Comparison of Landbird Abundance and Diversity in Hedgerows in Delta, BC between 2016 and 2017

Update from 2016 study: "Effects of Hedgerow Age, Structure, and Plant Species Composition on Landbird Abundance and Diversity in Delta, BC" by J. Sibbald

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Acknowledgements

This report is a 2017 seasonal update and continuance from the 2016 study "Effects of Hedgerow Age, Structure, and Plant Species Composition on Landbird Abundance and Diversity in Delta, BC" by J. Sibbald for the DF&WT. The current author has permission from J. Sibbald to use the 2016 report as a base for the updated 2017 Report; as such, a large portion of the content of this report was authored by J. Sibbald; with much appreciation from the current author.

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Summary

This report and associated spreadsheets summarize findings from the 2017 internship that entailed studying abundance and diversity of Landbirds using hedgerows planted by the Delta Farmland and Wildlife Trust (DF&WT) in Delta, BC. This research began as a pilot study in 2015 that entailed comparing bird communities to hedgerow age (Kujawiak 2015). In 2016, the study additionally focused on the relationships between Landbirds and characteristics of hedgerow vegetation (Sibbald, 2016).

The 2017 study focused on the same hedgerows and paired-control sites established in the 2016 study. The 2016 study included surveys of vegetation and bird behavior and breeding that were not performed in 2017. The 2017 study included updated summaries of associated site features including water sources, fences, power lines, and roadways. The 2016 and 2017 studies focused mainly on surveys of birds along a single side of each hedgerow, but 2017 including surveys of birds on both sides of four hedgerows. The purpose of surveying both sides of a hedgerow was (1) to verify whether bird communities were similar on both sides of a hedgerow (and thus whether surveys of a single side were sufficient), and (2) to assess the influence of site features (e.g., roads) that occurred only on a single side of a hedgerow on bird communities.

Values of bird abundance, species richness and Simpson's diversity for each hedgerow are compared by hedgerow and between survey years. Species present at each site proved to have consistent patterns in both years with highest total seasonal number of species in the two Reference sites (Reference 1 & Reference 2) and least number of species observed in the DFWT7 and DFWT5 sites. Abundance and diversity were lower in 2017 vs. 2016, which could be due either to observer bias or annual differences in weather. The DFWT1 site proved to be the most peculiar between the two years; having the greatest abundance and richness in 2016 but substantially lower in 2017. A great suspect for this was based on difference in active usage of the field in 2017 converse to little activity in 2016. Abundance and Simpsons Diversity for all species compared to hedge associated species was found to be much higher in sites with increased number of anthropogenic features and connectivity (DFWT6 & DFWT4).

Finally, abundance and diversity were mainly similar between the two sides of the four hedgerows, and thus a single survey is likely sufficient to document a hedgerow's bird community. However, it is advisable to continue with this procedure for at least one additional season, in order to accurately observe active Landbirds within the early half of the breeding season.

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1.0 Background

In 2015 an internship position was created in partnership between DF&WT, City of Surrey, and British Columbia Institute of Technology's (BCIT) Rivers Institute (RI) to study the diversity and abundance of Landbirds along planted hedgerows in Delta, BC. With the success of the 2015 pilot study, this internship was again offered in 2016 (Sibbald, 2016) and 2017. This report focuses on results of surveys conducted during May through July of 2017, including comparisons with results from 2016. The 2015 results conducted by A. Kujawiak are not compared in this report.

1.1 Study Purpose

One purpose of this study was to provide work experience and training for an intern enrolled in BCIT's Ecological Restoration Program. For the 2017 survey, I had no previous birding knowledge; hence, the beginning weeks of the study were used to learn bird identification in the field. It was understood that this lack of previous knowledge could impede comparisons of results from other years.

The purpose of this study was to:

1. Continue the 2016 study that entailed assessing the abundance and diversity of bird species within hedgerows of various ages that were planted as part of the DF&WT Hedgerow Stewardship Program (Sibbald, 2016),
2. Compare results between the 2016 to 2017 study years,
3. Assess the suitability of survey methods; as well as,
4. List of site features (e.g. roads, buildings) with potential impacts on bird communities.

1.2 Brief Overview of Changes to the 2016 Study

The studies included nine sites. I used bird survey methods in 2017 that were identical to those used in 2016, with the following exception.

The 2016 bird surveys entailed transects along a single side of each hedgerow. In 2017 bird survey transects were established along both sides of the hedgerow at four sites (Reference 1, DFWT7, DFWT5 and DFWT1) to enable additional analyses and suitability of survey methods (see sections 2.1.2, 2.3.3, 2.7.3, 2.9.2 below).

