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Student Research Report

Birds on UBC's Campus

A Mixed-Method Approach to Prioritize Bird Species and Assess Habitat Needs to Inform Policy & Campus Design

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A Mixed-Method Approach to Prioritize Bird Species and Assess Habitat Needs to Inform Policy & Campus Design

RES 510 Social Ecological System
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Executive Summary

Human-driven phenomena like land-use change and climate change currently threaten 15% of bird species with extinction, with many more expected to be affected in the coming decades. UBC Vancouver (UBCV) is situated within an area of critical importance to many bird species, the Fraser River Delta. The delta is a prominent stopover on the Pacific Flyway, a major migration route for birds. We find that 121 species of birds have been documented on UBC Vancouver's campus since 2000. Yet, UBC Vancouver's campus represents a heavily built environment, and the university plans to continue its rapid development. While the university has made many commitments to bird-friendliness in recent years, this development represents a threat to existing bird populations on campus. For this reason, we sought to provide our clients with recommendations to enhance UBC's campus to better support ten selected bird species that occur on UBCV's campus. We developed a novel scoring metric to prioritize birds for habitat enhancements on UBCV's campus using an iterative, mixed-methods approach. We drew on ecological data (e.g., conservation status, occurrences), a survey of UBC students values regarding bird conservation and habitat restoration, expert opinions, and the practical capabilities and limitations of our clients to make habitat recommendations for our top ten species of high conservation opportunity. The prioritized bird species represent a range of functional types, from primary consumers to insectivores, and habitat recommendations include specific planting recommendations for food and habitat, as well as providing human-mediated shelters (e.g., bird-houses, building modifications), to further support these species on campus.

1. Introduction

Human-driven phenomena like land-use change and climate change are driving unprecedented rates of biodiversity loss (Dirzo et al., 2014; Pimm et al. 2014; Rosenberg et al., 2019; Urban, 2015). Left unabated, this loss will lead to declines in critical ecosystem functions and services on which humans and all life on Earth depend (Gorenflo and Brandon 2006, Hooper et al. 2012, Rosenberg et al. 2019). Birds, among the best-monitored class of vertebrates, exemplify the effects of global change on wildlife (McClure et al. 2012). Globally, around 10,052 bird species persist, over 15% of which are classified as Critically Endangered, Endangered, or Vulnerable (IUCN 2021). Since 1970, habitat loss due to changes in land use and the warming climate, among other stressors, directly contributed to the loss of 2.9 billion birds in North America (Rosenberg et al. 2019). This number is projected to climb in the coming decades: at least 1 in 7 bird species will likely become extinct in the next 80 years (Dayer et al. 2020, IUCN 2021, Sekercioglu et al. 2004).

In Vancouver, Canada, around 260 species of resident and migratory birds are regularly sighted because of the city's proximity to the Fraser River Delta, a major stopover along the Pacific Flyway extending from South America to Alaska (Schaefer 2004) (see Figure A1 in Appendix). The delta is traversed by over a billion birds each year as its temperate climate and rich habitats support Canada's largest over-wintering population of birds (Harrison and Dunn 2004). Birds provide critical ecosystem services including seed dispersal, pest control, pollination, and intangible services such as a sense of connection with nature or spiritual and cultural significance (Dayer et al. 2020, Echeverri et al. 2021, Karp

et al. 2018, Mainwaring 2017). However, Canada's aerial insectivore, shorebird, and grassland bird populations declined by 40-60% since 1970 (NABCI Canada et al. 2019). The decline in bird diversity and abundance has greatly reduced the numerous evolutionary, ecological, economic, and social benefits these birds provide to their environment (Bauer and Hoye 2014, Gaston and Fuller 2008, Hooper et al. 2012, Whelan et al. 2015). The challenges facing bird populations pose an array of obstacles in bird conservation efforts. Urbanization, the introduction and prevalence of invasive plant species, predation and disturbance by domestic pets, and building collisions are just a few of the many threats affecting birds in Vancouver and around the world (City of Vancouver 2020).

Given that the global human population continues to grow and natural landscapes - particularly key biodiversity hotspots - are being replaced by built environments (Seto et al. 2012, Aronson et al. 2014), the future outlook of bird populations is increasingly dependent on the restoration of vegetation within urban landscapes and the pro-environmental actions of people (Dayer et al. 2020). With 20% of bird species worldwide occurring in urban settings, sustainable urban planning and conservation necessitate a better understanding of the global trends of urban species composition (Aronson et al. 2014). Moreover, since ecological outcomes are often intimately linked to human behaviors, it is important to understand how socio-economic and cultural factors indirectly drive changes to biodiversity (Mascia et al. 2003).

Situated along the Pacific Flyway, our study site (Figure 1) - the Vancouver campus of the University of British Columbia (UBCV) - is of critical geographic importance. Recognizing the challenges facing birds and the importance of bird abundance and diversity, UBCV has taken notable steps in enhancing its bird-friendliness through design strategies such as green facades, fritted glass and paintings on windows to limit collisions (University of British Columbia 2019). While these strategies mark a significant first step towards informing campus policy and decision-making, UBCV campus design and policy does not currently consider the unique needs of individual bird species. Past student-led SEEDS Sustainability Program bird projects primarily approached the goal of bird-friendly campus policies from the perspective of preventing bird collisions by modeling the frequency of bird collisions and specific species' susceptibility to collisions on campus (De Groot et al. 2021). While this information is useful for informing bird-friendly building guidelines, it has limited applicability to other aspects of the campus design (e.g., landscape). It is therefore the wish of our client Dean Gregory (UBCV Landscape Architect - Building Operations) that we examine how the landscape of UBCV provides more than visual appeal by providing birds with habitat and foraging support, and how this functionality can be improved. Particularly, Dean is interested in having us fill the knowledge gap by providing species-level habitat and planting guidelines for high priority species at UBCV through thoughtful and intentional analysis.

Our project consists of both quantitative and qualitative methods. Social-ecological systems research is critiqued for not adequately considering social theory, which is argued as being integral for effective policy creation and decision-making (Cote and Nightingale 2012). Further, Nightingale (2003) discusses how coupling quantitative data, which provides context, with qualitative data, which enhances and explores nuance, can make research more substantial and robust. Therefore, we aim to use both quantitative and qualitative methods to develop more informed and comprehensive recommendations of

priority species and associated habitats for our clients and stakeholders in the project, Penny Martyn (UBCV Green Building Manager) and Dean Gregory (D. Gregory and P. Martyn, personal communication, Oct. 28, 2021). We ask two research questions: (1) Which species occurring on UBC Vancouver campus are a. with the greatest conservation opportunities and b. highly valued by the UBCV community? (2) How can UBCV honor these species' habitat and foraging needs through changes to landscape design and plant selection? We aim to take into consideration the species' conservation status, the cultural value they hold to members of the UBCV community, and their conservation opportunities (Moon et al 2004). It is known that birds possess cultural significance and by engaging with the UBCV community, we hope to add nuance to our determination of bird importance by taking cultural and relational values into account (Tidemann and Gosler 2011, Echeverri et al. 2021). This could lead to campus planting guidelines that provide needed support to vulnerable birds and also strengthen the connection of community members to birds on campus. We will use an iterative approach by (1) surveying UBCV students and birders; (2) coupling survey responses with information on bird species population ecology to inform the construction of a list of high priority bird species on campus; (3) modifying this list based on communications with experts; (4) conducting a literature review to provide actionable, species-specific recommendations concerning planting design, ecosystem structure, and indigeneity to support priority bird species, and disseminating research results to campus stakeholders.

2. Methods

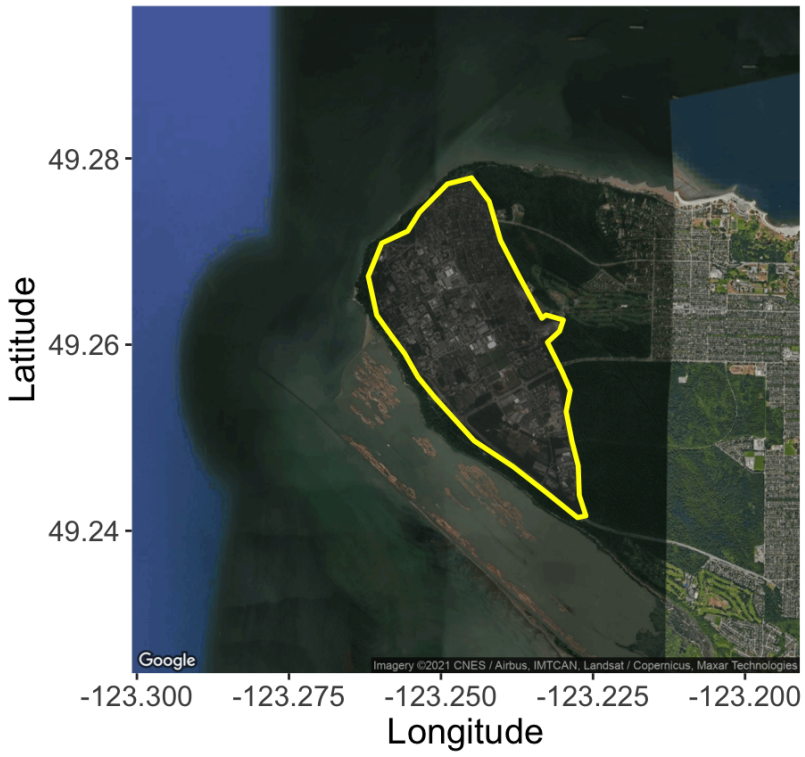

Figure 1. Map of the study area, UBC Vancouver, defined by the yellow polygon.

