The Northern Red-legged frog (*Rana aurora*) at the Millard Learning Center

A habitat assessment, monitoring protocol and a strategy for bullfrog prevention

Created for the Galiano Conservancy Association

ES 471/ER 412
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1.0 Introduction

For our project, we focused on amphibian habitat present on the property where the Millard Learning Center is situated. Galiano Island is a unique area to study amphibians as it is home to a provincially blue-listed species, the Northern Red-legged Frog (*Rana aurora),* and has not yet faced the threat of the invasive American Bullfrog (*Rana catesbeiana).* Our aim is to provide the Galiano Conservancy with a protocol and monitoring plan for collecting data on presence and population of *R. aurora* on this site, since no information is known thus far. Furthermore, the study area allows for a comparison of the differences between a constructed and naturally occurring breeding habitat. Both locations have the potential to house populations of *R. aurora;* however, we wanted to understand if differences in vegetation and annual water levels affected *R. aurora's* preference for breeding habitat. The aim of our study was to not only understand the viability of habitat at each location, but to provide the Conservancy with an annual monitoring protocol to confirm the presence and possible population fluctuations of *R. aurora.* This will be vital to ensure the ecosystem remains healthy and capable of supporting this sensitive species while it is under the constant threat of climate change and possible bullfrog invasions throughout its range. Additionally, we encourage monitoring of invasive plant species on site to determine if they have an effect on the breeding habit use of *R. aurora*. In conclusion, we hope to provide the Conservancy with an understanding of the unique source of refuge they provide to sensitive animal species like *R. aurora* and to encourage the conservation, monitoring and possible restoration of this habitat in the future.

2.0 Goals

1. Assess two wetland areas of the Millard Learning Center property for suitable amphibian habitat
2. Provide a user-friendly protocol annual monitoring plan with a focus on *R. aurora's* population health and density
3. Encourage preservation and restoration of identified suitable habitat for *R. aurora*
4. Create opportunities to document the presence of other amphibians inhabiting the wetlands
5. Provide the conservancy with a bullfrog prevention strategy
6. Encourage people to engage with and get excited about amphibians!

3.0 The Northern Red-legged Frog

3.1 Range

The Northern Red-legged Frog (*Rana aurora)* is present along the northwest coast of Canada and the United States, with approximately 35% of its range in Canada (COSEWIC, 2015; Figure 1). Over 50% of Canada's *R. aurora* inhabit Vancouver Island while other populations are present on the mainland of British Columbia, Haida Gwaii, and on several of the Gulf Islands (COSEWIC, 2015). The species is typically found at elevations below 500m but have been found as high as 1040m (COSEWIC, 2015). It is known that *R. aurora* exists on Galiano Island; therefore, it is likely on the Millard Learning Center property.

Figure 1. The known range of *R. aurora* stretches from the west coast of British Columbia to the northwest coast of California. (IUCN, 2008)

3.2 Habitat

The habitat of *R. aurora* consists of both aquatic and terrestrial components. The species depends on both wetland and forested habitats to support its different life stages (B.C. Ministry of Environment, 2018). During the breeding season (typically beginning late February or early March and lasts for 2-4 weeks), *R. aurora* spends most of its time in wetland areas consisting of intricate assemblages of vegetation including sedges, grasses, rushes, and some shrubs (B.C. Ministry of Environment, 2018). This vegetation is used for egg-mass attachment and is used further by tadpoles as cover from sunlight and predators (B.C. Ministry of Environment, 2018). The species has been found frequently in dense, partially submerged forest vegetation adjacent to wetlands (Ostergaard, 2001). R. aurora use permanent and temporary bodies of water; however temporary wetlands serve as a more viable site for *R. aurora* to breed, as risk of predation by fish is eliminated and water temperature may be warmer for faster incubation and larval development (B.C. Ministry of Environment, 2018). Their terrestrial habitat must provide a cool, moist environment and consist of relatively thick vegetation for cover. Woody debris is also vital for survival on land (B.C. Ministry of Environment, 2018). Both the natural wetland area and the constructed pond on the Millard Learning Center property have the potential to provide important breeding habitat for *R. aurora* and we assume the natural wetland will have greater long-term viability because it dries seasonally.

3.3 Identification

The eggmass of *R. aurora* can be identified by size and structure. When first laid, the mass is spherical in shape, gelatinous and flexible, becoming looser as the embryos grow (Hallock & McAllister, 2009). As it loosens, the mass may detach from vegetation and float to the surface (Hallock & McAllister, 2009). The egg-mass is originally 10-20 cm in diameter while each egg itself is 3mm in diameter, not including the gelatinous exterior (COSEWIC, 2015). A typical egg-mass is depicted in Figure 2.

Figure 2. Egg-mass of *R. aurora* in Vedder Creek, BC. Photo taken by Kristiina Ovaska. (COSEWIC, 2015)

As tadpoles, *R. aurora* ranges in color from tan to green-brown covered in gold specks and has a light pink underbelly (COSEWIC, 2015). Its tail is quite short in comparison to its body while its dorsal ridge is relatively tall (COSEWIC, 2015). In both its tadpole and adult stage, the eyes of *R. aurora* point outward as opposed to upwards which is an important identification feature when compared to morphologically-similar species (Maxcy, 2004). When first hatched, tadpoles are typically around 12mm in length and grow to nearly 30mm by the time metamorphosis begins (Brown, 1975). *R. aurora* in its tadpole stage can be seen in Figure 3.

Figure 3. Tadpole of *R. aurora* (lateral view) in Vedder Creek, BC. Photo taken by Kristiina Ovaska. (COSEWIC, 2015)

In *R. aurora's* adult life stage, it ranges in length from 50-70mm (COSEWIC, 2015). Males have been found up to 100mm and females up to 136mm (Altig & Dumas, 1972). Adult frogs appear mostly brown with black specks on their backs and often have a black marking from their nostril, through their eye and down to their mouth. A light line is present below this on the upper part of the lip (COSEWIC, 2015). The name of the Northern Red-legged Frog is attributed to the red-color of its hind legs (COSEWIC, 2015); however, the intensity of the red color is highly dependent on genetics and location of the species (Altig & Dumas, 1972). *R. aurora's* groin is speckled with yellow and black and there is a somewhat prominent ridge on each side of its back (Altig & Dumas, 1972). Additionally, it has relatively large legs when compared to other members of the *Ranidae* family (Altig & Dumas, 1972). *R. aurora* in its adult life stage can be seen in Figure 4.

