WESTERN SCREECH-OWL MONITORING AND HABITAT RESTORATION IN THE CAMPBELL RIVER WATERSHED – YEAR 2

PROJECT #: COA-F23-W-3742

Prepared for:

Fish and Wildlife Compensation Program (FWCP)
11th Floor, 6911 Southpoint Drive,
Burnaby, BC, V3N 4X8

Prepared by:

Madrone Environmental Services Ltd.
Roxan Chicalo, M.Sc., R.P.Bio.
Tania Tripp, M.Sc., R.P.Bio.

30-Nov-22

Prepared with financial support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and Public Stakeholders. Additional financial support by MOSAIC Forest Management.

MADRONE ENVIRONMENTAL SERVICES LTD.
1081 CANADA AVENUE • DUNCAN • BC • V9L 1V2
TEL 250.746.5545 • FAX 250.746.5850 • WWW.MADRONE.CA

DOSSIER: 22.0126-001

Executive Summary

The Campbell River (CR) watershed has been impacted by hydro-electric damming activities resulting in significant losses of riparian habitat. Conservation and remediation of riparian areas is important because they are hotspots for biodiversity. To enhance and protect habitat for fish and wildlife, The Fish & Wildlife Compensation Program (FWCP) provides significant funding and support for projects aimed at preserving ecological values in watersheds affected by BC Hydro's dams (CR Watershed Action Plan 2018).

Western screech-owls (*Megascops kennicottii kennicottii*; hereafter 'screech-owl' or 'WESOke'), a Schedule 1 Threatened Species at Risk (SAR), are sensitive to loss of riparian habitat due to reliance on suitable nesting cavities in trees adjacent to ponds, wetlands, river, and lakes (MOE 2013). Moreover, common screech-owl prey species (e.g., insects, amphibians, and small rodents) are riparian-dependent and likewise are negatively impacted by habitat loss. In addition, colonization of Barred owls (*Strix varia*), a known screech-owl competitor and predator, are likely displacing screech-owls from high quality habitats (MOE 2013). Therefore, implementing conservation measures for screech-owls is important.

Beginning in 2000, an Owl Monitoring Program kickstarted surveys for screech-owls in the CR watershed to assess occupancy and distribution. Active (call playback; CPB) nocturnal surveys using call playback (CPB) was the primary inventory method used for efforts between 2000 - 2020. Guided by locations of owl detections in 2000, 160 small owl nest boxes were installed between 2002 and 2006 to enhance habitat values. In 2015, an additional 94 boxes were installed, and nest box inspections and maintenance were conducted in 2018 and 2019 to assess frequency of use and construction performance.

The Owl Monitoring and Nest Box Program took a hiatus during 2020 and resumed activities in 2021, which was considered 'Year 1' of a four-year project cycle. Current project objectives are listed below.

#	Objective
1a	Assess the effectiveness of the nest box habitat-based efforts to date.
1b	Assess the condition and maintenance of nest boxes; make repairs/perform maintenance when identified
2a	Conduct WESOke surveys at sites with historical detections to assess long-term occupancy.
2b	Conduct desktop assessment of areas with high likelihood of occupancy based on new information regarding habitat selection; design new survey transects.
2c	Conduct WESOke surveys at new transects with high likelihood of presence to guide future installments of owl nest boxes.
3a	Install additional owl nest boxes in new areas.
3b	Adjust nest box installation configuration to create 'breeding area clusters' to attract owl.
4	Provide data in a format useful to the BC Conservation Data Centre for Element Occurrence data in order to aid in addressing species knowledge gaps.

Actions taken in **Year 1** (2021 - 2022) resulted in inspections of 57 of 97 owl nest boxes. There was no conclusive evidence that screech-owls have been using nest boxes since last checked in 2018/2019; however, one box contained circumstantial evidence (e.g., feathers of prey species). Moreover, most boxes appeared to be in good condition since deployment in 2015 thus indicating that construction and attachment methods are effective.

Passive (Autonomous Recording Units; ARUs) survey techniques were added in 2021 during nest box inspections in mid-May. A total of 21 ARUs were deployed next to nest boxes to passively listen for owls each night from sunset to midnight for two weeks. Initial analysis of sound recordings collected from ARU surveys did not yield any detections of screech-owls, however, timing of surveys was not ideal (post peak vocalization period).

A WESOke conservation presentation was delivered to outdoor educators at Strathcona Park Lodge and was followed by a nest box building workshop. Sixty-three nest boxes were built, and 31 boxes were installed along the Bog Trail near the lodge to support outdoor education programs. Remaining boxes were installed west of Paterson Lake.

New candidates for nest box installations and owl survey transects were identified to expand coverage in Year 2, and recommendations were provided.

Year 2 efforts (2022-2023) began with a desktop assessment to identify areas with high likelihood of screech-owl occupancy based on new information regarding habitat preferences. As a result, three new transects (White River, East Memekay, and C-Branch) were designed in the western portion of the CR watershed. Those areas have never been surveyed and have habitat features that may support screech-owl occupancy.

In early March of 2022, 33 ARUs were deployed for 10 nights along three historical transects (11 units/transect). Analysis and validation of recordings yielded no WESOke detections. However, Great horned owls (*Bubo virginianus*), Barred owls, Northern saw-whet owls (*Aegolius acadicus*), and Northern pygmy-owls (*Glaucidium gnoma swarthi;* a blue-listed species) were detected using this passive survey technique.

In addition, the White River transect was surveyed using call playback methods. Although no screech-owl or other owl species were detected during the one night of surveys, this transect is considered to have high potential for screech-owl occupancy. A follow-up survey using ARUs is recommended.

In mid-March, another 20 nest boxes were installed in riparian forests parallel to Jubilee Parkway. While not directly in the CR Watershed, having boxes set-up within the city limits of Campbell River offers an opportunity to engage with the public about owl conservation and the nest box program.

During the screech-owl nestling period (May), boxes that were not inspected in 2021 (40) were assessed for signs of use. Two boxes contained feathers of prey species and grass. Moreover, 51 recently installed boxes were inspected (Bog Trail and Jubilee Parkway boxes) as part of community outreach events. Excitingly, one box had a female Northern saw-whet owl with two chicks.

All data collected from survey efforts, nest box installations and inspections have been compiled in databases formatted to BC's Wildlife Species Inventory (WSI) standards.

Lastly, in collaboration with partners, several community outreach events were conducted in May and June. Tania Tripp (Madrone) delivered a presentation for a school group at Strathcona Park Lodge about Western screech-owl conservation and the nest box program. Afterwards, students joined Biologists on the Bog Trail to inspect boxes.

A second presentation was delivered in June to members and non-members of the CR Fish and Wildlife Club. Madrone Biologists combined efforts with Pacific Megascops Research Alliance (PMRA) to discuss Western screech-owl conservation and opportunities to participate in citizen science. The presentation was followed by nest box building workshop. Due to significant interest from CR Fish and Wildlife club members with wood-working skills, an FWCP Community Engagement Grant was awarded to the club to buy raw materials for building nest boxes. Moreover, a guardian from the We Wai Kai First Nation was hired to help with event facilitation. This short contract was a springboard to discuss plans to train and hire guardians to assist on future surveys, nest box installations and inspections, as well as the potential to collaborate on additional grant proposals.

Overall, recent survey efforts indicate that WESOke are no longer occupying historical territories and there are higher occurrences of other species. Therefore, it will be important to survey new areas to assess if WESOke are selecting different habitat types than previously thought, possibly in response to colonization of Barred owls. New detections may guide locations for future nest box installations; however, development of a Small Owl Habitat Model may provide important insights in the absence of detections and may have other useful applications.

To date, the nest box project has installed over 340 nest boxes in the CR watershed, and 180 boxes installed since 2015 would benefit from periodic monitoring and maintenance (boxes installed in 2002 and 2006 are likely non-functional given age and are not worth visiting). Significant momentum is building for interest and support of this project as we continue to engage guardians and volunteers to participate. It is likely through training and capacity building that many aspects of this project could be accomplished by volunteer efforts; specifically nest box building and inspections of boxes installed near (within a 30-minute drive) Campbell River.

Table of Contents

List of Tables

List of Figures

WESTERN SCREECH-OWL MONITORING AND HABITAT RESTORATION IN THE CAMPBELL RIVER WATERSHED – YEAR 2

1. Background

Since the mid 1940's the Campbell River (CR) watershed has been subjected to severe ecological disturbances including forest clearing, mining, and hydro-damming activities. As nearby communities grew, demand for energy infrastructure increased concurrently. The construction of John Hart, Ladore, and Strathcona dams resulted in diversion of natural watercourses to increase water supply. In doing so, over 50 km^2 of riparian areas were destroyed and/or altered due to flooding of surrounding shrublands and forests.

The Western screech-owl (*Megascops kennicottii kennicottii*; hereafter 'screech-owl' or 'WESOke'), is sensitive to loss of riparian areas since they nest in cavities of trees that are adjacent to ponds, wetlands, river, and lakes. Common prey species (e.g., insects, amphibians, and small rodents) are riparian-dependent and likewise are negatively impacted by habitat loss. In addition, colonization of Barred owls (*Strix varia*), a known screech-owl competitor and predator, are likely displacing screech-owls from high quality riparian habitats (MOE 2013). Provincially, population trends are declining (MOE 2013), which has resulted in a federal status of 'Threatened' (COSEWIC 2021) and a provincial status of 'Special Concern' (BC Conservation Data Centre 2021). As such, WESOke has been listed as a Schedule 1 Threatened Species at Risk (SAR). Therefore, implementing conservation measures for screech-owls is important. For a complete species account, see Appendix A.

Fortunately, The Fish & Wildlife Compensation Program (FWCP) [1] compensates for fish and wildlife impacted by BC Hydro dams and provides funding for conservation projects in affected watersheds (CR Watershed Action Plan 2018). Thus, in 2000, the Owl Monitoring Program was developed to assess occupancy and distribution of WESOke within the CR watershed. Prior to 2000, very little was known about screech-owls in this area (Mico and Van Enter 2000). Surveys were first conducted in 2000 using active (call playback; CPB) survey techniques and resulted in several WESOke detections per transects. Surveys continued in 2002, 2003, 2006, 2007, 2014, and 2015. By 2007, survey results were suggesting that populations of WESOke were declining in the CR watershed (Menzies and Tripp, 2007).

By the end of 2015, innovations in survey techniques were developing such that passive survey methods using Autonomous Recording Units (ARUs) were becoming more common. ARUs are battery-powered sound recording machines that are programmed to record when

[1] Fish & Wildlife Compensation Program

owls are most likely to vocalize (e.g., sunset, sunrise). Units can be left at survey stations for multiple nights, thus significantly increasing the likelihood that owls will be detected if present. Recordings are saved on SD cards which are later downloaded for analysis. Using machine learning software, recordings can be efficiently analyzed to determine owl presence. The Convolutional Neural Network software developed by Ruff et al. (2021) not only flags screech-owl detections, but other species too (e.g., Barred owl, Great horned owl [*Bubo virginianus*], Northern pygmy-owl [*Glaucidium gnoma swarthi*], Northern saw-whet owl [*Aegolius acadicus*], Marbled Murrelet [*Brachyramphus marmoratus*], Red squirrel [*Tamiasciurus hudsonicus*], etc.).

Following surveys in 2000, the Owl Monitoring Program began habitat enhancement activities funded by FWCP. Guided by locations of WESOke detections via surveys, 80 small owl nest boxes were installed in 2002, followed by another 80 boxes installed in 2006. Inspections of nest boxes were conducted in 2015 and found sign of use (e.g., whitewash, downy breast feathers, sawdust depression, and pellets) at four boxes. Of 160 boxes, forty-three boxes were not found and thirty-two were damaged and considered unusable. Therefore, only 85 boxes were deemed in usable condition for owl breeding. In 2015, an additional 94 boxes were installed in the CR watershed and were inspected in 2018 and 2019. Ninety-two boxes were observed to be intact and useable. One box had flattened shavings and prey remains which indicates it was used for breeding.