2.0 Study Area

All surveys were conducted in Delta, BC. Delta provides important nesting, breeding, and over-wintering habitat for birds along the Pacific Flyway (British Columbia Waterfowl Society 2015). Agricultural fields and hedgerows stewarded by DF&WT are used by numerous species of Landbirds (Kujawiak 2015, Sibbald, 2016).

A total of sixteen bird transects were surveyed in 2017 across nine sites in Delta, BC (Figure 1). Transects varied in length, width, height, age, and landscape context. I used three categories of bird survey transects. First, I replicated transects used in 2016 that were established along a single side of hedgerows at each of the nine sites. Second, I also replicated paired-control transects used in 2016 that were located adjacent to hedgerows (while excluding hedgerow habitat) in three sites (DFWT1, DFWT5, and DFWT4). These paired-controls were included to enable additional inferences into the effects of hedgerows on Landbird communities (Sibbald, 2016). Third, I also established transects along the alternate side of hedgerows at four sites (Reference 1, DFWT7, DFWT5 and DFWT1). These transects were used to assess whether survey results were comparable between both sides of a hedgerow, and thus whether surveys along one side of each hedgerow were sufficient (see Methods).

For the purposes of the study, primary hedgerow transects are the transects established in 2016, control transects are the additional non-hedgerow 'paired-control' transects established in 2016, and secondary hedgerow transects are the transects added to four sites in 2017 along the opposite side of hedgerows compared to primary transects. Note that the secondary hedgerow transects may be referred to as 'backsides' in the accompanying excel spreadsheets.

2.1 Reference 1

The Reference 1 and Reference 2 hedgerows are located within the Alaksen National Wildlife Refuge, which is managed by Canadian Wildlife Service (CWS) and is located on Westham Island in Delta, BC (Figure 2). Alaksen National Wildlife Refuge is adjacent to Reifel Migratory Bird Sanctuary, and collectively these areas comprise roughly 630 ha of contiguous protected land. The high connectivity of these reference hedgerows to other protected land may contribute to higher bird diversity and abundance compared to the remaining hedgerows in this study that are in more fragmented landscapes (Sibbald, 2016).

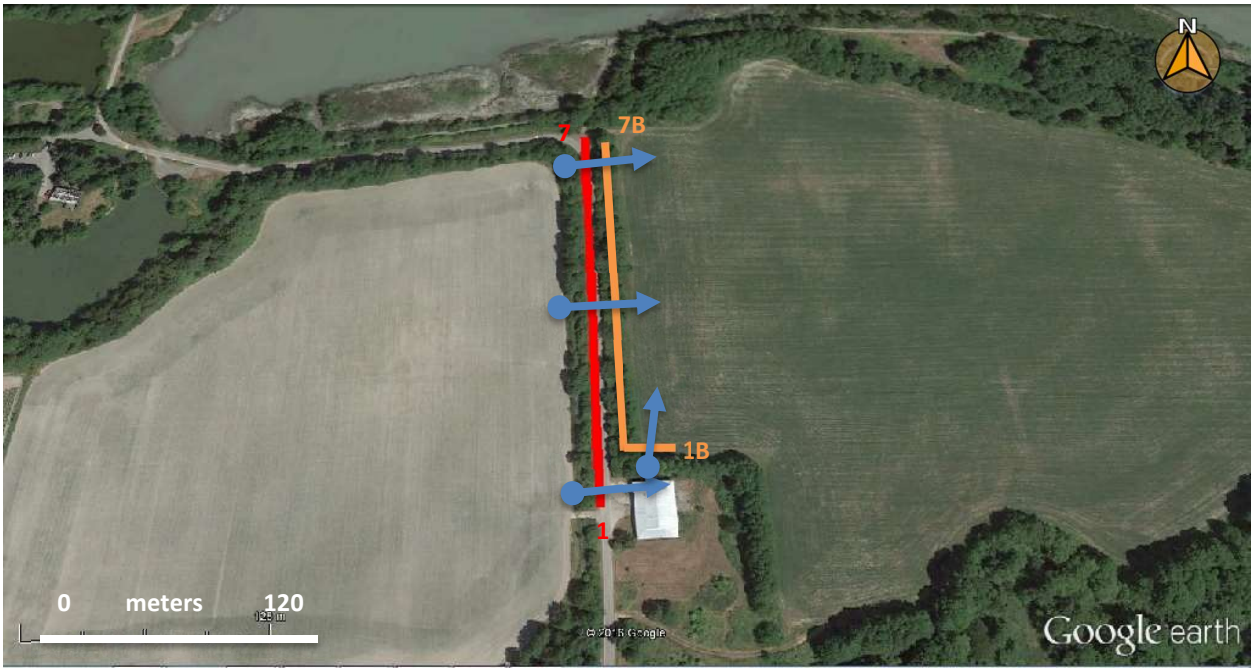

Figure 1: Location along the Reference 1 hedgerow of the transects used for Landbird surveys, including the primary transect (red) and secondary transect (orange). Blue arrows indicate transect width (50 m). Surveys were conducted in May through July of 2017 in Delta, BC. Numbers along transects indicate the first and last survey sections.

