



Assessing for Bird Species at Risk in Quadra Hill
ER 412 Galiano Island Field School Design Project
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Abstract/Executive Summary

Passive acoustic monitoring (PAM) is a relatively new technique for determining the presence of species at risk using relatively inexpensive equipment. PAM can guide wildlife conservation and restoration efforts and potentially indicate healthy and supportive habitats. The Galiano Conservancy Association (GCA) employed PAM in the spring of 2023 with the hope of detecting the threatened Western Screech-Owl *kennicottii* subspecies at a site known as Quadra Hill. As part of our ER 412 Assignment, the GCA requested we assess and attempt to optimize their PAM program. Specifically, GCA staff requested help pinpointing the best times and locations for bird monitoring, as well as an assessment of the trustworthiness of BirdNET, a machine-learning bird identification software. In response to this request, we identified three avian species at risk to monitor. We used a variety of methods for obtaining data including community consultation with local experts, the citizen science platform iNaturalist, and field observations. BirdNET, which uses machine learning to identify bird species from audio recordings, was determined to be a useful tool with approximately 75% accuracy. Despite its relative trustworthiness, it is still important to confirm the accuracy of recordings, particularly avian species at risk. Recommendations for optimizing the GCA's PAM and avian SAR monitoring program include: PAM specific to the life histories of each species; the installation of nest boxes; engaging with Galiano community members and landowners; and applying for funding through the Government of Canada's Environmental Damages Fund program.

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ER 412 GALIANO CONSERVANCY RESTORATION DESIGN PROJECT

Territorial Acknowledgement

The property described in this report (DL 58) is located within the traditional, unceded, and shared territory of the Penelakut, Hwlitsum, and other Hul'qumi'num-speaking Indigenous peoples of the Salish Sea, as well as the ceded territory of the Tsawwassen First Nation.

INTRODUCTION

This integrative wildlife conservation-ecological restoration project was conducted at the request of the Galiano Conservancy Association (GCA) in June 2023. This project has two core aims: 1) Identify optimal passive acoustic monitoring (PAM) sites within Quadra Hill to assess the presence of select bird species-at-risk (SAR), and 2) Assess the reliability and accuracy of the BirdNET software for acoustic monitoring.

BACKGROUND

The following section provides:

1. A description of the GCA's passive acoustic monitoring project, including the site(s) chosen for monitoring.
2. Life histories of select avian SAR.
3. An outline of the research problem emerging from consultation.
4. An articulation of the GCA's overarching restoration goals and how this project aligns with those goals.

GCA's Acoustic Monitoring Project for the Western Screech-Owl

In the spring of 2023, the GCA began an acoustic monitoring program for the Western Screech-Owl *kennicottii* subspecies (*Megascops kennicottii kennicottii*), a SAR in southern coastal British Columbia (BC). Wildlife Acoustics "Song Meter" microphones were installed at two sites, including Qw'xwulwis-Cable Bay and Quadra Hill. The machine learning software program BirdNET was used for acoustic monitoring. Preliminary results have identified 52 bird species at Quadra Hill, including two SAR: the Marbled Murrelet (*Brachyramphus marmoratus*) and the Olive-sided Flycatcher (*Contopus cooperi*). Acoustic data to date has not shown the presence of the Western Screech-Owls. Questions remain about the trustworthiness of BirdNET, particularly concerning the identification of the Marbled Murrelet.

Life History of Avian SAR

Western Screech-Owl

The Western Screech-Owl *kennicottii* subspecies is a small, non-migratory owl with a mottled grey-brown plumage that provides excellent camouflage in forest habitats (BC Ministry of Environment, 2014). Western Screech-Owls are generalist predators that feed on

small mammals, small birds, fish, frogs, slugs, and large insects (BC Ministry of Environment, 2014). The Western Screech-Owl is considered an umbrella species, meaning that its protection indirectly protects other species found in its habitat, such as the common nighthawk, Peregrine falcon, bats, pollinators, lichens, and mosses (Islands Trust Conservancy, 2023).

The Western Screech-Owl is listed as threatened under the Species at Risk Act (SARA) and is a Blue-listed species of special concern provincially (COSEWIC, 2012; BC Ministry of the Environment, 2014). Significant declines in southern range populations, including the Southern Gulf Islands, have occurred (COSEWIC, 2012). However, given the outdated threatened species data from provincial and federal governments, more precise estimates are missing. As such, citizen science initiatives such as iNaturalist may fill the gaps in data.

Olive-sided Flycatcher

The Olive-sided Flycatcher *Contopus cooperi* is a medium-sized aerial insectivore and songbird with a distinctive three-note whistle “Quick, three beers”. This widespread migratory species breeds in areas across North America while wintering in Central America and South America (COSEWIC, 2018).

The Olive-sided Flycatcher is a SARA species of species concern (COSEWIC, 2018). Through his experience with spring migration bird counts, Mike Hoebel (personal communication July 12, 2023) notes Olive-sided Flycatcher populations have been pretty steady on Galiano Island for the past 12-15 years, when he first began monitoring and guiding bird walks locally. Population declines are primarily due to disappearing wintering habitats (COSEWIC, 2018).

Marbled Murrelet

Marbled Murrelets are North Pacific seabirds from the Auk family (Ministry of Environment, Lands and Parks, 1998). They are small but plump, weighing approximately 200 g and are about 25 centimetres long. Marbled Murrelets have slim black bills, stubby tails, and small webbed feet like a duck.

In Canada, Marbled Murrelets are found only along the west coasts of British Columbia’s (BC) mainland and Vancouver Island (Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2018). They spend most of their lives at sea within ½ km of the shore but may nest as far as 80 km inland. Murrelets lay only one egg per year and therefore are slow to reproduce.

Marbled Murrelets are a threatened species and are blue-listed in BC (BC Ministry of the Environment, n.d.). Habitat loss is a primary threat. Marbled Murrelets need large areas of old-growth coastal forests for nesting (Ministry of Forests, Lands, Natural Resource

Operations and Rural Development, 2018). Additional threats include predation, increasing oil tanker and other boat traffic, gill-net fishing, oil spills and ocean pollution.

What is Passive Acoustic Monitoring?

Passive acoustic monitoring (PAM) involves using field-based specialized audio recording equipment to capture and record sounds in the natural environment without human intervention (Ross, S., 2023). PAM is useful for studying animals that communicate through vocalizations, such as birds, bats, whales, and insects. Wildlife Acoustics “Song Meter” recorders are a commonly used PAM equipment (Pérez-Granados & Traba, 2021) and the type the GCA uses to determine the presence of birds and bats. Sound recordings obtained are later analyzed using techniques such as machine learning programs such as BirdNET, which extracts bird songs and identifies specific species. Two passive acoustic monitoring techniques are considered in this report, BirdNET, used by the GCA, and Cornell University’s “Merlin Bird ID” app, used by one of the authors for bird identification on site in late June/early July 2023..



Figure 1. A passive acoustic monitoring audio device, fixed to a Douglas fir tree. Photo credit: Ren Ferguson (2022)

Quadra Hill Site

Quadra Hill, located mid-Galiano Island, British Columbia (BC), is a 46.81-hectare site comprising forest and wetland communities in the Georgia Depression ecoprovince and the critically endangered Coastal 1 Douglas fir moist marine (CDFmm) biogeoclimatic zone (Huggins & Thompson, 2023). The CDFmm zone is a unique ecological region along the

southwestern coast of BC, characterized by Douglas fir (*Pseudotsuga menziesii*) and Garry oak (*Quercus garryana*) ecosystems. The Quadra Hill site has a range of young and mature forest ecosystems (Huggins & Thompson, 2023). Most forest stands were cleared in the 1940s and 1990s, with regenerating broadleaf and mixed forests in low areas and dense regenerating conifer forests dominating upland sites (Huggins & Thompson, 2023). The GCA's baseline survey conducted by Huggins & Thompson (2023) identified 17 ecological communities likely to support a variety of SAR confirmed on neighbouring properties within the Mid-Island Protected Areas Network. Quadra Hill is a priority for forest protection and, as part of the CDFmm, is ranked high in the Islands Trust Conservancy's most recent 5-year Regional Conservation Plan (Huggins & Thompson, 2023).

