COLUMBIA SHUSWAP
INVASIVE SPECIES RISK ASSESSMENT
AMERICAN BULLFROG *(Lithobates catesbeianus)*

Photo: Carl D. Howe

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COLUMBIA SHUSWAP INVASIVE SPECIES SOCIETY

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EXECUTIVE SUMMARY

This risk assessment was created to examine the risks associated with the introduction of American bullfrogs *(Lithobates catesbeianus,* here-after referred to as bullfrogs*)* into the Columbia Shuswap Region. These risks include the potential for introduction (natural dispersal or human assisted), the potential for bullfrogs to survive and thrive in the region, and the impacts on social, economic and environmental factors in the region.

Bullfrogs are large generalist predators with high reproduction rates. They have been introduced to over 40 countries around the world and are known as one of the world's 100 worst invasive species (Lowe et al. 2000). They are able to outcompete and prey upon many native fauna, including several threatened and endangered species. They are likely to be more damaging to native species in highly modified environments.

Eradication of bullfrogs is often cost-prohibitive in waterbodies larger than one hectare in size bullfrogs from well-established areas, and in wetlands greater than one hectare is cost-prohibitive (Govindarajulu et al. 2005, Govindarajulu and Anholt 2002). The most reliable method of bullfrog eradication from a small pond is fencing and draining. Eradication attempts in ponds that are not able to be drained are most likely to have strong effects if post metamorphs, specifically juveniles, are targeted (Govindarajulu et al. 2005). Electro-frogging is a possible method to target this life stage.

The current range of bullfrogs in BC includes populations on Vancouver Island, the lower mainland, a population that is encroaching across the border from Idaho and Washington into the Creston area, and a possibly eradicated population around Osoyoos. A suitability model generated by Ficetola *et al*. (2007) shows that bullfrogs could survive in many lower elevation parts of the Columbia Shuswap region. The areas between known populations and the Columbia Shuswap region contain no definite barriers to bullfrog dispersal. Natural dispersal of bullfrogs may be as much as 11.5 km per year (Sepulveda *et al.* 2015). Assuming no containment actions in their current locations, bullfrogs may disperse to the Columbia Shuswap region within approximately 15 years from 2019, so by the year 2034.

Human assisted introduction could be driven by reasons ranging from use as ornamentals in gardens to use as a food source, pet or as bait. The highest risk waterbodies for human assisted introductions have been determined through a risk matrix using factors such as proximity to human populations, ease of access, perceived "suitable habitat", and opportunities for covert dumping.

Potential actions to prevent or monitor for introductions of bullfrogs in the Columbia Shuswap include:

1) Targeted education at locations which score high on the risk matrix may deter people from dumping bullfrogs at these locations.
2) Targeted education to groups most likely to introduce bullfrogs to the region.
3) Monitoring for high risk waterbodies to facilitate rapid response if detected. This could include eDNA testing, surveys, and/or encouraging and educating stewardship groups in surveillance techniques.

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1.0 PURPOSE

The purpose of this document is to examine the risks associated with the introduction of American Bullfrogs (*Lithobates catesbeianus* - referred to as 'bullfrogs' for the remainder of this document) into the Columbia Shuswap region of British Columbia (B.C.), and to assess the relative risk of various potential pathways of introduction to the region. The information will be used to define appropriate early detection and rapid response (EDRR) plans and to determine how best to prevent bullfrogs from entering the Columbia Shuswap area. This document is based on best available knowledge and is considered to be a living document that may be updated as new information becomes available. Risk analysis of pests that may be associated with the target species is not within the scope of this document.

2.0 BACKGROUND

There are six steps in the B.C. Early Detection and Rapid Response (EDRR) Program: early detection, identification, alert screening, risk assessment, rapid response, monitor and reassess. Bullfrogs have not yet been detected in the Columbia Shuswap region, however neighbouring regions do have bullfrogs meaning that introduction via natural or human assisted introduction is a distinct possibility. This risk assessment constitutes part of our early detection process, as it will inform decisions on prevention and monitoring processes over the coming years.

2.1 IDENTITY OF ORGANISM

2.1.1 Name

Lithobates catesbeianus, Ranidae
(Synonym: *Rana catesbeiana,* Shaw 1802)

2.1.2 Common Names

American bullfrog, bullfrog

2.1.3 Description

Adult bullfrogs have compact bodies, moist skin, horizontal pupils, and a conspicuously large ear drum (i.e. tympanum) (IDDFG 2013). A fold of skin extending from the eye down to the shoulder partially surrounds the tympanum.

Adult male bullfrogs have tympanums that are two times the size of their eyes and females have tympanums that are approximately the same size as their eyes (BCFW 2017). Additionally, adult males have enlarged grey pads on their thumbs, commonly referred to as nuptial pads (WDFW 2009). To distinguish bullfrogs from Green frogs, Columbia Spotted frogs and Oregon spotted frogs, it is important to note that Green, Columbia and Oregon frogs all have prominent dorsolateral skinfolds, whereas bullfrogs do not (BCFP 2018).

Adult female bullfrogs may measure 20 cm in length (i.e. snout-to-vent length). Male bullfrogs are smaller. Female bullfrogs may grow to be approximately 750 grams (BCFP 2018). Longevity for wild bullfrogs is estimated to be eight to ten years. Sexual maturity in bullfrogs usually occurs at one to two years in males, and at two to three years in females (Howard 1981, in Casper and Hendricks 2005).

Eggs may range in size from 0.12 – 0.17 mm. After being laid, egg masses float for the first few days then sink. Egg masses may cover between 0.5 and 1 m^2 (Parmelee *et al.* 2002; BCFP 2018). Bullfrogs' egg masses are commonly confused with Green frog eggs. However, Green frog eggs are smaller in diameter (i.e. 0.10 – 0.15 mm) and laid in two layers of jelly per egg (Parmelee *et al*. 2002).

Bullfrog tadpoles have round bodies that are distinct from the tails, dorsal eyes, and dorsal fins that begin behind the base of the tail trunk (IDDFG 2013). Tadpoles are greenish brown with black spots on the dorsum and tail of their body; black spots are commonly clustered on the dorsal half of the tail (Parmelee et al. 2002). Additionally, the spots have a distinct border. Bullfrog tadpoles can grow to become 16 cm or larger.

Morey and Guinn (1992) describe juvenile bullfrogs as measuring under 80mm (snout-vent length), however WDFW (2009) reported tadpoles of 110mm in length prior to metamorphosis. Juveniles look similar to adults, but with distinctive inky black on the dorsal side (WDFW 2009). Commonly, juvenile or metamorph eyes are orange or bronze-coloured. Specimens at this stage may or may not have a remnant tail (ODFW, date unknown). As opposed to the prominent adult call, juvenile bullfrogs emit a smaller squeak as they jump into the water after being disturbed (WDFW 2009).

2.1.4 Similar Species & Look-a-Likes

Green frogs (*Lithobates clamitans*) are similar to bullfrogs in that both species have a noticeable tympanum (ear drum). Additionally, juvenile green frogs and bullfrogs avoid predators in the same manner, with a high-pitched call and a quick water entry. However, green frogs are generally smaller than bullfrogs and have a dorsolateral skin fold, which is absent in the bullfrog (BC Frogwatch Program 2018).

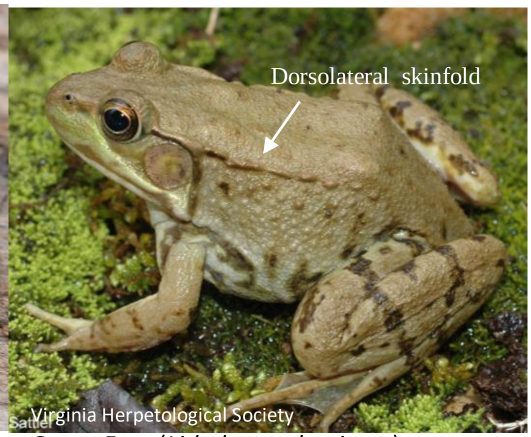
Western toads are large amphibians that are often misreported as bullfrogs. However, the similarities between toads and bullfrogs are slight, toads have warty skin, small tympanum, parotoid glands behind the eyes, and often have a prominent dorsal stripe (BC Frogwatch Program 2018).

Columbia and Oregon spotted frogs are medium sized frogs that are also often mistaken for bullfrogs. However, both species have markedly smaller typanums than bullfrogs, and have dorsolateral skin folds and usually have visible spots. The Oregon spotted frog is often red-tinged.

American Bullfrog tadpole

American Bullfrog *Lithobates catesbeianus*

Western Toad (*Anaxyrus boreas)*



Green Frog (*Lithobates clamitans)*

Columbia Spotted Frog (*Rana luteiventris)*

Oregon Spotted Frog *(Rana pretiosa)*

Figure 1: American Bullfrog *(top)* and look-a-like BC native frog species

2.1.5 Reproduction

The reproductive season of bullfrogs is characterized by male calling activity periods (Emlen 1976, Ryan 1980, Bury and Whelan 1984, in Casper and Hendricks 2005) and by intense movement of females for partner selection (Wiewandt 1969, Howard 1978, Ryan 1980). Spawning may occur once or twice in a given reproductive cycle (Emlen 1977, Ryan 1980, Govindarajulu et al. 2006).

