



Northern Leopard Frog Preservation - American Bullfrog Control (COL-F21-W-3258)

Prepared for: Fish and Wildlife Compensation Program

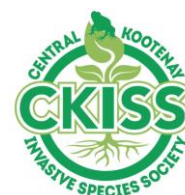
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Working Together to
Reduce the Impacts
of Invasive Species

Executive Summary

American bullfrogs (*Lithobates catesbeianus*) pose a significant threat to the biodiversity of aquatic habitats in the Central Kootenay Invasive Species Society's operational area, and to the survival of the endangered northern leopard frog (*Lithobates pipiens*) population of the Creston Valley. In this project, improvements to habitat conditions and ecosystem function for northern leopard frog and other species at risk were undertaken through extensive surveillance and eradication actions on American bullfrog. This project aligns with the *Columbia Region: Wetlands & Riparian Areas Action Plan*, in which northern leopard frog is defined as a recovery species of interest. The work of the American Bullfrog Action Team and the Central Kootenay Invasive Species Society directly protects northern leopard frog and the significant recovery efforts made by the FWCP to date. This project's primary objective is to eradicate American bullfrog in the Creston Valley.

The American Bullfrog Action Team, whose members represent a broad spectrum of government, rights holders and stakeholders, international partners, and non-government organizations has undertaken various efforts to monitor at-risk wetlands and waterbodies for bullfrog presence in the Creston Valley. In 2019, transboundary funding agreements between Ministry of Forests, Lands, Natural Resource Operations, and Rural Development, Washington State, and Idaho Fish and Game facilitated control efforts in northern Idaho (location of main source population of bullfrogs). However, despite plans for that effort to extend into 2020, no work occurred outside of B.C. due to cross-border travel restrictions implemented in response to COVID-19.

The deployment of numerous surveillance and capture techniques resulted in the euthanasia of 170 adult and juvenile bullfrogs. From May – October, 171 surveys were conducted across nineteen sites employing every available method known to effectively and efficiently detect and capture bullfrogs including the effective trialing of a Conservation K9 team. Between years, effort increased, while capture rate decreased in 2020. This is an indication of population reduction in the Creston Valley as increased effort with reduced capture rates infers a lower population density. However, it is imperative that continued surveillance and capture occur in former breeding sites and on the Kootenay River, as well as

areas with low-resistance pathways into extensive wetland, lake, or riparian habitats to assist in prevention of breeding events.

Program success will require the continued review of efficacy of detection and capture techniques and adaptation of operational plans accordingly. Furthermore, as the control of American bullfrog is a cross-border issue, it is imperative to continue to build new and maintain existing partnerships with agencies and organizations that have the shared goal of bullfrog eradication.

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Introduction

The Central Kootenay Invasive Species Society (CKISS) was established in 2005 as a non-profit with the mission to protect ecosystems and communities by preventing and reducing the harmful impacts of invasive species. In order to fulfill its mission, CKISS educates, works with, and calls to action area residents, visitors, and a diverse range of communities and organizations.

CKISS has three focus areas:

- Education, Collaboration and Sharing Knowledge;
- Action on Invasive Species; and
- An Innovative, Effective and Sustainable Organization.

Aquatic invasive species include non-native fish, animal, and plant species that have been introduced into an aquatic ecosystem where they have not been found historically. The risk of aquatic invasive species introductions to British Columbian waters is escalating rapidly, due to a number of factors including but not limited to, increased global trade, illegal dumping of horticultural and aquarium species, and water-based recreation. Once introduced, aquatic invasive species such as American bullfrog (*Lithobates catesbeianus*) can have vast implications on endangered native herpetofauna species (Crayon, 2009), including but not limited to the northern leopard frog - Rocky Mountain population (*Lithobates pipiens*) and the western painted turtle (*Chrysemys picta bellii*) (Jancowski & Orchard, 2013).

In 2015, the Central Kootenay Invasive Species Society and partners observed a population of American bullfrogs in a lake near Nelway, B.C. Limited control efforts have occurred at this site due to capacity restraints. In 2016, Idaho Fish and Game biologist Michael Lucid advised members of the American Bullfrog Action Team to expand bullfrog surveillance to the Creston Valley, in response to observations of bullfrogs in habitat near the Canada-US border.

Bullfrogs were subsequently observed and captured in a small, private lake at Rykerts, B.C., known locally as Mawson Lake. This initiated an Early Detection Rapid Response (EDRR) program for the Creston area with the aim of preventing bullfrogs from establishing in the critical habitat of the endangered northern leopard frog (NLF). Since 2018, landscape-level

bullfrog surveillance and eradication efforts have occurred in the Kootenay River Valley with the multi-jurisdictional, transboundary support of partners, rights holders, and stakeholders. Increased funding, capacity, and collaboration between CKISS, Ministry of Forest, Lands, Natural Resource Operations and Rural Development (FLNRORD), Ktunaxa Nation Council (KNC), Yaqan Nukiy-Lower Kootenay Band (YNLKB), Creston Valley Wildlife Management Area (CVWMA), and Idaho Fish and Game (IFG) has resulted in development of an effective control effort with increased understanding of bullfrog occupancy and distribution in the Creston Valley.

With continued collaboration and allocation of resources this important program may be able to fully eradicate bullfrogs from the Creston Valley. However, maintained effort and transboundary collaboration is essential for long-term success. Without continued pressure, bullfrogs will further establish and continue to migrate from source populations in Idaho northwards into NLF habitat via the flow of the Kootenay River as it flows into Kootenay Lake. To date, 2,121 bullfrogs have been removed from the Kootenay River Valley, with peak observations and captures occurring in 2019. An eleven-kilometre buffer remains between known bullfrog occurrence and NLF critical habitat.

1.0 Goals and Objectives

The objective of this project is to protect the productivity of wetland and riparian habitats critical to the recovery and expansion of the northern leopard frog in the Creston Valley. American bullfrogs generate a direct and specific threat to NLF recovery via predation and reduction of habitat quality and quantity due to their ability to outcompete native aquatic herpetofauna.

The goals of this project are as follows:

- Prevent American bullfrog from gaining a biological foothold in the region;
- Ensure the protection of critical habitat for species at risk including western toad, western painted turtle, northern leopard frog;
- Create a buffer along the Canada-US border to ensure that northern leopard frog habitats are protected;
- Inform the public about species at risk and American bullfrog through a targeted

- education program;
- Support regional Ministry staff in securing long-term stable funding and capacity to continue a surveillance, monitoring, and eradication program at priority sites throughout the region; and
 - Continue to support the Yaqan Nukiy-Lower Kootenay Band to conduct independent surveillance and eradication activities on reserve lands.

