Technical Report & Restoration Plan for Iona Beach Regional Park

Report prepared by

Laura Newberry, WildResearch Field Technician, M.Sc. student

Report reviewed by

Azim Shariff, WildResearch Program Manager

Courtney Lahue, WildResearch Director at Large

Andrew Huang, WildResearch Program Manager & Director at Large

Myles Lamont, WildResearch Director at Large

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Acknowledgements

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2 Project Overview

This project was conducted from May 1 to August 20, 2017 in Iona Beach Regional Park (IBRP) located in Richmond, B.C. Two (2) studies were conducted during this time:

1. A biological inventory on the wildlife and vegetation within IBRP.
2. A Master of Science (MSc) thesis for British Columbia Institute of British Columbia (BCIT) and Simon Fraser University (SFU) focusing on the effects of vegetation diversity and complexity on North American breeding bird behaviour in IBRP, with the objective of developing a Himalayan blackberry (*Rubus armeniacus*) management plan.

The purpose of the biological inventory study was to generate an understanding of the biotic community within IBRP. Using the collected baseline data, the MSc thesis aims to determine the best-suited restoration strategies to manage invasive plants in IBRP, while promoting and enhancing bird habitat usage and avian biodiversity.

Surveys were conducted in IBRP between June and August 2017 to document vegetation and wildlife species, including amphibians, reptiles, breeding birds, owls, bats, and small mammals (see Appendix Table 1 for details). One of the main stressors in IBRP is the abundance of invasive vegetation, specifically Himalayan blackberry. The restoration plan found in this report is designed to remove Himalayan blackberry while causing the least amount of interference and stress to wildlife that use the park.

Key findings:

- In areas dominated by Himalayan blackberry, species richness of native plants was dramatically lower than in areas with low Himalayan blackberry percent coverage.
- Preliminary results from mist-net surveys show that overall, breeding birds did not discriminate between using habitat largely dominated by Himalayan blackberry and by other native vegetation. However, behaviour observation surveys suggest that native plants were more heavily used by breeding birds than non-native plants.
- At least one, potentially two, federally-listed species at risk bats were detected in the woodlot area: little brown myotis (*Myotis lucifugus*) and big brown myotis (*Eptesicus fuscus*).
- In addition to breeding songbirds, IBRP was also used by a variety of other wildlife species, including both natives and non-natives such as American bullfrog (*Lithobates catesbeianus*), green frog (*Rana clamitans*), garter snake (*Thamnophis sirtalis*), Townsend's vole (*Microtus townsendii*), deer mouse (*Peromyscus maniculatus*), and red-eared slider (*Trachemys scripta*).

3 Site Assessment

3.1 Overview

The study site is located in the northeast corner of IBRP and is approximately 9.2 ha in size (Figure 1). IBRP is a designated recreational area and a popular wildlife viewing spot. The study site lies within a sensitive wildlife area designated by Metro Vancouver (MV). The park is managed by Metro Vancouver and has six main stakeholders: Vancouver International Airport (YVR), Iona Island Wastewater Treatment Plant (IIWTP), Iona Island Bird Observatory (IIBO), Musqueam First Nation Band, MV, and park visitors (R. Worcester, MV, pers comm).

Figure 1. Iona restoration plan study site (red outline), located in the northeast corner of Iona Beach Regional Park, Richmond, BC.

3.2 Historical Conditions

Historically, Iona Island was considered flood plain comprised of estuarine marshes and tidal channels (Page 2011). Dredging of the Fraser River in the early 1900s led to disposal of the spoil material onto Iona Island. IIWTP was established in 1963 and included four settling ponds located east of the facility. MV has been managing the northern and southern ponds since 1980 (Figure 1). Both ponds are considered part of IBRP. The surrounding area is a popular location for park users and draws many bird watchers in annually.

3.3 Current Physical Conditions

3.3.1 Soil

Due to historic dredging which resulted in the spoils being deposited on Iona Island, the predominant soil type of IBRP is sand (Page 2011). Sandy soil does not retain water well and loses nutrients rapidly. As such, vegetation within the park is adapted to growing in nutrient-poor conditions and sandy soils.

3.3.2 Water Quality

Monitoring water quality was planned to be conducted by MV throughout the course of the summer field season. MV initially planned to take water quality measurements within the southern pond of IBRP. A request was made for measurements to be taken in the northern pond as well, to be incorporated in this project. Unfortunately, the samples were not taken in the northern pond due to miscommunication. In future studies, water quality measurement points should be established and monitored seasonally due to potential concerns of seepage from the adjacent waste water treatment plant.

3.4 Current Biological Conditions

3.4.1 Vegetation

Methods: Vegetation surveys were conducted throughout the study area in August 2017. Variable-radius circle plots were used to determine diversity and percent cover of vegetation within the study area (MOELP 2015). Sampling plots were set on either side of mist net lanes which were used for bird surveys (Figure 2). A total of 20 sample plots were measured. Ten (10) plots were located in predominately native vegetation sites ("N sites") and ten (10) in predominantly Himalayan blackberry sites ("HB sites"). Circular plots were 2.82 m in radius. All species and their percent cover within each plot were recorded.

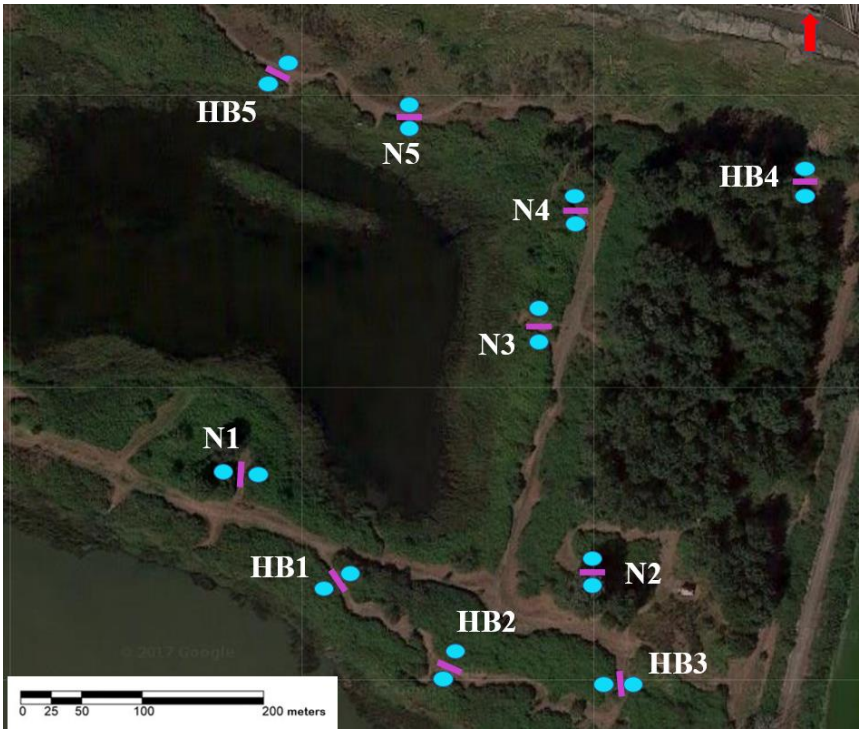

Figure 2. Vegetation circle plots (blue circle) located on either side of mist nets (delineated by purple line and used for breeding bird surveys). Surveys were conducted in August 2017 in IBRP.