We used an iterative, mixed-methods approach to prioritize bird species for conservation and management efforts on UBC's Vancouver campus and make landscape design recommendations for those species. This approach included (1) a student survey evaluating the importance of aspects of species' endangerment, frequency of encounters, and contribution to ecosystem service categories in prioritizing species for conservation, (2) communicating with experts about a feasible approach to conservation prioritization, (3) creating multiple lists of bird species' occurring on campus which include different components of species' endangerment, sighting frequency, position in the food web, and adjusting the weights of these components based on survey feedback, and finally 4) reviewing the literature for habitat requirements of species in our list to make recommendations of feasible, actionable modifications to UBC's Vancouver campus which would support these species. We describe each of these components in the subsections below.

2.1. Student Survey on Bird Species' Prioritization for Conservation

We developed a survey using UBC's Survey Tool, Qualtrics, to understand the extent of students' knowledge, engagement and values of birds and their habitats on UBC's Vancouver campus. The survey was distributed to graduate and undergraduate student groups, including the Master of Land and Water Systems program via email, Faculty of Land and Food Systems and Faculty of Forestry via emailed newsletters, and Graduate Student Community as a forum post.

Our survey was anonymous and included 17 questions, plus a question requiring consent to participate. Questions 1 to 6 included questions about the participants, while questions 7 to 9 related to their knowledge about birds and their habitats. Those who self-reported as 'birders' (defined as those with experience observing birds), were given an opportunity to provide their email for follow-up and feedback. Questions 10 and 11 focused on engagement, and 12 to 15 on values. The value questions in particular were designed to enhance our understanding of the relative values of birds and their habitats to participants, in addition to any ecosystem services they may offer (Klain et al. 2014, Gould et al. 2015, Chan et al. 2016). Question 13 was explicitly used to affirm and modify our prioritization approach by asking participants to place factors relevant to conservation prioritization (e.g., local conservation status, global conservation status, and frequency of occurrence) in order of importance, wherein they created their own prioritization scheme. Lastly, questions 16 and 17 were open-ended narrative prompts that provided participants an opportunity to share context and perspectives that were not addressed in previous questions.

2.2. Prioritizing Bird Species on UBC's Vancouver Campus

We created multiple priority bird species lists for conservation and rewilding efforts on UBC's Vancouver campus by iterating through scoring systems. We used the statistical computing software, R, to perform all of the following data operations and calculations, including importing, cleaning, and formatting data, and making subsequent prioritization score calculations (R Core Team 2021). First, we obtained bird species occurrences on UBC Vancouver's campus from the Global Biodiversity Information Facility (GBIF) (GBIF.org 2021). We filtered GBIF's database to only include birds (Order *Aves*), and subsequently drew a polygon around UBC's Vancouver campus (Fig. 1), defined to be bounded by Pacific

Spirit Park to the east, SW Marine Drive to the south and west, and NW Marine Drive to the north and west, to exclude observations outside of our study area. We lastly filtered to exclude species observed before the year 2000, pelagic-feeding (feeding far from shore) species, and those with less than five observations to make our list relevant to contemporary conditions and exclude potentially erroneous sightings. Next, we obtained Provincial and Global Conservation Status from the BC Species and Ecosystem Explorer, which uses NatureServe status definitions, for all species in our filtered list (B.C. Conservation Data Centre 2021). Lastly, we obtained categorical definitions of each species' diet from the Elton Birds database (Wilman et al. 2014). We used these data to populate the variables in all prioritization score calculations.

Our first scoring system only included conservation status and frequency of occurrence, and appears as follows:

1. $S = Status_{Global} + Status_{Provincial} + f_{occurrence}$

where $Status_{Global}$ equals Global Conservation Status and $Status_{Provincial}$ equals Conservation Status in British Columbia, both as assessed by NatureServe (B.C. Conservation Data Center 2021). Regarding global conservation status, species in our list were either considered demonstrably widespread, abundant, and secure (G5) and received 0 points, or apparently secure (G4) and received 0.25 points. No species in our dataset had a ranking of vulnerable to extinction (G3, 0.5 points), imperiled with extinction (G2, 0.75 points), or critically imperiled (G3, 1 point). Regarding local conservation status, species spanned five levels of vulnerability and received scores accordingly: critically imperiled (S1, 1 point), imperiled (S2, 0.75 points), special concern (S3, 0.5 points), apparently secure (S4, 0.25), and demonstrably widespread, abundant, and secure (S5, 0 points). $f_{occurrence}$ is the frequency of occurrence or $\frac{1}{Occurrence}$, where occurrence equals the number of times a species with greater than five observations was recorded in the GBIF database within our study area since the year 2000 (GBIF.org 2021).

Next, we created a scoring system where each variables' weight was modified by survey responses. The equation is written as follows:

2. $S = \alpha\left(Status_{Global}\right) + \beta\left(Status_{Provincial}\right) + \gamma\left(f_{occurrence}\right)$

where α, β, and γ are constants calculated as $\alpha = \frac{a}{b}$ where a is the mean of all possible positions in the ranked list (i.e., 4.5 in a list of 1 to 8) and b is the mean position of our focal variable across all survey responses. Data to inform this calculation came from Q13 of our student survey (detailed in Methods Section 2.1). From survey responses, α = 2.01, β = 2.03, and γ = 0.98. In other words, Global Conservation Status and Provincial Conservation Status scores were multiplied by approximately two, and the frequency of occurrence score was multiplied by approximately one. This resulted in each status score having approximately twice the weight it held in our first scoring system, whereas the frequency of occurrence's weight remained the same.

Third, we created another scoring system that incorporated trophic structure, or a species' position in the food web as determined by diet, as recommended by an expert in creating conservation prioritization (A. Echeverri, personal communication, Nov. 24, 2021). That equation is written as follows:

3. $$S = \alpha\left(Status_{Global}\right) + \beta\left(Status_{Provincial}\right) + \gamma\left(f_{occurrence}\right) + T$$

where T is a categorical description of trophic level obtained from the Elton Birds database on biological characteristics of birds which make up their "Eltonian" niches - functional traits regarding diet, body size, etc. (Wilman et al. 2014). Following the Elton Birds categories, a species scored a 1 if they primarily (>50%) feed upon vertebrates, fish, and/or detritus, 0.66 if they primarily feed on invertebrates, 0.33 if they are omnivorous (maximum for any single category is less than 50%), and 0 if they are primary consumers (primarily feed on plants, seeds, fruits, and/or nectar).

This final scoring system ("Scoring System 3") was used to generate a list of species for conservation, restoration, and rewilding prioritization on UBC's Vancouver campus. Species that received the ten highest scores in Scoring System 3 were included in this list (Table 1).

2.3 Literature Review for Habitat Requirements

2.3.1 Information for Species-Specific Habitat

In order to assess the needs of bird species occurring in our prioritized list, we reviewed available literature for information concerning their general habitat needs, food sources, nesting site requirements and migration behaviors. It was important to first determine what portion of the year migratory species reside in the Vancouver area, as their habitat requirements change according to whether they are in their breeding (summer) or non-breeding (winter) season. Birds present at UBCV during their breeding season require nesting and foraging sites, and birds present on campus during their non-breeding season require foraging and roosting sites. Birds may also migrate through the Vancouver area, requiring habitat to suit specific migration needs.

2.3.2 Information for Campus Planting and Modification

We also had to determine which bird species could benefit from actionable recommendations for habitat support on campus. Our SEEDS partners are limited in what changes they can make to the existing campus landscape, and these limitations had to be factored into our recommendations. For instance, bird species that require large lakes for foraging and nesting sites most likely could not be accommodated on campus. Similarly, species that require forest habitat may find nearby Pacific Spirit Park suitable for their needs, but could not be accommodated by changes made to the campus proper. Gathered habitat information, therefore, had to be considered against limitations, and only species that could benefit from campus habitat accommodations were further considered. We chose to recommend support for the top two to four species from each trophic level (i.e., dietary category) whose habitat and life history needs could be met through existing habitat or feasible changes to UBC Vancouver's campus landscape. In other words, we selected species with existing and potential conservation opportunities

(Moon et al. 2014). Once ten species were selected for which actionable recommendations were possible, further information was gathered concerning the habitat benefit of specific plant species native to the Vancouver area, as well as more general habitat needs that could be met through broader recommendations for campus landscape management.

2.3.3 Sources of Information

The majority of information gathered in order to determine birds' basic habitat needs and filter out species for which campus support is infeasible came from the Cornell University Lab of Ornithology's "All About Birds'' web database (available at: https://www.allaboutbirds.org/guide). Each entry for specific bird species described in this database is supported with citation of peer-reviewed studies and bird guide books. We pulled information concerning indigeneous plants that could be used to support bird species from the "Grow Green'' guide (available at: http://www.growgreenguide.ca/plants), which was created in partnership with the UBCV Botanical Garden, as well as a few other native BC plant sources.