Throughout the years the Owl Monitoring and Nest Box Program has partnered with various stakeholders to achieve conservation goals and to collaborate on community outreach events. Financial and in-kind support has been provided by the following companies, communities, and organizations:

- FWCP
- Mosaic Forest Management Ltd.
- We Wai Kai First Nation
- Laich-Kwil-Tach Nation
- BC Timber Sales
- Ministry of Land, Water and Resource Stewardship (LWRS)
- Campbell River Fish and Wildlife Club
- Comox Valley Naturalist Society
- Strathcona Park Lodge

Owl Monitoring and Nest Box Program achievements to date would not be possible without support from those listed above.

2. Over-arching Project Objectives

The Owl Monitoring and Nest Box Program took a hiatus for two years and resumed activities in 2021, which was considered ‘Year 1’ of a four-year project cycle. Over-arching project objectives were developed from consulting the *Recovery Plan for the Western*

Screech-Owl, kennicottii subspecies (Megascops kennicottii kennicottii) in British Columbia (MOE 2013) and have been linked to FWCP Action Plan items (see Table 1 below).

Table 1: Over-arching owl monitoring program objectives. Objectives are linked to FWCP Campbell River Watershed Action Plan (FWCP 2018) and *Recovery Plan for the Western Screech-Owl, kennicottii subspecies (Megascops kennicottii kennicottii) in British Columbia* (MOE 2013).

#	Objective	Linkage to FWCP Campbell River Watershed Action Plan (FWCP 2018)	Linkage to BC's WESOke Recovery Plan Objectives (MOE 2013)
1a	Assess the effectiveness of the nest box habitat-based efforts to date.	#7 – **Monitoring and Evaluation**: Develop and implement an integrated monitoring plan for fish and/or wildlife in the Campbell watershed #8 – **Monitoring and Evaluation**: Assess success of habitat-based actions supported by the FWCP. #9 – **Monitoring and Evaluation**: Conduct condition assessments and/or maintenance on habitat enhancements supported by the FWCP.	#2 – Establish and implement a monitoring program to assess trends in occupancy and habitat availability across the subspecies range. #4 – Address knowledge gaps (e.g., subspecies distribution and abundance, habitat requirements).
1b	Assess the condition and maintenance of nest boxes; make repairs/perform maintenance when identified		
2a	Conduct WESOke surveys at sites with historical detections to assess long-term occupancy	#24 – **Research and Information Acquisition:** Inventory for species of interest that are likely in the watershed.	#2 – Establish and implement a monitoring program to assess trends in occupancy and habitat availability across the subspecies range. #4 – Address knowledge gaps (e.g., subspecies distribution and abundance, habitat requirements).
2b	Conduct desktop assessment of areas with high likelihood of occupancy based on new information regarding habitat selection; design new survey transects.		
2c	Conduct WESOke surveys at new transects with high likelihood of presence to guide future installments of owl nest boxes.		
3a	Install additional owl nest boxes in new areas.	#25 – **Habitat-based Actions**: Implement priority species- and habitat-related conservation actions in the following (or most recent) Recovery Strategies and Management Plans for species at risk that are known to be in the watershed. #29 – **Habitat-based Actions**: Enhance the existing nesting box program for Western Screech-owl	#3 - Assess and mitigate current threats (e.g., limited breeding habitat) for the known populations.
3b	Adjust nest box installation configuration to create 'breeding area clusters' to attract owl.		
4	Provide data in a format useful to the BC Conservation Data Centre for Element Occurrence data in	#25 – **Habitat-based Actions**: Implement priority species- and habitat-related conservation actions in the following (or most	#4 – Address knowledge gaps (e.g., subspecies distribution and abundance, habitat

#	Objective	Linkage to FWCP Campbell River Watershed Action Plan (FWCP 2018)	Linkage to BC's WESOke Recovery Plan Objectives (MOE 2013)
	order to aid in addressing species knowledge gaps.	recent) Recovery Strategies and Management Plans for species at risk that are known to be in the watershed.	requirements).

2.1. Year 1 Efforts

Actions taken in year 1 (2021 - 2022) resulted in inspections of 57 of 97 owl nest boxes, deployment of 21 ARUs to passively survey owls along historical transects, and building and installation of 63 nest boxes (Madrone 2021a). There was no conclusive evidence that screech-owls have been using nest boxes since last checked in 2018/2019, however, one box contained circumstantial evidence (e.g., feathers of prey species). Moreover, boxes were in good condition since 2015 thus indicating construction and attachment methods are effective.

Initial analysis of sound recordings collected from ARU surveys did not yield any detections of screech-owls. However, further validation of recordings for WESOke and other owl species was not possible due to a hard drive malfunction.

A WESOke conservation presentation was delivered to outdoor educators at Strathcona Park Lodge and was followed by a nest box building workshop. Sixty-three nest boxes were built, and 31 boxes were installed along the Bog Trail near the lodge to support outdoor education programs. Remaining boxes were installed west of Paterson Lake.

2.2. Year 2 Objectives

For year 2 (2022/2023), project objectives were as follows:

- Identify additional sites for habitat enhancement (e.g., Conduct desktop assessment of areas with high likelihood of occupancy; design new survey transects.)
- Deploy ARUs are sites with historical WESOke detections.
- Inspect nest boxes that were missed in year 1.
- Install additional nest boxes in new areas.
- Collaborate with local First Nations and partners on community outreach events.
- Format and submit data to BC's Wildlife Species Inventory (WSI) standards.

3. Study Area

The Campbell River watershed (Figure 1) is located within the Coastal Western Hemlock (CWH) biogeoclimatic (BEC) zone. The CWH zone occurs from low to mid elevation,

extending up to 900 m on windward slopes and 1,050 m on leeward slopes, along the majority of coastal BC (Pojar et.al. 1991). This zone receives higher annual rainfall than any of the other thirteen BEC zones, with precipitation from 1,000 to 4,400 mm/year (mean annual precipitation is 2,228 mm). Mild winters and cool summers, with frequent dry, hot spells, are typical in the CWH zone (Pojar et.al. 1991). The Campbell River drainage includes predominately second growth Douglas-fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterphylla*) which was initiated after the Sayward fire in 1938.

3.1. Loveland Bay

The majority of the Loveland Bay study area is located within the Coastal Western Hemlock eastern very dry maritime (CWHxm1) variant. Warm dry summer and moist mild winters with little snowfall characterize this area. The CWHxm1 is located on the east coast of Vancouver Island. Douglas-fir and western hemlock are the dominant tree species in this subzone with small amounts of western red cedar (*Thuja plicata*). The western portion of the John Hart study area encroaches into the CWHxm2 (see description below) (Green and Klinka 1994).

3.2. Strathcona Dam, Quinsam, Paterson Lake, and Buttle Lake

The Strathcona Dam, Quinsam, Paterson Lake, and Buttle Lake study areas are located within the CWH western very dry maritime (CWHxm2) variant. This subzone is also characterized by warm, dry summers, and moist, mild winters with relatively little snowfall and occurs to the west of the CWHxm1. The vegetation is dominated by Douglas fir and western hemlock with small amounts of western red cedar (Green and Klinka 1994).

3.3. Heber

The Heber study area is located in the CWH Submontane very wet maritime variant (CWHvm1), which is characterized by wet, humid climate with cool summer and mild winters featuring very little snow fall. The vegetation is dominated by western hemlock, amabillis fir (*Abies amabillis*) and some western red cedar (Green and Klinka 1994).

3.4. Salmon River

The Salmon River study area is located in the CWH submontane moist maritime (CWHmm1), which is characterized by moist, mild winters and cool but relatively dry summers, which has contributed to occasional stand-replacing wildfires. The vegetation is dominated by western hemlock and Douglas-fir (Green and Klinka 1994).

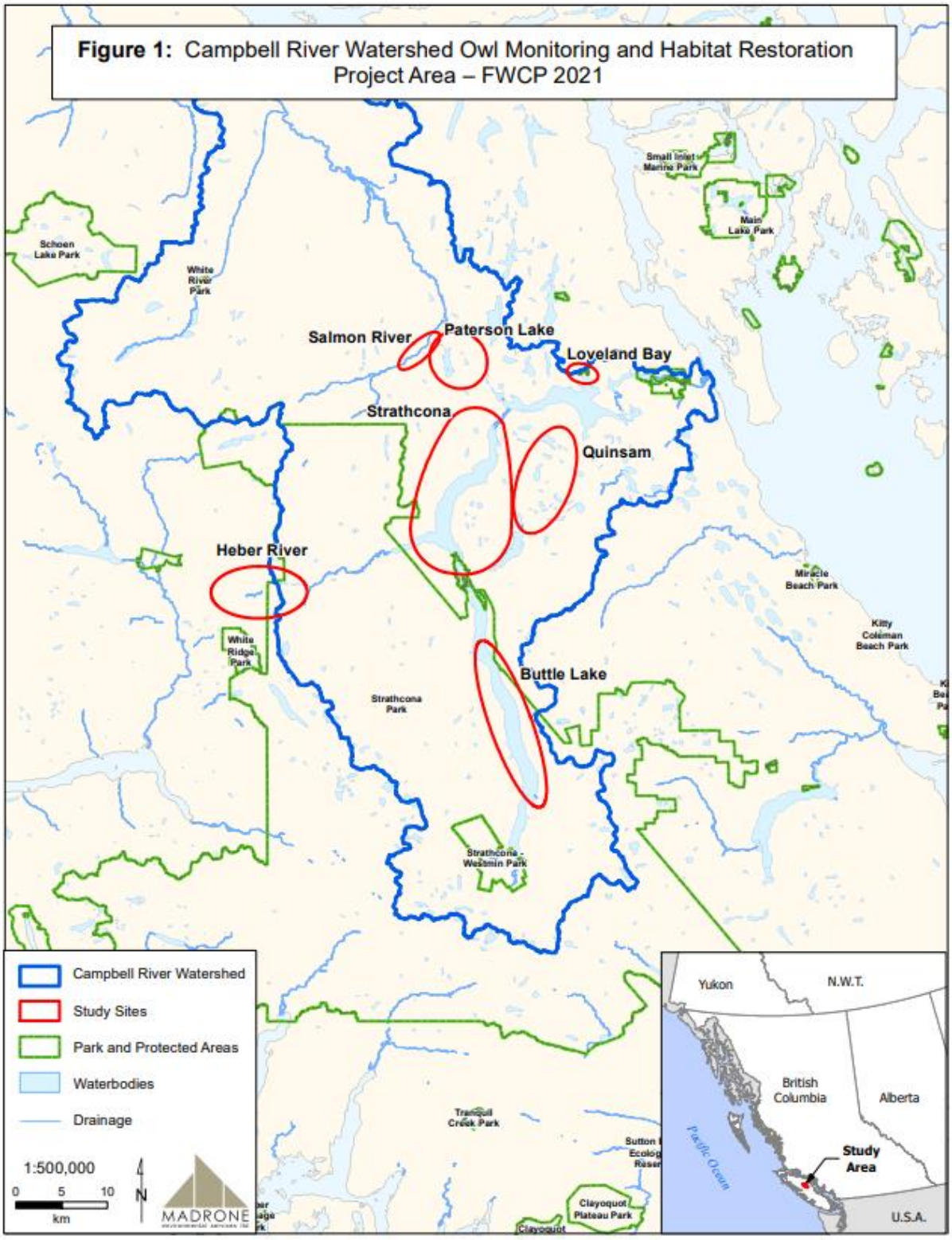


Figure 1: Campbell River Watershed Owl Monitoring and Habitat Restoration Project Area – FWCP 2021
Salmon River
Paterson Lake
Loveland Bay
Strathcona
Quinsam
Heber River
Buttle Lake
Campbell River Watershed
Study Sites
Park and Protected Areas
Waterbodies
Drainage
1:500,000
0 5 10
km
N
MADRONE
Yukon
N.W.T.
British Columbia
Alberta
Study Area
U.S.A.
Pacific Ocean

4. Methods

4.1. Desktop Assessment

To identify new areas to deploy nest boxes, a desktop assessment was conducted to identify areas with high likelihood of screech-owl occupancy based on new information regarding habitat preferences. Recent surveys on southwest Vancouver Island have detected owls in remnant mature and old forests patches along steep, incised river canyons (Madrone 2021b, Madrone 2022). These landscape conditions are not uncommon on Vancouver Island since Old Growth Management Areas (OGMA) tend to track historically inoperable forests along steep river canyons. Figure 2 provides an example of screech-owl detections related to OGMAs on southwest Vancouver Island (Madrone 2021b).