Map 2: Location of Quadra Hill relative to the Mid-Island Protected Areas Network

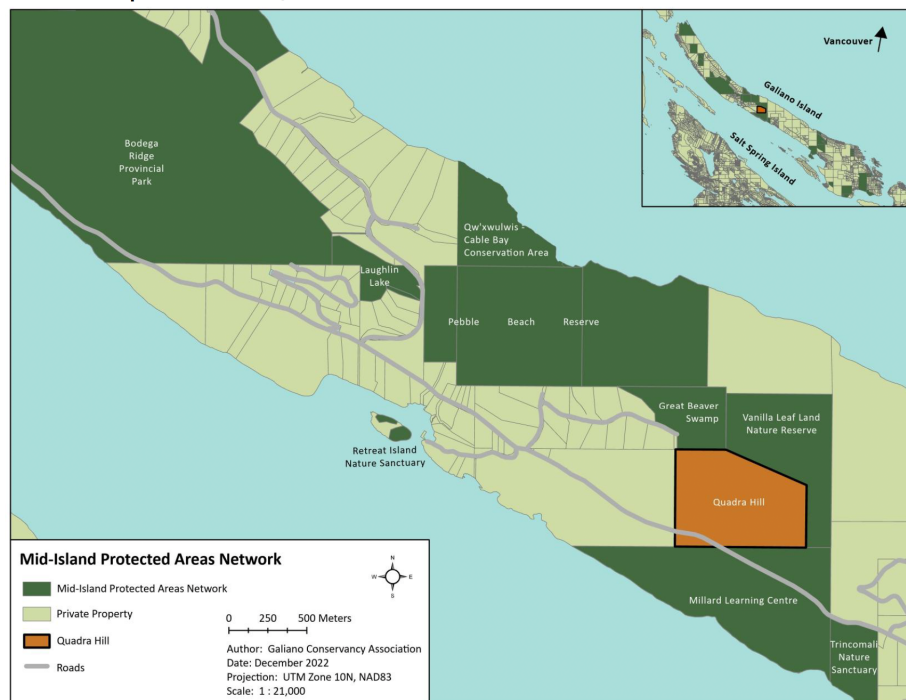


Figure 2. An aerial map of Galiano Island, provided by the Galiano Conservancy Association. The Quadra Hill property is coloured in orange. Huggins & Thompson, 2023, p. 10

Restoration Goals Aligned with this Project

GCA Restoration Plans

GCA staff, led by Ecological Restoration Coordinator Adam Huggins and Conservation and Climate Coordinator Michelle Thompson, are in the early stages of planning for wetland and forest restoration activities at the Quadra Hill site. They are early in the process of consultation with experts, including a wetland ecologist and a forester, who will assist in assessing the current condition of the Quadra Hill forests and wetland area and provide guidance throughout the restoration process. According to Michelle Thompson, wetland restoration will focus on a degraded site dominated by introduced species in the northwest corner of the property. Wetlands are crucial in providing habitat and maintaining regional biodiversity, hydrological cycles, and water quality, and contributing to carbon sequestration

(Community Mapping Project, 2018). The wetland restoration will be informed by the work of the “Cedars for the Next Century” project at the Millard Learning Centre. Forest restoration at this site will likely focus on thinning the densest areas of regenerating Douglas fir forest. Forest thinning in ecological restoration involves selectively removing a portion of trees to improve forest health and biodiversity and to reduce the likelihood and severity of wildfires (Douglas & Burton, 2005). Thinning can create gaps in the forest canopy, allowing more light to reach the forest floor and promoting the growth of understory vegetation. Ecological restoration at Quadra Hill has broad implications as forests within the Islands Trust area of the CDFmm have been shown to sequester more carbon per hectare than anywhere else in BC (Islands Trust, 2018).

Ecological Restoration Goals

It is beyond the scope of this report to provide a rigorous and comprehensive restoration plan for Quadra Hill’s disturbed wetland and plantation forests. In terms of practical objectives, we propose obtaining data on the presence and patterns of Western Screech-Owl, Olive-sided Flycatcher, and Marbled Murrelet in Quadra Hill before, during, and after the commencement of wetland and forest restoration work onsite.

METHODS

Consultation with GCA Staff, Board, Galiano Island Community Members and the Salt Spring Island Conservancy

Consulting with GCA staff, primarily Michelle Thompson, on the conservation and restoration priorities of the GCA guided this project. While on Galiano Island at the Millard Learning Centre, we had the opportunity to meet with Michelle face-to-face on several occasions to discuss the GCA’s needs and goals. Further, we conducted several field visits to the Quadra Hill site. On our initial visit, we accompanied Michelle to the location of sound recorder #1 to assess the site and record bird sounds en route. At this initial visit, we also observed the central wetland area and recorded bird sounds, noting the presence of several avian SAR, including the Sooty Grouse (*Dendragapus fuliginosus*) and Band-tailed Pigeon (*Patagioenas fasciata*). On our second visit to Quadra Hill, we accompanied GCA Executive Director Chessi Miltner on a walk through the southwest area of the property to observe the densely regenerating Douglas fir forest and hear his thoughts on needed restoration for the area.

Further consultation with Galiano Island community members occurred through several pathways. We presented our preliminary findings and outline of this project on July 1st, an event that several GCA Board members attended. Board members expressed interest in the project, including commenting on the habitat preferences and behaviour of Western Screech-Owls. Two Galiano Islanders stand out as bird and biodiversity experts: Mike Hoebel (ornithologist) and Andrew Simon (Ph.D. candidate, Biodiversity Data Science). We have aimed to incorporate the ideas and priorities discussed during the consultation process.

The Salt Spring Island Conservancy is currently running a 3-year funded Western Screech-Owl Stewardship Project. Ren Ferguson, project lead, was consulted as an expert in monitoring for Screech-Owls and establishing a successful monitoring program.

In addition to the parties consulted, additional considerations include private landowners in and around monitoring sites, Galiano Island citizen scientists and bird enthusiasts, and members of the Penelakut First Nation. Consultation with Penelakut First Nation community members is intended to honour their cultural heritage and presence in this territory since time immemorial. Consultation can support integrating Penelakut's traditional ecological knowledge rooted in millennia of observation and interaction with local fauna and flora. Indigenous communities like the Penelakut are currently experiencing significant demand for consultation and a high level of discernment is required before requesting engagement. GCA staff, particularly Adam Huggins, have been working to establish trust and build relationships with Penelakut elders and cultural advisors. We think leaving consultation regarding this project (interconnected as it is with Quadra Hill restoration) in the hands of GCA staff to consult as appropriate is prudent.

Given the constraints of this project, we did not engage in community-based focus groups or other forms of public consultation, such as surveys or online platforms. However, once our draft report for the GCA is completed (potentially an 'executive' type 2-page summary), we will share it with the GCA and other stakeholders for review and feedback, making necessary revisions based on input received. By engaging in a consultative process that fits this project, we hope to contribute to the conservation and restoration efforts on Galiano Island while respecting the needs and priorities of the local community and GCA.

Literature Review

- The GCA's Quadra Hill Baseline Report (2023) provided the collateral and detailed information about ecosystems within the Quadra Hill site.
- Erickson, K. (2012). *Species at risk on Galiano*.
<https://galianoconservancy.ca/species-at-risk-on-galiano/>
- Verbenkov, M. (2011). *Species at risk status report: Galiano Island*.
https://galianoconservancy.ca/wp-content/uploads/2016/11/SAR_Local_Galiano_Status_Report_March_2011.pdf

Database Review

A database review was conducted to determine a prioritized list of avian SAR that could feasibly be found on the Quadra Hill site. The following databases were consulted:

- iNaturalist, "Galiano Island": This scientist and citizen scientist compilation of field sightings was used to determine which bird species have been identified on Galiano.