Breeding activity in anuran amphibians is more strongly influenced by abiotic than by biotic factors: environmental variables such as light, rainfall and temperature (Duellmann and Trueb 1994, Wells 2007).

2.1.6 Life Cycle

According to BC Frogwatch (2018), *"Adult bullfrogs gather at breeding ponds in early summer, much later than most native frog species. Males stake out territories with good egg-laying sites and defend them, calling loudly to attract females and chasing away rival males. After mating, females lay masses of* *up to 20,000 eggs in a film on the water's surface; the eggs hatch in four or five days (depending on temperature). Tadpoles hatch out in July and remain in the ponds through that summer and the following winter, metamorphosing in August or September of their second year. They may not reach breeding age for two or more years after metamorphosis. Bullfrogs may live up to ten years in the wild, but mortality is very heavy in the first few years."*

2.1.7 Diet

Bullfrog tadpoles are mainly herbivorous and consume algae, aquatic plant material and some invertebrates (Treanor and Nichola 1972, Bury and Whelan 1984). Their efficient gill filters allow them to feed on an impressive diversity of algal species and their labial teeth allow them to graze periphyton (Pryor 2003). Bullfrog tadpoles will also prey on the tadpoles of other species (Blaustein and Kiesecker 2002).

Adult bullfrogs are gape-limited opportunistic predators that employ a sit-and-wait approach to feeding (Casper and Hendricks 2005). Bullfrogs essentially eat whatever they can fit into their mouths (Roach 2004), including crayfish, dragonfly nymphs, aquatic hemipterans and water beetles and small vertebrates such as fish, frogs, turtles, snakes, birds, bats, and weasels (Hirai 2004). They have also been known to eat other bullfrogs.

2.1.8 Habitat

In B.C. the height of the bullfrog breeding period occurs after ambient air temperatures exceed 20°C (Govindarajulu et al. 2006); this may occur in May or June in the Columbia Shuswap area. Eggs are laid in a thin, single layer of jelly on the surface of permanent water bodies. They are often found attached to vegetation (Parmelee et al. 2002) and may totally or partially submerge over time. Once the eggs are fertilized and given an adequate water temperature range, eggs can hatch between 3-5 days (Govindarajulu et al. 2006).

Tadpoles may spend one year or two years in the tadpole stage, depending on whether environmental conditions are conducive to fast-track past the second-year tadpole stage to the metamorph stage (Govindarajulu et al. 2006). Because tadpoles rely on aquatic vegetation for cover, tadpoles are often found close to the edge of water bodies near logs, stumps, and brush (Graves and Anderson 1987).

Juvenile bullfrogs were noted as having a wide distribution throughout Central California sites between February and April, but moved into large, deeper pools between May and June (Balfour and Morey 1999). Additionally, juvenile bullfrogs were often found in vernal habitats if perennial habitats were nearby. Individuals have even been sighted in road puddles (WDFW 2009).

Bullfrogs can occupy a wide variety of aquatic habitats, from freshwater to brackish. Adult bullfrogs are commonly found in lentic, sheltered, and relatively warmer environments. Examples of these environments include oxbows, farm ponds, reservoirs, marshes, and back-waters with dense vegetation (Govindarajulu 2004). Interestingly, it has been suggested that bullfrogs prefer human-modified environments such as grazing ponds (GISD 2017). Habitats that are highly modified by human activity are typically characterized by a decrease or complete lack of habitat complexity (Doubledee *et al*. 2003). In such environments bullfrogs are expected to have high attack rates (the attack rate is a measure of bullfrog search efficiency, specifically the length of shoreline that is kept clear of prey items by a bullfrog in a given time interval). Bullfrogs are expected to be less efficient at keeping a complex shoreline choked with cattails and bulrushes clear of prey items than they would be along a shoreline devoid of such vegetation (Doubledee *et al.* 2003).

Adult bullfrogs commonly use seasonal corridors to disperse from artificial water bodies to natural, permanent water bodies (Govindarajulu 2004). They are typically found on or near shorelines due partly to vegetation cover protection. When water temperature is higher than air temperature, adult bullfrogs may move farther into the water (Willis *et al.* 1956). Additionally, when male bullfrogs are amplifying breeding calls they may move away from the shore (Howard 1978).

2.1.9 Habitat Preferences

Table 1: Habitat preferences for American bullfrogs and estimate of occurrence of these habitat types within the Columbia Shuswap

Habitat Parameter	**Preferred Range**	**Range in Columbia Shuswap**
Distance from source population	Less than 10km overland Dispersal rate between 3.2 - 11.5 km per year	Few, if any, areas are more than 10km from permanent ponds or lakes, therefore, it is assumed that almost all water bodies including vernal pools could provide suitable habitat for dispersal with permanent water bodies being suitable for breeding.
Summer Water Temperature	20°C	Most non-alpine water bodies in the Columbia Shuswap attain at least 20°C from July through August
Current Velocity	Low to nil, or stagnant	Many available water bodies, lakes, ponds, oxbows
Silt in Substrate	High	Many available water bodies, lakes, ponds, oxbows
Productivity	Moderate	All non-alpine water bodies with the exception of glacial systems (Kinbasket, Lake Revelstoke, Upper Arrow Lake).

Littoral Zone Availability	> 1m from shore to 1.5m depth.	Many available water bodies with extensive littoral zones.
Prey Availability	Moderate	Most non-alpine water bodies with the possible exception of glacial systems (Kinbasket, Lake Revelstoke, Upper Arrow Lake).
Depth of pond	Greater than winter ice depth	All non-alpine water bodies

2.2 CURRENT RANGE

2.2.1 Native Range

Bullfrogs are native to eastern North America, ranging from Nova Scotia, southern Quebec and Ontario in Canada, through eastern United States and Mississippi drainage and southward along the eastern coast of Mexico. (Figure 2).

Figure 2: Native range of American bullfrogs

2.2.3 Behaviour in Native Range

Bullfrogs are an integral part of the ecosystem in their native range and provide food for species as diverse as kingfishers and blue herons, to otters and American alligators (Murray and Jehl, 1964).

2.2.4 Uses

Bullfrogs can be beneficial for ecosystems and human use, but mainly where they are naturally occurring. Bullfrogs are often thought of as a prey species for larger predators; adults, juveniles, tadpoles, and bullfrog eggs are important food sources for a variety of aquatic and terrestrial wildlife within their native range. Bullfrogs provide some economic benefits, when used by humans as a food source (i.e. frog legs) or as research specimens (Culley 1981, Bury and Whelan 1984).

For decades, bullfrogs have been transported and released around the world by prospective frog-farmers, pet owners, game managers, recreational fishermen, biological supply houses, and even by entrants in frog jumping contests (McKinley 2007). Bullfrogs were brought to Vancouver Island in the 1930's and farmed for their meaty legs (Errico 2013).

Some cultures continue to view bullfrog legs as a meat source, creating the potential for animals to be introduced to ponds. Bullfrogs may be used to supply frogs and tadpoles for fish bait, or kept as pets.

Bullfrogs have traditionally been used in school dissections ("Dissecting A Frog: A Middle School Rite Of Passage". NPR.org. Retrieved 2016-01-20) and may also be used by health education groups for similar purposes.

2.2.5 Non-native Range

Bullfrogs have been introduced and have established in over 40 countries and four continents over the past 100 years (Lever 2003 in Ficetola et al. 2007b). Bullfrogs have been introduced to Hawaii, Japan, China, Korea, Italy, the Netherlands, Germany, the United Kingdom, Spain, Greece, Belgium, France, Cuba, Jamaica, parts of Malaysia, and several South American countries.