Figure 4. *R. aurora* adult on Galiano Island, BC. Photo taken by Kevin Toomer (iNaturalist.ca, 2018)

3.4 Breeding Biology/Physiology

In their juvenile stage (1-2 years for males and 2-4 years for females), *R. aurora* will remain in forested areas before reaching sexual maturity and returning to the aquatic environment to breed (COSEWIC, 2015). When breeding occurs from late winter to early spring, the sexually mature individuals travel to and remain in the aquatic sites for 2-4 weeks (COSEWIC, 2015). A hydrophone is required to hear the mating call of the male *R. aurora* which will begin during this time. The ideal water temperature for egg-laying is 6-7 degrees Celsius, although eggs will still incubate if this fluctuates after being laid (COSEWIC, 2015). The threshold temperatures for survival of the egg-mass are from 4-21 degrees Celsius (Licht, 1971 as cited in COSEWIC 2015). *R. aurora* are not known to survive freezing temperatures and will spend winter months at the bottom of ponds or the forest floor (COSEWIC, 2015).

3.5 Importance

Monitoring amphibian populations is central to understanding the overall health of wetland ecosystems. Amphibians are sensitive to many aspects of the surrounding environment including UV radiation, climate change, pollution, and pathogens, making them a valuable tool for understanding fluctuating ecosystem health (MacDonald, 2002). Additionally, amphibians contribute largely to energy and nutrient cycles as they are predators of insects and other invertebrates and serve as a prey item for other wetland inhabitants. As their habitat shifts annually between aquatic and terrestrial, they act as a nutrient transporter between the two areas (COSEWIC, 2002).

R. aurora are of special importance on Galiano Island as they can be found in areas that are protected from direct habitat degradation as is the case on the Millard Learning Center property; however, they continue to face an array of external threats and must be monitored to ensure their populations do not decline to unsustainable levels. The habitat provided within the Learning Center property has the potential to support a thriving population of *R. aurora* and provides a unique opportunity to preserve and possibly enhance habitat within the area to safeguard abundant populations. In the long-term, we hope that the natural wetland may serve as a breeding ground for a source population if translocations/reintroductions of the species become necessary. The species is blue-listed under provincial legislation and is under continuous threat of population decline (COSEWIC, 2015). Threats to the *R. aurora* population on Galiano Island include climate change, habitat destruction and bullfrog invasion. Since this valuable habitat is already protected and bullfrogs have not yet been detected, it is important that the habitat be monitored consistently to detect any early population fluctuations.

4.0 Initial Habitat Assessment

4.1 Study Area

The study areas on the Millard Learning Center property were chosen to compare the viability of a natural habitat to that of a constructed habitat. We aimed to determine the differences in breeding habitat suitability and habitat preference, with an emphasis on vegetation characteristics. Figure 5 displays the two study areas with the natural wetland at the north end of the property and the constructed pond near the south.

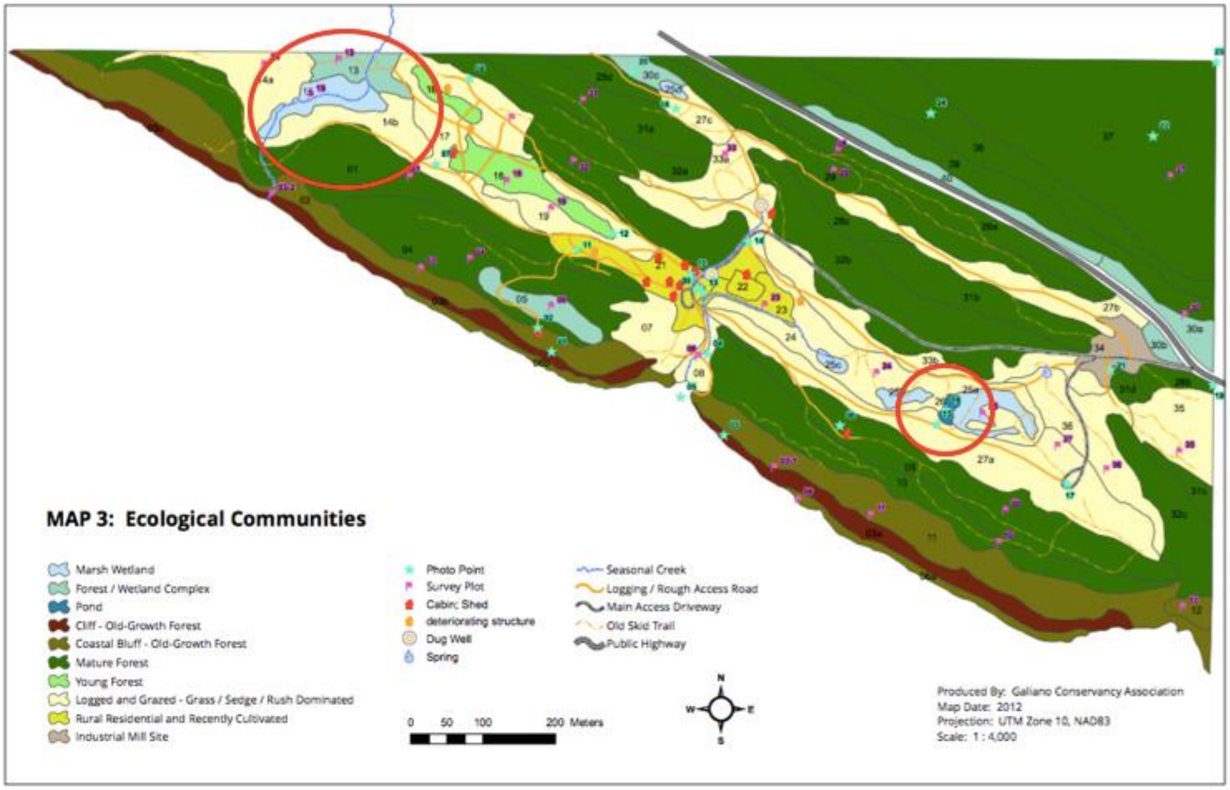

Figure 5. The Millard Learning Center Property. Red circles (not included in original map, added by Jessica Duncan) indicate the two study areas. The natural wetland lies on the northwest edge while the constructed pond habitat lies in the southeast section of the property. (Galiano Conservancy Association, 2012)

Our initial habitat assessment suggests that the natural wetland is an optimal breeding site for *R. aurora.* The wetland consists largely of native vegetation with an adjacent wet-forest, providing desirable habitat for both the aquatic and terrestrial life stages of *R. aurora* (see Figure 6). As the assessment was carried out in August, we were unable to determine the duration of water inundation throughout the seasons nor the average temperature monthly. For this reason, we suggest that a water level and temperature monitoring system is implemented and measurements are recorded on a monthly basis. Since breeding depends largely on water levels and temperature, this monitoring strategy will indicate what areas of the wetland and at what time of year *R. aurora* is likely to breed here.

