FOREST PATCH SIZE AND BREEDING TERRITORY SELECTION BY COASTAL SWAINSON’S THRUSH (CATHARUS USTULATIS USTULATIS) IN BC’S GEORGIA BASIN

By

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We accept this thesis as conforming to the required standard

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Abstract

Many of North America’s 250 species of Neotropical migrant songbirds have declined in the 20th and early 21st centuries. Forest fragmentation can introduce limiting factors to bird habitats as edge to interior ratios increase with potentially harmful related impacts. Avian habitat fragmentation research is biased towards Eastern North America. A breeding study of the coastal population of Swainson’s thrush (*Catharus ustulatus ustulatis*) in the Georgia Basin was conducted with the research question: What effect does forest patch size have on Swainson’s thrush breeding territory selection? Four forest patches representing a broad range of sizes were used, with control for additional environmental variables. Exhaustive avian sampling in the breeding season focused on density, abundance and habitat use. There were statistically significant causal relationships between forest patch size and total avian density and abundance. Density increased in smaller forests while total abundance declined. The study also covered the management implications of the research findings.
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Introduction and Literature Review

Habitat Fragmentation and Neotropical Migrants

Many of the approximately 250 species of Neotropical migrant songbirds breeding across North America have exhibited serious declines in the 20th century (Rich et al., 2004). These songbirds are among the most specifically adapted birds on the planet, and are sensitive to habitat changes. Birdlife International (2008) notes that 44 out of 62 Neotropical migrants studied had declined over 10 years. Some forest passerines in Canada, including thrush, warbler and flycatcher species are now considered to be at risk (Bird Studies Canada, n.d.).

Schmidt (2003) notes that many Neotropical migrants are finely adapted, ecologically sensitive species, often rapidly affected by environmental changes. Fragmentation of forests due to land use changes such as road building, development and agriculture forms a significant driver of Neotropical migrant songbird declines according to many authors including Temple (2004) and Rosenberg et al. (2003). Neotropical migrant passerines are readily appreciated by scientists, birders and general members of the public. These songbirds are valuable environmental indicators and serve as core components of healthy terrestrial ecosystems in North and South America and form an ecological bridge between the continents. Work to conserve Neotropical migrants is increasingly prominent and the value of these birds to the economy and environment is becoming more widely known as recognized by Partners in Flight (Rich et al., 2004).

Fragmentation transforms contiguous forests into smaller patches with both reduced territory availability, drier microclimates more prone to invasive species and disturbance (Robinson & Wilcove, 1994). In addition, fragmentation allows aggressive habitat generalists such as crows, jays, cowbirds, house wrens and grackles to increase in abundance, where they...
may destroy nests, feed on young or in the case of cowbirds, parasitize nests, as observed by Temple (2004, p. 9.97)).

Many Neotropical migrants are area sensitive. Certain species may claim territories close to one hectare in size but require them to be located within a larger parcel in order to possess the necessary interior forest qualities (Temple, 2004, p. 9.99). Hames (1999) notes that area sensitive species may show increased abundance or breeding attempt rates at times in smaller forest patches. However, further investigation has shown that these attempts may be met with lower successful breeding rates (fitness) compared to larger sites. Fragmentation effects vary according to the species involved and the landscape matrix, with effects intensifying in heavily impacted areas and when highly vulnerable species are involved (Rosenberg et al., 2003).

Studies exploring the links between fragmentation, habitat loss or alteration and declines in bird populations show that many Neotropical migrants are Area Sensitive, meaning they depend on habitat qualities that are best afforded by forest parcels of a certain minimum acreage (Cavitt & Martin, 2002). My study addresses breeding territory selection as a function of forest patch size to measure area sensitivity in coastal populations of the Swainson’s thrush. The breeding success rate warrants further study given these findings and the strong variations in area sensitivity between the East and West of North America, as noted by Rosenberg et al. (2003).

While a high percentage of Neotropical migrants are known to claim territories of around 1 ha, the territories must often be located within a much larger parcel in order to possess the necessary interior forest qualities found on a substantial expanse of habitat (Temple, 2004)). Norris, Hemesath, Debinski & Farrar (2003) published relevant literature quantifying declines in a number of Neotropical migrant bird populations bird status gradients and levels of disturbance.
Numerous studies, such as the work by Robinson & Wilcove (1994) have explored fragmentation in the temperate zone, giving a strong precedent for this study. Further research may shed light on whether the increased density of birds found in smaller forests indicates favorable habitat conditions on these sites, or whether these habitats selected by birds act as population sinks with reduced breeding success.

**Western North America Research**

Despite improvements, research gaps exist on the subject of fragmentation in Western North America (Freemark et al., 1995) with more limited data on area sensitivity in western populations. Gaps are highly apparent in the coastal lowland regions of British Columbia. Most research has addressed Eastern North America, where conditions are different and Eastern findings on relationships between habitat matrix conditions and bird population trends may not always apply (Cavitt & Martin, 2002).

My study seeks to add to the knowledge of patch size effects on avian territory selection in Western North America. The study explores the relationship between breeding territory selection measured in density and abundance in the Swainson’s thrush and forest patch size in the Georgia Basin Region. Neotropical Birds Online (2010) notes gaps in breeding territory selection studies in the Pacific Northwest. Addressing these gaps is a primary focus of my study.

George & Dobkin (2002) published a paper addressing the “Effects of habitat fragmentation on birds in Western landscapes: contrasts with paradigms from the Eastern United States”. The paper cites Cavitt & Martin (2002), who examined > 10,000 nests from the Breeding Biology Database for 23 songbirds across Eastern and Western Regions, finding inconsistent results in area sensitivity. Cavitt and Martin (2002) suggest that Western birds are less sensitive to fragmentation due to greater natural landscape heterogeneity. Western bird
populations are thought to be less sensitive to fragmentation due to greater levels of natural fragmentation and lower ecological productivity in the region to which birds have become adapted. George & Brand, (2002) noted that area sensitivity has been defined by reduced avian abundance in relation to smaller patch sizes. Patterns of lower area sensitivity in Western landscapes were highlighted in their review.

Rosenberg et al. (2003) describe mixed findings among research available that deals with Swainson’s thrushes. The Swainson’s thrush may or may not be area sensitive, depending on the specific population studied and specific environmental conditions, particularly vegetation. Research by Lehmkuhl, Ruffieoro & Hall (1991) did not find area sensitivity among Swainson’s thrush study subjects in Douglas -fir Forests of the Washington State’s Cascade Mountains, near the Pacific coast, while Freemark et al. (1995) found Swainson’s thrush populations to be area sensitive in Nevada riparian habitats. Evans (1995) found no significant relationship between patch size and Swainson’s thrush abundance in mixed Coniferous Forests in the Northern Rockies. Stands in more fragmented landscapes; however, had fewer nests and lower nest success than stands in more contiguous landscapes in the same study area (Evans et al. 1998 as cited in Rosenberg et al., 2003). A more heavily impacted matrix seems to amplify fragmentation effects in individual patches.