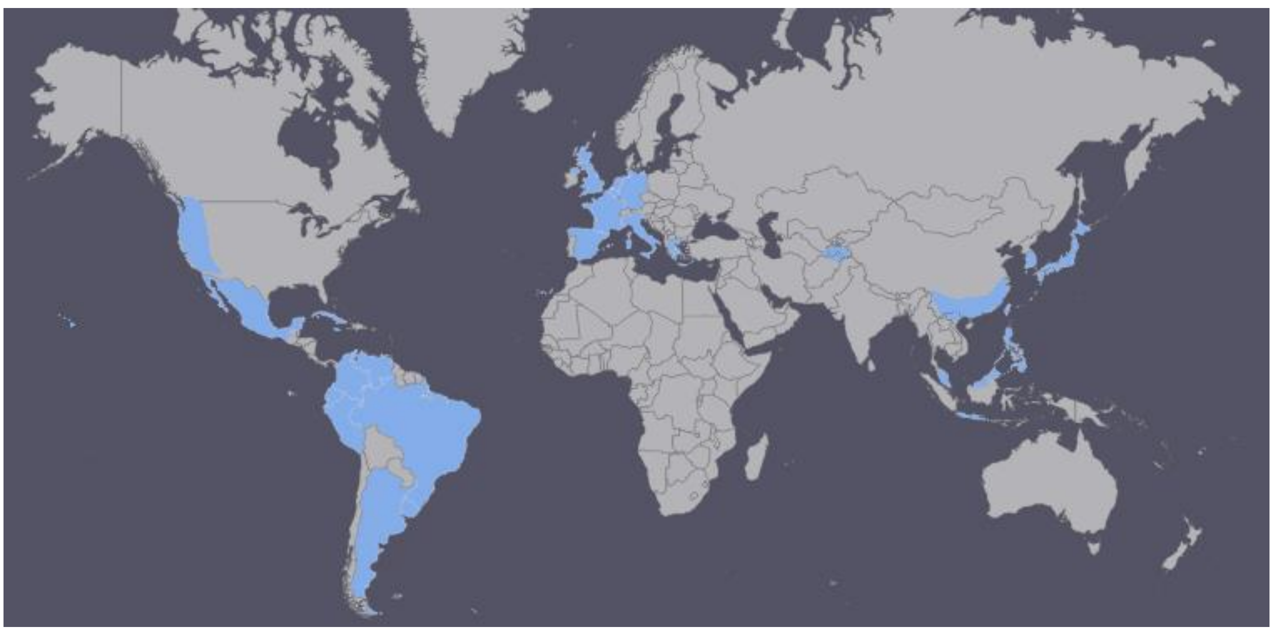


Figure 3: Countries invaded by American bullfrogs (after Ficetola 2007b).

Bullfrogs are not native to, but are widely established in western United States including Montana, Idaho, and Washington states. They are also entrenched in the lower mainland of BC, on south-eastern Vancouver Island and some Gulf Islands. Bullfrogs are now known to be present in the Creston Valley, near the Creston Valley Wildlife Management Area and are located in off-channel habitat in the Pend D'Oreille River, upstream of where the river dips into Canada (USGS 2017). Bullfrogs were known to exist in the southern Okanagan around Osoyoos but have not been recorded since 2013 after extensive eradication effort. A positive eDNA sample in 2017 did indicate their potential presence in this area (S.

Ashpole Pers. Comm.) (Figure 4), however further eDNA sampling in 2018 was negative and there has been no further detection of live animals during searches.

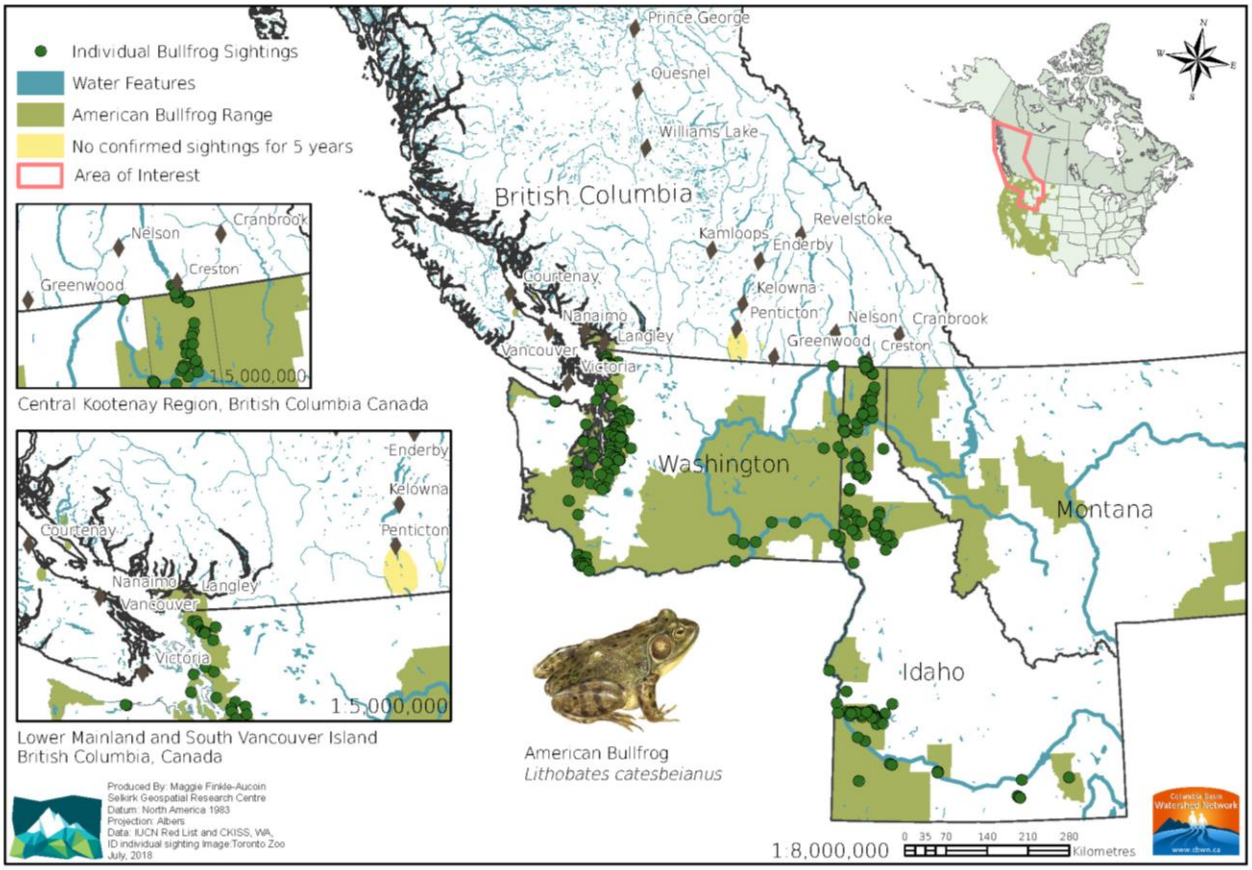


Figure 4: Current known range of American bullfrogs in BC and the Pacific Northwest

2.2.6 Behaviour in Non-native Range

Adult bullfrogs are gape-limited opportunistic predators that employ a sit-and-wait approach to feeding (Casper and Hendricks 2005). Bullfrogs essentially eat whatever they can fit into their mouths (Roach 2004), including crayfish, dragonfly nymphs, aquatic hemipterans and water beetles and small vertebrates such as fish, frogs, turtles, snakes, birds, bats, and weasels (Hirai 2004). They have also been known to eat other bullfrogs. Adult bullfrogs commonly prey on some predators of bullfrog tadpoles and juveniles, reducing their effectiveness in suppressing bullfrog population growth (Jancowski & Orchard 2013).

2.3 CURRENT REGULATORY STATUS

2.3.1 British Columbia
Bullfrogs are regulated in British Columbia under the Wildlife Act Schedule C. Under Schedule C, bullfrogs are not protected and a hunting license is not required to capture or kill individuals. Individuals of this species cannot be transported alive, released, or traded (BC Laws 1990).

2.3.2 Canada

Bullfrogs are not regulated federally in Canada; each province has its own regulations and it is not necessary to determine for the purposes of this document. Within Canada the bullfrog is not listed under Schedule 1 of the federal Species at Risk Act (SARA).

2.3.3 International

Bullfrogs are not regulated federally in the US. As in Canada, it may be regulated within each state. For the purposes of this assessment, the regulatory status is reported for Washington State (http://apps.leg.wa.gov/WAC/default.aspx?cite=220-416-120), Idaho State and Montana State.

In Washington State, bullfrogs are considered a Prohibited Aquatic Animal Species. This means that the species cannot be possessed, purchased, sold, propagated, transported or released into Washington State waters (Washington State Legislature, Chapter 220-12-090).

In Idaho State, bullfrogs are considered a game fish by Idaho Department of Fish and Game (https://idfg.idaho.gov/question/it-legal-catch-bullfrogs-idaho-and-if-so-what-are-laws-it-and-where-can-i-find-them). It is illegal to release bullfrogs.

In Montana State, bullfrogs are considered a prohibited species by Montana Fish, Wildlife and Parks (http://fwp.mt.gov/fishAndWildlife/species/exotics/prohibited.html). Specifically, the species may not be possessed, sold, purchased, exchanged, or transported (Rule: 12.6.2215).

The International Union for Conservation of Nature lists the global status of the bullfrog as Least Concern meaning that it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

There is no CITES listing for bullfrogs.

3.0 RISK ASSESSMENT

3.1 PROBABILITY OF ENTRY

Bullfrogs have not been reported as present within the Columbia Shuswap region. The closest known population is in the Creston Valley. A second managed population near Osoyoos has not been recorded for several years since an effective eradication program was carried out. Both locations are approximately 150km to the south of Columbia Shuswap boundary.

Natural or human assisted bullfrog dispersal is possible in the Columbia Shuswap region. A summary of pathways of entry is provided in Table 2.