Northern leopard frog is defined as a recovery species of interest within the *Columbia Region: Wetlands & Riparian Areas Action Plan*. The work of the American Bullfrog Action Team and CKISS directly protects northern leopard frog and the significant recovery efforts made by the FWCP to date. This project's primary action is to eradicate American bullfrog in the Creston Valley.

2.0 Study Area

The study area for this project is within the CKISS' operational area (Figure 1), with activities localized within the Creston Valley (Figure 2). Site prioritization within the valley is based on known presence of American bullfrogs; suspected presence of bullfrogs due to proximity to known populations; suitable habitat for bullfrog survival and reproduction; probable migration corridors/water connectivity; presence of listed species; or accessibility and feasibility of capture.

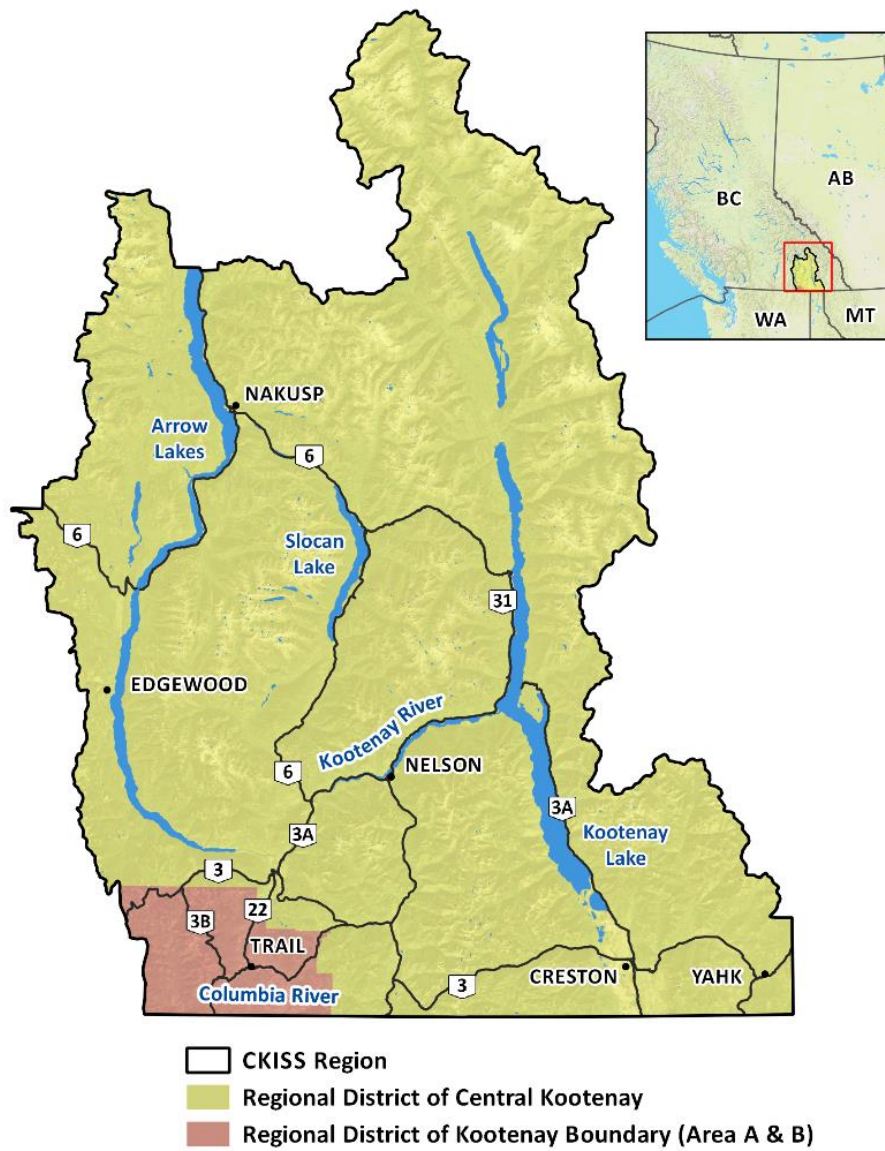


Figure 1. Map of Central Kootenay Invasive Species Society's Operational Area.



Figure 2. Creston Valley American bullfrog study area, 2020.

The Kootenay River Valley, which includes the Creston Valley, encompasses an extensive network of valley-bottom wetlands and lakes hydrologically connected to the Kootenay River, from Bonners Ferry, Idaho north to the outflow of the Kootenay River into Kootenay Lake. In B.C., this habitat stretches from Dale Marsh to Six Mile Slough on the east side of the valley and includes Corn Creek Marsh and Leach Lake. On the west side of the valley, this habitat includes Rykerts Lake, YNLKB lands, Duck Lake, and the old goat river channel. Additionally, the Canyon-Lister Bench offers potential habitat and should be subject to additional survey effort. There is extensive private property throughout the valley, with agriculture land use dominating the landscape.

In 2019, transboundary funding agreements between FLNRORD, Washington State, and IFG facilitated control efforts in northern Idaho. However, despite plans for that effort to extend into 2020, no work occurred outside of B.C. due to cross-border travel restrictions implemented in response to COVID-19.

3.0 Methodology

3.1 PASSIVE ACOUSTIC SURVEILLANCE

Autonomous recording devices (hereafter referred to as songmeters) were deployed at nine locations throughout the Creston Valley (Table 1) between June 8 and August 24, 2020, with the goal of recording adult male bullfrog calls during breeding season. Songmeters were set to record for the first 30 minutes of each hour between 20:00 and 24:00 nightly. Recording settings (e.g. filter and gain) were set to default recommendations from the manufacturer.

Table 1. Location of FLNRORD/CKISS maintained acoustic recording devices for American bullfrog detection in the Creston Valley, 2020.

Area	Site Description	UTM Location
Creston	Nick's Island Pond	11 U 529033 E 5439922 N
Creston	Creston Water Treatment Plant	11 U 534290 E 5438074 N
Creston	Old Goat Channel South	11 U 532460 E 5438171 N
Creston	Sutcliffe Farm – Ski Jump Bay	11 U 530911 E 5441813 N
Creston	Happy Hunting Grounds 1	11 U 532105 E 5436284 N
Creston	Happy Hunting Grounds 2	11 U 532950 E 5437007 N
Creston	Happy Hunting Grounds 3	11 U 533343 E 5437063 N
Creston	Frederick's Farm	11 U 529385 E 5434886 N
Creston	Nick's Island Cross-Ditch	11U 529169 E 5438949 N

The data was collected and analysed every two weeks by FLNRORD staff using Kaleidoscope Pro Software (Version 5.1.9). Cluster Analysis was applied to the sound files to concentrate possible bullfrog calling for manual verification. The analysis used a Classifier developed from sound files containing known bullfrog calling.