Figure 6. The natural wetland and adjacent wet forest on the Millard Learning Center property. Photograph taken by Maria Catanzaro.

The constructed pond has the potential to support a population of *R. aurora* (Figure 7). The surrounding vegetation consists largely of native cattail (*Typha latifoli*) which may act as a viable support for the deposition of egg-masses; however, there is an extensive amount of invasive plant species in adjacent areas which may pose a problem for *R. aurora* oviposition habitat if permitted to spread throughout the shoreline. An egg-mass survey will help address this concern by demonstrating what vegetation is preferred while allowing further action to be taken if invasive species prove problematic.

Figure 7: The constructed pond on the Millard Learning Center property. Photograph taken by Maria Catanzaro.

4.2 Vegetation Composition of Natural Wetland

The natural wetland at the northern end of the property has a great abundance of native species (see Table 1). Sitka sedge (*Carex sitchensis)* are the most prolific species at the natural wetland and are concentrated in the areas where there would be standing water or water-saturated soil during most of the year. At the slightly higher elevations and surrounding edges of the wetland there is suitable habitat for *R. aurora's* terrestrial life-stages (B.C. Ministry of Environment, 2018). As Table 2 demonstrates, there are many plant species present that create suitable habitat for *R. aurora*. The tree species that are in the area are at all life stages, including saplings, mature trees and an abundance of decaying logs on the ground. Decaying logs are important for *R. aurora* habitat because of the moist, dark environment that they provide (Pers. comm. Green, 2018). The only invasive species noted on this site was reed canary grass (*Phalaris canariensis*). This species was present in clusters at a few locations near the southern west end of the wetland (Table 3).

Table 1. Dominant species present of the natural wetland, located on Millard Learning Center property, Galiano Conservancy Association, August 2018

Trees	**Shrubs/ Ferns**	**Grasses/Sedges**	**Aquatic**
Western Red Cedar *(Thuja plicata)*	Salal (*Gaultheria shallon)*	Hard Stemmed Bulrush *(Scirpus Iactustris)*	Skunk Cabbage *(Lysochiton americanus)*
Douglas Fir *(Pseudotsuga menziesii)*	Nootka Rose *(Rosa nutkana)*	Giant Horsetail *(Equisetum telmatiea)*	Sitka Sedge *(Carex sitchensis)*
Red Alder *(Alnus Rubra)*	Bracken Fern *(Pteridium aquilinum)*	Reed Canary Grass *(Phalaris canariensis)*	
	Sword Fern *(Polystichum munitum)*	Common Rush *(Juncus effusus)*	
	Trailing Blackberry *(Rubus Ursinus)*	Bull Thistle *(Cirsium vulgare)*	
		Various other grass species	

4.3 Vegetation Composition of the Constructed Pond

The constructed pond, northwest of the Millard Learning Center building, is composed of different species in comparison to the natural wetland (see Table 2). Due to the pond being spring fed, it has standing water all year which allows for common cattail (*Typha latifolia)* to thrive along the bank's edge. The composition of plant species at the constructed pond site is interesting as a different species dominates each part of the surrounding area. For example, reed canary grass (*Phalaris canariensis)* dominates the east side of the pond. There is a large, dead tree fallen across the ground at the Western edge and an abundance of coarse woody debris. At the north side of the pond there is an abundance of giant horsetail (*Equisetum telmatiea)* and some larger, more established trees. The north side also consisted of many young Western red cedar (*Thuja plicata*) saplings. On the west side of the pond there appears to be a slightly higher elevation, which allows for the establishment of cedar saplings and blackberries (*Rubus ursinus* and *Rubus armeniacus*). Along the south side of the pond was a mixture of *P. canariensis* and bull thistle (*Cirsium vulgare*) that were interrupted by the presence of a dead fallen tree. The presence of these dead trees is important as they provide protective cover for adult-stage *R. aurora* in a highly impacted area.

Table 2. Vegetation assessment of the constructed pond at Millard Learning Center property, Galiano Conservancy Association, August 2018.

Trees	**Shrubs/ Ferns**	**Grasses/Sedges**	**Flower/Forbes**	**Aquatic**
Western Red Cedar *(Thuja plicata)*	Salal (*Gaultheria shallon)*	Hard Stemmed Bulrush *(Scirpus Iactustris)*	Foxglove *(Digitalis purpurea L.)*	Common Cattail *(Typha latifolia)*
Douglas Fir *(Pseudotsuga menziesii)*	Nootka Rose *(Rosa nutkana)*	Giant Horsetail *(Equisetum telmatiea)*		
Red Alder *(Alnus Rubra)*	Bracken Fern *(Pteridium aquilinum)*	Reed Canary Grass *(Phalaris canariensis)*		
	Sword Fern *(Polystichum munitum)*	Common Rush *(Juncus effusus)*		
	Trailing Blackberry *(Rubus Ursinus)*	Bull Thistle *(Cirsium vulgare)*		
	Himalayan Blackberry *(Rubus armeniacus)*	Creeping Spike Rush *(Eleocharis palustris)*		
		Large Awned Sedge *(Carex macrochaeta)*		
		Various other grass species		

4.4 Comparison of the two habitats

The species present at each site have some similarities; however, the two sites present different habitats that *R. aurora* can use for breeding. The moist forest environment adjacent to both sites provides habitat for the terrestrial life-stage. The natural wetland is a much larger area and has a greater amount of suitable terrestrial environment. This allows for competition for habitat space and prey resources to be reduced. In the natural wetland there is no standing water during the driest months of the year, while the constructed pond has standing water all year. This could provide more consistent egg laying habitat for the frogs; however, the pond is a smaller area that is closer to the Millard Learning Center. This could increase competition for habitat and cause stress to *R. aurora* due to the closer presence of humans. While this is a preliminary comparison between the two habitats, future monitoring can help determine which habitat has a greater concentration of frogs present and can provide insight into which of the two sites are preferred.