Table 2: Potential pathways of entry for American bullfrogs into the Columbia Shuswap Region

Type of Introduction	Specific Pathways	Description
Natural dispersal	Via lakes	Bullfrogs may travel along large lakes, though it is not known if they will breed in these lakes unless there is suitable habitat at the margins or on adjoining ponds.
	Via River systems	Bullfrogs are known to travel both upstream and downstream in rivers. They may breed in swales and ponds associated with rivers.
	Via ephemeral ponds	Bullfrogs may inhabit ephemeral ponds but are typically unable to breed in these locations due to their requirement for an extended tadpole life stage. They may however use these ponds as temporary homes during migration to new permanent water bodies.
	Over Land	Bullfrogs are known to travel short distances over dry land. Miera (1999) suggests up to one kilometre may be possible.
Human Assissted Introduction Pathways	As food animals	Bullfrogs were originally introduced to the lower mainland as farmed animals. There is no known farming of bullfrogs in BC at this time. A possibility exists that individual people may want to keep bullfrogs in a backyard ponds as a food source.
	As pets, ornamentals	Live bullfrogs are available from online retailers. Bullfrogs are ocasionally available in pet stores and garden centres within BC
	Scientific subects of study	Bullfrogs have been used to teach disection in schools and may be bred for this purpose.
	As fishing bait	Bullfrog tadpoles have been sold as fishing bait.

3.1.1 Natural Introduction

Bullfrogs are mobile and readily spread to, and occupy, new habitats. For example, Orchard (1999), describes how, in the mid-1990's, a population of bullfrogs became established north of the City of Victoria, B.C., and subsequently expanded unchecked and invaded dozens of lakes and ponds throughout regional Victoria.

Bullfrogs use seasonal water corridors for natural dispersal from artificial water bodies to natural water bodies (Govindarajulu, 2004). Dispersal distances have been reported between 3.2 km to an estimated seven or eight kilometres (Schwalbe and Rosen, 1999) and up to 11.5 km per year in the Yellowstone region (Sepulveda et al. 2015). Upon becoming adaptable to land-travel, Miera (1999) suggests that over-land travel to other suitable habitats may approach up to one kilometre.

Natural dispersal depends on available habitat occurring continuously between known populations and the Columbia Shuswap region. A region of high mountains or very dry climate without regularly occurring bodies of permanent water may create a natural barrier to bullfrog movement (Govindarajulu Pers. Comm.). There are no significant barriers to natural dispersal into the Columbia Shuswap region from known population sources. Bullfrogs may naturally disperse into the Columbia Shuswap region if not managed.

3.3.2 Potential for Spread in B.C.

Bullfrogs are primarily found within permanent ponds, with potential for distribution in wetlands and proximate areas between permanent ponds (Skelly et al. 1999; Hermann et al. 2005). Murray et al. (2015) utilized occupancy models and an ecological niche model (ENM) to determine landscape predictors for suitable bullfrog current and potential invasions. The model analyses identified landscape-scale characteristics (i.e. wetland connectivity, distance from historical introduction site) as the greatest predictors of bullfrog occurrence (Murray et al. 2015). Murray et al. (2015) noted the increased probability of bullfrog incursion for ponds with greater pond connectivity and a decrease in incursion potential if isolated ponds were 50 km from the introduction site. In agreement with Murray et al. (2015), others have specified that suitable landscape characteristics for bullfrog incursions include considerable natural ground and forest cover, open-water wetlands that are not complex, and a lower degree of general and agricultural development (Kolozsvary and Swihart 1999; Houlahan and Findlay 2003).

Between the Creston population and the boundary of the Columbia Shuswap region there exist several corridors of almost continuous waterbodies (Figure 5). However, some of these waterbodies, specifically the large glacial lakes, may be less suitable to bullfrog breeding. Their ability to travel along these types of waterbodies is unknown (P. Govindarajulu, Pers. Comm.).

Between the unconfirmed Osoyoos population and the Columbia Shuswap there are areas around Armstrong, BC, without any streams or ponds for approximately 2km (Google Earth). Miera (1999) suggests that over-land travel may approach up to one kilometre. However, scientific data on dry land dispersal are not available and therefore it is not certain that natural dispersal will not take place along this route.

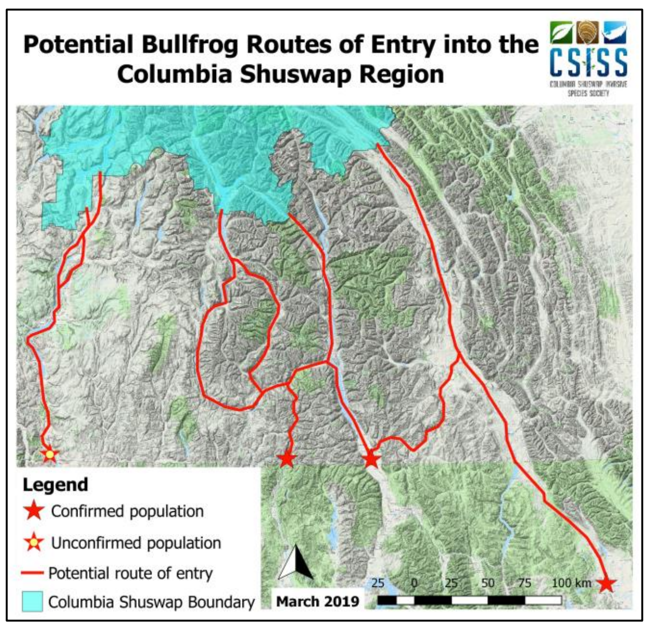


Figure 5: Potential routes of entry from known American bullfrog populations into the Columbia Shuswap region.

Natural bullfrog dispersal from the Creston BC population to Columbia Shuswap boundary is estimated to be 15 years – using the highest dispersal rate of 11.5 kilometres per year (Sepulveda *et al.* 2015) and more than 50 years – using the lowest dispersal rate of 2.8 kilometers per year (Bury and Whelan 1984 in Adams et al. 2003).

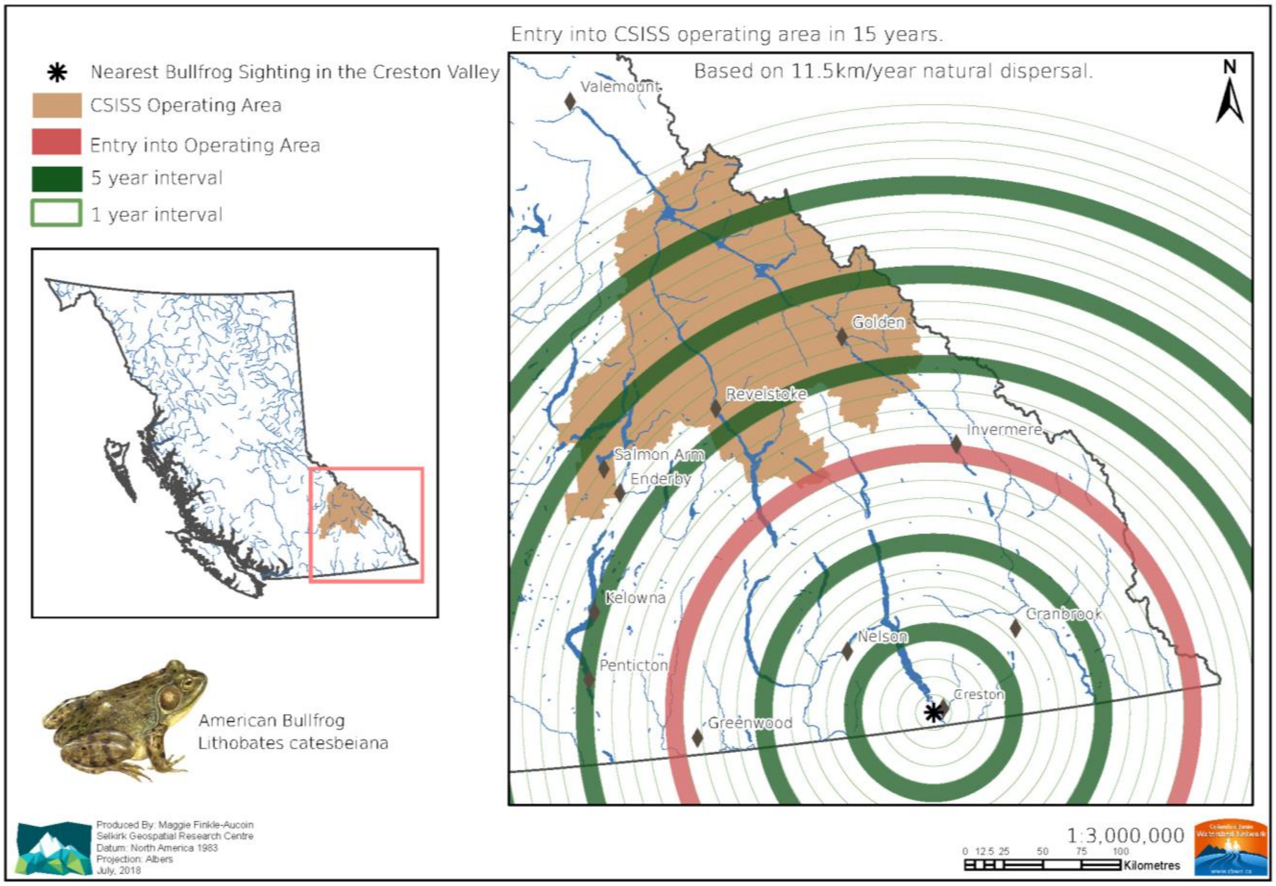


Figure 6: Natural American bullfrog dispersal from Creston BC population to Columbia Shuswap boundary.