An additional four songmeters were deployed, maintained and sound files analysed by the CVWMA within CVWMA property boundaries. Results from all songmeters were shared between FLNRORD, CVWMA, CKISS, and KNC crews.

3.2 VISUAL AND ACTIVE ACOUSTIC SURVEILLANCE

Survey efforts occurred throughout the Creston Valley between May 18 and October 2, 2020 with peak detections in June and July. Nocturnal eyeshine surveys were conducted in accordance with *Inventory Methods for Pond-breeding Amphibians and Painted Turtle*¹ developed by the B.C. Ministry of Environment. Additionally, the B.C. *Interim Hygiene Protocols for Amphibian field staff and researchers*² was followed to reduce the spread of infectious diseases such as the amphibian chytrid fungus, as bullfrogs are a known asymptomatic vector of this disease (Miaud, et al., 2016). Efficient visual detection of bullfrogs requires nighttime lighting to activate the reflective properties of amphibian eyeballs (eyeshine). Trained field crews utilize high powered lights (1000+ lumens) to key in on target species from up to 50 metres away using eyeshine observations. Crews generally are able to identify bullfrogs based on the shape and colouration of the eyeshine, however, species are verified visually at a proximity of less than 10 metres prior to capture attempts.

Male calling during peak breeding season (late May to mid July) can be a useful detection method, as calls are distinct and travel far (up to 2 km) over flat, open terrain. However, only a sub-set of the target population is responsive to call playback surveys, therefore, nocturnal eyeshine surveys were utilized in conjunction with auditory signals of bullfrogs, which allowed field crews to move through large areas of potential habitat with reasonable confidence in results (presence/not-detected).

Survey data was collected using the ArcGIS “Collector” Application, which spatially relates all capture and survey data in the field. It is stored as a File Geodatabase on the Government of B.C. ArcGIS Enterprise account, and as back-up files within FLNRORD’s Network Drives.

¹ <https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/pond.pdf>

² https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/wildlife-health/wildlife-health-documents/bc_protocol-amphibian_field_researchers.pdf

3.3 CONSERVATION K9 SURVEILLANCE

In 2020 a Conservation K9 team was retained to trial the efficacy of canines to increase the surveillance capacity of the American bullfrog control program. The canines were trained for detection of bullfrogs in low densities and were most useful in sites considered difficult for traditional visual encounter survey methods. To train the canines, the handler was issued permits to hold two adult bullfrogs in captivity for two weeks for scent profile development. Once the scent profile was developed, the canines were deployed to known bullfrog sites to verify their ability to detect and indicate bullfrog presence as trained. They were then deployed to known negative sites as a control. Once all indication behaviours from the canines were verified by the handler to be accurate, the team was deployed to the Creston Valley for additional validation/training and to begin surveillance. In total, the Conservation K9 team conducted five days of surveillance in the Creston Valley between August 15 and October 4 with promising and useful results being produced by detections and indications from the K9 team. The program intends to expand the use of the Conservation K9 team in the 2021 field season.

3.4 CAPTURE AND EUTHANASIA

Bullfrog capture methods employed in 2020 included electro-frogging (an adapted electrofishing wand), dip netting, hand capturing, minnow trapping, fyke netting, custom-built traps, pit-fall traps, and shooting with airsoft pellet rifles. Each method has an appropriate application based on site, life stage, and survey specific factors. Sites were accessed using canoes, motorized pontoon boat, walking, and wading through potential bullfrog habitat. The preferred method of accessing sites depends on the geography, connectivity of wetlands, and capture method being employed. When using electrofishing equipment, it is preferable to use a canoe as it is best suited for the “tote-method.” On the Kootenay River, a motorized pontoon was used to traverse larger stretches of shoreline. Most non-river sites involve some boat access, while the extensive, complex habitat within wetland areas requires attentive navigation and is often labour intensive.

Where feasible, the perimeter of different types of waterbodies was navigated by boat or walking to locate adult and juvenile bullfrogs using eyeshine from high powered headlamps and flashlights. Once identified, dip nets, hand capture, or use of the electro-frogger wand were used to attempt capture. If using pellet rifles, one person would shoot while the other

spot-lit the target. If capture was successful, bullfrogs were placed in a sealed-lid container containing an anaesthetic emulsion of clove oil.

Euthanasia protocol was in accordance with *guidelines on: the care and use of wildlife* developed by the Canadian Council on Animal Care³. For all captured bullfrogs, capture method, life stage, length, weight, health, and sex were recorded, if known.

3.5 EDUCATION AND OUTREACH

The CKISS Education Program was altered to adapt to pandemic-related restrictions, and the program has pivoted to include many new ‘virtual’ avenues or adapted historic programming. For example, many public events were cancelled where CKISS would host their outreach booth; therefore, CKISS hosted online webinars, created educational videos to post on YouTube, and initiated a citizen science project on iNaturalist to encourage public observations of invasive species. A new “Bullfrogs Unwanted” poster was developed in 2020 and posted at sites throughout the Creston valley.

4.0 Results and Outcomes

4.1 PASSIVE ACOUSTIC SURVEILLANCE

From the nine songmeter installations in the Creston Valley by FLNRORD, over 2,000 hours of acoustic data was collected and run through Kaleidoscope Pro Software. Results were shared between the CVMWA and FLNRORD, who operated and analysed an additional four songmeters in the Wildlife Management Area. One songmeter in the Happy Hunting Grounds on Yaqan Nukiy lands was situated within a known calling group to collect additional bullfrog vocalizations for refinement of the Classifier in Kaleidoscope Pro. No other bullfrog vocalizations were detected by FLNRORD songmeters. The CVWMA songmeters detected one individual bullfrog calling near Corn Creek Marsh (UTM 11U 528509 E 5438792 N) on July 29. Subsequent visual encounter surveys located and captured the calling male on August 5.

³ <http://www.ccac.ca/Documents/Standards/Guidelines/Wildlife.pdf>

4.2 ACTIVE ACOUSTIC SURVEILLANCE

In addition to passive acoustic surveillance, crews conducted 16 active acoustic surveys via 10-minute listening stations throughout the Canyon-Lister Bench on July 15 and 16. This is a large area above the Kootenay River and between the Skimmerhorn mountain range. It is primarily agricultural land and offers potential habitat via agricultural ponds, ditches, and some natural lakes and streams. Crews drove between sites and listened for male bullfrog calling adjacent to potential habitat identified using aerial imagery. No bullfrog calling was detected during these active acoustic surveys.