- Government of Canada, Species at Risk Public Registry, “Special Concern, Threatened and Endangered bird species in British Columbia”: This public registry listing was utilized to hierarchically bird species by their respective level of concern.
- Avibase - The World Bird Database, “Galiano Island Ecological Reserve”: A collection of birds identified within the Galiano Island Ecological Reserve, located 9.1 km north of Quadra Hill.

Historical Bioacoustic Monitoring Data Review

GCA microphone data from April 21-May 4, 2023 were reviewed. Future work should involve listening to samples of recorded data to confirm the accuracy of BirdNET identification. See Appendix A for a sample of the recorded and identified bird species, time of recording, and confidence in identification from BirdNET software. Recordings comprise approximately 100 pages and were not appended in this report, but can be accessed through the GCA’s records.

Present Bioacoustic Monitoring

Cornell University’s “Merlin Bird ID” app was used to assess the presence of bird life within three areas at the Quadra Hill site: #1 sound recorder site (30 mins recording), the site of future wetland restoration (1 hr recording) and site future forest restoration.

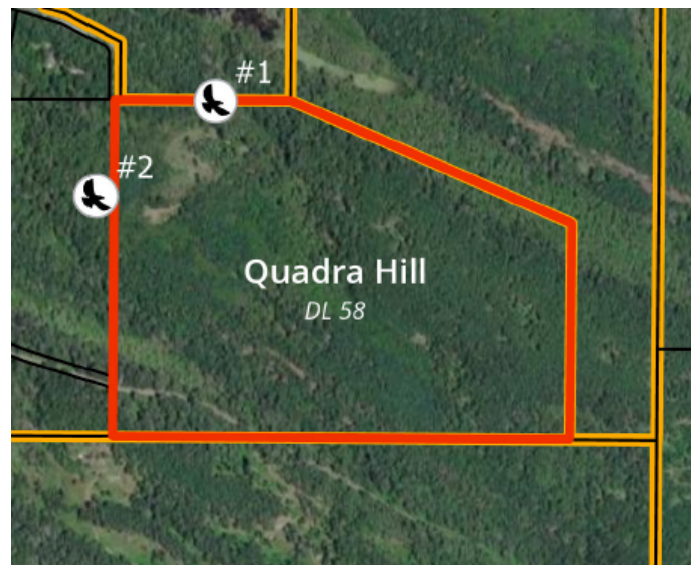


Figure 3. The two PAM audio device locations, previously positioned by the GCA, are presented on the map as #1 and #2. Huggins & Thompson, 2023, p. 3

Observation of Sites

GCA staff had previously arranged one PAM device in a lower-slope, mature Douglas fir and Western redcedar forest on the north edge of the site (Device #1 in Figure 3). This site was selected for its likelihood of providing Western Screech-Owl habitat, a species which prefers mixed, older-growth forests. Trees older than 100 years old were present, as well as native undergrowth species such as salal (*Gaultheria shallon*) and Dull Oregon grape (*Mahonia*

nervosa), though sparsely. Western Screech-Owls were not detected on this site in the April/May nocturnal recording period. This site is referred to as Site #1.



Figure 4. Mature Douglas fir and Western redcedar trees in PAM audio device #1 location, on the northern edge of the Quadra Hill property.

The GCA wished to explore the feasibility of alternative, possibly more effective PAM sites on the Quadra Hill property. Within an ecosystem restoration context, there was a desire to position devices in sites slated for ecosystem restoration work. Collecting baseline PAM data in these sites prior to, during, and after restoration work would provide valuable insight into the benefit of habitat restoration for bird species-at-risk. With this in mind, two sites were selected, illustrated in Figure 5:

- Site A: a disturbed swampland in the North-west corner of the Quadra Hill property;
- Site B: a young, highly dense, Pole-sapling conifer forest on the Southern border.

Site visits were conducted on July 29, 2023 and July 30, 2023, to visually assess the feasibility of acoustic monitoring in the proposed sites. The relative locations of Sites A and B are circled on the aerial map in Figure 5.

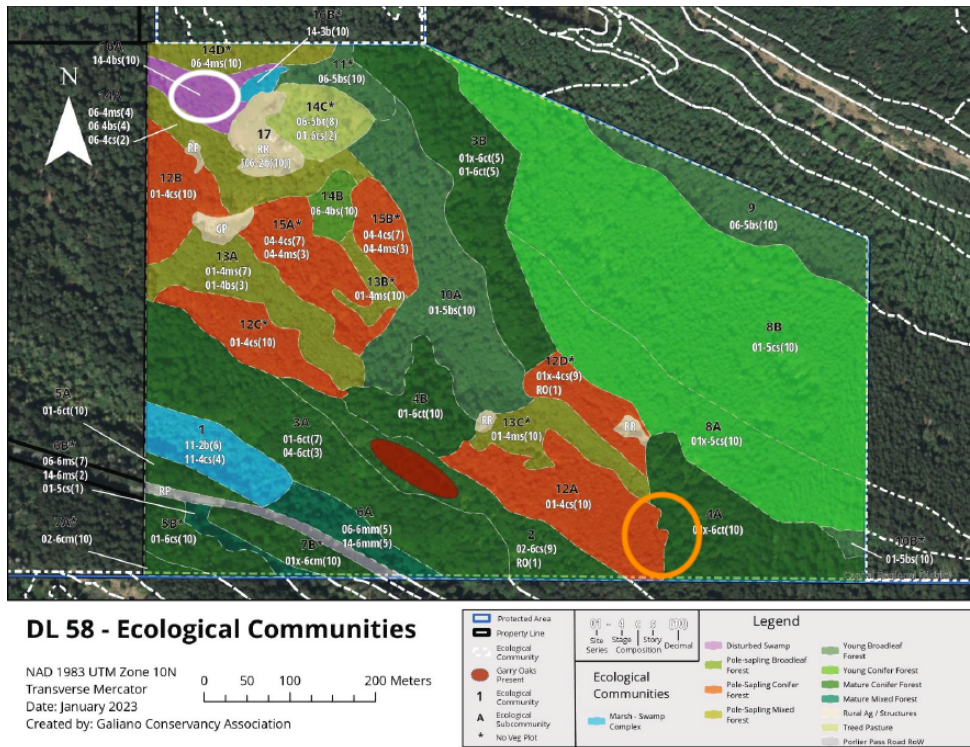


Figure 5. Site A is depicted by the white circle in the north-west corner of the Quadra Hill property. Site B is depicted by the orange circle along the property’s southern border.

Site A was most recently used for goat pasture and currently consists of tall grasses, Canada thistle (*Cirsium arvense*), foxglove (*Digitalis purpurea*), Bracken fern (*Pteridium aquilinum*) and a ring of Red alder (*Alnus rubra*) and small Western redcedar (*Thuja plicata*) trees encircling the open grassland. No evidence of standing water exists in the former swamp.



Figure 6. Red alder, bracken fern, and foxgloves pictured around the disturbed swamp/current pasture of Site A.

Site B consists of highly dense, pole-sapling (younger than 40 years) Douglas fir trees. The forest is arid with significant surface fuels comprised of dry, dead branches on the ground and lower trunks of trees. Deciduous trees and native understory species such as salal, trailing blackberry and ferns are absent.



Figure 7. Site B consists of a highly dense, immature Douglas fir forest along the southern border of the Quadra Hill property. Vehicle-supporting roads and rough trails run through the site.