3.1.2 Human-Assisted Introduction

According to McKinney and Lockwood (1999) and Rahel (2002), humans can assist bullfrog dispersal primarily through two processes: a direct introduction into new systems (i.e. the bucket brigade) and by altering habitat to increase species suitability.

Bullfrogs have been widely distributed around the globe to over 40 countries and four continents (Lever 2003). Bullfrogs are able to expand their range naturally and with the assistance of anthropogenic activities. Commercial bullfrog farms were likely responsible for the initial introductions of bullfrogs in B.C., but other vectors, such as releases from the pet and bait industry, are thought to be responsible for more recent introductions (Sepulveda et al. 2015; Kamath et al. 2016). Many of these introductions have had dire consequences on the biodiversity at these locations (Maxwell 2000).

Intentional bullfrog introductions are most likely to take place in areas where humans feel that the animals will be happy (i.e. humane reasons), that are covert (i.e. less likely to be seen dumping), that are easily accessible by road, and are close to human population areas. Within the Columbia Shuswap region, waterbodies with high potential for releases have been identified for both Columbia and Shuswap regions in Figure 7.

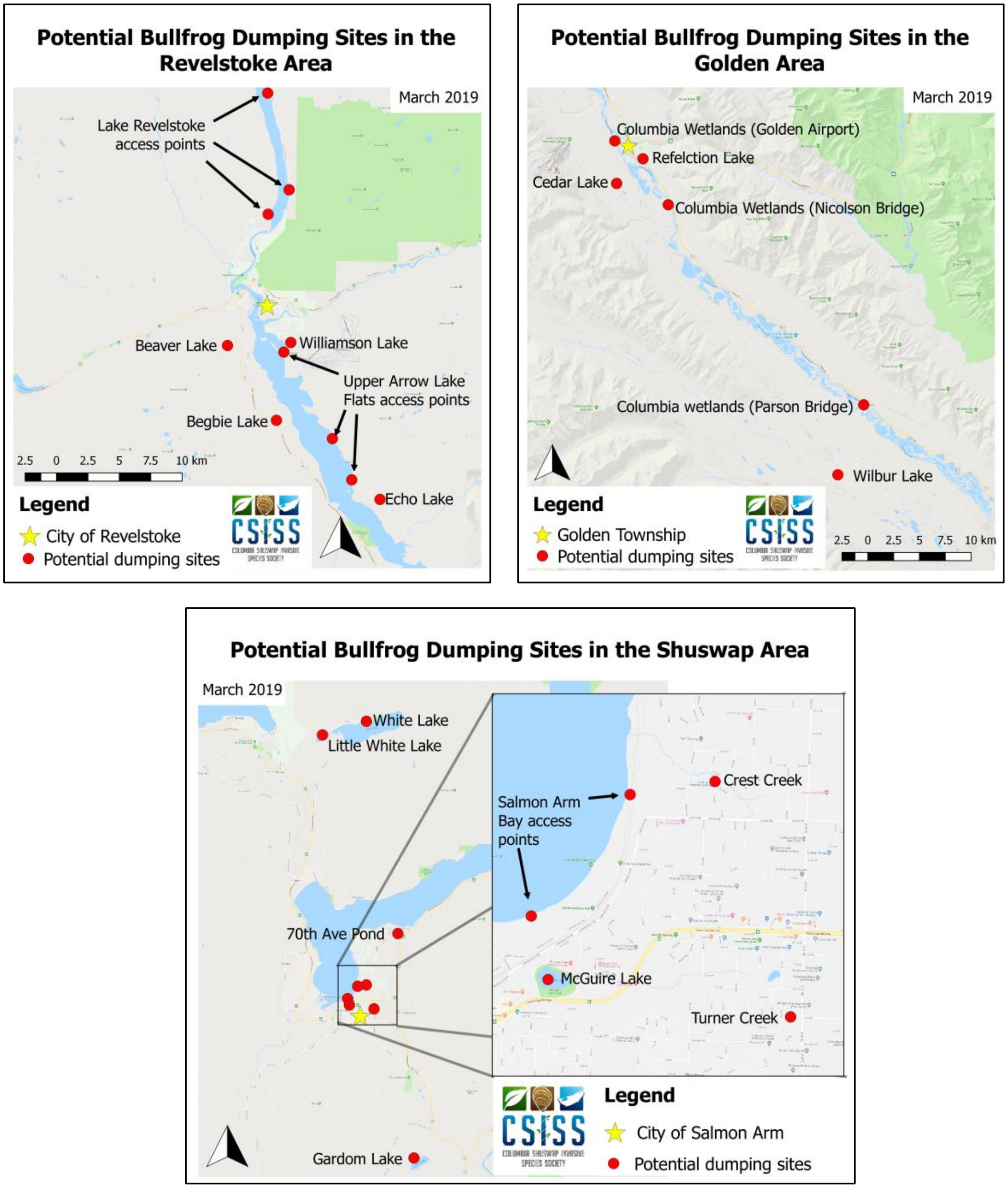


Figure 7: Locations in Revelstoke, Golden and Shuswap areas that have high potential for American bullfrog release, based on accessibility, proximity to human population centres, and opportunities for covert dumping.

3.2 PROBABILITY OF ESTABLISHMENT

Bullfrogs may reproduce successfully and therefore establish a population in regions where summer water temperatures rise above 20°C (Govindarajulu et al 2006). In climatic conditions similar to those found in the Columbia Shuswap, bullfrog tadpoles require two years before metamorphosis into juveniles, making permanent ponds a requirement for successful reproduction (Govindarajulu et al 2006).

Climate modeling by Ficetola *et al* (2007) shows areas suitable for bullfrog habitat. The model shows moderate suitability in parts of the Rocky mountain trench and Columbia River valley, and moderate to high suitability in most of the Shuswap Region.

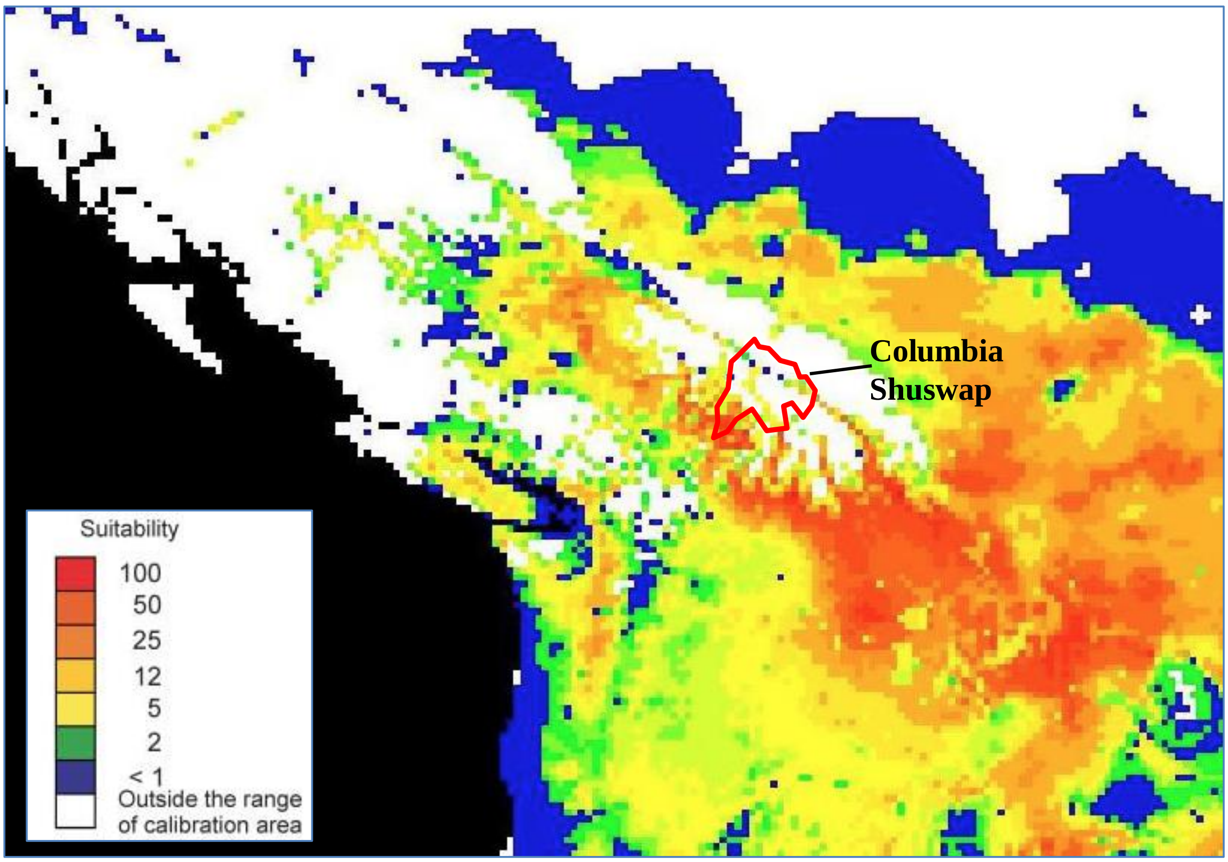


Figure 8: Climate modeling by Ficetola et al. 2007 shows areas suitable to American bullfrog establishment. Values of 100 = highly suitable habitat, <1 = unsuitable habitat. Columbia Shuswap boundary added after Ficetola.