4.5 Invasive Species Removal and Monitoring

At the natural wetland, there are eight isolated clusters of *P. canariensis* (Table 3). *P. canariensis* has the potential of encroaching on, and outcompeting, the native sedge cover. The amount of *P. canariensis* per cluster at present is not at a high enough concentration to be a serious threat to the biodiversity of the ecosystem; however, there is potential for this species to spread quite rapidly (Adams & Galatowitsch, 2005). We recommend that this species is further monitored and, if necessary, removed in the years following this initial assessment. It is important that monitoring continues annually after the initial species removal to prevent the possible return of this invasive species. Monitoring can be done simultaneously with the amphibian monitoring to apply resources in that area more efficiently and minimize habitat disturbance. It is crucial to keep this natural wetland as an uncompromised habitat for *R. aurora* as it has the potential to safeguard this vulnerable species against a variety of external threats.

Another species that should be monitored is the yellow flag iris (*Iris pseudacorus).* This plant species is present elsewhere on the property and has the potential to spread to these ecosystems. This species is difficult to remove as it spreads through the rhizomes of the plant (Pojar, MacKinnon 2004). The danger of this species is its potential to encroach on the native species in the area, consequently replacing open water areas leading to a decrease in habitat diversity and suitable breeding grounds for *R. aurora*.

Table 3. Location of the invasive reed canary grass clusters at the northern natural wetland, Galiano Conservancy Association, August 2018.

Reed Canary Grass	**UTM Coordinates**
Cluster #1	0465731E 5419572N
Cluster #2	0464650E 5420113N
Cluster #3	0464654E 5420115N
Cluster #4	0464655E 5420115N
Cluster #5	0464880E 5420183N
Cluster #6	0464835E 5420041N
Cluster #7	0464823E 5420043N
Cluster #8	0464848E 5420045N

5.0 Northern Red-legged Frog Survey Protocol

5.1 Annual Inventory and Monitoring Protocol

Our aim is to obtain a detailed inventory of *R. aurora* on The Millard Learning Center property, and to help provide high quality monitoring and comparison over time. We recommend the following protocol yearly to monitor *R. aurora* and to detect changes and identify trends over time (Rombough 2012).

5.2 Water Depth and Quality Assessment

The process should begin in the fall with the placing of water depth marker sticks at various spots at each site along the shore, which can help provide data on water depth throughout the year (see figure 7). Water depth marker sticks can be used in areas based on vegetation at each site. This will allow for variance of topography (e.g., some higher areas can be seen by spotting patches of ferns within the wetland which may indicate higher ground). We will consult with professionals to ensure the most appropriate placement. Starting in October, water depth can be checked on a monthly basis. This will help us gain a better understanding of how long there is standing water at the seasonal wetland and provide monitoring for water level fluctuations occurring due to climate change.

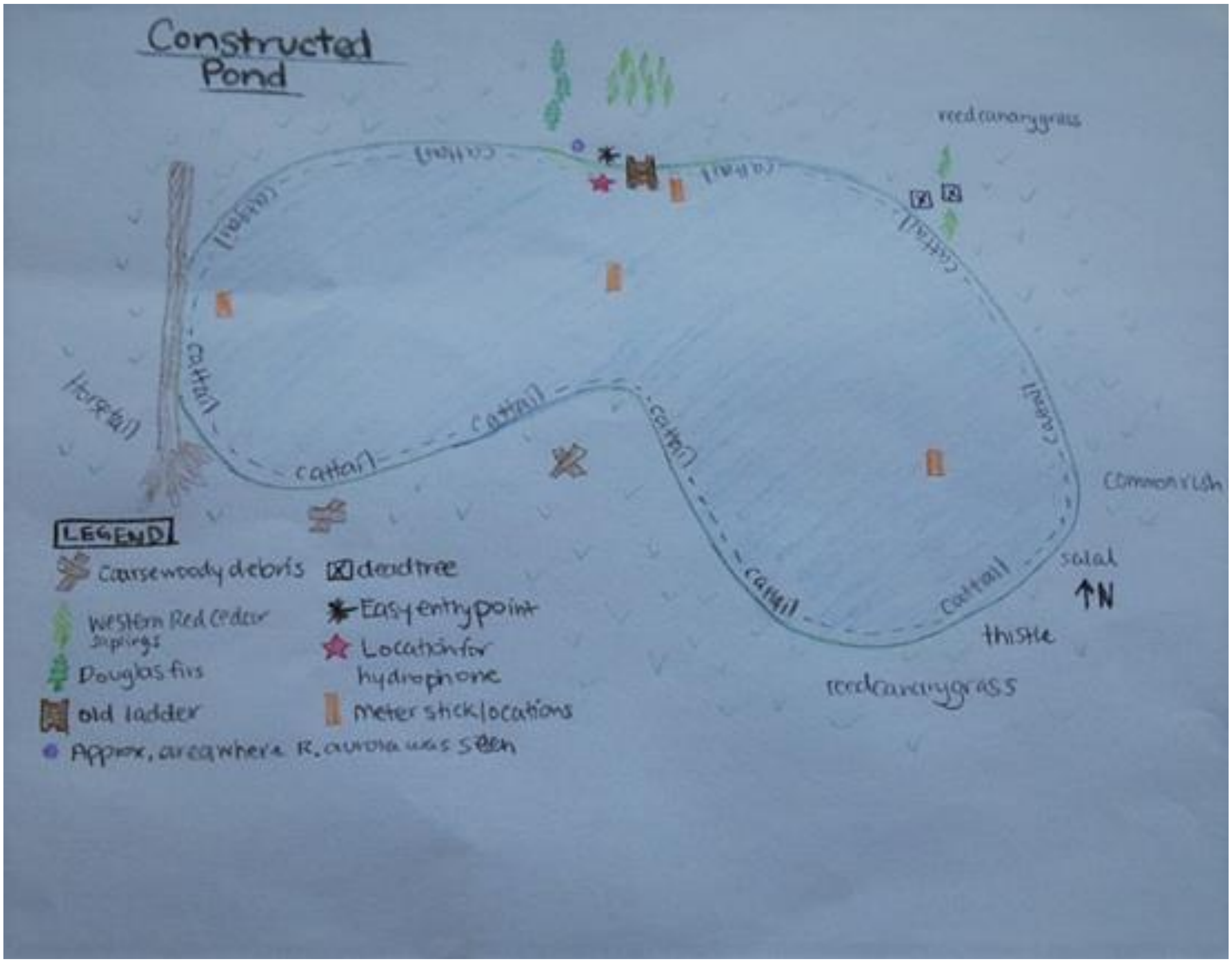

Figure 8. Hand drawn map of the constructed pond drawn by Maria Catanzaro highlighting key vegetation and locations for monitoring.