3. Results

3.1 Student Survey on Bird Species' Prioritization for Conservation

Participants

A total of 75 currently-enrolled students (96% full-time, 4% part-time) participated in our survey, representing 8 different faculties and a variety of programs (see Figures A2 and Table A1 in Appendix). We found there was a diversity of programs represented within the faculties, many of which weren't directly related to environmental science. We noted that there was interest in birds and their habits, despite not being in a program directly related to them.

Participants reported their type of program, whether they were a domestic or international student, whether they lived on campus or not, and how often they were on campus on average (see Figure A3 in Appendix). Survey respondents were mostly graduates (55%), including Master's and Doctoral students. Also, domestic students made up the majority (58%), as did those living off-campus (59%). Despite the majority living off-campus, most students reported spending over 24 hours per week on campus on average this semester (53%).

Knowledge

Students were asked to self-report to what extent they do or do not consider themselves a 'birder'. As shown in Figure A4 in Appendix, most do not consider themselves a birder, but are interested in birds (59%). Those who selected "other" noted their appreciation for animals in general but not specifically birds. Of the 'birders' (29%), 11 respondents provided their email and 1 responded with feedback that they didn't feel they had enough knowledge to make recommendations about

prioritization. Further, the 'birders' reported Google, YouTube, other birders, friends, family, books, online university courses, and apps as resources used to gain knowledge about birds.

We asked to what extent participants were knowledgeable about birds and their habitats separately. As shown in Figures A5 and A6, respondents mostly felt slightly knowledgeable about birds and not knowledgeable at all about their habitats. Few (4%, rounded) felt very knowledgeable about birds, despite 29% having considered themselves 'birders' with experience observing them. Furthermore, nobody reported feeling extremely knowledgeable about birds nor their habitats.

Engagement

When asked to select the types of interactions students have with birds on campus, most selected "I observe birds for enjoyment" (see Figure A7 in Appendix). Of the reported interactions, most of them (54%, rounded) do not happen often, which we defined as less than 3 times a week (see Figure A8 in Appendix).

Values

When asked to rank to what extent different value factors were important to them in relation to each other, environmental value was most often ranked 1st, followed by cultural value (see Figure A9 in Appendix). Examples were given for each value and this particular question, while all value questions were framed by stating "if you were to choose species to protect for future generations". Economic value and a bird that is aesthetically pleasing were ranked nearly equally as 3rd and 4th relative to the previously mentioned values.

When we asked participants to rank conservation factors specific to our prioritization on average, 'globally threatened', 'locally threatened', and 'native' species were ranked as more important (Figure 2). Since all species in our prioritization were native species already, infrequently encountered was the next most important factor that was used for our prioritization.

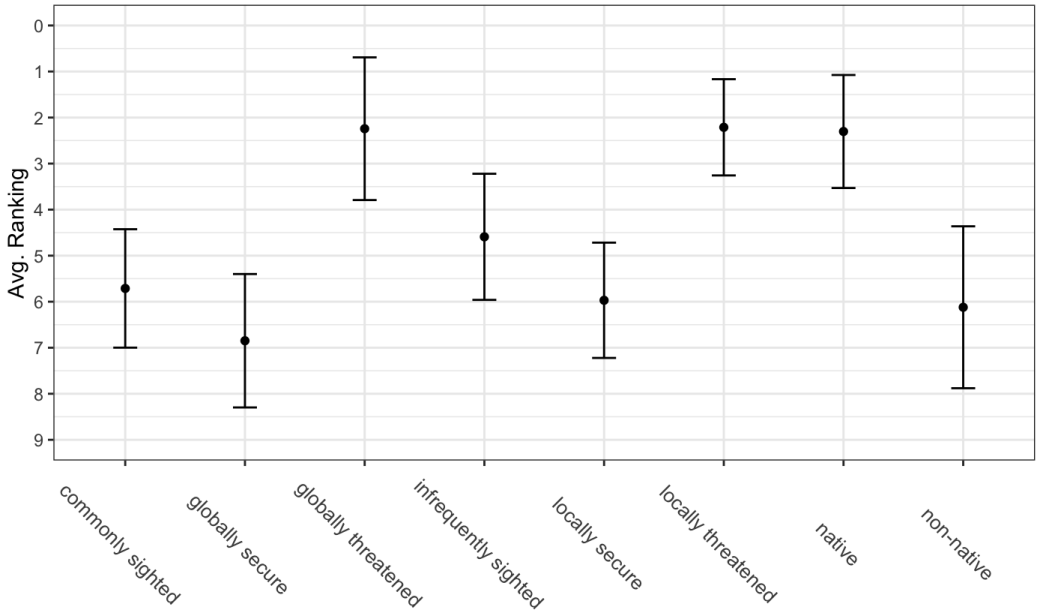

Figure 2. Mean and standard deviation of students' rankings of conservation factors (from Survey Question 13).

We then asked participants to select only 3 of 12 of all previously mentioned options (i.e., values and conservation factors in the previous two questions). Environmental value remained the most reported of all options, followed by locally threatened and cultural value. Furthermore, we asked to what extent they agreed with the statement "I would prioritize a bird that may cause problems to other species if they had factors that are important to me" (see Figure A10 in Appendix). Of those that selected an option that was not "neither agree nor disagree", most were on the side of disagreement and the majority selected "somewhat disagree".

Open-Ended Questions

We did not methodologically code the open-ended responses, but made note of the comments and locations of particular importance to them. We grouped the locations and created a map representing how frequently they were mentioned (see Figure 3). Pacific Spirit Regional Park and UBCV's Rose Garden were mentioned most often, followed by the Forest Sciences Center, Wreck Beach, Nitobe Garden and select libraries (Irving K. Barber, Koerner). Additionally, students generally reported interest in the following:

- Learning more about birds on campus, their habitats, and human impacts to the latter
- Birds in relation to other things in the environment (e.g., fighting, feeding)
- Cultural importance to local Indigenous Peoples (including local First Nations) and the need for environmental projects to include consultation and traditional knowledge
- Reducing bird strikes
- Planting more native plants than ornamentals
- Supporting more birds and creating more habitats for them on campus

Figure 3. Map displaying the total number of mentions of "important campus locations" from survey participants. Data from survey question 16.

3.2 Prioritization Scores

The species with the highest ten prioritization scores appear in Table 1. These scores range from 3.52 to 1.95. The Western Grebe (*Aechmophorus occidentalis*) received the highest score, as this species is critically imperiled at the provincial level, is rarely observed on campus, and is a predator. However, the Western Grebe is a primarily aquatic bird that requires large freshwater bodies, and is therefore likely to be sighted only as a transient species on UBC's Vancouver campus (Ehrlich et al. 1988, Sibley 2014, Sauer et al. 2017). The second highest score, the Peregrine Falcon (*Falco peregrinus*) is vulnerable to extirpation at the provincial level, globally secure, observed somewhat infrequently, and is a predator. Again, this species is likely only transiently observed on campus, as it requires cliffs to nest and spends much of its time feeding on shorelines (like those adjacent to campus) (Ehrlich et al. 1988, Sibley 2014, Sauer et al. 2017). The Olive-sided Flycatcher (*Contopus cooperi*) received the third highest score, as it is vulnerable to extirpation at the provincial level, globally secure, an insectivore, and is only observed infrequently. This species may have its full habitat and life history requirements met on campus, as it nests in coniferous trees and feeds on insects, typically in meadows or grassy areas (Ehrlich et al. 1988, Sibley 2014, Sauer et al. 2017).

Table 1. Top ten species for prioritization as a result of Scoring System 3.

Rank	Common Name	Scientific Name	Score
1	Western Grebe	*Aechmophorus occidentalis*	3.52
2	Peregrine Falcon	*Falco peregrinus*	2.67
3	Olive-sided Flycatcher	*Contopus cooperi*	2.45
4	Black Swift	*Cypseloides niger*	2.33
5	California Gull	*Larus californicus*	2.30
6	Purple Martin	*Progne subis*	2.05
7	Double-crested Cormorant	*Phalacrocorax auritus*	2.05
8	Great Blue Heron	*Ardea herodias*	2.04
9	Cliff Swallow	*Petrochelidon pyrrhonota*	1.99
10	Turkey Vulture	*Cathartes aura*	1.95

Table 2 contains species with clear conservation opportunities at UBCV that appear in our prioritized list. Part of the reason the Table 2 list differs from the list presented in Table 1 is that that list prioritizes species of higher trophic level, while the Table 2 list deliberately includes species of lower trophic levels, represented by dietary categories (herbivores, omnivores, and invertebrate-eaters).

Predatory species, such as the Peregrine Falcon, are excluded from this list due to the limitations determining the scope of changes that can be made to the campus landscape, namely the fact that planting of specific plants is more useful to support small, herbivore and omnivore species. It should be noted, however, that directly supporting smaller bird species may indirectly support larger predatory birds that feed on smaller birds. Species such as the Western Grebe were also removed from this list, as their habitat and life history needs (large lakes that contain fish) could not presently be met at UBCV, and are extraordinarily unlikely to be met in the future. Many of the omnivore species prioritized by Scoring System 3 fall into this category, such as the California Gull and Double-breasted Cormorant, which is why some of the scores of birds selected for Table 2 list are noticeably low.

Table 2. Top ten species for prioritization as a result of Scoring System 3 after filtering for feasible changes to UBC's Vancouver campus and to include three species from each dietary category.