The model shows the upper Columbia River (above the Kinbasket Reservoir), a wetland area of almost 17,000 ha, and a critical area for regional conservation of several amphibian species, to be moderately suitable habitat for bullfrogs.

Several authors suggest that bullfrogs may have a preference for highly artificial and highly modified habitats, such as millponds, livestock grazing ponds and reservoirs (Zampella and Bunnell 2000 in Adams et al. 2003, Doubledee *et al.* 2003, Ficetola *et al*. 2007b). Hayes and Jennings (1986, in Cook and Jennings 2007) pointed out that human-driven habitat modification, such as changes in hydrology from seasonal to permanent water, removal of emergent vegetative cover, and elevation of water temperatures from increased sunlight all favor the establishment of bullfrogs.

Climate change in the Columbia Shuswap region is predicted to increase mean annual temperature up to 2.7°C and decrease annual rainfall as much as 11% by the year 2050 (www.pacificclimate.org/analysis-tools/plan2adapt). Increased temperatures will potentially benefit bullfrogs by raising summer water temperatures in higher elevation water bodies. Decreased precipitation may increase the ephemeral nature of some ponds potentially reducing areas of habitat.

3.4 POTENTIAL ECONOMIC, SOCIAL &ENVIRONMENTAL CONSEQUENCES

Bullfrogs may have positive economic impacts, as they are easy to propagate and can be sold or farmed for profit, for food, or as specimens (Culley 1981, Bury and Whelan 1984). However, being strong competitors as tadpoles and aggressive generalist predators as adults, invading bullfrogs predominantly have a negative effect on native fauna that utilize similar resources or are hunted as prey. Several authors (Doubledee et al. 2003, Ficetola et al. 2007b) suggest that bullfrogs have a stronger negative effect on native species in highly modified ecosystems.

Bullfrog tadpoles have been described as “ecosystem engineers” altering biomass, and the structure and composition of algal communities (Kupferberg 1997). High food intake and high population densities (up to thousands of individuals per m^2; Alford 1986, in Pryor 2003) suggest that tadpoles have considerable impact on nutrient cycling and primary production in freshwater ecosystems (Pryor 2003).

Bullfrogs may also be carriers of pathogens that can adversely affect native amphibian populations. Recent research has implicated introduced bullfrogs as reservoir hosts of the chytrid fungus *Batrachochytrium dendrobatidis*, which can be severely pathogenic to some amphibians (Hanselmann *et al.* 2004, Pearl and Green 2005, Garner et al. 2006). Bullfrogs have also been implicated in transmission of Ranavirus, a pathogen that can produce very high mortality in non-bullfrog ranids (Daszak *et al.,* 1999; Schloegel *et al.,* 2009). Bullfrogs are suitable hosts for the pathogenic bacterium Escherichia coli (Gray *et al.,* 2007) and can be infected with *Blastocystis*, a parasite that can infect humans (Yoshikawa *et al.,* 2004). A cholera outbreak in Hunan, China in 2006 was associated with aquatic products including bullfrogs (Deng *et al.,* 2008).

Carrying pathogens and competitive/predatory behaviours can lead to declines in native fauna (Wind 2007). The Columbia Shuswap region is home to several aquatic species at risk which could be further threatened by invasions of bullfrogs (SAR BC 2019) (Table 3).

Table 3: Species at risk within the Columbia Shuswap region that may be threatened by bullfrog invasions.

Common Name	Scientific Name	Status (Act)
Bull Trout	*Salvelinus confluentus*	Threatened (IUCN)
Great Basin Spadefoot	*Spea intermontana*	Threatened (SAR BC)
Western Toad	*Anaxyrus boreas*	Special Concern (SAR BC)
Northern Leopard Frog	*Lithobates pipiens*	Threatened (SAR BC)
Western Painted Turtle	*Chrysemys picta bellii*	Special Concern (SAR BC)
Westslope Cutthroat Trout	*Oncorhynchus clarkii lewisi*	Special Concern (SAR BC)
Coeur d'Alene Salamander	*Plethodon idahoensis*	Special Concern (SAR BC)
White Sturgeon	*Acipenser transmontanus*	Endangered (SAR BC)

3.5 PREVENTION AND MONITORING OPTIONS

3.5.1 Prevention

Prevention will be both easier and more cost effective than eradication (Leung et al., 2002). Preventing natural dispersal of bullfrogs must focus on containing populations closest to the Columbia Shuswap region. The Province of British Columbia directs eradication efforts in the Creston area. Monitoring of the potentially eradicated Osoyoos bullfrog population continues (S. Ashpole Pers. Comm).

Preventing human assisted dispersal to the Columbia Shuswap region should focus on education and outreach activities and supporting enforcement. Education and outreach efforts can be broad or targeted. Targeted efforts can focus on individuals or groups most likely to be involved with bullfrog imports to the Columbia Shuswap region. Table 4 lists specific pathways by which humans are likely to import bullfrogs, and the potential ways to target education to these audiences.

Table 4: Pathways of introduction, target audiences, and options for prevention of bullfrogs being imported to the Columbia Shuswap region.

Specific Pathways	**Target Audiences**	**Options for Preventative Education**
As food animals	Ethnic groups	Target education to ethnic communities where frogs are a cultural food source.
	Local food groups	Seek groups such as local foods initiatives to educate about the environmental impacts of introducing non-native species such as bullfrogs.
As pets, ornamentals	Pet Stores	Educate pet stores with the "Don't let it Loose" message. Visit stores annually, leave materials for customers, and promote the Invasive Aliens Species app. Encourage owners/managers to contact CSISS with any questions and unusual reports.
	School children	Promote "Don't let it Loose" within schools and at youth events.
	Garden centres	Call garden centres in early spring (ordering season) to provide information about invasives including bullfrogs. Visit garden centres annualy in May to inspect inventory and provide materials to customers.
Dumping	People at potential dumping sites	Install posters at areas of high likelyhood of dumping (suitable habitat, proximity to municipalities, and with opportunities for 'covert dumping'). Posters will help ID bullfrogs, offer reasons to prevent unwanted releases, and provide re-homing options.

Specific Pathways	Target Audiences	Options for Preventative Education
Fishing bait	Anglers, fishing store owners	Visit fishing stores with informarion about the impacts of bullfrogs. Produce bulfrog “Invader Alert” cards that can be distributed to anglers at stores and events. Use social media to discourage the use of bullfrog tadpoles as live bait.
Scientific subjects of study	Science teachers	Visit schools and colleges to ensure science teachers, medical trainers, and material procurers are aware of the impacts of bullfrogs, and advise that live bullfrogs are never imported into the region.

3.5.2 Monitoring

Environmental DNA (eDNA) sampling is a possible tool for the early detection of bullfrogs. However, this technology depends on developing suitable primers to screen out expected taxa in the Columbia Shuswap region (Herder et al 2014).

Song-meters may be used to monitor for bullfrog calls during the mating season. Song-meter recordings can be challenging to interpret in areas where there is significant human activity such as roads and railways. Recordings need to be paired with specialized software to “listen” to hours of data and highlight presence of bullfrog calls to be verified (Central Kootenay Invasive Species Society staff, Pers. Comm.).

Lower technology ways of monitoring for bullfrogs include nocturnal eye-shine surveys, and egg mass surveys.

Given the large number of water-bodies in the Columbia Shuswap region, it is important to prioritize monitoring efforts. Priority of water-bodies can be assigned by many factors such as possibility of human assisted bull frog release and presence of threatened or endangered species. A priority risk matrix is being developed (Appendix 1) by adapting a similar risk matrix that was developed for the Canadian Columbia Basin Regional Framework for an Aquatic Invasive Species Program (Columbia Basin Aquatic Invasive Species Steering Committee, 2015).