RESULTS

The Western Screech-Owl *kennicottii* subspecies was previously selected by the GCA for bioacoustic monitoring at the Quadra Hill site. We selected two additional bird species to recommend for bioacoustic monitoring as suitable for the scope of this project. A benefit of BirdNET software is its capacity to identify many diverse species captured by PAM beyond the project's priority species. When selecting the 2 additional at-risk species, we chose two species previously detected with a relatively high degree of confidence at the Quadra Hill site. Baseline detections may serve as a metric of successful habitat restoration, indicating an increase in local populations following the forest and wetland restoration. The Olive-sided Flycatcher and the Marbled Murrelet were detected, as seen in Table 1, and are listed as Special Concern and Threatened, respectively (SARA, 2012; 2018). Therefore, we recommend these bird species to monitor: Western Screech-Owl, the Olive-sided Flycatcher, and the Marbled Murrelet.

Are Western Screech-Owls *kennicottii* subspecies on Galiano Island?

There is little question the Western Screech-Owl population is small in Southern coastal BC, with threats such as large-scale forest harvesting, land conversion, loss of snag trees, and predation/competition from Barred Owls *Strix varia* (Ferguson, 2022). Older, complex forests likely protect Screech-Owls from Barred Owl predation (Habitat Acquisition Trust, 2021).

Data from various sources, including INaturalist, anecdotal information from Galiano Island community members, older reports (i.e., Verbenkov, 2011) and PAM from April-May 2023 do not show the presence of Western Screech-Owls on Galiano Island. According to Mike Hoebel (personal communication July 12, 2023), there was a breeding pair behind his house when he moved to Galiano Island 40 years ago - alas, this owl hasn't been detected on Galiano Island in 30 years. Mike led citizen science monitoring on Galiano Island in February for the Western Screech-Owl without any detections. He agrees this species could have been extirpated.

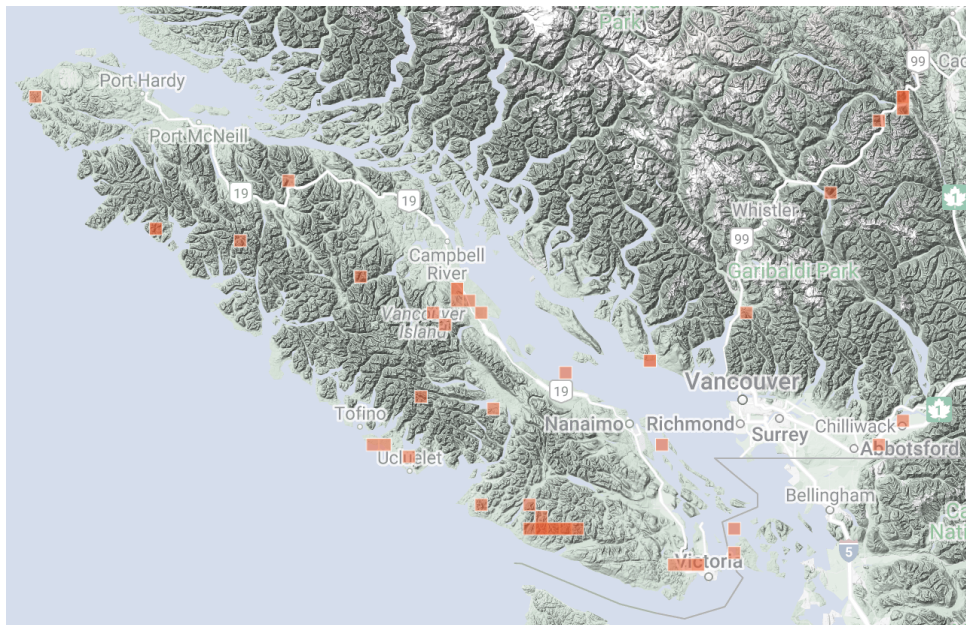


Figure 8. INaturalist. (n.d.a). Western Screech-Owl sightings around Vancouver Island.

What time of day is best to detect Western Screech-Owls?

Western Screech-Owl vocalizations are used for territorialism, mating, and communication with their young and include a series of trills, whinnies, and hoots, sounds that imitate a bouncing ball (Ferguson, 2022). These owls are primarily active at night, and owl surveys are typically conducted half an hour after sunset until midnight (Birds Canada, 2023). Owl call rates are the lowest between midnight and 4 AM (Birds Canada, 2023). Ren Ferguson, lead of SSIC's (2022) Western Screech-Owl monitoring project, notes that their team searched forest habitats after dark in February and March.

What season is it best to hear Western Screech-Owls?

According to iNaturalist (n.d.a) data, between 2014-2023, most sightings of the Western Screech-Owl in southern coastal BC occurred in late April and early May. This owl's breeding season typically occurs from late winter to early spring, when they vocalize to establish territories and communicate with mates (COSEWIC, 2012). According to Mike Hoebel (personal communication July 12, 2023), February is a good time to hear the Western Screech-Owl as this is when mating season begins, and the British Columbia Nocturnal Owl Survey occurs on BC's south coast. Ren Ferguson (personal communication July 17, 2023), lead of the Salt Spring Island Conservancy's Western-Screech Owl monitoring program, recommends nocturnal surveys in February and March. Birds Canada (2023) notes that surveys can also be done in the spring months.

What habitat is the best site to place the acoustic monitoring?

To increase the likelihood of hearing a Western Screech-Owl, it is generally recommended to monitor in their preferred habitats, which include multi-aged, low-elevation coniferous and deciduous forests with moderate ground cover and relatively open canopy cover close to riparian zones. They are a secondary cavity-nesting species requiring large-diameter trees (Ferguson, 2022). While typically associated with old-growth forests, they can also be found in stands aged 30 to 100 years if older remnant structures, such as mature snags for nesting, remain (BC Ministry of the Environment, 2013). According to the BC Ministry of Environment 2013 report, preferred forest stands include Douglas fir (*Pseudotsuga menziesii*), Western hemlock (*Tsuga heterophylla*), Western redcedar (*Thuja plicata*), grand fir (*Abies grandis*), red alder (*Alnus rubra*), big-leaf maple (*Acer macrophyllum*), Garry oak (*Quercus garryana*), and arbutus (*Arbutus menziesii*).

Ren Ferguson (personal communication July 17, 2023) has encountered Western Screech-Owls in second-growth Arbutus and Douglas Fir forests in the past several years on Salt Spring Islands. Ren also notes that these owls do not prefer riparian areas on Salt Spring or Link Island, perhaps because the Barred Owl takes up that preferred habitat.

On Galiano Island, Verbenkov (2011) identified 8.42% of the Island as potential habitat, 29% of which is protected. Given that this data is more than a decade old, however, potential habitat may have increased marginally due to reduced tree harvesting and forestry activities on the island. Quadra Hill, included in a swath of protected land stewarded by the GCA, has potential for Western Screech-Owl habitat.

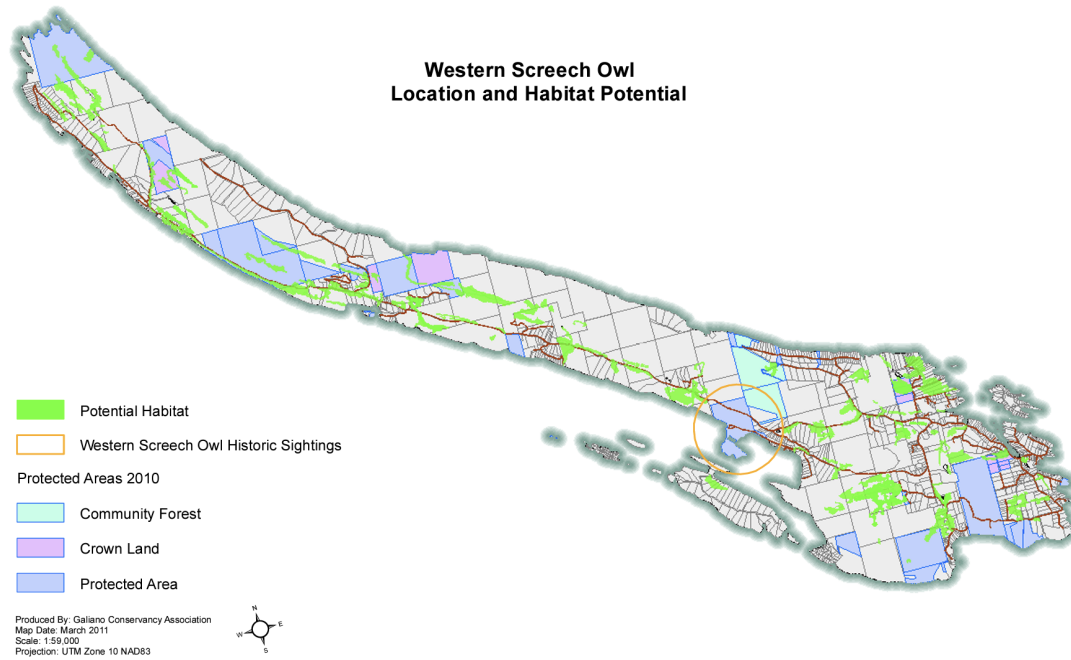


Figure 9. An aerial depiction of the potential habitat for Western Screech-Owls on Galiano Island. Verbenkov, 2011, p. 80

Any other indicators or general information that would help determine the location of the acoustic monitoring?

