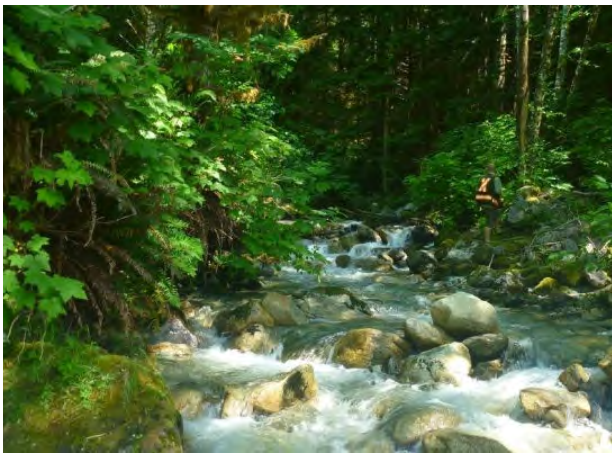
Surveys of Species at Risk and their Associated Habitats in the Clowhom Watershed – Year 2

FWCP Project No. 14.W.COM.01

Final Report - August 2015



Prepared for: **Fish and Wildlife Compensation Program**
6911 Southpoint Drive, Burnaby, BC, V3N 4X8

Prepared by: **Michelle Evelyn and David Stiles, Project Leaders**
Halcyon Professional Services & Sunshine Coast Wildlife Project
650 Gower Point Road, Gibsons, BC, V0N 1V8

Chris Currie
3839 Penticton Street, Maple Ridge, BC, V5R 1X6

Aimee Mitchell
Athene Ecological, 103-1516 East 1st Avenue, Vancouver, BC, V5N 1A5

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 the public

EXECUTIVE SUMMARY

Wetlands and riparian zones are essential to wildlife. These fragile and ecologically important ecosystems are also among those most affected by hydroelectric development and operations. On British Columbia's Sunshine Coast, the installation of the Clowhom dam in the 1950s flooded the lower Clowhom valley, causing substantial loss of riparian forests and wetlands. Widespread forest harvesting triggered further negative impacts to wildlife by altering hydrology and limiting the suitability and availability of terrestrial habitats adjacent to streams and water bodies. The 2011 Clowhom Watershed Plan prioritizes the need to map and assess remaining wetland and riparian ecosystems, survey associated wildlife, and design and carry out restoration and enhancement activities to benefit these habitats and species.

This report describes the second year of a multi-year project in the Clowhom watershed. Our objectives are: (1) to identify, assess and map wetlands and riparian ecosystems; (2) to undertake comprehensive surveys of species at risk and their associated habitat; (3) to work with partners to develop, implement, monitor and adaptively manage multi-species restoration, management and enhancement plans; and (4) to carry out an active outreach, education and community engagement program. Through these activities, we aim to identify sensitive habitats; locate new occupied sites for threatened and endangered species; highlight locations for future inventory efforts; prioritize sites for habitat conservation, restoration, and enhancement; increase and improve habitat for wildlife; reduce direct threats to populations of species at risk; increase community participation in wildlife and habitat stewardship activities; and improve public awareness of FWCP.

This year, we continued with activities initiated in Year 1, including wetland mapping and assessment, and surveys of pond-breeding amphibians and Western Screech-Owls. We also launched new activities, including riparian mapping and assessment, and surveys of Coastal Tailed Frogs, Northern Goshawks, Pacific Water Shrews, and bats. Between April 2014 and March 2015, field survey activities included: mapping and evaluating riparian zones throughout the watershed; assessment of 6 wetlands; 18 call-playback surveys for Northern Goshawks; 69 call-playback surveys for Western Screech-Owls; identification and mapping of Screech-Owl territories; over 100 bat mist net hours and 10 hours of acoustic bat surveys; environmental DNA surveys for Pacific Water Shrew at 5 wetlands and Coastal Tailed Frog at 9 streams; time-constrained surveys of Tailed Frogs at 8 sites; and surveys of pond-breeding amphibians at 15 sites, including 17 km of shoreline perimeter searches and over 1,600 amphibian trap hours.

In addition to research activities, we also carried out an active public engagement program to increase community awareness and participation in wildlife stewardship efforts. Activities included presentations, school programs, outreach tables, media articles, a landowner stewardship program, an owl and bat house-building program, and habitat enhancement community work parties to improve degraded riparian sites by removing invasive plants and planting native riparian vegetation. In all, we carried out 25 public engagement events this year, reaching over 1,500 community members of all ages. In addition, 57 landowners signed voluntary stewardship agreements this year, pledging to maintain over 69 hectares of wildlife habitat.

Wetlands in Clowhom are very limited in scope and abundance due to the watershed's steep slopes and narrow valley bottom. Over the past two years, we have identified, mapped and assessed 15 wetlands. The majority are small, less than a hectare in size, and most have been heavily impacted by human activity. Because of their limited number, those wetlands that do exist are particularly important to wildlife.

Riparian zones make up 16% of the total area of Clowhom watershed. Most are located at higher elevations around the numerous headwater streams and lakes; only 25% of riparian areas are located below 600 m. These low elevation riparian zones have been disproportionately impacted by human activity, with 54% harvested in the last 50 years. Clowhom riparian areas are also impacted by four microhydro operations and associated transmission lines, and 39 km of roads within riparian habitats, including 110 road crossings.

Our work demonstrates that the wetlands and riparian areas of the Clowhom watershed support a rich diversity of wildlife. Over the past two years of surveys, we have documented the presence of at least 118 vertebrate species. They include many high priority species of conservation concern, including 14 provincially listed species, 11 federally listed species, 8 Pacific Coast Joint Venture priority bird species in BC, 11 Partners in Flight species of continental importance in the Pacific Avifaunal Biome, and 3 species listed as Identified Wildlife under the BC Forest and Range Practices Act.

Our owl surveys have documented and mapped 4 Western Screech-Owl territories, pinpointed one nest cavity, and confirmed successful fledging in at least one territory. Our amphibian surveys have confirmed the presence of at least 8 amphibian species in the watershed, including provincially blue-listed Western Toads, Red-legged Frogs and Coastal Tailed Frogs. Our bat surveys have demonstrated the occurrence of a diverse bat community composed of at least 8 species, including federally endangered Little Brown Bats. Our environmental DNA surveys have confirmed the presence of Coastal Tailed Frogs in at least 9 streams, and provided suggestive evidence for the possible presence of Pacific Water Shrews in one Clowhom wetland. Thus far, we have not detected Northern Goshawks in the watershed.

Key threats to wetland- and riparian-associated wildlife in the Clowhom watershed include impacts from hydro operations, forest harvesting, and roads and transmission lines. Wildlife living in wetlands adjacent to the reservoir are significantly impacted by the dramatic and unpredictable variations in water levels caused by hydro activities. These water level fluctuations likely limit reproduction and recruitment of wildlife species, including amphibians, fish, invertebrates, and shoreline-nesting birds. For amphibians, rapid decreases in water levels can strand egg masses on land, while low water levels can cause breeding pools to dry up before larvae have time to metamorphose. Rapid inundation can wash egg masses away or decrease water temperatures, hindering development. High water levels can also substantially increase predation risk by allowing fish to enter the fish-free areas where amphibians prefer to breed. In 2014, water level fluctuations appear to have reduced breeding success at two of the three known Western Toad breeding sites, and at one of two identified Red-legged Frog breeding sites in the watershed.

Widespread forest harvesting in the Clowhom valley has led to a loss of mature forest, and related structural features such as large diameter coarse woody debris and cavity-bearing wildlife trees, upon which many species depend. Future forest harvesting decisions in the Clowhom watershed should seek to conserve and maintain habitat values for wildlife species at risk around important breeding, hibernating, nesting and foraging sites, and within identified territories.

Roads and transmission lines are situated near many Clowhom wetlands and riparian zones. Maintenance of hydro right of ways that pass through wetlands should ensure that clear flight pathways remain for drinking bats. Maintenance activities should be timed to avoid critical developmental periods for amphibians and should avoid the use of chemical herbicides. Invasive plant species growing along roads and transmission lines should be monitored and controlled. Although several important amphibian breeding sites are situated next to roads, traffic is light and road mortality does not appear to be a significant issue at this time.

In the upcoming 2015-2016 project year, we will continue our efforts to evaluate wildlife habitat, assess threats, and identify priority areas and actions for habitat conservation, restoration, and enhancement in the Clowhom watershed. We will continue to evaluate wetlands and riparian zones, and to survey diverse species at risk, including amphibians, bats, owls, goshawks and water shrews.

We will also undertake habitat enhancement and threat mitigation activities including: (i) removing invasive plants and planting native riparian vegetation in order to improve wetland health and function, increase habitat quality, and mitigate road impacts; (ii) installing woody debris to improve upland wetland habitat for amphibians, reptiles, birds and invertebrates; (iii) installing owl nest boxes and bat houses to increase available nesting and roosting habitat for these species; and (iv) installing interpretive signs, sensitive habitat signs and road crossing signs to decrease human disturbance of Clowhom wetlands and to reduce threats of wildlife road mortality.

Finally, we will work with project partners to develop a comprehensive plan to restore wetlands in the watershed by creating stable habitats that will not be subject to the same harmful water level fluctuations experienced by areas directly connected to the reservoir. Our goal is to construct water bodies of various sizes adjacent to those currently being affected. These wetlands will be designed to provide a diverse mixture of habitats to support the greatest diversity of wildlife species.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The importance of wetlands and riparian zones to wildlife cannot be overstated. Across North America, 80% of breeding birds and 50% of species at risk rely on wetlands for some portion of their lifecycle (Tori et al. 2002). In British Columbia, more than 30% of species-at-risk are wetland-dependent (Austin et al. 2008). Wetlands and riparian areas are also among those most affected by the construction and operation of hydro facilities.

In the 1950s, BC Hydro built the Clowhom Dam at the head of Salmon Inlet on the Sunshine Coast. The dam flooded two existing lakes and 315 ha of land, including 41 ha of riparian habitat and 9 km of streams, to create the Clowhom Reservoir which measures 800 ha at full pool (FWCP 2011). This substantial landscape change had significant impacts on wetland and riparian wildlife in the Clowhom watershed.

The 2011 Clowhom Basin Watershed Plan identifies an urgent need to map and assess wetland and riparian habitats, survey associated species at risk, and plan and carry out restoration and enhancement activities to benefit these habitats and species. To this end, "*riparian and wetland mapping and restoration*" and "*amphibian surveys*" have been highlighted as two of the five top priorities for FWCP funding in the Clowhom watershed (FWCP 2011).

Prior to this study, Clowhom wetlands and riparian zones and their associated wildlife species had received very little attention. The Sunshine Coast Sensitive Ecosystem Inventory did not include the Clowhom watershed (Environment Canada 2005). Prior FWCP investment in the Clowhom basin was focused on fish, rather than wildlife (FWCP 2011). The shíshálh First Nation and BC Hydro conduct a regular seasonal wildlife census in the large wetland complex at the end of the reservoir as part of a 20-year monitoring program (Bates 2007, 2008; Bates et al. 2009, 2011; Bates & Ferguson 2010; Ferguson et al. 2012). However, this activity takes place in just one area of the watershed and does not include specialized live trapping surveys, call-playback surveys, nocturnal, or environmental DNA surveys necessary to assess populations of rare, elusive, and threatened wetland and riparian-associated species at risk, including amphibians, owls, bats, and water shrews.

In 2013, with FWCP support, we initiated a multi-year project to assess and map wetland and riparian habitats, survey associated wildlife species-at-risk, and identify and carry out restoration and enhancement activities in the Clowhom watershed. During this second year of the project (2014-2015), we continued these efforts by mapping and assessing wetlands and riparian zones, conducting surveys of high priority wildlife species, evaluating threats, and developing restoration and enhancement plans.

2.0 GOALS AND OBJECTIVES

The objectives of this project are to:

1. Identify, assess and map wetlands and riparian ecosystems in the Clowhom watershed in order to identify sensitive habitats and prioritize sites of future species at risk inventories.

2. Undertake comprehensive surveys of species at risk and their critical habitat in the Clowhom watershed in order to identify new occupied sites for threatened and endangered species, evaluate threats, and prioritize sites for habitat restoration, enhancement, and conservation.

3. Work with partners to develop, implement, monitor and adaptively manage multi-species restoration, management and enhancement plans in order to increase and improve habitat for wildlife and reduce direct threats to populations of species at risk.

4. Carry out an active outreach, education and engagement program in order to increase community participation in wildlife and habitat stewardship activities, and improve awareness of the Fish and Wildlife Compensation Program along with its program partners.

3.0 STUDY AREA

The 390 km^2 Clowhom watershed, is located at the head of Salmon Inlet, northeast of Sechelt and west of Squamish (Figure 1). It is located in the Coastal Western Hemlock biogeoclimatic zone, including moist maritime and very wet maritime subzones (CWH mm and CWH vm). Elevations range from 30 to 2400 m and vegetation classes range from dense forest to alpine. Footprint impacts from dam construction included loss of 41 ha of riparian habitat, 6 km of mainstem, 3 km of lower tributary channels, and flooding of 430 ha of existing lake, including 17 km of shoreline habitat (FWCP 2011). In addition to BC Hydro activities, this industrial watershed is also impacted by logging operations (Interfor) and four IPP run-of-the-river operations (Veresen Incorporated's Clowhom Power operations on Clowhom River, and Regional Power's Bear Hydro operations on Bear Creek).

This year, project activities included mapping of wetlands and riparian zones, and surveys of diverse wildlife groups including pond-breeding amphibians, owls, goshawks, bats, tailed frogs, and water shrews. Most surveys took place along the Clowhom Reservoir and in the Clowhom River valley and Bear Creek valley (Figure 2). Riparian zones were mapped across the entire watershed, while wetland assessment and monitoring occurred at 15 sites. Surveys of pond-breeding amphibians included perimeter searches and auditory surveys at 16 sites and live-trapping at 12 wetlands. Western Screech-Owls were surveyed at 69 call-playback stations along 38 kilometers of riparian transects, and habitat assessment, territory delineation, and nest monitoring occurred within 4 occupied Screech-Owl territories. Northern Goshawk call-playback surveys were carried out at 18 sites. Bat surveys were conducted at 10 acoustic monitoring stations and 16 mist net sites. Coastal Tailed Frog surveys included time-constrained searches at 8 streams and environmental DNA (eDNA) sampling at 9 streams. Pacific Water Shrew eDNA sampling occurred in 5 wetlands. The locations of all field survey activities in the 2014/2015 project year are summarized in Figure 2 on the following page.

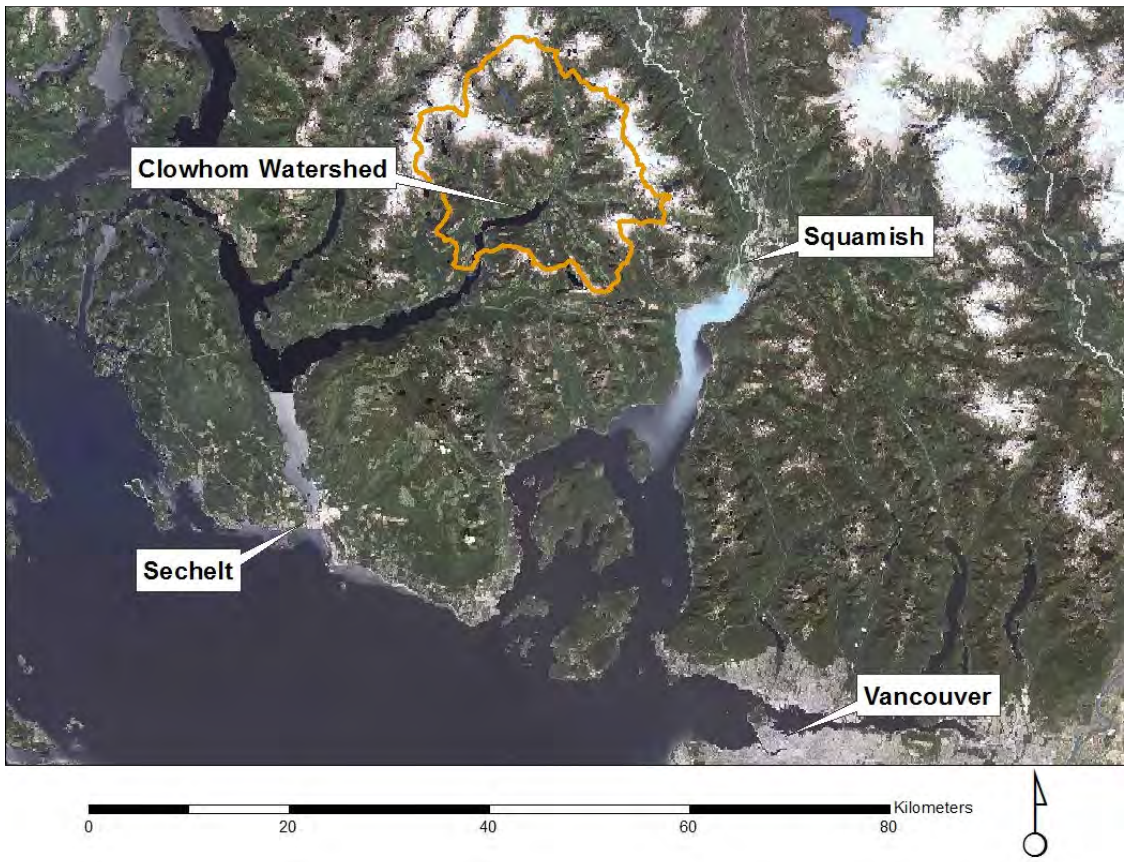


Figure 1: Location of the Clowhom Watershed, Sunshine Coast, BC

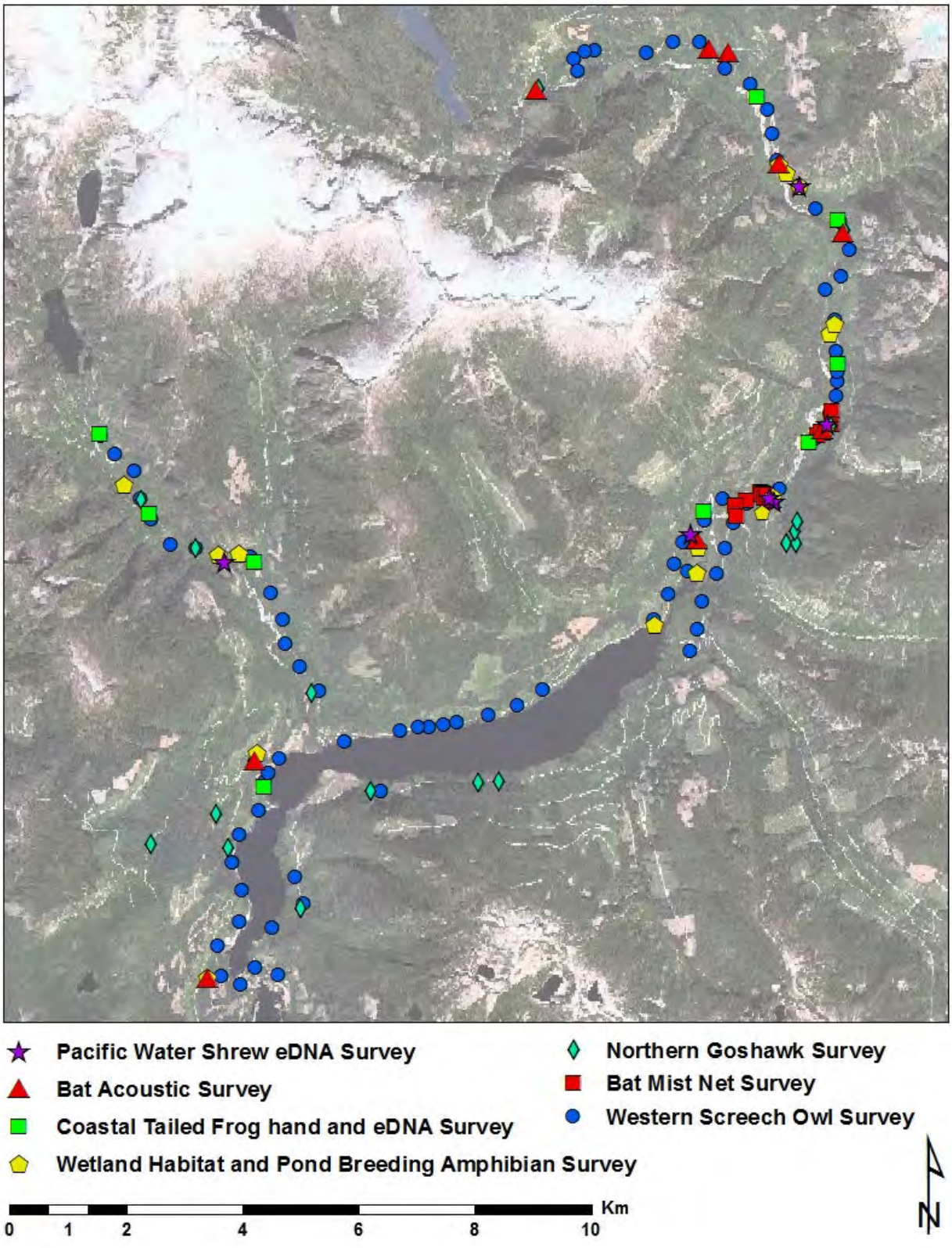


Figure 2: Locations of Survey Activities in the Clowhom Watershed, 2014/2015

4.0 METHODS

4.1 Wetland Mapping, Assessment and Monitoring

To evaluate the nature, abundance and health of Clowhom wetlands, and to detect priority sites for wildlife monitoring, habitat enhancement and threat mitigation, we have been working to identify, map and assess wetland sites in the watershed. Last year we mapped 14 wetlands. Of these, nine sites (Wetlands 3-10 and 14) received comprehensive ground assessment, while five sites (Wetlands 1-2 and 11-13) received preliminary evaluation based on orthophotography interpretation plus visual inspection. This year, we undertook more comprehensive assessments of Wetlands 1, 2, 11, 12 and 13, including evaluations of physical characteristics, soil, hydrology, and vegetation. We also identified, mapped and assessed one new site (Wetland 15). All wetlands were visited several times throughout the spring and summer to monitor water levels and evaluate changes in habitat suitability. Surveys of pond-breeding amphibians occurred in all 15 wetlands (please see Section 4.3 for amphibian survey details).

Our wetland assessments followed Sensitive Ecosystem Inventory (SEI) methods (Environment Canada 2005) with some additions based upon other standardized survey protocols (BC Ministry of Forests & Range 2010; Green & Klinka 1994; MacKenzie and Moran 2004). Wetland features were digitized using ArcGIS 10.1 and photo interpretation of the 2004 Pan 321 enhanced orthophotography layer for BCGS Map sheet 92G, located on the BC Integrated Land Management Bureau's GeoBC web map server. This imagery has a resolution of 15 m. Wetlands were also digitized using Google Earth imagery (2009), which was then converted into an ArcGIS shapefile. During ground truthing visits team members took photos, made sketches, and recorded detailed notes which were then used when delineating polygons in ArcMap.

Figure 3: Assessing Wetlands in the Clowhom Watershed

4.2 Riparian Mapping and Assessment

To evaluate the extent of riparian areas in the Clowhom watershed, and to assess impacts to these habitats, we used ArcGIS to map buffers along the watershed's streams, creeks, lakes and wetlands and evaluate land use within these delineated riparian zones.

Riparian areas are dynamic and may be defined in numerous ways, depending largely on the context in which they are being discussed. For the purposes of this report, we have used an ecosystem approach, based on Naiman and Décamps (1997), considering the ecological function of the riparian zone in the watershed's biophysical processes.

Water features were mapped according to the Freshwater Atlas (FWA), the Province of British Columbia's standardized dataset for hydrological features. However, because the data within the FWA are typically limited to line features (which represent streams as having no width), and do not account for temporal shifts in habitats, we also included features that we had mapped on the ground during the previous project year.

For small headwater streams (1st to 3rd order streams), where riparian zones are typically small and confined by steep topography, we delineated 30 m buffer zones surrounding streams. For larger 4th and 5th order streams, we delineated a riparian zone extending 70 m (1 tree length) from the stream edge. Around lakes and wetlands, we set the riparian distance at 30 m.

The Clowhom River mainstem is a very dynamic system, with the stream channel frequently shifting its position on the valley bottom. To account for these temporal shifts in the habitat, we mapped the floodplain of the river, represented by a distinct band of vegetation and physiographic characteristics which are determined by the long-term channel dynamics (Naiman et al. 2010, Gregory et al. 1991). This was accomplished through a combination of air photo interpretation and elevation data from the provincial Terrain Resource Information Management program (TRIM).

Once the riparian areas within the watershed had been delineated, we overlaid land use spatial layers acquired through the provincial Land Resource Data Warehouse. We used this information to evaluate percentage of riparian zones impacted by such factors as forest harvesting, road crossings, and hydro operations.

It is important to point out the limitations of these analyses. Due to the difficulty of mapping the full extent of stream width, the calculated area of the riparian zone includes both the aquatic habitat as well as the true riparian habitat (not including lakes which were accounted for). This limitation is not likely to cause a substantial difference in the calculated riparian area around higher elevation headwater streams, where stream courses are relatively narrow. However, around the larger order streams, particularly the mainstem of the Clowhom River, the wetted width is substantial, resulting in an overestimation of the area of riparian habitats around those streams.

4.3 Surveys of Pond-breeding Amphibians

This year, we continued surveys to assess the distribution and abundance of amphibian species in the Clowhom watershed and to monitor activity of two species at risk (Red-legged Frog and Western Toad) at breeding sites identified during the previous project year. We used a combination of survey methods, including perimeter surveys, auditory surveys, and live trapping, following Resource Information Standards Committee (RISC) procedures (1998b), methods outlined in Olson et al. (1997), and BC Ministry of Environment hygiene protocols to prevent the spread of amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) between individuals and between water bodies (BC Ministry of Environment 2008).

Perimeter Surveys

Perimeter surveys took place in March, May, June and July 2014. Water bodies were surveyed by systematically searching shoreline habitat for egg masses, larvae, juveniles and adult amphibians. Larger water bodies were searched by kayak, while smaller, shallow water bodies were surveyed by wading and/or observing with binoculars from the shoreline. Total effort exceeded 17 km of shoreline surveys in 2014 (Table 1). All 15 identified Clowhom wetlands were visited.

Auditory Surveys

Auditory surveys were conducted in March 2014. We listened for calling frogs during breeding season while conducting surveys at 14 wetlands. Survey effort totalled 20 person hours of auditory surveys (Table 1).

Live Trapping

Amphibian live trapping surveys were carried out at 12 of the 15 identified wetlands. Funnel traps (collapsible mesh minnow traps) were placed randomly at a density of 1 trap per 25m^2 of habitat strata. Traps were set in the evening and checked the following morning. Floats were placed inside each trap to ensure that any air-breathing animals that could potentially enter the traps would not be harmed (e.g., water shrews). Total survey effort in 2014 was over 1600 trap hours (Table 1).

Incidental Encounters

We also documented incidental detections of amphibians spotted while traveling to and from sites and while conducting surveys of other wildlife groups.

Table 1: Surveys of Pond-breeding Amphibians in Clowhom Watershed, 2014

Survey Method	Dates	Locations	Total Effort
Auditory Surveys	27-30 March 2014	All Wetlands 1 to 14	20 hours
Perimeter Surveys	27-30 March 2014	All Wetlands 1 to 14	3.4 km surveyed
	1-4 May 2014	All Wetlands 1 to 14	9.7 km surveyed
	28 May 2014	Ditch near Wetland 15	45 m surveyed
	29-30 June 2014	Wetlands 4, 5, 7, 8, 10	2.2 km surveyed
	14-18 July 2014	Wetlands 4, 7, 15	2.5 km surveyed
Live Trapping	1-5 May 2014	Wetlands 1, 2, 3, 4, 5, 8, 11, 12, 13, 14	1385 trap hours
	14-18 July 2014	Wetlands 7 and 15	222 trap hours

4.4 Coastal Tailed Frog Surveys

This was our first year surveying Coastal Tailed Frogs and their habitat in the Clowhom watershed. These tiny frogs are blue-listed in BC and federally classified as species of special concern (COSEWIC 2011). They are associated with fast-flowing, cool, clear, well-oxygenated mountain streams (Figure 4).

We began by conducting extensive reconnaissance surveys. Through these efforts we identified 36 creeks with potential suitable habitat for Coastal Tailed Frogs that were also accessible and appropriate for survey activities. Many more suitable sites are believed to exist among the watershed's abundant headwater streams.

As preliminary presence-not detected surveys, between July 15 and 17, 2014, we carried out time-constrained searches at 8 of the 36 identified streams following RISC standards (RISC, 2000). At each site we examined microhabitat for 30 minutes. We visually scanned stream banks for adult frogs and inspected stream pools and cover objects such as rocks and coarse woody debris, searching for clinging Tailed Frog tadpoles. Unembedded cover objects were turned over and inspected and then returned to their original position. Large anchored rocks were swept by hand. To avoid degrading habitat, displaced cover objects were immediately replaced and well-anchored boulders and cobble were left undisturbed.

Where Tailed Frog individuals were encountered, they were placed in shaded buckets immersed in the streams. For each captured tadpole we recorded total length (tip of snout to coccyx) and weight, and estimated age based on size and stage of development of limbs and mouth parts. Upon completion of each survey, we returned captured individuals to the stream. We documented the position of each capture and collected detailed information about the habitat, including bedrock geology, reach type, and information about the stream channel, substrate, and vegetation.