To select transects, an elevational cut-off of 500 m above sea level (a.s.l.) was used to identify areas that were likely accessible (i.e., low snowpack) during the sampling period (mid-Feb. to March). To select mature and old forests along steep river canyons, BC's OGMA layer[2], Fresh Water Atlas Rivers layer[3], and TRIM contour lines[4] were used as reference layers to guide transect placement. Fifteen potential stations per transect were drawn to allow for situations where one or two stations may need to be skipped due to unforeseen issues (e.g., long cliff feature, etc.).

[2] https://catalogue.data.gov.bc.ca/dataset/old-growth-management-areas-legal-current

[3] https://catalogue.data.gov.bc.ca/dataset/freshwater-atlas-rivers

[4] https://catalogue.data.gov.bc.ca/dataset/trim-contour-lines

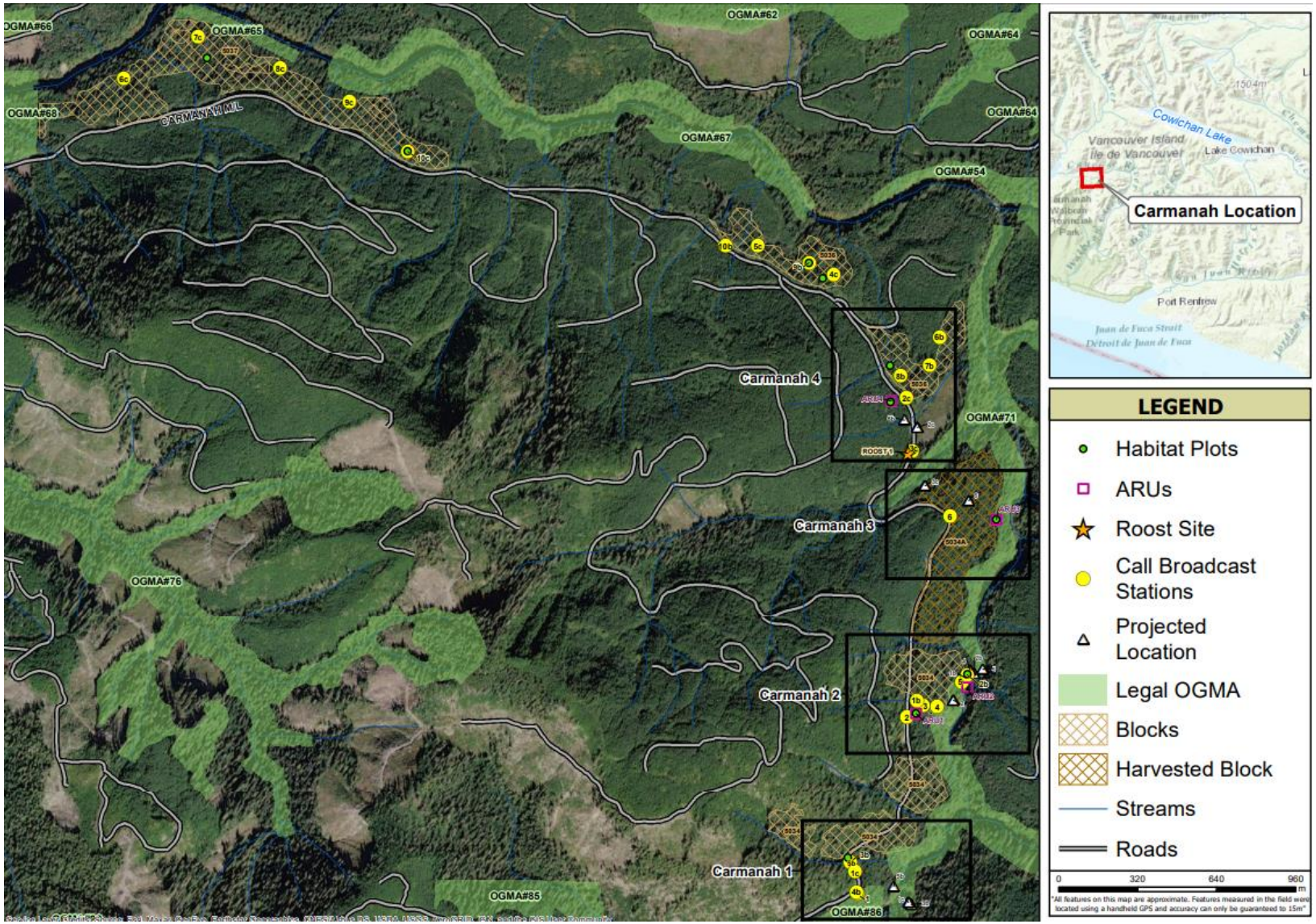


Figure 2: Example of screech-owl detections related to OGMAs on southwest Vancouver Island (Madrone 2021b).

4.2. Western screech-owl surveys

4.2.1. Passive surveys

To survey areas with historical WESOke detections, ARUs were deployed at 33 stations along Quinsam, Heber and Strathcona Dam transects (11 stations/transect; Table 2). Units (SM4 models from Wildlife Acoustics) were recording for 10-11 nights. Locations of transects are presented in Figure 6 in section 5.2.

To deploy ARUs, units were secured to trees using two decking screws. The SM4 units have two microphones on either side of the unit, each facing parallel to the ground (see Figure 3). The recording radius (distance the ARU can "hear") is estimated to be 200 m however, it can vary by habitat type and ambient noise conditions.

The units were programmed to record continuously from sunset to midnight (as 1 hour .wav files) and then record every 15 minutes on the hour until an hour before sunrise when it records continuously until an hour after sunrise. Recordings are saved on SD cards which are later downloaded for analysis.

Figure 3: SM4 model of ARU by Wildlife

After ARU retrieval, sound recordings were downloaded and analyzed using an automated recognizer developed for identification of forest animals. The Convolutional Neural Network software developed by Ruff et al. (2021) is an efficient way to detect screech-owls and can be used to detect other species too (e.g., Barred owl, Great horned owl, Northern pygmy-owl, Northern saw-whet owl, Marbled Murrelet, Red squirrel, etc.).

Table 2: Information regarding WESOke survey transects.

Transect location	# of Stations	BEC	Previous years CPB surveyed	ARU Deployment Date	ARU Retrieval Date	# of ARU Listening Nights
Quinsam	11	CWHxm1	2000, 2002, 2003, 2007	03-07-2022	03-17-2022	11
Strathcona Dam	11	CWHxm1	2000, 2002, 2003, 2006, 2007	03-08-2022	03-18-2022	11
Heber	11	CWHvm1	2000, 2002, 2003, 2006, 2015	03-09-2022	03-18-2022	10

4.2.1. Active surveys

Call playback surveys were conducted once at 11 stations along the newly designed White River transect (see Section 4.1 for how transects were designed). Call playback surveys followed protocols outlined by RISC (2001), Pendergast (2002) and Hausleitner (2006). Each survey station was initiated with a two-minute listening period to allow for detection of owls that may already be calling. If a natural, 'spontaneous' owl detection occurred during the first two minutes, no calls were broadcast. The detection information was recorded (species, detection distance, and direction) and then the surveyors continued on to the next station.

If after two minutes no owls were heard, four call sets were broadcast toward each cardinal direction using a FoxPro NX5 game caller. Each set consisted of a series of four male territorial calls with pauses in between for a total of 20-30 seconds, followed by 30 seconds of silence and then continued with the next set for a total of four sets.

Call playback was followed by five minutes of silence. If an owl species was detected during the call broadcast, detection information was recorded and no additional calls were broadcasted at that station. If an owl flew into the station but the species was not confirmed, calls were continued until positive species identification was made, if possible.

4.3. Next box construction and installation

Nest box materials were supplied by DonCol Nature Products and were milled out of reclaimed western red cedar timber. Box measurements followed guidelines provided in Appendix C. Boxes were assembled by Madrone Biologist and volunteers. Each box was given a unique label on the bottom panel (Figure 4).

Figure 4: Adding ID labels to the bottom of each owl nest box.

Small owl nest boxes were installed at sites within the CR watershed for habitat enhancement. In the absence of WESOke detections, site selection was dependent on predicted high-quality habitat within or next to reserve forests not likely to be logged.

Working in teams of two, the nest boxes were installed approx. 3 m off the ground. One team member secured the ladder while the second team member used an impact driver to attach the nest box to the tree and then added wood shavings for nest lining. Site data was recorded at each nest box installation site including nest box ID, elevation, slope, aspect, tree height, tree diameter at breast height, and tree species.

4.4. Nest box inspections

Nest boxes installed in 2015 were inspected to determine effectiveness as a method of habitat enhancement. To inspect nest boxes, a wireless camera attached to a telescopic pole was used to view inside each nest box. Any signs of use by WESOke or other species were noted (e.g., whitewash, feathers, etc.) as well as any natural nest material that may have been added. If nest material was present, the depth of material was recorded. The general condition of each nest box was recorded as 'good', 'usable', 'replace' or 'needs cleaning'. Photos were taken, when possible, for comparison of future inspections.

4.5. Data consolidation and mapping

Data collected from nest box inspections/installations and owl surveys were entered into a MS excel database formatted to BC's Wildlife Species Inventory (WSI) standards. WSI provides templates[5] to use for various wildlife projects, therefore, the 'Bird Nest Visit Template' was used to document nest box installation and inspections, and 'General Survey Using Sample Stations' was used to document surveys. Databases and spatial shapefiles were submitted via the online portal.