According to Birds Canada (2023), nocturnal owl surveys on the south coast of BC use playback of Western Screech-Owl calls to increase the potential detection of these owls. Five minutes are spent at each spot positioned 1.6 km apart on secondary roads. However, Ren Ferguson (personal communication, July 17, 2023) does playback very judiciously given that the call of a Western Screech-Owl will attract its predator the Barred Owl.

Which additional avian species at risk should be assessed for?

The Olive-sided flycatcher and the Marbled Murrelet were detected, as seen in Table 1, and are listed as Special Concern and Threatened, respectively (SARA, 2012; 2018). The preferred habitat of these species is also present at the Quadra Hill site, once sufficient restoration work is completed. For the location of the previous audio devices, refer to Figure 3.

Table 1. Historical Bioacoustic Monitoring Data, recorded from April 21- May 4, 2023.

Microphone 1	Microphone 2
Marbled Murrelet x 1	Marbled Murrelet x 65
Olive-sided flycatcher x 6	

Olive-sided Flycatcher

What time of day is best to detect Olive-sided Flycatchers?

Like most songbirds, the early morning hours before sunrise and at dawn (i.e., the “dawn chorus”) are the most likely times for audio detection. Merlin app recordings obtained at the GCA’s Millard Learning Centre indicated the presence of the Olive-sided Flycatcher at 4:45 and 5:30 AM in late June and early July 2023.

What season is it best to hear Olive Sided-flycatchers?

Olive-sided Flycatchers arrive on BC breeding grounds between April and June, with a spike in mid-May (COWESIC, 2018). The spring migration in April and May is the best time to hear this bird (Mike Hoebel personal communication July 12, 2023). Olive-sided Flycatchers migrate south from late July until early September (COWESIC, 2018).

What habitat is the best site to place the acoustic monitoring?

The Olive-sided Flycatcher's preferred habitat includes mixed coniferous forest with tall trees and/or snags. The forest should be adjacent to open land in the form of wetland, meadow, or open area created by fire or human disturbance (COSEWIC, 2018).

The GCA’s #1 acoustic monitor picked up the Olive-sided Flycatcher. On our visit to the site, we observed a mixed-age coniferous forest with several older trees and nearby openings (i.e., the road into the property).



Figure 10. A mature forest composition of older Douglas fir and Western redcedar trees, integrated with open canopies and young pole-saplings. Moss, lichen, and native undergrowth species such as salal and bracken fern were present.



Figure 11. Restoration students walk along a vehicle road adjacent to the old-growth forest on the north-west edge of the Quadra Hill property. Roads create edge effects in forest habitats.

Mike Hoebel (personal communication July 12, 2023) has reliably encountered this bird in the Bodega Ridge area of Galiano Island. In accordance with Verbenkov (2011), however, Mike notes that Olive-sided Flycatcher can be found across Galiano Island. Verbenkov (2011) also noted sightings on Galiano Island primarily near wetlands and meadows, cliffs and ridges, and mature mixed canopy forests.

According to Verbenkov (2011), nearly 40% of Galiano Island is potential habitat for this bird. Further, most of the forest on Galiano Island is second growth and tree harvesting has not occurred in recent decades. As such, forest stands with naturally created (e.g., by windfall) openings may provide adequate habitat for the Olive-sided Flycatcher.

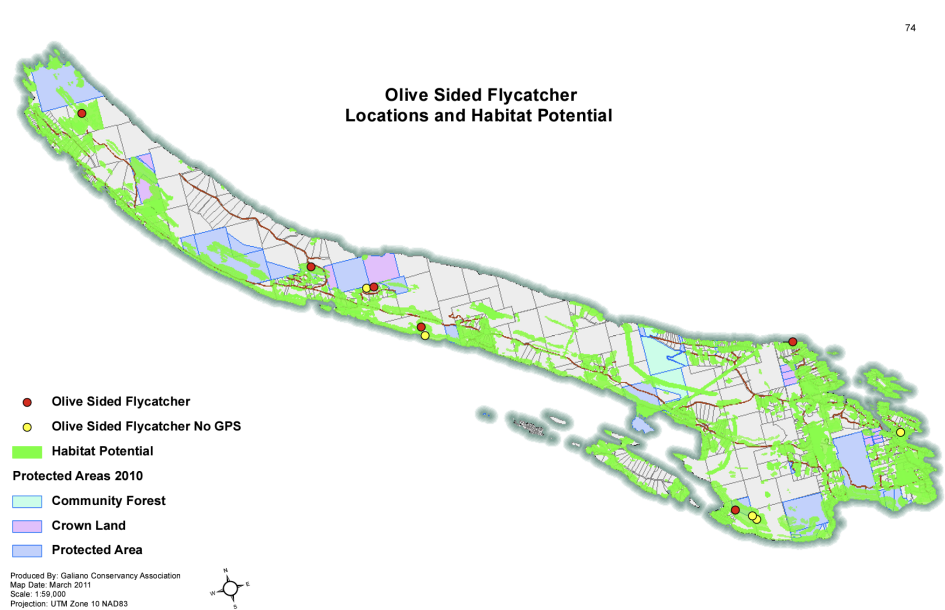


Figure 12. An aerial depiction of the potential habitat for Olive-sided Flycatchers on Galiano Island. Verbenkov, 2011, p. 74

Any other indicators or general information that would help determine the location of the acoustic monitoring?

Olive-sided Flycatchers prefer to perch in tall trees and snags, therefore a tall snag would be an ideal location for positioning the PAM device on.

Marbled Murrelet

What time of day is best to detect Marbled Murrelet?

Dawn or dusk is typically the best time to hear their vocalization, a “keer-keer” sound, as this is when individuals fly to and from their nests (Ministry of Environment, Lands and Parks, 1998). According to the GCA’s acoustic monitoring (and BirdNET’s interpretation), Murrelets were heard at about 5:30 AM consistently.

What season is it best to hear Marbled Murrelet?

Marbled Murrelets occur year-round in BC, and the fluctuation of local populations is not well understood (Burger 2001). GCA acoustic monitoring from spring 2023 identified Marbled Murrelets at both audio recorder sites. However, Mike Hoebel (personal communication July 12, 2023), notes that hearing this bird in the spring on Galiano Island is unlikely. Mike states he has only heard the occasional Marbled Murrelet during the Christmas bird count. Indeed, the two iNaturalist sightings logged for Galiano Island (by Galiano community member Andrew Simon) are from December 20, 2015 and February 8, 2023. Murrelets were spotted and heard nearby on Salt Spring Island in October 2019 and February 2022. That said, there have been 1224 logged observations on iNaturalist spanning the entire North American west coast from the Aleutian Islands to San Diego and in the Salish Sea bioregion, sightings have occurred throughout the year (iNaturalist, n.d.b).