4.3 VISUAL SURVEILLANCE

Visual surveillance occurred in the Creston Valley from the Canada-US Border at valley bottom as far north as Leach Lake. Twenty-three “sites” have been identified as potential bullfrog habitat. Sites range in geographic extent and are related to access and/or land ownership. The total area subject to visual surveillance is roughly 160 square kilometers. Visual surveillance occurred between May 18 and October 2 and involved two crew members per survey. Three, 2-person crews operated in a near full-time capacity during the field season. Both banks of the Kootenay River were visually surveyed from the north end of Leach Lake (UTM 11U 526558 E 5448025 N) to the Canada-US border (UTM 11U 536322 E 5427579 N).

146 Eyeshine Visual Encounter Surveys (EVES) and 25 Daytime Visual Encounter Surveys (DVES) were conducted in the Creston Valley, for a total survey effort of 171 Visual Encounter Surveys (VES). This resulted in the visual observation of an estimated 263 juvenile and adult bullfrogs, and the successful capture of 170 adults and juveniles. Additionally, one egg mass was detected and removed in the Creston Valley. Uncertainty in visual observations is due to the possibility of double-counting individuals and inconsistency with reporting missed capture attempts in the field.

At Lomond Lake near Nelway, B.C., three EVES resulted in 52 observations and 42 captures of bullfrogs, consisting of 34 adults, seven juveniles, and one tadpole. Additional surveillance occurred once each at Rosebud Lake and Erie Lake to verify bullfrogs had not migrated from Lomond Lake or elsewhere. No bullfrogs were detected at these sites.

4.4 CAPTURE AND EUTHANASIA

4.4.1 Capture

In 2020, the total number of bullfrogs captured in the Creston Valley was 171, comprised of 93 adults, 77 juveniles, and one egg mass. This a significant and promising reduction from 2019 capture numbers. There were zero tadpole or metamorph life stages observed or captured in 2020, indicating breeding or overwinter survival of larval stages did not occur in 2018 or 2019. One egg mass was detected and removed on Yaqaan Nukiy lands on June 29 at UTM 11U 532129 E 5436293 N within the area of a known calling group.

For each captured bullfrog, date, time, surveyor, capture method, and morphometric data was collected, as well as any comments on health. Incidental native herpetofauna observations were also recorded as unique point data. No NLF were observed incidentally in 2020. However, there were numerous observations of other native species, including western painted turtle (*C. picta bellii*), western toad (*Anaxyrus boreas*), Columbia spotted frog (*Rana luteiventris*), chorus frog (*Pseudacris triseriata*), long-toed salamander (*Ambystoma macrodactylum*), and common garter snake (*Thamnophis sirtalis*).

Bullfrog eradication efforts have occurred in the Creston Valley since 2016 (Table 2). In 2018, it became clear that bullfrog had bred in Rykert's Lake with the emergence of metamorphs from that system. Since 2018, landscape-level efforts have increased understanding of the distribution and abundance of bullfrogs throughout the valley with relatively high-degrees of confidence. Peak observations and captures occurred in 2019, with 1,464 captures. The downward trend in population size in 2020 is a promising indication that eradication efforts have been successful in slowing the spread of bullfrogs into critical NLF habitat. In comparing 2019 to 2020 capture numbers from the Creston Valley, adult captures increased while all other age classes decreased (Figure 3). The increase in adult captures is an important observation, as adults pose the greatest risk to further population spread via breeding events. The main source population in Idaho did not receive any control effort in 2020, however maintaining and increasing pressure in Idaho will be an important part of long-term success of this project. Using past capture data for age class and location can inform future efforts in the Creston Valley. Preventing breeding into new or formerly occupied sites will be the primary goal of future efforts. Through multiple years of observations, bullfrogs are now known to be using the Kootenay River as a primary migration corridor from south to north. Finding ways to increase capture rates in the river offers the greatest potential for preventing

population spread. Bullfrogs appear to congregate and move towards areas with warmer water seepage into the river, which acts as a lure for bullfrogs. These locations can be targeted through repeated surveys and with traps.

Table 2. Inter-year bullfrog captures in the Kootenay River Valley – Copeland, Idaho to Creston, B.C.

Year	Adult	Juvenile	Metamorph	Tadpole	Egg Mass	Total
2016	5	0	0	0	0	5
2017	14	2	0	0	0	16
2018	7	173	238	36	0	454
2019	181	517	251	515	0	1,464
2020	93	77	0	0	1	171
					Total Captures	2,117

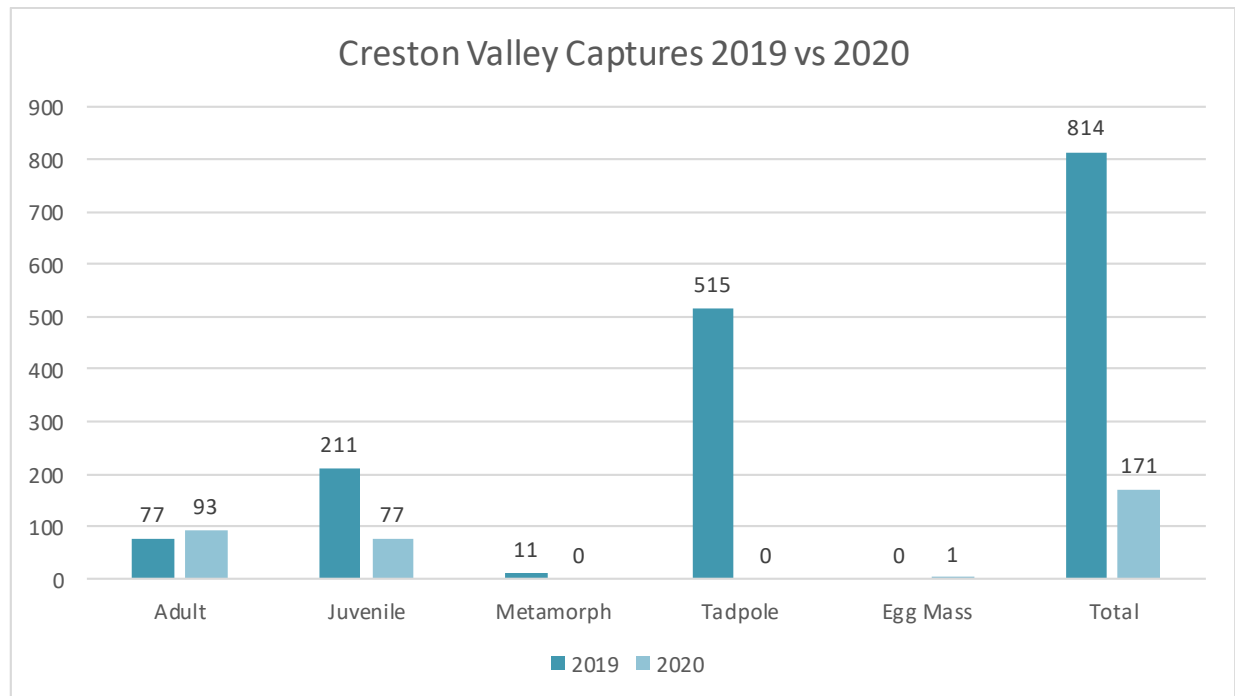


Figure 3. Comparison of American bullfrog captures in the Creston Valley, B.C., 2019 - 2020.