3.6 Eradication Feasibility

Eradication feasibility depends on several factors such as the size and type of waterbody infested, its proximity to other waterbodies, and the degree to which a population is established. Eradication of bullfrogs from well-established areas, and in wetlands greater than one hectare is cost-prohibitive (Govindarajulu et al. 2005, Govindarajulu and Anholt 2002). However, some success has been achieved in smaller areas where populations have been either kept in check or eradicated through diligent efforts (Govindarajulu 2013).

Eradication attempts can take several forms including egg mass removal, tadpole removal, and post metamorph removal (Govindarajulu et al. 2005). Methods include fyke, seine or dip netting, hand capture, spearing, shooting, gee trapping, pond draining and fencing (Louette et al., 2013), and electro-shocking (Orchard 2011).

The South Okanagan bullfrog management program worked from 2004-2012 to suppress a bullfrog population in several small ponds in the region. The advantages and disadvantages of the methods used are shown in table 5 (adapted with permission from N Lukey 2017).

Table 5. Advantages and disadvantages of main detection and removal methods used in the South Okanagan bullfrog management program (adapted with permission from N Lukey 2017)

Method	**Advantage**	**Disadvantage**
Gee trapping	Captured tadpoles, juveniles, and adults; captured a high number of individuals; can be conducted in any water body. Cages able to remain in situ for extended times.	Requires large amount of observer time; may put native species at mortality risk if bullfrogs and native individuals are confined to the same trap.
Active searches	Detects a diversity of life stages; minimal gear required; allows for behavioral observations and detections of native species.	Requires large amount of observer time; requires skill to manually capture detected individuals; limited by shoreline access and turbidity.
Night-time canoe searches	Allows access to water bodies with dense shoreline vegetation; can cover a large area in less time than active searches by foot. Water-side capture more effective than shoreline capture; allows for "eye-shine" detection over large shoreline area.	Only detects juveniles and adults; access to water bodies via canoe is limited at many locations; not effective in small water bodies; requires large amount of observer time.
Auditory surveys	Relatively low observer effort required; cost-effective with respect to gear required.	Requires training to minimize misidentification; may give false absence for low density or rare species; only detects calling males.

It is important to note that due to the huge number of tadpoles and the significant competition between individuals, that partial removal of tadpoles may result in higher survival and development rates and lead to a higher post-metamorph population (Govindarajulu et al. 2005). Similarly, removal of adults may lead to higher survival of early metamorphic stages through reduced cannibalism. Modeling by Govindarajulu et al. (2005) suggests that culling of metamorphs in fall is the most effective method of decreasing bullfrog population growth rate. Orchard (2011) describes the successful use of a modified electro-fisher (electro-shocker) to target the removal of metamorphs from ponds and smaller lakes.

3.6.1 Cost of Eradication.

Eradication costs vary widely depending on type of waterbody infested and degree of infestation. Orchard (2011) estimates total cost to eradicate an early establishment population in a small pond to cost between $9,000 and $16,000 over three years. Costs were based on use of electro-shocker, boat and a two person per team over 25-40 nights per year.

Cost estimate of an eradication and monitoring program in the Creston area (2 locations) is between $254,000 and $338,000 per year (estimate includes salaries and wages, equipment and analyses (i.e. electro-shocker, high intensity halogen headlamps, song meters, eDNA supplies, etc.), travel and accommodation, and project administration (Kootenay Boundary American Bullfrog Risk Assessment 2019–Draft).

Estimates for effort (person hours) population suppression (to the point of no detections for several years) of an established population in southern Okanagan at 7 sites in 3 ponds

3.7 TECHNICAL ISSUES FOR CONSIDERATION

Bullfrogs are difficult to detect when in low densities unless eDNA techniques are well developed (Herder et al. 2014). Local databases of expected taxa must be developed if eDNA sampling techniques are to become more refined.

Using songmeters to survey for bullfrog song can be challenging due to sound interference by traffic, trains, and other human sounds. Songmeters also produce vast data streams that must be sifted through by humans, or alternatively use a sound analysis program search for potential calls within the data. Sound analysis programs vary in their ability to detect bullfrog calls among other sounds on the recording.

Accessing potential bullfrog habitat on private land is challenging. Education and landowner outreach are possible options for mitigation of this issue.

Accessing waterways without road access can create challenges for survey and eradication efforts.

General public may misidentify the species. Western toads and Columbia spotted frogs (both medium to large species) are present in the Columbia Shuswap region and can be misidentified by public. Training and amphibian identification courses can increase public identification accuracy.

3.8 COST BENEFIT ANALYSIS OF POTENTIAL ACTIONS

Currently, no bullfrog populations exist within the Columbia Shuswap region. Decisions regarding appropriate actions for bullfrog prevention and detection need to be made early.

Table 6. Management options for Bullfrogs within the Columbia Shuswap region; costs, benefits, challenges.

Actions	Costs	Benefits	Challenges
Educate target audiences – schools, colleges, pet stores, fishing stores, garden centres, ethnic foods outlets.	Staff time	Concentrate efforts on highest risk human transport audience	Identifying target audiences
Establish risk ranking matrixes for waterbodies in the Columbia Shuswap region based on natural distribution and human assisted distribution.	Staff time	Concentrate efforts on highest risk areas	Large number of water bodies, Data unavailable for suitability of bullfrogs on many lakes, Access to privately owned ponds
Survey for bullfrog presence/ absence via song-meters and/or eye-shine surveys.	Cost of equipment, Staff time	Early Detection	Access to private ponds, Song-meter disruption near roads and railways, Safety plan for nocturnal work
Encourage Citizen Scientists to survey for bullfrog songs.	Inexpensive, Staff time to coordinate	Public engagement at high risk dumping areas, Stewardship of waterbodies	Many waterbodies with few to no public during bullfrog singing times
eDNA testing	Expensive equipment, staff time, requires local databases of expected taxa	Simple water sample can detect low infestation levels.	Databases for expected taxa may not be available

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APPENDIX 1: RISK RANKING FOR HUMAN ASSISTED INTRODUCTION OF AMERICAN BULLFROGS TO THE COLUMBIA SHUSWAP REGION

Points are assigned as follows:

- Points for Proximity to Human Population are: approximately one or more hours travel from large town = 1, around half an hour away = 3, less than ten minutes away = 5.
- Points for recreation use are calculated by counting recreation icons in the BC Backroads Map book: 1 icon = 1 point; 2 to 4 icons = 2 points; 5+ icons =3 points)
- Points for ease of access are: paved = 5; gravel = 2, foot = 1
- Points for ***perceived*** habitat suitability are: 5 = very suitable, 3 = somewhat suitable, 0 = unsuitable or not known
- Points for Covert Dumping are: many = 5, some options = 3, few options = 1
- Points for Species at Risk are: Endangered = 6; Threatened or special concern = 3

Waterbody	IPMA	Risk Ranking	Proximity to Human Population	Recreational Use	Ease of Access	Perceived Habitat Suitability	Covert Dumping	Species at Risk	Species (source of data)
Salmon Arm Bay waterfront	Salmon Arm	**29**	5	3	5	5	5	6	White Sturgeon, Bull trout, Westslope Cutthroat Trout (SAR BC and iMap BC)
Airport Flats	Revelstoke	**27**	5	1	5	5	5	6	Sturgeon, Western Toad, Coeur d'Alene Salamander, Bull Trout, West Slope Cut Throat Trout (SAR BC and iMap BC)
Shuswap Lake	Salmon Arm	**25**	5	3	5	3	3	6	White Sturgeon, Bull trout, Westslope Cutthroat Trout (SAR BC and iMap BC)
Columbia Wetlands	Golden	**23**	2	2	3	5	5	6	White Sturgeon, Bull trout, Westslope Cutthroat Trout, Western Toad (SAR BC and iMap BC)
70th Ave Pond (Canoe)	Salmon Arm	**23**	5	3	5	5	5		
Crest Creek	Salmon Arm	**23**	5	3	5	5	5		
Gardom Lake	Salmon Arm	**23**	3	2	5	5	5	3	Painted Turtle (iMap BC)
Turner Creek	Salmon Arm	**23**	5	3	5	5	5		
Williamson Lake	Revelstoke	**22**	5	1	5	5	3	3	Western Toad (SAR BC and iMap BC) Painted turtle (iMap BC)
Little White Lake	Salmon Arm	**22**	4	0	5	5	5	3	Painted turtle (iMapBC)