Rosenberg et al. (2003) describe findings showing area sensitivity in interior west studies on Swainson’s thrush with a contrasting absence of area sensitivity on the coast, where the birds are strongly associated with understory shrubs. Hames (1999) found declines in Swainson’s thrush and Western tanager in Western North America and the scarlet tanager and veery in the East. Rosenberg et al. (2003) note that certain thrush populations select patches of a smaller size for breeding but fail to succeed in successful nesting to the extent found in larger forests.
Neotropical Birds Online (2010) notes that predation seems to be a serious limiting factor to Swainson’s thrush nesting. However, Tewksbury, Hejl & Martin (1998) noted a benefit to Swainson’s thrush breeding success in the west as a result of smaller patch sizes with lower predation rates. Mixed results define the literature in Western North America. Hejl et al. (2002), as cited in Rosenberg et al. (2003) found that mixed relationships between habitat patch size and edge effects and Swainson’s thrush populations depending on region and habitat type. However, Rosenberg et al. (2003) further describes studies in California that show a “false benefit” to edge habitats where density increases but breeding success declines.

Looking at other thrush species, Rosenberg et al. (2003) noted 50% decline in hermit thrush after logging, and nearly equivalent declines from extensive forest fragmentation in varied thrush. Reasons for conflicting thrush findings may include adaptations and biogeoclimatic zone differences. Hansen et al. (2008) note that fragmentation effects may be partially due to biogeoclimatic effects resulting from reductions in biomass. These effects may be lowered in naturally drier, lower biomass or otherwise harsher environments. This consideration is consistent with many western habitat characteristics, but slightly less so in the lowland areas are study addresses. Individual and population adaptations and site fidelity may also play a role.

**Swainson’s thrush Biology and Use as a Focal Species**

The Swainson’s thrush *Catharus ustalatis* Nuttall was selected as the focal species for my fragmentation study through several criteria. These included observability and a reasonable amount of sensitivity to habitat change while not being so specialized as to introduce excessive non-patch size related variables. The Swainson’s thrush has sufficiently frequent occurrence in suitable habitat and is not so rare as to limit adequate sampling. However, population declines and disappearances are known to threaten this species (Boreal Songbird Initiative, 2007). While
the Swainson’s thrush is still fairly common, it is sensitive to environmental impacts over the long term (Hames, 1999). This species has experienced statistically significant declines (1.78 percent per year, \( p = .006 \)) over the last 40 years in the Pacific Northwest (Jenkins, Betts, Huso & Hagar, 2013), which may be linked to habitat loss and environmental changes. As a result, this bird has been identified as a species of conservation concern in certain regions with varying degree of area sensitivity (Rosenberg et al., 2003).

Rosenberg et al. (2003) identify thrushes as “good indicators of forest health and the ability of our forests to support healthy bird populations,” because forest thrushes “select habitat based on forest type, elevation and moisture regimes.” The birds nest on the ground and build their nests in dense and low vegetation types, with “sensitivity to the structure, productivity and configuration of the forest.” The Swainson’s thrush was identified as a prime candidate for a baseline avian area sensitivity and patch size study to add to the literature on Neotropical migrant songbirds in Western North America through a study in the Georgia Basin ecoregion.

A long distance Neotropical migrant songbird, the Swainson’s thrush has migration routes and associated wintering and breeding range latitudes and longitudes varying by subspecies and population. Western populations of the ustulatis subspecies winter further north, residing in tropical Mexico and Central America. Eastern North American populations winter in Northern South America through the Western Amazon Basin to Northern Argentina (Boreal Songbird Initiative, 2007). These patterns were recently confirmed with further detail added by Delmore, Fox, & Irwin (2012).

Sixty percent of the Swainson’s thrush population breeds in the Boreal forest region of North America, with a preference for dense coniferous forests, especially spruce, fir and hemlock
across the majority of its range (Boreal Songbird Initiative, 2007). In California and the Rocky Mountains, Swainson’s thrush use deciduous riparian woodlands and shrubby meadows with standing water. In the Northeast the bird is found in Hardwood Forests. Campbell et al., (2001, p. 394-401) describe the Swainson’s thrush as a characteristic bird of forests across much of British Columbia. A portion of the bird’s range is found at sea level in different conditions than the boreal forest, California or Eastern North America.

In the Georgia Basin region where I am looking to increase knowledge of patch size effects on breeding territory selection, the Swainson’s thrush ustulatis subspecies is especially abundant in riparian forests of alder, willow and cottonwood as well as coastal forests rich in berry bushes such as salmonberry, salal, and devil’s club, which provide a rich source of food combined with invertebrates found near beaches (Campbell et al., 2001, p. 394-401). Mixed cedar, thimbleberry and crab apple zones surrounding lakes, wetlands, roads and other forest edges are also popular habitats.

Campbell et al. associate the bird largely with lower stage vegetation within forests that forms an understory, mixed vegetation types and ages, and edges of forest habitats with transition zone characteristics.

Swainson’s thrush are omnivores, feeding primarily on insects during the spring and summer and fruits in the fall and winter with some overlap. “Beetles, caterpillars, and ants are among the principal insect prey; few temperate songbirds exploit ants to the extent that this and related species do,” according to the Boreal Songbird Initiative (2007). Fruit components of the bird’s diet include blueberries, elderberries, crowberries, blackberries, raspberries, twin berries and huckleberries as well as the Pacific Northwest species of berries? discussed by Campbell et
al. (2001). The Swainson’s thrush often forages on the ground but this species spends a greater amount of time foraging in the canopy and higher branches than most other thrushes. Long wings and shorter feet may be adaptations, according to the Boreal Songbird Initiative, which notes a tendency to feed on army ants in the wintering grounds. This bird also forages on mosquitos to a considerable degree (Neotropical Birds Online, 2010).

On the West coast of Vancouver Island, the bird is more closely associated with 30 to 60 year old conifers, consisting of Western hemlock, amabalis fir, Douglas-fir, Western red cedar and Sitka spruce, as well as a deciduous species, red alder. A variety of factors affect the extent and nature of fragmentation related impact by region, which complicates research and calls for continued studies across a variety of regions. Biogeoclimatic differences affect baseline productivity, species abundance and habitat matrix conditions and fragmentation will have differing effects in different regions even in the same species, as noted by George & Dobkin (2002).

Swainson’s thrush breeding patterns are of particular interest and they were factored into the design of the study. Like the majority of North American songbirds, the Swainson’s thrush is seasonally monogamous. However, “females show an unusually high degree of between-year fidelity to their nest sites and pairs often re-form in multiple seasons after repeating the pair-bonding process,” according to the Boreal Songbird Initiative (2007). Such behavior is thought to facilitate rapid pairing in Northern and generally higher elevation habitat zones with short breeding seasons.

According to the Boreal Songbird Initiative, Male Swainson’s thrush “arrive on the breeding grounds first and initially try to drive arriving females off their territories. After several
days of female persistence, which may be strengthened by the male's defensive behavior, the male accepts the female and mating occurs.” The Boreal Songbird Initiative (2007) states “The nest is built by the female and typically placed in dense understory cover.” The vegetation used consists of small trees and shrubs, with well-built cup nests constructed from mosses, twigs, leaves, grasses and lichens. “One to five (usually four) speckled, blue eggs are laid and incubated for 10 to 14 days. The young fledge at 10 to 14 days as well, after being fed by both parents. The Boreal Songbird Initiative further notes “Nest failure rates in this species are very high, sometimes exceeding 60%; it is believed that most females never nest successfully.” Nesting success rates may be as low as 16% according to Campbell et al. (2001). Measuring additional effects on nesting success could foreseably prove challenging due to sample size. Neotropical Birds Online (2010) notes that locating Swainson’s thrush nests can be extremely challenging. Clutches from thrushes nesting in the Georgia basin ecoregion where this study is being conducted started on June 3, peaked at around June 17th and then fell off by July 8th, while clutches were first noticed July according to Campbell et al. (2001, p. 400). Campbell et al., (2001, p.400) observe that Swainson’s thrush arrive in late May with 51% of clutches occurring between 14 and 30 of June. Incubation lasted 11 to 14 days. At the end of June, there is then an 11 to 14 day nestling period. Brood numbers increased rapidly by July 7th and peaked at around the 11th of July.