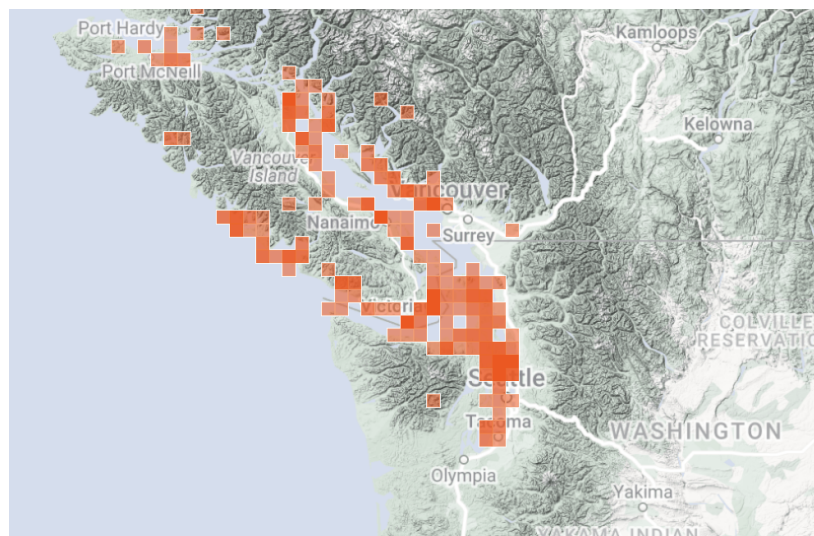


Figure 13. iNaturalist. (n.d.). Marbled Murrelet sightings around Vancouver Island.

What habitat is the best site to place the acoustic monitoring?

Marbled Murrelets are commonly found in sheltered inshore waters hunting for prey consisting mainly of schooling fish like herring, but also including crustaceans and large fish like salmon (Burger, 2001). They are unique in their preference to nest in the large mossy boughs of old conifer trees aged at least 200 years old. Old forest logging has and does pose a threat to their populations.

Any other indicators or general information that would help determine the location of the acoustic monitoring?

Not as yet identified.

Table 2. Summary of the selected three avian species at risk.

	Western Screech-Owl	Marbled Murrelet	Olive-sided flycatcher
At risk classification	Threatened	Threatened	Special concern
Habitat	Mixed coniferous and deciduous forest adjacent to riparian zones, prefers old forest	Old forests within 80 kilometres of the ocean	Mixed coniferous forest with open areas and tall trees or snags, requires some mature forest
Best day/time of year to detect them	Sunset to midnight	Dawn and dusk	Dawn
Best season to detect them	Late winter through spring	Winter	Spring and early summer

Assessing BirdNET

What is an acceptable percentage or level of confidence in the acoustic monitoring software? How can the acoustic monitoring equipment be improved (e.g., using a sponge to cover the monitor during rain)?

Passive acoustic monitoring coupled with BirdNET has been identified as an accurate, repeatable, and cost-effective method to rapidly and efficiently surveying avian diversity, and for some researchers revolutionize the fields of avian ecology, conservation, and citizen science (Kahl et al., 2021; Manzano-Rubio et al., 2022).

BirdNET, developed by the Center for Conservation Bioacoustics at the Cornell Lab of Ornithology and the Chemnitz University of Technology, is a free and recently developed bird sound recognizer that uses machine learning trained on a vast dataset of bird sounds. This dataset of bird sounds consists of thousands of recordings, primarily from citizen scientists, ornithologists and wildlife biologists. BirdNET's machine learning deep neural network learns

to recognize patterns and features within the audio signals to differentiate between different bird species. While this technology is impressive, questions remain about its accuracy. Indeed, in conversations with GCA staff and Galiano community members, we consistently heard doubts about the trustworthiness of BirdNET.

The reliability of BirdNET is generally considered to be quite high (Cole et al., 2022; Wood et al., 2022). Kahl et al. (2021) assessed BirdNET's ability to correctly classify bird vocalizations of 984 species. They found an overall precision of 0.791 (see an extended review in Pérez-Granados, 2023) or 79%, while Mazano-Rubio et al. (2022) found an average precision of 0.75 or 75%.

However, Pérez-Granados (2023) found BirdNET's ability to correctly identify bird songs varied among species and generally decreased over distance. Accuracy of species identification may be impacted by the quality of the audio recording, the presence of background noise, and when encountering rare or less frequently documented birds with limited representation in the data set (Pérez-Granados, 2023). In such cases, BirdNET might provide a similar-sounding species as a potential match. According to ornithologist Mike Hoebel (personal communication July 12, 2023), Merlin and BirdNET applications are impressive bird identifiers but he observed several glaring discrepancies in the past year when comparing birds by sound and sight.

Assessing Available Habitat & Habitat Quality

Quadra Hill Property - Geographical Details

- Latitude and Longitude 45°51'18.23"E, 54°20'33.30"N
- Zoning DL 58 is zoned Forestry 1 (F1), a classification intended for forestry-related activities (e.g., sawmilling, timber production, and nursery).
- Elevated Groundwater Catchment Areas, DPA 5 - Sensitive Ecosystems, and DPA 7 - Steep Slopes in Galiano Island's Official Community Plan (OCP).
- 46.94 ha (116 acres) Elevation 57.88 - 185.77m

Old Forest

The location used by the GCA for Audio Device #1 consists of lower-slope, mature, mixed Douglas fir and Western redcedar forest. Audio Device Trap #2 is located off of the Quadra Hill property and is therefore not recommended as a PAM device location in the case of private landowner changeover or change in permission.

Site A: Wetland Restoration Site

The disturbed swamp-turned-pasture is an ideal site for restoring a native wetland. Already, many songbirds and several avian SAR (Band-tailed pigeon, Sooty grouse) were detected in Site A, as the open area and prominent insect populations provide ideal hunting habitat.

Site B: Forest Restoration Site

The highly dense, plantation forest of Douglas fir saplings represents an ideal opportunity for forest restoration. The visit to Site B yielded very little bird detections through the Merlin ID app, and was palpably more silent than Site A and the mature forest areas of Site #1 and the south-east corner.

DISCUSSION

The following summaries and discussions relate to the original two core aims outlined in the introduction of this report.

Core Aim #1: Identify optimal passive acoustic monitoring (PAM) sites within Quadra Hill for three at-risk bird species.

Sites #1, A and B are important to continue to include in the GCA's PAM program. Site #1 represents a mature Douglas fir and Western redcedar forest with an adjacent open grassland/former wetland. Based on the forest's conditions and characteristics, the Western Screech-Owl, and the Olive-sided flycatcher would likely use this habitat. The Marbled Murrelet, which tends to nest in trees which are over 200 years old, would have some difficulty finding sufficiently mature trees in Site #1 (Mather et al, 2010). This mixed, old-growth forest can also provide data to compare to Site B before, during and after the forest restoration work.

Site A, a goat pasture converted from a swamp wetland, represents an optimal PAM site on the Quadra Hill property. Once wetland restoration is complete, Site A will consist of permanent or long-standing water, and mature Red alder, Western redcedar and skunk cabbage (*Lysichiton americanus*). Western Screech-Owl and the Olive-sided flycatcher will greatly benefit from this habitat, as they both require open grasslands or wetlands nearby to mixed, old-growth forest.

Site B, an immature plantation with high density, minimal canopy openings, and monoculture Douglas fir trees, is an optimal PAM site, specifically to showcase the potential for at-risk species support following restoration work. Restoring a mature, diverse forest with tall trees and complexity would create ideal habitat for all three avian SAR. In addition, numerous other avian SAR could be recorded, including the Band-tailed pigeon, Sooty grouse, common nighthawk, and barn swallow.