4.4.2 Euthanasia

170 bullfrogs were euthanized in accordance with Canadian Council on Animal Care guidelines. Most were euthanized using an emulsion of pure clove oil and water, which is a strong anaesthetic for amphibians and eventually leads to mortality. After each shift, frogs that had been placed in clove-oil emulsion were transported to a location with deep-freezer space. Deep anaesthesia was insured before placement in freezers. A subset of larger adult captures were euthanized without clove-oil emulsion to allow for the opportunity to explore the food value of bullfrog legs. All bullfrogs euthanized manually were properly processed and thoroughly cooked to ensure food safety.

4.5 CAPTURE METHODS

The Kootenay-Boundary American Bullfrog program utilizes numerous capture methods deemed safe and appropriate by the American Bullfrog Action Team. Capture methods vary depending on age class, survey method, and site-specific conditions (Figure 4). For adult captures, primary methods include dip netting, hand capturing, and electro-frogging. Pellet rifles also are used by trained crew members. For juvenile and metamorph life-stages, dip netting and hand capturing are the main methods of capture. For tadpoles, baited minnow traps have proven to be most effective. Other passive capture methods used include fyke nets, pit-fall traps, and custom-built “mega traps”.

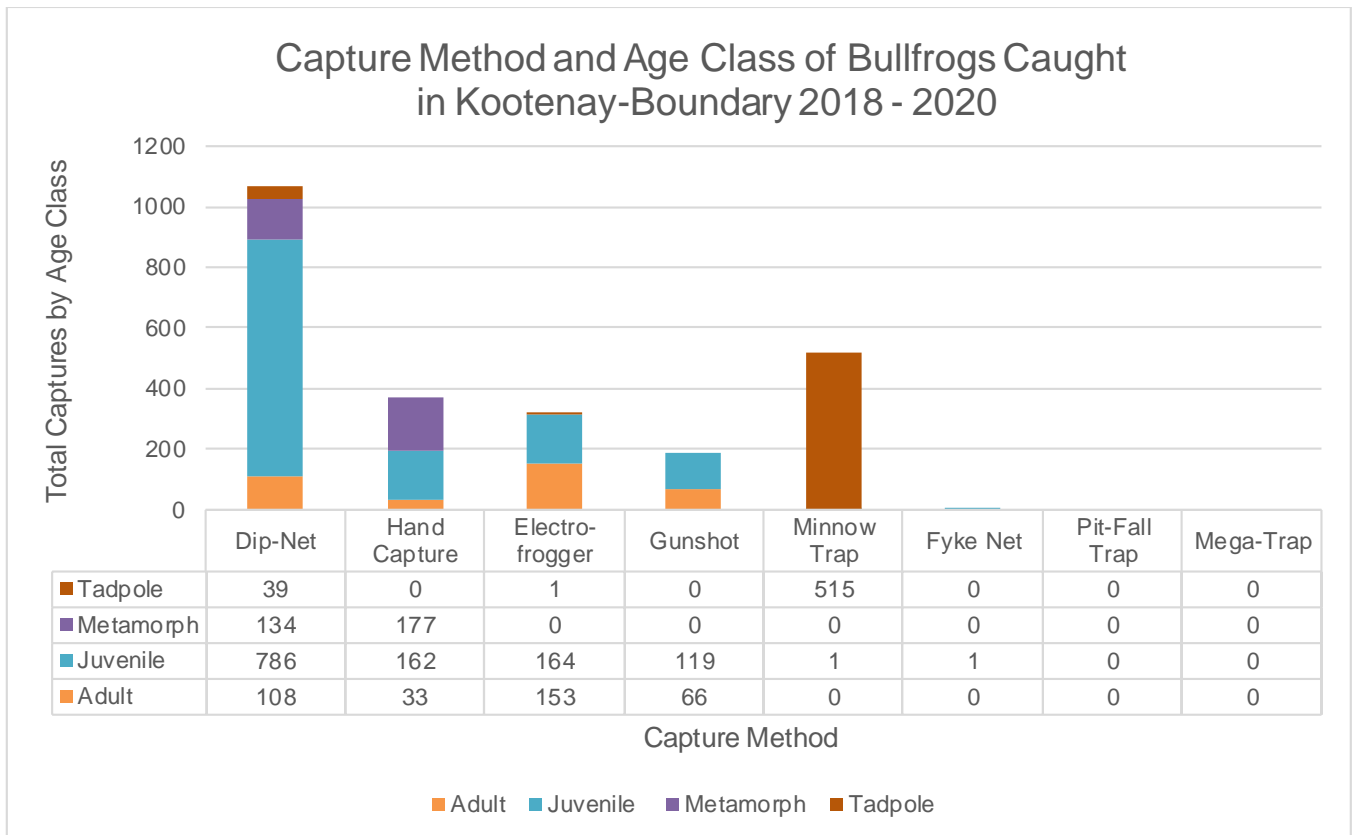


Figure 4. American bullfrog captures by method and age class, Kootenay-Boundary Region, 2018 - 2020.

4.5.1 Active Capture

Generally, active capture has proven to be the most effective for bullfrog control. Individual capture of non-tadpole life stages, although labour intensive, has consistently achieved effective catch rates. In 2020, crews refined their dip-netting skills, and found the benefits of this lighter, simpler, and more agile method to increase their catch rates, compared to the previously dominant method of electro-frogging. The electro-frogger requires specific training and certification to safely operate but utilizes electricity to stun the target from up to one metre away, which can increase catch-rates for skittish individuals. Generally, the electro-frogger works best on adults. Successful capture using any active capture method usually requires a team member skilled in operating a canoe or motorized boat. All methods have advantages and disadvantages, and method selection is often guided by preference and skill level of the technician.