Rank	Common Name	Scientific Name	Score	Diet Category
1	Olive-sided Flycatcher	*Contopus cooperi*	2.45	Invertebrate
2	Purple Martin	*Progne subis*	2.05	Invertebrate
3	Cliff Swallow	*Hirundo rustica*	1.98	Invertebrate
4	Western Meadowlark	*Sturnella neglecta*	1.82	Omnivore
5	Band-tailed Pigeon	*Patagioenas fasciata*	1.61	Herbivore
6	Common Redpoll	*Acanthis flammea*	1.49	Herbivore
7	Mourning Dove	*Zenaida macroura*	1.12	Herbivore
8	Rufous Hummingbird	*Selasphorus rufus*	1.02	Herbivore
9	Townsend's Solitaire	*Myadestes townsendi*	0.41	Omnivore
10	Lincoln's Sparrow	*Melospiza lincolnii*	0.37	Omnivore

3.3 Species-Specific Recommendations

Actionable, species-specific recommendations are listed in Table 3. We included recommendations that would support the general habitat, feeding, or nesting needs of our final top ten species, and could feasibly be carried out on campus based on current and projected limitations. The needs of some bird species could not be translated into actionable recommendations across all three categories. For instance, the Band-tailed Pigeon generally requires forests for roosting and nesting, but will travel outside of this habitat in order to feed on berries, acorns, and pine nuts (see Tables A2-A11 in the Appendix for more complete species-specific habitat information). Therefore, recommendations could be made for planting native berry bushes on campus to provide food source for Band-tailed

Pigeons, while more general habitat recommendations could not be made, as it is not feasible to create forest habitat on campus. The same is true for the Common Redpoll and Townsend's Solitaire. In the opposite vein, some species have adapted to urbanized habitats, and are already having their general habitat needs met by campus landscapes and infrastructure. For those species (e.g., Mourning Dove and Rufous Hummingbird), suggestions were made for providing specific food sources and nesting conditions.

All of the actions associated with recommendations fall into one or more of the following three categories: new planting of native plant species on campus, supporting of existing native plant species on campus, or minor additions to campus landscape and infrastructure. The latter category would include actions like installing small birdhouses for nesting sites, encouraging cliff swallow nesting by deliberately designing/modifying window ledges or roof overhangs to suit their needs, or putting up bird feeders containing certain seeds. Recommendations for new plantings were determined under the assumption that these plantings would be done in relatively small areas, such as building perimeters or borders along walkways. Native plant species listed for these recommendations are fairly small and limited in their vertical growth in order to allow for planting near buildings and paths. Suggestions for habitat creation or maintenance (mainly meadows) was considered feasible based on the current existence of these habitats on campus (e.g., adjacent to the Beaty Biodiversity and Frederic Lasserre buildings).

Table 3. Actionable recommendations for the top ten bird species for prioritization with clear conservation opportunities on UBCV campus. Recommendations fall into three categories, recommendations for providing habitat, food sources, and nesting requirements, with actionable recommendations taking the form of planting specific species on campus, supporting specific species that already exist on campus, or making minor infrastructure changes to landscapes and existing or planned buildings (e.g., adding birdhouses and feeders). Not all bird species had actionable opportunities for conservation across all three categories (represented with n/a). See sources cited below table.

Species	General Habitat	Feeding	Nesting
Olive-sided flycatcher *Contopus cooperi*	Open meadows with native grasses[1]: e.g., plant Western Wheatgrass (*Pascopyrum smithii*), Green Needlegrass (*Nassella viridula*), Blue Grama (*Bouteloua gracilis*), and Sagebrush (*Artemisia tridentata*)	Provide habitat for a diversity of insects, upon which this species feeds[2]: e.g., plant Showy Milkweed (*Asclepias speciosa*) to attract butterflies and moths.	Nest in coniferous trees trees[2]: e.g., support Sitka Spruce (*Picea sitchensis*), Western Redcedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziesii*), Ponderosa Pine (*Pinus ponderosa*), Western Hemlock (*Tsuga heterophylla*) on campus
Purple Martin	n/a	Provide habitat for a diversity of	Nest in small cavities[2]: e.g.,

Progne subis		insects, upon which this species feeds[2]: e.g., plant Showy Milkweed (*Asclepias speciosa*) to attract butterflies and moths.	provide small bird houses around campus (may also make use of sides of buildings, downed trees, etc.)
Cliff Swallow *Petrochelidon pyrrhonota*	n/a	n/a	Nest on the side of buildings under horizontal overhangs[2]: e.g., could provide this infrastructure under window ledges or roof overhangs on new and existing buildings
Western Meadowlark *Sturnella neglecta*	Open meadows with native grasses[1]: e.g., plant Western Wheatgrass (*Pascopyrum smithii*), green needlegrass (*Nassella viridula*), blue grama (*Bouteloua gracilis*) and sagebrush (*Artemisia tridentata*).	Will eat from feeders[2]: e.g., eats cracked corn, millet and black-oil sunflower seeds in feeders.	n/a
Band-tailed Pigeon *Patagioenas fasciata*	n/a	Feeds on berry bushes[3]: e.g., plant Black Elderberry (*Sambucus nigra*), Chokecherry (*Prunus virginiana*), Red Huckleberry (*Vaccinium parvifolium*), Salmonberry (*Rubus spectabilis*) and Trailing Blackberry (*Rubus ursinus*); Feeds on acorns[2]: e.g., support Garry oak (*Quercus garryana*) on campus; Feeds on pine nuts[2]: e.g., support ponderosa pine (*Pinus ponderosa*), and western white pine (*Pinus monticola*) on campus	n/a
Common Redpoll *Acanthis flammea*	n/a	Feeds on birch seeds[2]: e.g., support Paper Birch (*Betula papyrifera*) on campus	n/a
Mourning Dove *Zenaida macroura*	n/a	Feeds on seeds from wild grasses[1]: e.g., plant Western Wheatgrass (*Pascopyrum smithii*), Green Needlegrass (*Nassella viridula*), and Blue Grama (*Bouteloua gracilis*); Will eat from feeders[2]: e.g, eats cracked corn, millet and black-oil sunflower	Nests in crotches of trees[2]: e.g., put “nesting cones” (wide-based, fabric cones) in forks of trees, or hang empty baskets from trees

		seeds in feeders.	
Rufous Hummingbird *Selasphorus rufus*	n/a	Brightly colored, tubular flowers[3]: e.g., plant Red Columbine (*Aquilegia formosa*), Red Flowering Currant (*Ribes sanguineum*), Snowberry (*Symphoricarpos albus*), and Indian paintbrush (*Castilleja spp.*)	Nest in coniferous and hardwood trees[2]: e.g., support Sitka spruce (*Picea sitchensis*), Western Redcedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziesii*), Ponderosa Pine (*Pinus ponderosa*), western hemlock (*Tsuga heterophylla*), paper birch (*Betula papyrifera*), bigleaf maple (*Acer macrophyllum*) on campus
Townsend's Solitaire *Myadestes townsendi*	n/a	Feeds on seeds and berries [2,3]: e.g., plant/support Rocky Mountain Juniper (*Juniperus scopulorum*), Winterberry (*Ilex verticillata*), Buckthorn (*Rhamnus* spp.), Currant (*Ribes* spp.), Shadbush (*Amelanchier* spp.), hackberry (*Celtis occidentalis*), and elderberry (*Sambucus* spp.).	n/a
Lincoln's Sparrow *Melospiza lincolnii*	Meadows with native grasses[1]: e.g., plant Western wheatgrass (*Pascopyrum smithii*), green needlegrass (*Nassella viridula*), blue grama (*Bouteloua gracilis*) and sagebrush (*Artemisia tridentata*) and dense patches of trees[2]: e.g., support Red Alder (*Alnus rubra*), willow (*Salix* spp.), Bigtooth Aspen (*Populus grandidentata*), Black Cottonwood (*Populus trichocarpa*), and Soft Rush (*Juncus effusus*) on campus.	Will eat from feeders[2]: e.g., eats cracked corn, millet and black-oil sunflower seeds in feeders.	Nest in thick covering of plants [2,3]: e.g., plant Buttercup (*Ranunculus bulbosus*) and Sedge Grass (*Carex* spp.)

1. Albertson, F. W. 1937. "Ecology of Mixed Prairie in West Central Kansas". *Ecological Monographs. 7* (4): 481-547.
2. The Cornell Lab. 2021. All About Birds (https://www.allaboutbirds.org/)
3. . 2017. GrowGreen. (http://www.growgreenguide.ca/plants)

4. Discussion

UBC's Vancouver campus is rapidly developing, with plans to densify through new housing developments, shops, and other amenities. Yet, the University has several initiatives in place to support biodiversity (many specifically citing birds) and further plans to expand and improve these initiatives in the future (University of British Columbia 2019, 2020). These plans are clearly at odds, as existing habitats will be disturbed or destroyed in the process of construction and species will be displaced. Our clients, therefore, sought recommendations for changes or improvements to campus that might further support bird populations within existing or newly created spaces on campus, even making use of small vegetated areas on the perimeter of buildings, or the buildings themselves. To address this objective, we used an iterative, mixed-methods approach, in which we considered both ecological data, UBC student's values and opinions, and the limitations of our clients to produce a list of priority bird species on campus and make habitat recommendations for these species.