5. Results and Outcomes

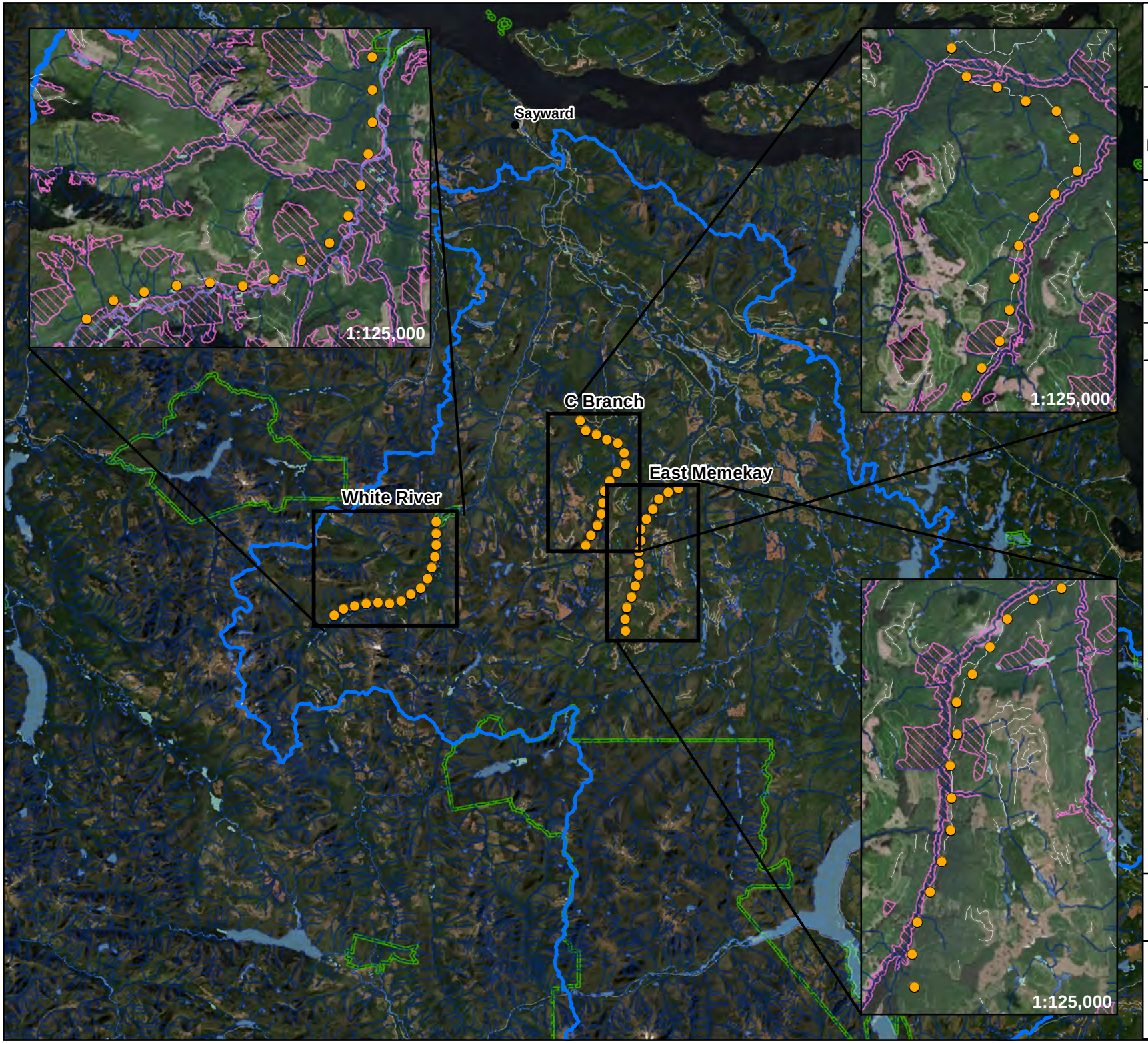
5.1. New transects

Using methodologies described in Section 4.1, three new transects were designed:

1. White River,
2. East Memekay, and
3. C-Branch

Transects fall in the western portion of the CR watershed (Figure 5); areas that have been less studied since project initiation in 2000. Each transect has 15 stations spaced 800 m apart (Figure 5).

[5] https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-data-information/submit-wildlife-data-information/data-submission-templates.



MADRONE environmental services ltd

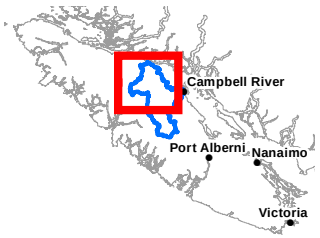
Figure 5: Proposed White River, East Memekay, and C-Branch survey transects

PROJECT:
Western screech-owl monitoring and habitat restoration in the Campbell River watershed – Year 2

CLIENT:
BC Hydro Fish and Wildlife Compensation Program

MAP SCALE:	MAPPING DATE:
1:350,000	October 27, 2022
DOSSIER NO:	DRAWN BY:
22.0126	Alyssa Etherington

- Campbell River Watershed
- Transect Stations
- Cities
- Lakes
- Rivers
- Wetlands
- Streams
- Parks and Protected Areas
- Legal OGMA
- Roads



0 1.75 3.5 7 10.5 km

1:350,000

N W E S

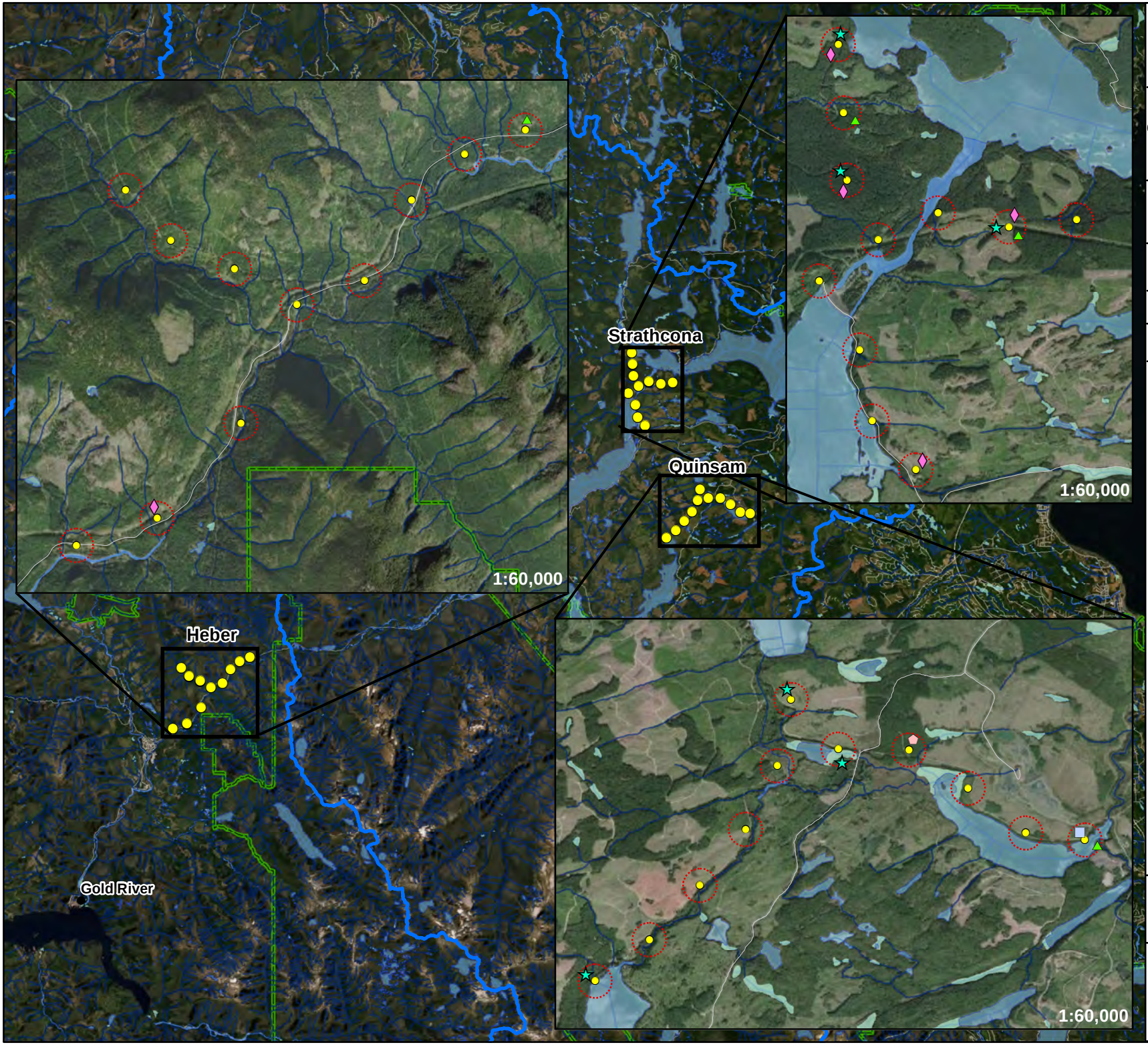
5.2. Western screech-owl surveys

From ARU surveys conducted along transects with historical WESOke detection (Quinsam, Heber, and Strathcona Dam), analysis and validation of recordings yielded no WESOke detections. However, non-targeted species were detected and are documented in Table 3 and Figure 6. Moreover, call playback surveys conducted along the White River transect resulted in no detections of owls. A follow-up survey using ARUs is recommended since call playback surveys are less reliable for reporting true absences.

Table 3: Avian species detected along transects in the CR Watershed. 'ARU' = Autonomous Recording Units and 'CPB' = Call Playback. 'GHOW' = Great-horned owl, 'BDOW' = Barred owl, 'NPOW' = Northern pygmy-owl, 'NSWO' = Northern saw-whet owl, and 'COSN' = Common snipe (*Gallinago gallinago*). '-' indicates no individuals were detected.

Transect	Survey Method	Station	GHOW	BDOW	NPOW	NSWO	COSN
Quinsam	ARU	1	X	X	-	-	-
Quinsam	ARU	2	-	-	-	-	-
Quinsam	ARU	3	-	-	-	-	-
Quinsam	ARU	4	-	-	-	-	X
Quinsam	ARU	5	-	-	-	X	-
Quinsam	ARU	6	-	-	-	X	-
Quinsam	ARU	7	-	-	-	-	-
Quinsam	ARU	8	-	-	-	-	-
Quinsam	ARU	9	-	-	-	-	-
Quinsam	ARU	10	-	-	-	-	-
Quinsam	ARU	11	-	-	-	X	-
Heber	ARU	1	-	X	-	-	-
Heber	ARU	2	-	-	-	-	-
Heber	ARU	3	-	-	-	-	-
Heber	ARU	4	-	-	-	-	-
Heber	ARU	5	-	-	-	-	-
Heber	ARU	6	-	-	-	-	-
Heber	ARU	7	-	-	-	-	-
Heber	ARU	8	-	-	-	-	-
Heber	ARU	9	-	-	-	-	-
Heber	ARU	10	-	-	X	-	-
Heber	ARU	11	-	-	-	-	-

Transect	Survey Method	Station	GHOW	BDOW	NPOW	NSWO	COSN
Strathcona Dam	ARU	1	-	-	X	-	-
Strathcona Dam	ARU	2	-	-	-	-	-
Strathcona Dam	ARU	3	-	-	-	-	-
Strathcona Dam	ARU	4	-	-	-	-	-
Strathcona Dam	ARU	5	-	-	-	-	-
Strathcona Dam	ARU	6	-	-	X	X	-
Strathcona Dam	ARU	7	-	X	-	-	-
Strathcona Dam	ARU	8	-	-	X	X	-
Strathcona Dam	ARU	9	-	-	-	-	-
Strathcona Dam	ARU	10	-	X	X	X	-
Strathcona Dam	ARU	11	-	-	-	-	-
White River	CPB	1	-	-	-	-	-
White River	CPB	2	-	-	-	-	-
White River	CPB	3	-	-	-	-	-
White River	CPB	4	-	-	-	-	-
White River	CPB	5	-	-	-	-	-
White River	CPB	6	-	-	-	-	-
White River	CPB	7	-	-	-	-	-
White River	CPB	8	-	-	-	-	-
White River	CPB	9	-	-	-	-	-
White River	CPB	10	-	-	-	-	-
White River	CPB	11	-	-	-	-	-



MADRONE environmental services ltd

Figure 6: 2022 species detections along historical owl survey transects in the CR watershed

PROJECT:
Western screech-owl monitoring and habitat restoration in the Campbell River watershed – Year 2

CLIENT:
BC Hydro Fish and Wildlife Compensation Program

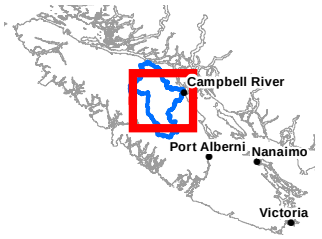
MAP SCALE:	MAPPING DATE:
1:350,000	October 27, 2022
DOSSIER NO:	DRAWN BY:
22.0126	Alyssa Etherington

- Campbell River Watershed
- Transect Stations
- Listening Range Buffer (200m)
- Cities
- Lakes
- Rivers
- Wetlands
- Streams
- Parks and Protected Areas
- Roads

Species Detections

It is not possible to determine exact location of species since ARUs only identify species that are within listening range (e.g., 200m). Therefore, species symbols were placed next to ARU station to denote a detection.