Findings: 17 species in total were observed across the 20 plots, including 3 exotic species: Himalayan blackberry (*Rubus armeniacus*), scotch broom (*Cytisus scoparius*), and evergreen blackberry (*Rubus laciniatus*). The most common native species included red-osier dogwood (*Cornus sericea*), red elderberry (*Sambucus racemosa*), and Nootka rose (*Rosa nutkana*) (Figure 3; Appendix Table 2). The mean number of native plant species found is significantly higher in N sites (mean = 6; range = 5-7) than that of HB sites (mean = 1.8; range = 0-3) (Figure 4). Species found in N sites but were absent in HB sites included: black twinberry (*Lonicera involucrate*), common snowberry (*Symphoricarpos albus*), crabapple (*Malus fusca*), paper birch (*Betula papyrifera*), and red elderberry.

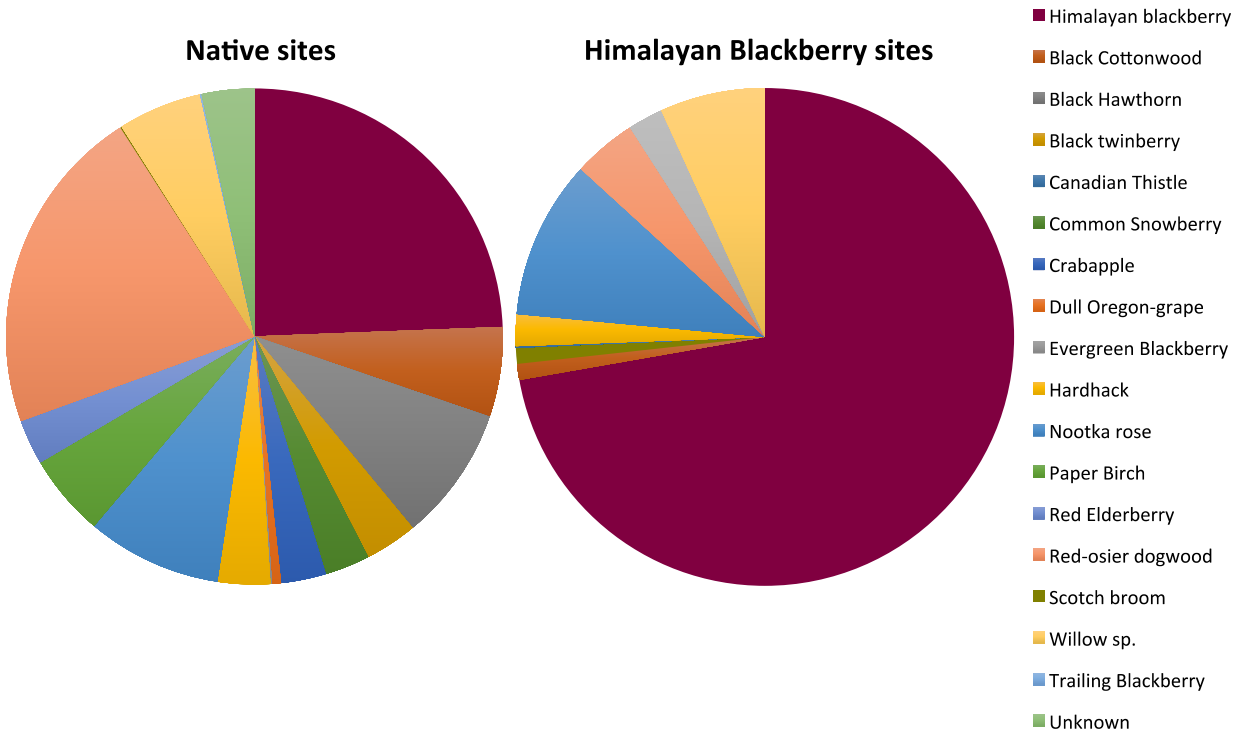

Figure 3. Proportion of average percentage cover of the plant species found in predominantly Himalayan blackberry sites (N=10) and predominantly native vegetation sites (N=10).

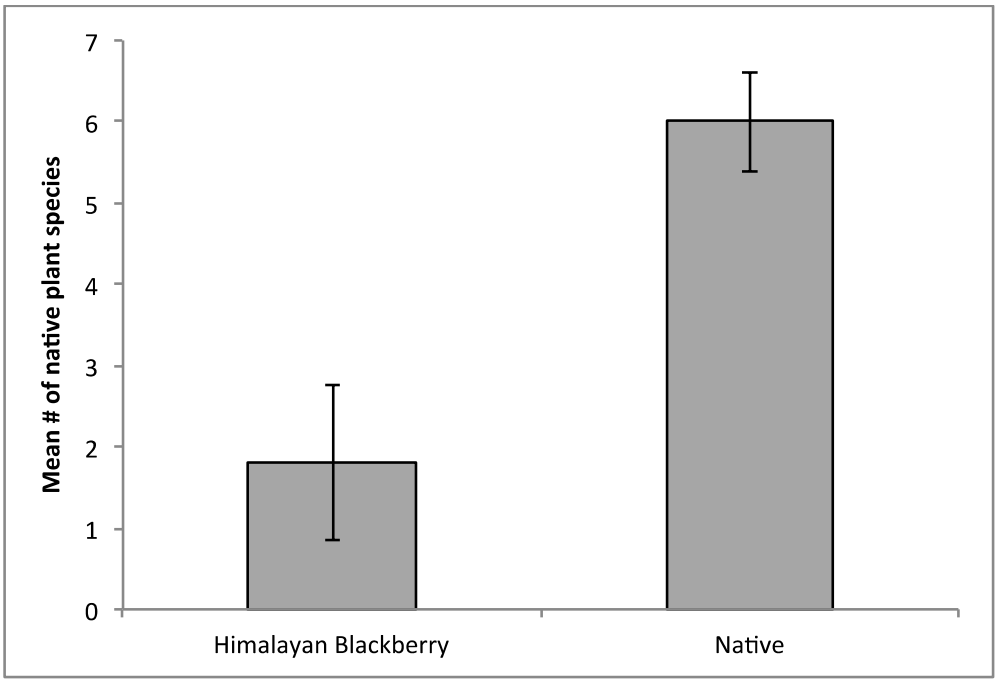

Figure 4. Mean number of native plant species found (i.e. native species richness) in predominantly Himalayan blackberry sites and native vegetation sites in IBRP. Error bar depicts 95% confidence interval.