4.5.2 Passive Capture

Minnow trapping has proven effective for tadpole life stage capture in shallow, ephemeral wetland sites. In deeper ponds, these traps have not produced effective catch rates. Fyke nets have not produced effective catch rates for bullfrogs, despite significant adjustments to deployment methods and site selections. Pit-fall traps are effective at capturing metamorph life stages in certain locations where directional fencing can be installed. Adult bullfrogs are likely able to escape most pit-fall traps given their strong ability to jump vertically. Trap-door style pit-fall traps have been trialed, and refinements to this method are planned to occur in 2021 at Rykerts Lake. The custom-built “mega traps” were adapted from successful traps designed by the Washington State Department of Fish and Wildlife. These traps were designed to capture invasive African clawed frogs (*Xenopus laevis*) and had American bullfrog by-catch in pond systems where they were deployed (Richard Vissar, personal communication, June 2020) These traps will be refined and re-deployed in 2021 to improve efficacy.

4.6 EFFORT AND CATCH RATE

There were 171 EVES conducted between May 18 and October 2, 2020 in the Creston Valley. Fifty-nine surveys (34%) captured bullfrogs. Of the 25 DVES conducted, only one survey captured bullfrogs. One VES usually included two crew members, but occasionally involved up to six personnel in 2020. EVES are significantly more effective, as eyeshine illumination during darkness allows crews to overcome the cryptic and camouflage nature of bullfrogs. DVES generally are used to survey an area for habitat quality and quantity, as well as to assess hazards and access. Effort was spread across 19 sites, and 160 square kilometres in the Creston Valley. Initially, effort was focused to areas that formerly had high bullfrog density and/or were breeding sites. With additional crew capacity in the 2020 field season, coverage of surveillance increased across the entire valley, evident by the increase of sites visited and surveys conducted from 2019 (Table 3). In 2020, additional crew capacity also increased the ability to maintain a consistent effort in the Kootenay River, especially close to the border where a significant source population of bullfrogs enters the Creston Valley from Idaho. Known sites of bullfrog occurrence were consistently surveyed, with a strong focus on the Yaqaan Nukiy Happy Hunting Grounds area. One calling group was detected, with the successful removal of numerous adults and one egg mass.

Table 3. American bullfrog catch rate by site, Creston Valley, B.C., 2020.

Site ID	Surveys at Site	Surveys w/ Bullfrogs Caught	Catch Rate at Site
Browne Burrow Pit	3	0	0%
Corn Creek Marsh	2	1	50%
Corn Creek Slough/Outflow	5	0	0%
Dale Marsh	18	7	39%
Dodd's Creek	1	0	0%
Fredericks Farm	2	0	0%
French Slough	10	1	10%
Glaser Creek	2	0	0%
Kootenay River	22	16	73%
Leach Lake	2	0	0%
LKB 1/South End	31	17	55%
LKB2/Kupi Bay	1	1	100%
LKB3/HHG South	4	1	25%
LKB4/HHG	44	9	20%
Nicks' Island Pond	1	0	0%
Reclamation Rd. Ditch	10	1	10%
Rykerts Lake	12	3	12%
Summit Creek Marsh	4	0	0%
Swan Rd. Ditch	6	2	33%

Between years, effort increased, while capture rate decreased in 2020 (Table 4). This is a promising indication of population reduction in the Creston Valley as increased effort with reduced capture rates infers a lower population density. The distribution of effort across sites cannot be maintained for statistically useful catch per unit effort in an EDRR framework. Rather, effort is directed to areas with known bullfrog occurrence to maximize eradication potential. However, sufficient human resources provided capacity for extensive surveillance in addition to eradication, which increased confidence in density and distribution of bullfrogs across the landscape. This information will guide the 2021 field season.

Table 4. Comparison of effort and survey catch rate of American bullfrog, Kootenay River Valley, 2018 – 2020.

Year	Sites Surveyed	Total Surveys	Surveys w/ Bullfrogs Caught	% of Surveys w/ Bullfrogs Caught
2018	7	67	20	30%
2019	15	94	43	45%
2020	19	171	59	34%

4.6.1 Trends by Site

Using sites with consistent effort between years provides important information related to efficacy of the treatment at the site, as well as potential future population trends. Rykerts Lake has had the most consistent effort between years (Figure 6), while the Happy Hunting Grounds was an area of extensive survey effort in both 2019 and 2020 (Figure 7). Results in both sites indicate that through consistent pressure to remove all life stages, the opportunities for population establishment and growth are limited. With ongoing surveillance and eradication at Rykerts Lake, no new breeding events have occurred at least since 2017. It appears, with the lack of emerging tadpoles from the Happy Hunting Grounds that breeding was prevented in 2019. Addressing the emergence of a population of tadpoles requires immense effort, so preventing breeding is essential to maintaining a viable and efficient control program.