Acoustic Monitoring and Conservation Considerations for Avian Species at Risk

In the interest of optimizing their PAM program, the GCA may consider obtaining additional sound recorders. For example, the Salt Spring Island Conservancy (SSIC) has borrowed ten from the province and has 5 of their own for their Western Screech-Owl monitoring project,

with spacing of between 400-800 metres between each recording unit (Salt Spring Island Conservancy, 2022). The total monitoring area for their project is unknown. The GCA can determine the size of the monitored areas (e.g., the total size of site A & B on the map may total ~1 hectare) and therefore the ideal number of recorders. With cost an issue, the GCA may consider making a request to borrow sound recorders from the BC Ministry of the Environment (as the SSIC has done), or purchasing several more. Alternately, Wildlife Acoustics has a grant program (see <https://www.wildlifeacoustics.com/grant-program>) with multiple sound recorder options. Finally, sound recorders can simply be moved along within the appropriate habitat.

Western Screech-Owl Monitoring

Monitor for the Western Screech-Owl from half an hour after sunset to midnight in February and March. According to Ren Ferguson (personal communication July 17, 2023) it is ideal to space audio recording units between 400-800 metres apart, then move them along throughout the appropriate habitat at Quadra Hill and have decent coverage through these two months. However, Ren has observed that BirdNET has occasionally misidentified a Western Screech-Owl call. As such we recommend that to assess for the presence of Western-Screech Owls, the GCA needs to conduct a nocturnal owl survey (which includes both auditory and visual survey) in and around the Quadra Hill site in February and/or March by engaging with Mike Hoebel, Andrew Simon and other local experts and citizen scientists. In his 2011 study, Verbenkov (2011) recommended ongoing monitoring particularly by local landowners.



Figure 14. A Western Screech-Owl pictured nesting in a cavity on Salt Spring Island. Photo credit: Ren Ferguson (2022)

The Salt Spring Island Conservancy launched an Environmental and Climate Change Canada-funded three-year Western Screech-Owl monitoring project in 2021 led by Ren Ferguson (Ferguson, 2021). The project has consisted of nocturnal surveys, monitoring of active territories, habitat enhancements (i.e., 30 nest boxes), and public education. In addition to engaging with interested landowners and visiting sites where owls are known to

present (or have been in the past), the SSCI team has conducted nocturnal surveys over 60 kilometres of forested habitat along Salt Spring roads. In the first season of the project, three males and one pair were detected (Ferguson, 2022). In the greater Victoria area, the Habitat Acquisition Trust (HAT, 2021) is working to identify Screech-Owl-appropriate nesting locations and to create nest boxes that are attractive to Screech-Owls and resistant to Barred Owl predation. HAT is also working to protect older forest stands where the few remaining pairs live. In collaboration with Power to Be, a non-profit organization increasing access to nature for diverse groups in the Greater Victoria region, HAT has monitored a site near Prospect Lake. While PAM did not show the presence of the Western Screech-Owl, the annual nocturnal owl survey did find their presence (Power to Be, 2021).

There is clearly much to be learned from collaborating with local conservation organizations engaged in the same work, especially when it comes to optimal acoustic monitoring and field observation of this small owl.

Olive-sided Flycatcher Monitoring

Olive-sided Flycatcher monitoring sites #1, A, and B are appropriate to monitor in spring and early summer (April - June) for the dawn chorus. With the knowledge that Olive-sided Flycatchers prefer to perch in tall trees, snags, or previously burned trees, the PAM device should be positioned in one of these, with some canopy openness surrounding the perch tree. Care should be taken in positioning the device at a height that is both easily accessible to humans (without a ladder or additional equipment), but high enough that the PAM device can detect the Olive-sided Flycatcher. Both Site A and B have potential to provide habitat for the Olive-sided Flycatcher. Site A contains the adjacent, open grassland and prominent hunting ground for many songbirds. Following restoration work, Site B should contain mixed conifer and deciduous forest, with older growth trees and a native undergrowth present.



Figure 16. Two Olive-sided Flycatchers. Photo credit: Daniel Streiffert/Flickr (CC-BY-NC-2.0)

In the context of the Quadra Hill property, tall snags and saplings with the potential to grow tall should be mindfully protected. Selective thinning of Douglas fir trees in Site B should

allow some saplings to grow tall enough to entice the Olive-sided Flycatchers to nest in. While difficult to inform policy on deforestation and land conversion regulation in South America, research and policy recommendations may still play a significant role in protecting critical winter habitat (Norris et al., 2021).

Marbled Murrelet Monitoring

Following restoration, Site B represents the long-term potential for an ideal habitat and acoustic monitoring site for the Marbled Murrelet. Site B should eventually contain a mixed coniferous-deciduous forest, with plenty of old-growth trees present and rich, native undergrowth present. Site B is located within 2.5 km of the shore, which is adequate for the Marbled Murrelet's nesting.

The Canadian Marbled Murrelet Recovery Team, in conjunction with researchers across Vancouver Island, developed a habitat suitability algorithm to assess the potential available habitat for the Marbled Murrelet (Mather et al, 2010). Deforestation is a major threat to the large, mature conifer trees which Marbled Murrelet nest in, which are older than 200 years on average. With this understanding, the timescale for measuring success of forest restoration efforts in the Douglas fir plantation of Site B extend far into the future. Monitoring plans should be planned such that they extend into the future, as current saplings in Site B are on average less than 30 years old.



Figure 17. A nesting Marbled Murrelet, perched in a nest of moss and lichen in the crook of an old-growth redwood tree in California. Photo courtesy of the National Park Service of California, accessed from <https://www.nps.gov/redw/learn/nature/marbled-murrelet.htm>.

Core Aim #2: Assess the reliability and accuracy of the BirdNET software for acoustic monitoring.

While utilizing deep neural networks (DNN) in the context of bird identification via audio recordings is a relatively new technique, current results assessing the accuracy of BirdNET are promising, and warrant incorporating the software into the GCA's monitoring plan. Consideration must be given to the trend of decreasing accuracy across farther distances,

and we encourage the vetting of detection of scarce bird species with locally-based avian specialists. As the repository of bird calls fed to the DNN increases, the accuracy of identification will increase, so enhanced trust in the BirdNET software can be predicted over time.

Considerations for BirdNET for the GCA's Use

1. Validate results with field observation. Cross-referencing BirdNET's results can help to verify the accuracy of identified species.
2. If identifying a particular bird species is critical or requires a high degree of confidence, as is the case with species-at-risk monitoring, consider reaching out to local ornithologists, birding experts, or birdwatching communities for their input.
3. BirdNET is continuously evolving and learning from data entered by citizen and professional scientists so contributing data is important.

While current applications of BirdNET often focus on one or a few species, the raw audio contains sounds from many other bird species, thus enabling community-level studies (Wood et al., 2019a). Beginning to track various avian SAR is relevant for the GCA's mandate and in regards to bird conservation, species at risk recovery, and ecological restoration.

Considerations for Ecological Restoration

The GCA has previously assessed the 17 unique ecological communities on the Quadra Hill property, and created a general plan for restoring the disturbed swamp in Site A and the dense, Douglas fir plantation in Site B. Therefore, the recommendations for ecosystem restoration in this report offer tailored suggestions based on the habitat requirements of our avian SAR.

(Site A) For the disturbed wetland habitat in the central area of the north-west corner of the property, ecosystem restoration approaches would focus on:

- Decompaction of the soil, previously housing goats and derelict buildings
- Introduction of a large depression or series of depressions to collect and retain water
- A more historically continuous composition of native wetland species

Predicted restoration co-benefits of the restored wetland in Site A to the Western Screech-Owl and the Olive-sided Flycatcher include an increased space for effective hunting and an increase in the population of native insects for feeding, respectively.

(Site B) For the dense, 2nd growth Douglas fir forest in the south-east corner of the property, ecosystem restoration approaches would focus on:

- Decreasing the density and opening the canopy of the Douglas fir trees present
- Reducing ladder and surface fuels in the understory of the forest

- Encouraging a return of native undergrowth species in line with a Coastal Douglas fir ecozone

Predicted restoration co-benefits of the restored mature, mixed forest in Site B to the Western Screech-Owl, Olive-sided Flycatcher and the Marbled Murrelet are the development of tall, mature trees aged over 200 years old (eventually).