Swainson’s thrush pairs typically claim territories of around 0.809 to 1.01 ha in Western North America (Montana Natural Heritage Program and Montana Fish, Wildlife and Parks, n.d.). Thrush territories may be located side by side or scattered throughout a larger habitat region due to selection of the most suitable subsets of a given habitat by the birds. My study looks at the coastal populations migrating from Central America to coastal areas of Western North America,
as described by Delmore, et al. (2012). Delmore et. al clear variation in life history and adaptations within a species. Interior west populations of Swainson’s thrush (subspecies *ustulatis*) winter further south, while populations wintering further north in Central America and even parts of Mexico tend to migrate to coastal regions. The study seeks to address the lack of research on breeding habitat selection and key requirements in the Coastal Swainson’s thrush population. Swainson’s thrush tend to winter in primary forest and to a lesser extent, in secondary forest (Boreal Songbird Initiative, 2007).

**Coastal Douglas-fir Forest Patches: Ecosystem Facts and Ecology**

The moist maritime Coastal Douglas-fir Biogeoclimatic Zone (CDFmm) contains a range of plant communities with similar overall ecosystem conditions characterized by rain shadow dynamics that leave it drier than other moist maritime forest zones (BC Minister of Forests, March 16, 1999). The CDFmm encompasses much of the Georgia Depression region in BC, particularly southeastern Vancouver Island and the Sunshine coast in Canada. There is a southern extension into the Puget Sound Trough in Washington State (Cadrin, 2011). Conditions are fairly similar throughout the extent of this ecosystem.

This ecosystem is classified as threatened in Canada and worldwide, state declines in forest cover with only 1% in old growth remaining, and a 50% reduction in remaining forested area extent (Cadrin, 2011). An especially high diversity of plant and animal species including many songbirds are characteristic of this ecosystem region. Due to forestry and development, fragmentation, structural stage simplification and loss of CDF ecosystems and other forest types on Southeastern Vancouver Island, conditions may resemble some parts of Eastern North America with reduced habitat integrity.
Additionally, certain songbirds that occur may be more adapted to habitat characteristics such as moist or extensive forests that are vulnerable to change through fragmentation. In contrast, Western birds adapted to forests with lower levels of moister and higher natural levels of fragmentation may be less sensitive to fragmentation, as discussed further on in the study. The question as to whether coastal populations would therefore be more sensitive than interior populations is worth exploring. Neotropical Birds Online (2010) notes that Swainson’s thrush populations seem to have mixed results to variability or reductions in forest age.
Methodology

Study Area Description

The four study sites selected were located in the moist maritime Coastal Douglas-fir Biogeoclimatic Zone (CDFmm) (Ministry of Forests (1999). Sites were selected within the Parksville area to be fairly close geographically with similarities in distance from the sea, elevation, vegetation composition and stage as well as latitude and longitude. This allowed for a better attempt at isolation of patch size and related characteristics as my area of focus for the independent variable affecting the variables of bird occurrence. Four study areas of significantly different sizes were selected in order to determine the potential relationships between forest patch size and breeding territory selection in Swainson’s thrush. Sites were selected with ample variation and representation of habitat sizes in mind, within the limitations of local environmental conditions and study area availability. Sites ranged from 2.15 ha to a 95.31 ha site, with a 4.06 ha and 21.44 ha site in the middle. The goal of the study centered around determining the suitability of habitats of different sizes for breeding territory use with a view to assessing potential differences in abundance and density between all four sites.
The four study sites are shown below in Figure 1 which is a map of all study areas.

Figure 1. The four study sites surveyed for Swainson’s Thrush in the City of Parksville. Located in the Georgia Basin Park on Vancouver Island, British Columbia, Canada. Image © 2014 Digital Globe. Google Earth image. © 2014 Google Earth. © 2014 City of Parksville. Scale Bar 2 cm (----------) = 600 m.

In order to compare the effects of habitat patch size on breeding territory selection in the Swainson’s thrush, study areas, sampling methods and timing related factors were carefully reviewed and chosen to ensure the most accurate and relevant results with a minimum of bias, oversight or error. Exhaustive sampling of four differently sized forests was conducted during the Swainson’s thrush breeding season. The characteristics of each site are described in the subsections below.
Site 1: Mark’s Nature Park. Site 1, the smallest site was 2.15 ha in area extent. The latitude for this site was 403531 ° East and 5464259 North, with a center plot elevation of 22 m.

A photograph of representative Site 1 vegetation shown below in Figure 2.

Figure 2. Mark’s Nature Park Study site photo. 2.15 ha CDFmm with moister Coastal Douglas-fir, Western Red Cedar and Sword Fern vegetation components.
Figure 3 is a map of Site 1 showing the forest in the urban and suburban landscape context.

**Figure 3.** Mark’s Nature Park study site Google Earth image. © 2014 Google Earth. © 2014 City of Parksville. Scale Bar 2 cm (---------------) = 50 m.

**Site 2: Forsyth Avenue Forest.** Site 2, the second smallest site was 4.06 ha in extent. The latitude for this site was 403174 ° East and 5464410 North, with a center plot elevation of 33 m.

A photograph of representative Site 2 vegetation shown below in Figure 4.
Figure 4. Forsyth Avenue forest study site photo. 4.06 ha CDFmm with moist to moderately coastal Douglas-fir, Western red cedar and sword fern vegetation components with cottonwood in riparian areas and extensive shrubbery in places.
Figure 5 below shows a map of the Site 2 forest in context with the land use matrix.

*Figure 5. Forsyth Avenue forest study site Google Earth image. © 2014 Google Earth. © 2014 City of Parksville. Scale Bar 2 cm (---------------) = 100 m.*
Site 3: The Englishman River Estuary West Side. Site 3, the middle sized site was 21.44 ha in area extent. The latitude for this site was 405860 ° East and 5464248 North, with a center plot elevation of 5m.

A photograph of representative Site 3 vegetation is shown below in Figure 6.

Figure 6. Englishman River Estuary West Study site photo. 21.44 ha CDFmm Northern section with drier Coastal Douglas-fir vegetation components and understory vegetation.
A map of study site 3 in context is shown below in a map in Figure 7.

*Figure 7.* Englishman River Estuary West study site Google Earth image. Boundaries delineated by yellow placemarks. © 2014 Google Earth. © 2014 City of Parksville.

Scale Bar 2 cm (--___________) = 200 m.
Site 4: Rathrevor Provincial Park. Site 4 was the largest by far at 95.31 ha in area. The latitude for this site was 407690 ° East and 5463905 North, with a center plot elevation of 4 m.

Representative Site 4 vegetation is shown below in Figure 8.

