Chapter One: Methods 0.2

### Study Area

In North America, the northern goshawk ranges from boreal forests of the Yukon south to high-elevation forests of Arizona and New Mexico. Two subspecies are currently recognized: the widespread *atricapillus* and the limited *laingi* (Birds of North America). The *laingi* subspecies was first described on the Haida Gwaii archipelago in British Columbia and is generally smaller in size and darker in plumage than the *atricapillus* subspecies found elsewhere on the continent (Taverner 1940). It’s range, as defined by morphological characteristics and habitat modeling, is limited to the west coast of North America from southeast Alaska through British Columbia and Vancouver Island, possibly as far south as Washington’s Olympic Peninsula (COSEWIC 2013). *A. g. laingi* is considered a species at risk in British Columbia by both the federal and provincial governments (NGRT 2008, Parks Canada 2017).

We studied goshawks in the Sunshine Coast and Lower Mainland regions of the south coast of British Columbia. This population of goshawks is currently classified as *A. g. laingi*, though recent genetic evidence suggests *laingi* is strictly limited to Haida Gwaii and may lead to future reclassification of the coastal mainland population (Geraldes etal 2018). The south coast region is primarily temperate rainforest dominated by Douglas-fir (*Pseudotsuga menziesii*), western redcedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*). Summers are cool (mean temp) and winters are mild and wet (mean temp, mean precip). Forests are naturally fragmented by mountain ranges and coastal fjords, and artificially fragmented by human development and natural resource extraction. Industrial timber harvest has created a patchwork of differently aged forest stands, ranging from recent clearcuts to old growth over two hundred years old. Within this region, goshawk managers have delineated a *transitional zone* comprised of low-elevation valleys connecting the wet coast with the dry interior. Goshawks in this transitional zone may have morphological characteristics and habitat requirements intermediate between the coastal *laingi* population and the interior *atricapillus* population. As a result, this zone is of particular interest to goshawk managers.

### Data Collection

We assessed goshawk diet within the British Columbia south coast in 2019 and 2020 through a combination of egested pellets, prey remains, and nest cameras. We identified prey from pellets and remains collected from n nests and from photographs taken at n nests across two ecological regions, the coastal zone and the transitional zone. Goshawk nests were located as part of long-term monitoring conducted by the British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRO) (for detailed survey methodology see McClaren 2005).

Prey remains and egested pellets were collected from n occupied sites (2019 *n* = n, 2020 *n* = n) with active nests. N sites had collections from both years. Prey remains and pellets were gathered from beneath active nests, from within nests after the juveniles had fledged, and from plucking posts located within the site. All prey remains and all pellets from a single collection location (i.e., a single nest or a single plucking post) were combined into a single sample for each visit to that location.

At a subset of these sites (2019 *n* = 6, 2020 n = n), cameras were installed at nests to record prey delivered to the chicks. N nests had cameras installed in both years. Nest cameras are an effective and relatively unbiased method of measuring avian diet (Garcia-Salgado 2015, Harrison et al 2019). However, cameras may overestimate prey deliveries because goshawks are known to cache prey items for re-delivery to the nest at a later time, creating a risk of double-counting items. Due to the discrete nature of our data, we were unable to differentiate cached and re-delivered items from new items and did not attempt to account for caching in our analysis.

Nest cameras were digital trail cameras (Reconyx brand, UltraFire and HyperFire models) mounted 2-5 meters distant from and slightly above the nest, usually in an adjacent tree. Cameras in 2019 were programmed to take three photos one second apart when triggered by motion, and an additional one photo every thirty minutes. In 2020, cameras were programmed to take five photos one second apart when triggered by motion, and an additional one photo every twenty minutes. Installation took place during the early nestling phase (between x June and x June) and cameras were left in place until after juveniles dispersed in the fall. Camera site selection was not random but rather constrained by topography, access, and timing of discovery.

Breeding chronology was not available for most sites. At sites with cameras, chicks were aged from photos taken shortly after camera installation using a pictorial guide (Boal 1994). Hatch date and lay date were calculated from this date using known breeding chronology (Boal 1994, McClaren et al. 2015). Productivity was defined as the number of chicks to reach some number of days age (citation).

### Diet Quantification

We reconstructed prey remains and pellets following a modification of Lewis et al. (2004). Within each sample, prey remains were identified to the lowest possible taxonomic category and the minimum number of individuals counted (i.e. 11 squirrel claws = 2 *Tamiasciurus douglasii*). Intact and broken but reassembled pellets were analyzed individually within each sample, while fragmented pellets were combined within each sample. Pellets were dissected and feathers, fur, and hard parts (bones, teeth, claws) were identified to the lowest taxonomic level. Items were additionally categorized by size (small, medium, or large). We counted the minimum number of individuals represented within the pellet or pellet collection.

Prey items identified to species were assigned mass using data from the literature. We assigned mass to mammal species from Nagorsen (2002) and birds from Birds of World (2020), using the geographically closest estimates and averaging the mass of males and females. When unable to differentiate between species within a single, relatively homogeneous genus (such as *Eutamias* or *Myotis*), we assigned mass by averaging the masses of all possible species, based on range maps. Red squirrels (*Tamiasciurus hudsonicus*) were present at a single site within out study area; when unable to distinguish between the two members of the genus *Tamiasciurus* we assigned the item to the more common *T. douglasii*. Unidentified items were assigned mass by averaging the masses of the identified species in that size and class. As very few items could be successfully aged, we did not include prey age in our analysis. We report diet composition as both percent of items and percent of biomass.

Data from prey remains and egested pellets are known to be heavily biased indices of diet. Some authors have found combining data from both sources to produce relatively unbiased results that can serve as a helpful supplement to camera data (Lewis et al. 2004). However, after testing for differences between pooled pellets-and-remains and camera data we found significant differences between these two sources. We therefore uhhhhhhh idk what we did.

Nest camera photos were reviewed and each new prey item delivered to the nest was recorded and identified to species when possible. When items could not be identified to species, they were identified to the lowest possible taxonomic level. Prey items identified from photos were assigned a size class and biomass by the same method used for remains and pellets. Partial items were assigned the average mass for that size and class.

Using data from nest cameras, we quantified the diet of each nest in several ways. We calculated the relative proportion of avian and mammalian biomass delivered to the nest. We also calculated the proportion of total biomass composed of squirrels (genus *Tamiasciurus*), which are known to be an important source of prey for goshawks in the British Columbia (Ethier 1999, Lewis et al. 2006). We also calculated diet diversity for items identified to genus and species using Simpson’s Diversity Index and diet overlap between nests using Morisita’s Index of Similarity.

We used pooled pellets and remains to calculate prey species richness for the entire study area. And ?????

### Statistical Analysis

Sites were classified as either coastal or transition based on whether the site centroid fell within the transition zone defined by the NGRT (citation). We calculated the site centroid as the central point between all known nests within that site.

To simplify comparison of diet between coastal and transition sites, we condensed prey items identified from nest cameras, pellets, and remains into eight broad categories: squirrel (genus *Tamiasciurus*), hare (genus *Lepus*), all other mammals, grouse (family Tetraoninae), thrush (family Turdidae), corvid (family Corvidae), all other birds, and unidentified items. We pooled all data from each source (cameras, pellets, and pellets-and-remains) within each zone and tested for differences between the zones with a chi-squared test using proportional counts of items.

To determine the reproductive consequences of dietary variation, we examined how two aspects of diet, diet diversity and proportion of biomass composed of squirrel, influenced productivity. We used linear regressions (lme package in R citation ) with productivity as the response variable and diet as the explanatory variables.