- GHOW
- BDOW
- NPOW
- NSWO
- COSN



0 1.75 3.5 7 10.5 km

1:350,000

N W E S

Comparisons of 2022 results with the long-term dataset for surveys completed at Heber, Quinsam, and Strathcona Dam display a steady decline in WESOke occupancy in the CR watershed, yet the trend is not statistically significant[6] (n = 6, r^2 = -0.53, p = 0.06; Figure 7). Occupancy estimates take into account number of survey stations along each transects (11-14; see Table B2 in Appendix B) but does not account for detectability probability (likelihood of detecting an owl using call playback), nor number of survey replicates (i.e., re-sampling stations within the same year). Therefore, the term 'naïve' has been used to qualify these differences and is used in other WESOke occupancy reports (Hemmera 2017 & 2020). Note that surveys conducted in 2014 and 2015 were not included in analyses due to too few replicates (only included years with three or more replicates/year).

A similar downward trend was observed for Northern saw-whet owls, yet the trend is not statistically meaningful (n = 6, r^2 = -0.07, p = 0.3; Figure 7). Interestingly, Northern pygmy-owls appear to be increasing (n = 6, r^2 = -0.68, p = 0.03; Figure 7). Occupancy rates of Barred owls and Great horned owls indicate a stable trend (n = 6, r^2 = -0.23, p = 0.83, and n= 6, r^2 = -0.25, p = 0.91, respectively; Figure 7). Note that 2022 was the first year that ARU surveys were implemented and future ARU survey efforts will likely improve robustness of analyses. Biases in comparing results from call playback and ARU methodologies are addressed in section 6.1.

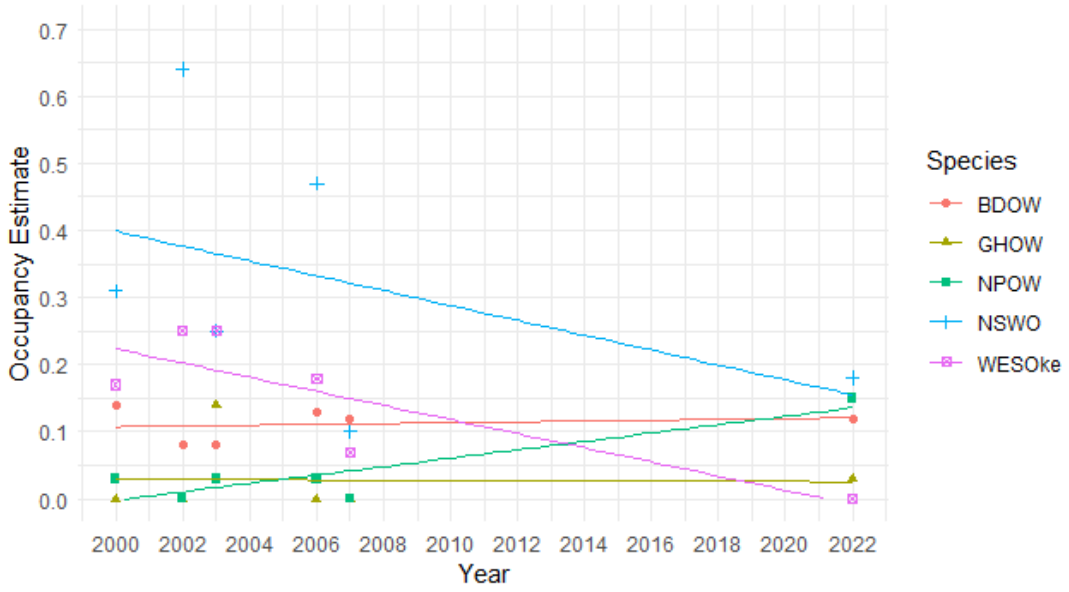


Figure 7: Naïve occupancy estimates for WESOke, BDOW, GHOW, NPOW, NSOW in the CR w between 2000 and 2022. 'WESOke' = Western screech-owl, 'GHOW' = Great-horned owl, 'BDOW' = Barred owl, 'NPOW' = Northern pygmy-owl, 'NSWO' = Northern saw-whet owl.

[6] If $r^2 \geq 0.65$ at $p \leq 0.05$ in regressions, then trend is regarded as statistically meaningful (Bryhn & Dimberg 2011).

5.3. Next box construction and installations

In mid-March, another 20 nest boxes were installed in riparian forests parallel to Jubilee Parkway. Assembled boxes were leftovers from volunteer activities in November 2021. While not directly in the CR Watershed, having boxes set-up within the city limits of Campbell River increases accessibility to engage with the public about owl conservation and the nest box program.

Overall, there has been three 'series' of boxes deployed since project inception:

- 2002/2006 series,
- 2015 series, and
- 2021 series.

Each series are characterized by different installation techniques and site selection methods (Table 4). Transitioning from nails to decking screws and washers has increased nest box longevity since they are less likely to fall out of trees due to rusting nails. Cedar shingles will likely reduce roof rot and moisture inside boxes. Installing boxes along transects will increase efficiency for inspections and maintenance, and provide owls a 'core breeding area'. Figure 8 shows locations of 2015 and 2021 nest box series, which are likely intact and require periodic inspections and maintenance.

Table 4: Number of nest boxes installed by year, installation techniques, and site selection method. Transitioning from nails to decking screws with washers better secured boxes to trees, cedar shingles will likely

Nest box installation year	Nest box series	Tree attachment method	Cedar shingle roof? (Y/N)	Site selection method	Number of boxes installed
2002	2002/2006	2 Nails	N	4 box clusters near WESOke detections	80
2006	2002/2006	2 Nails	N	4 box clusters near WESOke detections	80
2015	2015	3 Decking screws w/ washers	N	4 box clusters near WESOke detections	94
2021	2021	3 Decking screws w/ washers	Y	20+ boxes along transect with suitable habitat	63
2022	2021	3 Decking screws w/ washers	Y	20+ boxes along transect with suitable habitat	20

MADRONE environmental services ltd

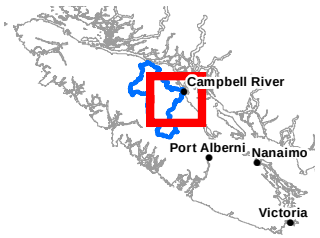
Figure **8**: Locations of 2015 and 2021 nest box series in the CR Watershed

PROJECT:
Western screech-owl monitoring and habitat restoration in the Campbell River watershed – Year 2

CLIENT:
BC Hydro Fish and Wildlife Compensation Program

MAP SCALE:	MAPPING DATE:
1:300,000	November 18, 2022
DOSSIER NO:	DRAWN BY:
22.0126	Alyssa Etherington

- Campbell River Watershed
- Study Sites
- Nest Box
- Active NSWO Nest Box
- Cities
- Lakes
- Rivers
- Wetlands
- Streams
- Parks and Protected Areas
- Roads



0 1.5 3 6 9 km

1:300,000

N W E S

5.4. Nest box inspections

On May 18th, 2022, 33 boxes installed in 2021 along the Bog trail were inspected for signs of use. The next day (May 19th), the remaining 40 nest boxes installed in 2015 that were not inspected in 2021 were visited. Lastly, on June 7th, 2022, 20 boxes installed along Jubilee Parkway were assessed. Two boxes in the Quinsam area contained feathers of prey species and grass and, one box had a female Northern saw-whet owl with two chicks (Figure 9; Table 5).

Table 5: Notable findings from nest box inspections conducted in 2021.

Location	Box ID	Comments
Quinsam	2015-14	feathers of prey species and grass
Quinsam	2015-15	feathers of prey species and grass
Jubilee Parkway	2021-82	Nesting Northern saw-whet owls (two chicks and one unhatched egg)

Figure 9: Northern saw-whet owl using a nest box (2021-82) on June 7th, 2022, in the Jubilee Parkway area. Inspection of nest box found two chicks and one unhatched egg.

Using data from past nest box inspections, condition of nest boxes was assessed across years (Table 6; Figure 10). There has been three 'series' of boxes deployed since project inception (described and defined in section 5.3).

Table 6: Nest box inspection results across years.

Nest box series	Year Inspected	Number Inspected	Number functional	Number non-functional	Number used by wildlife
2002/2006	2015	117	85	32	25
2015	2018	88	80	8	3
2015	2019	93	86	7	6
2015	2021/2022	93	76	17	13
2021	2022	51	51	0	2

When inspected in 2015, 73% of 2002/2006 series boxes were considered usable (9-13 years since deployment; Figure 10) Boxes deployed in 2015, which had improved design and placement (see Table 4), were 91% usable when checked three years later. Planned maintenance activities improved conditions (92%) when assessed the following year; however, conditions declined in 2021 mostly due to box shavings becoming wet and growing mushrooms. Again, boxes deployed in 2021 has improved design such that cedar shingles have been added to roof to protect from rain and were placed on sides of trees less exposed to rain. All 2021 boxes inspected in 2022 were in usable condition (Table 6; Figure 10).

The proportion of nest boxes used by wildlife across years was assessed (Table 6; Figure 11). The proportion of use increased given time elapsed since deployment. While there has only been one direct observation of nest box use by WESOke (e.g., box near Strathcona Dam in 2006), there has been numerous signs of use by nesting birds and other wildlife. Common signs included flattened nest box shavings, feathers, prey remains, grass, moss, or sticks inside the box, and white-wash in or along the front of the box.

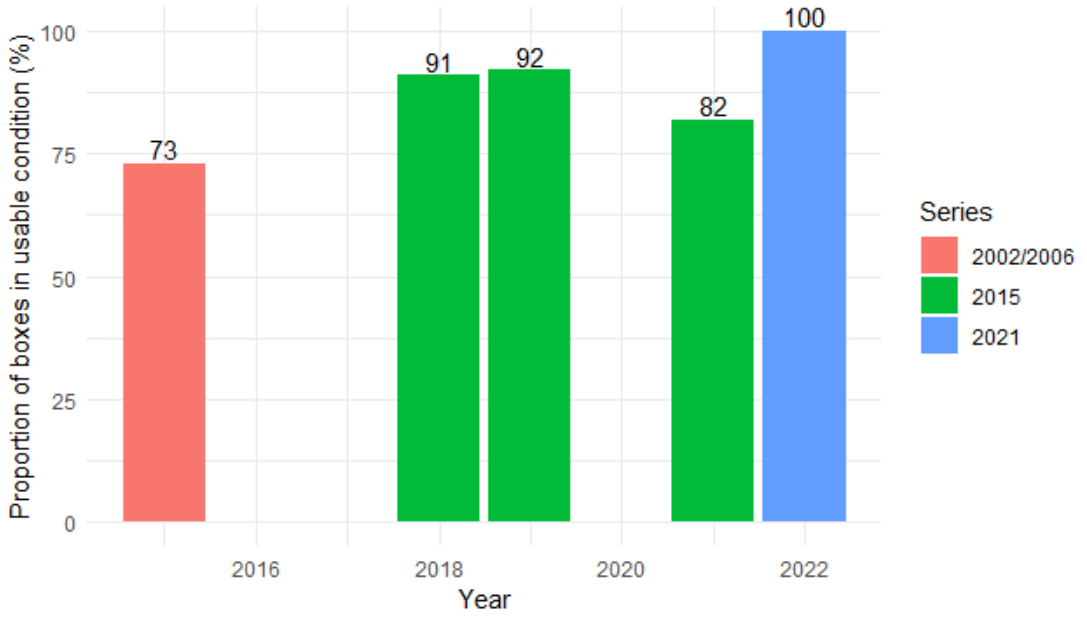


Figure 10: Proportion (%) of nest boxes in usable condition by series and year. 'Series' indicates years boxes were installed, therefore indicating time elapsed since deployment. Series 2002/2006 were only inspected once in 2017, series 2015 were inspected three times, and Series 2021 were only inspected once. Note that some boxes in 2002/2006 were inspected at random between years 2002 – 2016, yet those data are not presented here.