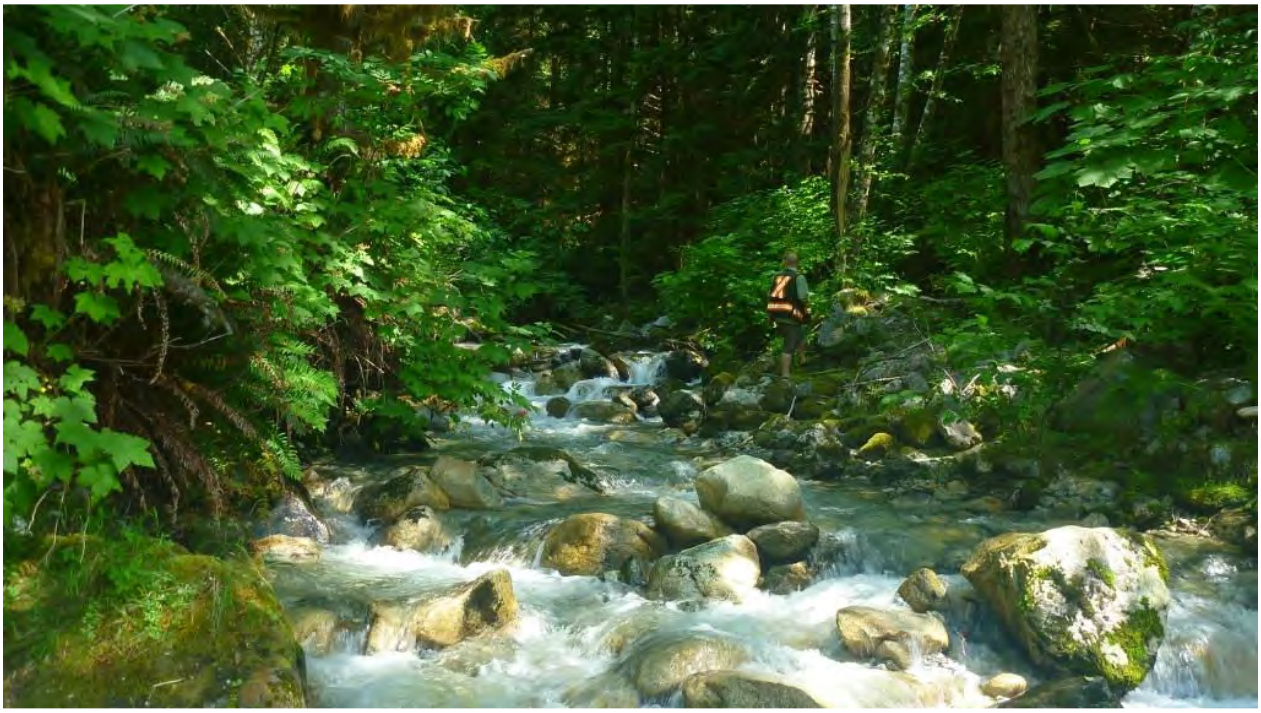


Figure 4: Suitable Habitat for Coastal Tailed Frog in the Clowhom Watershed ("Detection Creek")

4.5 Environmental DNA (eDNA) Surveys

As they go about their daily lives, all animals leave behind traces of their DNA in the environment, through skin cells, urine, feces, blood, and gametes. Known as environmental DNA (or eDNA), these traces of genetic material can be used to detect the presence of a species at a site. Recent studies have demonstrated the efficacy of eDNA as an exciting new technique to detect presence of aquatic vertebrate species from a variety of freshwater ecosystems (Ficetola et al. 2008, Goldberg et al. 2011, Thomsen et al. 2012).

Environmental DNA surveys involve collection of water samples from habitats potentially inhabited by the target species. Collected water samples are pumped through filters which are tested for the presence of the species' DNA using a quantitative Polymerase Chain Reaction (qPCR) assay using species-specific primers that target a small section of the mitochondrial DNA cytochrome b gene (Goldberg et al. 2011). This method has proven to be highly accurate, efficient, and cost effective. The technique is extremely sensitive so can detect species even when they exist in very low densities. Numerous studies have demonstrated the detection of species using eDNA techniques where traditional survey methods have failed to find them.

We used eDNA sampling to search for two aquatic species at risk in the Clowhom Watershed – the Coastal Tailed Frog and the Pacific Water Shrew. The eDNA primer for Coastal Tailed Frog had been previously developed; however, the primer for Pacific Water Shrew required development and testing. This was accomplished by Dr. Caren Goldberg at the School of Environment at Washington State University with support from our organization, Hemmera Envirochem Inc., and the BC Ministry of Forests, Lands and Natural Resource Operations.

Sample Collection

We carried out eDNA sampling in the Clowhom watershed on August 18 and 19, 2014. Nine streams across the basin were sampled for the presence of Coastal Tailed Frogs, while five wetlands were sampled for Pacific Water Shrews (Wetlands 3, 6, 7, 9 and 12).

At each site, water samples were collected in polypropylene bottles, each labelled with the site name, collection time, date, and name of collector (Figure 5). To prevent contamination from boots and other gear, biologists did not enter the water during sampling and wore clean, sterile nitrile gloves. Sample bottles were triple rinsed with site water before being filled with water from the surface of the water body. In the case of streams, wherever possible, samples were taken from the thalweg (lowest point along the stream bed). Because exposure to elevated temperatures and sunlight can degrade DNA (Pang and Cheung 2007), sample bottles were placed in an insulated cooler with ice packs to prevent DNA degradation in the field prior to subsequent off-site filtration and preservation.

To reduce the likelihood of false negatives and increase detection probability, we collected duplicate 1 L samples at Coastal Tailed Frog survey sites and triplicate 250 mL samples at Pacific Water Shrew sampling sites. One of the five surveyed wetlands (Wetland 7), was larger than 0.12 ha. Because of its larger size, we collected samples from two different locations within the wetland.

At each sampling location, we took site photos and recorded the UTM coordinates, elevation, and water temperature. For each Tailed Frog eDNA survey site, we collected additional data about the structure of the stream, including information about the channel unit, step-forming materials, substrate embeddedness and substrate texture.

Figure 5: Collecting Water Samples from Clowhom Creeks and Wetlands for eDNA Analysis

Sample Filtration

We processed samples following a modified version of a standard eDNA protocol (Goldberg and Strickler 2013). Water samples were stored in coolers and filtered within 24 hours of collection in order to minimize degradation of DNA. Each sample was poured into a 250 mL sterile polypropylene filter funnel with a 0.45 µm pore diameter cellulose nitrate membrane and filtered through the membrane using a peristaltic pump to create a vacuum. Once filtration was complete, the filter was removed using sterile gloves and sterile tweezers.

Each filter membrane was placed in its own 2 mL sterile polypropylene cryogenic vial filled with 95% molecular-grade ethanol, individually labelled, and placed inside labelled whirl-pak storage bags for shipping. At the end of each day, and when switching between Tailed Frog and Water Shrew samples, one control sample of distilled water was processed using the same filtration protocol. These control samples served as a contamination test for both the filtration and laboratory analysis procedures. All of the preserved membranes were shipped to Dr. Caren Goldberg at Washington State University for subsequent extraction and laboratory analysis.

Laboratory Analysis

The preserved filter samples were extracted in a laboratory dedicated to the analysis of low-quantity DNA sources using a Qiashredder/DNeasy protocol (Goldberg et al. 2011). Each extract was run in duplicate (Tailed Frog) or triplicate (Water Shrew) using a species-specific qPCR assay that included positive and negative controls in each plate as well as an internal control to detect PCR inhibition. When PCR inhibition was detected, samples were run through a One-Step PCR Inhibitor Removal kit column (Zymo Research) and reanalyzed. When triplicate wells did not test consistently (i.e., one or two samples tested positive), the positive sample was rerun to confirm the result.

The Coastal Tailed Frog assay was designed to not cross-amplify with sympatric amphibians and was validated against DNA from Western Toad (*Anaxyrus boreas*), Pacific Chorus Frog (*Pseudacris regilla*), and Northern Red-legged Frog (*Rana aurora*).

The Pacific Water Shrew assay was designed to not cross-amplify with other sympatric shrew species to the extent possible, and was validated against the DNA of sympatric shrew species that may occasionally spend time in the water, including Vagrant Shrew (*Sorex vagrans)*, Masked Shrew (*Sorex cinereus)*, Trowbridge's Shrew (*Sorex trowbridgii)* and Olympic Shrew (*Sorex rohweri*).

Due to similarities in the genetic sequence of DNA on the cytochrome b gene of Montane Shrew (*Sorex monticulus*) and Cordilleran Water Shrew (*Sorex navigator*) (Hope et al. 2014), the assay used for this project may produce a false positive in the presence of Montane Shrew and/or Cordilleran Water Shrew.

4.6 Western Screech-Owl Surveys

This was our second year conducting surveys of Western Screech-Owls in the Clowhom watershed.

Call-Playback Surveys

To identify areas used by Western Screech-Owls, we conducted nocturnal call-playback surveys following RISC standards (Hausleitner 2006). Survey stations were established in Year 1 of the project and are located roughly every 400-500 m along transects in suitable riparian habitat located along the Clowhom, Powder, and Bear Creek Forest Service Roads. Areas of inappropriate or low quality habitat, such as cliffs, large cutblocks, or dense coniferous forest, have been excluded.

Between May 1 and 4, 2014, we carried out call-playback surveys at 69 stations. Surveys took place from one half hour before sunset to one half hour after midnight. Upon arriving at a station one minute of silence was followed by a one minute playback of a male Western Screech-Owl "bouncing ball" territorial call followed by three minutes of silence during which the surveyors listened intently for any response. This process was then repeated, pointing the caller in each of the four cardinal directions, for a total survey time of 15 minutes per station. Calls were produced with a FoxPro NX4 electronic caller. Upon seeing or hearing any owl, the call-playback was stopped and observations were recorded as to the species, distance, direction, type and duration of the response. Weather, noise and habitat conditions were also documented at each station.

Territory Assessment and Nest Searches

Based on the records from our call-playback surveys conducted in September 2013, March 2014 and May 2014, we undertook territory assessments in areas with previous Western Screech-Owl observations. Our goal was to delineate territories, determine the status in each territory, identify nest groves, and ideally locate and monitor nest cavities. We used data on location, direction, and distance of call-playback responses to narrow down search locations during the nesting period of May and June 2014.

To minimize disturbance to the owls, we first used passive monitoring to search for birds. At dawn and dusk, male Screech-Owls commonly visit the boundaries of the nest grove and broadcast their presence with a territorial call. We entered each estimated Screech-Owl territory prior to dawn or dusk and listened quietly for male territorial announcements. If no spontaneous calling was heard, we played one or two bouts of the male bouncing ball call in an effort to illicit a response.

Once a bird was detected, the incoming and outgoing directions and distances were closely observed. GPS locations were taken for all owl observations and used to delineate the territory and nest grove. Nest searches were conducted by walking transects in the nest grove area and checking potential nest cavities for signs of occupation, such as feathers, whitewash, or owl pellets.

At sites where pair status was confirmed and observations indicated active nesting, we assessed juvenile fledging status in July 2014. This also involved passive monitoring and playing a bout or two of call-playback if no spontaneous calling was heard.

4.7 Northern Goshawk Surveys

This was our first year searching for Northern Goshawks and assessing habitat for the species in the Clowhom watershed. To search for occupied goshawk territories, we undertook assessments of historically occupied sites, habitat suitability modeling, reconnaissance surveys, and call-playback surveys.

We initially focused our survey effort on two historic Northern Goshawk observations within the watershed (Clowhom Lake and Red Tusk) (Figure 6). Next we used the Northern Goshawk Habitat Suitability Model produced by the Provincial Recovery Team (Mahon et al. 2008) to highlight areas identified by the model as high and moderate suitability habitat. We undertook reconnaissance surveys to investigate the impacts of recent logging on these areas. We discovered that most patches ranked as high and moderate suitability by the model had recently been logged. Thus, we focused surveys near the historical records and at the few remaining suitable habitat patches. In all, we carried out call-playback surveys at 18 stations, including sites on or near the Clowhom, Nagy, Powder, and Bear Creek Forest Service Roads (Figure 7).

Call-playback surveys took place on May 31, June 28, June 29 and July 16, 2014. Where forest patches were large enough, stations were placed along transects every 300 to 400 m, depending on the terrain and level of acoustic obstruction. In areas with very steep topography and dense vegetation, distances between stations were decreased. Call-playbacks were conducted using a FoxPro NX4 Caller following RISC standards (RISC 2001) and using protocols and data forms designed by the Recovery Team. A Northern Goshawk call was broadcast for six bouts of 10 seconds each, followed by 30 seconds of silence in which to detect birds. Each of the six broadcasts was played in a different direction, rotating the megaphone 120° between bouts. At the end of the broadcasts an additional one minute was spent actively looking and listening for goshawks. The adult alarm call was used in May and June, while the juvenile begging call was used in July.

At each survey location, we also carried out a habitat assessment. We evaluated goshawk nesting and foraging habitat quality, availability of nesting platforms and flyways, and documented natural and anthropogenic disturbances and landscape context of each site.

Figure 6: Goshawk Call-Playback Survey Location near Historical Sighting at Red Tusk

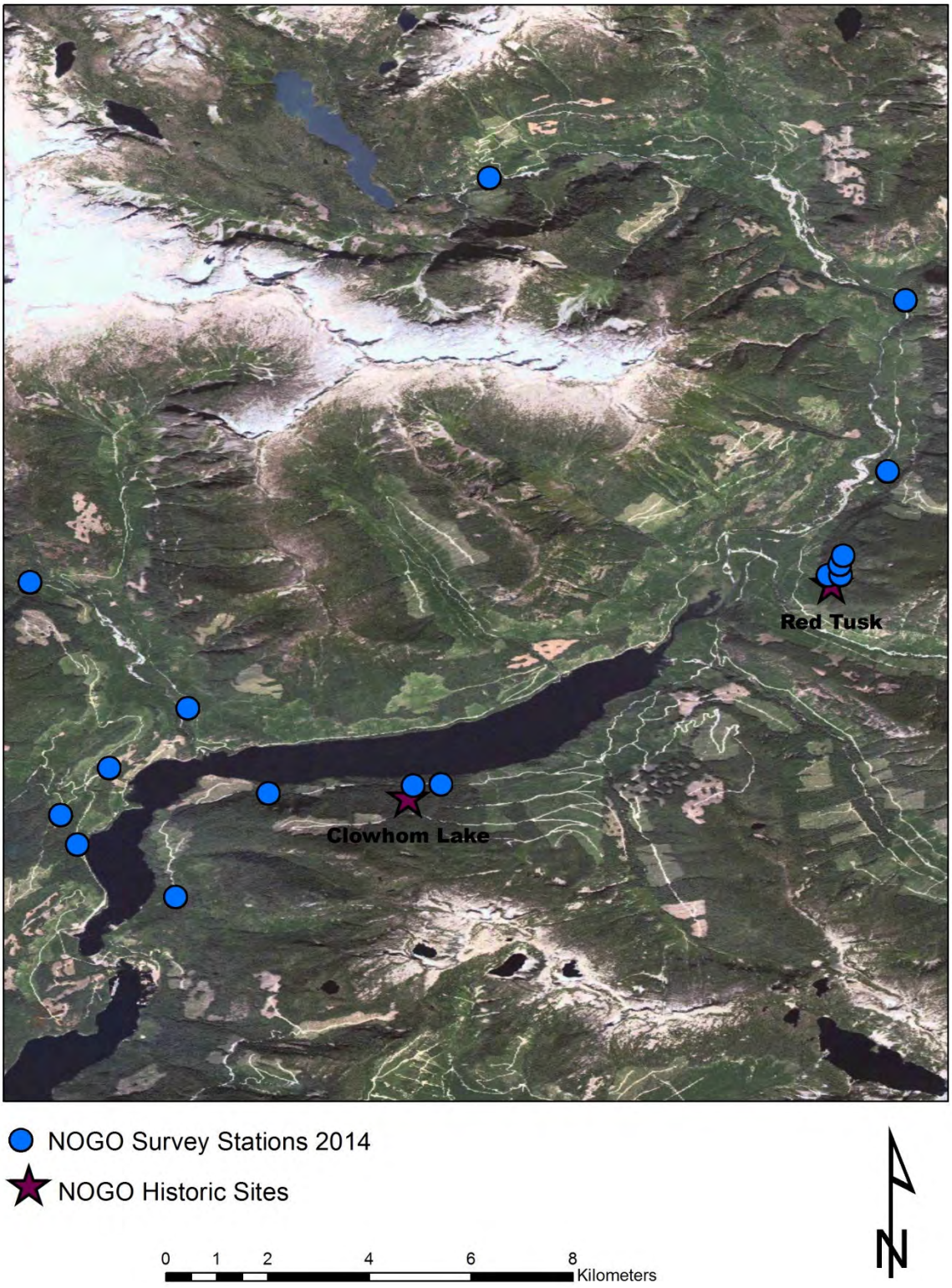


Figure 7: Northern Goshawk Survey Locations, 2014

4.8 Bat Surveys

This was our first year surveying bats in the Clowhom watershed. To locate areas of high bat activity, identify priority sites for future assessments, and begin to document community composition and species distribution, we carried out mist net and acoustic surveys.

Mist Net Surveys

We used 9 m x 2.6 m monofilament mist nets (Avinet TB09, mesh size 38mm) to capture bats in flight following RISC Standards (RISC 1998a) and other recommended best practices (Vonhof 2006, BC Ministry of Environment 2012).

On August 18, 2014, we set seven mist nets at Wetland 6, including three single nets over still water in the wetland, and two sets of double high net combinations on the road (Figure 10). Nets were open from 8:30pm to 12:30am. On August 19, 2014, we set nine mist nets, including three single nets over the floodplain next to Wetland 7 and three double high net combinations 500 meters away near the fish migration channel at the junction between Powder and Clowhom Forest Service Roads (Figure 10). Nets were open from 8:30pm to 5am. Total mist net survey effort across the two nights was 104.5 mist net hours (Table 2).

Captured animals were handled according to the BC Bat Action Team's White Nose Syndrome protocols (BC Ministry of Environment 2012), which require animals to be handled with separate sets of gloves, and all equipment sterilized between each use, to ensure we did not transfer any pathogens between bats. Bats were kept for one hour to ensure their food was digested and confirm that accurate weights were measured. For each trapped bat, we recorded species, age, sex, and reproductive status, and took various morphometric measurements, including weight, forearm length, ear length, and tragus length. Each bat was handled for less than 10 minutes before being released.

Table 2: Mist Net Surveys of Bats in Clowhom, August 2014

Date	Location	# of Nets	Time Deployed	Total Hours
Aug 18	Wetland 6	7	8:30pm-12:30am	28 hours
Aug 19	Floodplain next to Wetland 7, and fish migration channel at junction of Powder and Clowhom FSR	9	8.30pm-5:30am	76.5 hours
				104.5 hours

Acoustic Surveys

Bats produce echolocation calls to assess their environment and search for food. While these calls are outside the range of human hearing, they can be recorded using equipment that digitizes the sound. The particular properties of each species' echolocation calls (frequency range, call shape, use of harmonics, etc.) can then be used to identify which species was recorded (Figure 9).

The technology, however, does have limitations. Calls are only diagnostic during the search phase, which varies according to the amount and type of "clutter" in the environment; bats may alter their calls when navigating obstacles. Some species have echolocation calls that are practically indistinguishable from each other, and in these cases identification can often only be narrowed to two or more species.

We recorded the echolocation calls of bats at 10 sites throughout the Clowhom watershed using an Anabat SD2 Bat Detector (Figure 10). Surveys were either active (carrying a bat detector around a survey location), or passive (deploying the detector overnight and then retrieving it in the morning). In this initial year of bat surveys in Clowhom, we focused our efforts on active and short-term passive monitoring in order to maximize the number of areas surveyed. This broad coverage is useful to locate areas of high bat activity which can then be targeted for more intensive study at a later date.

Acoustic bat surveys were carried out on June 1, July 14, July 15, July 17, and August 18, 2014. Total survey effort is difficult to accurately quantify because there were equipment malfunctions that caused the bat detector to shut off at some point during the four overnight deployments. These problems have since been solved. Survey effort was a minimum of 10.5 hours.

Figure 8: Bat Detector Deployed in the Clowhom Watershed

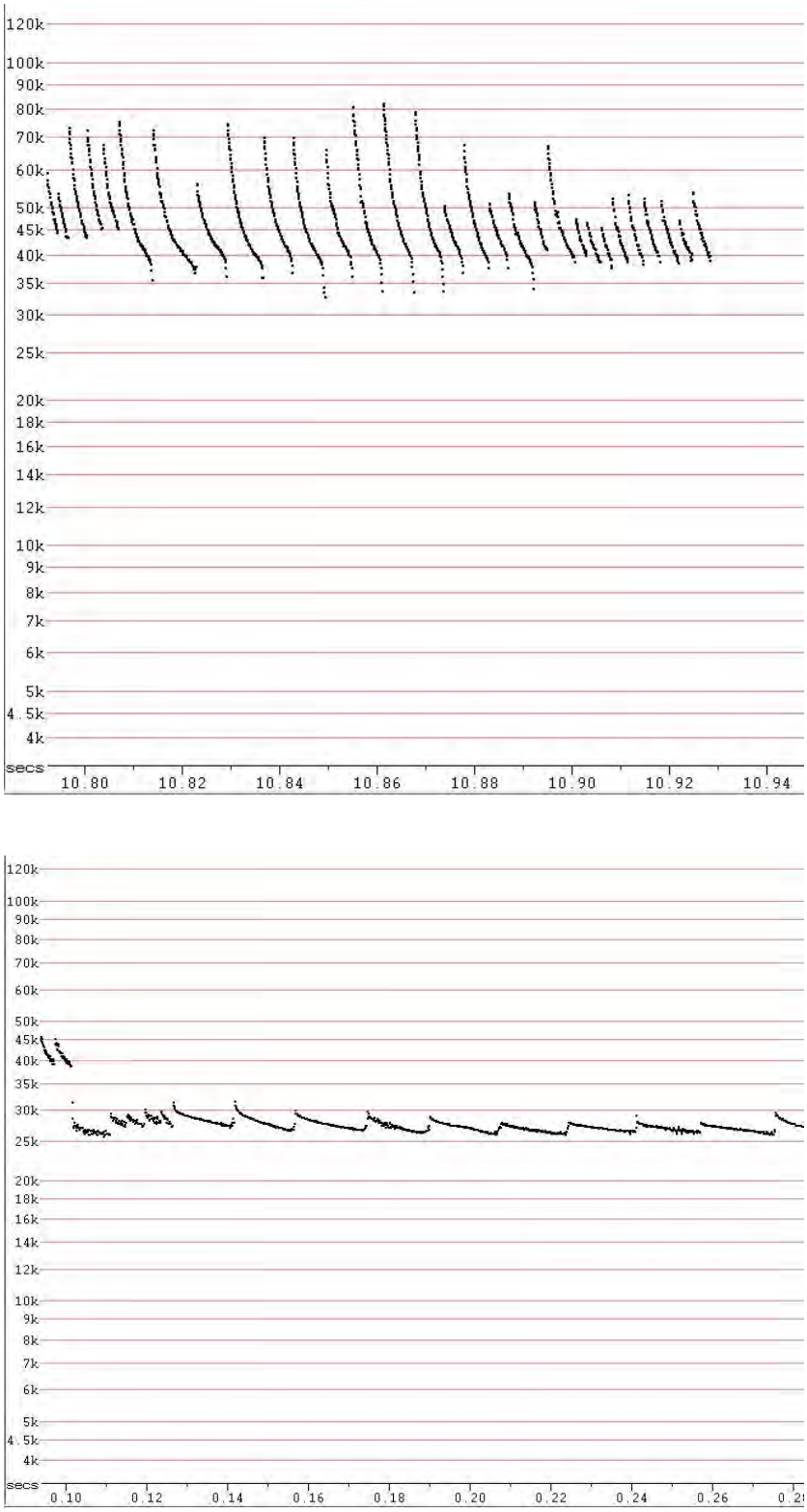


Figure 9: Sample Acoustic Recordings of Bats in the Clowhom Watershed

Above: Little Brown Bat (*Myotis lucifugus*); Below: Silver-haired Bat (*Lasionycteris noctivagans*)

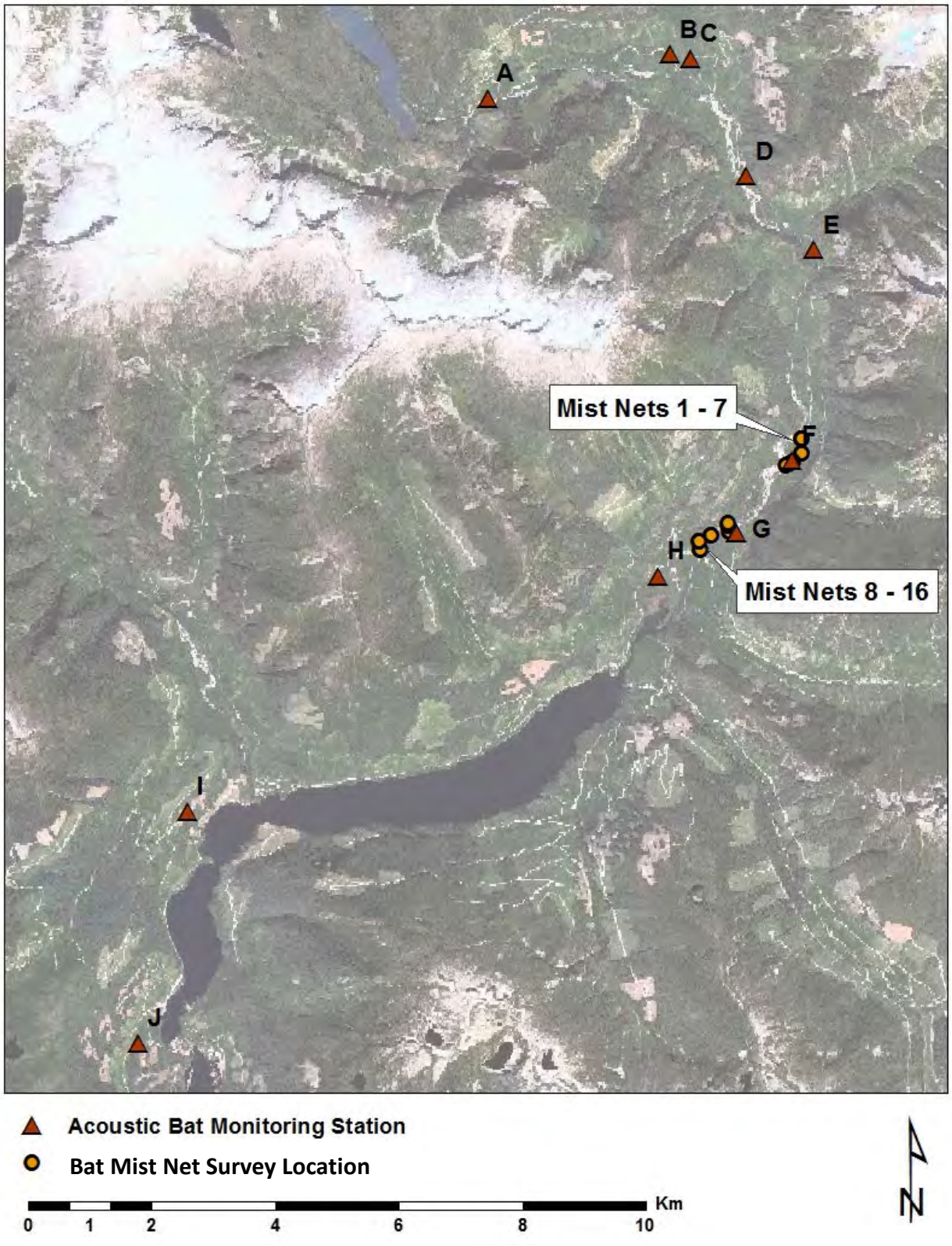


Figure 10: Locations of Bat Acoustic and Mist Net Surveys in Clowhom Watershed, 2014

4.9 Public Outreach and Engagement

Public outreach and community engagement are important aspects of this project. We carried out diverse activities designed to engage Sunshine Coast residents in conservation of species at risk, and increase awareness of the wildlife stewardship efforts of Fish and Wildlife Compensation Program and its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and the public.

This project year we carried out 25 public engagement events, reaching over 1,500 community members of all ages (Table 3, Figure 11). We hosted outreach tables at community events and festivals, offered bat house and owl nest box building workshops, gave presentations to landowner associations, conservation organizations and business groups, provided special programs to elementary school classes, and hosted more than dozen community volunteer days where residents could assist in hands-on habitat enhancement efforts on the Sunshine Coast. We also published media articles and provided project updates on our website and Facebook page. Finally, we encouraged landowners to sign voluntary wildlife stewardship agreements pledging to maintain wildlife habitat on their property. This project year, 57 Sunshine Coast residents signed agreements as stewards of 69 hectares of land.

During our public outreach activities, and on our pamphlets and outreach materials, we have been pleased to acknowledge FWCP's support of our project and highlight the program's role in wildlife and habitat stewardship efforts in British Columbia.