We attempted to triangulate our approach to prioritization, results, and conclusions by using mixed methodologies including ecological data collected by citizen scientists and government agencies, survey responses from UBCV students, and the direction of experts and our clients (Nightingale 2003). First, we corroborated our assumptions about the directionality (e.g., should rarity contribute to or detract from a species' score?) and importance of conservation components included in our scoring systems (provincial and global conservation status and frequency of occurrence) with findings from our student survey. Next, we appealed to two experts in conservation prioritization and SES thinking (Drs. A. Echeverri and K.M.A. Chan) for direction in what should be included in our metric. Lastly, we considered the desires of our clients and the potential for them to act on our recommendations.

We centered our thinking about potential actions and impact on the concepts of existing and potential "conservation opportunity" (Moon et al. 2014). Existing conservation opportunity is defined by Moon et al. to mean that "everything is in place for conservation action (i.e., no barriers exist) and an actor takes advantage of the existing circumstances to solve problems." Whereas, Moon et al. define potential conservation opportunity to mean that "actors remove barriers to problem solving by identifying the capabilities within the system that can be manipulated to create support for conservation action." Thus, we made our recommendations relevant to existing and potential conservation opportunity, but we will speak to a third category, "traction conservation opportunity" (i.e., "actors identify windows of opportunity that arise from exogenous shocks, events, or changes that remove barriers to solving problems'') in our consideration of future work and the potential for transformation in the way that UBCV's campus is planned and designed.

Our methodological capabilities and time constraints forced us to make a number of assumptions, depend on others' biased or subjective assessments, and forgo the consideration of many relevant system components. Given time constraints and limitations to our approach (e.g., BREB restrictions to survey participants, access to data), we did not receive input from all interested and affected human groups (e.g., indigenous peoples, local people, UBC professors and post-docs, etc.). Moreover, the bird observations we obtained from GBIF have a known bias towards over-representation of societally promoted species - citizen scientists are biased observers who often opportunistically record species of interest, gravitating towards more charismatic species and away from the mundane (Troudet et al. 2017). We were also dependent on government assessments of provincial and global conservation

status which consider a limited set of criteria including population trends and range size, but do not consider habitat quality, vulnerability to human activity and disturbance, resilience, and other relevant factors (Anions and NatureServe Canada 2006). Lastly, our consideration of trophic structure utilized low-resolution categorical definitions of diet, which does not reflect true positionality within a food web.

Our recommendations reflect habitat recommendations for the top ten species resulting from a single approach to prioritization and a small group of scientists and decision-makers. They reflect the desires of our clients, opinions of a small number (n = 75) of UBC students from certain faculties (mainly Forestry), and two experts' opinions, in addition to the thoughts and opinions of the authors of this report. Prioritization is an inherently subjective task, and could greatly benefit from a more diverse group of decision-makers (Prell et al. 2009) and adaptive co-management approaches (Armitage et al. 2009). For example, the species that we prioritize do not represent the views of Musqueam people, even though UBCV's campus is situated on their ancestral, unceded territory. Several students shared in the open-ended section of our survey that they interpreted cultural value as value to Indigenous Peoples specifically. They also recommended consultation with the Musqueam First Nation to consider traditional knowledge. While we were unable to engage with Musqueam First Nation in this project due to ethical restrictions, we were told by our clients that there is high-level engagement regarding decision-making on campus (D. Gregory and P. Martyn, personal communication, Oct. 28, 2021). Thus, we see an opportunity to develop guidelines to protect culturally valuable species and develop habitats as recommended by Musqueam First Nation. An adaptive co-management approach might bring together a diverse group of Musqueam people, UBC students, staff, and faculty, those that live on or frequently visit UBCV's campus, and other stakeholder groups to monitor and research, make decisions, and reassess and learn from previous research and decisions to continually adapt to the changing conditions.

We could also benefit from a more inclusive, systems-thinking approach, drawing on Actor-network Theory, for example, to consider the many actants, interactions, and multiple scales of interactions not directly considered in this report (Dwiartama and Rosin 2014). For example, birds on UBCV's campus exist within a complex adaptive system, competing with other birds and mammals for food and space, entering and leaving the campus throughout their existence for food, nesting, migrations, and other parts of their life-history, interacting with the built environment, and feeding on garbage, supporting larger populations of species that can make use of this resource and displacing species that cannot. Many species seasonally migrate and depend on resources thousands of kilometers away. To fully support these species would require efforts at much larger scales. Additionally, our survey results concerning the types of interactions students had with birds highlighted that most interactions are for enjoyment, but whether these interactions are intentional or not was not explicitly asked in the survey. This differentiation may affect functionality and success of curating bird-friendly habitats if human activity may negatively, or positively, interfere.

Lastly, our prioritization could have benefited from a number of additional considerations. For example, our survey participants indicated that a species' contribution to ecosystem services (Daily 1997, IPBES 2019) (e.g., a bird's ability to control agricultural pests by feeding on them, to pollinate a plant, or provide spiritual or cultural significance) was the most important aspect in prioritizing species of those listed in our survey. Thus, an explicit consideration of ecosystem services that birds provide (birds' contributions to people) and keystone or umbrella species would have better reflected the importance

of each species to the ecosystem and their value to humans. Additionally, a spatial analysis of habitat suitability and an understanding of the percentage of suitable habitat that UBCV represents to a species would have better represented the local importance and existence of species. Reflecting human values and other social factors were a challenge in our project. Yet, as evidenced by our survey, values play a large role in how people may prioritize species. In this study, we did not code and analyze all open-ended survey responses and see an opportunity for more research in terms of place-based and cultural values within the campus context. Also, the open-ended responses revealed interest in learning more about birds, their habitats, and the cultural importance of native species to local peoples. The most frequently mentioned locations on campus that were important to surveyed students were Pacific Spirit Regional Park and UBCV's Rose Garden, both of which are not modifiable to our clients as they have strict restrictions (D. Gregory and P. Martyn, personal communication, Oct. 28, 2021), whereas the other reported locations may be modifiable to some extent (e.g., Main Mall, Totem Park, etc.). All locations could be relevant to our clients should they wish to prioritize bird-friendly habitats in areas valued by students, and perhaps create educational opportunities (e.g., signage, bird-watching, etc.).

5. Conclusions

Our project sought to prioritize bird species present on the UBCV campus to inform landscape and infrastructure modifications using a mixed-methods approach. We produced a list of ten priority species and made a number of recommendations for possible changes to the landscape and built environment on campus to support species' general habitat, feeding, and nesting needs. However, this process brought to light the impacts of including diverse perspectives and the presence of subjectivity in defining the importance, or value, of a species. Whether value is defined using cultural, environmental, or economic metrics will change the outcome of a prioritization analysis, and the perspectives included in the defining process will determine the weight of any single metric. There are an infinite number of ways to prioritize species for conservation, restoration, and rewilding efforts. All of these involve an element of subjectivity, and therefore, the values of affected and interested groups should be thoroughly represented and influence the prioritization scheme. This notion lends further support to employing adaptive co-management or other co-governance approaches in order to allow all relevant groups to play a role in decision-making, learning, and reassessment. In addition, expectations and assumptions concerning the appearance and impact of bird habitat may be at odds with what is actually feasible for landscape and building managers. UBCV's habitat is already a heavily modified, built environment, and thus, interventions do not always need to appear or be perceived as "natural". For example, bird houses or modifications to buildings to provide additional nesting habitat are valid ways to help species make use of an otherwise less-than-ideal nesting area. Lastly, many of the species deemed "high-priority" by our analysis, experts, and the values of the campus community could not be supported with actionable recommendations at present and at the scale of UBCV's campus; however, interventions to support these species may be possible were we to re-imagine campus design, policies, and priorities, and/or expanded our efforts to include a broader region and network of actors.

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Appendix

Table A1. Reported Programs and Departments (Question 6)

Faculty	**Program or Department**
Applied Science	● Chemical and Biological Engineering ● Community and Regional Planning ● Architecture and Landscape Architecture
Arts	● French, Hispanic and Italian Studies ● History ● Art History ● Cognitive Systems
Education	Not included
Forestry	● Natural Resources Conservation ● Forest Sciences ● Urban Forestry ● Sustainable Forest Management ● Bioeconomy Sciences and Technology
Graduate and Postdoctoral Studies	● Interdisciplinary Studies Graduate Program
Land and Food Systems	● Land and Water Systems ● Food Science ● Plant Science
Medicine	● Biochemistry
Science	● Institute for Resources, Environment and Sustainability (IRES) ● Biology ● Zoology ● Microbiology and Immunology

Table A2. Species-specific habitat information of *Contopus cooperinus.*

Olive-sided Flycatcher *Contopus cooperinus*	**Info**	**Sources**
General	Coniferous forests (spruce, fir, hemlock, redcedar, tamarack, larch) near open areas (meadows, logged or burned areas, rivers and streams), Garry oak specifically in BC, Use dead trees as perches for singing, watching for predators, and foraging.	(Robbins et al. 2001, Sibley 2014, Sauer et al. 2017)

Feeding	Aerial insects (flying ants, wasps, bees, dragonflies, grasshoppers, beetles, flies, moths), occasionally berries.	
Nesting	Horizontal branches of coniferous trees (or aspen, willow, oak, sycamore, alder, cottonwood and elm) near open areas.	
Migrating	Semi-open forested areas next to waterways or bodies of water.	
Misc	In BC during the breeding season. Very territorial, with a single bird having a territory over 40 hectares.	