Figure 8. Rathrevor Provincial Park Study site photo. 95.31 ha CDFmm with mature Coastal Douglas- fir in drier regions as shown, looking into the forest on the left with the interior on the right. There were also extensive patches of bigleaf maple and Western red cedar with sword fern as the predominant understory. Mixed riparian vegetation and wetland and grand fir/Western red cedar/Coastal Douglas-fir patches were present, with a variety of shrub understory plants.
Figure 9 is a map of the Site 4 forest of Rathtrevor Park in context.

Figure 9. Rathtrevor Provincial Park study site Google Earth image © 2014 Google Earth. Image © 2014 City of Parksville. Scale Bar 2 cm (---------------) = 400 m.

Survey Location Considerations

Biogeoclimatic zones and location. One biogeoclimatic zone was selected for surveys to prevent biogeoclimatic zone factors from influencing the results with additional variables. Only sites within the Coastal Douglas-fir moist maritime biogeoclimatic zone (CDFmm) were selected for comparison based on patch size. Further restrictions were used to prevent additional variables from being introduced. All sites were located at similar elevations and average distances from the ocean. Levels of human impact were thought to be comparable, although variations in disturbance levels became more apparent as the breeding season progressed.
**Vegetation and local ecological conditions.** Secondary data on vegetation type, structural stage and habitat conditions were considered during site selection and factored into survey reports. A fair degree of similarity with regard to habitat conditions apart from patch size could be ascertained through preliminary habitat surveys. All four forests surveyed for thrushes with a view to determining relationship between breeding season occurrence and patch size contained at least one water feature.

Structural stages as defined by the Ecosystems Working Group of the Terrestrial Ecosystems Task Force, Resources Inventory Committee (1998) exhibited variation within sites, which is a benefit to forest birds such as the Swainson’s thrush through enhancement of ecosystem diversity and productivity noted to be important by Rosenberg et al. (2003). There was considerable overlap and a degree of variation between sites. Swainson’s thrush are often associated with wet areas (Campbell et al., 2001, p. 394-401). Structural Stage 5 and 6 vegetation predominated in the two smaller sites, with elements of structural Stage 6 and even 7 vegetation observed in the largest site.

All four sites had some structural Stage 4 sapling vegetation. On average, a slight increase in overall age was observed as forest patch size increased, hinting at earlier disturbance. Ecological diversity through landforms variation and differing vegetation patterns combined to create a mix of vegetation types that averaged out to be fairly similar across all four sites. The two smallest sites had around 65 to 85% canopy cover, while the larger sites had between 70 and 80% canopy cover. Canopy cover was fairly uniform at around 75%, give or take 5% across the majority of each site. Snags, watercourse and wetland vegetation elements were present on all
four sites. All four sites had mixing of vegetation with a range of dominant conifers. Deciduous components were present and used by thrushes where mixed. However, thrush presence was greatly reduced in dominant maple swaths found in the largest site. Thrush occurrence in mixed and coniferous sections with appreciable understory vegetation in the form of berry bearing shrubs was especially steady and strong, while edges near wetlands and forest transition zones attracted a continual thrush presence. Coastal Douglas-fir, grand fir and Western red cedar formed a high percentage of structural Stage 4 to 5 vegetation on all four sites with a more limited occurrence of coastal western hemlock, shore pine and Gary oak.

Coastal Douglas-fir and a few Western red cedars forming the majority of structural Stage 6 to 7 trees, while deciduous bigleaf maple, red alder and black cottonwood occurred from Stage 4 to 6. A wide variety of deciduous shrubs were found, especially in structural Stage 5 sections with mixed vegetation and near edges or variations in landforms or water feature occurrences. These are also the areas where the thrushes were most frequently detected in the same spot during each survey. Such forests are neither so young as to limit structural diversity and the availability of nutrients and light, nor so mature as to limit the light reaching the forest floor and productivity in the understory.

Vegetation in the understory included sword fern, red huckleberry, snowberry, salmonberry, Pacific ninebark, oceanspray, Nootka rose, baldhip rose, salal, creeping Oregon grape, dull Oregon grape, and tall Oregon grape. A variety of small trees and large shrubs including Pacific dogwood, Indian plum, cascara, bitter cherry and Pacific crab apple were also found. These areas were favored by thrushes, though occurrence was also frequent in mixed age Western red cedar and coastal Douglas-fir stands with sparser understories and woody debris. These moist but sparser areas may have abundant insect food for the thrushes in addition to the
availability of berries and perch sites seen in shrubbier most zones. Drier areas of the 20.33 ha site had lower thrush occurrence patterns than the moister areas.

**Survey Timing – One Breeding Season Limit on Temporal Variables**

The Swainson’s thrush is a long distance Neotropical migrant (Campbell et al., 2001). Changes in habitat on the breeding grounds and wintering grounds could skew results if data were collected over two breeding seasons. Study design was completed in 2013 and fieldwork was limited to the early spring of 2014 for habitat assessment and late spring of 2014 for bird data collection.

**Survey Timing and Seasonal Considerations**

Swainson’s thrush is a later Neotropical migrant (Campbell et al., 2001). Like many other Neotropical migrant songbirds, this species is less particular in its selection of migratory stopover habitat than it is in breeding territory selection (Boreal Songbird Initiative, 2007). As the study aims to document only breeding territory selection as a measure of the suitability of forest patches in relation to their size for breeding Swainson’s thrush, surveys were carefully timed to exclude all migrants to the extent reasonable, without excluding vital breeding data. In addition, surveys were stopped early enough in the season to reasonably prevent double counting or skewed results that might include a second brood, which Campbell et al. (2001, p. 400) identify as a possibility in the Georgia Basin. Clutches from thrushes nesting in the Georgia Basin ecoregion where this study was conducted started on June 3, peaked at around June 17th and then fell off towards July 15th, while clutches were first noticed in July according to Campbell et al. (2001, p. 400). The brood numbers rose by June 17 when the highest numbers of clutches were observed, and peaked at around July 11. According to Campbell et al., (2001, p. 394-401) Swainson’s thrush arrive in late May with 51% of clutches occurring between 14 and
30 of June. Incubation lasts 11 to 14 days. At the end of June, there is then an 11 to 14 day
nestling period.

Surveying from the beginning of June aimed to capture only breeding birds by hopefully
eliminating migrants. While a few late migrants cannot be guaranteed to be absent, the benefit of
not missing late migrants offsets this consideration. In addition, replication of the surveys
throughout June and July should allow fairly steady numbers to be found. The month of June is
therefore core, with the first two weeks being dedicated to settlement and nest building. Females
are accepted and territories are delineated. The second and third weeks of June are when
breeding is more strongly established with incubation occurring in this period. Only the first
brood is potentially counted. Counting in the first 11 days of July does introduce the risk that an
early incubator that started in the first two weeks of June will have fledged young and started
nesting again. However, the risk is very minimal in regards to the chance of counting second
broods compared to surveying in the second two weeks of July or into August.

Surveys were begun on June 3 and ended on July 4. Bird surveys in Coastal British
Columbia can be extended past the typical end date of June 19 all the way to the second week of
July to include Northern and Mountain regions according to the Inventory Methods for Forest
and Grassland Songbirds: Standards for components of British Columbia Biodiversity No. 15
(Ministry of Environment, Lands and Parks, 1999). Because the surveys were being conducted
in lowland regions of Southern British Columbia, a middle of the road approach was taken, with
surveys being started in the first week of June and continued into the first week of July.
Temperatures ranged between a low of 10º C and a high of 15º C. Conditions were calm and
clear on the majority of survey days with a light breeze and partial overcast for part of some
mornings. All surveys were conducted in conditions consistent with the Inventory Methods for Grassland Songbirds (Ministry of Environment, Lands and Parks, 1999 p. 5).