2.1.1 Primary Transect

The Reference 1 hedgerow was planted by CWS in 1976. This site includes two parallel hedgerows separated by an access road. For this study, the 2 rows were considered a single hedgerow. The survey conducted in 2017 was performed as though the surveyor was walking through the centre of a single hedgerow. The survey area included the western (field side) edge of the western hedgerow extending 50 m eastward across the road including the eastern hedgerow and a portion of the adjacent field. This survey area was maintained in order to replicate surveys in 2015 and 2016, but it is challenging to detect

birds on the opposite side of this hedgerow. The surveyor walked in a single direction scanning each of the hedgerows for birds.

The bird survey methods used during 2017 in the Reference 1 and 2 sites may have differed from those of previous study years. Specifically, survey methods in past years were detailed in the 2016 report as "observing each hedge individually first heading south to north, and the other was surveyed on the way back from north to south" (Sibbald, 2016). However, indirect confirmation through communications with Eric Anderson revealed that single passes of paired hedgerows may have occurred. Hence, I determined that the technique used in the 2017 study should reflect the methods used at all other sites in the study, by performing a single pass survey along the transect to avoid biasing the data.

Additional landscape features that may affect bird communities in the Reference 1 hedgerow included:

- Low-traffic road running parallel to and between the two hedgerows;
- Powerlines (4 cables and 6 poles) running parallel along the west side of road;
- Ephemeral ditch running parallel to and along the base of both hedgerows;
- Actively managed farm fields to the west and east – using pesticides;
- Within Section 1 - Farm building and parking lot (west side of road) included in survey area;
- Within Section 1 - Functioning generator operating next to farm building;
- Outside survey area – North of flag 6 (south of 6B) is the entrance to the eastern field;
- Outside survey area – South of flag 1 is the entrance to the western field;
- Outside survey area - <50 m from a riparian area to the North of survey area;
- Outside survey area - Northern end of surveyed hedgerow(s) met with perpendicular mature hedgerow;
- (*As seen from Secondary only*) 3 bird boxes between hedge and field (Section B5 = 1) & (Section B3 = 2).

2.1.2 Secondary Transect

New to the 2017 survey included a pseudo-replicate secondary survey of the backside of the primary hedgerows (Figure 4). Although unique to the other secondary surveys, Reference 1 secondary survey method was performed similar to the standard survey techniques used in all but the two primary Reference sites (See Methods). Reference 1 secondary surveyed area included the total volume of the double hedgerow and extended approximately 50m into the eastern field (Figure 2). This area physically duplicated the surveyed area of the primary Reference 1 survey; however, the secondary survey was surveyed from the eastern edge of the hedgerow and extended 50m into the farmers field.

It should be noted that, as with the primary survey, detecting birds on the far side of this well-established hedgerow was virtually impossible; therefore, may reflect difference in observations between the primary site compared to the secondary.

Figure 2: View northward of the road running between the two hedgerows that comprise the Reference 1 site during 2017 in Delta, BC.

Figure 3: View southward from Reference 1 (i.e., along secondary transect) during 2017 in Delta, BC. Note hedgerow is immediately adjacent to an actively farmed field.

2.2 Reference 2

Reference 2 also occurs within Alaksen National Wildlife Refuge (Figure 5). This hedgerow differs from all others in this study because it is a naturally occurring 'remnant hedgerow', as opposed to a planted hedgerow. Reference 2 is dominated by native trees and shrubs, though there are invasive plants that make up a significant part of its understory. For Landbirds, remnant hedgerows serve a functionally similar role to planted hedgerows, as both can provide food, shelter, and breeding habitat (Sibbald, 2016).