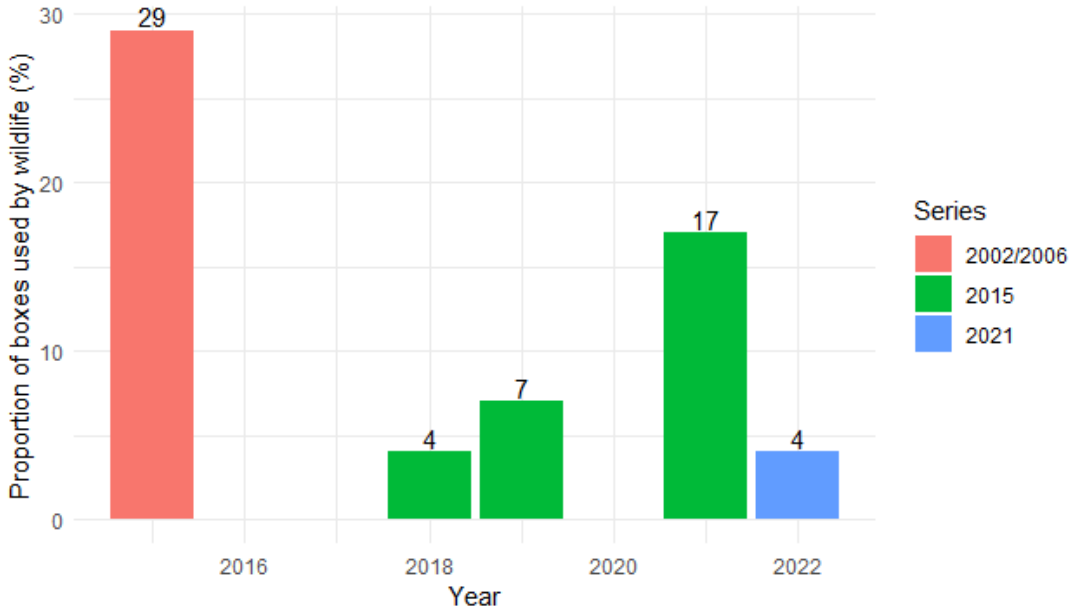


Figure 11: Proportion of boxes used by wildlife by series across years. 'Series' indicates years boxes were installed, therefore indicating time elapsed since deployment. Common signs of use included flattened nest box shavings, feathers, prey remains, grass, moss, or sticks inside the box, and white-wash in or along the front of the box.

5.5. Community outreach and collaborations

Several community outreach events were conducted in May and June that involved working alongside collaborators. On May 18th, as a way to integrate nest box inspections with community outreach, Tania Tripp (Madrone) delivered a presentation to a school group (15 students) at Strathcona Park Lodge about Western screech-owl conservation and the nest box program. Afterwards, the students walked along the Bog Trail to watch Biologists use camera gear to inspect boxes.

Figure 12: Tania Tripp delivering a Western screech-owl presentation at Strathcona Park Lodge on May 18th.

A second presentation was delivered in June to members and non-members of the CR Fish and Wildlife Club. Madrone Biologists combined efforts with Pacific Megascops Research Alliance (PMRA) to discuss Western screech-owl conservation and opportunities to participate in citizen science. The presentation was followed by nest box building workshop. Approximately 25 people attended. Due to significant interest from CR Fish and Wildlife club members with wood-working skills, an FWCP Community Engagement Grant was awarded to the club to buy raw materials for building nest boxes. Moreover, a guardian from the We Wai Kai First Nation was hired to help with event facilitation. This short contract was a springboard to discuss plans to train and hire guardians to assist on future surveys, nest box installations and inspections, as well as the potential to collaborate on additional grant proposals for SAR species.

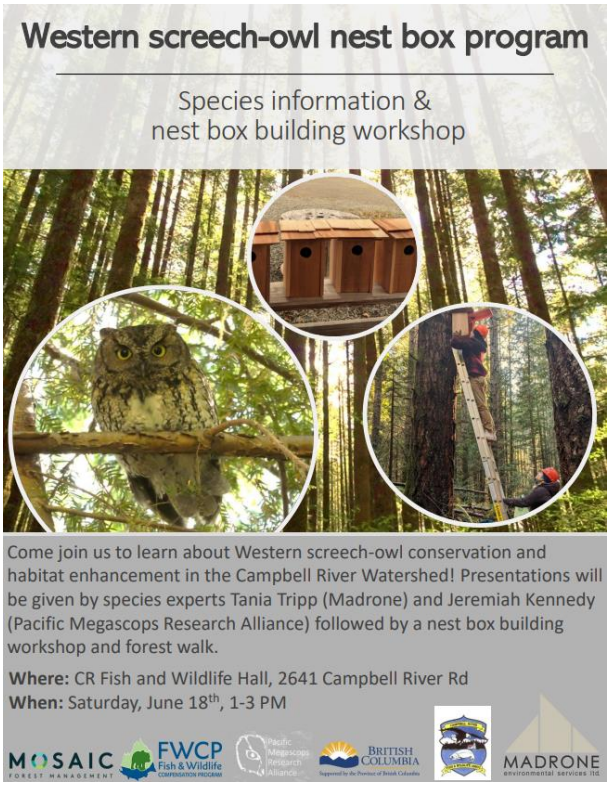


Figure 13: Flyer created for event at CR Fish and Wildlife clubhouse on June 18th, 2022.

6. Discussion

6.1. Western screech-owl monitoring

Unfortunately, no screech-owls were detected along transects which may indicate that territories historically occupied by WESOke are currently vacant. Between 2000 and 2006, occupancy rates of Quinsam, Heber, and Strathcona Dam transects ranged from 0.08 to 0.58 (Table B2; Madrone 2016). Surveys conducted in 2015 detected a single screech-owl along the Heber transect (Madrone 2016), and now, recent surveys have yielded zero detections. Therefore, WESOke populations in the CR watershed are likely experiencing significant declines, yet trends are not statistically meaningful, possibly due to data limitations. Low counts (characteristic of rare species) combined with infrequent sampling can influence statistical significance.

While survey methodologies have changed through the years (from active CPB surveys to passive ARU surveys), comparisons of survey results are still valuable. Due to active survey methodology used in 2000 – 2015, it is possible that the number of WESOke territories were underrepresented. Detectability rates for call playback surveys are unknown and it is assumed that some individuals do not respond to call playback or have a delayed response, consequently missed by surveyors. ARU surveys are considered more reliable since surveys are conducted for 10 to 11 consecutive nights, which provide more opportunities to detect an owl if present. Therefore, it is likely there were more WESOke territories than documented between 2000 and 2007, and now, using ARU techniques, there is high confidence that territories are no longer occupied.

In regard to ARU recording analysis, it is important to note that only a high-level analysis of the recordings was available through the automated recognizer software used to scan sound files. The recognizer identifies screech-owl calls with a 95% confidence threshold and, therefore, any calls for which the recognizer is less confident (<95%) will not be identified. The software developers (Ruff et al. 2021) are currently working on a manual fix to adjust the threshold to improve sensitivity. Nevertheless, standardized comparisons between the recognizer created by Ruff et al. (2021) and manual listening of recordings are underway and preliminary results suggest that there are very few false negatives using the recognizer (R. Chicalo pers. comm. 2022).

Moreover, the ability of the recognizer to identify other owl species can be helpful. Northern pygmy-owls *swarthi* subspecies, a blue-listed subspecies that is included on the *Forest, Range, and Practices Act* as an 'Identified Species' was detected at five survey stations (Table 3) and trends presented in Figure 8 indicate that populations could be increasing. These detections will be submitted via the WSI, a government-managed public database, so land managers can manage for them accordingly. In addition, tracking the instances of Barred owl detections, a known WESOke predator and competitor, will likely be important for population and habitat modelling; activities that Regional Government Biologists are pursuing.

6.2. Nest box inspections

2021/2022 inspections of nest boxes installed in 2015 have shown little sign that they are being used by nesting owls. Across both years of inspections, nine nest boxes showed signs of nesting (e.g., accumulation of nesting material such as grass, moss, bark, and twigs), however these materials could have been gathered by other cavity nesters such as squirrels or other bird species. Feathers and whitewash that were found in and around the nest boxes (n = 7) also indicate nest box activity, but again, are not conclusive in determining WESOke use. Puffball mushrooms (*Calvatia* sp.) and mold were found in 2 nest boxes that were notably wet on the inside, possibly due to leaky roofs and/or that those boxes had little protection from heavy rains. Presence of fungi may be deterring owl use and should be cleaned out and re-installed in a nearby location that may be more protected.

Several factors may contribute to the lack of nest box use by WESOke. An unfortunate explanation may be that there are no screech-owls present in areas where previously detected (see Section 6.1 for discussion of survey results). For individuals that persist yet go undetected, perhaps there are sufficient natural cavities available for the apparent low density of WESOke that occur in the CR Watershed. Alternatively, the locations of installed nest boxes may be too close to recent or current forest disturbances (e.g., construction, tree harvesting, road traffic, etc.). According to the *Guidelines for Raptor Conservation during Urban and Rural Land Development in British Columbia*, nesting WESOke are considered to have a moderate tolerance to disturbance and thus require a 600m 'quiet' nesting buffer in undeveloped areas (BC MOE, 2013). Therefore, locations of future nest box installments should consider harvesting plans and level of activity in the vicinity.

Excitingly, a pair of Northern saw-whet owls bred in a box installed along Jubilee Parkway. It is possible that the new deployment configuration may have contributed to its success. Previously, boxes were installed in groups of 2-4 spread across the landscape, potentially making them difficult for owls to find. A new strategy was developed which deploys clusters of 20 - 30 nest boxes along a short transect (200 - 300 m trail), thus providing a 'core breeding area' within suitable riparian habitats. This strategy also increases efficiency for inspecting and maintaining nest boxes since there is less travel between boxes. Nest boxes deployed in 2021 and 2022 followed this new strategy.

6.3. Community outreach and collaboration

Momentum is building with collaborators. Since hiring a guardian to assist with the event at the Campbell River Fish and Wildlife Club, the We Wai Kai Guardian program is interested in integrating screech-owl monitoring and conservation into landscape planning on their traditional lands. Currently, there is a partnership to submit proposals for federal Habitat Stewardship Program (HSP) and Aboriginal Fund for Species at Risk (AFSAR) funding. The intent is to support capacity building for participating and co-leading

the Owl Monitoring and Nest Box Program, such that guardians build skills in the following areas:

- ARU surveys,
- Screech-owl habitat assessments,
- Nest box monitoring, maintenance, and installation,
- Ground-truthing habitat models,
- Developing a Best Management Practices for Western screech-owl that could be used as a reference for We Wai Kai guardians when consulted for land development projects.

Funds can also be used to buy equipment (e.g., ARUs, nest box inspection camera, ladders, etc.) that can be used by guardians for future projects and contracts.

Regarding other collaborations, thanks to the FWCP engagement grant awarded to the CR Fish and Wildlife Club, members with wood-working skills will be supplied with raw materials to compile nest box kits. Kits will be assembled by volunteers as part of an event organized by Joanne Saunders, the club's president. In collaboration with stakeholders and We Wai Kai guardians, Madrone's project Biologists will determine new locations for nest boxes and train guardians to install boxes.

Educational presentations for school groups at Strathcona Park Lodge is set to continue. These are excellent opportunities to engage younger generations in wildlife conservation and how science is used to inform management activities for SAR. There is interest by Strathcona Park Lodge's outdoor educators to purchase camera gear to inspect nest boxes along the Bog Trail and to conduct call playback surveys in the area. Madrone's Biologists will provide adequate training for safe animal care techniques and using camera equipment.

7. Next Steps

The long-term nature of the Owl Monitoring and Nest Box Program provides valuable insight and opportunities to learn more about WESOke and enact conservation measures to protect this species. Therefore, the following list provides recommendations that align with FWCP Action Plan items, as well as BC's WESOke Recovery Plan:

1. Additional inventory efforts are needed, especially along new transects. Conducting ARU surveys along White River, East Memekay, and C-Branch will be a priority. In addition, surveying the Buttle Lake transect (within provincial park boundaries) is important since forested areas along this transect will likely have fewer disturbances, which may be a key factor in long-term occupancy. Funding for the Buttle Lake transect may be available from BC Parks. Overall, results from surveys will hopefully identify new areas for habitat enhancement.
2. In the event that surveys do not occur or no owls are detected, creation of a WESOke Nesting Habitat Model is recommended. There are currently several

Terrestrial Ecosystem Mapping layers that exist for the CR watershed that could be leveraged for a Wildlife Habitat Ratings model. Madrone created a model for the Capital Regional District's Water Supply Area in 2021 (see Figure 14 for an example), and this framework could be used to expedite the modelling process in the CR watershed. Not only could this model provide new locations for habitat enhancements, but it could also be used by government and other stakeholders for land use planning to achieve screech-owl conservation goals.