Table A3. Species-specific habitat information of *Progne subis.*

Purple Martin *Progne subis*	**Info**	**Sources**
General	Live near cities and towns (used to breed along forest edges with dead trees), forage in cities and towns, parks, open fields, wet meadows, and other open areas. Roost in urban areas at night (ex trees of village plazas).	(Robbins et al. 2001, Sibley 2014, Sauer et al. 2017)
Feeding	Insectivores: flying insects (bees, beetles, flies, dragonflies, butterflies, moths, wasps, mayflies) as well as spiders, cicadas, termites, crickets and grasshoppers. Need to eat small pieces of gravel to help digestion.	
Nesting	Common to supply nest boxes, also nest in trees with woodpecker holes, or cavities in buildings, traffic lights, street lamps etc (defend small territory, but will share as more birds arrive).	
Migrating	n/a	
Misc	Vancouver area for breeding season. Low conservation concern.	

Table A4. Species-specific habitat information of *Petrochelidon pyrrhonota.*

Cliff Swallow	**Info**	**Sources**

Petrochelidon pyrrhonota		
General	Live in grasslands, towns, broken forest, river edges, colonies close to a water source, open fields for foraging, and mud for nest building.	(Robbins et al. 2001, Sibley 2014, Sauer et al. 2017)
Feeding	Flying insects (especially swarming insects like flies and bees) above grassy pastures, plowed fields, and towns. Feed over lakes and ponds in rainier climates where insects are more abundant.	
Nesting	Nest on cliff faces and trees, but also buildings, bridges, and other manmade structures. Require juncture between vertical wall and horizontal overhang to construct nest (200 - 1,000 nest colonies).	
Migrating	n/a	
Misc	In BC (entire province) during breeding season. Low conservation concern. Food source for American Kestrels and Peregrine Falcons.	

Table A5. Species-specific habitat information of *Histrionicus histrionicus.*

Western Meadowlark *Histrionicus histrionicus*	**Info**	**Sources**
General	Open grasslands, prairies, meadows. This species avoids wooded edges and areas with heavy shrubs.	(Ehrlich et al. 1988, Robbins et al. 2001)
Feeding	Diet consists largely of grains and weed seeds (during winter and early spring) and insects (later spring and summer). Favorite insects include beetles, crickets, cutworms, grasshoppers, weevils, and wireworms. Attracted to cracked corn, millet and black-oil sunflower seeds in feeders.	
Nesting	Female Western Meadowlark birds select nesting spots in grassland or meadow	

	habitat. They either look for or create a small dip using their bill and make sure it is shielded by dense vegetation that makes the nest hard to see.	
Migrating	n/a	
Misc	Western Meadowlarks are extremely sensitive to humans when nesting and will abandon a nest if they are disturbed while incubating their eggs. Low conservation concern. Occurring year-round in Vancouver.	

Table A6. Species-specific habitat information of *Patagioenas fasciata.*

Band-tailed Pigeon *Patagioenas fasciata*	**Info**	**Sources**
General	Wet forests of pacific coast (coniferous trees like sitka spruce, red cedar, hemlock, red alder).	(Keppie and Braun 2000, Sibley 2014, Sauer et al. 2017)
Feeding	Fruiting shrubs (cascara, elderberry, madrone, cherry, huckleberry), grain seeds, acorns, pine nuts, and flowers of woody plants. Travel far distances to feed away from breeding habitat. They visit bird feeders.	
Nesting	Nest in trees such as douglas-fir, acacia, lodgepole pine, live oak (in forests).	
Migrating	n/a	
Misc	In the BC coastal area for breeding. Declining conservation status (8% breeding pop in Canada) mostly because of hunting. Eaten by peregrine falcons and great horned owls.	

Table A7. Species-specific habitat information of *Acanthis flammea.*

Common Redpoll	**Info**	**Sources**

Acanthis flammea		
General	Open woodland, around towns, scrubby and weedy fields. Will burrow into snow to roost during winter.	(Knox et al. 2000, Sibley 2014)
Feeding	Small seeds (birch, willow, alder, spruces, pine), studies show winter diet may consist entirely of birch seeds. Also eat grass, sedge, wildflower and seeds, occasionally berries.	
Nesting	n/a	
Migrating	n/a	
Misc	Non-breeding (winter) in BC Low conservation concern.	

Table A8. Species-specific habitat information of *Zenaida macroura.*

Mourning Dove *Zenaida macroura*	**Info**	**Sources**
General	Open country with scattered trees (woodland edges), grasslands, ag fields, backyards, roadsides.	(Otis et al. 2008, Sibley 2014, Sauer et al. 2017)
Feeding	99% of the diet is seeds (cultivated grains, peanuts, will grass, weeds, herbs seeds) and occasionally berries and snails. Will eat seeds from feeders (millet). Feed on the ground and in the open.	
Nesting	Dense foliage (evergreen, orchard trees, mesquite, cottonwood, vines, shrubs), will nest in “nesting cones”, also gutters, eaves and abandoned equipment.	
Migrating	n/a	
Misc	Year-round in southern BC. Low conservation concern (5% of breeding pop in Canada). Very popular game bird.	

Table A9. Species-specific habitat information of *Selasphorus rufus.*

Rufous Hummingbird *Selasphorus rufus*	**Info**	**Sources**
General	Breed in open or shrubby areas (forest openings, yards, parks, swamps, meadows).	(Ehrlich et al. 1988, Robbins et al. 2001, Sibley 2014, Sauer et al. 2017)
Feeding	Nectar from colorful, tubular flowers (columbine, scarlet gilia, penstemon, Indian paintbrush, mints, lilies, fireweeds, larkspur, currant, heaths). Also eat insects (gnats, midges, flies and aphids). Will feed at hummingbird feeders.	
Nesting	Coniferous or deciduous trees (sitka spruce, western red cedar, douglas-fir, pines, hemlock, birch, maples, thimbleberry, ferns).	
Migrating	n/a	
Misc	In western BC for the breeding season (summer). Declining conservation concern. Are very aggressive towards other hummingbirds.	

Table A10. Species-specific habitat information of *Myadestes townsendi.*

Townsend's Solitaire *Myadestes townsendi*	**Info**	**Sources**
General	Pine, fir, and spruce forests with sparse shrub layers. Rocky Mountain juniper (*Juniperus scopulorum*) trees are their primary wintering habitat.	(Robbins et al. 2001, Sibley 2014, Sauer et al. 2017)
Feeding	<u>Winter time:</u> ripe, fleshy cones of Rocky Mountain juniper (*Juniperus scopulorum*) during winter time. <u>Summer time:</u> winterberry (*Ilex verticillata*), buckthorn (*Rhamnus* spp.), currant (*Ribes* spp.), shadbush (*Amelanchier* spp.), hackberry (*Celtis occidentalis*), and elderberry (*Sambucus*	

	spp.).	
Nesting	Female Townsend's Solitaire birds build the nest on the ground in dips. They build the cup nest using pine needles, strips of bark and grasses.	
Migrating	n/a	
Misc	Low conservation concern. Year-round in Vancouver.	

Table A11. Species-specific habitat information of *Melospiza lincolnii.*

Lincoln's Sparrow *Melospiza lincolnii*	**Info**	**Sources**
General	Wet meadows dotted with dense patches of willows, alders, sedges, and corn lily. At lower elevations they use patches of aspens, cottonwoods, and willows as well as shrubby areas near streams.	(Robbins et al. 2001, Sibley 2014, Sauer et al. 2017)
Feeding	Primarily feed on insects including beetles, caterpillars, flies, moths, and leafhoppers. Attracted to cracked corn, millet and black-oil sunflower seeds in feeders in winter times.	
Nesting	The female builds a nest on the ground or just above the ground inside a willow or birch shrub that is surrounded by a thick cover of sedges and flowering plants such as corn lily and buttercup.	
Migrating	During migration Lincoln's Sparrows often associate with other sparrows, including White-crowned, Song, and Swamp Sparrows.	
Misc	n/a	

Figure A1: Location of Fraser River Delta along the Pacific Flyway (City of Vancouver 2015).

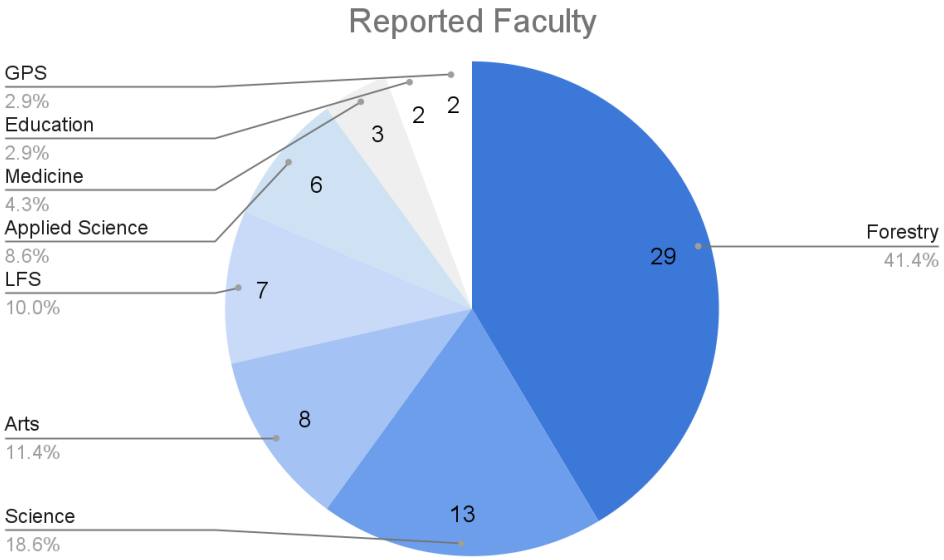

Figure A2. Represented Faculties Reported by Survey Respondents (Question 6). Note. Graduate and Postdoctoral Studies (GPS) and Land and Food Systems (LFS).