**Start Time Considerations and Methods**

Start times were planned so that surveys could be finished within 4 hours of sunrise on each survey day for each location in accordance with the Inventory Methods for Forest and Grassland Songbirds (Ministry of Environment, 1999, p. 6). All surveys for all four sites during all repeat survey weeks were completed prior to 4 hours after sunrise. However, due to study logistics, there were some incidental variations in start time that were presumed to have minimal impacts on the survey. Singing, calling and general activity were found to remain steady on most surveys despite modest variations in survey time windows. Time of day effects were considered in this study and primarily addressed through avoidance of surveying past the 4 hours after sunrise cut-off prescribed by the Inventory Methods for Forest and Grassland Songbirds (Ministry of Environment, Lands and Parks, 1999, p. 6). Survey timing could not be perfectly equalized as larger sites completed in one morning necessarily finish later in the day than small survey sites with some equalization of effort.

Surveys for the two smallest sites were started later than the largest sites on certain survey dates. Survey days for the smallest site were combined with the second smallest site due to proximity and the short survey time required. Combining these sites was felt to be reasonable given the later survey times for the largest sites with all sites being completed within the 4 hour post sunrise window. On certain mornings, a brief repeat visit back to the smallest site was made after the second smallest site was surveyed. Findings did not differ during those repeat checks.
**Repetition of Surveys to Collect Sufficient Usable Data**

Repetition is very important to ensure sufficient sampling and data collection across a sufficiently large timeframe when assessing bird population dynamics. The comparisons between patch sizes and bird abundance and density were repeated on each site for five survey weeks.

Inventory Methods for Forest and Grassland Songbirds (Ministry of Environment, Lands and Parks, 1999, p. 16) recommends spacing sampling visits saying “If the objective is to document abundance over the breeding season, a minimum of 3 to 4 visits well spaced in time (>1 week apart) are required and 6 to 8 visits are better.”

**Site Selection**

**Effort and Site Visit Time Proportions**

Amount of time per ha was necessarily greater in small patches compared to larger patches. Less time was spent in smaller patches, but a minimum amount of time has to be spent in order to allow a reasonable length of time for detection. Full equalization of effort is not feasible as it would result in greatly extended search times for large patches and inadequate detection windows for small sites. Cumulative time is given to each ha on larger patches as extra time is given to the surrounding area when birds are heard (Ministry of Environment, Lands and Parks, 1999).

Increased density was found in smaller forests, and due to increased observer effort due to minimum sampling efforts as previously mentioned, concerns over a sampling bias could be raised. However, a given amount of time in a larger forest allows more ha to be sampled than could be sampled at a smaller site in the same amount of time as the detectability of thrushes across several ha is high. However, a minimum amount of time had to be spent on smaller
patches to ensure proper detectability and avoid the unreasonably low detection times that would result from a purely acre to hours proportion based approach.

Table 1 displays the effort allotted to each site in relation to patch size in minutes per ha and ha per hour.

Table 1. Observer effort in ha covered and hours used: See effort rationale section below explaining how possible bias was taken into consideration.

<table>
<thead>
<tr>
<th>Patch Size (ha)</th>
<th>Mean Time (min)</th>
<th>Rate (ha/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.15</td>
<td>22</td>
<td>6</td>
</tr>
<tr>
<td>4.06</td>
<td>25</td>
<td>9</td>
</tr>
<tr>
<td>21.44</td>
<td>80</td>
<td>17.86</td>
</tr>
<tr>
<td>95.31</td>
<td>180</td>
<td>33</td>
</tr>
</tbody>
</table>

Swainson’s Thrush Observation Protocols and Observer Information

I have found that Swainson’s thrush sing in the early morning hours just before sunrise and continue on into the mid-morning as far as activity peaks are concerned. In the mid-afternoon, the thrushes usually resume singing and continue vocalizing well into the evening hours. Swainson’s thrush are easily detected through careful listening, which is the best approach to locating this species in my experience. Quiet observation in suitable habitat should quickly produce sightings as the birds make their way from perch to perch or forage on berry bushes. It is important to avoid disturbing the birds, which could potentially bias or reduce observations.

One experienced observer (the author of the study) detected all thrush calls, songs and relevant vocalizations as well as sightings. GPS coordinates, habitat data and detailed information surrounding each bird sighting or auditory detection were passed on to a thoroughly briefed field assistant with knowledge of ecology and habitat conditions in the study areas. The observer and author of the study has over 10 years of experience with ear birding and is
especially familiar with the calls of the Swainson’s thrush and all local songbirds in the Mid-Vancouver Island Area. It can therefore be stated that error rates from identification would be minimal, with detection of singing thrushes near 100% due to careful listening. Visual observation with binoculars allowed close up views of thrushes and analysis of their habitat and precise location. Quiet walking and careful movement through the forest was a closely observed goal to avoid disturbance of the thrushes and alteration of results.

**Survey Routes and Selected Survey Methodology**

Each study area was examined by map and carefully ground truthed prior to the start of breeding bird monitoring days. In conjunction with vegetation surveys, which are reflected in this report, biophysical traits of each site, animal occurrences of note and ecological conditions of special interest were documented and accounted for in field notes.

Exhaustive sampling techniques were used in all forest patch study sites to fully account for each ha and bird present. After extensive consideration, site assessments, consultation with third party advisors and literature review, a customized approach with combined approaches was used. Exhaustive sampling through closely spaced transect lines and frequent stops to cover the entire forest efficiently without missing spots or double counting was selected. Each parcel was mapped out with survey tape and GPS waypoint collection in order to divide parcels into distinct sections with accurate survey routes. Due to the small size of each forest parcel and the interest in measuring the total number of birds for each parcel, survey routes were designed to ensure full coverage, 1 ha at a time without any undue risk of recounting or missing birds. Flagging tape was put up to identify 100 m intervals. Walking along these lines allowed proper coverage of each forest section on surveys, with stops every 100 m to listen for birds not previously detected.
While survey routes were carefully cordoned off, there was some variation in the exact path walked to avoid dangerous terrain or challenging conditions as the surveyor and assistant became more familiar with each site. However, variation in route and time taken for each repeat visit to a given site was minimal. Some variation was taken within blocks as experience was gained to avoid sensitive ecosystems patches, wet terrain, snags or dangerous obstacles. Detection rates were maximized through careful starting and stopping in each 1 ha section defined by the pre-surveyed study area boundaries within each site. 100 m transect lines ensured that no bird would foreseeably be missed. At the same time, the lines also prevented over-counting by allowing proper assessment of the location of each bird. At any one time, the researchers were within 50 m of birds being recorded on either side. The 1 ha figure is obtained by stopping at least every 100 m along the transect lines spaced 100 m apart. Singing birds heard beyond the immediate boundaries for counting were flagged and then approached for further investigation and note taking before continuing along transects.