Table 3: Public Outreach and Engagement Activities, Year 2 (2014-2015)

DATE	LOCATION	ACTIVITY	AUDIENCE	NUMBER
01-Apr-14	Camp Byng, Roberts Creek	Kids Program	Spider Homeschooling Program students	40
09-Apr-14	Davis Bay Hall, Davis Bay	Presentation	Davis Bay/Wilson Creek Community Assoc.	40
26-Apr-14	Earth Day Festival, Roberts Creek	Outreach Table	Community Members	500
14-May-14	Gibsons Chamber of Commerce	Presentation	GibsonsChamber of Commerce	25
09-Jun-14	Egmont Day Festival, Egmont	Outreach Table	Community Members	100
07-May-14	Iris Griffith Interpretive Centre	Presentation	Ruby Lake Landholders' Assocation	75
22-Aug-14	Synchronicity Festival, Gibsons	Outreach Table & Workshops	Community Members	250
23-Aug-14	Synchronicity Festival, Gibsons	Outreach Table & Workshops	Community Members	250
05-Sep-14	Sunshine Coast Botanical Garden	Work Party	Community Members	4
05-Oct-14	Sunshine Coast Botanical Garden	Work Party	Community Members	3
11-Oct-14	Sunshine Coast Botanical Garden	Workshop	Community Members	40
15-Oct-14	Iris Griffith Interpretive Centre	Presentation	Ruby Lake Lagoon Society	2
22-Oct-14	Gibsons Chamber of Commerce	Outreach Table & Presentation	Gibsons Chamber of Commerce	50
05-Nov-14	Sunshine Coast Botanical Garden	Work Party	Community Members	3
6-Feb-15	Arts Centre, Sechelt	Presentation	Sunshine Coast Natural History Society	75
17-Feb-15	Pender Harbour High School	Presentation	Pender Harbour Wildlife Society	20
20-Mar-15	Wildlife Project native plant storage	Work Party	Community Members	10
22-Mar-15	Lily Lake, Madeira Park	Work Party	Community Members	11
26-Mar-15	Redrooffs Trail, Halfmoon Bay	Work Party	Community Members	6
27-Mar-15	White Tower Park, Gibsons	Work Party	Community Members	10
28-Mar-15	Egmont oceanfront, Egmont	Work Party	Community Members	7
29-Mar-15	Coopers Green Park, Halfmoon Bay	Work Party	Community Members	20
30-Mar-15	Georgia Beach Park, Gibsons	Work Party	Community Members	15
31-Mar-15	Garden Bay Lake, Garden Bay	Work Party	Community Members	1
31-Mar-15	Coopers Green Park, Halfmoon Bay	Kids Program / Work Party	Halfmoon Bay Elementary Students	25
				1582

Figure 11: Community Engagement Including School Programs, Work Parties & Outreach Tables

4.10 Owl and Bat Habitat Enhancement

To inform community members about owl and bat conservation issues, encourage community participation in wildlife habitat enhancement efforts, and increase nesting and roosting habitat for owls and bats where suitable wildlife trees are lacking, we worked with community members of all ages to build 50 owl nest boxes and bat houses. The wildlife homes were constructed by community volunteers and local students (Figure 12). They were built and installed using construction plans and recommended best practices provided by reliable sources (e.g., Kaufman 2002, Cornell Lab of Ornithology 2013, Bat Conservation International), with modifications based on recent advice from experts. Bat houses included three different designs: maternity box, rocket box, and 'Uncle George' style houses. Owl nest boxes were designed for Western Screech-Owls but would also suit other small owls like the Saw-whet Owls.

Figure 12: Students Build Owl Nest Boxes and Bat Houses

The owl boxes and bat houses were installed at various sites on the Sunshine Coast. Twenty were installed in the Clowhom watershed (Figure 13) and another 30 were installed by landowners and community members in parks and on private properties as part of a "*Homes for Wildlife*" community engagement and wildlife stewardship and monitoring program.

Figure 13: Installed Owl Boxes and Bat Houses in the Clowhom Watershed

5.0 RESULTS

5.1 Wetlands

In the past two years, we have identified, assessed, mapped and monitored 15 wetlands in the Clowhom watershed (Figure 14, Table 4). Twelve of these are located along the main Clowhom valley and three are situated in the Bear Creek valley.

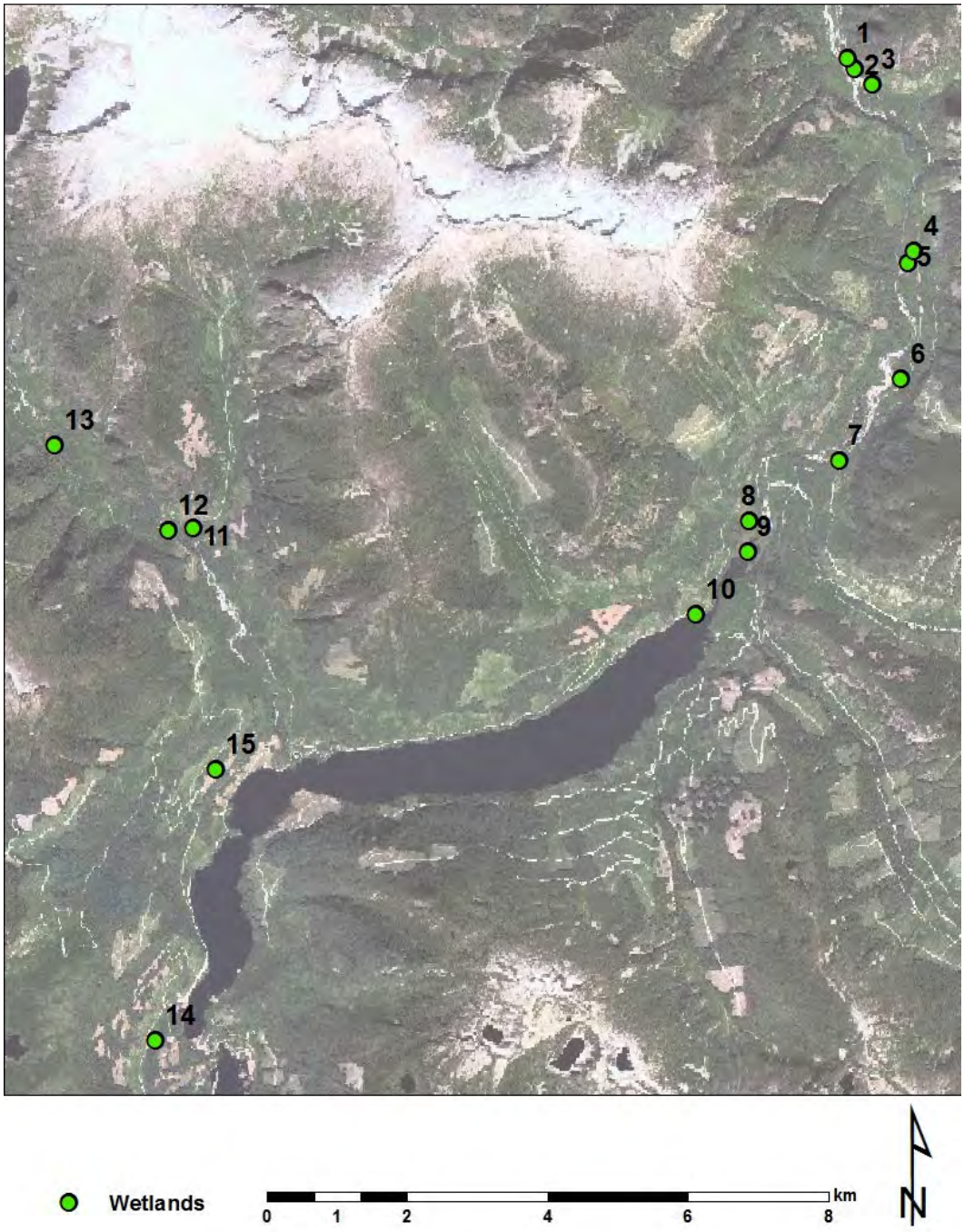


Figure 14: Locations of Mapped Wetlands in the Clowhom Watershed

Table 4: Summary of Identified Wetlands in the Clowhom Watershed

Wetland Number	Location	UTM *Datum: NAD 83 UTM Zone: 10U* Easting	UTM Northing	Dominant Wetland Subclass	Elevation (m)	Perimeter (m)	Area (ha)	Wetland Subclasses
1	Off Clowhom Mainline km 24	470635	5520703	swamp	234	441	0.22	10 WN: sp
2	Off Clowhom Mainline km 24	470747	5520554	swamp	232	225	0.08	10 WN: sp
3	Off Clowhom Mainline km 23.5	470993	5520323	swamp	233	218	0.09	10 WN: sp
4	Off Clowhom Mainline km 20	471600	5517949	marsh	100	411	0.32	5 WN: ms 3 RI: fm 2 WN: sw
5	Off Clowhom Mainline km 20	471485	5517732	marsh	95	788	1.26	9 WN: ms 1 WN: sw
6	Off Clowhom Mainline km 18.5	471516	5516185	swamp	97	1159	0.84	4 WN: sp 4 RI: fm 2 RI: fl
7	Off Clowhom Mainline km 17	470474	5514951	fen	57	1156	1.94	4 WN: fn 4 RI: fm 2 WN: bg
8	North part of large wetland complex, end of the reservoir	469222	5514238	fen	53	2329	8.45	6 WN: fn 3 WN: bg 1 RI: fm
9	Main part of large wetland complex, end of the reservoir	469300	5513850	marsh	54	3224	24.22	5 WN: ms 3 RI: fl 2 WN: fn
10	Small bay at north end of Clowom Reservoir, km 13.5	468522	5512698	marsh	65	1103	2.55	7 WN: ms 3 RI: fm
11	Bear Creek Mainline km 3.5	461334	5514003	fen/ swamp	225	460	0.23	5 WN: fn 5 WN: sp
12	Bear Creek Mainline km 3.5	460969	5513977	shallow water	235	481	0.49	10 WN: sw
13	Bear Creek Mainline km 6	459354	5515182	swamp	320	1785	7.90	5 WN: sp 5 RI: fm
14	Off Clowhom Mainline km 2	460796	5506688	marsh	55	812	0.89	5 WN: ms 3 WN: sw 2 WN: sp
15	Up Nagy FSR, on first spur, under transmission lines	461573	5510449	shallow water	294	760	0.54	6 WN: sw 4 WN: sp

Wetland Classes: Marsh (WN: ms); Swamp (WN: sp); Fen (WN: fn); Shallow water (WN: sw);

Riparian Classes: High bench floodplain (RI: fh); Medium bench floodplain (RI: fm); Low bench floodplain (RI: fl)

One new wetland site (Wetland 15) was discovered and mapped for the first time this project year, and is described in detail below. For detailed descriptions, photographs and mapping of the remaining 14 wetlands, please refer to last year's FWCP annual report (Evelyn et al. 2014).

Description of Wetland 15

Location, Classification and Description

Wetland 15 is a shallow water and swamp complex located along a spur road of the Nagy Forest Service Road, approximately 300 meters above Clowhom Reservoir. The wetland is located in a naturally flat area on the mid-slope which collects groundwater and surface runoff from areas above. It is bisected by a decommissioned forest service road, and includes a large pond upslope (Figure 15) and a series of shallow pools and permanently saturated areas downslope. The road may be helping to impound water in the upslope pond, increasing its depth, but the extent to which this is occurring is unclear. Both areas include coarse textured mineral soils on top of impermeable bedrock. The downslope portion of the wetland has a thin veneer of organic soil as well. In the upper pond, water depth averages 1 m and reaches a maximum depth of 2 m. The average depth in the downslope section of the wetland is approximately 20 cm. A transmission line runs over the wetland and there has been substantial recent harvesting of the surrounding forest (Figure 16).

Vegetation in the wetland is dominated by willows (*Salix* spp.) and Hardhack (*Spiraea douglasii*) at the perimeter, with open areas of rushes (*Juncus* spp.), Skunk Cabbage (*Lysichiton americanus*), Broad-leaved Cattail (*Typha latifolia*) and various mosses. On drier and elevated microsites, Salal (*Gaultheria shallon*), Trailing Blackberry (*Rubus ursinus*), Red Huckleberry (*Vaccinium parvifolium*), Bracken Fern (*Pteridium aquilinum*) and Red Alder (*Alnus rubra*) are the most common species.

Figure 15: Upslope Pond at Wetland 15

Wildlife Habitat Value

Wetland 15 provides important wildlife habitat, as it is one of the few permanent wetlands in the area. The site supports a high diversity and abundance of invertebrates, including water striders, arachnids, numerous beetles, dragonflies, damselflies, butterflies and moths. It provides excellent habitat for songbirds, amphibians, reptiles and mammals. The fish-free waters are a haven for Roughskin Newts, Pacific Chorus Frogs and Northwestern Salamanders, all of which breed in the wetland. The site also offers excellent potential breeding habitat for Western Toads and Long-toed Salamanders. The upland habitat has been harvested, and does not appear to be suitable for adult Red-legged Frogs; thus this species is unlikely to use the wetland for breeding. We observed abundant sign from Black Bear and Columbia Black-tailed Deer, which appear to frequently forage on the shrubs and berries in the area. With its open water, numerous wildlife trees, and high abundance of invertebrates, Wetland 15 provides excellent roosting and foraging habitat for multiple bat species. Bats were observed foraging in the area but could not be identified to species this year due to an equipment malfunction. This wetland is also highly suitable for many small mammal species, including shrews and rodents.

Human Impact / Management Issues

Human impacts to Wetland 15 are considerable and ongoing. There has been a great deal of harvest in the surrounding forest, both for timber and to keep the right of way for the overhead transmission line clear (Figure 16). Although the forest service road has been decommissioned, it still provides access for hunters, and will likely be used on continuing basis by crews brushing the transmission right of way. A few invasive plants, including Himalayan Blackberry, have established along the forest service road. So far these invasives do not appear to be problematic within the wetland area itself, but they should be monitored, and controlled if they spread. When brushing activities do occur along the transmission right of way, best management practices should be followed. The slash from small cut trees and shrubs can be left in the wetland, where they will enhance wildlife habitat, providing egg-laying sites for amphibians. Care should be take, however, not to overload any one area and to maintain stretches of open water so bats can continue to access the site for drinking. Conducting brushing in the late fall or very early spring would help to limit impacts to breeding amphibians.

The large pond is deep enough to persist through periods of low water inputs; however, the downslope section of the wetland may dry out in drought years, stranding developing amphibian larvae. This is a natural occurrence, but the frequency of these events should be monitored, and could be mitigated if persistent drought continues due to the effects of climate change.

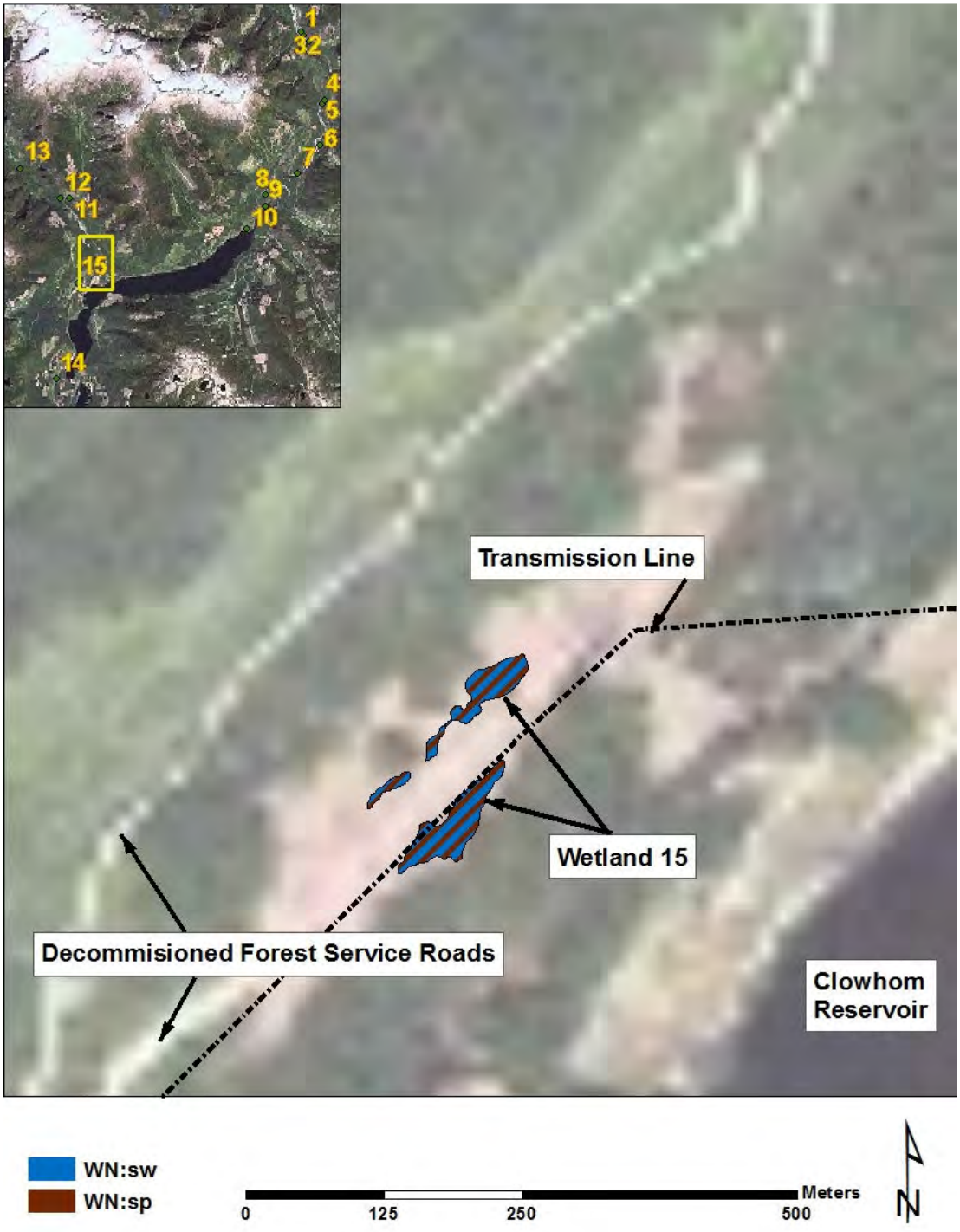


Figure 16: Location, Classification and Mapping of Wetland 15

Wetland Classes: Shallow water (WN: sw); Swamp (WN: sp)

5.2 Riparian Zones

We mapped 6,178 ha of riparian zones in the Clowhom basin. Together they account for 16% of the total watershed area (Table 5, Figure 17). The majority of riparian zones are located at higher elevations, around the numerous headwater streams and lakes of the watershed; only 25% of riparian areas are located below 600 m.

Widespread forest harvest since the 1960's has impacted many of these habitats. Close to 20% of all riparian areas within the watershed have been harvested. For lowland riparian zones, this number is much higher: 54% of riparian areas below 600 m in elevation have been harvested in the last 50 years (Figure 18).

In addition to BC Hydro's Clowhom Generating Station, the watershed is also home to four run-of-river microhydro operations. They include two Veresen facilities operated by Clowhom Power on the Clowhom River, and two Regional Power facilities operated by Bear Hydro on Bear Creek (Figure 19).

To facilitate both harvest and hydroelectric operations within the watershed, numerous roads have been built throughout the valley. Many of these cross through riparian areas, particularly along the valley bottom where flat topography simplifies road construction. There are currently 39 km of roads within riparian habitats, and a total of 110 riparian road crossings (Figure 20).

Our analyses substantially underestimate the scale of impacts on riparian zones. Due to lack of up-to-date imagery and land use information, we did not take into include the footprint of transmission lines. Nor did we assess the impacts of inundation within the footprint of the reservoir. However, the Clowhom Watershed Plan (FWCP 2011) states that 41 hectares of riparian habitats were lost when the lower valley was flooded.

Table 5: Mapped Riparian Areas in the Clowhom Watershed and Land Use Impacts

Description	Amount
Total watershed area (ha)	38,491
Total riparian area (ha)	6,178
Riparian area: below 600 m (ha)	1,559
Riparian area harvested since 1964 (ha)	1,173
Riparian area harvested since 1964: below 600 m (ha)	846
Length of roads crossing riparian habitat (km)	39
Number of road crossings	110
Number of hydroelectric operations	5

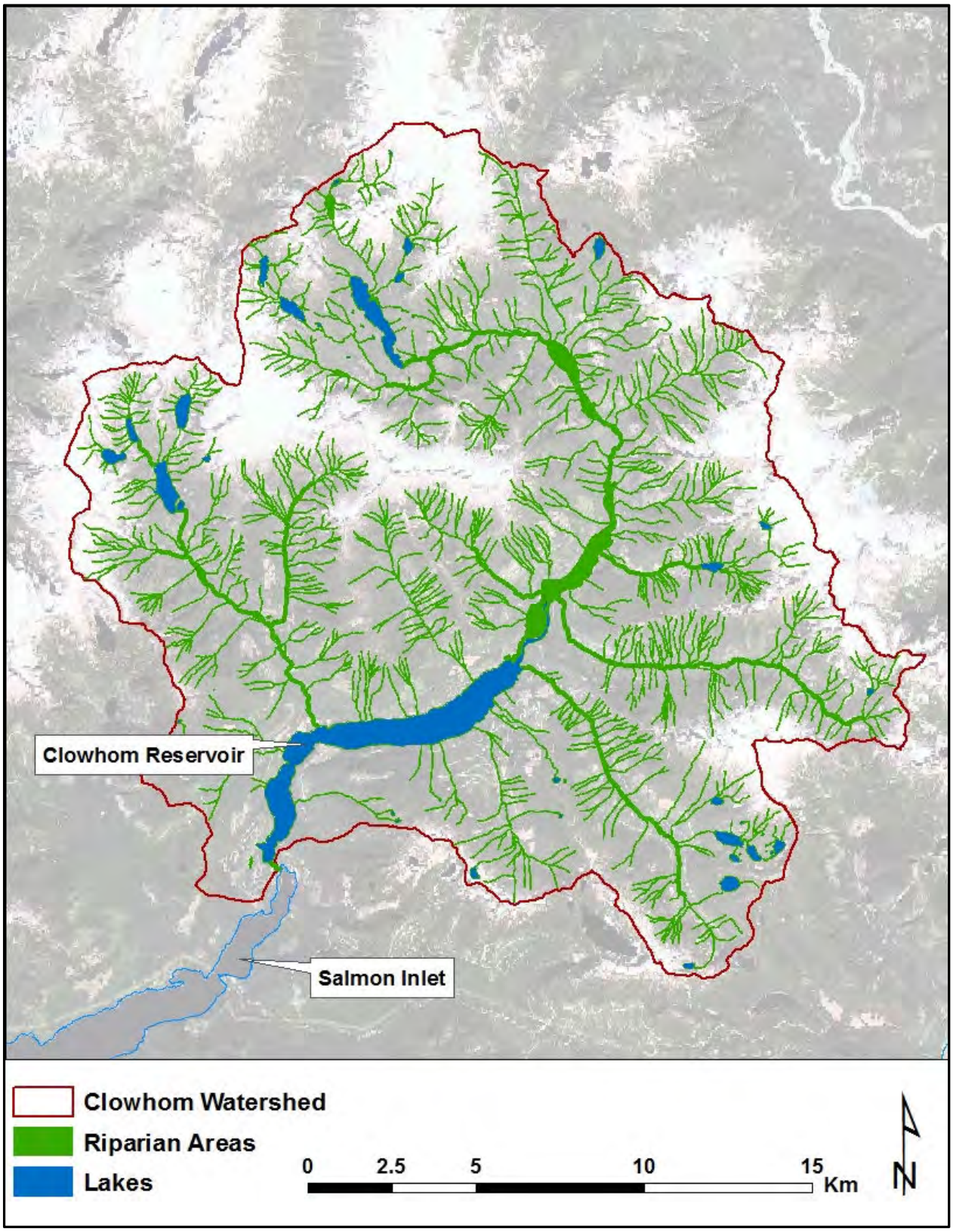


Figure 17: Riparian Areas within the Clowhom Watershed

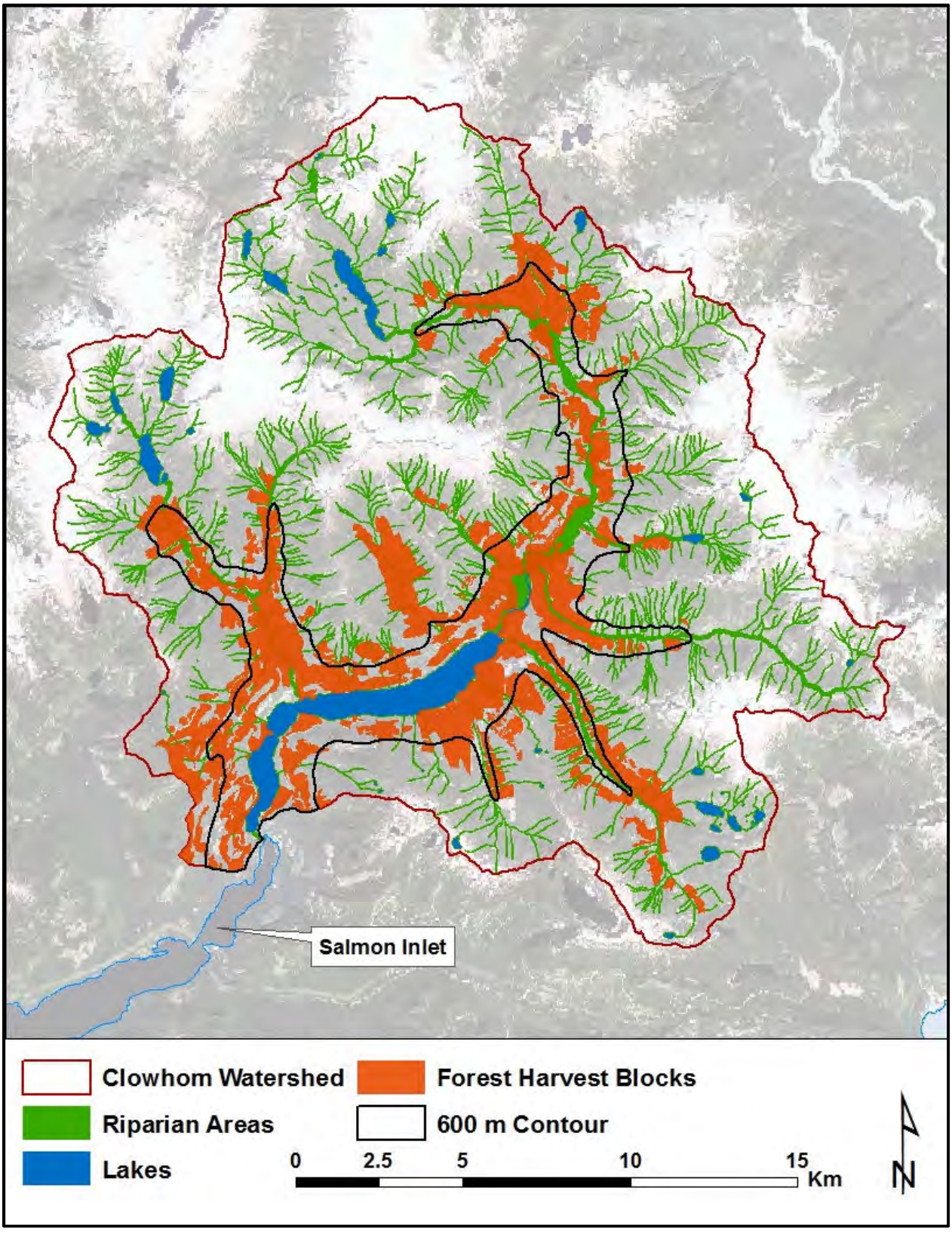


Figure 18. Forest Harvest Impacts on Riparian Areas within the Clowhom Watershed

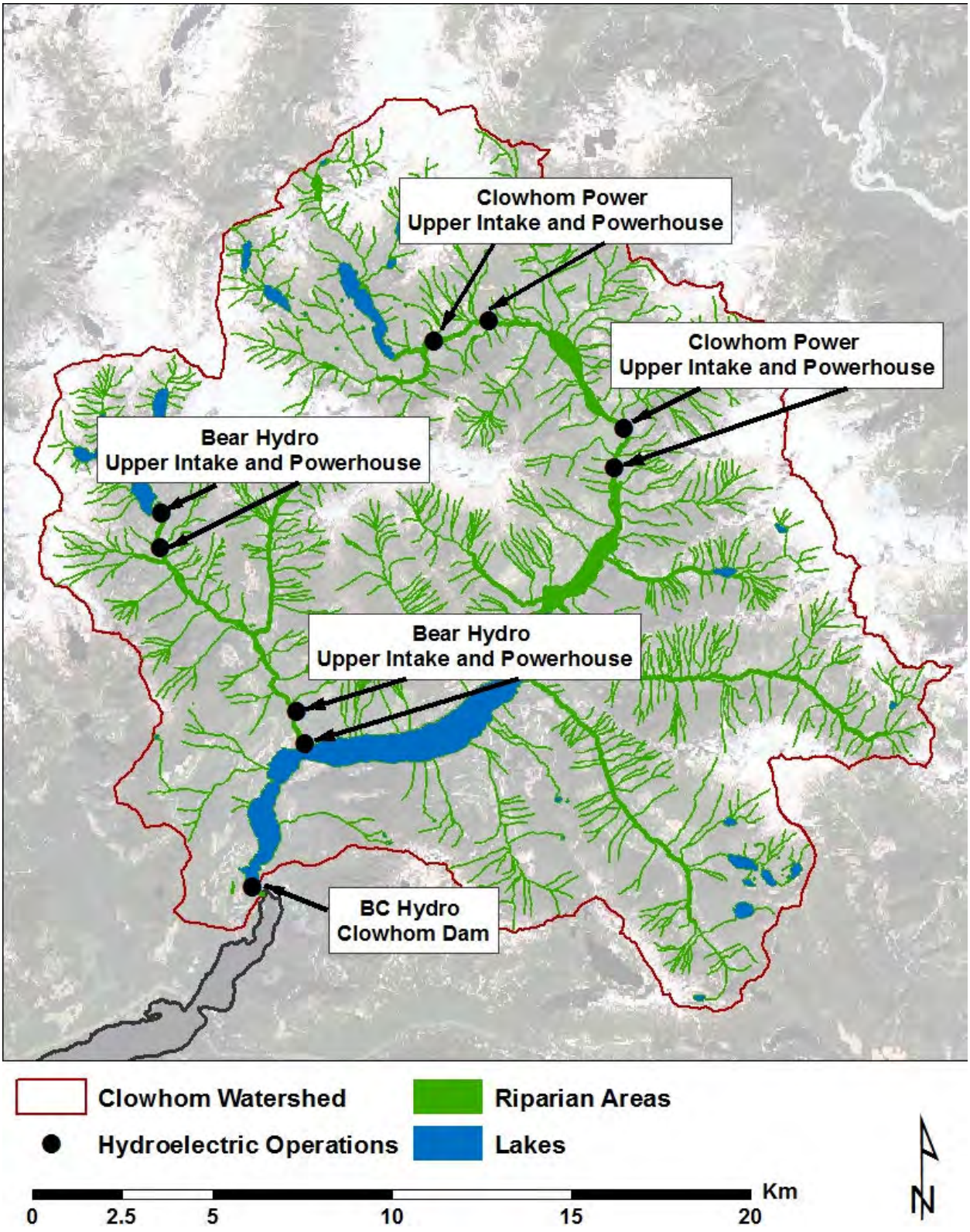


Figure 19: Hydroelectric Operations Impacts on Riparian Areas in the Clowhom Watershed