Water quality should be tested to determine the health of these sites. Several elements should be assessed, including pH, heavy metal concentrations, phosphorus levels, nitrogen levels, dissolved oxygen levels, water temperature, and oxygen saturation level. This would take place monthly for the first year and once per season for ongoing monitoring.

5.3 Call Survey Protocol

The next step would be to conduct call surveys at both sites to detect habitat use during the breeding season. Any on-site employee, such as from the Food Forest or Native Forage Forest,can help with this step and can be trained in the proper protocol. Starting at the beginning of January, an employee or volunteer will take water temperature at the same time each day, either using a Kestrel device (cite make/model) or other handheld meter, or a standing, permanent thermometer at each site. In the third week of January, the surveyor should begin call surveys to detect the arrival of breeding males. Call surveys should be conducted between 30 minutes after sunset and early morning, which is the peak calling period of *R.aurora*. To listen for the presence of *R. aurora*, the surveyor must place a hydrophone (Dolphinear) into the water at each site. This should be repeated every few days until the calls are heard. Water temperature should continue to be taken until eggs begin to be laid. This will provide valuable information for the next stage of egg mass inventory, since eggs are laid once the water hits 6-7 degrees Celsius. There will be specific sites laid out that provide ease of entry to monitor the water temperature and to insert the hydrophone. The same location at each site will be used each time to minimize habitat disturbance.

5.4 Egg-mass Survey Protocol

Egg-mass surveys can be used as an indication of species presence, breeding success, and population density or abundance. Crouch and Paton (2000) determined that egg-mass counts are indicative of the number of breeding female and male wood frogs (*Rana sylvatica).* Similarly, breeding females of *R. aurora* lay one egg mass per breeding season allowing the breeding population density to be estimated by multiplying egg-mass count by 2 to account for males (B.C. Ministry of Environment, 2015). It is believed that the ratio of females to males is nearly equal in this species (cite). This type of survey will provide baseline data into the population density or abundance, vegetation preference for oviposition, and habitat preference of *R. aurora* on the Millard Learning Center property.

We suggest surveying the sites at the egg-mass stage as this is the most detectable life stage for *R. aurora* (Rombough, 2012). A site visit is recommended to gain a more detailed understanding of the area and topography. It is important to conduct surveys at times of maximum light penetration (Rombough, 2012). Figure 9 shows an example of how egg masses can be hidden and more difficult to find. Rombough (2012) advises surveying in early morning to early afternoon, on clear days or days with high overcast, and avoiding wind and rain, for best visibility. It is not recommended to assess when the sun is at a low angle. Photographs should be taken of egg-masses without changing its natural shape and proportion; the most important aspects are allowing the mass to freely float as is, whilst collecting information on the shape, size, location (surrounding habitat) and position (Rombough, 2012). Fill flash will help reduce glare from the water's surface (Rombough, 2012). It is critical that researchers thoroughly study the difference between species egg-masses and how to properly identify them.

As they age, frog egg masses often become distorted (*left*) or covered with silt (*right*) and can be hard to identify.
Photos of northern red-legged frog (*Rana aurora*) egg masses.

Figure 9. *R. aurora* egg masses that may be more difficult to identify. (Rombough, 2012).

The first day for data collection on egg-masses should occur one month after the first calls are detected, and again every two weeks until the end of March (or April if the breeding season is delayed by cold temperatures). Three groups of two can survey the sections of the seasonal marsh wetland (see Figure 10 for sections). The entire area should be observed at each site. A visual inventory of egg masses will take place, following the stated protocol for each occurrence. Only two individuals are needed to examine the constructed pond site, as its size is more manageable. A kayak or rowboat will be used to examine the deeper areas of the site, while the shallow edges will be completed on foot. Hip or chest waders may be required. One surveyor will record data while the other completes the inventory.