**Data Entry and Analysis**

Environmental parameters, bird occurrences, observations and GPS data were double checked by the researcher and field assistant due to the sensitivity of the study to potential errors. Even a few errors could have significantly impacted on the viability of the bird count and forest data. GPS mapping was conducted with a Garmin GPS, while a mercury thermometer was used to take ambient air temperatures. Beaufort scale and American Sky Code measures were used to assess weather conditions on each survey morning. Vortex Viper Binoculars with coated lenses, well suited to low light conditions, were used.

Careful field notes were made for each GPS waypoint on a clip board to document bird vocalization types, vegetation notes and presence of environmental or animal factors of interest.
such as water courses, mammalian predators, avian predators and sudden changes in elevation or vegetation composition. Each GPS point was double checked to ensure accuracy. The GPS waypoints were taken after ample time for the GPS to become oriented had elapsed. GPS waypoints were then entered onto Google Earth for assessment and used to create weekly maps for each survey. Each week, the maps of bird occurrence for each site were analyzed for occurrence and distribution patterns relating to vegetation types, patch size effects as well as territory locations and bird behaviors. After comparing all the maps for occurrence patterns, data were compiled into a spreadsheet for review and statistical analysis.

**Survey Method**

I opted to use exhaustive sampling as my bird survey method for the project rather than selecting a sample portion of the forest. Transect lines were used as guidance and to divide the forest into easily surveyed plots, but we did not use plots or transect lines as samples. The study was distinct in nature from even territory sampling and was instead tailored to the specific forest environments present that was characterized by relatively small patches and a need for thorough and complete assessment of bird occurrences and environmental conditions. These decisions would not be feasible or ideal for many studies, but my goal of surveying abundance and related variables in urban forests and near urban forest patches in Coastal BC made the approach of systematic sampling the most feasible. This is not to say that the effort was not considerable, especially since I repeated the surveys no less than five times. It would be more challenging and meaningful to design a study to sample part of each forest study site.

Given the small size of the smallest patches (less than 3 to 5 ha), the only option was to survey the entire patch. The physical effort was greater, but the benefits in accuracy and the reliability of findings outweigh the potential challenges of true exhaustive sampling repeated on
multiple sites. Forest patch size was the independent variable. The dependent variables were measures of bird abundance and/or density. Attention was paid to behavior, possible gender based on calls and location within each patch. In order to ensure the results were meaningful and reliable, careful methods were used to ensure proper site selection, proper and thorough surveys of each site. Bird surveys were carefully timed and scheduled for maximum effectiveness.
Results

Figure 10 illustrates the relationship between the mean abundance of singing male Swainson’s thrush detected and forest patch size in ha.

There was a strong linear association between patch size and the mean number of males singing ($r^2 = .998$, $p < .001$) (Figure 9). In patch sizes between 2.15 ha and 4.06 ha, mean abundance of singing males were around 1 and 1.2 respectively, while numbers increased to about 3.1 in the 21.44 ha site. At 95.31 ha, around 9.8 singing males were present. Thus, abundance in birds increases by close to 10 fold with increase in patch size by about 44 fold.
Figure 11 relates the mean density of singing male Swainson’s thrush detected and forest patch size in ha.

![Graph showing the relationship between patch size and mean number of singing males per ha.]

There is a causal relationship between patch size and mean number of singing males per ha. However, the relationship is not linear. The curve follows a pattern that resembles a mild exponential increase in the dependant variable of avian density as patch size declines. The density of singing males is high at around 0.57 per ha in the 2.15 ha zone, dropping to 0.25 approaching 4.06 ha. Density of birds appears to reach a threshold of about 0.14 birds at a threshold at 21.44 ha, while declining slightly to 0.11 in the 95.31 ha zone.

*Figure 11. Mean density of singing males as a function of patch size*
Figure 12 relates mean density of singing male Swainson’s thrush to forest patch size in ha log\(_{10}\) transformed.

\[
y = -0.249 - 0.398 x
\]
\[
r^2 = 0.800
\]
\[
p = 0.069
\]

Figure 12. Mean density of singing males per ha log\(_{10}\) transformed

When the data for singing males were log\(_{10}\) transformed (Figure 11) there was a non-significant linear relationship between the variables of avian density and patch size. Density increased as patch sizes declined. \(r^2 = .8, p = .069\) which is not significant but there is a fairly clear trend showing higher densities as patch sizes decrease. The density of thrushes per ha rises noticeably as patch size declines. \(r^2 = .92\) while \(p = .027\) which is notably less than .05 so the
effect is statistically significant. Given the fact that $r^2$ was .8 and the $p$ value was close to .05, the non-significance may be a result of small sample size and minor variations in data.

Figure 13 relates the mean abundance of total Swainson’s thrush individuals detected and forest patch size in ha.

\[
y = 1.101 + 0.197 x \\
r^2 = 0.999 \\
p < 0.001
\]

*Figure 13. Effect of patch size on mean total seen or heard (abundance)*

There is a strong causal relationship between patch size and the mean total of thrushes seen or heard, whether calling or singing. $r^2 = .999$ with $p < .001$, which is very significant statistically. At around 2.15 ha, around 1.1 birds are detected. Abundance declined slightly to a mean of around 1 bird at 4.06 ha. At 21.44 ha, around 3.1 birds are found while the increase to 95.31 ha zone puts numbers to 10 birds detected.
Figure 14 relates the mean density of total Swainson’s thrush individuals detected and forest patch size in ha.

The relationship is very similar to that shown for density of singing males only density of singing males. There is non-linear causal relationship between patch size and the mean number of birds per ha. The curve follows a pattern that resembles a mild exponential increase in the dependant variable of avian density as patch size declines. The density of birds is exceptionally
high in the 2.15 ha zone at about 0.66 birds per ha, with a notable drop to 0.46 approaching 4.06 ha. Density of birds reaches threshold of 0.27 around 21.44 ha, while declining slightly further in the 95.31 ha zone to 0.20 birds.

Figure 15 relates the mean abundance of total Swainson’s thrush individuals detected and forest patch size in ha log_{10} transformed.

Figure 15. Effect of patch size on the mean total per ha log_{10} transformed
When the data are log transformed there is a significant linear relationship between patch size and density of thrushes in total numbers seen or heard. The density of thrushes per ha rises notably as patch sizes decline. \( r^2 = .92 \) while \( p = .027 \) which is notably less than .05 and so the effect is statistically significant.

Figure 16 relates the ratio of edge to interior habitat for each study site in to forest patch size.

Smaller forests have a much higher edge to interior ratio compared to larger forests. A nearly 7-fold decrease in the ratio of interior to edge habitat is observable when comparing a 2.15 ha site with a 95.31 ha site.

*Figure 16. Patch size in ha and edge to interior ratio*
Figure 16 relates forest edge to interior ratio for each study site to patch size log_{10} transformed.

![Graph showing the relationship between log_{10} patch size and log_{10} edge:area ratio with a line equation y = -1.262 - 0.469 x, r^2 = 0.978, p = 0.007.]