Recommendations: See section 4.0 Restoration Treatments for recommendations for managing vegetation in IBRP.

3.4.2 Amphibians

Methods: Two (2) pond breeding amphibian trap surveys were conducted using live trapping techniques (MOELP 1998a). For each trapping session, 12 minnow traps were set along the perimeter of the northern pond in IBRP (Figure 5). Traps were set in the evening, then checked and analyzed the following morning. Auditory and presence surveys of amphibians were also conducted during trap surveys.

Figure 5. Location of minnow traps for amphibian survey set around the Northern pond in IBRP. Surveys were conducted on June 22-23 and July 5-6, 2017.

Artificial cover object surveys for terrestrial breeding amphibians were not conducted during this project. These surveys should be conducted earlier in the season while the ground is still wet. In addition, artificial cover objects may not be the best survey type for IBRP as MV has expressed concerns of interference and disturbance by the public using the park.

Findings: Only one (1) amphibian species, American bullfrog (*Lithobates catesbeianus*), was captured during surveys. Both adult American bullfrogs and tadpoles were caught (Figure 6). Three (3) non-target species were also captured during trapping sessions, including brown bullhead (*Ameiurus nebulosus*), stickleback (*Gasterosteiformes sp.*), and signal crayfish (*Pacifastacus leniusculus*). Two (2) species of amphibians were detected via auditory surveys: American bullfrog and green frog (*Lithobates clamitans*).

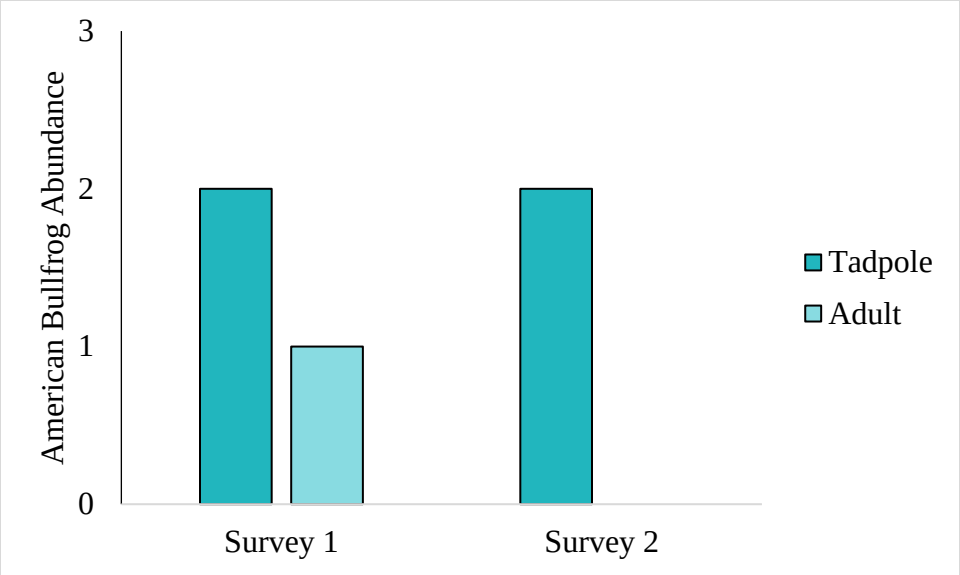

Figure 6. Abundance of American bullfrog tadpoles and adults caught on June 22 (Survey 1) and July 06 (Survey 2) in IBRP.

Recommendations: For future studies, we recommend conducting physical searches (i.e. "Encounter Transects") for amphibians by looking through wet rotting wood in the woodlot. Surveys should be conducted in the spring and early summer, as amphibians are found more easily during wet seasons (Matsuda 2002, MOELP 1998a, MOELP 1999).

3.4.3 Reptiles

Methods: Turtle and snake surveys were conducted in early September. The northern pond perimeter was surveyed on foot to look for basking turtles along the shoreline or in the water. Artificial cover objects were used for one (1) week to survey for snakes. Black paper was set along the edge of the pathways in sunny locations with the intention that snakes would use them as locations for sunning themselves.

Findings: Red-eared sliders (*Trachemys scripta*), an invasive species, were observed in the southern pond along the east side of the island sunning themselves on bare batches of mud with no reeds (Table 1 and Figure 7). No native western painted turtles (*Chrysemys picta bellii*) were observed during the survey. From July-August, red-eared sliders were also incidentally observed nesting along the pathways between the northern and southern ponds in IBRP.

No snakes were found using artificial cover objects. However, seven (7) garter snakes were incidentally observed throughout the summer while walking along park pathways (Table 1; Figure 8). Garter snakes could not be distinguished down to species level (i.e., common garter snake [*Thamnophis sirtalis*], northwestern garter snake [*Thamnophis ordinoides*] and western garter snake [*Thamnophis elegans*]), as the snakes were young, and their scales were too small to count.

Table 1: Number of red-eared sliders and garter snakes observed in IBRP during the summer field season of 2017.

Species/Activity	# of Sightings
Nesting red-eared slider	4
Basking red-eared slider	9
Garter snake	7

Figure 7. Location of turtles observed basking in the sun (orange symbol) and location of observed turtle nesting sites (green symbol) from July-August 2017 in IBRP.

Figure 8. Locations of observed snakes during surveys conducted from June-August 2017 in IBRP.

Recommendations: Historical records indicate there was once a resident population of western painted turtles in IBRP (MOELP 1998a) (R. Worcester, MV, pers comm). Thus, it is recommended that more vigorous turtle surveys be conducted to determine if there is still a population residing in the park. If painted turtles are found in IBRP, then a management plan should be developed to control the red-eared slider populations to reduce competition for the painted turtle population.

Artificial cover objects would have been more successful if they were left out for the entire summer, as it would have allowed snakes to become accustomed to their presence and establish them as known sunning locations.

3.4.4 Small Mammals

Methods: Two separate small mammal surveys were conducted in June and July following MOELP 1998d. For each trapping session, 30 traps were set in the northeast section of IBRP in both invasive Himalayan blackberry (N = 12) structures and native vegetation structures (N = 18) (Figure 9).

Figure 9. Location of small mammal traps within IBRP from June-August.

Findings: Two (2) species were observed and tagged: Townsend's vole and deer mouse. The two species were found in both Himalayan blackberry patches and native vegetation patches in approximately equal proportion (Figure 10), with no significant differences using Fisher's exact test ($p > 0.05$).