Figure 18. A mature, Douglas fir tree located in the south-eastern mature forest on the Quadra Hill property. Chessi Miltner, Executive Director of the GCA, estimates it to be over 200 years old, and a survivor of a low intensity fire.

RECOMMENDATIONS

Monitoring Program Recommendations

1. The PAM program should include monitoring in December (Murrelet), beginning February-mid April (Screech Owl), and May (Flycatcher). Consider nocturnal monitoring for the Screech-Owl, dawn for the Olive-sided Flycatcher and dawn and dusk for the Murrelet. Sites can be located and shifted throughout Quadra Hill and include #1, A, and B.
2. In forest areas where potential roosts and nesting trees (tall and mature coniferous trees) are not present (or will not be for 100+ years), consider installing artificial nest boxes (BC Conservation Science Data Centre, 2017). Nest boxes should be designed similar to the HAT design such that they are attractive to screech-owls and resistant to barred owls and racoons. Nest boxes would be most appropriate if the owls are sited or heard.

3. Engage with Galiano Island community members, including interested landowners where owls were known to be present in the past as well as those having advanced local bird knowledge. Collaborate on a nocturnal owl survey and a morning songbird appreciation and identification event, and inviting members of the Galiano Island community will raise public awareness on habitat conservation, especially useful amidst private landowners who may be encouraged to conduct citizen science-style monitoring programs.
4. Expand the available resources by applying to grant funding programs related to the conservation of at-risk species, and the improvement of damaged ecosystems. Of particular note, the Government of Canada's Environmental Damages Fund (EDF) program has strong applicability to the restoration objectives and slated plans for Sites A and B on the Quadra Hill property (Government of Canada, 2023). With funding allotments beginning at \$250,000, the EDF program could create sizable improvement to habitat for many at-risk bird species on Galiano Island.
5. Consult with the Salt Spring Island Conservancy regarding their Western Screech-Owl survey protocol



Figure 19. A restored wetland in the Cedars for the Next Century project, a GCA managed initiative to convert pasture and agricultural land to a functional and biodiverse wetland.

Conclusion

Sites A and B on the Quadra Hill property represent potential habitats for the Western Screech-Owls *kennicottii* subspecies, Olive-sided Flycatcher, Marbled Murrelet upon their restoration to a functional, biodiverse wetland and mature forest respectively. Increasing the available habitat of the Western Screech-Owl by restoring Site A will improve the likelihood that this threatened species will return to Galiano Island. While the Olive-sided Flycatcher

has been detected at Quadra Hill, this species of special concern is especially vulnerable to habitat degradation in Canada and its winter habitat in Mexico and South America. Supporting breeding habitats on Galiano Island will offer some buffer effects for its population. The Marbled Murrelet has also been detected at the Quadra Hill site, but this threatened species relies on nesting in old-growth forests, which are dwindling across coastal BC. Restoring Site B is a worthwhile step towards providing critical mixed, mature forest habitat for the Marbled Murrelet, and other old-growth reliant species.

Acknowledgements

We would like to express our thanks to Michelle Thompson and Adam Huggins of the GCA, as well as Galiano Island Community Members Mike Hoebel and Andrew Simon for sharing their knowledge of Galiano bird life. We would also like to thank Ren Ferguson for sharing knowledge about the Salt Spring Island Conservancy's Western Screech-Owl Monitoring Project.

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Appendix A

A sample of the audio recordings collected by the GCA's PAM device at the Quadra Hill Site is included in Table 3. As an illustrative sample of the BirdNET software's identification, only one table was included in this report. The GCA saves hundreds of identification records from the initial acoustic monitoring period.

Table 3. A sample of audio recordings identified by BirdNET software from the Quadra Hill site.

Quadra Hill - Audio trap 1					
Date	Start	End	Scientific name	Common name	Confidence
MM/DD/YYYY	hh:mm:ss	hh:mm:ss			
April 21, 2023	8:13:59 PM	8:14:02 PM	<i>Zonotrichia leucophrys</i>	White-crowned Sparrow	57.56%
April 21, 2023	8:14:05 PM	8:14:08 PM	<i>Zonotrichia leucophrys</i>	White-crowned Sparrow	92.23%
April 21, 2023	8:14:17 PM	8:14:20 PM	<i>Zonotrichia leucophrys</i>	White-crowned Sparrow	71.10%
April 21, 2023	8:14:32 PM	8:14:35 PM	<i>Melospiza melodia</i>	Song Sparrow	62.26%
April 21, 2023	8:14:44 PM	8:14:47 PM	<i>Zonotrichia leucophrys</i>	White-crowned Sparrow	69.14%
April 21, 2023	8:14:53 PM	8:14:56 PM	<i>Zonotrichia leucophrys</i>	White-crowned Sparrow	94.19%
April 21, 2023	8:20:56 PM	8:20:59 PM	<i>Aix sponsa</i>	Wood Duck	65.33%
April 21, 2023	8:22:17 PM	8:22:20 PM	<i>Turdus migratorius</i>	American Robin	69.48%
April 21, 2023	8:22:29 PM	8:22:32 PM	<i>Turdus migratorius</i>	American Robin	82.78%
April 21, 2023	8:22:32 PM	8:22:35 PM	<i>Turdus migratorius</i>	American Robin	53.09%
April 21, 2023	8:23:08 PM	8:23:11 PM	<i>Turdus migratorius</i>	American Robin	62.69%
April 21, 2023	8:23:26 PM	8:23:29 PM	<i>Zonotrichia leucophrys</i>	White-crowned Sparrow	52.95%
April 21, 2023	8:23:41 PM	8:23:44 PM	<i>Turdus migratorius</i>	American Robin	58.75%
April 21, 2023	8:24:44 PM	8:24:47 PM	<i>Zonotrichia leucophrys</i>	White-crowned Sparrow	50.21%
April 21, 2023	8:28:08 PM	8:28:11 PM	<i>Aix sponsa</i>	Wood Duck	64.35%
April 21, 2023	8:33:17 PM	8:33:20 PM	<i>Turdus migratorius</i>	American Robin	81.61%
April 21, 2023	8:34:41 PM	8:34:44 PM	<i>Anas platyrhynchos</i>	Mallard	86.16%
April 21, 2023	8:35:17 PM	8:35:20 PM	<i>Bubo virginianus</i>	Great Horned Owl	51.96%
April 21, 2023	8:38:53 PM	8:38:56 PM	<i>Anas platyrhynchos</i>	Mallard	53.10%
April 21, 2023	8:47:29 PM	8:47:32 PM	<i>Bubo virginianus</i>	Great Horned Owl	79.02%
April 21, 2023	8:52:53 PM	8:52:56 PM	<i>Nucifraga columbiana</i>	Clark's Nutcracker	57.89%
April 21, 2023	8:53:32 PM	8:53:35 PM	<i>Nucifraga columbiana</i>	Clark's Nutcracker	51.11%
April 21, 2023	9:20:48 PM	9:20:51 PM	<i>Strix varia</i>	Barred Owl	74.06%
April 21, 2023	9:24:18 PM	9:24:21 PM	<i>Strix varia</i>	Barred Owl	56.02%
April 22, 2023	5:20:54 AM	5:20:57 AM	<i>Branta canadensis</i>	Canada Goose	68.57%
April 22, 2023	5:20:57 AM	5:21:00 AM	<i>Branta canadensis</i>	Canada Goose	53.93%
April 22, 2023	5:21:03 AM	5:21:06 AM	<i>Branta canadensis</i>	Canada Goose	64.95%
April 22, 2023	5:21:06 AM	5:21:09 AM	<i>Branta canadensis</i>	Canada Goose	75.00%
April 22, 2023	5:27:21 AM	5:27:24 AM	<i>Turdus migratorius</i>	American Robin	53.96%