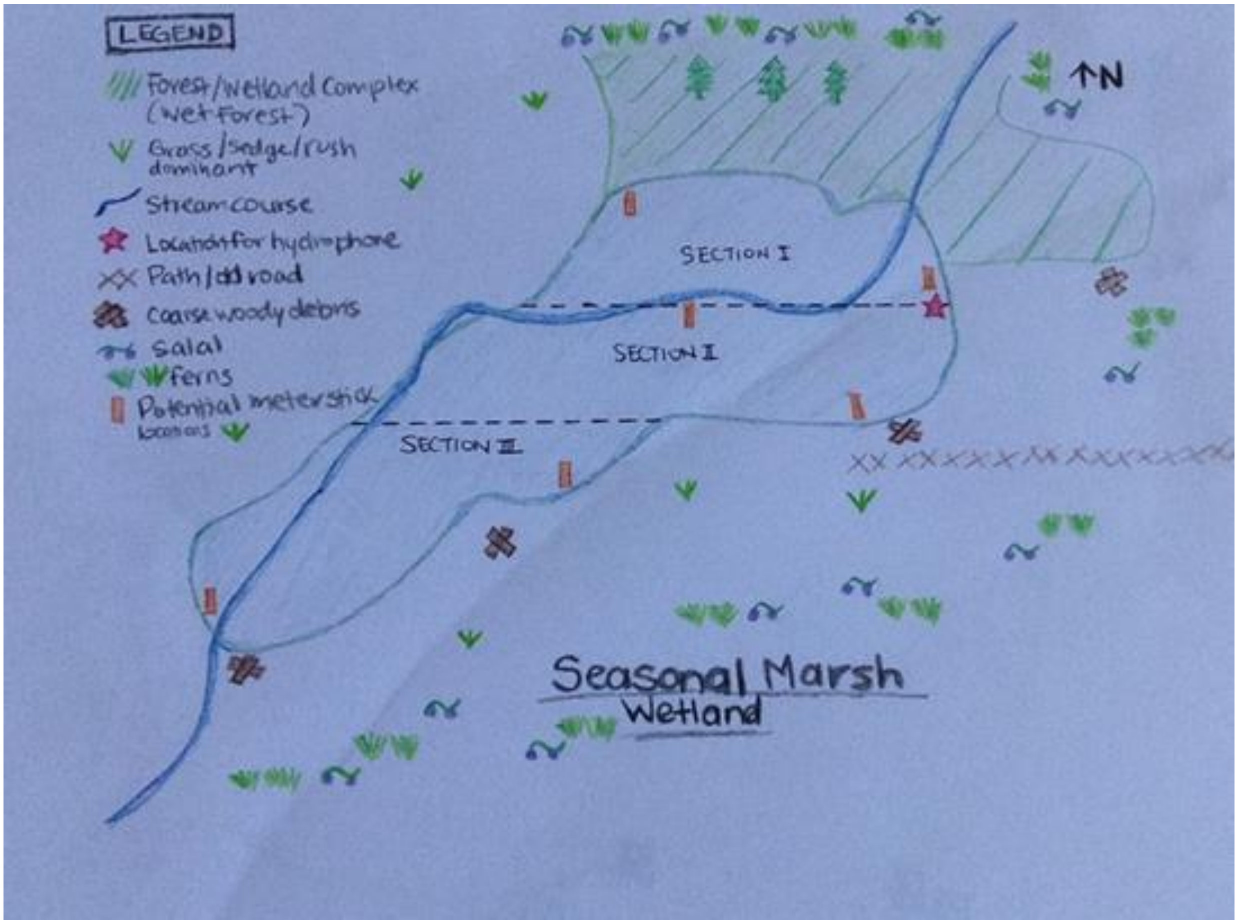

Figure 10. Hand drawn map of the natural wetland (seasonal marsh) drawn by Maria Catanzaro highlighting vegetation, inventory/monitoring sections and locations for hydrophone and meter stick placements.

Once data is collected, it should be organized to determine a count of total egg masses, the most common vegetation preference, areas of high egg masses density, and average water depth where they were found. Data can then be compared between sites and presented to the Galiano Conservancy Association, discussed with interested individuals, such as researchers at the University of Victoria, and sent in excel file format to bcfrogwatch@victoria1.gov.bc.ca.

Important Considerations

- ✓ To start, examine areas with shallow edges with high vegetation coverage, areas bordered by woods, areas where frogs were heard calling with hydrophone and ranging from around four inches to two feet deep (Rombough 2012).
- ✓ Walk, wade, or paddle slowly to reduce disturbance of water and visibility (Rombough 2012).

- ✓ Pay close attention to areas adjacent to suitable terrestrial habitat
- ✓ Pay close attention to emergent vegetation that can hold egg masses

5.5 Task checklist and equipment needed

General checklist for each day:

- Take water temperature prior to surveying for egg masses
- Take a photo of the wetland from the same spot each day that data is collected. This will illustrate environmental conditions. Take a photo that represents the average conditions of the surveying area (Rombough 2012).
- Put together a summary of where egg masses were found based on location of wetland (see Map for separate zones). This may provide an overview of where most egg masses have been found and what areas are likely preferred/closest to their most desired habitat locations.
- Take photos of any sites where egg masses are found in abundance (of typical sites that most egg masses have been found to visually assess habitat).
- Collect data on egg masses found, including those that are not *R. aurora*. Record GPS coordinates and take a photo of each occurrence.
- Save field notes and data to hard drive after each field day.
- Download photos and save to hard drive after each field day.
- Dry out field equipment and clothing.

Checklist for each egg mass occurrence:

1) Document each egg mass by taking photograph and marking GPS coordinates
2) Measure the size of the egg mass, which can provide a rough estimation of number of eggs per mass. Use ruler to do this and calculate depending on shape
3) Take a photo of each egg mass found, number it for later reference, and include photo numbers on data sheet
4) Note the shape of the egg mass
5) Note if egg mass is attached to vegetation or free floating – free floating may indicate a different species. If unsure, gently move vegetation to assess
6) Mark down what depth they occur at

7) Fill out entire data form (see Appendix A and attached excel file in email; Rombough, 2012), including weather data using a Kestrel 3500 Series Pocket Wind Meter

Table 4. Equipment for egg mass inventory field work

Equipment required • Test surface water (6-7 degrees for egg laying) (Kestrel?) • Waders (hip or chest, depending on depth) • Water quality kit (DO meter, pH kit, etc.). • Small boat depending on water depth (canoe, kayak or rowboat) • Data sheet/rite in the rain notebook • Pencils • GPS (plus a spare; spare batteries) • Compass • Camera • Digital thermometer • Plastic ruler • Measuring tape • Map of sites • Field guide for plants • Images of egg masses for helping with identification
Equipment - Optional • Flagging tape • First Aid kit • Phone • Food/water • Polarized sunglasses

6.0 Bullfrog Risk and Prevention

6.1 Potential Risk of Invasion

By now, most Southwestern BC residents have heard about the American bullfrog (*Rana catesbeiana*) and their detrimental invasive tendencies. Native to eastern North America, *R. catesbeiana* was introduced by humans in BC during the early part of the 20th century in attempt to farm frog's legs (B.C. Ministry of Environment, 2018). *R. catesbeiana* pose incredibly high risk for native species of amphibians, especially those listed at risk such as *R. aurora*. *R. catesbeiana* have a voracious appetite and eat any prey they can fit in their mouth, causing a threat of both competition for resources with native species as well as predation on native species (Ficetola et al., 2007). All life-stages of *R. aurora* are vulnerable to predation by *R. catesbeiana* as *R. catesbeiana* tadpoles are known to predate on native amphibian tadpoles and other larval stages (Kiesecker and Blaustein, 1998). The presence of *R. catesbeiana* has been shown to cause stress and avoidance behaviour in *R. aurora* tadpoles, who will alter their microhabitat use by moving into deeper water more frequently and unintentionally allowing *R. catesbeiana* to establish along wetland exteriors (Kiesecker and Blaustein, 1998). As if that wasn't enough, *R. catesbeiana* in Victoria have been found to have much higher parasite species richness than their conspecifics in Eastern Canada and the United States (Dar and Forbes, 2013). *R. catesbeiana* is classified as invasive for all these reasons coupled with the fact that it has no natural predators in western North America, allowing for rapid population growth and spread (Roach, 2004). A species spreading its range so quickly gives native amphibians no chance to defend themselves, as any detection or avoidance of *R. catesbeiana* by native frogs in BC is learned behaviour, not inherited (Murray et al., 2004).