Figure 17. Patch size in ha and edge to interior ratio log_{10} transformed

Log transformed, the data show a steady linear relationship between increased patch size and a clearly reduced edge to interior ratio. In the course of general observation of occurrence patterns, my study suggests that there were lower numbers of birds concentrated in drier or primarily deciduous sections of forest away from moisture, conifers and abundant shrubbery and berry bearing vegetation. Many waypoints were concentrated near habitat transition zones, mixed structural stage conifer and deciduous forests, riparian zones and shrubby wetlands. More mature forest sections were a less rich in birds compared to earlier stage forest areas within study areas.
Discussion

The data show clear causal relationships between forest patch size and abundance of birds as well as the density of birds present. I assessed various factors to obtain a clear picture of the relationships between bird occurrence and forest patch size. Abundance rises as forest patch size increases while density declines. The causal relationships between abundance and forest patch size are clear and statistically significant for both singing males and total birds detected. Density of singing males present shows a non-linear causal relationship in the form of a decline in density as patch size increases. This relationship does not remain statistically significant when log_{10} transformed. Density of total birds present shows a similar relationship, slightly stronger relationship that remains statistically significant when log_{10} transformed.

Swainson’s thrush territories average around 0.809 to 1.01 ha (Montana Natural Heritage Program and Montana Fish, Wildlife and Parks, n.d.). In the smallest patches which are close to that size in total area, density seems to approach a near saturation point, while the larger forests show a greatly reduced density with expanses of unoccupied territory according to GPS mapping patterns. There appears to be a threshold as there is little difference between total avian density at 21 ha and 95.31 ha. The crucial area lies somewhere between 4 and 21 ha, where a sharp change in territory size changes. There is a very sharp change in density between 2.15 and 4.06 ha from -0.6 birds per ha to 0.2 birds per ha.

The summarized findings of higher absolute abundance in larger forests with lower density in smaller forests raise a variety of interesting questions as an addition to avian ecology literature in the west. Figures 15 and 16 show increased edge habitat per ha as forest size decreases. Reduced edge to interior ratios increase the amount of interior forest habitat with
increased moisture and reduced edge predator occurrence. However, forest raptors and a lack of sunlight for berry bushes may limit habitat suitability for thrushes. There are trade-offs as far as patch size is considered for Swainson’s thrush habitat suitability in the breeding season.

Contrasting my findings with existing literature in Western North America raises several interesting considerations. While density was found in smaller forests could be offset by increased nest predation rates and area sensitivity. As the Swainson’s thrush is known to have a fairly low rate of nesting success as a species (Boreal Songbird Initiative, 2007) analysis of nest predation rates could shed further light on the effects of patch size.

Rosenberg et. al. (2003, p. 12) note that certain thrush populations such as the Wood Thrush may select patches of a smaller size for breeding but fail to succeed in successful nesting to the extent found in larger forests. However, Tewksbury et al. (1998) note that reduced patch sizes in western forests correlated with lower Swainson’s thrush nest predation rates and consequently higher rates of breeding success. It may be possible that smaller patches support lower numbers of predators in some regions while still providing enough habitat for songbirds. This could be the case in Parksville, where increased numbers of hawks and owls were found in larger forests.

From a different perspective, Brand & George, 2000 note that Swainson’s thrush may occur in higher densities near edges of fragmented habitats in California. However, nesting success was reduced, and these areas seem to be ecological traps in this region. Could this be the case in Parksville? More research is needed on the specifics of Swainson’s thrush ecology, nesting and predation now that abundance and density of birds during the breeding season has been outlined through this study.
The presence of crows presents a potential concern as nest predators that could take advantage of fragmentation. Several crows were noted in at all four study locations. Grey squirrels are potential nest predators and a non-native species present at all sites. Feral and free roaming cats are known to be present in the three smaller study areas. Invasive plant species presence was noted in sections of all four study areas, with the highest density of ivy and non-native ground cover at the smallest site. Brown-headed cowbirds were found in the vicinity of all four study areas. However, cowbird parasitism was found to be a lesser consideration in the Swainson’s thrush by Campbell et al. (2001), who detected 8% parasitism rates in 395 nests sampled. White & Gardali (2004) observed that 4% of 224 nests sampled were parasitized, compared to 35% of Wilson’s warbler nests parasitized. Cowbirds being less likely to parasitize Swainson’s thrush raises interesting questions as to the potential resilience of Swainson’s thrush in fragmented habitat. In my study no cowbird parasitism was found in Swainson’s thrush. Limited cowbird parasitism stood out in work discussed by Neotropical Birds Online (2010, p. 2), while nest predation rates were high, making predators of all types a potential concern. Warbling vireo nests were found to be parasitized by cowbirds in my largest study area. Potential factors such as increases in mesopredator numbers due to declines in top predator populations are standard factors in the field of ecology that could relate to Swainson’s thrush nesting success in smaller patch sizes. At the same time, larger patches could foreseeably attract higher numbers of native nest predators such as owls, hawks and even ravens. Trade-offs may exist.

Certain minimum patch size requirements for bird use seem to be present depending on the species and ecosystem type studied. For the Swainson’s thrush, findings vary. Rosenberg, et al. (2003, p. 19-22) describe conflicting findings among the limited Swainson’s thrush literature available and highlight the significance of variation by region and habitat type in this species.
The Swainson’s thrush may or may not be area sensitive, depending on the specific population studied. Alderfer (2006) notes that the Swainson’s thrush has limited available habitat in Western North America, identifying habitat fragmentation as a possible further limiting factor.

Research by Lehmkuhl et al. (1991) did not find area sensitivity among Swainson’s thrush study subjects in Douglas-fir Forests of the Washington State’s Cascade Mountains, near the Pacific coast. This region is fairly close to the habitat my study area falls within, but the habitat is outside of coastal lowlands fir forest ecosystems. Rosenberg et al. (2003) observe that area sensitive Neotropical migrants may prefer forest areas 100 m from an edge, which requires that patches be larger in order to be suitable. My study has preliminary elements to its design, as the main question involved density and abundance of breeding birds as opposed to a secondary study of breeding success rates in relation to forest patch size.

Looking further to the South, Swainson’s thrush populations in riparian areas in Nevada did display area sensitivity, according to Freemark et al. (1995). Evans (1995) found no significant relationship between patch size and Swainson’s thrush abundance in mixed coniferous forests in the Northern Rockies. Stands in more a fragmented landscape matrix had fewer nests and lower nest success than stands in more contiguous landscapes in the same study area (Evans et al., 1998 as cited in Rosenberg et al., 2003). A more heavily impacted matrix seems to amplify fragmentation effects in individual patches. Rosenberg et al. (2003) note a strong relationship between the condition of the surrounding habitat matrix and level of fragmentation and the minimum area required for breeding by given thrush species. In Parksville, a moderate to high level of fragmentation was found in the surrounding habitat matrix, with comparable types of edge habitat nearby.
Studies such as those by Hames (2002) explored fragmentation effects on thrushes in the interior West, but did not address any coastal areas. George and Brand, (2002, p. 4), noted that area sensitivity has been defined by an increased abundance of birds in relation to patch size, and point to patterns of reduced area sensitivity in Western landscapes according to their literature findings (p. 10). However, discussions by Rosenberg et al. (2003, p. 2-12) describe thrush related research where area sensitivity is measured in terms of nesting success in relation to patch size. However one defines area sensitivity, nesting success and patch relationships, it is clear from a detailed review of the literature on North American thrushes, particularly the Swainson’s thrush that current knowledge is limited. Mixed findings to date add further complexity.