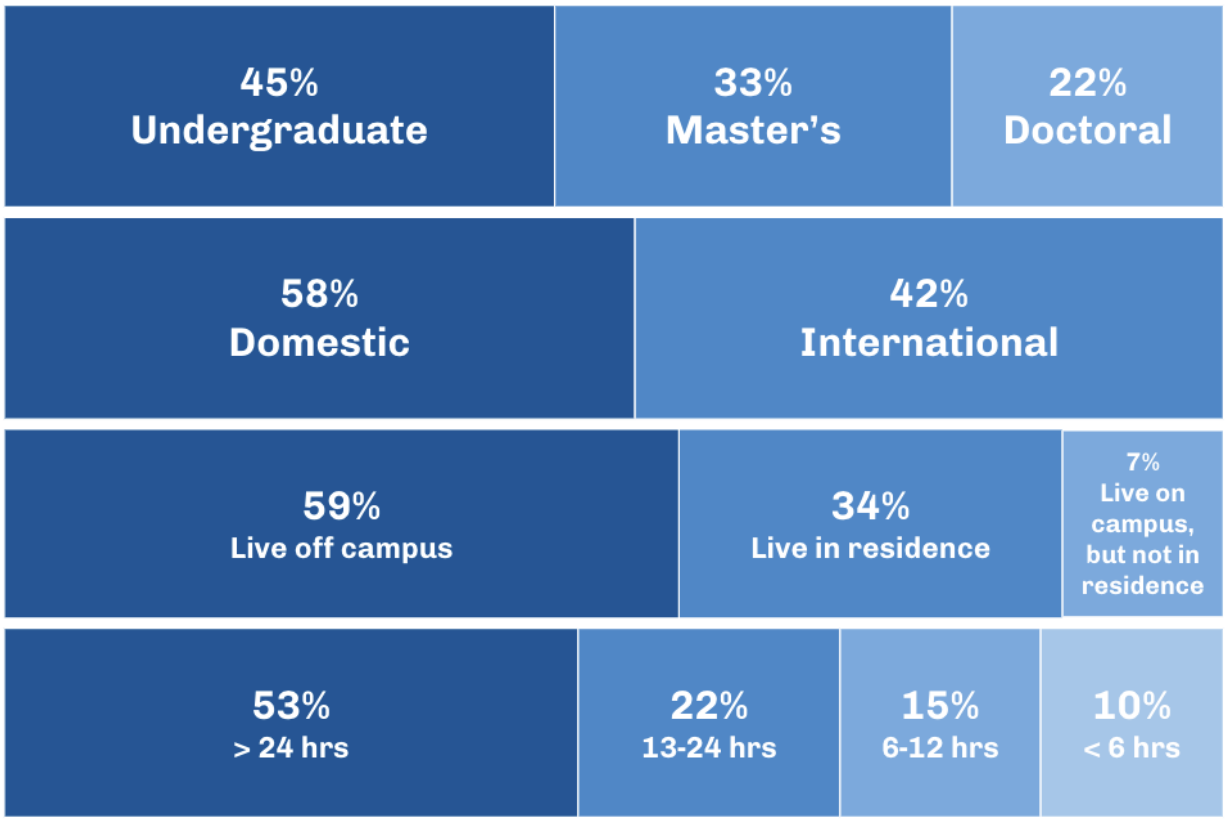

Figure A3. Participants overview (Questions 3 to 5). Note: the number of hours relates to the number of hours spent on campus on average per week as of November 2021.

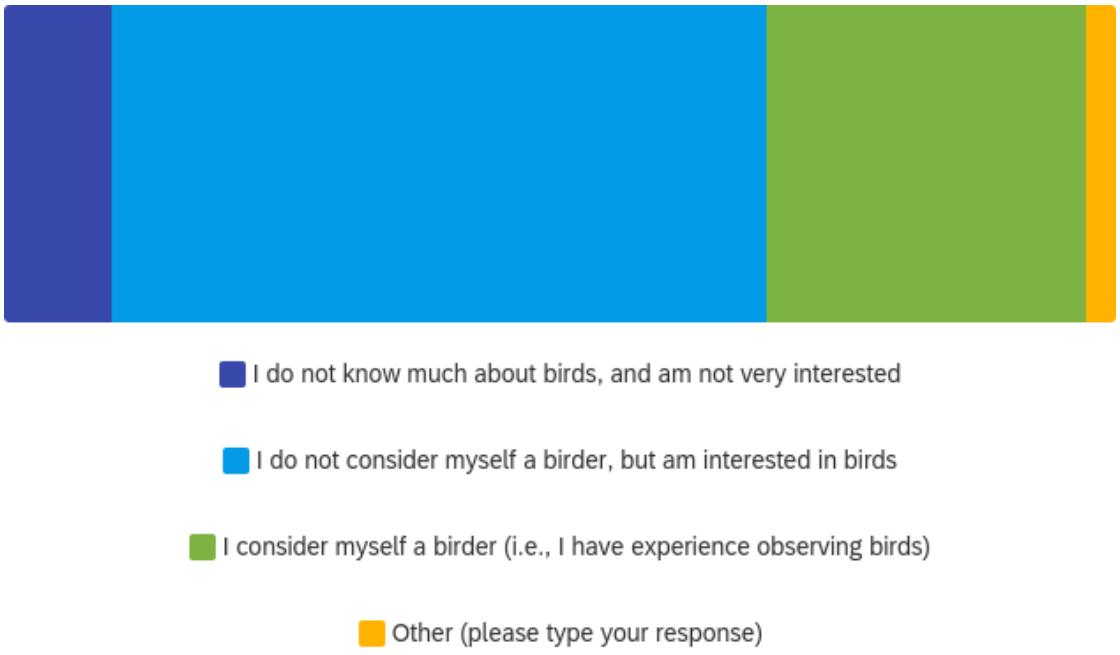

Figure A4. Student self-reported knowledge and interest in birds (Question 7)

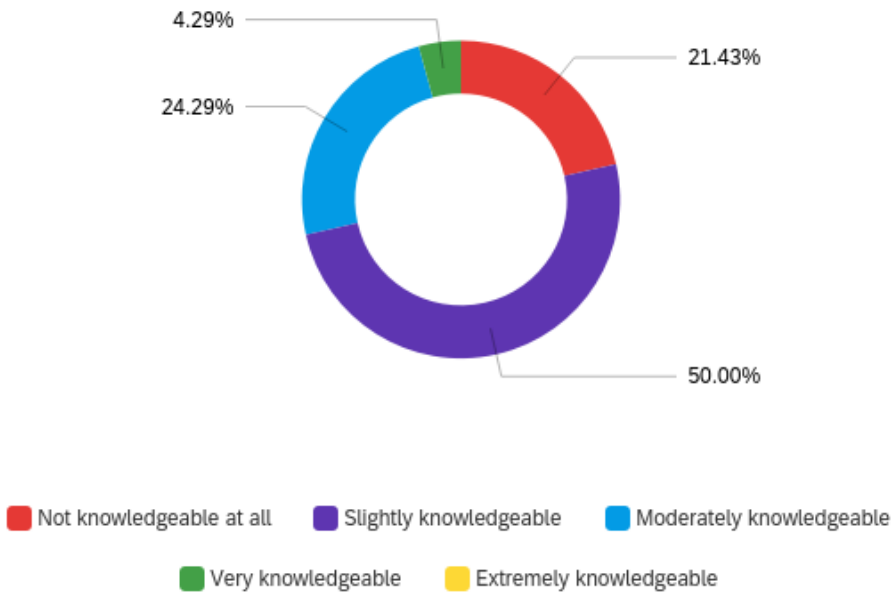

Figure A5. Reported knowledge level of birds (Question 8)