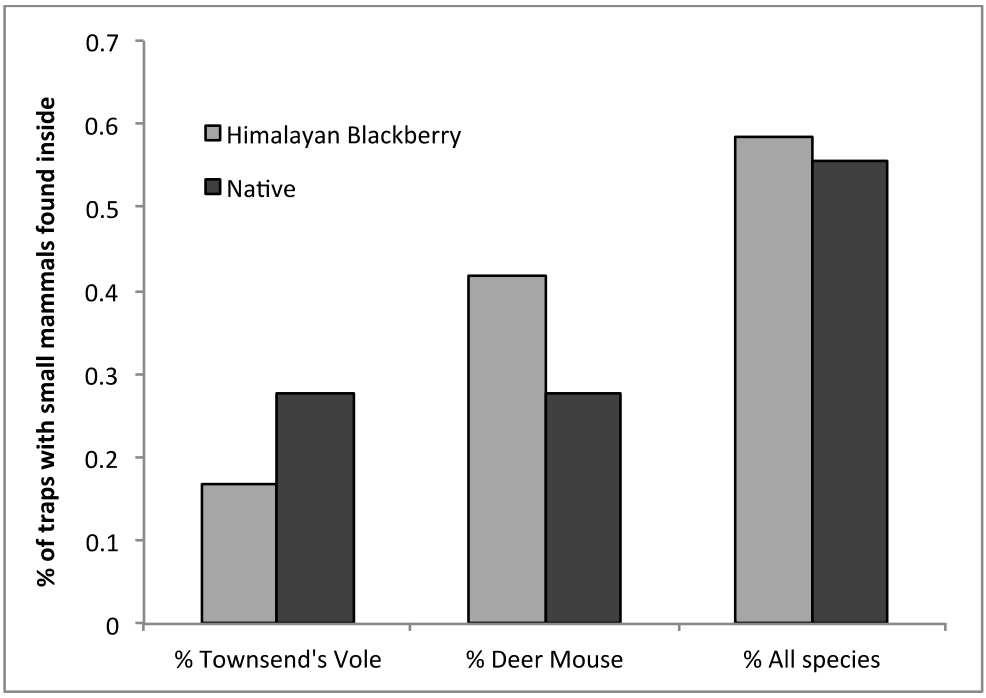

Figure 10. Proportion of traps with small mammals found inside, in Himalayan Blackberry structures and native vegetation structures.

Trapping was successful, as traps were not completely saturated with small mammals during each sampling survey. Thus, we can assume that most species within the park were sampled as there were still empty traps in the morning. Three (3) possible recaptures were identified, as indicated by the small mammals exhibiting a torn ear and a missing tag.

Recommendations: Small mammal surveys should be conducted inter-annually and inter-seasonally to determine whether variation in species diversity and abundance is a function of vegetation change. More effort should be focused on determining habitat preference of small mammals, which can be used to aid vegetation and species management within the park.

3.4.5 Bats

Methods: An Anabat bat detector (®Titley Scientific) was used to conduct two 30-minute bat surveys in July. Surveys were conducted in a 2827.43 m^2 circular plot (i.e. approximately a 30m detection radius) out front of the IIBO banding hut (Figure 11). The vegetation in the circle plot consisted of both native shrubs, trees and invasive Himalayan blackberry. The detector was connected to a smart phone, using the Echo Meter (®Wildlife Acoustics) app, and vocalizations of bats within range were recorded. The app suggests the species that is vocalizing based on the frequencies and patterns being detected. However, vocalization traits can overlap between closely related bat species, and therefore species suggested by the app was taken with caution due to the potential inaccuracy in species identification.

Figure 11. Location of bat and owl surveys (circle outline) conducted at the edge of the woodlot and in front of the IIBO banding hut.

Findings: Three (3) species were observed during surveys: little brown bat silver-haired bat (*Lasionyceris noctivagans*), and the big brown bat. The little brown bat and big brown bat are federally listed as Endangered under the Species at Risk Act (SARA). Bats appeared to be roosting in the woodlot in the northeast corner of IBRP. It should be noted that little brown myotis and long-legged myotis tend to produce echolocation pulses with overlapping minimum frequencies, and as such, can be difficult to differentiate acoustically by the app.

Recommendations: Future bat surveys should include the analysis (i.e. manual inspection) of bat vocalization on sonograms to discern between species. Importantly, critical habitat has yet to be identified for the two federally-listed bat species. As such, it is recommended that mist net surveys be used to further investigate bat habitat usage within IBRP (e.g. roosting, foraging), and ultimately to inform any potential bat management plan.

3.4.6 Owls

Methods: Two (2) owl call playback surveys were conducted in June and July 2017, following MOELP (2006). The surveys were conducted outside of the IIBO banding hut in 30-minute sessions. Calls were played in the following sequence: northern saw-whet owl (*Aegolius acadicus*), barred owl (*Strix varia*), and great horned owl (*Budo virginianus*).

Findings: No owls were detected during surveys. This may be due to the interference of ambient noise around IBRP, including car traffic and planes at the Vancouver Airport.

Recommendations: Surveys were conducted later in the breeding season, when owls are known to demonstrate lower response rate to call playbacks. Success of surveys may

increase if the surveys were conducted earlier in the summer during the mating season when owls demonstrate more territorial behaviour. Owl species that are known to occur within IBRP include northern saw-whet owls, barred owls, and great-horned owls.

3.4.7 Breeding Birds – Mist-net Surveys

Methods: Mist net surveys of breeding birds were conducted from June to August 2017 in IBRP, following WildResearch's standard mist-netting protocol. Five (5) mist nets were set in predominantly Himalayan blackberry sites and five (5) in predominantly native vegetation sites (Figure 12). The nets were placed at least 20m apart from each other, following McDermott and Wood (2010) and Vitz and Rodewald (2007). The purpose of this survey was to compare bird habitat usage between areas dominated by native vegetation and those inundated with invasive Himalayan blackberry.