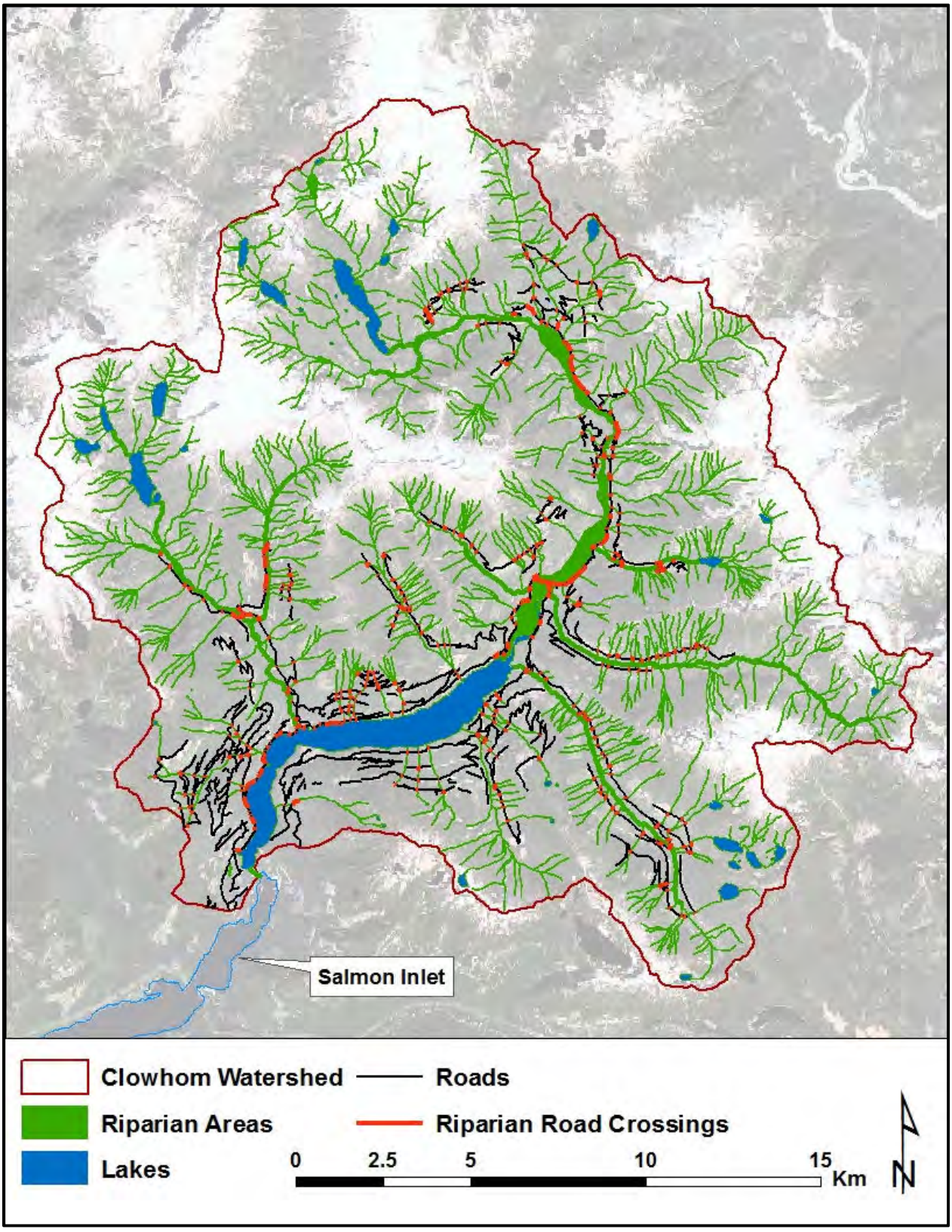


Figure 20. Road Impacts on Riparian Areas within the Clowhom Watershed

5.3 Pond-breeding Amphibians

Six species of pond-breeding amphibians were observed within the wetlands of Clowhom watershed in 2014: Red-legged Frog (*Rana aurora*), Western Toad (*Anaxyrus boreas*), Pacific Chorus Frog (*Pseudacris regilla*), Northwestern Salamander (*Ambystoma gracile*), Long-toed Salamander (*Ambystoma macrodactylum*), and Roughskin Newt (*Taricha granulosa*). Figure 21 illustrates the locations of all pond-breeding amphibian detections over the past two years. Detailed survey results for individual species are presented on the following pages.

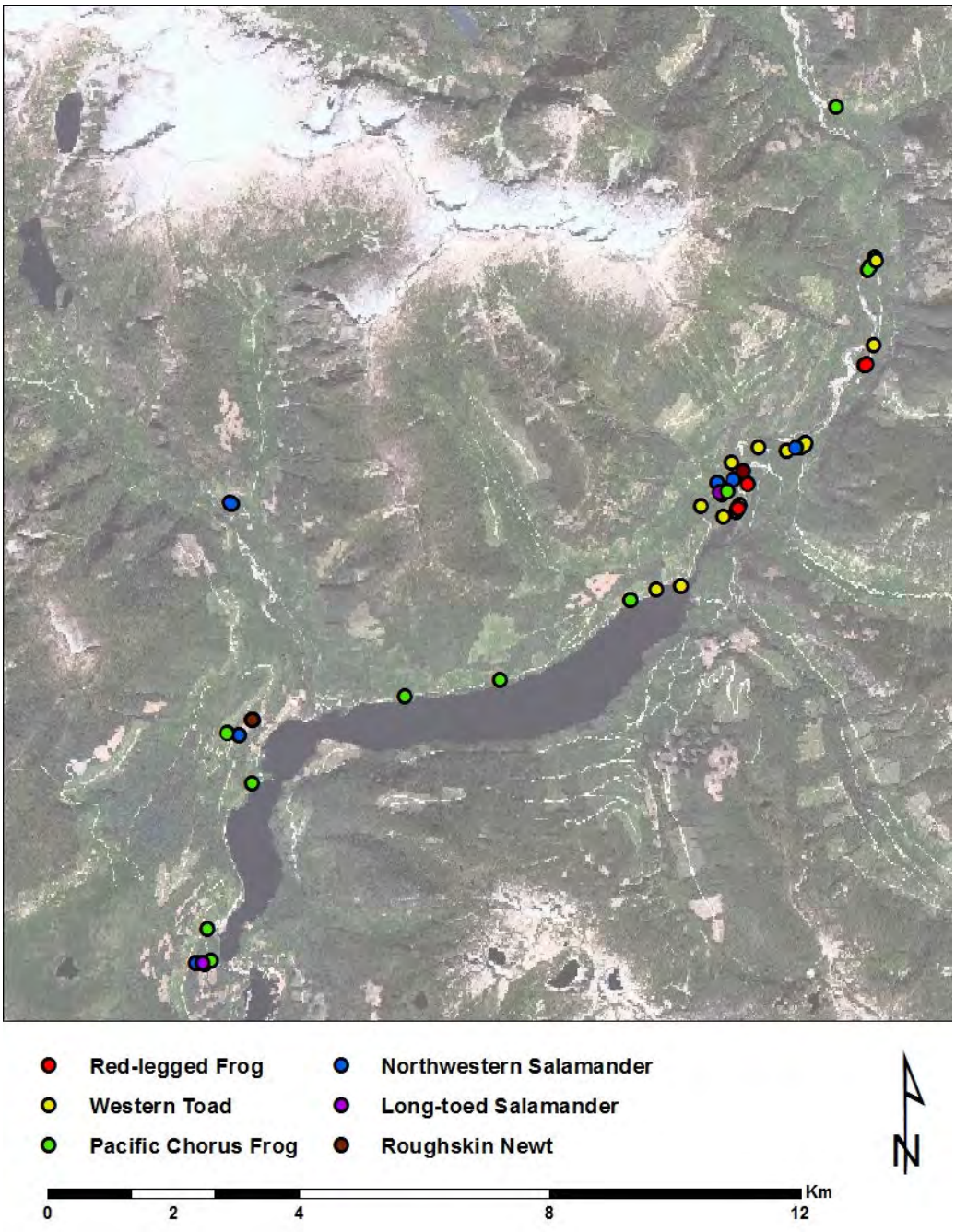


Figure 21: Detections of Pond-Breeding Amphibians in Clowhom Watershed, 2013 and 2014

Red-legged Frog

In late March 2014, Red-legged Frog egg masses were found Wetlands 6 and 9 (Table 6, Figures 22 and 23). We continued to monitor these breeding sites by carried out trapping and shoreline visual surveys for tadpoles in May, June and July 2014.

At Wetland 6, we observed recently hatched tadpoles in early May 2014. At Wetland 9, no tadpoles were detected and it appeared that larvae may have been flushed out of the site by water level fluctuations.

No Red-legged Frogs have been detected in any of the other surveyed wetlands over the two years of amphibian survey activities.

Table 6: Red-Legged Frog Detections in Clowhom Watershed, 2013 and 2014

Number and Life Stage	Date	Location	UTM *Datum: NAD 83* *UTM Zone: 10U*		Survey Type
6 egg masses	27-Mar-14	Wetland 6	471445	5516220	Perimeter survey
20 egg masses	27-Mar-14	Wetland 6	471436	5516228	Perimeter survey
6 egg masses	28-Mar-14	Wetland 9	469407	5513933	Perimeter survey
15 egg masses	28-Mar-14	Wetland 9	469430	5513932	Perimeter survey
30 larvae	02-May-14	Wetland 6	471472	5516233	Perimeter survey

Figure 22: Red-legged Frog Breeding Pond at Wetland 6

Figure 23: Red-legged Frog Detections in the Clowhom Watershed, 2013 and 2014

Western Toad

In 2013, Western Toad breeding activity was observed at three locations within the Clowhom watershed (Wetlands 7, 9 and 10) (Table 7, Figure 26). We continued to monitor these breeding sites, as well as survey all other identified wetlands, using a combination of live trapping and perimeter shoreline surveys in May, June and July 2014.

This year, Western Toads were detected at only one of the three known breeding sites. At Wetland 7, over 2,000 tadpoles were observed in early May 2014 (Figures 24 and 25). In late June, 200-300 larvae were detected in several different groups with approximately half having developed leg buds. By mid-July, no larvae were found in the pools. Based on these observations, it appears that eggs were laid at this site from mid to late April and that metamorphosis and migration occurred during the first two week of July.

Incidental toad detections this year included one adult on the Clowhom Main Forest Service Road near km 20 in May 2014, and another adult toad on the road near Wetland 7 in June 2014. Over the past two years, adult toads have been detected at a variety of spots along the Clowhom valley bottom (Table 7, Figure 26).

Table 7: Western Toad Detections in Clowhom Watershed, 2013 and 2014

Number and Life Stage	Date	Location	UTM *Datum: NAD 83* *UTM Zone: 10U*		Survey Type
5 tadpoles	14-Jun-13	Wetland 9	469444	5513995	Incidental
1 tadpole	14-Jun-13	Wetland 9	469186	5513801	Trapping
2 tadpoles	14-Jun-13	Wetland 9	469400	5513876	Trapping
2000+ tadpoles	14-Jun-13	Wetland 7	470475	5514959	Perimeter survey
1 adult	14-Jun-13	Wetland 7	470475	5514959	Perimeter survey
1 adult	14-Jun-13	Road near Wetland 7	470205	5514849	Road transect
1 adult	14-Jun-13	Road Km 14.5	468828	5513982	Road transect
1 adult	14-Jun-13	Road Km 16	469757	5514921	Road transect
2 adults in amplexus	15-Jun-13	Wetland 10	468522	5512698	Incidental
1 egg string	16-Jun-13	Wetland 10	468522	5512698	Incidental
1 adult	16-Jun-13	Wetland 8	470499	5514980	Incidental
1 adult	06-Sep-13	Road near Wetland 7	470428	5514912	Incidental
1 adult	06-Sep-13	Road Km 15.5	469328	5514671	Incidental
1 adult	06-Sep-13	Road Km 19	471579	5516544	Incidental
1 adult	06-Sep-13	Road Km 8.5	468120	5512657	Incidental
1 adult	1-May-14	Road Km 20	471627	5517885	Incidental
2000+ tadpoles	2-May-14	Wetland 7	470475	5514959	Perimeter survey
1 adult	1-Jun-14	Road near Wetland 7	470205	5514849	Incidental
200-300 tadpoles	29-Jun-14	Wetland 7	470475	5514959	Perimeter survey

Figure 24: Western Toad Breeding Site at Wetland 7

Figure 25: Thousands of Toad Larvae at Wetland 7 in May 2014

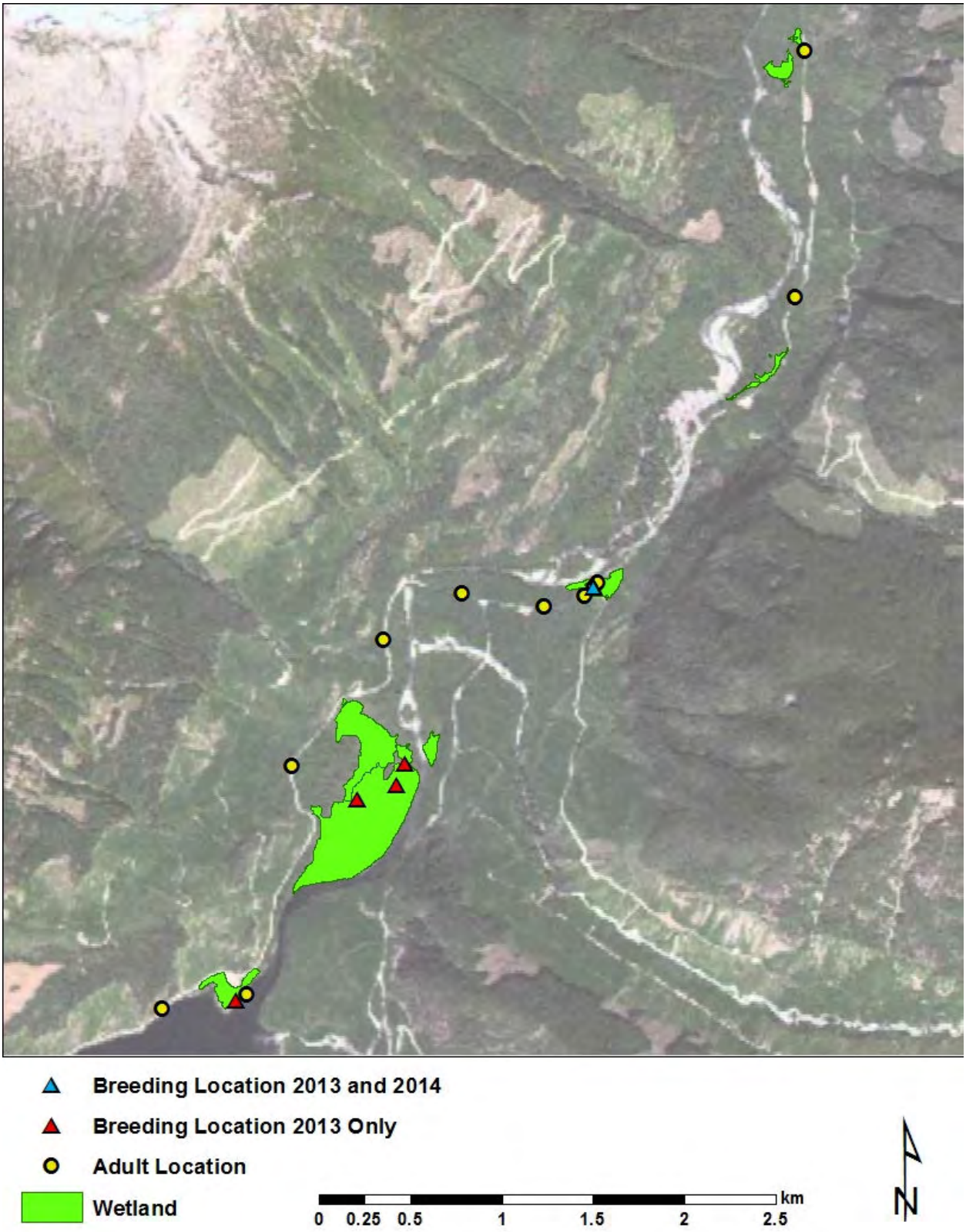


Figure 26: Western Toad Detections in Clowhom Watershed, 2013 and 2014

Pacific Chorus Frog

Over the past two years, Pacific Chorus Frogs have been detected at 16 different sites in Clowhom (Table 8, Figure 27). This year, we observed breeding at Wetlands 5, 7, 8, 14, and 15, and in a small roadside ditch off Nagy FSR a few hundred meters southwest of Wetland 15. Observations included egg masses in early May, tadpoles from early May to late June, and metamorphs in late June and mid-July.

Table 8: Pacific Chorus Frog Detections in Clowhom Watershed, 2013 and 2014

Number and Life Stage	Date	Location	UTM		Survey Type
			Datum: NAD 83		
			UTM Zone: 10U		
5 adults	14-Jun-13	Roadside Km 8	467714	5512473	Audio survey
6 egg masses	15-Jun-13	Roadside Km 8	467714	5512473	Perimeter survey
300+ tadpoles	15-Jun-13	Roadside Km 8	467714	5512473	Perimeter survey
1 juvenile	06-Sep-13	Wetland 4	471600	5517949	Perimeter survey
1 juvenile	06-Sep-13	Wetland 5	471485	5517732	Perimeter survey
1 adult	26-Mar-14	Wetland 7	470475	5514959	Audio survey
1 adult	27-Mar-14	Wetland 14	460796	5506688	Audio survey
32 egg masses	27-Mar-14	Wetland 8	469222	5514238	Perimeter survey
2-5 adults	27-Mar-14	Clowhom – north mainline	470976	5520333	Incidental audio
50+ adults	30-Mar-14	Clowhom – central lake	465636	5511204	Incidental audio
50+ adults	28-Mar-14	Clowhom – central lake	464114	5510944	Incidental audio
50+ adults	28-Mar-14	Clowhom – south lake	461036	5506728	Incidental audio
50+ adults	28-Mar-14	Clowhom – south lake	460979	5507240	Incidental audio
50+ adults	28-Mar-14	Clowhom – south lake	461684	5509563	Incidental audio
1 adult	26-Mar-14	Wetland 7	470475	5514959	Audio survey
1 adult	27-Mar-14	Wetland 14	460796	5506688	Audio survey
32 egg masses	27-Mar-14	Wetland 8	469222	5514238	Perimeter survey
2-5 adults	27-Mar-14	Clowhom – north mainline	470976	5520333	Incidental audio
50+ adults	30-Mar-14	Clowhom – central lake	465636	5511204	Incidental audio
50+ adults	28-Mar-14	Clowhom – central lake	464114	5510944	Incidental audio
50+ adults	28-Mar-14	Clowhom – south lake	461036	5506728	Incidental audio
50+ adults	28-Mar-14	Clowhom – south lake	460979	5507240	Incidental audio
50+ adults	28-Mar-14	Clowhom – south lake	461684	5509563	Incidental audio
12 egg masses	01-May-14	Wetland 5	471530	5517795	Perimeter survey
3 adults	1-May-14	Wetland 5	471474	5677749	Perimeter survey
30 egg masses	2-May-14	Wetland 7	470475	5514959	Perimeter survey
5 adults	2-May-14	Wetland 9	469407	5513933	Incidental audio
7 larvae	4-May-14	Wetland 14	460935	5506670	Perimeter survey
100+ larvae	28-May-14	Off Nagy FSR	461474	5510331	Incidental
400+ larvae	30-Jun-14	Wetland 5	471530	5517795	Perimeter survey
12 metamorphs	30-Jun-14	Wetland 5	471530	5517795	Perimeter survey
2 metamorphs	14-Jul-14	Wetland 15	461694	5510567	Perimeter survey
1 metamorph	18-Jul-14	Wetland 7	470502	5514967	Trapping

Figure 27: Pacific Chorus Frog Detections in the Clowhom Watershed, 2013 and 2014

Salamanders and Newts

Three species of aquatic-breeding salamanders and newts are present in Clowhom watershed. Over the past two years we have detected Northwestern Salamanders at six sites, Long-toed Salamanders at three sites, and Roughskin Newts at two sites (Table 9, Figure 29).

NORTHWESTERN SALAMANDER: This year, Northwestern Salamander breeding was observed at Wetlands 7, 8, 11, 14, and 15, along with a small roadside ditch off Nagy Forest Service Road a few hundred meters southwest of Wetland 15 (Table 9). Egg masses were observed throughout the spring (late March, early May, late May and late June), while larvae were observed from early-May to mid-July. Adult salamanders were trapped in Wetlands 8 and 11 (Figure 28)

LONG-TOED SALAMANDER: Long-toed Salamander breeding was observed this year at two wetlands. At Wetland 6, egg masses were observed in early May 2014 and larvae in late June 2014. At Wetland 14, egg masses were observed in late March 2014 (Table 9).

ROUGH-SKINNED NEWT: Thirteen adult Roughskin Newts were trapped this year in Wetland 15 (Table 9). The species is assumed to breed at this site; however, because the species lays eggs singly on aquatic vegetation, the eggs are rarely seen.

Figure 28: Northwestern Salamander in Clowhom Watershed

Table 9: Salamander and Newt Detections in Clowhom Watershed, 2013 and 2014

Number and Life Stage	Date	Location	UTM *Datum: NAD 83* *UTM Zone: 10U*		Survey Type
Long-toed Salamander					
12 egg masses	27-Mar-14	Wetland 14	460899	5506689	Incidental
1 adult	28-Mar-14	Wetland 8	469176	5514161	Incidental
20 egg masses	02-May-14	Wetland 6	471453	5516215	Perimeter survey
5 larvae	27-Jun-14	Wetland 6	471453	5516215	Perimeter survey
Northwestern Salamander					
1 larva	13-Jun-13	Wetland 8	469197	5514250	Trapping
1 larva	13-Jun-13	Wetland 8	469193	5514245	Trapping
1 larva	13-Jun-13	Wetland 8	469223	5514219	Trapping
1 neotenic adult	13-Jun-13	Wetland 8	469237	5514238	Trapping
1 larva	14-Jun-13	Wetland 8	469197	5514250	Trapping
2 larvae	14-Jun-13	Wetland 8	469193	5514245	Trapping
1 larva	14-Jun-13	Wetland 8	469206	5514226	Trapping
2 egg masses (hatched)	14-Jun-13	Wetland 8	469223	5514219	Perimeter survey
1 egg mass (hatched)	14-Jun-13	Wetland 8	469243	5514227	Perimeter survey
1 neotenic adult	14-Jun-13	Wetland 8	469243	5514227	Trapping
1 neotenic adult	14-Jun-13	Wetland 8	469237	5514238	Trapping
24 egg masses	28-Mar-14	Wetland 8	469103	5514353	Perimeter survey
7 egg masses	02-May-14	Wetland 7	470475	5514959	Perimeter survey
1 adult	03-May-14	Wetland 8	469103	5514353	Trapping
2 egg masses	03-May-14	Wetland 11	461335	5514025	Perimeter survey
1 adult, 1 larva	04-May-14	Wetland 11	461360	5514007	Trapping
2 larvae	04-May-14	Wetland 11	461349	5514016	Trapping
67 larvae	04-May-14	Wetland 14	460785	5506696	Perimeter survey
1 larva	04-May-14	Wetland 14	460816	5506691	Trapping
1 larva	04-May-14	Wetland 14	460798	5506692	Trapping
5 larvae	28-May-14	Off Nagy FSR	461474	5510331	Incidental
1 egg mass	28-May-14	Wetland 15	461691	5510577	Perimeter survey
13 egg masses	29-Jun-14	Wetland 8	469103	5514353	Perimeter survey
2 larvae	16-Jul-14	Wetland 15	461691	5510577	Trapping
1 larva	18-Jul-14	Wetland 7	470448	5514929	Trapping
2 larvae	18-Jul-14	Wetland 7	470489	5514962	Trapping
Roughskin Newt					
1 adult	14-Jun-13	Wetland 8	469223	5514219	Trapping
13 adults	16-Jul-14	Wetland 15	461691	5510577	Trapping

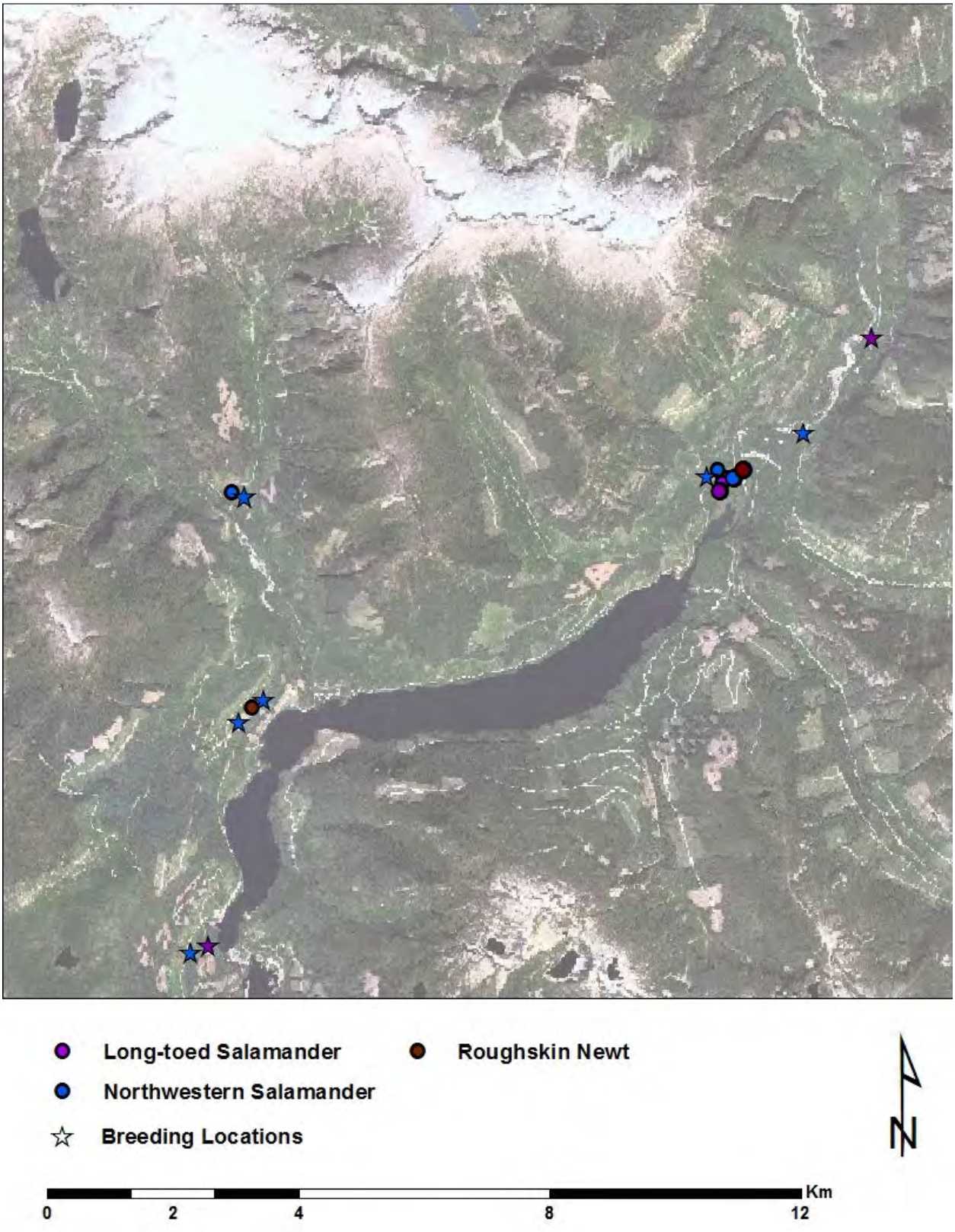


Figure 29: Salamander and Newt Observations in Clowhom Watershed, 2013 and 2014

5.4 Coastal Tailed Frogs

Through our reconnaissance surveys, we identified 36 creeks with suitable habitat for Coastal Tailed Frogs that were accessible and appropriate for hand searches and environmental DNA (eDNA) surveys (Table 10). Many more streams with appropriate habitat are thought to exist within the abundant headwater streams of the Clowhom watershed.

Coastal Tailed Frog DNA was recovered from all nine of the creeks surveyed using eDNA sampling in August 2014 (Table 10, Figure 31). Results were positive for all replicate samples collected from each site. None of the control samples yielded positive results, confirming that field procedures were effective at eliminating potential sources of contamination during collection, filtration and extraction.

During time-constrained searches of eight potential Coastal Tailed Frog creeks in July 2014, we detected one 4th year metamorph at Site ASTR05 ("Detection Creek") (Table 10). No other frogs or tadpoles were found in the seven other surveyed creeks.

During an informal hand search conducted in conjunction with eDNA collection at Site ASTR16 ("Tadpole Creek"), we detected 35 Coastal Tailed Frog tadpoles, including five hatchlings and thirty first year tadpoles (Table 10).

Occupied Tailed Frog creeks were dominated by step-pool and pool-riffle channel units, and had substrates dominated by boulders and cobble, with lesser quantities of pebbles and sand (Figure 32). Table 11 summarizes habitat attributes of the nine creeks that tested positive for the presence of Coastal Tailed Frogs.