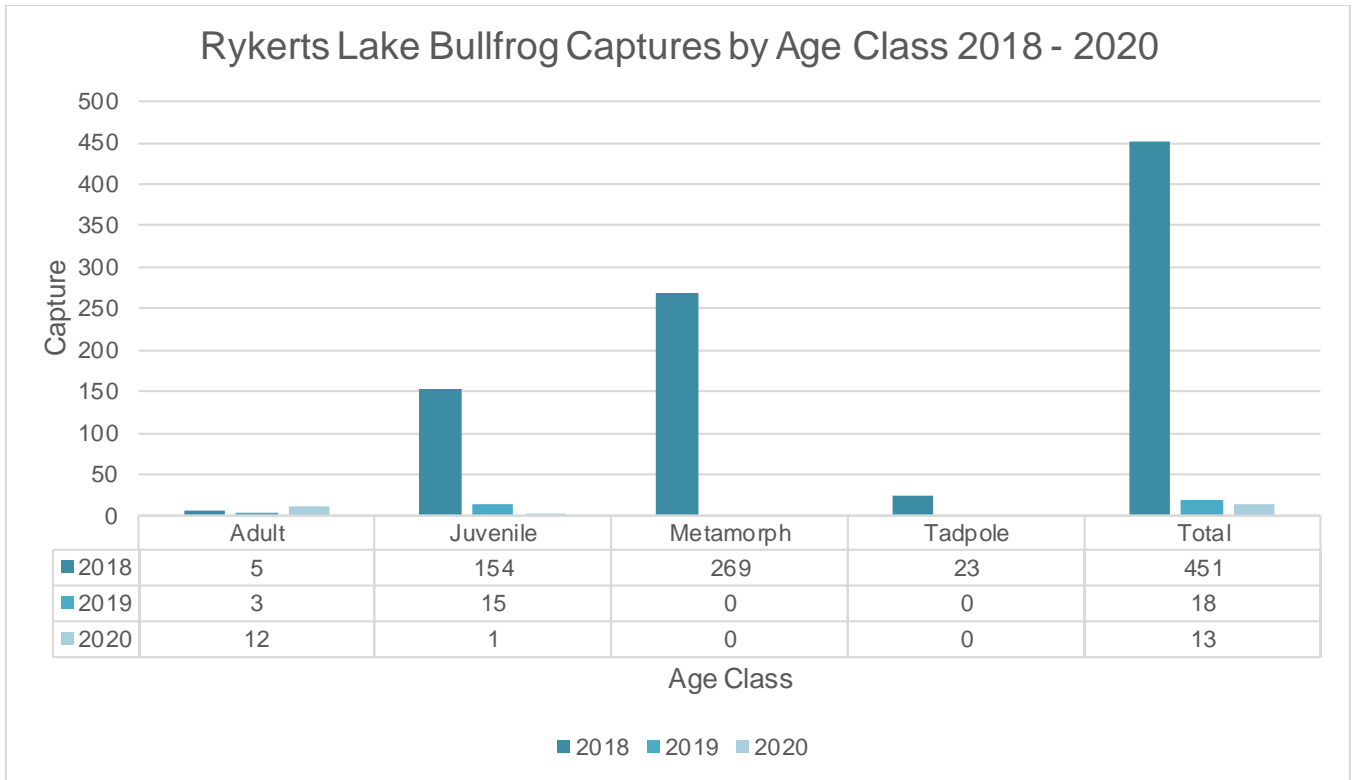


Figure 5. Comparison of American bullfrog captures by age class at Rykerts Lake, B.C., 2018 - 2020.

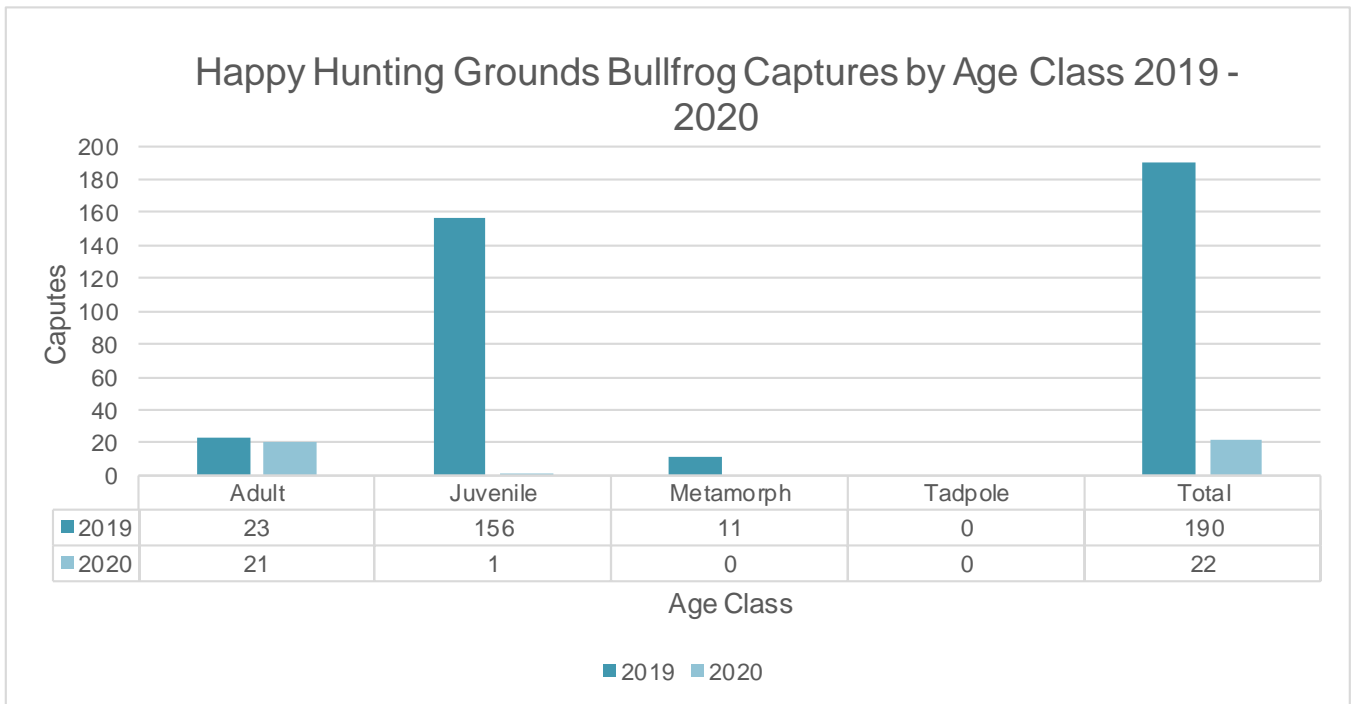


Figure 6. Comparison of American bullfrog captures by age class at Happy Hunting Grounds, in the Creston Valley, B.C., 2019 - 2020.

4.7 EDUCATION AND OUTREACH

Under COVID-19 restrictions, many annually attended in-person events were cancelled so the CKISS Education Program shifted its focus to either virtual offerings or smaller in-person events that adhered to public health guidelines (Table 5). Additionally, CKISS promoted Don't Let it Loose campaign messaging and bullfrog awareness through traditional and social media platforms (Table 6).

Table 5. Education and outreach activities delivered by the Central Kootenay Invasive Species Society for American bullfrog awareness, 2020.

Activity Type	Activity Number	No. of people reached
Presentation	4	151
Restoration / Native Planting Event	2	57
Youth Field Trip	3	90
Outreach Booth	5	198
Webinar	1	111
Don't Let it Loose and American bullfrog related resources distributed = 571		

Table 6. Media activities delivered by the Central Kootenay Invasive Species Society for American bullfrog awareness, 2020.

Media Platform	Number of Posts/Spots	Likes/Views/Hits/Followers/Subscribers
Facebook	9	572 like CKISS page, Posts reached 976 people
Instagram	3	495
Twitter	1	123 followers
Website Blogs	3	33, 875 visits
CKISS n'Tell E-newsletter	2	823 subscribers
Radio Interview	1	est. 200,000
Online Article	1	unknown

5.0 Discussion

It is generally understood that landscape level eradication of bullfrogs, once established, is logistically and financially prohibitive (Govindarajulu, 2004). However, when extirpation of native species is extremely likely without intervention, the importance and motivation to invest in controlling this highly invasive species only increases. Preserving northern leopard frog habitat and maintaining the potential of this critically endangered species to recover is what motivates this multi-partner, transboundary program to maximize efficiency and efficacy of available resources. Maintaining control effort is the only possible method of ensuring northern leopard frog recovery in the face of American bullfrog threats. The fragility of northern leopard frog combined with the voracity and high fecundity of the American bullfrog (Orchard, 2011) would certainly result in degraded northern leopard frog critical habitat.