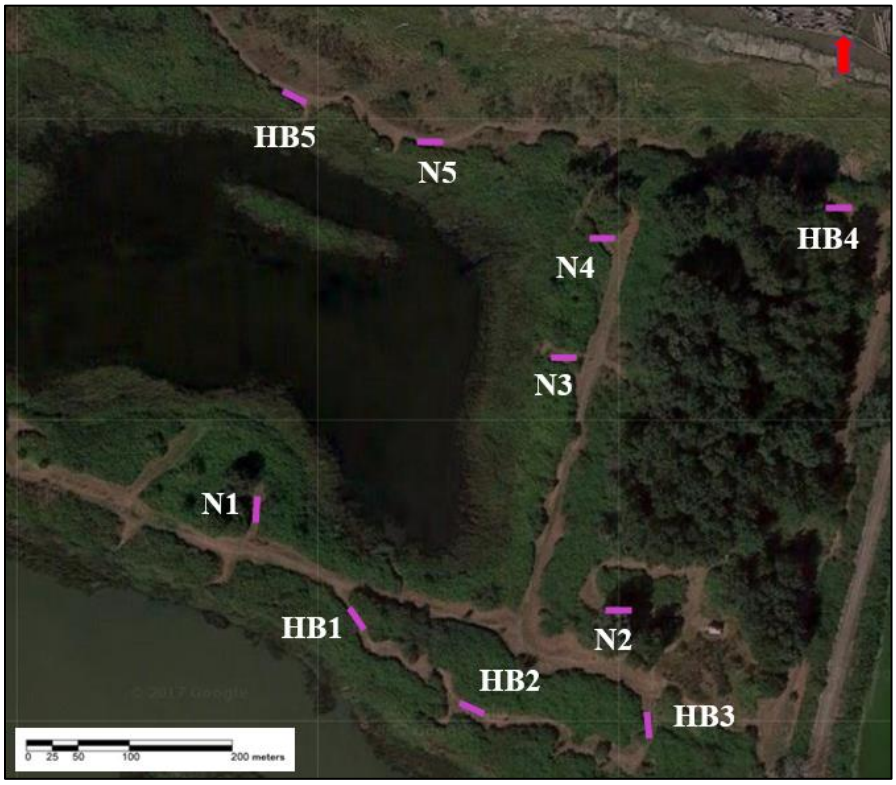

Figure 12. Location of mist nets used for the breeding bird survey in IBRP. Survey sites were set from June to August 2017 (N= Native vegetation, HB= Himalayan blackberry).

Findings: Initial reviews of the data have not shown a large difference in avian abundance and species richness between the two vegetation types (Figure 13; Figure 14

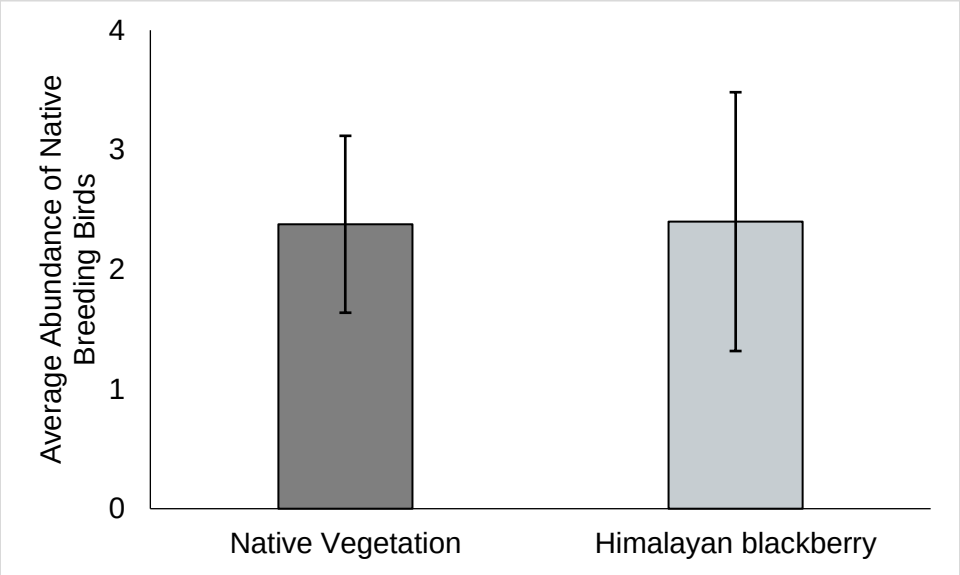

Figure 13. Preliminary results showing average abundance of native birds in native vegetation sites and Himalayan blackberry sites, using breeding bird mist net surveys conducted from June to August 2017 in IBRP. Error bars indicate 95% confidence intervals.

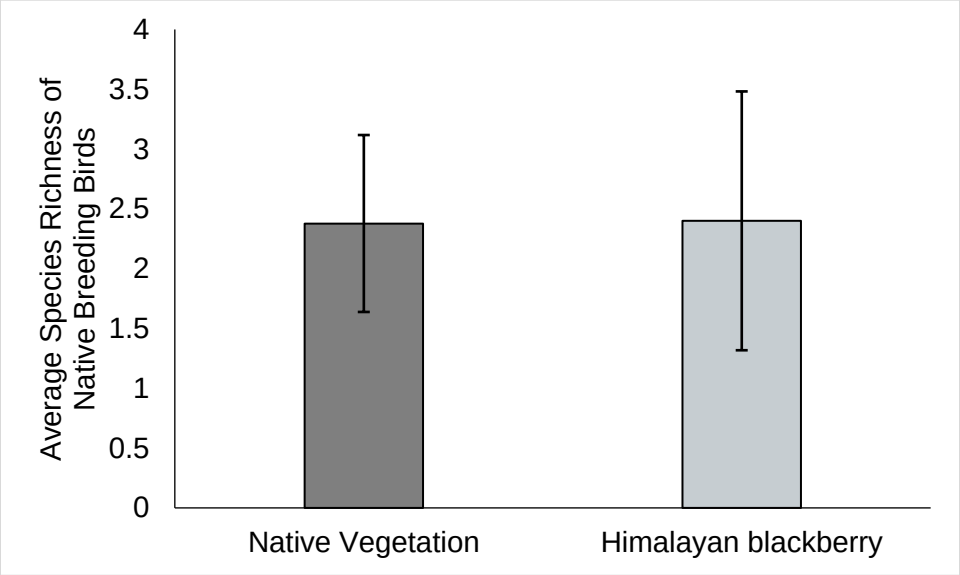

Figure 14: Preliminary results showing the average species richness of native breeding birds in native sites and Himalayan blackberry sites, using breeding bird mist net surveys conducted from June to August 2017 in IBRP. Error bars indicate 95% confidence intervals.

Recommendations: See section 3.4.8

3.4.8 North American Breeding Birds – Behaviour Observation Surveys

Methods: Observational surveys of breeding birds were conducted in July 2017 to determine bird use in native versus invasive vegetation. All bird activities (e.g., singing/calling, perching, nesting, foraging), number of individuals, species, and the duration of each activity were observed for 10-minute intervals in both native and Himalayan blackberry vegetation structures.

Findings: Preliminary review of this data set shows that there is a greater abundance of birds using native vegetation as opposed to Himalayan blackberry sites (Figure 15). A greater species richness was also observed in native sites as opposed to Himalayan blackberry sites (Figure 16; Figure 17).