Figure 30: Coastal Tailed Frog Larvae Detected in Clowhom Watershed Creeks

Left: One of 35 tadpoles in Tadpole Creek, August 2014; Right: Metamorph in Detection Creek, July 2014

Table 10: Identified Creeks with Suitable Habitat for Coastal Tailed Frogs and Survey Results

Survey Site	UTM		Surveys Results	
	Datum: NAD 83		eDNA Survey	Hand Survey*
	UTM Zone: 10U			
	Easting	Northing		
Sites Surveyed for Tailed Frogs				
ASTR02 - "Elizabeth Creek"	470249	5521873	Positive	N/A
ASTR04 - "Thermometer Creek"	471656	5519736	Positive	N/A
ASTR07 - "Dipper Nest Creek"	469337	5514725	Positive	N/A
ASTR18 - "Maybe Creek"	471164	5515913	Positive	N/A
ASTR23 - "Valley Creek"	461613	5513855	Positive	N/A
ASTR25 - "Nagy Creek"	461761	5509992	Positive	N/A
ASTR37 - "Bear Creek"	459787	5514681	Positive	N/A
ASTR16 - "Tadpole Creek"	458934	5516053	Positive	35 tadpoles
ASTR05 - "Detection Creek"	471645	5517269	Positive	1 metamorph
ASTR09	468725	5513206	N/A	No detections
ASTR20	469014	5514213	N/A	No detections
ASTR25B	461349	5510224	N/A	No detections
ASTR27	461348	5510224	N/A	No detections
ASTR29	469679	5522334	N/A	No detections
ASTR35	470809	5515279	N/A	No detections
ASTR36	469596	5515197	N/A	No detections
Sites with Suitable Habitat Not Yet Surveyed for Tailed Frogs				
ASTR01	470092	5522112	N/A	N/A
ASTR03	470364	5521758	N/A	N/A
ASTR06	471544	5516263	N/A	N/A
ASTR08	468821	5513922	N/A	N/A
ASTR10	464985	5511069	N/A	N/A
ASTR11	464382	5511003	N/A	N/A
ASTR12	464216	5510986	N/A	N/A
ASTR13	464056	5510945	N/A	N/A
ASTR14	463920	5510892	N/A	N/A
ASTR15	463060	5510826	N/A	N/A
ASTR17	460813	5514044	N/A	N/A
ASTR21	467310	5512210	N/A	N/A
ASTR22	465161	5511110	N/A	N/A
ASTR26	461254	5509930	N/A	N/A
ASTR26B	460774	5509914	N/A	N/A
ASTR28	469837	5522274	N/A	N/A
ASTR30	469453	5522581	N/A	N/A
ASTR30B	469255	5522795	N/A	N/A
ASTR31	467503	5522669	N/A	N/A
ASTR32	467259	5522587	N/A	N/A
ASTR33	467109	5522515	N/A	N/A
ASTR34	466357	5521945	N/A	N/A

*Time-constrained searches all took place in July 2014, except for the detection at “Tadpole Creek” which was the result of an informal hand search in August 2014 in conjunction with eDNA sample collection.

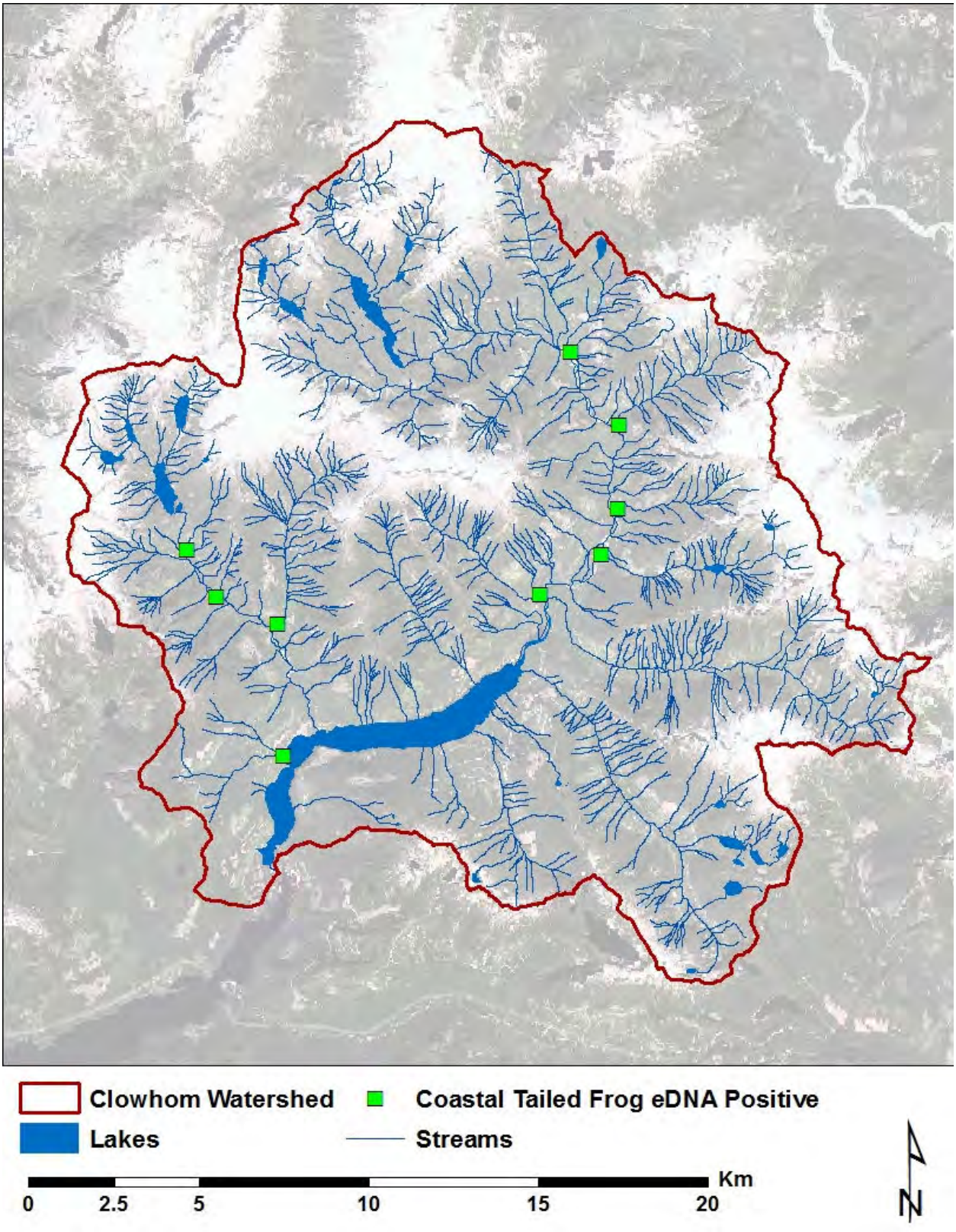


Figure 31: Clowhom Creeks Testing Positive for the Presence of Coastal Tailed Frog DNA

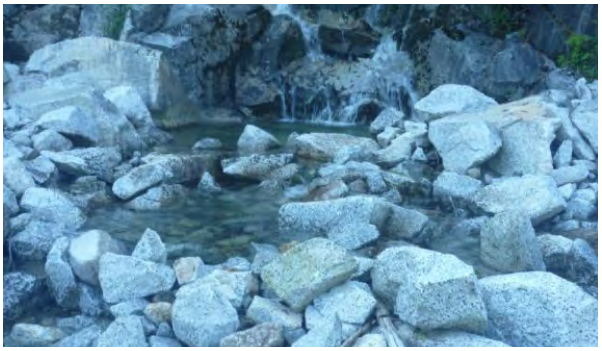
Detection Creek

Maybe Creek

Valley Creek

Bear Creek

Thermometer Creek



Nagy Creek

Elizabeth Creek

Dipper Nest Creek

Figure 32: Habitat in Clowhom Creeks Occupied by Coastal Tailed Frogs

Table 11: Habitat Attributes at Coastal Tailed Frog Detection Sites

Site Name	Channel Unit(s)	Step-Forming Material	Substrate Embeddedness[a]	Substrate Texture (%) [b]			
				Boulder	Cobble	Pebble	Sand
ASTR02 "Elizabeth Creek"	step-pool / cascade	boulder	medium	30	40	20	10
ASTR04 "Thermometer Creek"	step-pool	boulder	high	30	40	20	10
ASTR05 "Detection Creek"	step-pool	boulder	high	50	30	10	10
ASTR07 "Dipper Nest Creek"	pool / riffle	boulder	high	30	60	5	5
ASTR16 "Tadpole Creek"	step-pool/ pool-riffle	boulder	medium	60	30	5	5
ASTR18 "Maybe Creek"	step-pool	boulder	medium	50	35	10	5
ASTR23 "Valley Creek"	step-pool/ pool-riffle	boulder	high	45	45	5	5
ASTR25 "Nagy Creek"	step-pool/ pool-riffle	boulder	high	40	30	20	10
ASTR37 "Bear Creek"	step-pool/ pool-riffle	boulder	medium	45	40	10	5

[a]**Embeddedness** - high: very little interstitial space between particles; medium: some interstitial space between particles; low: high amount of interstitial space between particles; nil: less than 5% of the site is characterized by fines.

[b]**Particle Size** - sand: <2 mm; pebble: 2-64 mm; cobble: 64-256 mm; boulder: >256 mm; bedrock (Dupuis and Friele 2003)

5.5 Water Shrews

Pacific Water Shrew DNA was not conclusively recovered in any of the eDNA samples. However, there were suggestive results from Wetland 8. All three of the triplicate samples from this site were originally inhibited. These samples were run through a One-Step PCR Inhibitor Removal kit column (Zymo Research) and re-analyzed, at which point one sample remained positive and the other two tested negative. None of the control samples yielded positive results. The eDNA samples from the other survey sites did not show signs of PCR inhibition (Table 12).

The positive result from one of the triplicate samples collected at Wetland 8 may indicate the presence of Pacific Water Shrew (*Sorex bendirii*), or it may be a false-positive generated by the presence of either the Cordilleran Water Shrew (*Sorex navigator*) or the Montane Shrew (*Sorex monticulus*). Due to similarities in the genetic sequence on the cytochrome b gene of these three species (Hope et al. 2014), the Pacific Water Shrew assay used in this project may produce a false positive in the presence of Montane Shrew and/or Cordilleran Water Shrew (Dr. Caren Goldberg, pers. comm.).

Table 12: Pacific Water Shrew Environmental DNA Survey Results

Site	Location	UTM *Datum: NAD 83* *UTM Zone: 10U*		Result of qPCR Analysis
		Easting	Northing	
Wetland 3	Off Clowhom Mainline km 23.5	470993	5520323	Negative
Wetland 6	Off Clowhom Mainline km 18.5	471470	5516236	Negative
Wetland 7 (a)	Off Clowhom Mainline km 17	470552	5514900	Negative
Wetland 7 (b)	Off Clowhom Mainline km 17	470470	5514958	Negative
Wetland 8	North part of large wetland complex, end of the reservoir	461074	5513853	Positive/Negative: One of three replicates tested positive and the other two samples were originally inhibited but tested negative after samples were rerun
Wetland 12	Bear Creek Mainline km 3.5	469110	5514335	Negative

5.6 Western Screech-Owls

Call-Playback Surveys

Over the course of our surveys in September 2013, March 2014 and May 2014, we documented 17 Western Screech-Owl detections at 10 of 75 call-playback stations, while Barred Owls responded at 4 stations (Table 13, Figure 33). In addition, two Northern Pygmy Owls were detected incidentally during birding observations in March 2014, and one Barred Owl was spotted on the east side of Clowhom Reservoir during Northern Goshawk habitat reconnaissance surveys in early May 2014 (Figure 33).

.

Table 13: Western Screech-Owl Call-Playback Survey Results

Survey Site	Location	UTM *Datum: NAD 83* *UTM Zone: 10U* Easting	UTM Northing	Survey Dates Sept 2013	Mar 2014	May 2014	Western Screech-Owl Detections	Barred Owl Detections
001	Clowhom	471441	5518535	Y	Y	Y		
002	Clowhom	471618	5518011	Y	Y	Y		
003	Clowhom	471630	5517474	Y	Y	Y	Sept 2013 (1) Mar 2014 (1)	
004	Clowhom	471659	5516947	Y	Y	Y		
004b	Clowhom	471649	5517121			Y		
005a	Clowhom	471528	5516422	Y	Y	Y	May 2014 (2)	May 2014 (1)
005b	Clowhom	471621	5516708			Y	May 2014 (2)	
006	Clowhom	471267	5515973	Y	Y	Y		
007	Clowhom	470659	5515107	Y	Y	Y	Mar 2014 (1)	
007b	Clowhom	470400	5514903			Y		
008	Clowhom	470097	5514848	Y	Y	Y		
009	Clowhom	469673	5514939	Y	Y	Y		Sept 2013 (1)
010	Clowhom	469367	5514554	Y	Y	Y		
011	Clowhom	468986	5514184	Y	Y	Y		
012	Clowhom	468848	5513806	Y	Y	Y	Mar 2014 (1) May 2014 (2)	
013	Reservoir	468745	5513302	Y	Y	Y		
014	Reservoir	468492	5512850	Y	Y	Y		
015	Reservoir	466572	5511652	Y	Y	Y		
016	Reservoir	466135	5511378	Y	Y	Y		
017	Reservoir	465636	5511204	Y	Y	Y		
018	Reservoir	465105	5511094	Y	Y	Y	Sept 2013 (1)	
018b	Reservoir	464863	5511046			Y	May 2014 (1)	
019	Reservoir	464618	5511008	Y	Y	Y	Sept 2013 (2)	
020	Reservoir	464114	5510944	Y	Y	Y		
021	Reservoir	463162	5510752	Y	Y	Y		
022a	Reservoir	461792	5510063	Y				
022b	Reservoir	461853	5510215		Y	Y	Mar 2014 (1)	
022c	Reservoir	462039	5510468			Y	May 2014 (2)	
023	Reservoir	461684	5509563	Y	Y			
024	Reservoir	461347	5509164	Y	Y			Sept 2013 (1)
025	Reservoir	461238	5508671	Y				Sept 2013 (1)
026	Reservoir	461400	5508196			Y		
027	Reservoir	461352	5507647		Y	Y		
028	Reservoir	460979	5507240		Y	Y		
029	Clowhom	461036	5506728		Y	Y		
030	Clowhom	461382	5506579			Y		
031	Clowhom	471711	5518760	Y	Y	Y		

Table 13 (continued): Western Screech-Owl Call-Playback Survey Results

Survey Site	Location	UTM *Datum: NAD 83* *UTM Zone: 10U* Easting	UTM Northing	Surveyed Sept 2013	Surveyed Mar 2014	Surveyed May 2014	Western Screech-Owl Detections	Barred Owl Detections
032	Clowhom	471865	5519228	Y	Y	Y		
033	Clowhom	471686	5519708	Y	Y	Y		
034	Clowhom	471265	5519919	Y	Y	Y		
035	Clowhom	470976	5520333	Y	Y	Y		
036	Clowhom	470617	5520729	Y	Y	Y		
037	Clowhom	470533	5521229	Y	Y	Y		
038	Clowhom	470449	5521644	Y	Y	Y		
039	Clowhom	470147	5522075	Y		Y		
040	Clowhom	469721	5522332	Y		Y		
041	Clowhom	469272	5522796	Y		Y		
042	Clowhom	468828	5522794	Y		Y		
043	Clowhom	468357	5522618	Y		Y		
044	Clowhom	467474	5522662	Y				
044b	Clowhom	467304	5522635			Y		
045	Clowhom	467110	5522515	Y				
045b	Clowhom	467171	5522291			Y		
046	Powder	469855	5514511		Y	Y		
047	Powder	469719	5514074		Y	Y		
048	Powder	469577	5513654		Y	Y		
049	Powder	469316	5513171		Y	Y		
050	Powder	469247	5512699		Y	Y		
051	Powder	469118	5512316		Y	Y		
052	Clowhom	461617	5506877			Y		
056	Clowhom	462014	5506745			Y		
057	Bear	462735	5511626		Y	Y		
058	Bear	462396	5512042		Y	Y		
059	Bear	462144	5512446		Y	Y		
060	Bear	462104	5512857		Y	Y		
061	Bear	461890	5513315		Y	Y		
062	Bear	461532	5513949		Y	Y		
063	Bear	461018	5513922			Y		
064	Bear	460598	5514084			Y		
065	Bear	460175	5514152			Y		
066	Bear	459827	5514583			Y		
067	Bear	459650	5514927			Y		
068	Bear	459537	5515420			Y		
069	Bear	459216	5515711			Y		
070	Bear	458954	5516023			Y		

Clowhom = Clowhom Main Forest Service Road along the Clowhom River
Reservoir = Clowhom Main Forest Service Road along the west side of Clowhom Reservoir
Powder = Powder Main Forest Service Road along the east side of Clowhom Reservoir
Bear = Bear Creek Main Forest Service Road

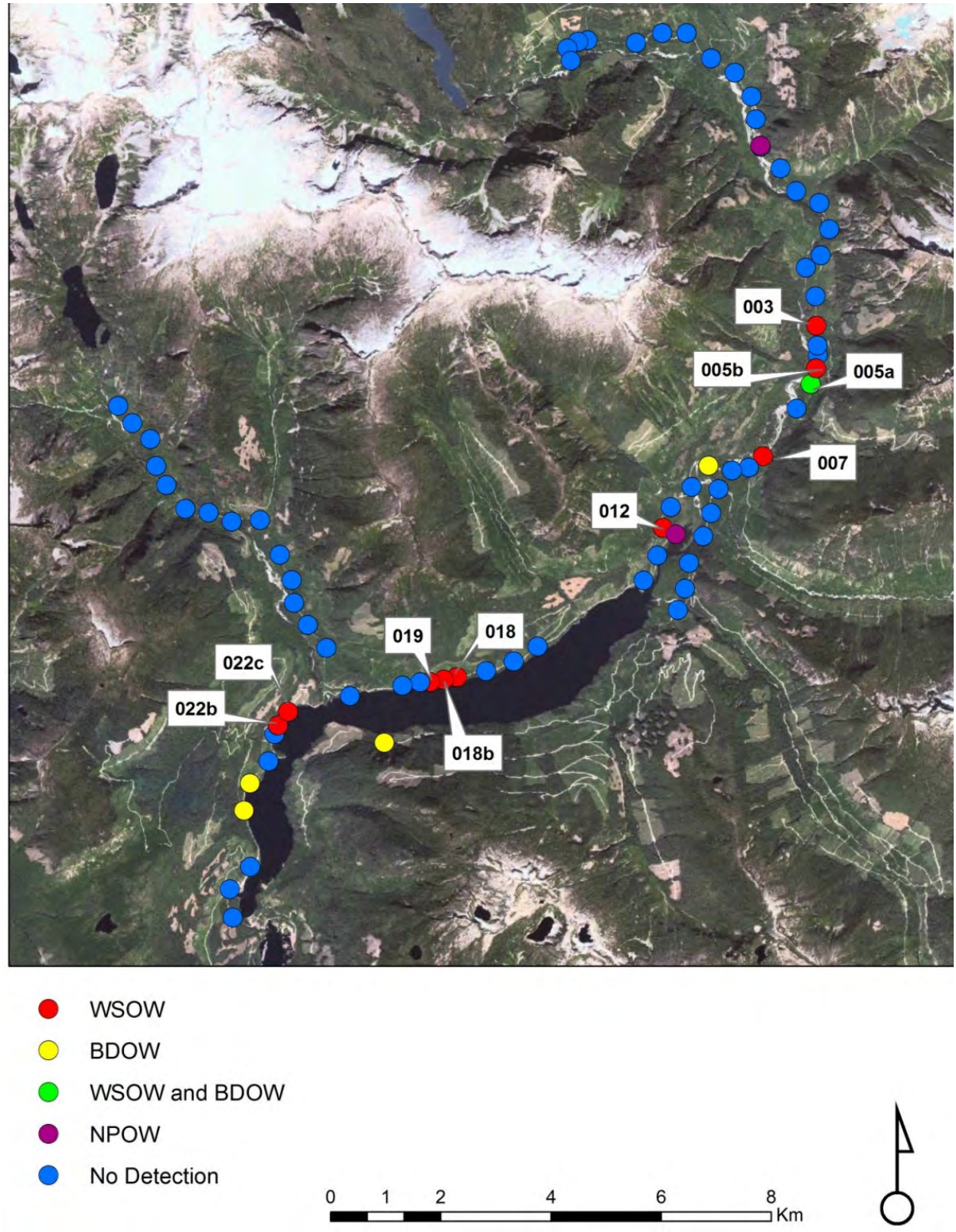


Figure 33: Owl Detections in Clowhom Watershed 2013 and 2014

(WSOW: Western Screech-Owl, BDOW: Barred Owl, NPOW: Northern Pygmy Owl)

Nest Searches, Territory Delineation, and Nest Monitoring

Based on information from active and passive monitoring of owls throughout the spring and summer, we were able to delineate four Western Screech-Owl territories within the Clowhom watershed (Kai, Fisher, Middle and Nagy) (Figure 34). The following pages provide descriptions of the habitat in each territory, along with detailed information about observed Screech-Owl activity in each of these territories.

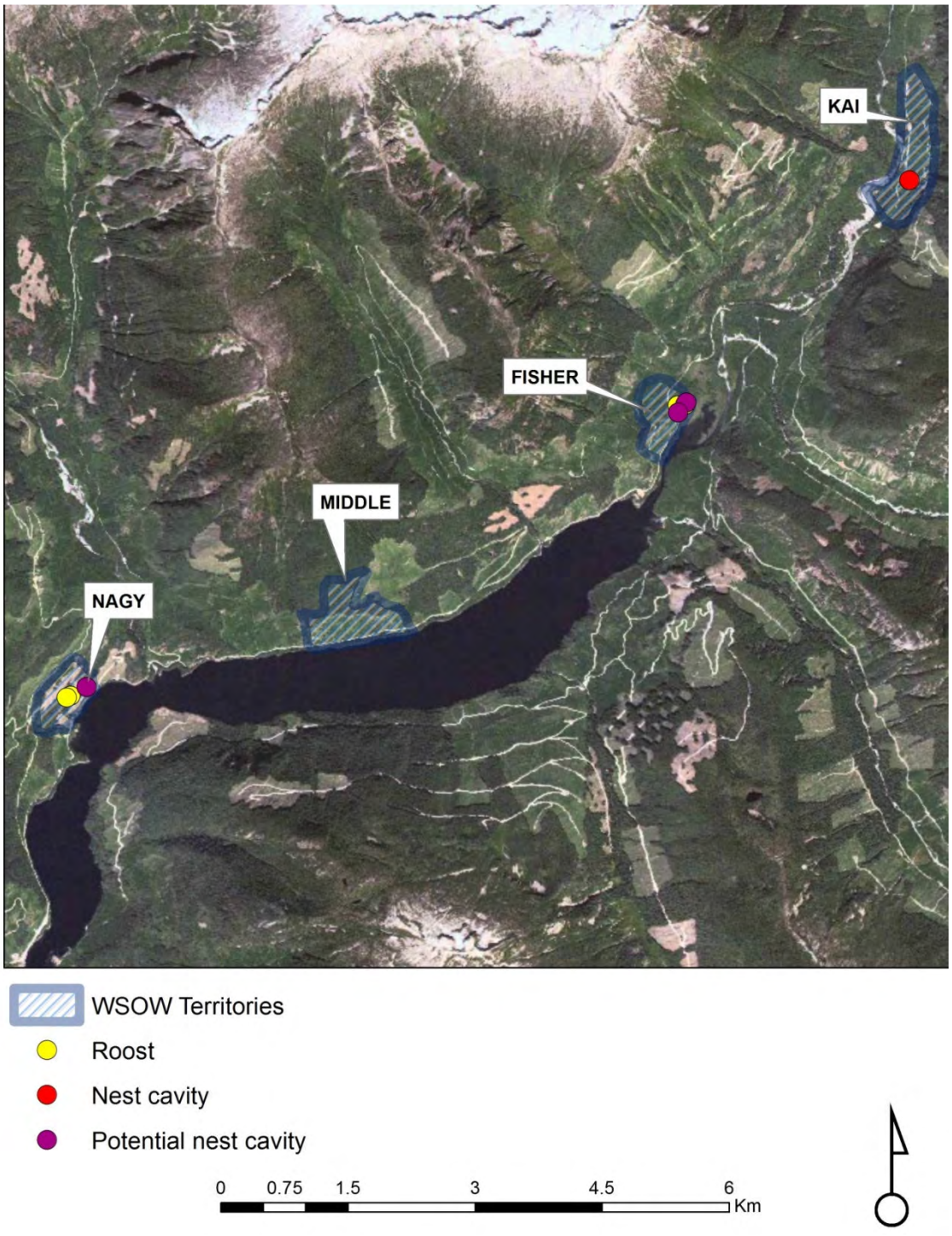


Figure 34: Identified Western Screech-Owl Territories in Clowhom Watershed, 2014

Kai Territory:

The Kai territory is situated along the Clowhom River, near km 19 of the Clowhom Main Forest Service Road. It runs along the flat floodplain of the river for roughly 2 km and is approximately 600 m wide. The territory includes the lower hillslopes of the eastern side of the valley from 80 m to 200 m elevation.

Kai territory includes a diversity of vegetation communities and structural stages, but is dominated by mature, unharvested mixed riparian forests and mature coniferous stands. The riparian forests include the high bench floodplain along the Clowhom mainstem, along with several draws with small streams that run down the eastern slopes of the valley. Trees species include large diameter Sitka Spruce and Bigleaf Maple, along with Western Hemlock, Western Red Cedar, and Black Cottonwood. Trees are widely spaced, providing excellent flyways. The understory is dominated by shrubs such as Stink Currant, Salmonberry, Devil's Club, and False Azalea, with a well-developed and diverse herb community including Pacific Bleeding Heart, Wild Ginger, and various lily and orchid species.

The drier coniferous stands that surround the riparian areas are dominated by Douglas-fir and Western Hemlock. In these stands, the understory is less developed than in the riparian zones due to the higher canopy closure; however, similar understory plant species are present, with Sword Fern and Deer Fern especially prevalent. There is a high amount of downed wood within the territory, providing habitat for Western Screech-Owl prey species, including amphibians, small mammals, and macroinvertebrates.

Human impacts within the territory include the forest service road and transmission line, which run through the entire length of the territory. In addition, there is a large opening left over from the concrete batch plant that was built during construction of the Clowhom Power run-of-river hydroelectric plant. Several areas at the periphery of the territory have been harvested within the past 30 years, and now consist of dense coniferous sapling forest.

In 2014, the Kai Screech-Owl pair's nest grove was located in a Bigleaf Maple stand, with scattered Sitka Spruce, and a very diverse understory, with deep moss growing over an old debris flow of large wood and boulders. Trees appeared to be at least 80 years, possibly much older. Many cavities were observed both in the occupied nest grove, and in the forest of the lower floodplain, particularly in Bigleaf Maple and Black Cottonwood trees. The owl nested in a large cavity in an enormous, old Bigleaf Maple tree (Figure 35).

Figure 35: Western Screech-Owl Nest in Bigleaf Maple Tree, Kai Territory, May 2014

Fisher Territory:

The Fisher territory is located at the north end of the Clowhom reservoir near the confluence with Clowhom River. It runs along the valley bottom for roughly 1 km and up approximately 700 m of the western slopes of the Clowhom valley. Elevations in the territory range from 60 to 160 m. The Fisher territory encompasses the riparian area of the large wetland complex (Wetland 8/9), along with its tributary streams, which are mostly mixed forests dominated by Bigleaf Maple, Western Hemlock, Western Red Cedar, Red Alder, and Sitka Spruce. Drier sites are dominated by Douglas-fir and Western Hemlock. The understory is diverse; some dry microsites with closed canopies possess very little understory vegetation, while other sites include shaded seepages covered in Skunk Cabbage and sedges, wildlife trees, and forest openings which promote tall berry-producing shrubs such as Salmonberry and various *Vaccinium* species.

Similar to all of the Western Screech-Owl territories found within the valley, the Fisher territory is divided by the Clowhom Main Forest Service Road and the transmission line from the Clowhom Power hydroelectric facilities. Other human impacts in this territory include forest harvesting on the western hillslopes, and associated forest service roads (e.g., Fisher Main FSR).

Although we were unable to locate the nest tree for the Fisher pair in 2014, repeated surveys did indicate that the male was defending a particular stand of trees, which we assume to contain the nest cavity. Within this nest grove, we found several wildlife trees with suitable looking cavities. The high diversity of plant communities and open flyways within the territory provide excellent foraging areas and presumably an abundant prey base.

Middle Territory:

The Middle territory is found near the middle of the west side of the Clowhom reservoir. It runs along approximately 1.5 km of shoreline, and extends 700 m upslope. Elevations range from 60 to 500 m. Much of the territory is steep, rocky, dry, Douglas-fir forest. The area between the shoreline and the Clowhom Main Forest Service Road provides a narrow strip of riparian forest with large Bigleaf Maple, Red Alder, Douglas-fir, and Western Red Cedar. There are large patches of young, densely-spaced planted pole/sapling forest along the lower slopes, as well as several recently harvested areas both within and surrounding the territory. Our surveys suggest that the Middle territory Screech-Owl pair are centered in a patch of mature coniferous forest on the mid-slope, between the regenerating forest on the lower slope and the recently harvested areas above.

The understory is patchy, and dominated by Salal and various *Rubus* species. In the mature stands, there are numerous wildlife trees (mainly western Red Cedar) with cavities that appear suitable for nesting Western Screech-Owls. The recently harvested patches may provide foraging opportunities for Screech-Owls, but also expose them to predation from Barred Owls which responded to call-playbacks in that area. The young regenerating forest provides generally poor habitat for Western Screech-Owls.

Nagy Territory:

The Nagy territory is situated along the edge of the Clowhom reservoir where Nagy Forest Service Road meets the Clowhom Main Forest Service Road. It runs along approximately 1 km of shoreline and extends 600 m upslope. Elevations range from 60 to 400 m. The area has been extensively harvested, and includes several active as well as decommissioned forest service roads, along with a transmission line. Nagy territory includes Wetland 15, and several small patches of mature forest (totalling 25 ha) composed primarily of Douglas-fir, with less abundant Western Hemlock, Western Red Cedar, and Red Alder. The understory is dominated by Salal, along with *Rubus* and *Vaccinium* species, with willows at the periphery; Sword Fern dominates the shaded areas with high canopy closure. As in the Middle territory, the young, dense regenerating forest stands provide poor habitat for Western Screech-Owls, while the recent cutblocks may increase foraging opportunities with the trade-off of higher predation risk.