R. catesbeiana need permanent standing water to survive as their larval stage lasts 1-3 years. Likelihood of *R. catesbeiana* occurrence can be loosely predicted by percent of permanent standing water, distance from original introduction site and wetland connectivity (Murray et al., 2015). At the Millard Learning Centre property, we observed that the natural wetland at the northern end of the property had completely dried by August, making it incapable of supporting *R. catesbeiana*. The only bodies of water that threaten to house *R. catesbeiana* are the constructed pond below the forage forest and the reservoir feeding the food forest, which, to our knowledge, contain year-round standing water. Galiano is distinctive in the region for the fact that no bullfrogs have been detected or reported on the island to date, though they have been detected on Pender Island and Salt Spring Island to the south (Heiman, 2006). Since we know *R.*

aurora is present on Galiano Island in relative abundance (one was spotted at the constructed pond on the Millard Learning Center property during the week of our course), it is important to act in the prevention of *R. catesbeiana* to preserve the native population. If it is found that *R. aurora* preferentially inhabits the natural wetland on site, we suggest that the conservancy continue to preserve this crucial habitat as it remains seasonally disconnected from areas of standing water. This puts the area at low risk of invasion by *R. catesbeiana* in the drier months; however, it is important to monitor for the presence of bullfrogs in the wetland area in wetter months as *R. catesbeina* can traverse to other areas if consistent moisture is available.

6.2 Recognition of R. catesbeiana

The first step in preventing *R. catesbeiana* is reliable recognition and identification of the species by Galiano visitors and residents alike. Surveys cannot be conducted consistently and thoroughly over the whole island due to time, money and countless other constraints. Casual and reliable monitoring by residents and visitors in their everyday lives is essential to the prevention of invasive species like *R. catesbeiana,* whose populations can often be controlled with early detection. *R. catesbeiana* is much bigger than *R. aurora* as an adult as *R. aurora* is usually 7-10 cm in length while *R. catesbeiana* can reach 20 cm, not including its legs (B.C. Ministry of Environment, 2018); however, they can be tricky to differentiate as tadpoles or juveniles (Figure 11 & 12).

Figure 11. Comparison of an *R. aurora and an R. catesbeiana* juvenile in Monroe, WA. (Alderleaf Wilderness College, 2010)

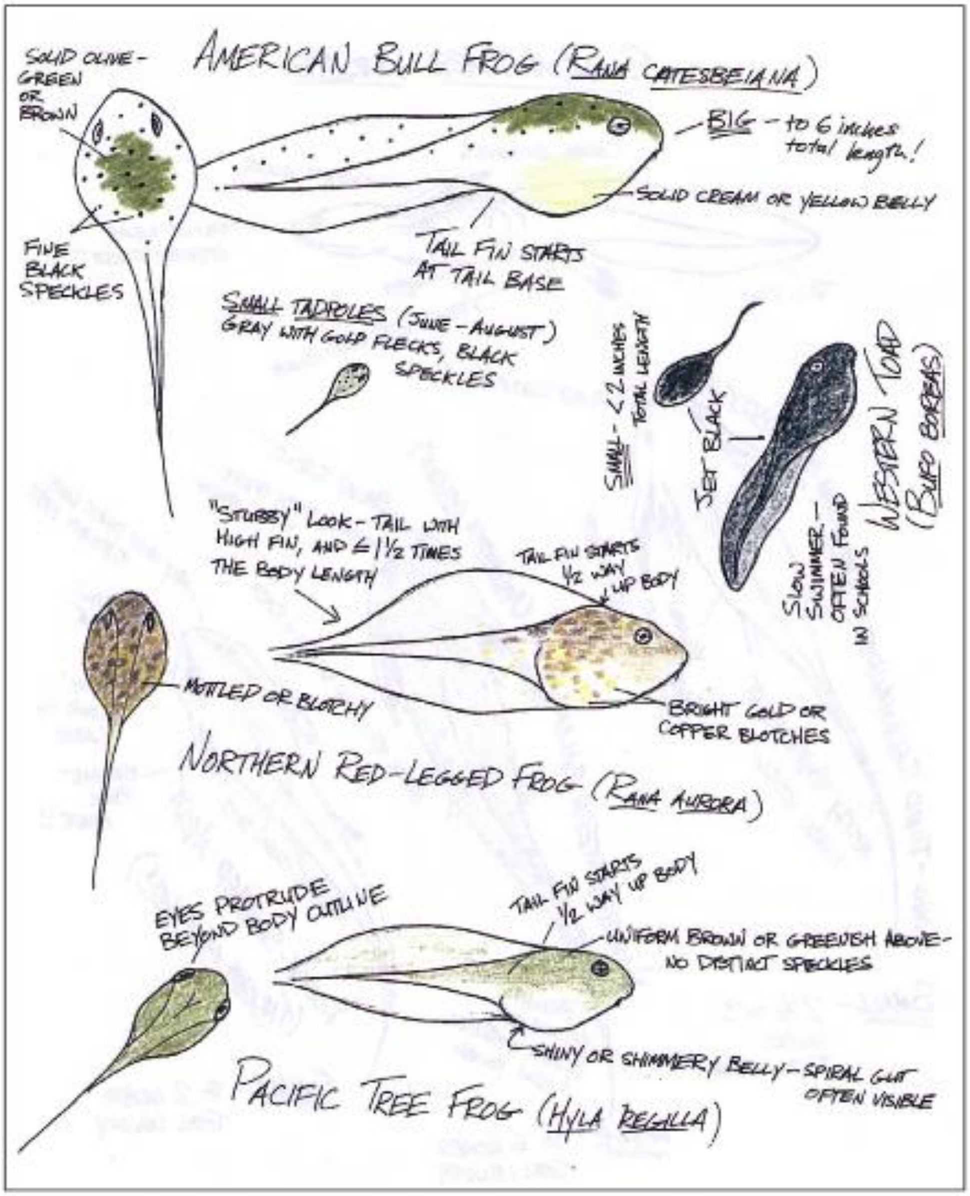

Figure 12. Drawing highlighting key visual differences in tadpoles of *R. aurora*, *R. catesbeiana* and Pacific Tree Frogs (Rombough, 2012)

Besides colouring, which can be elusive, there are a few key features to note. *R. aurora* (figure 9, pictured on the left) have two ridges reaching from eye to rump, which *R. catesbeiana* lacks. *R. catesbeiana* eyes are placed more on top of the head than *R. aurora*: seen from above, the eyeballs of *R. catesbeiana* would be visible where *R. aurora*'s eyes are covered by their eyelids. As adults, *R. catesbeiana* have a large tympanum (ear) behind and below their eye which can distinguish them further (B.C. Ministry of Environment, 2018).