Rosenberg et al. (2003, p. 19) describe findings showing area sensitivity in interior west studies on Swainson’s thrush with a contrasting absence of area sensitivity on the coast, where the birds are strongly associated with understory shrubs. Rosenberg et al. (2003) mention research with findings of higher abundance in larger forests, but note limited relationships between the extent of fragmentation in the habitat matrix and the requirements for a given patch size. Increased levels of fragmentation may reduce the value of small patch sizes across the landscape in some cases. This study is primarily concerned with nest site selection, but breeding success warrants further research in the Georgia Basin region.

Hames, (1999, p. 1-5) described symposiums focused on comparing fragmentation and patch size effects in the East and West of North America to assess the area sensitivity of focal species. The Swainson’s thrush and Western tanager were compared with the veery and scarlet tanager, with the finding that all four species tended to decline in association with fragmentation and reduced patch sizes in increasingly human dominated ecosystem matrix environments in both the east and west. However, Tewksbury et al. (1998) note that reduced patch sizes in
western forests have been correlated with lower Swainson’s thrush nest predation rates and consequently higher rates of breeding success. It may be possible that smaller patches support lower numbers of predators in some regions while still providing enough habitat for songbirds. Hejl et al. (2002 as cited in Rosenberg et al., 2003) reported that “Swainson’s thrushes in the Central Rocky Mountains were positively associated with amount of forest and patch size, and negatively associated with edge in “all coniferous forest,” but found no relationship among these habitat variables in ‘mixed conifer,’ ‘cedar/hemlock,’ or ‘ponderosa pine forest’ environments.”

A null hypothesis of no significant relationship between patch size and abundance and density can be soundly rejected. It appears from the data that higher absolute avian abundance in larger forests with a lower relative avian abundance in smaller forests is outweighed by the increase in density in small forests. There are more birds per ha in smaller forests, which raises a variety of questions as to why that is the case. For example, are smaller forests better for nesting Swainson’s thrushes, or is the increased density misleading? As previously discussed, higher density could be coupled with lower breeding success in the form of a population sink effect. Further investigation could be warranted to examine breeding success in forests in Parksville. The literature shows reductions in major limiting factors to nesting success in small forests some studies, while pointing to reduced nesting successes in other studies. Population sink effect may exist where the reproductive rate among birds in a specific habitat is exceeded by the population decline rate. Identification of whether habitats are actually sources or sinks over the long run is important for conservation planning (Swiss Ornithological Institute, n.d.).

Limiting factors such as predators may be more prevalent in larger forests, while nest raid rates could be higher in smaller forests due to increased crow or grey squirrel presence compared to more intact forests. Other factors that warrant consideration are ratios of interior to edge and
vegetation composition. Rosenberg et al. (2003) describe coastal Swainson’s thrush as a shrub dependant bird of mixed forests primarily at 62% occurrence, while purely deciduous or coniferous forests have much lower occurrence rates. Interestingly, smaller sites were estimated to have a higher percentage of suitable habitat in certain areas, while the largest site contains several hectares with very low detection rates. I observed higher numbers of owls in the largest sites, with two barred owls present on the 20.33 ha site and two barred and at least two great horned owls present in the 95.31 ha site. Cooper’s hawk and merlin were also more widely detected as patch sizes increased. Grey squirrels were observed in association with human activity and in natural forest sections in all four study areas and in deeper forest sections. Neotropical Birds Online (2010) notes that nest predators may be a significant factor affecting Swainson’s thrush breeding.
Conclusion

Overall, significant relationships were found between patch size and density and abundance of Swainson’s Thrush. Through an overview, it appears from the data that higher absolute avian abundance in larger forests with a lower relative avian abundance in smaller forests is outweighed by the increase in density in small forests. There are more birds per ha in smaller forests, which raises a variety of questions as to why that is the case. In smaller forest areas, habitat is less available, which could mean that Swainson’s thrush numbers are higher per ha due to crowding and limited habitat availability.

However, one might expect dispersal of a mobile avian species to result from higher densities, which limits this theory. It is possible that higher densities reflect increased habitat suitability through enhanced habitat characteristics such as increased light and berry bush availability and a reduced number of limiting factors such as predatory hawks and owls or dense forest areas devoid of essential vegetation features. Swainson’s thrush numbers were limited in certain parts of the largest patches where structural diversity, moisture or vegetation diversity were limited.

My study focuses on territory selection, which is an area of research deficiency for the Swainson’s thrush for the Pacific Northwest, rather than breeding success (Neotropical Birds Online, 2010). With density and abundance during the breeding season determined, further research may be indicated to determine breeding success in relation to patch size. Certain studies discussed in the literature have pointed to increased breeding success in Western North America in smaller patches. This could be the case in Parksville. At the same time, other studies previously mentioned show higher habitat utilization rates in forest edges associated with
fragmentation, coupled with higher predation and nest failure rates. As a result, smaller patches
could actually be ecological traps or population sinks as discussed by the Swiss Ornithological
Institute (n.d.). Results from my work could be considered in conjunction with existing and
future breeding success studies and possible population sink factors. My key recommendations
at this stage center on maintaining ecological diversity and habitat integrity in larger forests over
20 to 30 ha in size with higher levels of interior habitat. Protecting forest habitats and pursuing
further study on breeding success and avian survival in smaller forests under 20 ha with higher
amounts of edge habitat is worthwhile.

It is important to note that the findings of increased density in smaller forests should not
convince land managers that forest fragmentation is not a threat to Swainson’s thrush survival.
Lower densities of thrushes could be experiencing higher nesting success rates in larger forests.
In addition, land use patterns such as logging, insufficient natural disturbance by wildfires and
harmful effects caused by invasive species could be limiting the productivity and ecological
diversity required by thrushes in larger forests. With good management, sub-optimal habitat
conditions in larger forests such as overgrowth and loss of understory or densification of new
stands could be corrected, making these habitats increasingly viable. On an ecosystem scale,
connectivity and greater area extent in forests are generally positive factors that support
resiliency and are worth protecting. Further research and management can benefit the
Swainson’s thrush and help prevent declines among breeding populations. Selective thinning and
encouragement of understory vegetation in all forests encourages insect food, while silvicultural
practices that maintain both coniferous and deciduous vegetation of a variety of ages are
important as well as maintaining adequate area extent and connectivity (Rosenberg et al., 2003).
Encouraging structural diversity and maturation allows large woody debris to form, which supports the invertebrate prey required by Swainson’s thrush. Use of pesticides or loss of wetland elements in thrush habitats may pose a threat, as these birds rely on wet areas and insects as a large part of their diet. Smaller forest patches are also frequently associated with an increasingly deforested or otherwise altered habitat matrix. As forest patches become smaller, fewer patches remain and total habitat area is limited. As a result, dispersal in young thrushes may be impeded due to an absence or lack of sufficient new territory to claim. Further exploration into limiting and enabling factors for thrush habitat use, and comparison of breeding success rates are certainly worth pursuing now that habitat selection and occupation statistics in the breeding season have been obtained through this study. Studies of wintering populations in Central America with attention to habitat use and potential limiting factors could prove to be useful in understanding conservation needs. Overall, Swainson’s thrush appear to settle in small forests in numbers that add up to a higher density than the larger numbers of dispersed individuals in large patches during the breeding season in the Georgia Basin. The question as to whether breeding success is constant, increases or declines as patch size is reduced remains open to further research as this study focuses on territory selection.
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Ministry of Environment, Lands and Parks: Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Committee (1999). *Inventory Methods for Forest and Grassland Songbirds: Standards for components of British Columbia Biodiversity No. 15.*