Breeding Observations

We were able to confirm pairs in 3 of the 4 territories (Kai, Fisher, Nagy) based on pair duets (Table 14). The Middle territory was more difficult to evaluate and monitor due to steep, dangerous terrain. In the Kai territory we were able to locate the nest tree and cavity and confirm successful fledging this year with response from a juvenile owl in mid-July 2014.

Western Screech-Owl detections and breeding observations in each of the territories are summarized in Tables 14-18.

Table 14: Summary of Western Screech-Owl Territories and Breeding Observations 2013-2014

Screech-Owl Territory	Summary of Observations	Confirmed Breeding Stage Reached 2014
Kai near stations 003 to 007	Male detected in September 2013 Pair and nest located near WSOW 005b in early May 2014 Barred Owl also detected at station WSOW 005 in early May 2014 Pair observed at and near the nest in late May 2014 Adult observed making prey delivery to nest cavity in late June 2014 Confirmation of successful fledging of 1 juvenile in mid-July 2014	Fledged
Fisher near station 012	Male detected in March 2014 Pair detected in early May 2014 Only male observed in late-May 2014 'Nest Grove' was delineated based on male calling at boundaries Male was displaying behaviour of having an active nest Several potential nest cavities were also located at this time No detection of male or juveniles in late June or mid-July 2014	Nested
Middle near stations 018 and 019	Male detected in September 2013 2 males (Or possibly a pair with female making similar call) detected in March 2014 in different directions No detections in early May 2014 after multiple sunset targeted surveys Detections of male in late May 2014, late June, and mid-July Attempts to survey in and closer to forest patch were difficult due to terrain	Occupied
Nagy near stations 022b & 022c	Male detected in March 2013 Pair detected in early May 2014 Male and female detected in late May 2014 but male acting like a single bird. Two roost sites located Believed this may have been a failed nesting attempt and female was still in the territory Male detected in late June 2014 No detections of any owls in mid-July 2014	Paired

Table 15: Summary of Western Screech-Owl Observations, Kai Territory, 2013-2014

Survey Station	Date and Time	Time to Respond, Distance & Direction	Estimated Owl Location Datum: NAD 83 UTM Zone: 10U Easting	Northing	Sex and Type of Response	Nest Search Details
WSOW 003 471630 5517474	06-Sep-13 21:24	1 min 100 m 113 °	471705	5517395	**Male**: Bouncing ball	Fall detection - did not nest search
WSOW 003 471630 5517474	28-Mar-14 21:21	30 sec 300 m 45 °	471820	5517667	**Male**: Bouncing ball	No nest search
WSOW 007 470659 5515107	30-Mar-14 20:31	10 min 40 sec 25 m 90 °	470683	5515099	**Male**: Bouncing ball	No nest search
WSOW 005 471528 5516422	01-May-14 21:15	8 min 40 sec 150 m 40 °	471627	5516546	**Male**: Bouncing ball	Nest search several days later after had narrowed down area more
		10 min 40 sec ~300 m 25 °	471640	5516672	**Female**: Short overlapping call	
WSOW 005b 471621 5516708	04-May-14 20:54	4 min 50 sec 20 / 40 m 60 ° 300 ° 22 °	471632	5516699	**Male**: Bouncing ball, pair duet	Male responded very close, flew to the west, perched on power line, flew back to forest. Female eventually flew over just past male and then heard duet, and female solicitation call until male flew south likely to forage as observed twice later near road apparently foraging. Next day found cavity with female sitting at entrance.
		23 min 30 sec 40 m 22 °	471632	5516699	**Female**: Pair duet, female solicitation, trill	
2014 Nest 1	29-May-14 10:00	N/A	Sensitive data		**Female**: N/A	Visited Nest 1 - Female in cavity entrance. Male in nearby tree - flushed when we approached
		N/A	Sensitive data		**Male**: N/A	
2014 Nest 1	28-June-14	N/A	Sensitive data		**Adult**	Passive monitoring at nest cavity – Adult observed delivering prey to nest cavity
2014 Nest 1	15-Jul-14 21:25	5 min N/A N/A	Sensitive data		**Juvenile**: Juvenile call	Conducted passive monitoring from 20:40-22:10 with no observations. Played Bouncing Ball call at 21:25 and juvenile responded and flew in from Wetland 6 area

Table 16: Summary of Western Screech-Owl Observations, Fisher Territory, 2013-2014

Survey Station	Date and Time	Time to Respond, Distance & Direction	Estimated Owl Location Datum: NAD 83 UTM Zone: 10U		Sex and Type of Response / Observation	Comments and Nest Search Details
			Easting	Northing		
WSOW 12 468848 5513806	29-Mar-14 21:10	7 min 3 m 90 ^{o}	468853	5513792	**Male**: bouncing ball	
WSOW 12 468848 5513806	02-May-14 22:28	1 min 150-200 m 199 ^{o}	468785	5513623	**Male and Female**: pair duet	No nest search conducted as of yet
Roost 1 468938 5513843	29-May-14	N/A	468938	5513843	**Male**: bouncing ball	Male found at a roost and observed calling at boundaries of 'Nest Grove'
Roost 2 469026 5513854	30-May-14	N/A	469026	5513854	**Male**: bouncing ball	Male found at a roost and observed calling at boundaries of 'Nest Grove'
Nest Grove 468939 5513762	27-Jun-14 21:47	N/A	N/A	N/A	**No Response**	Passive monitoring at potential cavity (20:15-22:50), played Bouncing Ball at sunset (21:47), no response
Nest Grove 468939 5513762	14-Jul-14	N/A	N/A	N/A	**No Response**	Sat passively to listen for juveniles then played Bouncing Ball with no response

Table 17: Summary of Western Screech-Owl Observations, Middle Territory, 2013-2014

Survey Station	Date and Time	Time to Respond, Distance & Direction	Estimated Owl Location		Sex and Type of response	Comments and Nest Search Details
			Datum: NAD 83			
			UTM Zone: 10U			
			Easting	Northing		
WSOW 18 465105 5511094	07-Sep-13 21:53	30 sec 20 m 220 °	465094	5511073	**Male**: Bouncing ball	No nest search since fall detection
WSOW 19 464618 5511008	30-Mar-14 21:27	13 min >500 m 2 °	464633	5511492	**Male**: Bouncing ball	
		14 min ~400-500 m 332 °	464371	5511437	**Male**: Bouncing ball	
WSOW 18b 464929 5511056	31-May-14 21:56	7.5 min 80 m 17 °	464952	5511127	**Male**: Bouncing ball	Difficult terrain to search for nest and roosts, large clearcut/slash and steep before get to forest patches where male likely responded
N/A 464640 5511093	29-Jun-14 21:56	7 min 2 m 60 °	464643	5511098	**Male**: Bouncing ball	Hiked up hill side and conducted passive monitoring from 20:30 to 22:30. Played call half way between forest patch and road. Bird came close and called.
WSOW 18b 464929 5511056	16-Jul-14 21:40	12 min 80 m 17 °	464952	5511127	**Male**: Bouncing ball	Was trying to solicit juvenile response but did not detect one. Did get a response from the male.

Table 18: Summary of Western Screech-Owl Observations, Nagy Territory, 2013-2014

Survey Station	Date and Time	Time to Respond, Distance & Direction	Estimated Owl Location Datum: NAD 83 UTM Zone: 10U		Sex and Type of response	Nest Search Details
			Easting	Northing		
WSOW 022b 465105 5511094	28-Mar-14 22:33	6 min 20 sec 100-->0 m 298 ^{o}	461853	5510215	**Male**: Bouncing ball	Estimated location is WSOW 22b. Walked towards owl and took location and pics.
WSOW 022c 462039 5510468	03-May-14 23:59	<1 min 200-250 m 315 ^{o}	461893	5510594	**Male**: Pair duet, double trill	Saw owl fly by while driving, stopped and played call
		<2 min 200-250 m 315 ^{o}	461893	5510594	**Female**: Pair duet, double trill	
N/A 461767 5510419	29-May-14	N/A	461767	5510419	**Male**: Bouncing ball	Male found at a roost and observed calling at boundaries of 'Roost Grove'
N/A 461727 5510397	30-May-14	N/A	461727	5510397	**Male**: Bouncing ball	Male found at a roost and observed calling at boundaries of 'Roost Grove'
N/A 461815 5510435	31-May-14 6:34	1 min	461815	5510435	**Female**: Female call	Female heard
N/A 461704 5510382	29-Jun-14 22:20	5 min 240 m 96 ^{o}	461942	5510354	**Male**: Bouncing ball	Passive monitoring near 'Roost Grove' from 20:45-22:45. No response until played Bouncing Ball @ 22:15. Male heard down by road 5 minutes later.
WSOW 22c 462039 5510468	16-Jul-14	N/A	N/A	N/A	**No Response**	Sat passively to listen for juveniles then played Bouncing Ball with no response

5.7 Northern Goshawks

We did not detect Northern Goshawks at any of the 18 call-playback stations surveyed in 2014. Habitat assessment indicates that many of these sites have moderate suitability nesting and foraging habitat but tend to be in small forest patches surrounded by cutblocks and active forest service roads (Table 19).

Table 19: Habitat Suitability at Northern Goshawk Survey Locations

Station Name	UTM *Datum: NAD 83* *UTM Zone: 10U*		Nesting Habitat Quality	Foraging Habitat Quality	Habitat Suitability Comments
	Easting	Northing			
BEAR 1	459655	5514918	Moderate	Moderate	Several suitable diameter trees and foraging areas across Bear Creek and on both sides of valley, small patches, steep, surrounded by old cutblocks
BEAR 2	460588	5514083	Moderate	Moderate	Suitable patches with suitable diameter trees and moderate flyways on both sides of creek and valley, small fragmented with harvested areas, steep, surrounded by cutblocks
BEAR 3	462581	5511589	Moderate	Moderate	Suitable patches with suitable diameter trees and moderate flyways on both sides of creek and valley, small fragmented with harvested areas, steep, surrounded by cutblocks
MAIN 19KM	471519	5516194	High	High	Small fragmented high quality patches (400m), low bench site, surrounded by old cutblocks
MAIN 22KM	471761	5519554	Moderate	Moderate	Some patches of steep Old Growth Douglas Fir, Red Cedar and Western Hemlock. Some large diameter trees. Patchy, non-contiguous, moderate flyways, surrounded by cutblocks
NAGY 1	461573	5510423	Moderate	Moderate	Several suitable diameter trees ~ 80 m below and moderate flyways but very small patch surrounded by cutblocks and at the edge of clearcut
NAGY 2	461153	5508922	Moderate	Moderate	High suitability nesting and foraging above (large Douglas-firs, excellent flyways), NIL below (recent clearcut), surrounded by cutblocks and forest service road
NAGY 3	460943	5509502	Moderate	Moderate	Small fragmented high quality patches (Fir forest), part of large suitable patch recently logged, surrounded by cutblocks and forest service road
NAGY 4	459812	5508992	Moderate	Moderate	Small fragmented high quality patches (Fir forest), part of large suitable patch recently logged, surrounded by cutblocks and forest service road

Table 19 (continued): Habitat Suitability at Northern Goshawk Survey Locations

Station Name	UTM *Datum: NAD 83* *UTM Zone: 10U* Easting	UTM *Datum: NAD 83* *UTM Zone: 10U* Northing	Nesting Habitat Quality	Foraging Habitat Quality	Habitat Suitability Comments
PHANTOM 1	466483	5521992	Moderate	Moderate	Lacks a bit in # of large diameter trees due to climate, moderate flyways, likely lots of prey with *Vaccinium* dominated understory, near maintained forest service road and run of river hydro head pond
POWDER 1	462396	5507885	Moderate	Moderate	Several suitable diameter trees ~100 downslope, moderate flyways, within 400 m of clearcut
POWDER 2	463598	5509912	Moderate	Moderate	Several suitable diameter trees up slope and downslope, moderate flyways, decent understory, within 200m of clearcut
POWDER 3	465442	5510054	Low	Low	Lack of suitable trees near road, recent logging above close to historic Clowhom Lake record, within 200 m of clearcut
POWDER 4	465796	5510077	Moderate	Moderate	Several suitable diameter nest trees, moderate flyways and understory ~50 m downslope, at edge of clearcut
RED TUSK 1	470748	5514159	Nil	Nil	At clearcut - near historic Red Tusk observation - nest likely discovered during logging, at clearcut edge, 2km from active FSR
RED TUSK 2	470913	5514166	Low	Moderate	Few platforms - near historic Red Tusk observation - nest likely discovered during logging, good flyways and understory, within 200 m of ~ 15 year old clearcut
RED TUSK 3	470902	5514367	Low	Low	Few nesting platforms, good flyways, sparse understory, within 200 m of ~ 15 year old clearcut
RED TUSK 4	470945	5514543	Low	Moderate	Few nesting platforms, good flyways, sparse understory, within 200 m of ~ 15 year old clearcut

5.8 Bats

Acoustic Surveys

During our acoustic surveys between June and August 2014, we recorded at least eight different bat species in 208 individual detections at seven sites (Tables 20 and 21). Five of the 10 surveyed sites had more than one bat species present. Most species were detected at multiple locations with the exception of a long-eared bat species (Long-eared Myotis or Keen's Long-eared Myotis) detected near Wetland 6, and eight recordings of Big Free-tailed Bat at Wetland 1. The identification of the Big Free-tailed Bat recordings (Figure 36) was confirmed by several bat acoustic expects (Lausen 2015). This finding is significant because the species was last documented in BC in 1938 (Cori Lausen, pers. comm.).

Table 20: Results of Bat Acoustic Surveys June – August 2014, Summary by Species

Group Name	Species or Group	Number of Recordings	Sites Present	Locations Detected
LACI	*Lasiurus cinereus* (Hoary Bat)	12	2	A, F
LANO	*Lasionycteris noctivagans* (Silver-haired Bat)	41	5	B, C, F, H
EPFU/LANO	*Eptesicus fuscus* (Big Brown Bat) or *Lasionycteris noctivagans* (Silver-haired Bat)	55	4	B, C, D, F
MYCA/MYYU	*Myotis californicus* (California Myotis) or *Myotis lucifugus* (Little Brown Bat)	15	4	A, B, F, J
MY40	40 KHz *Myotis*, Likely *Myotis lucifugus* (Little Brown Bat) or *Myotis volans* (Long-legged Myotis)	67	4	A, B, C, D
MYEV/MYKE	*Myotis evotis* (Long-eared Myotis) or *Myotis keenii* (Keen's Long-eared Myotis)	3	1	F
NYMA	*Nyctinomops macrotis* (Big Free-tailed Bat)	8	1	D
UNKN	Unidentifiable Bat	7	1	C

Species grouped together represent recordings that were unable to be identified to any greater detail. Although there are numerous species with calls similar to the "40khz Myotis" only two are known to occur within the region - the Little Brown Bat (*Myotis lucifugus*), and the Long-legged Myotis (*Myotis volans*)

Please see Figure 10 on Page 24, for a map of acoustic survey locations

Table 21: Results of Bat Acoustic Surveys June – August 2014, Summary by Location

Site	Location	UTM		Sampling Dates	Time Deployed	Total Detections	Species Recorded
		Datum: NAD 83					
		UTM Zone: 10U					
		Easting	Northing				
A	Upper Head Pond (intake for Clowhom Power)	466456	5521972	17-Jul-14	30	49	LACI, MY40, MYCA/MYYU, UNKN
B	Clearing near Clowhom Mainline km 27	469418	5522679	17-Jul-14	15	82	LANO, MY40, EPFU/LANO, MYCA/MYYU
C	Clearing near Clowhom Mainline km 26	469749	5522614	17-Jul-14	15	20	LANO, EPFU/LANO, MY40
D	Wetland 1	470638	5520706	14-Jul-14	480*	25	EPFU/LANO, MY40, NYMA
E	Lower Head Pond (intake for Clowhom Power)	471737	5519521	17-Jul-14	20	0	
F	Near Wetland 6, Clearing in Old Growth Spruce	471375	5516113	18-Aug-14	480*	26	LACI, LANO, EPFU/LANO, MYCA/MYYU, MYEV/MYKE
G	Wetland 7	470482	5514938	1-Jun-2014 17-Jul-2014	20 960*	0 0	
H	Wetland 8	469222	5514238	1-Jun-2014	20	3	LANO
I	Wetland 15	461604	5510429	15-Jul-2014	480*	0	
J	Wetland 14	460796	5506688	1-Jun-2014	20	3	MYCA/MYYU

LACI = *Lasiurus cinereus* (Hoary Bat)
LANO = *Lasionycteris noctivagans* (Silver-haired Bat)
EPFU/LANO = *Eptesicus fuscus* (Big Brown Bat) or *Lasionycteris noctivagans* (Silver-haired Bat)
MYCA/MYYU = *Myotis californicus* (California Myotis) or *Myotis yumanensis* (Yuma Myotis)
MY40 = 40 KHz Myotis, Likely *Myotis lucifugus* (Little Brown Bat) or *Myotis volans* (Long-legged Myotis)
MYEV/MYKE = *Myotis evotis* (Long-eared Myotis) or *Myotis keenii* (Keen's Long-eared Myotis)
NYMA = *Nyctinomops macrotis* (Big Free-tailed Bat)
UNKN = Unidentifiable Bat

* Equipment failure; Duration of monitoring unclear

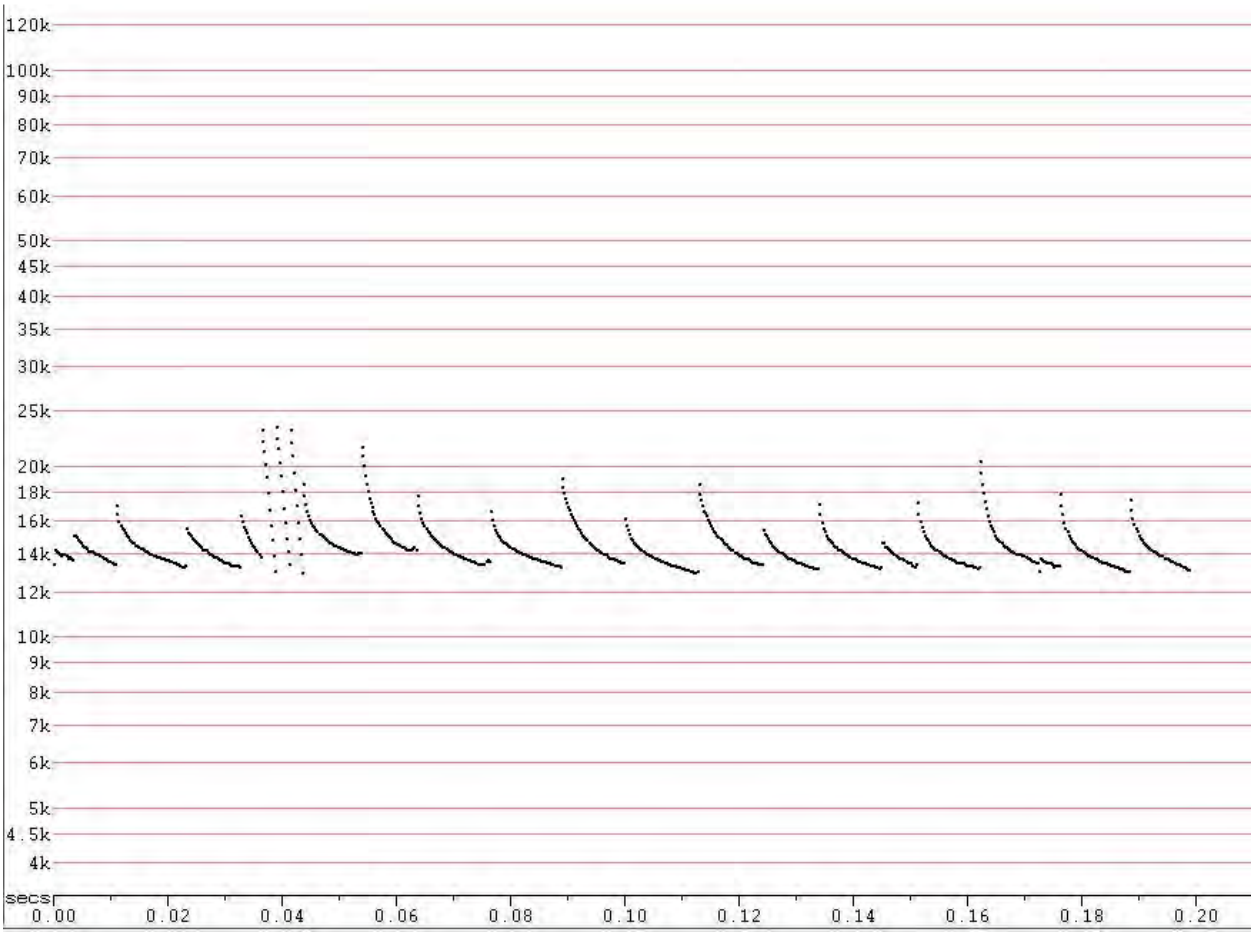


Figure 36: Sonogram Identified as Big Free-tailed Bat (*Nyctinomops macrotis*) near Wetland 1

Mist Net Surveys

Over two nights of mist net surveys, we captured 11 individual bats of three species (Table 22, Figure 37). All species captured were low flying bats, in relatively open areas. On August 18, 2014 we captured three Little Brown Bats (*Myotis lucifugus*) near Wetland 6. On the night of August 19, we captured three Little Brown Bats, four California Myotis (*Myotis californicus*) and one Yuma Myotis (*Myotis yumanensis*) near Wetland 7.

Table 22: Bat Mist Net Captures in Clowhom Watershed, August 2014

Mist Net	UTM *Datum: NAD 83* *UTM Zone: 10U* Easting	UTM *Datum: NAD 83* *UTM Zone: 10U* Northing	Date	Time	Species	Sex	Age	Reprod. Status	Mass (g)
4	471369	5516071	18-Aug-14	2120	MYLU	M	J	NR	5.0
5	471292	5516031	18-Aug-14	2120	MYLU	M	A	RP	5.6
5	471292	5516031	18-Aug-14	2130	MYLU	M	A	RP	5.8
7	470324	5515068	19-Aug-14	2115	MYCA	M	A	RP	4.4
8	470369	5515042	19-Aug-14	2205	MYCA	F	A	NP	4.8
9	470341	5515020	19-Aug-14	2240	MYYU	M	A	NR	4.7
10	470374	5514963	19-Aug-14	2300	MYLU	F	A	NR	5.3
11	470420	5515027	20-Aug-14	0040	MYLU	F	A	NP	4.9
12	470076	5514908	20-Aug-14	0130	MYCA	M	J	NR	4.1
13	469880	5514834	20-Aug-14	0130	MYCA	M	A	RP	3.8
14	469904	5514655	20-Aug-14	0130	MYLU	M	A	RP	4.8

MYLU = *Myotis lucifugus* (Little Brown Bat)
MYCA = *Myotis californicus* (California Myotis)
MYYU = *Myotis yumanensis* (Yuma Myotis)

RP = Reproductive
NR = Non-reproductive
NP = Non-parous

Figure 37: Myotis Bats Trapped During Mist Net Surveys

5.9 Other Wildlife

In addition to the target taxa, we detected numerous other wildlife species in the Clowhom watershed. Over the past two project years we have recorded 118 vertebrate species (82 bird species, 8 amphibians, 19 mammals, 6 fish, and 2 reptiles) (Table 23). These include many species of conservation concern including 14 provincially listed species, 10 federally listed species, 8 Pacific Coast Joint Venture Priority Bird Species in BC, and 11 Partners in Flight Species of Continental Importance in the Pacific Avifauna Biome. In addition to the 14 vertebrate species at risk, we also documented one invertebrate species at risk: the Pacific Sideband snail (Figure 38).

Northern Pygmy Owl

American Black Bear

Dolly Varden

Nest of Sooty Grouse

Pacific Sideband Snail

Terrestrial Garter Snake

Figure 38: Some of the Many Diverse Wildlife Species Detected in the Clowhom Watershed

Table 23: Vertebrate Species Detected in Clowhom Watershed, April 2013 - March 2015

FISH	**Coastal Cutthroat Trout** [B,SC]	Dolly Varden	Threespine Stickleback
	Rainbow Trout	Western Brook Lamprey	Sculpin sp.
AMPHIBIANS	**Coastal Tailed Frog** [B,SC, IW]	**Western Toad** [B,SC]	Ensatina
	Pacific Chorus Frog	Northwestern Salamander	Rough-skinned Newt
	Red-legged Frog [B,SC, IW]	Long-toed Salamander	
REPTILES	Terrestrial Garter Snake	Northern Alligator Lizard	
MAMMALS	American Beaver	**Little Brown Bat** [E]	Bobcat
	Douglas Squirrel	Long-legged Myotis	Cougar
	North American Water Vole	Yuma Myotis	Grey Wolf
	Snowshoe Hare	Big Brown Bat	American Black Bear
	Silver-haired Bat	Hoary Bat	**Roosevelt Elk** [B]
	California Myotis	Big Free-tailed Bat	Columbia Black-tailed Deer
	Long-eared Myotis		
BIRDS	Canada Goose	Belted Kingfisher	Swainson's Thrush
	Trumpeter Swan [PCJV]	**Red-breasted Sapsucker** [PIF]	American Robin
	Mallard [PCJV]	Hairy Woodpecker	**Varied Thrush** [PIF]
	Green-winged Teal	Northern Flicker	American Pipit
	Harlequin Duck [PCJV]	Pileated Woodpecker	Cedar Waxwing
	Bufflehead [PCJV]	**Olive-sided Flycatcher** [B, T, PIF]	Orange-crowned Warbler
	Common Merganser	Western Wood-Pewee	Yellow Warbler
	Ruffed Grouse	**Willow Flycatcher** [PIF]	Yellow-rumped Warbler
	Sooty Grouse	Hammond's Flycatcher	**Black-throated Gray Warbler** [PIF]
	Common Loon [PCJV]	**Pacific-slope Flycatcher** [PIF]	Townsend's Warbler
	Pied-billed Grebe	Cassin's Vireo	MacGillivray's Warbler
	Great Blue Heron [B, SC, PCJV, IW]	Hutton's Vireo	Common Yellowthroat
	Turkey Vulture	Warbling Vireo	Wilson's Warbler
	Osprey	Gray Jay	Spotted Towhee
	Bald Eagle [PCJV, PIF]	**Steller's Jay** [PIF]	Savannah Sparrow
	Red-tailed Hawk	Common Raven	Song Sparrow
	Peregrine Falcon [B, SC]	Tree Swallow	White-crowned Sparrow
	Killdeer	**Violet-green Swallow** [PCJV]	**Golden-crowned Sparrow** [PIF]
	Spotted Sandpiper	Northern Rough-winged Swallow	Dark-eyed Junco
	Wilson's Snipe	**Barn Swallow** [B, T]	Western Tanager
	Mew Gull	Black-capped Chickadee	Black-headed Grosbeak
	Band-tailed Pigeon [B, SC, PIF]	**Chestnut-backed Chickadee** [PIF]	Red-winged Blackbird
	Western Screech-Owl [B, T]	Red-breasted Nuthatch	Western Meadowlark
	Northern Pygmy-Owl	Brown Creeper	Brown-headed Cowbird
	Barred Owl	Pacific Wren	Pine Siskin
	Black Swift [B, E]	American Dipper	American Goldfinch
	Vaux's Swift	Golden-crowned Kinglet	
	Rufous Hummingbird [PIF]	Ruby-crowned Kinglet	

[B] = Blue-listed in BC, [E] = Federally Endangered, [T] = Federally Threatened, [sc] = Federal Species of Special Concern
[IW] = Identified Wildlife under the BC Forest and Range Practices Act, [PCJV] = Pacific Coast Joint Venture Priority Species in BC
[PIF] = Partners in Flight Species of Continental Importance in the Pacific Avifauna Biome

6.0 DISCUSSION

6.1 Wetlands

With its steep slopes and narrow valley bottoms, Clowhom watershed contains relatively few wetlands. There was likely substantial loss of wetland habitats with the construction of the Clowhom dam and flooding of the lower valley in the 1950s. The majority of wetlands that remain are relatively small; most are less than a hectare in area. Many are significantly impacted by human activities, including forest harvesting and construction of roads and transmission lines. Over two years of surveys, we have identified, assessed and mapped 15 wetlands in the watershed. Together these sites include a diversity of wetland and riparian subclasses, including swamp, fen, bog, marsh, shallow water, and low, medium and high bench floodplain. Our Year 1 FWCP Annual Report (Evelyn et al. 2014) includes a discussion of wetland types represented in the watershed, along with detailed mapping, photographs, and comprehensive descriptions of 14 wetland sites, including information about soils, hydrology, vegetation, management issues, and wildlife habitat values. Our wildlife surveys indicate that all of the identified wetlands provide valuable habitat and play important roles in maintaining populations of amphibians and other wetland-dependent species. Three sites are particularly noteworthy and are described below.

***Wetland 6*:** Situated near the Clowhom mainline at km 18.5, Wetland 6 includes an important Red-legged Frog breeding pond, the only site with confirmed successful breeding in 2014. This wetland borders undisturbed, mature riparian forest that offers superb habitat for many species. One of Clowhom's four occupied Western Screech-Owl territories includes this wetland. Wetland 6 has especially high bat diversity and was the only location in the watershed where Long-eared Bats were detected in 2014. Given its value to species at risk and other wildlife, efforts should be made to ensure there is no future alteration of the adjacent forest patch through harvest or any other industrial activity.

***Wetland 7*:** This heterogeneous wetland complex is situated between the toe of a mountain and the Clowhom Main Forest Service Road near km 17. It includes areas of swamp, fen and medium bench riparian floodplain. The site plays as important role as the only known breeding site for Western Toads in the watershed that is not connected to the reservoir and thus that does not experience harmful water level fluctuations. In 2014, it was the only site with confirmed Western Toad breeding. The area also receives high use from ungulates and is home to at least three bat species, including endangered Little Brown Bats. A Western Screech-Owl was observed nearby in 2014 and this area likely provides important foraging habitat for these owls.