Inter-year data analysis indicates the current suite of methods and actions (Guillera-Arroita, Hauser, & McCarthy, 2014) being taken to address the American bullfrog incursion into the Creston Valley are effectively reducing the existing bullfrog population. The lessons learned from 2020 and the previous set of years can inform future efforts. However, it is imperative that the battles won due to prior effort are not lost by the failure to prevent bullfrogs from replenishing habitats from which they have been removed (Govindarajulu, 2016). Continued surveillance and capture in former breeding sites and on the Kootenay River, as well as areas with low-resistance pathways into extensive wetland, lake, or riparian habitats can assist in prevention of breeding events.

Understanding bullfrog migration patterns from the Kootenay River or the Boundary Smith Creek Wildlife Management Area and intercepting them prior to colonization of wetlands in Creston is the most effective and efficient way to maintain the results of previous efforts (Kamath, Sepulveda, & Layhee, 2016; Orchard, 2011; Peterson, Richgels, Johnson, & McKenzie, 2013). The Kootenay River has been identified as the primary vector for bullfrog migration from northern Idaho into B.C.; therefore, capturing bullfrogs in the river will have a disproportionate benefit to preventing establishment of new populations. It will be critical to maintain capture and surveillance effort in the Kootenay River for the following years.

Pursuing increased involvement from Idaho Fish and Game, especially within the Boundary Smith Creek Wildlife Management Area, is also critically important for the long-term success

of this program. Tackling high density, source populations of bullfrog migration into the Creston Valley will be an integral component of the long-term viability of all native herpetofauna species in Creston, and especially that of the northern leopard frog.

6.0 Recommendations

To date, 2,117 bullfrogs have been removed from the Kootenay River Valley, with peak observations and captures occurring in 2019. An eleven-kilometre buffer remains between known bullfrog occurrence and northern leopard frog critical habitat. With continued collaboration and allocation of resources, this important project which preserves the quality and quantity of northern leopard frog and other native herpetofauna habitat, may be able to fully eradicate bullfrogs from sites formerly occupied. However, sustained effort and transboundary collaboration is essential for the long-term potential of success. Without continued pressure, bullfrog will certainly establish and continue to migrate northwards, via the flow of the Kootenay River. A long-term and strategic approach to bullfrog eradication in the Kootenay River Valley will be necessary to achieve the end goal of preventing bullfrog invasion into the core habitat of the critically endangered northern leopard frog, and the completion of a Kootenay-Boundary American bullfrog risk assessment will assist with future management decisions of this species.

Program success will require the continued review of efficacy of detection and capture techniques and adaptation of operational plans accordingly. Additionally, applying novel methods and maintaining a creative lens when approaching management challenges will allow the program to remain agile and its members ready to respond to emerging situations. Investing in tools such as the Conservation K9 team is one such action. Expansion of the Conservation K9 team component of the program as a consistent and effective tool for EDRR protocols in potential bullfrog habitat is recommended. Additional improvements to detection and capture efforts could include the development of telemetry for tracking bullfrog movement from USA into Canada, and improving passive capture methodology through use of lures, baits, and attractants.

The control of American bullfrog is a cross-border issue, as such it is imperative to continue to build new and maintain existing partnerships with agencies and organizations that have

the shared goal of bullfrog eradication. Cross-border partnership activities that will facilitate the goal of bullfrog eradication should include increased surveillance and capture pressure in the Kootenay River, and supporting Idaho Fish and Game in their efforts to control bullfrogs.

7.0 Multi-Year Project Review

7.1 SUMMARY OF RESULTS TO DATE

7.1.1 Management

- Development of a Kootenay-Boundary early detection and rapid response plan, the purpose of which is to provide detailed direction on the decisions and actions required to prevent, detect, evaluate, and respond to incursions of the invasive American bullfrog;
- Creation of the multi right/stakeholder, collaborative American Bullfrog Action Team
- Developed strong partnerships with essential agencies and organizations, such as, but not limited to, Ktunaxa Nation Council/Lower Kootenay Band, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife;
- Coordinated funding between Canadian and US partners; and,
- Funding secured for appointment of dedicated program coordinator.

7.1.2 Operations

- 2,117 bullfrogs euthanized;
- Utilization of proven capture methods and testing of new approaches for capture;
- Development and revision of priority areas for bullfrog detection and capture as required to ensure most effective effort;
- Implementation of the Kootenay-Boundary American Bullfrog Early Detection-Rapid Response Plan;
- Conservation K9 team trained for detection of bullfrogs in low densities where visual survey methods are more challenging; and,
- Between years, effort increased, while capture rate decreased in 2020. This is a

promising indication of population reduction in the Creston Valley.

7.1.3 Education-Outreach

- Preserved and utilized bullfrog specimens for educational purposes; and
- Delivered bullfrog and Don't Let it Loose information at over 140 education-outreach events, and through 138 traditional and social media spots/posts.

7.2 PROGRAM SUCCESS

- 2,117 bullfrogs of all age and sex classes euthanized;
- Discovery and subsequent implementation of new, successful capture techniques (e.g. hand capture of very young metamorphs);
- Yaqan Nukiy/Lower Kootenay Band field team instrumental in locating new bullfrog sites in complex, interconnected wetlands;
- Bullfrog detections through passive techniques such as songmeters and environmental DNA; and,
- Extensive and comprehensive education and outreach campaign, including development and delivery of a "Frog Watch" citizen science program, and the creation of a public reporting telephone hotline and email address.

7.3 PROGRAM CHALLENGES

- Field crew capacity is an ongoing challenge for this program - even with two full time crew in 2020 (largest on-the-ground effort to date), increased capacity could be utilized during peak months of breeding activity when bullfrogs are at their most detectable. Additionally, increased capacity to run daytime crew(s), who would search for and remove bullfrog egg masses, would aid in the overall success of the program;
- Complex, interconnected wetlands with minimal boat access increase the challenge of visually detecting and capturing bullfrogs; and,
- Spatial and temporal distribution of bullfrogs within the Creston Valley has exceeded anticipation in all years except one (2020). As such, work planning, coordination, equipment allocation, and site prioritization within each season is a challenge.

7.4 LESSONS LEARNED

- The early detection of bullfrogs on private properties requires additional effort; as such, we have learned that continued outreach to local residents is needed to help improve early detection potential; and,
- Following the first four years of monitoring and control efforts, bullfrog occurrence was found to be more widespread throughout the Creston Valley than anticipated, which led to the realization that the program required a coordinator dedicated strictly to project management.

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 - Northern Leopard Frog Recovery Team
 - Idaho Department of Fish and Game
 - Washington Department of Fish and Wildlife
 - Ministry of Environment
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- Doug Sutcliffe, Creston Dyking District

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- Habitat Stewardship Program for Species at Risk
- Environment Canada – Environmental Damages Fund

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