6.3 Prevention Suggestions

The most effective way for the general public to combat *R. catesbeiana* invasion is to recognize the species reliably and report findings. Reporting sightings to local organizations such as Bullfrogcontrol.com in Victoria and iNaturalist and government initiatives such as BC Frog Watch through the BC Ministry of Environment, Lands and Climate Change Strategy can help experts identify spread and invasion risk in different parts of BC. Should the conservancy want to take action against *R. catesbeiana* and actively protect *R. aurora*, we suggest two measures:

1. **Surveillance**

   R. catesbeiana spreads quickly due to its lack of natural predators and its own predatory and competitive behaviour, but their long larval life stage makes it possible to detect them early with regular surveillance. Studies have shown that the presence of both larval and adult *R. catesbeiana* has a disproportionately large stress effect on *R. aurora* than either life stage individually (Kiesecker and Blaustein, 1998). Regular surveillance of the wetlands of the Millard Learning Centre, with special attention to the constructed pond and reservoir with year-round standing water, for *R. catesbeiana* adults, juveniles, tadpoles and egg masses is essential to prevention.

   Ideally, one would monitor all watercourses and areas that have year-long standing water on the entire Island. Residents would be informed of this surveillance procedure and encouraged to report sightings to the Galiano Conservancy and/or the previously listed organizations immediately. A one-page informational sheet can be created and distributed to help inform residents on how to identify bullfrogs at all life stages and should include the Conservancy's phone number. The same educational sheet can be used as posters. We also suggest outreach to the community of Galiano to make them aware of potential risk of *R. catesbeiana* to the Island's permanent standing water and slow moving streams, and the importance of reporting any findings to the appropriate organizations.

   R. catesbeiana cannot transport themselves across bodies of saltwater, yet they are found away from the mainland on Vancouver Island, Salt Spring Island and a few other Gulf Islands. This is almost certainly due to human facilitated spread, such as children catching and keeping frogs and frogs and tadpoles being transported on boats which have entered their habitat before perhaps boarding a ferry or transitioning into saltwater. After all, *R. catesbeiana* was originally introduced to British Columbia by farmers who wished to produce frog legs for consumption. Placing informational posters on bullfrogs at the ferry terminals and on ferries connecting Galiano Island to the mainland and neighboring islands, and at freshwater lakes and public boat launches, will help this process and also educate the public on the importance of early detection. An example poster from Parks Canada is included as a potential reference (Figure 13).

Figure 13. Example poster of distinguishing features of *Rana catesbeiana* issued by Parks Canada. Photo provided by fellow student, Christophe Boyer.

2. Protection of the natural wetland

As previously mentioned, *R. catesbeiana* needs permanent standing water and pond connectivity to establish and be successful. Upon visual assessment in August 2018, we believe the natural wetland would be both the best habitat for *R. aurora* on the property and the least likely patch for successful *R. catesbeiana* invasion. This would depend on water levels throughout the year, which we have suggested be monitored for a better understanding of what time of year the wetlands are drying. This will help with determining the suitability of the habitat for *R. aurora* and for long term monitoring of changes in the water table due to climate change and other determining factors of landscape changes.

7.0 Other Risks

Other than the previously mentioned risks, agricultural development poses a slight risk for the health of the wetland. The natural wetland is located along the property line, adjacent to land which is designated for agriculture use. Agricultural land use is not guaranteed to negatively affect the wetland; however, it should be thought about carefully. We suggest the Galiano Conservancy retain connections with the adjacent landowners, perhaps voicing concerns about potential land use changes and the protection of *R. aurora*, as they arise.

8.0 Further Research and Concluding Statements

We hope to further understand population dynamics of not only *R. aurora* but of other amphibians that inhabit the Millard Learning Centre property. Other species that we expect to find are the Pacific Chorus Frog (*Pseudacris regilla),* Rough-skinned Newt (*Taricha granulosa),* Northwestern Salamander (*Ambystoma gracile),* and the Long-toed Salamander (*Ambystoma macrodactylum),* as they have been seen elsewhere on Galiano Island (iNaturalist, 2018). We will determine if these species are present by installing cover boards in future years. Cover boards are harmless, passive survey structures that can be placed in areas of suitable, potential habitat and left to be checked on a weekly, monthly, or seasonal basis. Depending on the design of cover board placement, this can provide data on species presence, directionality of movement, and habitat preferences. We would also like to incorporate inviting schools to come visit and partake in the cover board research, in hopes to encourage children to become more engaged and interested in amphibians.

Since *R. catesbeiana* is such a quick-spreading species, prevention is of the utmost importance. As conservationists are experiencing, detecting the species often means invasion has already occurred and it may be too late. Galiano is unique in that no *R. catesbeiana* have been detected on the island, and with public outreach and education the Island could be one of few safe havens (and potential future breeding grounds) for *R. aurora*.

With these two habitats under the Galiano Conservancy Association's protection, the conservation and monitoring of *R. aurora* populations can be achieved by following the protocols we describe. Through the protection of habitat and the monitoring of populations of *R. aurora*, the Galiano Conservancy Association can help provide a site for *R. aurora* and other native amphibians to thrive.

R. aurora Inventory at the Millard Learning Center — Page __ of __

Date:	Start time:	End time:	Project surveyors:	Site photo taken: Yes
				Photo #:

Cloud cover			
Clear	*Cloud cover <50%*	*Cloud cover >50%*	*100% Unbroken clouds*

Wind speed	Kestrel:					
None	*Leaves move slightly*	*Leaves rustle but not twigs*	*Leaves and twigs move constantly*	*Small branches move, dust rises*	*Small trees sway*	*branches move, wind*

Air Temp (°C):	Water Temp	Preceding 24 hr	Current Precipitation:			
None	Foggy *Reduced visibility, like a cloud*	Misty Drizzle *No distinct rain drops but can dampen clothing*	Drizzle *Fine rain drops (<0.5mm diameter), visible on ground*	Light Rain *Puddles not forming quickly, <2.5 mm rain per hour.*	Hard Rain *Puddles form quickly, >2.5 mm rain per hour*	Snow

Site Name (SW=seasonal wetland, P= constructed pond)	UTM Zone	Easting	Northing	Species ID	What vegetation is it attached to?	Water depth	Was it freefloating? Y/N	Size of egg mass in cm	Photo taken? Y/N	Comments (other notes on site observations and specific observation)

Appendix A. *R. aurora* data collection sheet (please see attached excel file for complete file). Ideas taken from Rombough (2012) and https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/wildlife-wildlife-habitat/amphibians-reptiles-and-turtles/call-survey-protocol-and-datasheet-oct312014.pdf

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