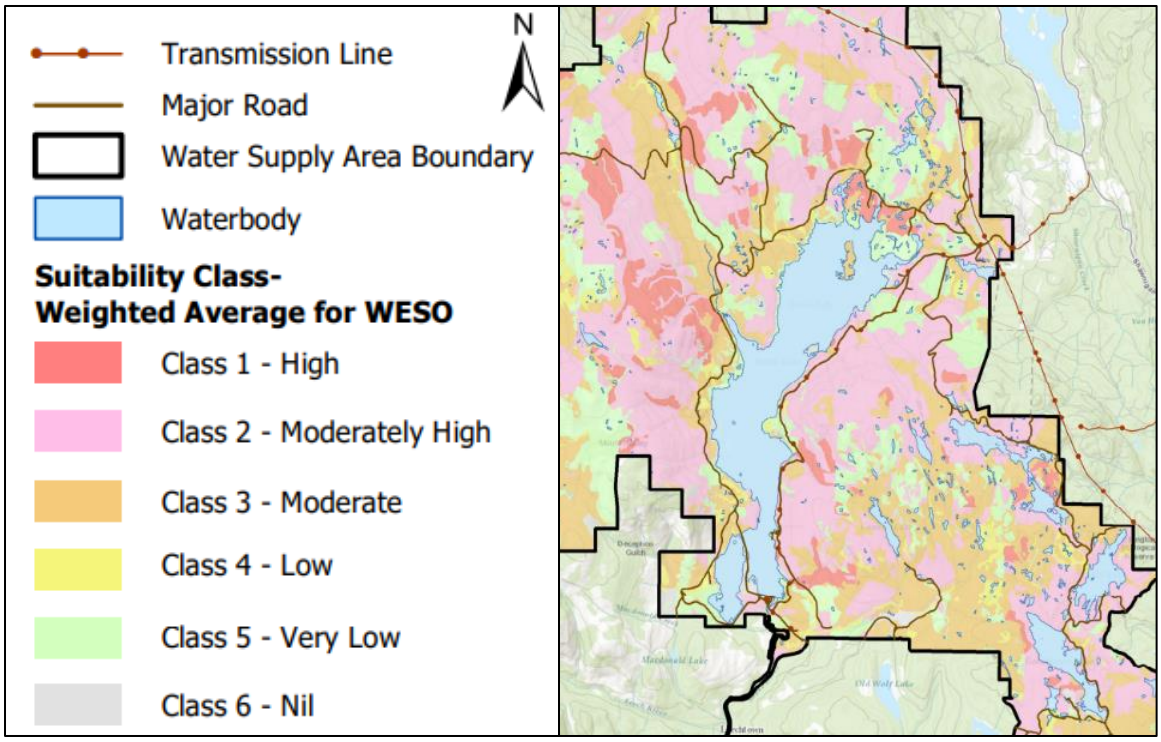


Figure 14: Example of WESOke Nesting Habitat Suitability Model in the Capital Regional District's Water Supply Area (Sooke watershed), on Vancouver Island, BC.

3. Continuation of nest box monitoring and maintenance is essential to assess the efficacy of this habitat enhancement measure. The CR Watershed now has 178 boxes that require various levels of monitoring and maintenance to meet habitat enhancement goals. Visual inspections of nest boxes will reveal signs of WESOke use and may further guide locations of additional owl nest boxes. Continued work with local groups is important to encourage independent monitoring.
4. Work with We Wai Kai guardians to set-up a multi-year monitoring program to assess condition and/or maintenance of nest boxes, conduct surveys, and ground-truth habitat model outputs.
5. Continue to work and collaborate with Government Biologists and Species at Risk experts to coordinate research and information acquisition efforts.

8. Acknowledgments

Funding for this project was provided by the Fish & Wildlife Compensation Program (FWCP) and MOSAIC Forest Management Ltd. In addition to funding, MOSAIC also provided in-kind support. Professional Biologist David Vey with MOSAIC installed many of the nest boxes with Madrone. His contribution to this project is greatly appreciated.

In-kind support from the Ministry of Forests, Lands and Natural Resource Operations and Rural Development in the form of time and equipment, specifically the loaning of autonomous recording units (ARUs), were put to good use.

We would also like to thank the Wei Wai Kum First Nation, Campbell River Fish and Wildlife Club, and Strathcona Park Lodge for their letters of support and use of facilities for presentations.

Last but not least, this work could not have been accomplished without the help from numerous enthusiastic volunteers from The Strathcona Park Lodge. Thank you!

9. References

BC Conservation Data Centre. 2008. Provincial tracking list for red and blue-listed species in British Columbia. Ministry of Sustainable Resource Management, Victoria, BC.

BC Ministry of Environment, Lands and Parks and BC Ministry of Forests. 1998. Field Manual for Describing Terrestrial Ecosystems. Land Management Handbook No 25. Victoria, BC.

BC MOE. 2013. Guidelines for Raptor Conservation during Urban and Rural Land Development in British Columbia. https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/best-management-practices/raptor_conservation_guidelines_2013.pdf

Blood, D.A. and G.G. Anweiler. 1994. Status of the Bald Eagle in British Columbia. Wildlife Branch, Ministry of Environment, Lands and Parks Wildlife Working Report #62. Victoria, BC.

Bryhn AC, Dimberg PH. 2011. An operational definition of a statistically meaningful trend. PLoS One. 2011 Apr 28;6(4):e19241.

Campbell, R.W., N. Dawe, I. McTaggart-Cowan, J.M.Cooper, G.W.Kaiser, & M.C.E. McNall. 1990a. Birds of British Columbia. Volume Two, Nonpasserines. Diurnal Birds of Prey through Woodpeckers. Royals BC Museum and Environment Canada.

Cannings, R.J. 1987. The breeding biology of Northern Saw-whet Owls in British Columbia. In Biology and conservation of northern forest owls: symp. proc. R.W. Nero, R.J. Clark, R.J. Knapton, and R.H. Hamre (editors). U.S. Dep. Agric. For. Serv., Rocky Mtn. For. Range Exp. Stn., Fort Collins, Colo., Gen. Tech. Rep. RM-142, pp. 193–198.

Cannings, R.J. 1993. Northern Saw-wet Owl (*Aegolius acadicus*). *In* The Birds of North America, No. 42 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washigton, D.C.: The American Ornithologists' Union.

Cannings, R. J. and T. Angell. 2001. Western screech-owl (*Otus kennicottii*). In The Birds of North America, No. 597 (A. Poole and F. Gill eds.). The Birds of North America Inc., Philadelphia, PA.

Cannings, R. 2007. The BC-Yukon Nocturnal Owl Survey 2007. Bird Studies Canada. Naramata, BC.

Cannings, R. 2006. The BC-Yukon Nocturnal Owl Survey 2006. Bird Studies Canada. Naramata, BC.

COSEWIC. 2002. COSEWIC assessment and update status report on the Western screech-owl *Otus kennicottii, macfalanei* subspecies and *kennicottii* subspecies in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 33pp.

COSEWIC 2006. COSEWIC assessment and status report on the Northern Saw-whet Owl *brooksi* subspecies *Aegolius acadicus brooksi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 23 pp. (www.sararegistry.gc.ca/status/status_e.cfm)

Darling, L.M. 2003. Status of the Vancouver Island Northern Pygmy Owl (*Glaucidium gnoma swarthi*) in British Columbia, BC Minist. Sustainable Resour. Manage., Conservation Data Centre, and BC Minist. Water, Land and Air Protection, Biodiversity Branch, Victoria, BC Wildl. Bull. No B-113. 14 pp

Davis, H. and R. Weir. 2006. Conserving Western screech-owl Habitat along the Shuswap River (Project #05.W.Sh.01) – Year End Report. Prepared by Artemis Wildlife

Consultants for BC Hydro Bridge Coastal Restoration Program, and World Wildlife Fund. Armstrong, British Columbia.

Davis, H. and R. Weir. 2007. Western screech-owl Conservation along the Shuswap River: 2007 Year-End Report. Prepared by Artemis Wildlife Consultants for BC Hydro Bridge Coastal Restoration Program, and World Wildlife Fund. Armstrong, British Columbia.

Feusier, S. 1989. Distribution and behavior of Western screech-owls (*Otus kennicottii*) of the Starr Ranch, Audubon Sanctuary, Orange County, California. M.Sc. Thesis, Humbolt State University, Arcata, California.

Fish Wildlife Compensation Program (FWCP). 2018. Campbell River Watershed Action Plan.

Fraser, D.F., W.L. Harper, S.G. Cannings and J.M. Cooper. 1999. Rare Birds of British Columbia. Ministry of Environment, Lands and Parks, Wildlife and Resources Inventory Branches, Victoria, BC

Fuller, M.R. and J.A. Mosher. 1981. Methods of detecting and capturing raptors: a review. Pages 235-246. In: C.J. Ralph and J.M. Scott, eds. Estimating numbers of terrestrial birds. Study of Avian Biology No. 6.

Green, R.N. and K. Klinka. 1994. A field guide to site identification and interpretation for the Vancouver Forest Region. BC Ministry of Forests, Victoria, BC.

Hausleitner, D. 2006. Inventory Methods for Owl Surveys: Standards of British Columbia's Biodiversity No. 42. v 1.0 Prepared for Ecosystems Branch of the Ministry of Environment for the Resource Information Standards Committee.

Hayward, G.D. 1983. Resource partitioning among six forest owls in the River of No Return Wilderness, Idaho. M.Sc. Thesis, University of Idaho, Moscow.

Hemmera 2017. Western screech-owl (coastal subspecies): Compilation and Analysis of Records to Inform Trend Monitoring. Prepared for Ministry of Forests, Lands, and Natural Resource Operations in March 2017.

Hemmera 2020. Coastal Western screech-owl Occupancy Analysis to Inform Study Design - 2020: Compilation and Analysis of Records to Inform Trend Monitoring. Prepared for Ministry of Forests, Lands, and Natural Resource Operations in April 2020.

Holschuh, C. 2004. Monitoring Habitat Quality and Condition of Queen Charlotte Saw-whet Owls (*Aegolius acadicus brooksi*) Using Vocal Individuality. M.Sc. Thesis, University of Northern British Columbia, Prince George, BC, Canada.

Holt, D. W., and J. L. Petersen. 2000. Northern Pygmy Owl (*Glaucidium gnoma*). *In* The Birds of North America, No. 494 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Houston, C.S., D.G. Smith, and C. Rohner. 1998. Great Horned Owl (*Bubo virginianus*). *In* The Birds of North America, N^{o} 372 (A. Poole and F. Gill, eds.). The birds of North America, Inc., Philadelphia, PA.

Johnsgard, P. 1988. North American Owls: Biology and Natural History. Smithsonian Press, Washington D.C.

Joy, J., L. Petersen, N. Winchester, A. Mackinnon, D. Meidinger, M. Kellner and J. Voller. 1999. Coastal montane biodiversity inventory. Unpubl. Rep. BC Minist. Environ., Lands and Parks, Nanimo, BC and BC Minist. For., Victoria, BC 174 pp.

Leigh-Spencer S. and L Menzies. 2008. Owl abundance on the Sechelt Peninsula. Unpublished report for Terminal Forest Products.

Madrone Environmental Services Ltd. 2016. Wester Screech-owl Habitat Enhancement and Inventory – Campbell River. Project #: 16W CBR 03. Prepared for the Fish and Wildlife Conservation Fund on August 18, 2022.