***Wetland 8/9*:** This 33-hectare wetland complex is the largest wetland we have identified in Clowhom, and is arguably the most significant location for wildlife in the watershed. Situated at the junction between the Clowhom River and the reservoir, this site includes both an area of stable, natural habitat (Wetland 8), along with areas that are greatly influenced by water level fluctuations caused by hydro operations (Wetland 9). This site incorporates a diversity of different wetland classes, including bog, swamp and shallow water within the dominant fen and marsh communities. It is representative of the type of wetland habitat that likely existed in the lower valley prior to the construction of the Clowhom dam.

Wetland 8/9 supports a great diversity of wildlife species, including invertebrates, frogs, toads, salamanders, snakes, small mammals, waterfowl, songbirds, raptors, ungulates and carnivores. All six pond-breeding amphibian species have been detected in the wetland. We have documented the presence of at least five different species at risk at the site (Western Toad, Red-legged Frog, Sooty Grouse, Roosevelt Elk, and Little Brown Bat).

The biggest issue affecting wildlife in Wetland 8/9 is the dramatic, unnatural, and unpredictable raising and lowering of reservoir water levels. These water level fluctuations appear to be negatively impacting amphibians at the site. When water levels rise too quickly, inundation with cold lake water can lower temperatures dramatically, and change habitat quality and quantity. Conversely, when water levels drop too quickly, amphibian breeding pools can dry out and egg masses or tadpoles may become stranded. Because the wetland is directly connected to the reservoir, large fish may also present an increased predation risk when tadpoles are forced into deeper water.

Figure 39: Wetland 6

Figure 40: Wetland 7

Figure 41: Wetland 8/9

6.2 Riparian Zones

The Clowhom basin is home to abundant riparian zones around the watershed's many headwater creeks. Lower elevation riparian zones are more rare; less than 25% of the mapped riparian areas in the watershed are below 600 m in elevation. These low elevation riparian sites are more productive and generally provide higher quality wildlife habitats than the higher elevation sites.

Clowhom's low elevation riparian areas have also been disproportionately affected by human activity; 54% of riparian zones below 600 m have been harvested in the past fifty years and many are impacted by roads and transmission lines.

Many species at risk found within the Clowhom watershed are dependent on riparian areas for some part of their life cycle, and several are obligate to these habitats. These species are threatened by human impacts on riparian forests.

Roads running through habitats have been well documented to have negative effects on wildlife populations through fragmentation, road mortality, and facilitation of colonization by invasive species (Trombulak & Frissell 2000). These effects are even more pronounced in species with limited dispersal ability such as amphibians. Although several of the roads crossing through riparian areas are deactivated after use, the ecological impacts may continue for several years. Additionally, many of the roads within the Clowhom watershed were built before rigorous environmental standards were in place. These roads, combined with the geologic instability of many of the hillslopes within the watershed, may result in increased impacts to riparian and aquatic habitats, through increased slope failure and siltation.

Our analyses clearly illustrate that there is a limited amount of low elevation riparian habitat within the watershed, and even fewer areas that are not substantially degraded due to human activity. In turn, this highlights the importance of conserving and managing those riparian habitats that remain in good ecological condition. These habitats may be able to function as refugia for many species, allowing recolonization of previously degraded areas, and helping to mitigate continued impacts.

Figure 42: Lowland Elevation Riparian Habitats Impacted by Humans

Low elevation riparian habitats have been disproportionately impacted by human impacts such as forest harvesting, hydro operations and transmission lines

6.3 Pond-breeding Amphibians

Amphibians are considered one of nature's best indicators of biodiversity and overall ecosystem health in both aquatic and terrestrial ecosystems due to their longevity, small territory size, site fidelity, and sensitivity to environmental alterations. Globally, amphibians are experiencing dramatic population declines and as many as 40% of species worldwide face imminent extinction (Wake 2012). Amphibians are also among the species most impacted by hydro operations.

The Sunshine Coast is home to six amphibian species, including frogs, toads, salamanders and newts, that breed in water bodies such as ponds, lakes, wetlands, marshes, sloughs, ditches and slow-moving streams (herein referred to as "pond-breeding amphibians"). Our surveys demonstrate that wetlands of the Clowhom watershed support all six of these species: Red-legged Frog (*Rana aurora)*, Western Toad (*Anaxyrus boreas)*, Pacific Chorus Frog (*Pseudacris regilla*), Northwestern Salamander (*Ambystoma gracile*), Long-toed Salamander (*Ambystoma macrodactylum*) and Roughskin Newt (*Taricha granulosa*).

Of particular conservation concern are the two pond-breeding amphibians classified as species at risk: Red-legged Frog and Western Toad. Both species are provincially blue-listed and federally listed as species of special concern (COSEWIC 2002a, COSEWIC 2002b). The Red-legged Frog is classified as 'Identified Wildlife' and afforded special protection under the BC Forest and Range Practices Act (Maxcy 2004). The Western Toad is one of the few Canadian amphibians on the IUCN Red List of Threatened Species (category "Near Threatened") (IUCN 2014).

Red-legged Frogs

Despite intensive survey effort over the past two years, we have detected very low numbers of Red-legged Frogs in the Clowhom watershed compared with other regions of the Sunshine Coast where these frogs are common and abundant. To date, Red-legged Frogs have been detected at only two sites in the Clowhom basin: Wetland 6 and Wetland 9.

Wetland 6 is a small swamp within a largely intact patch of mature riparian forest. Red-legged Frogs breed in shallow pools within the site. As long as this habitat remains unharvested, it could support a small population of Red-legged Frogs. Some road impacts may be occurring but could be mitigated by fencing and potentially planting roadside vegetation to limit runoff and siltation.

Wetland 9 is the downstream portion of the large wetland complex at the mouth of the Clowhom River. It contains a diversity of wetland subclasses, including marsh, bog, fen and riparian floodplain. This section of the wetland has a dramatically fluctuating water table, subject to frequent inundation and draw down from the reservoir downstream. Water levels can drop several feet in a matter of days. In March 2014, Red-legged Frog egg masses were detected in small remaining pools within the wetland. However, no tadpoles were observed on subsequent visits during the year. It appears that larvae may have been flushed out of the site this year by water level fluctuations. Water levels in Wetland 9 can change by many meters in a matter of days. Red-legged Frog breeding success at Wetland 9 is most certainly being affected by the frequency and rate of drawn down in this area.

No Red-legged Frogs were detected in any of the other surveyed wetlands, despite the fact that many other sites, including Wetlands 1, 2, 3, 4, 5 and 14, appear to provide excellent potential breeding habitat for the species. Red-legged Frogs may yet be present in some of these sites but at very low densities making them difficult to detect.

In the 2015/2016 project year, we will continue to monitor known breeding locations and search for additional occupied sites for Red-legged Frogs within the Clowhom watershed using perimeter surveys, live trapping and eDNA surveys.

Western Toads

In 2013, we documented Western Toad breeding sites at three locations in the Clowhom watershed (Wetlands 7, 9 and 10). This year, breeding was observed at only one of these three sites (Wetland 7).

Wetland 7: This location appears to be the most consistent Western Toad breeding site discovered thus far in the watershed. Unlike the other two sites, it is not connected to the Clowhom Reservoir and thus is unaffected by water level fluctuations associated with BC Hydro operations. Transmission lines run through this wetland, and maintenance of the hydro right of way at this site has promoted high habitat quality by creating open, warm wetland pools (Evelyn et al. 2014).

The number of larvae observed in the past two years (approximately 2,000 tadpoles each year) suggests there may be only a few toads breeding in this wetland (one female Western Toad can produce 5,000 to 16,500 eggs in in a single breeding season) (COSEWIC 2002b). Based on our observations, it appears eggs are laid at this site in April and young toadlets disperse from the pond in July. To avoid harming toads at this breeding site, we recommend that maintenance of the transmission line right of way should take place earlier than April or later than July to avoid disturbing the habitat when developing toads are present.

Road mortality is a potential concern at this location as the breeding site is located right beside the Clowhom Main Forest Service Road. However, traffic on the road is light and over the past two years we have not detected any roadkill or observed any toadlets on the road. It is possible that juvenile toads are dispersing away from the breeding pond in the direction away from the roadway. Over the next two years, we will continue to monitor the site to try and track the path of dispersing toadlets. If road mortality becomes a problem, signage and fencing, and/or a road crossing structure, are all possible mitigation options.

Wetland 9: Wetland 9 is the downstream portion of the large wetland complex at the mouth of the Clowhom River and experiences frequent and unpredictable water level fluctuations as the result of BC Hydro operations (Evelyn et al. 2014). No toads were detected in Wetland 9 this year. Unlike the previous year when water levels were higher, and many suitable breeding sites existed along the shallow vegetated edges of the wetland, this year only shallow pools were present in early May and no larvae were detected. By late June, water levels were considerably higher making it difficult to survey the breeding locations.

Water level fluctuations during breeding season are likely to have a strong influence on Western Toad breeding success in this wetland from year to year. During site visits in 2013 and 2014, water level fluctuations of approximately 10 m were observed. This year, rising water levels flushed the site at least twice during the breeding season, which may have washed the tadpoles away. However, the wetland is very large making detection difficult, particularly when water levels are high, so it is also possible that toads were present and we were unable to locate them.

Wetland 10: Wetland 10 is a small sedge marsh at the edge of Clowhom Reservoir, and like Wetland 9, the site is subject to periods of inundation and drawdown due to BC Hydro operations (Evelyn et al. 2014). There was no evidence of Western Toad breeding at the site this year. In early May 2014, the pool in this wetland was dry and not suitable for breeding. This is likely the reason no breeding was observed even though water levels were higher in late June; water levels would have been too inconsistent for larva to have survived if breeding did occur.

During the 2015-2016 project year, we will continue surveys to search for additional occupied sites and breeding ponds for Western Toads in the Clowhom watershed. We will also monitor breeding activity and water levels at known breeding sites, and evaluate movements of juvenile toads to assess potential road impacts.

Mitigating Threats to Pond- Breeding Amphibians in the Clowhom Watershed

Suitable habitat for pond-breeding amphibians is relatively limited within the Clowhom watershed, and much of the habitat that does exist is less than ideal due to human impacts. The main threats to pond-breeding amphibians in Clowhom include water level fluctuations, impacts from roads and transmission lines, and forest harvesting.

Water Level Fluctuations

One of the most significant threats facing amphibian populations in the watershed is the dramatic and unpredictable variation in water levels due to hydro activity. In wetlands immediately adjacent to the Clowhom Reservoir (Wetlands 9 and 10), rapidly changing water heights are directly impacting Western Toad and Red-legged Frog breeding sites. Both of these locations offer high quality amphibian habitat when water levels are sufficient. However, the frequent water level fluctuations appear to be negatively affecting breeding success.

Water level fluctuations can impact amphibian reproduction and survival in several ways. If water levels are high during egg-laying season, amphibians are able to find suitable sites upon which to attach their egg masses. However, if water levels then drop before the eggs can hatch, the egg masses will become stranded on land and will die.

Alternately, if the water is severely drawn down at the time of egg-laying then there are insufficient attachment points for egg masses, and amphibians are forced to lay in very shallow pools. Such pools are at risk of drying out before amphibian larvae have sufficient time to complete their metamorphosis.

Rapid increases in water levels can wash away egg masses and inundate breeding sites with cold water from the reservoir, impeding development of amphibian larvae. Inundation can also increase predation risks by enabling fish to move into the formerly fish-free areas where amphibians prefer to breed.

It is unknown to what extent water level fluctuations are limiting to amphibian populations in the Clowhom watershed. These impacts likely depend upon the timing, magnitude and speed of shifts in water levels, and may vary from year to year. An analysis of reservoir levels through time is recommended to help determine what impacts water level variations are having on wildlife and their habitat.

To mitigate the problem of water level fluctuations, it may be possible to create stable habitats that will not be subject to the same harmful effects experienced by areas directly connected to the reservoir. Ponds of various sizes could be constructed in areas adjacent to those currently being affected. Ideally, these ponds would be designed to provide a diverse mixture of habitats, which would support the greatest diversity of amphibian and other wildlife species.

This year, to evaluate possible suitable locations for pond creation in the Clowhom watershed, we assessed numerous areas at the landscape scale in order to identify potential enhancement sites with appropriate soils, vegetation cover, and hydrology. We also considered position within the watershed in the context of possible implications for wildlife metapopulations, taking into account dispersal distances and wildlife movement corridors.

During the 2015/2016 project year, we will continue to assess candidate locations at the project scale, to determine if sites possess the specific characteristics that will ensure successful habitat restoration can occur. These characteristics include access, specific soil types, and hydrology, as well as future human impacts and possible implications of climate change. We believe that any increase in the amount and quality of wetland habitats within the watershed will be extremely beneficial for increasing the resilience and stability of amphibian populations, along with populations of other wildlife species.

Forest Harvesting

Timber harvesting is another factor that threatens amphibians in the Clowhom watershed. Most pond-breeding amphibian species spend the majority of the year outside of the water body and thus require suitable upland habitat adjacent to breeding sites in order to maintain viable populations. Many species depend on cool, moist forested upland habitat. Not only does forest harvesting negatively impact upland habitat, but it also can also have detrimental impacts on the hydrology, function, and productivity of wetlands used by amphibians (Richardson 1994). Red-legged Frogs, in particular, require forested landscapes and are negatively affected by clearcut logging (Maxcy 2004).

To aid with the survival of Red-legged Frogs and other pond-breeding species, it is vital to conserve forested areas adjacent to known breeding ponds. Such forests provide the necessary cool, moist microclimatic conditions and essential habitat structural features used by emerging juveniles and foraging adults.

Coarse woody debris, including logs, stumps, and piles of bark, constitutes an essential microhabitat component for amphibians. It provides a cool, moist environment, shelter from predators, and a source of invertebrate prey (Whiles & Grubaugh 1998). At sites where coarse woody debris is limited, we recommend adding logs and pieces of wood, especially large-diameter pieces in various stages of decay, to help improve terrestrial habitat for amphibians (BC Ministry of Environment 2014).

Roads and Transmission Lines

Another threat to amphibians in the Clowhom watershed is the impact of roads and transmission lines. Roads run adjacent to several amphibian breeding sites, and transmission lines cross at least eight wetlands. Potential impacts from roads and transmission lines include road mortality, pollution from road runoff, invasive species introduction, and harm to wildlife during right of way maintenance, brushing, and vegetation removal activities.

Road mortality is a significant issue for amphibians, particularly mass breeding species such as Western Toads (Andrews et al. 2008). At present, the relatively light traffic and low density of migrating amphibians in most areas in the valley means that the impact is likely to be minimal. However, there is one site where mitigation measures may be necessary. At Wetland 7, an important high density Western Toad breeding site is located right next to the road. Thus far we have not documented incidences of mortality of dispersing toadlets on the road. In the 2015/2016 project year, we will continue surveys to try to identify the routes used by dispersing toadlets, to inform any future mitigation measures.

Because transmission lines run over several Clowhom wetlands (including Wetland 7), these sites may be subject to periodic brushing and vegetation removal. This activity may be beneficial or detrimental to amphibians depending on how it is undertaken. If careful hand removal is practiced, clearing may be beneficial to amphibians by maintaining sunny exposures and warm temperatures for larval development. In fact, annual cutting is recommended to prevent vegetation growth from shading wetlands reducing habitat suitability. However these maintenance activities should be timed to avoid critical developmental periods for amphibians. To avoid harming developing amphibians, we recommend that maintenance activities take place before March or later than July in order to avoid time period when developing young amphibians may be present in ponds. In addition, chemical herbicides should be avoided around these sites as they can be acutely toxic to amphibians (Relyea 2005).

Roads and transmission lines also risk bring introduced, invasive and native weedy species to the area. Invasive weeds detected in Clowhom wetlands include Canada Thistle (*Cirsium arvense*), Oxeye Daisy (*Leucanthemum vulgare*), and Himalayan Blackberry (*Rubus armeniacus*). At present they seem to be confined to the gravelly areas at the roadside and around the transmission poles. Further monitoring should be undertaken to track the spread of these species and determine if removal is necessary.

6.4 Coastal Tailed Frogs

The Coastal Tailed Frog (*Ascaphus truei*) is an ancient and unusual species. It is the longest lived frog in North America, with the longest larval period, remaining in tadpole stage for up to 5-7 years. This species is blue-listed in BC, federally assessed as a species of special concern, and classified as 'Identified Wildlife' under the BC Forest and Range Practices Act (Mallory 2004, COSEWIC 2011).

Coastal Tailed Frogs are habitat specialists, living in cool, fast-flowing mountain streams with step-pool morphologies and adjacent mature forest. They reproduce via internal fertilization and females attach eggs to the underside of large rocks or boulders in streams in the summer. Tadpoles have a flattened oral disc that serves as a sucker for clinging to boulders in the fast-flowing water, where they feed by scraping diatoms and algae from rocks. Adult frogs may live for more than 20 years, and rarely venture far from their natal streams. They require cool, moist microclimates and habitats with sufficient structural diversity to provide refuge sites and food. As such, dispersal between streams and drainages is extremely limited.

The combination of a long larval stage, limited dispersal ability and specialized habitat requirements make this species particularly vulnerable to habitat degradation (COSEWIC 2011). Populations can be harmed as a result of human land use activities that remove riparian vegetation and/or alter stream flow, water temperature or turbidity. Key threats to the species include forest harvesting, road building, water intakes and diversions for run-of-river power projects, introductions of non-native fish, and the emerging amphibian disease chytridiomycosis.

Maintaining mature riparian forests is essential to the long term viability of individual populations. Loss of canopy cover through harvest or other activities may benefit the larval stage temporarily due to an increase in primary productivity associated with higher light levels. However, the habitat is typically unsuitable for adult frogs, and these types of habitat modification often result in the reduction or extinction of local populations. In addition, healthy riparian forests stabilize stream banks, limiting in-stream disturbances such as sedimentation and debris flows. Sedimentation is particularly detrimental to the species, as it fills the interstitial spaces in stream substrates required for cover.

We assessed several streams within the watershed using a combination of time-constrained searches and eDNA surveys. Environmental DNA analysis detected Coastal Tailed Frog DNA in all nine streams surveyed, while conventional hand searches resulted in only one detection of eight streams surveyed. This study illustrates that Coastal Tailed Frog occurrences can be effectively detected using eDNA techniques. This method is particularly useful in streams that are difficult to survey using traditional hand surveys, due to high water flows or other constraints. However, eDNA analysis provides no indication of the number of individuals within a sampled stream. The low numbers of Tailed Frogs observed during traditional time-constrained searches suggests that although the extent of occurrences throughout the watershed is quite widespread, the size of populations within each stream is quite variable, and likely small in many instances. Further surveys are required to accurately assess the distribution, size and overall health of the Coastal Tailed Frog population within the watershed.

In the 2015/2016 project year, we will continue to use eDNA surveys and time-constrained hand searches to assess the distribution and abundance of Coastal Tailed Frogs from drainage basins distributed throughout the Clowhom watershed, and to evaluate threats and mitigation opportunities within the basin.

6.5 Water Shrews

At this time, Pacific Water Shrew has not been confirmed present in Clowhom. However, suggestive eDNA results from Wetland 8 provide for the possibility that the species may occur in the watershed. All three of the triplicate samples from this site were originally inhibited and one sample continued to test positive when the samples were re-run.

This result may indicate the presence of Pacific Water Shrew (*Sorex bendirii*), or it may be a false-positive generated by the presence of either Cordilleran Water Shrew (*Sorex navigator*) or Montane (Dusky) Shrew (*Sorex monticulus*) (Dr. Caren Goldberg, pers. comm.). Unfortunately, due to the similarities in the genetic sequence of the Cytochrome b gene of these three species, with the small amount of DNA that was collected, we cannot distinguish between the three species at this time.

During eDNA sampling in August 2014, we collected 250 mL water samples from each wetland, as was the recommended procedure at the time. However, the protocol has since evolved to recommend collection of significantly greater quantities of water (3 L samples) (Caren Goldberg, pers. comm.). There is evidence that higher volume samples collected from known extant Pacific Water Shrew locations can detect the DNA of Pacific Water Shrews when the species is in fact present (Jared Hobbs, pers. comm.); however, the potential for false positives from *S. montiolus* and *S. navigator* still exists.

All eDNA replicate samples from the other four wetlands tested negative for the presence of Pacific Water Shrew. However, negative eDNA results should not be used to conclusively reject the potential for the target taxa to be present at the site (Pilliod et al. 2013). There are several possible reasons for negative eDNA results.

Our samples may have tested negative because low concentrations of eDNA were filtered due to low sample water volumes (as described above). Similarly, if Pacific Water Shrews were present in very low densities, or had discontinuous distributions within the sampled wetlands, this could have resulted in eDNA that was too diffuse to detect at very low concentrations.

Another factor that could have led to negative eDNA results was high water turbidity. High levels of tannins and other suspended particles in the water samples from these wetland sites may have impacted the results at both the filtration and analysis phase. Such compounds can clog the filter membrane, resulting in filtration of less than the desired quality of sample water. During the qPCR analysis, some of these compounds were co-extracted with the DNA and prevented the original amplification of the PCR. Further purification removed the compounds but the sensitivity of the assay was likely compromised for the samples that required this extra processing step.

Finally, samples may have tested negative if no Pacific Water Shrews were present in the wetlands during the period immediately preceding sampling. If no shrews were present during the 21 days prior to sampling, degradation of eDNA would have substantially diminished detection probability.

In order to further investigate the possible presence of Pacific Water Shrew at Wetland 8, along with other Clowhom sites, we will carry out additional eDNA sampling during the 2015/2016 project year. To increase the amount of DNA collected, we will gather larger 3 L water samples. We may also experiment with the use of filter membranes with a larger pore size to filter out compounds such as tannins and suspended particles while still collecting enough DNA for effective amplification and analysis.

6.6 Western Screech-Owls

The coastal subspecies of Western Screech-Owl (*Megascops kennicottii kennicottii*) is federally threatened and provincially blue-listed. These owls have experienced dramatic population declines since the 1990s (Kissling & Lewis 2009, Environment Canada 2011b). They appear to have nearly disappeared from areas of the south coast, including the Vancouver Lower Mainland, Victoria and the Gulf Islands. A rough estimate in the latest COSEWIC Status Report (2012) suggests that the coastal subspecies declined by 20 to 30% in Canada between 1995 and 2010. Numbers are poorly known, but there are estimated to be just 1,500-3,000 individual birds remaining in Canada. Population declines are thought to be related to loss of mature trees required for nesting and roosting, along with newly established populations of Barred Owls, which predate upon the smaller Screech-Owls.

The Clowhom watershed is one of the few places on the Sunshine Coast where the species has been detected in recent years. Western Screech-Owls were relatively common in the region until the mid-1990s when they declined sharply (T. Greenfield, pers. comm.). By 2001, Preston and Campbell failed to detect any Screech-Owls in 156 survey stations (COSEWIC 2012). Prior to our recent detections in Clowhom, there had been only 12 documented sightings of Western Screech-Owls on the Lower Sunshine Coast in the past dozen years, of which the most recent was in 2011 (T. Greenfield, pers. comm.). Over the past two years of conducting call-playback surveys throughout the region, our team has detected Western Screech-Owls only in Clowhom and one other site.

This year, we were able to delineate four Western Screech-Owl territories in the Clowhom watershed. We confirmed breeding pairs in three territories, pinpointed one nest cavity, and documented successful fledging in at least one territory. All four Screech-Owl territories included areas of mixed riparian forest, along with mature coniferous stands. This is consistent with observations from other regions where the subspecies is associated with low elevation, late successional riparian forest, typically including deciduous elements and large diameter cavity-forming trees for nesting (COSEWIC 2012). Such habitat is now extremely limited in Clowhom. The flooding of the lower valley to create the reservoir eliminated 41 hectares of riparian forest (FWCP 2011). Wide scale forest harvesting caused further losses of riparian and mature forest habitat, and removed dead trees and snags that could serve as potential nesting trees. As noted in our riparian mapping and assessment, low elevation riparian habitats that do remain have been disproportionately impacted, and little exists in its natural condition.

Over the past two years, we have detected Barred Owls at five spots in the Clowhom watershed. This species has expanded its range into the BC south coast over the past 50 years. It is now established as a resident breeding species. Barred Owl depredation has been strongly implicated in the decline of Western Screech-Owls (Cannings and Angell 2001, Elliot 2006). The presence of Barred Owls poses a threat to the survival of the species in Clowhom.

Past forest harvesting in the Clowhom watershed has substantially decreased the number of standing dead and dying trees, reducing availability of potential nest trees for Western Screech-Owls along with many other cavity-dependent wildlife species, including squirrels, flying squirrels, woodpeckers and bats. The size of Screech-Owl populations in some regions is believed to be limited by the number of available cavities (Belthoff & Richardson 1990), and the loss of cavity-bearing nest trees has been identified as one of the main causes of Western Screech-Owl population declines in recent years (COSEWIC 2012).

To ensure the survival of Western Screech-Owls in Clowhom, it is essential to maintain remaining areas of low elevation late successional riparian forest, mature coniferous stands, and associated large diameter cavity-forming trees, both within the four identified Screech-Owl territories (see Figure 34 on page 58), and in other areas of the watershed.

As an interim enhancement measure, we have started to supply artificial cavities in the form of man-made Western Screech-Owl nest boxes within the Clowhom watershed. The species has been observed to readily accept nest boxes both for nesting and roosting (Cannings and Angell 2001, COSEWIC 2012). Our nest box additions are not suggested as in any way sufficient to counteract the effects of any further removal of forest habitat used by Western Screech-Owls. However, in areas where there is already an absence of suitable nest trees, the addition of nest boxes may be a worthwhile activity that could potentially help to improve nesting success and recruitment, and increase the viability of the Western Screech-Owl population in Clowhom.

Western Screech-Owls are non-migratory and pairs will occupy and defend territories year-round. During Year 3 of the project, we will continue surveys to monitor occupancy and reproductive status in the four identified territories, characterize habitat associations, search for nest trees, and seek to identify additional territories in other areas of the watershed.

Figure 43: Western Screech-Owl Nesting in Large, Cavity-bearing Maple Tree, 2014

Large cavity-bearing trees, like this Bigleaf Maple nest tree in Kai Territory, are essential to Western Screech-Owl Survival in the Clowhom Watershed

6.7 Northern Goshawks

Our coastal subpopulation of Northern Goshawk (*Accipiter gentilis laingi*) is provincially red-listed, federally threatened, and classified as 'Identified Wildlife' under the BC Forest and Range Practices Act (COSEWIC 2000, Environment Canada 2011a, McClaren 2004, Northern Goshawk Recovery Team 2008). Fewer than 350 pairs are estimated to remain and populations are apparently declining throughout the range (McClaren 2004). This raptor is morphological and behaviourally adapted to hunting within forested habitats, and prefers extensive forests with large stands of mature trees, dense canopies, and an open understory (Environment Canada 2011a). The species is threatened by the loss and fragmentation of nesting and foraging habitat, and related subsequent reductions in prey diversity and availability (COSEIC 2000). The Northern Goshawk Recovery Strategy identifies protection of nest trees and Post-fledging Areas (PFAs) as high priority actions to meet recovery objectives (Northern Goshawk Recovery Team 2008).

We did not detect any Northern Goshawks in the Clowhom watershed this year. Two historic records of the species from the basin (Red Tusk and Clowhom Lake) date back to the 1990s. Extensive and continued clear-cut logging has drastically reduced the area of suitable habitat for these birds in the watershed; however, it is possible that they may yet be present. We will continue Northern Goshawk survey efforts during Year 3 of the project.

6.8 Bats

Bats are essential components of British Columbia's biodiversity. Outdoor enthusiasts need only look up to the sky at sunset to enjoy the aerial acrobatics of bats as they hunt for insects, an activity that contributes greatly to the health of forest and agricultural ecosystems across the province.

Unfortunately, bats are also highly threatened. Half of BC's bat species are officially listed as species at risk (BC Ministry of Environment 2015). Key threats to BC bats include habitat loss and degradation, deliberate or accidental human disturbance, and environmental contamination. Although many species have broad geographic ranges, within their ranges distributions are often patchy, and local populations may be reduced or eliminated as the result of human activity. Many populations are undergoing alarming reductions. With very low reproductive output for a small mammal, typically rearing only one young per year, bats are extremely slow to recover from population declines.

The recent introduction of White Nose Syndrome (WNS) to North America has increased the level of threat. This fungal disease attacks the exposed skin of cave hibernating bats, disrupting blood chemistry, and causing a cascade of physiologic disturbances leading to death (Verant et al. 2014). Although the fungus has not yet arrived in Western Canada, it has already had devastating impacts in eastern and central North America, where it is implicated in the deaths of an estimated six million bats (Frick et al. 2010, Forbes 2012, Sleeman 2013). White Nose Syndrome is moving steadily across the continent, and many experts in the field expect that it will inevitably reach British Columbia sometime in the next 5 to 15 years (Cori Lausen, pers. comm.). Fourteen of BC's 16 bat species hibernate and would therefore be vulnerable to the pathogen.

Due to the imminent threat posed by White Nose Syndrome, the British Columbia Bat Action Team (BCBAT), a group of government and non-government biologists, researchers, veterinarians and naturalists, has prioritized the assessment of current bat populations and identification of important roosting and foraging habitat in the province. This baseline information will allow a more accurate assessment of the overall health of bat populations in BC, and will help enable targeted actions to combat population reductions due to both WNS and habitat loss and modification.

This was our first year surveying bats in the Clowhom watershed. Despite a relatively limited sampling intensity due to equipment failures (since resolved), our initial acoustic and mist net surveys revealed a diverse bat community of at least eight species (Figure 44). Noteworthy observations included Little Brown Bats, Hoary Bats, Long-eared Bats, and the Big Free-tailed Bat.

The Little Brown Bat (*Myotis lucifugus*) was confirmed by acoustic and mist net surveys from various spots in the Clowhom watershed. The Little Brown is one of Canada's most common and widespread bats. However, the arrival of White Nose Syndrome has caused population declines up to 94% from Nova Scotia to Ontario, prompting an emergency listing of the species as endangered under the federal Species at Risk Act (Forbes 2012, COSEWIC 2013). This bat species roosts in rock crevices and caves, as well as in decaying trees. It appears widespread throughout the Clowhom valley and is likely resident year round.