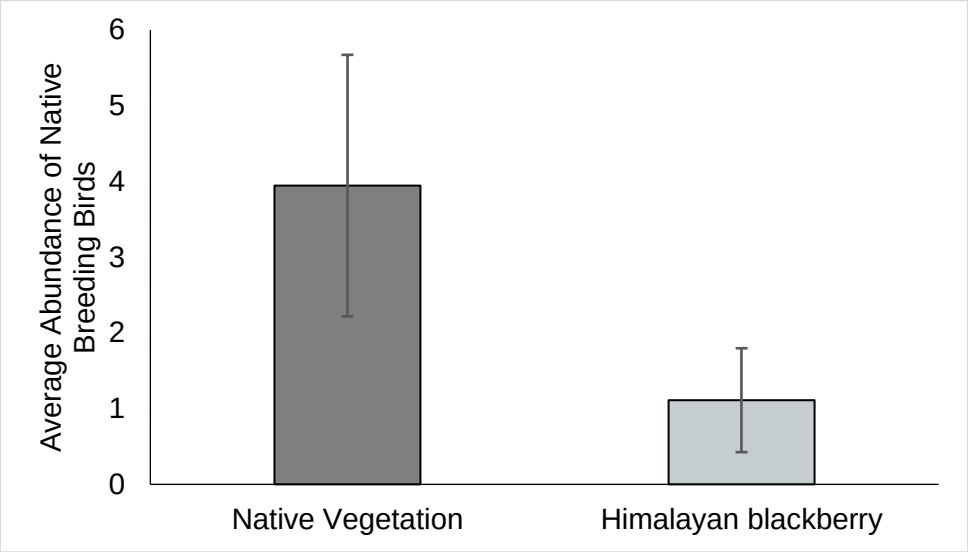

Figure 15. Preliminary results showing the average abundance of native birds in native vegetation sites and Himalayan blackberry sites, using breeding bird observational surveys conducted in July 2017 in IRBP. Error bars indicate 95% confidence intervals.

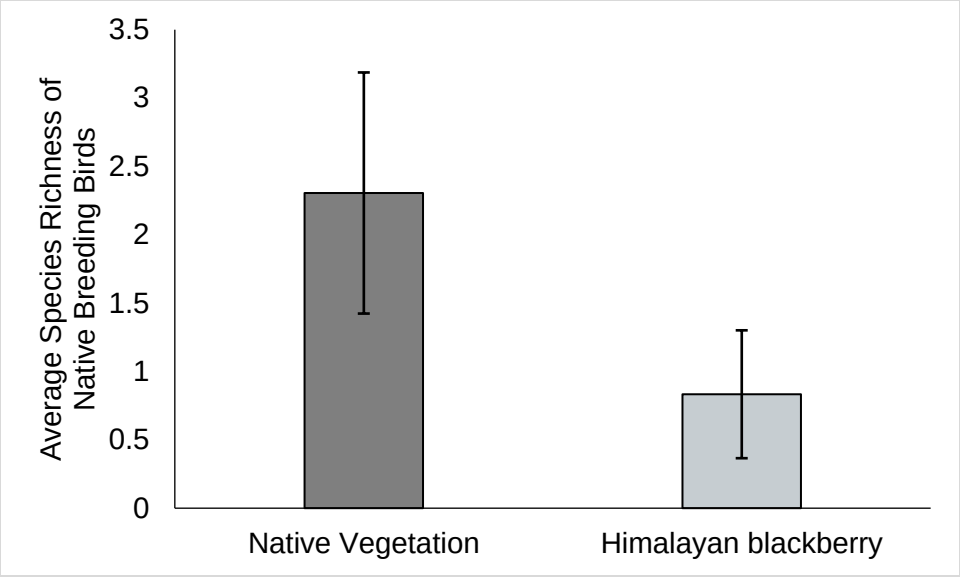

Figure 16: Preliminary results showing the average species richness of native birds in native vegetation sites and Himalayan blackberry sites, using breeding bird observational surveys conducted in July 2-17 in IBRP. Error bars indicate 95 % confidence intervals.

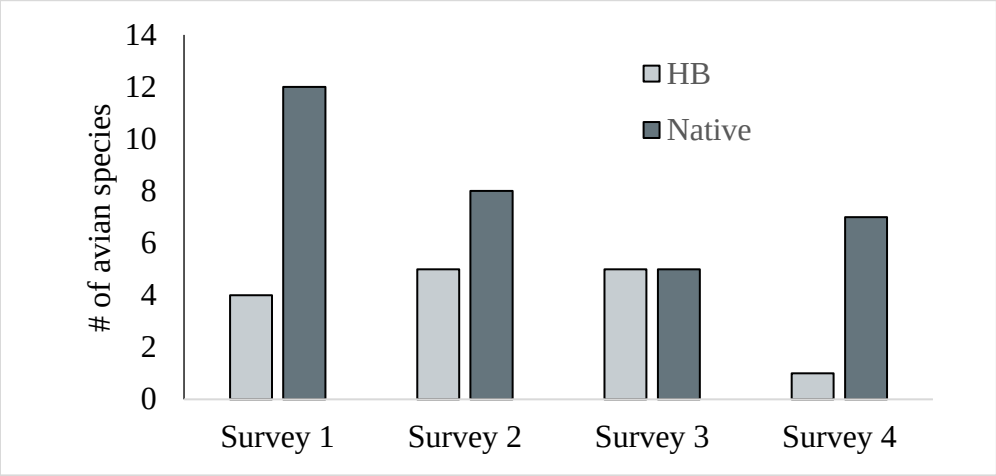

Figure 17. Number of breeding bird species observed in both Himalayan blackberry patches and native vegetation patches.

Recommendations for breeding birds and their habitat:

The difference in avian abundance between the two types of breeding bird surveys may be attributed to several factors. With the exception of great blue herons (*Ardea herodias*) and northwestern crows (*Corvus caurinus*), all species detected during observational surveys were also captured in mist-net surveys. In comparison, additional 15 species were detected in mist-net surveys, including Bewick's wren (*Thryomanes bewickii*), downy woodpecker (*Picoides pubescens*), Lincoln's sparrow (*Melospiza lincolnii*), MacGillivray's warbler (*Geothlypis tolmiei*), and purple finch (*Haemorhous purpureus*). It is possible that these

species select breeding habitat indiscriminately within a landscape composing of Himalayan blackberry and native shrubs. As such, differential habitat preference found in this study may not be reflective of the overall avian community in IBRP, but only of the bird species detected in the observational surveys. Further investigation and analysis are required to explicate the findings revealed from the surveys.

In addition, the breeding and foraging territory sizes of songbirds breeding within IBRP may exceed beyond the distance between the mist-nets. Throughout our mist-net survey, approximately half of the recaptured birds were in the same net as when initially captured, whereas the other half were captured in a different net. As such, we may have detected more pronounced differences in songbird habitat usage had we placed the nets further apart.

Invasive, non-native species can have adverse impacts on the abundance and stability of bird communities by altering resource availability and changing habitat structure and quality. Astley (2010) found that bird diversity was lower in areas where Himalayan blackberry was the dominant understory shrub, whereas species richness increased in areas with greater structural and compositional diversity. In comparison, Crombie et al. (2017) demonstrated that song sparrows exhibited similar reproductive performance when nesting in Himalayan blackberry compared to other Pacific Northwest native species such as trailing blackberry (*Rubus ursinus*), common snowberry (*Symphoricarpos albus*) and Nootka rose. However, other studies have found that the nests of species such as song sparrows, yellow-breasted chats (*Icteria virens*), and yellow warblers (*Setophaga petechial*) were surrounded by relatively more Himalayan blackberry cover than other native shrubs (Chase 2002; Rockwell and Stephens 2017). Tricolored blackbirds (*Agelaius tricolor*) also performed better in habitat dominated by Himalayan blackberry than in sites dominated by native wetland plants (Cook and Toft 2005). Himalayan blackberry forms dense, thorny patches that may impede predators from nests (Crombie et al. 2017; Chase 2002). A study conducted in the Lower Mainland of BC also showed that large berry-producing shrubs (including Himalayan blackberry) positively predicted the occurrence of ground-nesters such as spotted towhees (*Pipilo maculatus*), but not shrub nesters (Melles et al. 2003).