Waterbody	IPMA	Risk Ranking	Proximity to Human Population	Recreational Use	Ease of Access	Perceived Habitat Suitability	Covert Dumping	Species at Risk	Species (source of data)
Echo Lake	Revelstoke	**21**	4	2	2	5	5	3	Western Toad (SAR BC and iMap BC)
Cedar Lake	Golden	**20**	4	1	2	5	5	3	Westslope cutthroat Trout (SAR BC, iMap BC)
Reflection Lake	Golden	**20**	5	0	2	5	5	3	Painted turtle (iMapBC)
Mara Lake	Salmon Arm	**20**	3	3	5	3	3	3	Bull Trout (SAR BC and iMap BC)
Beaver Lake	Revelstoke	**19**	4	3	2	5	5	0	-
Lake Revelstoke	Revelstoke	**19**	2	3	5		3	6	White Sturgeon, Bull trout, Westslope Cutthroat Trout (SAR BC and iMap BC)
Upper Arrow Lake	Revelstoke	**19**	2	3	5		3	6	Sturgeon, Western Toad, Coeur d'Alene Salamander, Bull Trout, West Slope Cut Throat Trout (SAR BC and iMap BC)
Wilbur Lake	Golden	**18**	2	1	2	5	5	3	Western Toad (SAR BC and iMap BC)
McGuire Lake	Salmon Arm	**18**	5	0	5	5	3	0	-
Begbie Lake	Revelstoke	**17**	4	1	2	5	5		
Trout Lake	Revelstoke	**17**	4	2	2	3	3	3	Westslope cutthroat Trout, Western Toad, Bull Trout (SAR BC and iMap BC)
Little Shuswap Lake	Salmon Arm	**17**	3	3	5	3	3		
Skimikin Lake	Salmon Arm	**17**	2	2	2	5	3	3	Western Toad (SAR BC and iMap BC)
Adams Lake	Salmon Arm	**16**	2	3	5	3	3		
Spanish Lake	Salmon Arm	**16**	1	2	2	5	3	3	Western Toad (SAR BC and iMap BC)
Wallensteen Lake	Salmon Arm	**16**	1	2	2	5	3	3	Great Basin Spadefoot (SAR BC and iMap)
White Lake	Salmon Arm	**16**	3	2	5	3	3	0	-
Bittern Lake	Golden	**15**	2	1	2	5	5	0	-

Waterbody	IPMA	Risk Ranking	Proximity to Human Population	Recreational Use	Ease of Access	Perceived Habitat Suitability	Covert Dumping	Species at Risk	Species (source of data)
Kinbasket Lake	Golden	**15**	1	3	2		3	6	Northern Leopard Frog, Western Toad, Westslope Cutthroat Trout, Bull Trout, White Sturgeon (SAR BC and iMap BC)
Susan Lake	Golden	**15**	2	1	2	5	5	0	-
Pinaus Lake	Salmon Arm	**15**	3	2	2	5	3	0	-
Mitten Lake	Golden	**14**	4	2	2	3	3	0	-
Humamilt Lake	Salmon Arm	**14**	1	2	2	3	3	3	Bull Trout (SAR BC and iMap BC)
Joyce Lake	Salmon Arm	**14**	1	2	5	3	3	0	-
Kernaghan Lake	Salmon Arm	**14**	1	2	2	3	3	3	Great Basin Spadefoot, Western Toad (SAR BC and iMap)
Nellie Lake	Salmon Arm	**14**	2	2	2	5	3	0	-
Spa Lake	Salmon Arm	**14**	1	2	2	3	3	3	Great Basin Spadefoot (SAR BC and iMap)
Staubert Lake	Revelstoke	**13**	3	0	2	3	5	0	-
Bolean Lake	Salmon Arm	**13**	1	2	2	5	3	0	-
Griffin Lake	Salmon Arm	**13**	2	0	2	3	3	3	Western Toad, Westslope Cutthroat Trout, Bull Trout (SAR BC iMap BC)
Loon Lake	Golden	**11**	3	1	2	5		0	-
Arthur Lake	Salmon Arm	**11**	1	2	2	3	3	0	-
Gardiner Lake	Salmon Arm	**11**	1	0	5		5	0	-
Three Valley Lake	Salmon Arm	**11**	2	1	2		3	3	West throat Cutthroat Trout, Western Toad (BC SAR, iMap BC)
Blackwater Lake	Golden	**10**	2	1	2	5		0	-
Joyce Lake	Golden	**10**	1	0	1	5	3	0	-
Nixon Lake	Golden	**10**	1	0	1	5		3	Westslope cutthroat Trout (SAR BC, iMap BC)
Cranberry Lake	Revelstoke	**10**	2	0	2	3	3	0	-

Waterbody	IPMA	Risk Ranking	Proximity to Human Population	Recreational Use	Ease of Access	Perceived Habitat Suitability	Covert Dumping	Species at Risk	Species (source of data)
Victor Lake	Salmon Arm	**10**	1	0	2	3	1	3	Westslope cutthroat Trout (SAR BC, iMap BC)
Nine Bay Lake	Golden	**9**	2	1	1	5		0	-
Three Island Lake	Golden	**8**	2	1	2	3		0	-
Canyon Lake	Golden	**7**	2	0	2			3	Westslope cutthroat Trout (SAR BC, iMap BC)
Cooper Lake	Golden	**7**	2	0	5			0	-
McLean Lake	Golden	**7**	2	1	1			3	Westslope cutthroat Trout (SAR BC, iMap BC)
Clanwilliam Lake	Salmon Arm	**7**	1	0	2		1	3	Westslope cutthroat Trout (SAR BC, iMap BC)
Lady King Lake	Salmon Arm	**7**	2	0	2	3		0	-
Willis Lake	Salmon Arm	**7**	2	0	5			0	-
Quartz Lake	Golden	**6**	1	1	1			3	Westslope cutthroat Trout (SAR BC, iMap BC)
Wiseman Lakes	Golden	**6**	1	1	1			3	Westslope cutthroat Trout (SAR BC, iMap BC)
Heart Lake	Salmon Arm	**6**	1	0	5			0	-
Madelin Lake	Salmon Arm	**6**	1	0	5			0	-
Dejordy Lake	Golden	**5**	1	0	1			3	Westslope cutthroat Trout (SAR BC, iMap BC)
Fourteen Mile Lake	Golden	**5**	2	1	2			0	-
Help Lake	Golden	**5**	2	1	2			0	-
Jeb Lake	Golden	**5**	2	1	2			0	-
Rocky Point Lake	Golden	**5**	2	1	2			0	-
Summit Lake	Golden	**5**	2	1	2			0	-
Aid Lake	Golden	**4**	2	0	2			0	-
Comfort Lake	Golden	**4**	2	0	2			0	-
Loftus Lake	Salmon Arm	**4**	2	0	2			0	-
Jubilee Lake	Golden	**3**	1	0	2			0	-
Radcliff Lake	Golden	**3**	2	0	1			0	-

Waterbody	IPMA	Risk Ranking	Proximity to Human Population	Recreational Use	Ease of Access	Perceived Habitat Suitability	Covert Dumping	Species at Risk	Species (source of data)
Armstrong Lake	Revelstoke	**3**	1	0	2			0	-
Coursier Lake	Revelstoke	**3**	1	0	2			0	-
Hanner Lake	Revelstoke	**3**	2	0	1			0	-
Wetask Lake	Revelstoke	**3**	2	0	1			0	-
Bergerac Lake	Salmon Arm	**3**	1	0	2			0	-
Black Lake	Salmon Arm	**3**	1	0	2			0	-
Cummins Lake	Salmon Arm	**3**	1	1	1			0	-
Hunakwa Lake	Salmon Arm	**3**	1	0	2			0	-
Pisima Lake	Salmon Arm	**3**	1	0	2			0	-
Rabie Lake	Salmon Arm	**3**	1	0	2			0	-
Round Lake	Salmon Arm	**3**	1	0	2			0	-
Silvernail Lake	Salmon Arm	**3**	1	0	2			0	-
Will Lake	Salmon Arm	**3**	1	0	2			0	-
Wright Lake	Salmon Arm	**3**	1	0	2			0	-
Deserted Lake	Golden	**2**	1	0	1			0	-
Gavia Lakes	Golden	**2**	1	0	1			0	-
Gorman Lake	Golden	**2**	1	0	1			0	-
Holt Lake	Golden	**2**	1	0	1			0	-
Lang Lake	Golden	**2**	1	0	1			0	-
Kirbyville Lake	Revelstoke	**2**	1	0	1			0	-
Perry Lake	Revelstoke	**2**	1	0	1			0	-
Pettipiece Lake	Revelstoke	**2**	1	0	1			0	-
Watam Lake	Revelstoke	**2**	1	0	1			0	-
Blue Lake	Salmon Arm	**2**	1	0	1			0	-
Cranberry Lake	Salmon Arm	**2**	1	0	1			0	-
Gilfrid Lake	Salmon Arm	**2**	1	0	1			0	-
Grizzly Lake	Salmon Arm	**2**	1	0	1			0	-
Morton Lake	Salmon Arm	**2**	1	0	1			0	-

Waterbody	IPMA	Risk Ranking	Proximity to Human Population	Recreational Use	Ease of Access	Perceived Habitat Suitability	Covert Dumping	Species at Risk	Species (source of data)
Pyrite Lake	Salmon Arm	**2**	1	0	1			0	-
Santabin Lake	Salmon Arm	**2**	1	0	1			0	-
Waby Lake	Salmon Arm	**2**	1	0	1			0	-