The Hoary Bat (*Lasiurus cinereus*) was detected at two sites in the Clowhom watershed. British Columbia's largest bat, this species had not previously been documented within the Sunshine Coast Regional District. This observation is not entirely surprising, however, as there has been very limited bat species inventory effort in the region.

Three acoustic recordings were made of a long-eared bat species, either Long-eared Myotis (*Myotis evotis)* or Keen's Long-eared Myotis (*Myotis keennii*). These species are very closely related genetically and acoustically indistinguishable. Both are adapted for foraging in closed forest environments, where they glean invertebrates from vegetation and capture insects in flight. Keen's Long-eared Myotis is blue-listed in BC and threatened by loss of mature forests (COSEWIC 2003). It is the only bat currently listed as 'Identified Wildlife' under the BC Forest and Range Practices Act (Chatwin 2004).

The most surprising discovery was several recordings of a species whose acoustic signature did not match any species expected in BC. Following extensive consultation with experts in bat acoustic identification (Cori Lausen, Wildlife Conservation Society; Chris Corbin, designer of Anabat detector and Analook software), these recordings have been positively identified as the Big Free-tailed Bat (*Nyctinomops macrotus*) (Lausen 2015). This species was previously only documented in BC from a single specimen collected near Vancouver in 1938 (C. Lausen, pers. comm.). It may be an accidental vagrant from elsewhere in North America. During the 2015/2016 project year, we will intensify our search in the area where the bat was recorded to determine if there are any resident bats of this species.

Aside from any potential future impacts from White Nose Syndrome, threats to bats in the Clowhom valley are largely limited to habitat loss and modification. All of the species observed in the watershed use dead and decaying trees as roosts. These wildlife trees are limited in areas that have been harvested, as most of them are knocked down because they pose safety hazards to foresters. Hoary Bats and Silver-haired Bats are two obligate tree-roosting species that roost exclusively in large trees. Suitable roost trees for these species include large Cottonwoods, along with large diameter Douglas-firs possessing thick bark in which the bats can shelter. Such roosting habitat is limited to mature forests, which are rare in the watershed.

All bat species in British Columbia can only drink while in flight. Appropriate water sources must be relatively calm; moving water creates ultrasonic noise which interferes with a bat's echolocation ability. Bats also require open approach and exit flyways. This is particularly important for larger, less manoeuvrable bat species. As noted in other areas in this report, there are a limited number of small wetlands and ponds within the Clowhom valley. This increases the importance of those that do exist. Care should be taken to ensure that these pools are not negatively impacted by human activity. In particular, when brushing along roads and under transmission lines, it is important to make sure woody debris is moved to maintain open flyways in and out of pools.

Hoary Bat

Yuma Myotis

Little Brown Bat

Long-eared Myotis

Big Brown Bat

California Myotis

Silver-haired Bat

Big Free-tailed Bat

Figure 44: At Least Eight Bat Species were Detected in Clowhom in 2014

6.9 Other Species at Risk

Through the course of our targeted wildlife surveys, we have encountered numerous other species, including fish, amphibians, reptiles, birds and mammals. Over the past two years, we have documented 118 vertebrate species in the Clowhom basin (please see Table 23 on page 74 for the full species list). They include 14 provincially listed species at risk (11 of these, federally listed as well) (Table 24). For some species these records are particularly significant; Clowhom watershed is currently home to the only known breeding site for Western Toads and the only identified Western Screech-Owl nesting area on the Lower Sunshine Coast. These findings emphasize the importance of the watershed to the survival of threatened wildlife in coastal British Columbia.

Table 24: Vertebrate Species at Risk Documented in the Clowhom Watershed, 2013 and 2014

Common Name	Scientific Name	COSEWIC Listing	BC Listing	BC Conservation Framework Priority
Coastal Cutthroat Trout	*Oncorhynchus clarkii clarkii*		Blue	2
Coastal Tailed Frog	*Ascaphus truei*	Special Concern	Blue	1
Northern Red-legged Frog	*Rana aurora*	Special Concern	Blue	1
Western Toad	*Anaxyrus boreas*	Special Concern	Blue	2
Sooty Grouse	*Dendragapus fuliginosus*		Blue	2
Great Blue Heron	*Ardea herodias fannini*	Special Concern	Blue	1
Peregrine Falcon	*Falco peregrinus pealei*	Special Concern	Blue	1
Band-tailed Pigeon	*Patagioenas fasciata*	Special Concern	Blue	2
Western Screech-Owl	*Megascops kennicottii kennicottii*	Threatened	Blue	1
Black Swift	*Cypseloides niger*	Endangered	Blue	2
Olive-sided Flycatcher	*Contopus cooperi*	Threatened	Blue	2
Barn Swallow	*Hirundo rustica*	Threatened	Blue	2
Little Brown Bat	*Myotis lucifugus*	Endangered	Yellow	2
Roosevelt Elk	*Cervus elaphus roosevelti*		Blue	2

6.10 Planned Activities for Year 3 of this Project

This is a multi-year project. During Year 3 (2015-2016) we will build on our findings and expand our survey efforts, to include the following activities:

Wetland and Riparian Classification and Mapping

- Continue to identify, classify, delineate, assess, map and monitor wetlands and riparian habitat in the Clowhom watershed

Species at Risk Surveys

- **Pond-breeding Amphibians**: Continue egg mass, auditory and live trapping surveys; Use eDNA surveys to search for additional Red-legged Frog and Western Toad breeding ponds.
- **Western Screech-Owls**: Continue call-playback surveys, nest searches and habitat assessment.
- **Northern Goshawks**: Continue call-playback surveys, nest searches and habitat assessment.
- **Coastal Tailed Frogs**: Continue hand searches and eDNA surveys in suitable creeks.
- **Pacific Water Shrews**: Conduct further eDNA surveys at Wetland 8 (site of partial positive eDNA result in 2014) along with other locations in the watershed
- **Bats**: Continue acoustic and mist net surveys; Search for potential hibernation caves.

Multi-species Restoration and Enhancement Planning and Action

- Continue to prioritize sites for habitat protection, restoration, enhancement and threat mitigation
- Continue to work with partners, including government, Recovery Teams, experts and stakeholders to develop detailed multi-species restoration and management plans
- Work with partners to implement the recommended restoration and management activities. Priority actions for Year 3 include: increasing coarse woody debris, mitigating road impact, removing invasive plants, planting riparian vegetation and installing bat houses and owl nest boxes
- Undertake detailed planning for creation of a series of new wetland ponds, unaffected by water level fluctuations caused by hydro activities.

Public Education and Engagement

- Landowner outreach and stewardship agreements; Distribution of stewardship guides.
- Work with community members to build, install and monitor bat houses, swallow boxes, and owl nest boxes.
- Give presentations; Meet with First Nations, government, industry and conservation partners

7.0 SUMMARY RECOMMENDATIONS

A key goal of this project is to develop, implement, monitor and adaptively manage multi-species restoration and enhancement plans. This is an ongoing activity over the duration of this project, as we add more information, conduct further assessments, document species at risk, and evaluate sites and threats. The tables below summarize key recommendations to maintain and improve wildlife habitat and mitigate threats in the Clowhom watershed, summarized on a site-specific, species-specific, and threat-related basis (Tables 25-27). The issues are presented in detail in the Discussion section of this report.

Table 25: Species-Specific Management Recommendations for 5 Key Species at Risk in Clowhom

Species	Enhancement / Mitigation Recommendations
Western Screech-Owl	• Protect remaining areas of low elevation late successional mixed riparian forest and mature coniferous forest within occupied territories • Maintain large diameter cavity-bearing trees and snags to provide sufficient nesting and roosting opportunities • Install owl nest boxes to increase available nesting opportunities • Minimize disturbance to known roost and nest sites
Little Brown Bat	• Maintain and recruit large-diameter snags in middle stages of decay at a variety of elevations near water bodies to provide roosting sites for bats • Maintain open water with clear flyways into and out of waterbodies to provide access for drinking bats • Install bat houses to increase roosting opportunities
Coastal Tailed Frog	• Maintain forested riparian buffers • Maintain habitat structural features including coarse woody debris • Maintain sufficient water flow in occupied Tailed Frog streams • Maintain water quality characteristics of occupied streams, including temperature and clarity • Do not use pesticides near occupied streams • Maximize connectivity of riparian habitats • Minimize creation of new roads and stream crossings • Prevent fish introductions

Table 25 (continued): Species-Specific Management Recommendations for 5 Key Species at Risk in Clowhom

Species	Enhancement / Mitigation Recommendations
Red-legged Frog	• Maintain habitat quality at known breeding sites, including structural integrity of emergent vegetation to provide egg-laying sites and rearing habitat for developing tadpoles • Maintain important habitat features including coarse woody debris and understory vegetation surrounding wetlands • Maintain forest cover adjacent to breeding sites to provide suitable microclimatic conditions for emerging juveniles and foraging adults • Where transmission lines exist near wetlands, avoid carrying out right of way maintenance during breeding season from March to July • Avoid using chemical herbicides near wetlands • Monitor road impacts and, if necessary, take action to prevent road mortality • Maintain a network of suitable wetlands in close proximity, especially small, fish-free wetlands with high structural diversity of vegetation and surrounding forest that will maintain water until the end of August • Create new fish-free wetland ponds to provide stable habitats that will not be subject to the same deleterious effects experienced by areas directly connected to the reservoir
Western Toad	• Maintain habitat quality at known breeding sites, including structural integrity of emergent vegetation to provide egg-laying sites and rearing habitat for developing tadpoles • Maintain forest cover adjacent to breeding sites to provide suitable microclimatic conditions for emerging juveniles and foraging adults • Maintain important habitat features including coarse woody debris and understory vegetation surrounding wetlands • Monitor road impacts and, if necessary, take action to prevent road mortality • Avoid carrying out transmission line maintenance during breeding season from April to July • Avoid using chemical herbicides near wetlands • Create new wetland ponds to provide stable habitats that will not be subject to the same deleterious effects experienced by areas directly connected to the reservoir

Table 26: Site-Specific Management Recommendations for 15 Clowhom Wetlands

Wetland Number	Location	UTM *Datum: NAD 83* *UTM Zone: 10U*		Enhancement / Mitigation Recommendations
		Easting	Northing	
1-3	Off Clowhom Mainline km 24	470635	5520703	manage water levels; increase coarse woody debris; mitigate road impacts; plant riparian vegetation
4	Off Clowhom Mainline km 20	471600	5517949	mitigate road impacts
5	Off Clowhom Mainline km 20	471485	5517732	no restoration needed
6	Off Clowhom Mainline km 18.5	471516	5516185	maintain nearby old growth riparian forest; mitigate road mortality for migrating amphibians
7	Off Clowhom Mainline km 17	470474	5514951	mitigate road mortality; investigate toad road crossing structure; monitor invasive species; take care when clearing brush under transmission line (hand removal), avoid chemical herbicides
8	North part of large wetland complex, end of the reservoir	469222	5514238	monitor invasive weeds (remove if spread); maintain culverts; monitor human use does not exceed current levels; investigate establishment of Wildlife Management Area
9	Main part of large wetland complex, end of the reservoir	469300	5513850	water level management through sensitive timing of hydro operations; investigate excavation of deep pools nearby that will hold water during drawdown; investigate establishment of Wildlife Management Area
10	Small bay at north end of Clowhom Reservoir, km 13.5	468522	5512698	water level management through sensitive timing of hydro operations
11	Bear Creek Mainline km 3.5	461334	5514003	control invasive species; mitigate road effects; plant riparian vegetation
12	Bear Creek Mainline km 3.5	460969	5513977	consider planting riparian vegetation and providing large woody debris with smaller branches
13	Bear Creek Mainline km 6	459354	5515182	monitor road impacts
14	Off Clowhom Mainline km 2	460796	5506688	remove invasive plants; monitor water quality
15	Nagy FSR, 300 m from Clowhom Reservoir	461573	5510449	monitor invasive species; take care when clearing brush under transmission line; avoid chemical herbicides; monitor water levels

Table 27: Threat-Related Management Recommendations for the Clowhom Watershed

Threat	Enhancement / Mitigation Recommendations
Hydro Operations	• Conduct analysis of reservoir levels through time to assess impacts of water level fluctuations on breeding amphibians and other wildlife, and to enable development of management recommendations related to timing, frequency and duration of inundation of specific elevations. • Practice responsible water level management through sensitive timing of hydro operations. • Develop a detailed plan to restore wetland habitats by excavating a series of deep pools that will be unaffected by reservoir water levels, adjacent to the wetlands currently being affected. • Microhydro operations should follow sound practices to ensure sufficient water flow and maintain appropriate water quality and temperature in occupied Tailed Frog streams.
Roads and Transmission Lines	• Monitor road mortality, and if necessary, mitigate through fencing, signage and/or road crossing structures • Avoid clearing right-of-ways during amphibian breeding season between March to August • Monitor invasive and introduced plants and control if they become a problem • Take care when clearing brush in wetlands under transmission lines to avoid harming amphibians and their habitat • Avoid using chemical herbicides, pesticides or other chemical applications near wetlands and riparian zones • Monitor water quality in wetlands adjacent to roads • Where necessary, undertake roadside planting of native vegetation to prevent pollution due to road runoff
Forest Harvesting	• Ensure that future forest harvesting decisions seek to conserve and maintain habitat values for wildlife species at risk around important breeding, hibernating, nesting and foraging sites, and within identified occupied territories • Maintain remaining areas of mixed riparian forest and mature forest patches in occupied Screech-Owl territories • Maintain forested riparian buffers around occupied Tailed Frog creeks • Maintain and recruit snags and cavity-bearing wildlife trees • Maintain and restore woody debris as shelter for amphibians • Add nest boxes and bat houses to increase nesting/roosting habitat for owls and bats

8.0 ACKNOWLEDGEMENTS

Our deep appreciation to the shíshálh Nation for allowing us access to their lands and for providing letters of support for the project.

We gratefully acknowledge the 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 and the public. Thanks to FWCP staff, including Lorraine Ens, Patrice Rother, and Trevor Oussoren, for their guidance and logistical support. Additional funding for this project came from Environment Canada's Habitat Stewardship Program, Canada Summer Jobs, Gencon Foundation, Public Conservation Assistance Fund, and the Province of BC. The Ruby Lake Lagoon Nature Reserve Society and BC Conservation Foundation (BCCF) provided administrative services for some of our grants. Special thanks to Lagoon Society Chair, Dr. Michael Jackson and to BCCF's Executive Director Deborah Gibson and Project Coordinator Katie Calon.

We are very grateful to Regional Power and Bear Hydro LP for generously assisting with boat transportation, accommodation and use of their truck in Clowhom. Thanks especially to Babar Khan, James Florance, and David Carter. Our heartfelt appreciation to Veresen Incorporated and Clowhom Power LP for another year of in kind contributions that went above and beyond, including numerous boat rides, nights of accommodation, and use of their vehicle. Special thanks to Robert Kulka, William McDonagh, Kyle Edwards, Kyle Saylor, and Luke Till.

We are thankful for support and guidance from numerous BC Ministry of Forests, Lands and Natural Resource Operations and BC Ministry of Environment staff members, including Kym Welstead, Myke Chutter, Ian Blackburn, Joshua Malt, Helen Schwantje, Leah Ramsay, Scott Barrett, Darryl Reynolds, and Purnima Govindarajulu. We appreciate the experts who have shared freely of their knowledge and advice, including Dave Bates and Tony Greenfield for sharing knowledge of the Clowhom watershed, Erica McClaren for advice on Northern Goshawks, Cori Lausen for training in bat acoustic survey techniques, and Jared Hobbs for guidance about survey methodology for Western Screech-Owls and other species at risk.

We were blessed with an exceptional project team. Aimee Mitchell and Chris Currie provided outstanding leadership and professionalism. Summer students Kaiden Bosch and Rowan McEwen worked with tireless enthusiasm in the field. Susan Dulc assisted with Western Screech-Owl surveys, and Erin Rutherford helped with bat mist net surveys. Special thanks to Lou Drumond, Mike Ough and Rick O'Neill for helping to build beautiful owl and bat houses and construction kits, and to Lee-Ann Ennis for leading school and community outreach activities. The first-class graphic design talents of Maya Birkel helped make our interpretive signs and outreach materials look lovely.

Jared Hobbs and Elizabeth Vincer from Hemmera Envirochem Inc. introduced us to the joys of environmental DNA surveys and assisted with all aspects of the eDNA work, including methodology, collection of samples in the field, and data analysis. Development of the eDNA primer for Pacific Water Shrew was accomplished by Dr. Caren Goldberg at the School of Environment at Washington State University with support from our organization, Hemmera Envirochem Inc., and the BC Ministry of Forests, Lands and Natural Resource Operations. Caren Goldberg conducted all eDNA laboratory analyses.

We appreciate all of the wonderful Sunshine Coast community members, school classes and local organizations who assisted with wildlife habitat enhancement efforts this year. Thank you to the Sunshine Coast Regional District and Town of Gibsons for supporting wildlife conservation and habitat enhancement efforts on the Sunshine Coast.

Almost all photos in this document were taken by Aimee Mitchell, Chris Currie, Dave Stiles and Michelle Evelyn. The few exceptions, provide courtesy of Creative Commons licences, are on page 88: Hoary Bat (Daniel Neal), Yuma Myotis (Daniel Neal), Little Brown Bat (Batworlds.com), Long-eared Myotis (Merlin Tuttle), Big Brown Bat (Continis), California Myotis (Frank Carey), Silver-haired Bat (Merlin Turtle), Big Free-tailed Bat (US Bureau of Land Management).

9.0 REFERENCES

Andrews KM, Gibbons JW, Jochimsen DM (2008) Ecological effects of roads on amphibians and reptiles: a literature review." Herpetological Conservation 3: 121-143.

Austin MA, Buffett DA, Nicolson DJ, Scudder GGE, Stevens V (eds.) (2008) Taking Nature's Pulse: The Status of Biodiversity in British Columbia. Biodiversity BC, Victoria, BC. 268 pp.

Bates DJ (2008) Clowhom Lake Water Use Plan – Clowhom Lake wildlife census – Year 2. Resource Management Department, shíshálh Nation, Sechelt, BC.

Bates DJ (2007) Clowhom Lake Water Use Plan – Clowhom Lake wildlife census – Year 1. Resource Management Department, shíshálh Nation, Sechelt, BC.

Bates DJ, Ferguson G (2010) Clowhom Lake Water Use Plan – Clowhom Lake wildlife census – Year 4. Resource Management Department, shíshálh Nation, Sechelt, BC.

Bates DJ, Staats M, Ferguson G (2009) Clowhom Lake Water Use Plan – Clowhom Lake wildlife census – Year 3. Resource Management Department, shíshálh Nation, Sechelt, BC.

Bates DJ, Ferguson G, Coombes O (2011) Clowhom Lake Water Use Plan - Clowhom Lake Wildlife Census– Wildlife Rotation 2 – Year 1. Resource Management Department, shíshálh Nation, Sechelt, BC.

Belthoff JR, Ritchison G (1990) Nest-site selection by Eastern Screech-Owls in central Kentucky. Condor 92: 982-990.

BC Ministry of Environment (2014) Guidelines for Amphibian and Reptile Conservation during Urban and Rural Land Development in British Columbia (2014). A companion document to Develop with Care 2012: Environmental Guidelines for Urban and Rural Land Development in British Columbia.

BC Ministry of Environment (2008) Interim Hygiene Protocols for Amphibian field staff and researchers. Ecosystems Branch, Ministry of Environment.

BC Ministry of Environment and Ministry of Forest, Lands and Natural Resource Operations (2012) Standard Operating Procedures for Minimizing White Nose Syndrome Transmission. Decontamination SOPs for working around bats and bat habitats

BC Ministry of Environment (2015) BC Species and Ecosystem Explorer. Available at: http://a100.gov.bc.ca/pub/eswp/.

BC Ministry of Forests and Range & BC Ministry of Environment (2010) Field Manual for Describing Terrestrial Ecosystems, 2nd Edition. Land Management Handbook #25.

Cannings RJ, Angell T (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.

Chatwin, TA (2004) Accounts and Measures for Managing Identified Wildlife – Accounts V.2004. Keen's Long-eared Myotis *Myotis keenii*. Biodiversity Branch, Identified Wildlife Management Strategy, Victoria, B.C.

Cornell Lab of Ornithology Nestwatch Program (2013) Nest Box Construction Plans: American Kestrel, Screech Owl, and Northern Saw-whet Owl.

COSEWIC (2000) COSEWIC assessment and update status report on the Northern Goshawk *laingi* subspecies *Accipiter gentilis laingi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 36 pp.

COSEWIC (2002a) COSEWIC assessment and status report on the red-legged frog *Rana aurora*. Committee on the Status of Endangered Wildlife in Canada. Ottawa**.**

COSEWIC (2002b) COSEWIC assessment and status report on the western toad *Bufo boreas* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

COSEWIC (2003) COSEWIC assessment and update status report on Keen's long-eared bat *Myotis keenii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

COSEWIC (2011) COSEWIC Assessment and Status Report on the Coastal Tailed Frog *Ascaphus truei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

COSEWIC (2012) COSEWIC assessment and status report on the Western Screech-Owl *kennicottii* subspecies *Megascops kennicottii kennicottii* and the Western Screech-Owl *macfarlanei* subspecies *Megascops kennicottii macfarlanei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

COSEWIC (2013) COSEWIC assessment and status report on the Little Brown Myotis *Myotis lucifugus*, Northern Myotis *Myotis septentrionalis,* Tri-colored Bat *Perimyotis subflavus* in Canada – 2013. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

Dupuis L, Friele P (2003) Watershed-level protection and management measures for the maintenance of *Ascaphus truei* populations in the Skeena Region. British Columbia Ministry of Water, Land and Air Protection, Smithers, BC.

Elliott K (2006) Declining numbers of Western Screech-Owl in the lower mainland of British Columbia. British Columbia Birds 14: 2-11.

Environment Canada (2005) Sensitive Ecosystems Inventory of the Sunshine Coast and Adjacent Islands.

Environment Canada (2011a) Status of Birds in Canada – 2011. Northern Goshawk.

Environment Canada (2011b) Status of Birds in Canada – 2011. Western Screech-Owl *kennicottii* subspecies.

Evelyn, MJ, Stiles DA, Currie C, Mitchell A (2014) Surveys of Species at Risk and their Associated Habitats in the Clowhom Watershed – Year 1. FWCP Project No. 13.W.COM.01. Final Report - July 2014

Ferguson G, Bates DJ, Coombes O (2012) Clowhom Project Water Use Plan - Monitor of Aquatic Wildlife in Wetland affected by Dam Operations Implementation Year 6. Reference: COMMON-1 Year 2 – Rotation 2: Clowhom Lake Wildlife Census Study Period: April 1, 2011 to March 31, 2012. Resource Management Department, shíshálh Nation, Sechelt, BC.

Ficetola GF, Miaud C, Pompanon F, Taberlet P (2008) Species detection using environmental DNA from water samples. Biology Letters 4: 423–425.

Fish and Wildlife Compensation Program (2011) Clowhom Watershed – Watershed Plan.

Forbes, G (2012) Technical Summary and Supporting Information for an Emergency Assessment of the Little Brown Myotis *Myotis lucifugus*. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

Frick, WF, Pollock JW, Hicks AC, Langwig KE, Reynolds DS, Turner GG, Butchkoski CM, Kunz TH (2010) Collapse of a Common North American Bat Species - An Emerging Disease Causes Regional Population. Science 329, 679-682.

Goldberg CS, Pilliod DS, Arkle RS, Waits LP (2011) Molecular detection of cryptic vertebrates in stream water: a demonstration using Rocky Mountain tailed frogs and Idaho giant salamanders. PLoS One 6:e22746.

Goldberg C, Strickler K (2013) eDNA protocol sample collection with cellulose nitrate filters. University of Idaho.

Green RN, Klinka K (1994) A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region. Land Management Handbook #28, BC Ministry of Forests.

Gregory SV, Swanson FJ, McKee, WA, Cummins, KW (1991) An ecosystem perspective of riparian zones. BioScience 41: 540-551.

Hausleitner D (2006) Inventory Methods for Owl Surveys. Standards for Components of British Columbia's Biodiversity No.42. Prepared for Ecosystems Branch of the Ministry of Environment for the Resources Information Standards Committee. Victoria, B.C.

Hope AG, Panter N, Cook JA, Talbot SL, Nagorsen DW (2014) Multilocus phylogeography and systematic revision of North American water shrews (genus: *Sorex*). Journal of Mammalogy 95:722–738.

IUCN (2014) The IUCN Red List of Threatened Species. Version 2014.1. http://www.iucnredlist.org

Kaufman K (2002) A Little Night Magic". In Audubon Magazine January-February 2002.

Kissling ML, Lewis SB (2009) Distribution, abundance and ecology of forest owls in Southeast Alaska. U.S. Fish and Wildlife Service, Juneau Field Office, Alaska, and Alaska Department of Fish and Game, Division of Wildlife Conservation, Douglas, Alaska.

Lausen, C. (2015) Three Bat Species to be on the Lookout for in BC. Western Canada Bat Network Newsletter, Issue No. 26 Spring / Summer 2015

MacKenzie WH, Moran JR (2004) Wetlands of British Columbia: A guide to identification. Land Management Handbook #52, BC Ministry of Forests.

Mahon T, McClaren EL, Doyle FI (2008) Parameterization of the Northern Goshawk (*Accipiter gentilis laingi*) Habitat Model for Coastal British Columbia. Nesting and Foraging Habitat Suitability Models and Territory Analysis Model. Northern Goshawk Recovery Team.

Maxcy KA (2004) Accounts and Measures for Managing Identified Wildlife – Accounts V.2004 Red-legged Frog *Rana aurora aurora*. Biodiversity Branch, Identified Wildlife Management Strategy, Victoria.

McClaren E (2004) Accounts and Measures for Managing Identified Wildlife – Accounts V.2004 "Queen Charlotte" Goshawk *Accipiter gentilis laingi* Biodiversity Branch, Identified Wildlife Management Strategy, Victoria, B.C.

.

Mallory A (2004) Accounts and Measures for Managing Identified Wildlife – Accounts V.2004 Coastal Tailed Frog *Ascaphus truei*. Biodiversity Branch, Identified Wildlife Management Strategy, Victoria, B.C.

Naiman RJ, Décamps H, McClain ME (2010) Riparia: ecology, conservation, and management of streamside communities. Academic Press.

Naiman RJ, Décamps H. (1997) The ecology of interfaces: riparian zones. Annual Review of Ecology and Systematics, 28: 621-658.

Northern Goshawk *Accipiter gentilis laingi* Recovery Team (2008) Recovery Strategy for the Northern Goshawk, laingi subspecies (*Accipiter gentilis laingi*) in British Columbia. BC Ministry of Environment.

Olson DH, Leonard WP, Bury RB (1997) Sampling Amphibians in Lentic Habitats: Methods and Approaches for the Pacific Northwest. Northwest Fauna Number 4. Society for Northwestern Vertebrate Biology, Olympia, WA.

Pang BC, Cheung BKK (2007) One-step generation of degraded DNA by UV irradiation. Analytical Biochemistry 360: 163–165.

Pilliod D, Goldberg C, Laramie M, Waits LP (2013) Application of environmental DNA for inventory and monitoring of aquatic species: U.S. Geological Survey Fact Sheet 2012-3146.

Relyea RA (2005) The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities. Ecological Applications 15: 618–627.

Resource Information Standards Committee (1998a) Inventory Methods for Bats. Standards for Components of British Columbia's Biodiversity No. 20. Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Committee. March 13, 1998, Version 2.0.

Resource Information Standards Committee (1998b) Inventory Methods for Pond-breeding Amphibians and Painted Turtle. BC Ministry of Environment, Ecosystems Branch. Published by the Terrestrial Ecosystems Task Force Resources Information Standards Committee, Victoria, B.C.

Resource Information Standards Committee (2000) Inventory Methods for Tailed Frog and Pacific Giant Salamander. Standards for Components of British Columbia's Biodiversity No. 39. Prepared by Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Committee. March 13, 2000. Version 2.0.

Resource Information Standards Committee (2001) Standard methodologies for the inventory of biodiversity in British Columbia: Raptors. Version 2.0. BC Ministry of Sustainable Resource Management, Victoria, B.C.

Richardson CJ (1994) Ecological functions and human values in wetlands: a framework for assessing forestry impacts. Wetlands 14: 1–9.

Sleeman J (2013) White-Nose Syndrome Updates. USGS, National Wildlife Health Center. Wildlife Health Bulletin 2013-04. 2pp

Thomsen PF, Kielgast J, Iversen LL, Wiuf C, Rasmussen M, Gilbert MT, Orlando L, Willerslev, E (2012) Monitoring endangered freshwater biodiversity using environmental DNA Molecular Ecology 21(11): 2565-2573.

Trombulak SC, Frissell CA (2000). Review of ecological effects of roads on terrestrial and aquatic communities. Conservation biology, 14(1), 18-30.

Tori GM, McLeod S, McKnight K, Moorman T, Reid FA (2002) Wetland conservation and Ducks Unlimited: Real world approaches to multispecies management. Waterbirds 25: 115-121.

Verant ML, Meteyer CU, Speakman JR, Cryan PM, Lorch JM, Blehert DS (2014) White-nose syndrome initiates a cascade of physiologic disturbances in the hibernating bat host. BMC Physiology 2014, 14:1

Vonhof M (2006) Handbook of Inventory Methods and Standard Protocols for Surveying Bats in Alberta. December 2006. Alberta Fish and Wildlife Division. Edmonton, Alberta.

Whiles MR, Grubaugh JW (1996) Importance of coarse woody debris to southern forest herpetofauna. Biodiversity and coarse woody debris in southern forests. USDA Forest Service, Asheville, NC, 94-100.

Wake, DB (2012) Facing extinction in real time. Science 335, 1052.