Our study suggests that habitat usage and selection within an area composed of Himalayan blackberry and other native vegetation may be highly dependent on songbird species and their ecological requirements. Himalayan blackberry removal is a common practice as part of many restoration plans due mainly to its notorious ability to aggressively invade and displace ecologically significant and even imperiled plant species. However, invasive species removal programs should concurrently ensure any potential deleterious effects to the avian community are minimized or avoided, perhaps carried out strategically at a spatial and temporal scale. We advise that further research is required to provide greater insight into the management of invasive and native vegetation within IBRP and other ecologically sensitive urban parks.

We recommend that mist-net and observational surveys be conducted annually, and that the surveys begin earlier in the breeding season in order to better characterize and ultimately understand the type of vegetation structures important for breeding birds. Importantly, we further recommend that nest-searches be conducted in various shrub species (e.g.

blackberry monoculture vs mixed structures of native and non-native vegetation), in order to better understand the specific nesting habitat requirements of songbirds in IBRP.

We caution the interpretation of these results as we present here only the preliminary findings of our breeding bird surveys. Further statistical analysis will be conducted on these datasets as part of the MSc. Thesis of Laura Newberry. The final copy of the thesis is expected to be completed by February - April 2018. Further information will also be provided to elucidate the ecological relationship between Himalayan blackberry vegetation and breeding birds in IBRP.

3.5 Site Stressors

Six (6) site stressors affecting the biological and physical factors of IBRP were identified during the 2017 field season (Table 4).

Table 2: Observed stressors affecting the biological and physical factors of IBRP during May to August 2017.

Stressor	Concern
Invasive vegetation	Many introduced species have colonized in IBRP. Himalayan blackberry has become the predominant species in the study site. This species outcompetes native vegetation and is reducing vegetation diversity. It also prevents any understory growth and therefore limits structural complexity that could be reducing potential nesting sites for breeding birds.
Human disturbance	IBRP is a public recreational park comprised of many walking trails. Some of the walking trails run through the study area. The presence of the public in the study area could cause soil compaction, trampling of vegetation, erosion along pond edges and wildlife disturbance.
Noise pollution	IBRP is located in close proximity to Richmond city centre, and as a result receives many visitors recreating in the park. The only means of transportation into the park is by vehicle and bicycle. This contributes to increased noise pollution around the park and potentially affects wildlife. The park is also located adjacent to the YVR airport which contributes the largest portion of the noise pollution in the park.

Airplane traffic	The YVR airport is the largest airport in BC and generates a lot of plane traffic, which can cause bird aircraft strike hazards.
Leaching from IIWTP	IIWTP is located to the east of IBRP. There are concerns that leaching could be occurring, which can potentially influence water quality in the northern and southern ponds in IBRP.
Climate change	With increasing trends in summer temperatures, there are concerns that species composition within the park may be influenced. Increased temperatures may facilitate the growth of heat-tolerant plants that require less moisture than most native species in the region. Additionally, trends in sea level rise may lead to significant flooding to IBRP.

3.6 Desired Future Conditions

The overall goal for this project is to help inform the management and restoration of the vegetation community within the study site in IBRP, particularly to enhance wildlife habitat in the park. Himalayan blackberry abundance should be reduced within the study area, while maintaining and creating structurally complex vegetation structures for nesting birds and other wildlife.

4 Proposed Restoration Plan

4.1 Goals and Objectives

Goal 1: Remove Himalayan blackberry that is encroaching on native vegetation patches within the study area.

- Objective 1.1: Manually hand pull Himalayan blackberry that has mixed in with native vegetation around the study area in IBRP on an annual basis.

Goal 2: Remove large monoculture patches of Himalayan blackberry within the study area.

- Objective 2.1: Mow and mulch whole patches of Himalayan blackberry structures from the study area in IBRP from November to March.

- Objective 2.2: Excavate patches of Himalayan blackberry from the study area in IBRP from November to March.

Goal 3: Suppress any regrowth of Himalayan blackberry from plots.

- Objective 3.1: Spread a thick layer of wood chip mulch over cleared plots.

- Objective 3.2: Lay black plastic over the surface of cleared plots to initiate soil solarization. Plastic will be removed at the end of the growing season.

Goal 4: Create and maintain important habitat for breeding birds.

- Objective 4.1: Revegetate cleared plots with plant communities of similar diversity to adjacent native vegetation plots.

- Objective 4.2: Avoid destruction of important nesting and foraging vegetation habitat for breeding birds in IBRP.

4.2 Proposed Restoration Treatments

Proposed treatments are aimed to:

i. Remove Himalayan blackberry,
ii. Prevent further growth and spread of Himalayan blackberry, and
iii. Increase abundance of native vegetation within IBRP.

There are two main vegetative structure types in the study area: mixed structures on native vegetation and Himalayan blackberry, and monoculture plots of Himalayan blackberry (Figure 16). We propose to use an experimental design tactic to determine the best method for Himalayan blackberry removal.

Figure 18. Location of mixed Himalayan blackberry and native vegetation patches and Himalayan blackberry monoculture patches observed in the summer of 2017 in the IBRP study site (yellow square = mixed vegetation, red square = Himalayan blackberry only).

4.3 Vegetation removal

Initially, Himalayan blackberry plots will need to be cleared outside of the avian breeding season (i.e., November to March), following guidance from Environment & Climate Change Canada (ECCC 2017). This will avoid contravention of the Migratory Bird Convention Act, such that incidental take is mitigated during these bird-sensitive seasons. There are two basic vegetation structures: 1) mixed native and Himalayan blackberry and 2) monoculture Himalayan blackberry. Both structure types require different techniques for managing the invasive vegetation.

4.3.1 Mixed structures

For vegetation structures that are a mixture of both Himalayan blackberry and native vegetation a more sensitive technique is needed to manage invasive vegetation. Hand pulling should be used to remove Himalayan blackberry, including the root, where possible (Ballin and deMontreuil N.D.). This technique will remove competition with invasive vegetation, but is more time consuming and will require seasonal maintenance.