Madrone Environmental Services Ltd. 2021a. Western Screech-owl Monitoring and Habitat Restoration in the Campbell River Watershed – Year 1. Prepared for Fish and Wildlife Compensation Fund in March 2021.

Madrone Environmental Services Ltd. 2021b. Western Screech-owl (*Megascops kennicottii kennicottii*) Territory Monitoring and Nest Search Efforts – Southern Vancouver Island, B.C. Prepared for Ministry of Forests, Lands and Natural Resource Operations and Rural Development on August 31, 2021.

Madrone Environmental Services Ltd. 2022. Surveys for Western screech-owl kennicottii subspecies on Vancouver Island. Prepared for Environment and Climate Change Canada and Canadian Wildlife Service on March 30, 2022.

Matkoski, W. 1997. Nimpkish owl inventory, 1996 annual report. Unpubl. Rep. Can. For. Products Ltd., Englewood Logging Div., Woss, BC. 43pp + App.

Matkoski, W. R. Matkoski. 2006. Monitoring Forest Owls on TFL 37, Northern Vancouver Island: 2006. Prepared for Western Forest Products Inc, Englewood Forest Operations.

Mazur, K.M., and P.C. James. 2000. Barred Owl. (*Strix varia*). *In* the Birds of North America, N^{o} 508 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Menzies, L. and T. Tripp. 2007. Campbell River Owl Monitoring and Habitat Restoration Summary Report. Prepared for BC Hydro: Bridge Coastal Restoration Project.

Mico, M. and T. Van Enter. 2000. Campbell River Watershed Owl Survey, 2000 (Year 1). Prepared for BC Hydro, Vancouver, BC.

Ministry of Environment. 2013. Recovery plan for the Western Screech-Owl, kennicottii subspecies (Megascops kennicottii kennicottii) in British Columbia. B.C. Ministry of Environment, Victoria, BC. 23pp.

National Audubon Society (2008). The Christmas Bird Count Historical Results [Online]. Available http://www.audubon.org/bird/cbc [March 21, 2008]

Pendergast, S. 2002. Campbell River Watershed Owl Survey and Nest Box Initiation Program: February to April 2002 (Year 2). Prepared for BC Hydro Bridge River/Coastal Compensation Fund, Vancouver, BC.

Pendergast, C and S. Pendergast. 2003. Campbell River Watershed Owl Survey Summary Report for 2000, 2002 and 2003 (Year 3). Prepared for BC Hydro Bridge River/Coastal Compensation Fund, Vancouver, BC.

Pojar, J., K. Klinka and Demarchi. 1991. Ch 6: Coastal Western Hemlock Zone. In Special Report Series 6: Ecosystems of BC. BC Ministry of Forests. Victoria, BC.

Resource Inventory and Standards Committee (RISC). 2001. Inventory Methods for Raptors. Standards for Components of British Columbia's Biodiversity No.11: Raptors version 2.0. Publication #206. Ministry of Environment, Lands and Parks, Victoria, BC.

Ruff, Z.J., Lesmeister, D.B., Appel, C.L. and Sullivan, C.M., 2021. Workflow and convolutional neural network for automated identification of animal sounds. Ecological Indicators, 124, p.107419.

Tripp, T. 2004. Use of Bioacoustics for Population Monitoring in the Western screech-owl (*Megascops kennicottii*). M.Sc. Thesis, University of Northern British Columbia, Prince George, BC, Canada.

Tripp, T. and K. Otter. 2006. Vocal individuality as a potential long-term monitoring tool for Western screech-owls (*Megascops kennicottii*). Canadian Journal of Zoology. 84: 744-753.

Appendix A

Species Account

The Western screech-owl (*Megascops kennicottii*) is a widespread non-migratory species that occurs along the Pacific Coast of North America, from southern Alaska to central Mexico (Cannings and Angell 2001). In Canada, this species occurs only in British Columbia (BC) and as two subspecies: *M. k. kennicottii*, along the coastal mainland and Vancouver Island, and *M .k. macfarlanei*, in the southern BC interior (COSEWIC 2002). This species is historically known to be locally abundant over parts of its range in BC (Campbell *et.al.* 1990), although some populations of this species are now believed to be in decline (Cannings and Angell 2001; Fraser *et.al.* 1999). The interior subspecies has a Federal listing of "Threatened" (COSEWIC 2002) and is provincially "red-listed" (BC Conservation Data Centre 2008). The subspecies occurring along the coast of BC has a Federal listing recently been updated to "Threatened" (COSEWIC 2021) and is provincially "blue-listed" (Special Concern) (BC Conservation Data Centre 2021).

The Western screech-owl is a small, streaked owl with tufted ears and yellow eyes. Adults vary in total length between 19 to 25.5 cm and 100 to 305 g in mass; however, females are generally larger and heavier than males (Cannings and Angell 2001). The primary song consists of a series of notes that is similar to a "ball bounding more and more rapidly over a frozen surface" (Johnsgard 1988, Tripp 2004). This opportunistic nocturnal raptor preys on mammals, fish, insects, invertebrates and other birds. It is also prey for other avian predators, such as the Barred Owl (*Strix varia*) (COSEWIC 2002).

Western screech-owls use a variety of habitats for roosting and nesting including; mature forests, 50 to 60 year old open Douglas-fir forests, dense young Douglas-fir forests, black cottonwood (*Populus trichocarpa*) and woodlands bordering marshes, ponds, wet areas or fields. In general, Western screech-owls are associated with mixed deciduous-coniferous woodlands near water (COSEWIC 2002). In BC, nests are usually found in cavities 1.2 to 12.2 m up a tree, mainly on sites located below 600 m in elevation (Campbell *et.al.* 1990).

Favoured nesting cavities/holes include Pileated Woodpecker and Northern Flicker excavations (cavities) in Douglas-fir, western redcedar (*Thuja plicata*), and bigleaf maple (*Acer macrophyllum*), Arbutus (*Arbutus menziesii*), Grand Fir (*Abies grandis*), Red Alder (*Alnus rubra*), Garry Oak (*Quercus garryana*) and Western Hemlock (*Tsuga heterophylla*) (Campbell et al 1990, Hobbs and Darling, pers. comm. 2001 as cited in COSEWIC 2002).

At present, few detailed home range and territory size estimate studies have been completed for this species in North America. Research by Hayward (1983) in central Idaho indicated a home range of two radio-tagged birds to be 3-9 hectares, and 29-58 hectares respectively. A study on Western screech-owls in southern California calculated an average of 2.1 territories per kilometer of river channel, with a minimum average distance of 420 m between nest sites (Feusier 1989). Recent telemetry efforts in the interior of British Columbia have documented territory ranges of 112 ha (mean minimum convex polygon for five tagged males), and a mean 95% utilization distribution estimate of home range size for four owls of 49 ha (Davis and Weir 2006 and Davis and Weir 2007).

Appendix B

Data Tables

Table B1: 2022 Occupancy Estimates of species by transect.

Transect	Survey stations	WESO		NPOW		BDOW		NSWO		GHOW	
		#	Occ. Est.	#	Occ. Est.	#	Occ. Est.	#	Occ. Est.	#	Occ. Est.
Heber	11	0	0	0	0	1	0.09	0	0	0	0
Quinsam	11	0	0	1	0.09	1	0.09	3	0.27	1	0.09
Strathcona Dam	11	0	0	4	0.36	2	0.18	3	0.27	0	0
All	33	0	0	5	0.15	4	0.12	6	0.18	1	0.03

Table B2: Number of stations, detections, and occupancy estimates for three transects in the CR watershed by year.

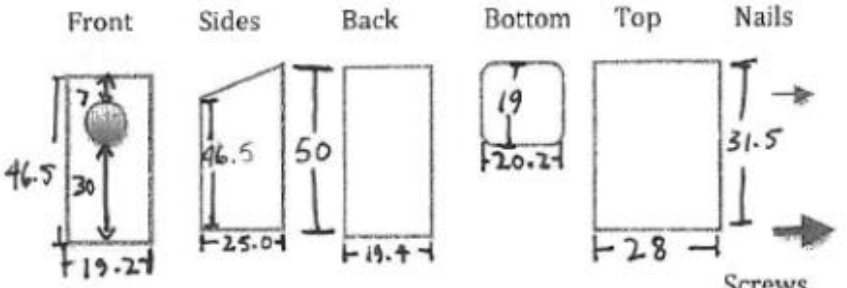
Year	Heber			Quinsam			Strathcona Dam		
	# of Sta.	# of Det.	Occ. Est.	# of Sta.	# of Det.	Occ. Est.	# of Sta.	# of Det.	Occ. Est.
2000	12	1	0.08	12	3	0.25	12	2	0.17
2002	12	3	0.25	12	3	0.25	12	3	0.25
2003	12	7	0.58	12	1	0.08	12	1	0.08
2006	12	2	0.17	14	2	0.14	12	3	0.25
2007	12	0	0	16	2	0.13	13	1	0.08
2014	11	1	0.09	-	-	-	11	0	0
2015	14	1	0.07	-	-	-	16	0	0
2022	11	0	0	11	0	0	11	0	0

Appendix C

Nest Box Design Instructions

"I Can Build It"

Screech Owl Nest Box : Assembly Instructions



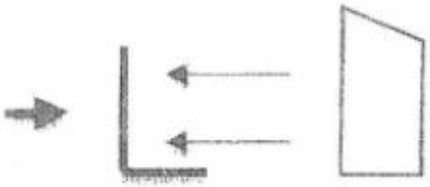
ALL MEASUREMENTS ARE IN "CM"

Step One

Attach back to bottom. Use the pre-drilled holes located on the back.
Note the **installations holes** located in the middle of the back piece.

Step Two

Attach sides to L shaped back/bottom. When assembled, there will be a narrow ventilation gap at the top.



Warning

This kit contains small nails and screws. Exercise caution when young children are present.
The wood used in this product has been salvaged from the forestry waste stream.

Manufactured by DonCol Nature Products
Abbotsford, B.C.
www.doncolnature.ca

Step Three

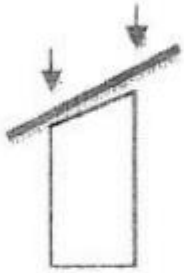
Attach the front. **Note -use only one nail as indicated on each side of the box.** These two nails will create a hinge which allows the nest box to be opened for cleaning. Ensure that the plastic mesh attached to the front is on the inside of the nest box. Use the galvanized nails provided for this procedure.

NOTE- leave a small gap (¼ ") at the top of the front as indicated by the arrow. This allows for ventilation and the proper operation of the door. Once sthe **cornice hook** provided will secure the front opening .

Side View

Step Four

Install Roof



Use the galvanized nails provided
Roof placement can vary.

Feathery Facts *-Credits- http://naturemappingfoundation.org*

The Western Screech-Owl is 15-22 cm in length with a squatty look. It has yellow eyes and may have gray or brown feathers with faint dark streaks on its lower body. The western screech owl also has ear tufts similar to those of a Great Horned Owl.

Range/Habitat: *The Western Screech-Owl is found across the Western United States and Canada. Screech-Owls can be found in a variety of different habitats including deserts, all types of forests and wooded areas.*

Nesting: *Western Screech-Owls usually build their nests in hollow trees or standing snags, often in a natural tree hole or an abandoned woodpecker hole. A female Screech-Owl will lay 3 or 4 eggs in the nest and will incubate them for about 26 days.*

Behavior: *The Western Screech-Owl is a master of disguise. When one of these small owls is frightened or threatened, it will stretch its body and tighten its feathers, causing it to look like a branch to all but the keenest of predators. This effective form of camouflage explains why these owls are rarely seen by people.*

INSTALLATION - Lower elevations, forests, parks, woodland clearings, forest edges, wooded stream edges, under a tree limb. Add 2"-3" of wood shavings. Height : 3 -4 m above the ground ensuring personal ladder safety is observed.