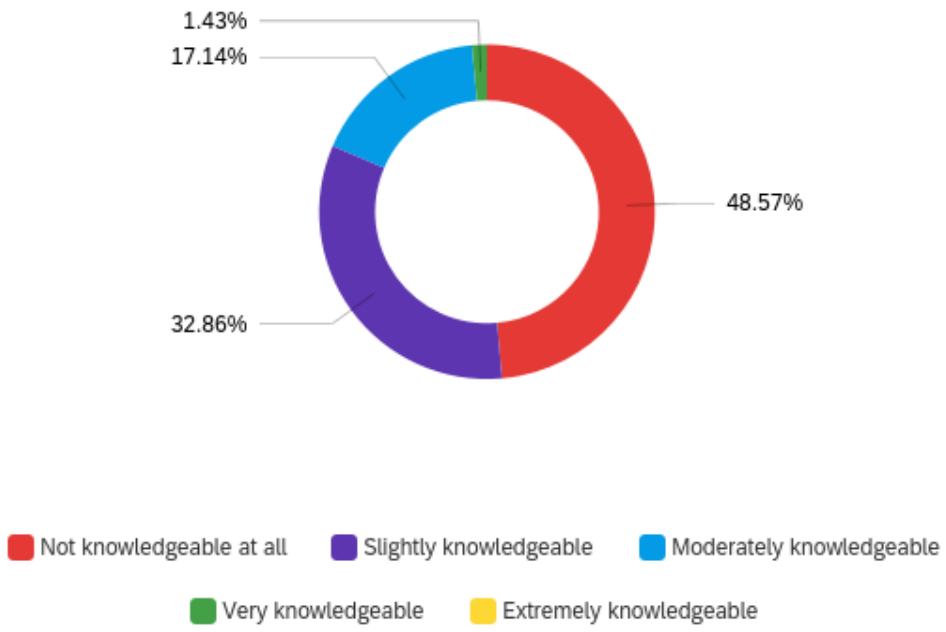

Figure A6. Reported knowledge level of bird habitats (Question 9)

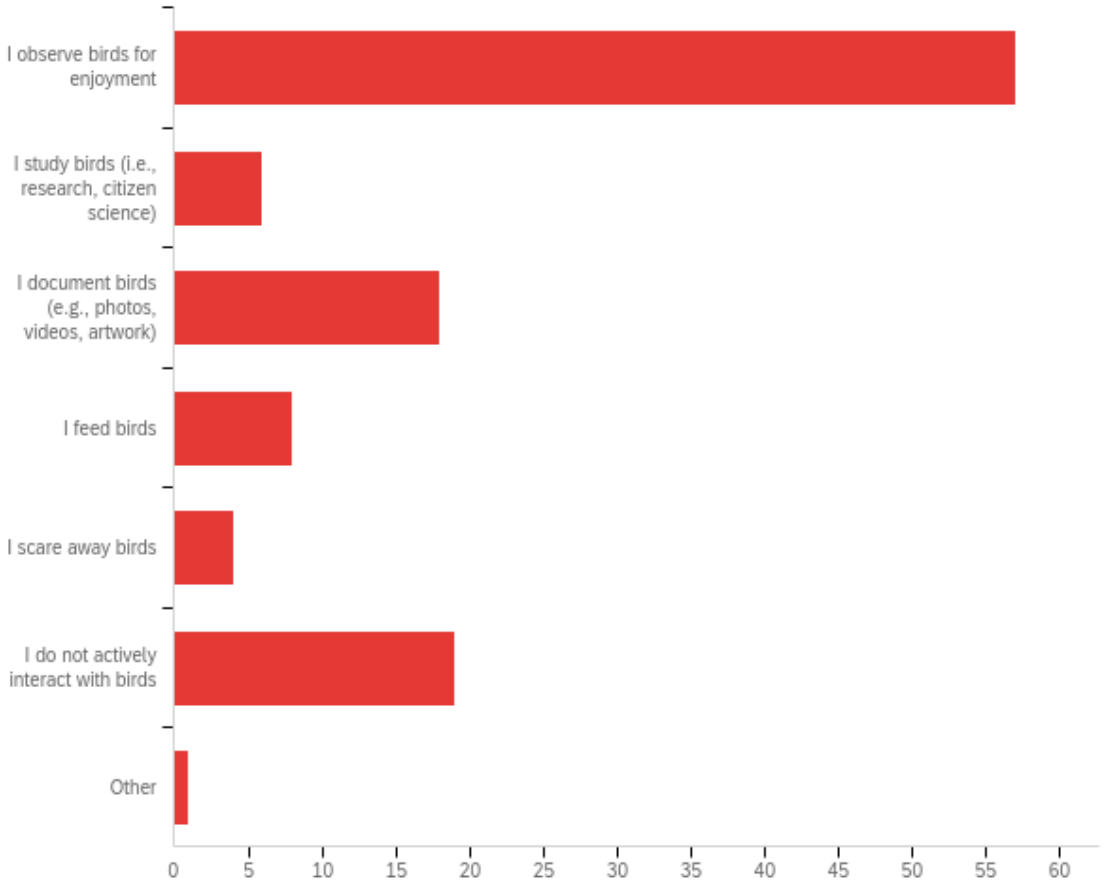

Figure A7. Types of student interactions & engagement with birds on campus (Question 10). Note: "Other" was a comment about witnessing birds steal people's food.

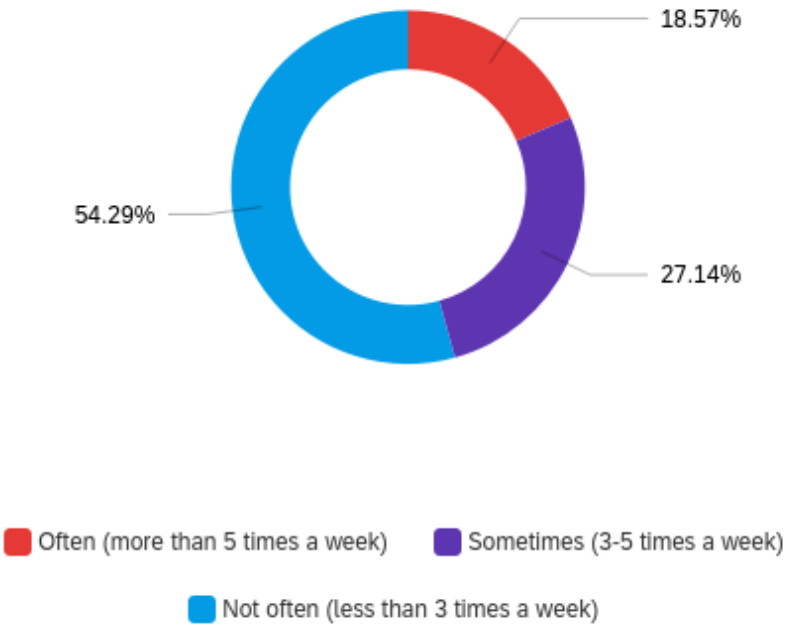

Figure A8. Frequency of student interactions with birds (Question 11)

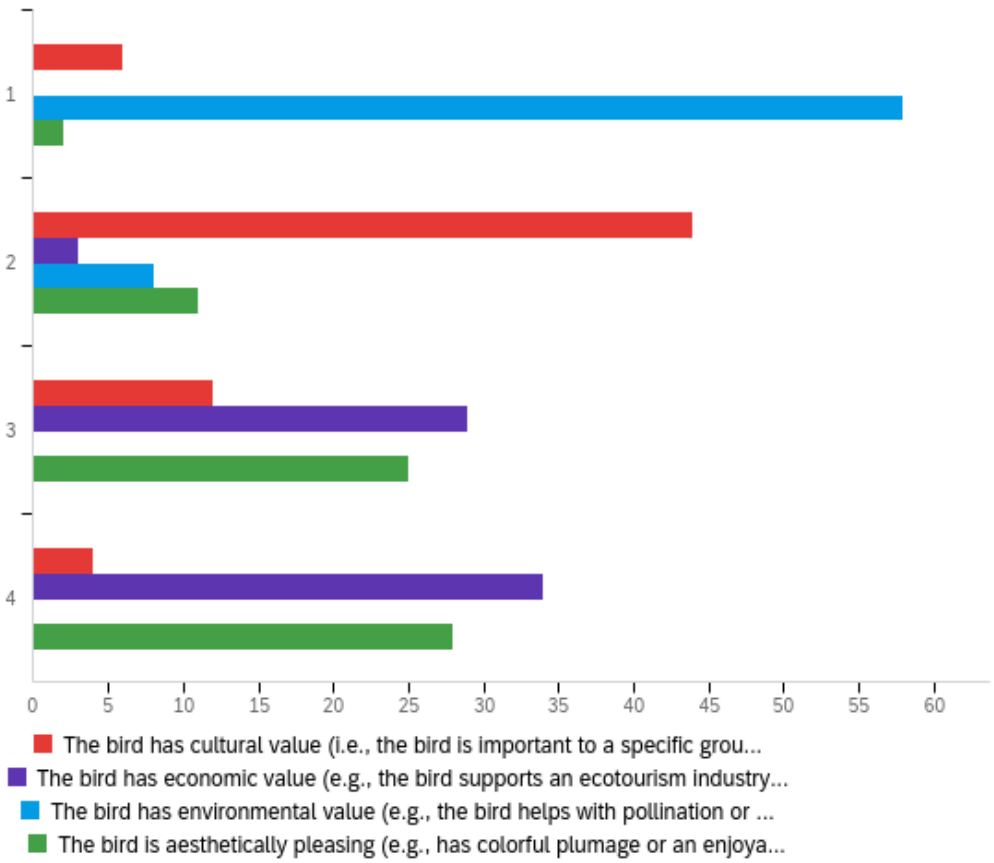

Figure A9. Student ranking of different value factors (Question 12)

1	Strongly disagree	19.70%
2	Somewhat disagree	36.36%
3	Neither agree nor disagree	27.27%
4	Somewhat agree	12.12%
5	Strongly agree	4.55%

Figure A10. Level of agreement with value statement (Question 15)