-70%)	Serious - Moderate (11-70%)	High (Continuing)
9.3	Agricultural & forestry effluents	D	Low	Small (1-10%)	Serious - Moderate (11-70%)	High (Continuing)
10	Geological events	D	Low	Small (1-10%)	Serious - Moderate (11-70%)	High (Continuing)
10.3	Avalanches/landslides	D	Low	Small (1-10%)	Serious - Moderate (11-70%)	High (Continuing)
11	Climate change & severe weather	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)