4.3.2 Monoculture Himalayan blackberry structures

There are two preferred methods for removing Himalayan blackberry monocultures in large quantities. One technique involves mowing large patches of blackberry and mulching the cut material. The mowing method eliminates the above ground mass but has no effect on the root mass under the soil. The second technique uses an excavator to mechanically remove blackberry above and below ground. Using excavators is more expensive but tends to be more successful as it removes the above ground biomass of the blackberry and root masses below the soil surface.

4.4 Post-removal Treatments

After the Himalayan plots have been cleared by either mowing or excavation, one of the following treatments can be applied: mulching or solarization. Treatments should be applied directly after plot clearing to prevent soil erosion from heavy winds and rain.

4.4.1 Mulch

The mulching treatment involves spreading wood chip mulch evenly over the surface of any exposed soil. A layer of at least two (2) inches should be applied to prevent sunlight from reaching the soil. This will prevent invasive regrowth by creating shade and preventing any remnants below the soil from receiving the sunlight required for survival (TNC 2001).

4.4.2 Solarization

Soil solarization is conducted by covering the soil surface with black plastic, following vegetation clearing. Black plastic absorbs sunlight and causes soil temperature to increase. The increase in temperature kills remnants of vegetation and seeds (TNC 2001). The plot should remain covered with black plastic for at least one full growing season.

4.5 Planting

Planting efforts should be conducted during the wettest seasons (i.e., spring and fall). Planting should include vegetation that already exists in IBRP (Table 5). Existing species will have a higher establishment and survival rate, as opposed to introducing new species that may not grow well in the sandy soils. If there is a desire to increase plant diversity by introducing new species to the park, then addition of a different soil type to the study site needs to be considered and further researched. This may beneficial as it could add more nesting option and food diversity for wildlife species.

Table 3: Proposed native planting list for the study area located in IBRP.

Common Name	Scientific Name
Black cottonwood	*Populus trichocarpa*
Black hawthorn	*Crataegus douglasii*
Black twinberry	*Lonicera involucrata*
Common snowberry	*Symphoricarpos albus*

Crabapple	*Malus fusca*
Dull Oregon-grape	*Mahonia nervosa*
Hardhack	*Spiraea douglasii*
Nootka rose	*Rosa nutkana*
Paper birch	*Betula papyrifera*
Red elderberry	*Sambucus racemosa*
Red-osier dogwood	*Cornus sericea*
Willow sp.	*Salix* sp.

5 Post-Restoration Monitoring

A monitoring plan should be developed post clearing and treatment implementation. Regrowth of Himalayan blackberry should be measured comparing removal techniques of mowing and excavation, as well as between mulching and solarization treatments. Vegetation surveys should also be conducted to monitor the survival of planted vegetation.

We recommend that all wildlife and vegetation surveys conducted in this study be continued annually in order to ensure consistent, long-term monitoring. Surveys should continue to focus on breeding birds and species-specific habitat needs, especially because IBRP is part of the "Boundary Bay - Roberts Bank - Sturgeon Bank (Fraser River Estuary) Important Bird Area". Priority should also be given to any species at risk occurring within the park (e.g. little brown myotis, big brown myotis, barn swallow (*Hirundo rustica*)). Information from these surveys could potentially help fill in knowledge gaps about habitat requirements for breeding birds and other wildlife using IBRP. Monitoring would also document ecological changes in the park against the backdrop of the wide array of anthropogenic and environmental stressors in the area, and ultimately provide solutions to mitigate these effects.

6 Maintenance and Public Outreach Plan

Restoration projects are more likely to be successful if an ongoing maintenance plan is followed annually. We recommend the development of a park stewardship group composed of MVRP staff members, WildResearch, and volunteers from the public. Volunteers would continue hand pulling treatments to ensure Himalayan blackberry does not recolonize and shade out native vegetation. The stewardship group could also focus on adding more wildlife features to IBRP, followed by continual monitoring. Features could include bat boxes, basking logs, nesting beaches for turtles, and standing wildlife logs. Importantly, this would also allow for MVRP and WildResearch to actively engage with members of the public and to connect them to nature through hands-on conservation.

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8 Appendix

***Appendix Table 1**: Summary of conducted wildlife and vegetation surveys in IBRP from June 2017 through August 2017.*

Survey Type	Date	Hr.	#Species	#Indivi.	Volun.
Songbird Mist-netting	14-06-17	3.5	9	25	2
Songbird Mist-netting	17-06-17	3.5	11	18	1
Songbird Mist-netting	21-06-17	3.5	11	18	2
Owls	21-06-17	1.0	0	0	1
Amphibians	22-06-17	17.0	1	3	2
Songbird Mist-netting	24-06-17	3.5	8	10	2
Small Mammal	27-06-17	14.5	2	19	2
Songbird Mist-netting	28-06-17	3.5	10	18	4
Amphibians	06-07-17	17.0	1	2	1
Bats	06-07-17	1.0	3	-	1
Small Mammal	12-07-17	14.5	2	15	1
Songbird Mist-netting	13-07-17	3.5	13	3	2
Bird Behavioural Observation (Native)	14-07-17	2.5	12	56	1
Songbird Mist-netting	17-07-17	3.5	8	25	2
Bird Behavioural Observation (HB)	19-07-17	2.5	4	7	1
Bats	20-07-17	1.0	1	-	1
Owls	20-07-17	0.5	0	0	1
Bird Behavioural Observation (Native)	25-07-17	2.5	8	23	1
Bird Behavioural Observation (HB)	28-07-17	2.5	5	13	1
Bird Behavioural Observation (Native)	04-08-17	2.5	5	12	1
Bird Behavioural Observation (HB)	14-08-17	2.5	5	14	1
Songbird Mist-netting	17-08-17	3.5	14	37	2
Songbird Mist-netting	18-08-17	3.5	11	33	2
Bird Behavioural Observation (HB)	23-08-17	2.0	1	4	0
Vegetation	24-08-17	2.0	18	NA	1
Bird Behavioural Observation (Native)	25-08-17	2.0	7	51	0
Small Mammal	31-08-17	10.0	1	1	3
Snake Survey	01-09-17	1.0	1	7	1
Turtle Survey	01-09-17	1.0	1	13	1

Appendix Table 2: Average percentage cover of plant species observed in predominantly Himalayan blackberry sites (N=10) and predominantly native vegetation sites (N=10).

	Himalayan blackberry sites	Native vegetation sites
Himalayan Blackberry	70	25
Black Cottonwood	1	6
Black Hawthorn	1	9
Black Twinberry	0	3.5
Canadian Thistle	0.1	0
Common Snowberry	0	3
Crabapple	0	3
Dull Oregon-grape	0	0.6
Evergreen Blackberry	0	0.1
Hardhack	2	3.5
Nootka Rose	10	9
Paper Birch	0	5.5
Red Elderberry	0	3
Red-osier Dogwood	4	22
Scotch Broom	2.2	0.1
Willow sp.	6.6	5.6
Trailing Blackberry	0	0.1
Unknown	0	3.5