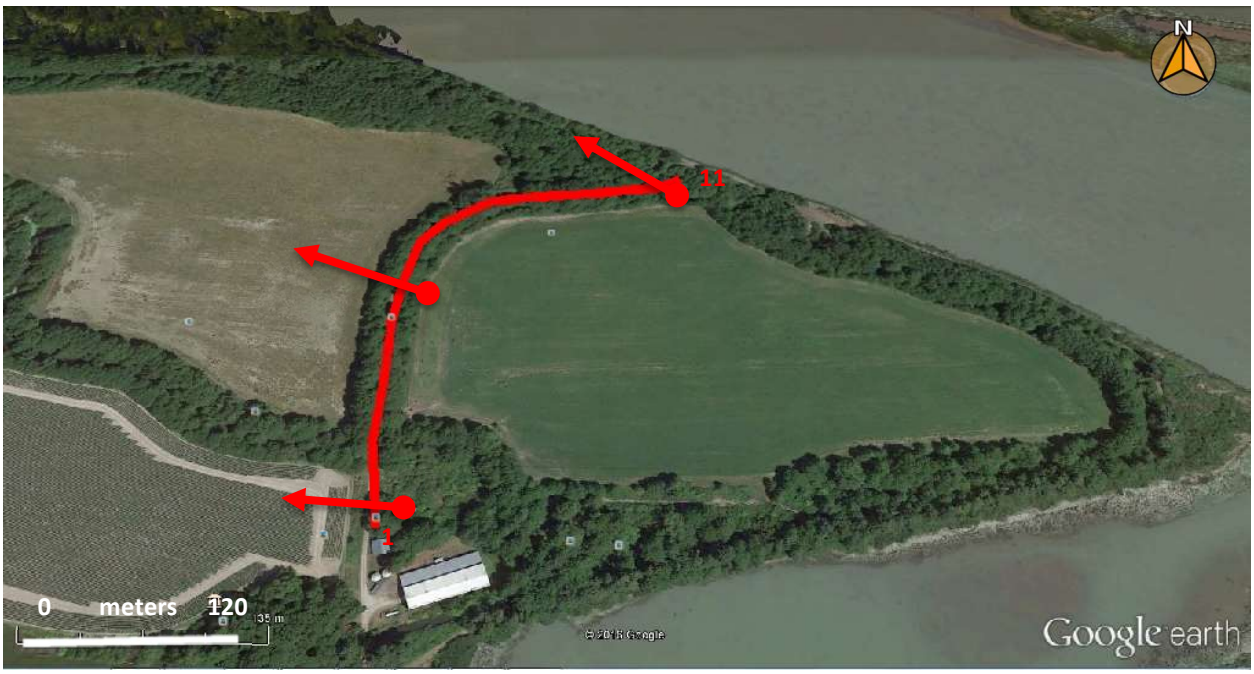

Figure 4: Location along the Reference 2 hedgerow of the transects used for Landbird survey (shown in red) conducted in May through July of 2017 in Delta, BC. Arrows indicate approximate 50m range limits of survey distance into farmers field. Number code indicates flag number.

2.2.1 Primary Transect

As with Reference 1, this site included two parallel hedgerows that were both surveyed and considered as one hedgerow. As per the Reference 1 site, survey conducted in 2017 was performed as though surveyor was walking through the centre of a single hedgerow (Figure 6). Boundaries of the survey area; beginning at north edge of barn – survey area was inclusive of eastern edge (field side) of eastern hedgerow and extended westward, inclusive of the western hedgerow to approximately 50m into the adjoining farmers field, west of the hedgerows. Due to the disjointed nature of the vegetative features of the survey area and non-permitted access to the farmers fields, 50m was approximated by eye. Like Reference 1, it was next to impossible to detect birds through the well-established hedgerows into the neighbouring fields.

Surveyor walked in a single direction scanning each side of the hedgerow for presence of birds. Birds physically engaged with the hedgerow vegetation were considered 'associated with hedgerow', birds observed on in the road or flying over were not.

As mentioned, the bird survey methods used during 2017 in the Reference 1 and 2 sites may have differed from those of previous study years. Specifically, survey methods in past years were detailed in the 2016 report as "observing each hedge individually first heading south to north, and the other was surveyed on the way back from north to south" (Sibbald, 2016). However, indirect confirmation through communications with Eric Anderson revealed that single passes of paired hedgerows may have occurred in 2016. Hence, I determined that the technique used in the 2017 study should reflect the methods used at all other sites in the study, by performing a single pass survey along the transect to avoid biasing the data.

Additional landscape features that may affect bird communities in the Reference 2 hedgerow included:

- Low-traffic unpaved road running parallel to and between the two hedgerows;
- Within Section 1 - no distinct hedgerow;
- Within Section 1 - east of road lies tall grasses and to west of road a swamp;
- Within Section 1 - farm building (east side of road) marks start point of survey area;
- Mature hedge begins at very end of Section 1 / beginning Section 2;
- Within Sections 2 through 10 a closed canopy covers the road from and varies sparse to dense changing dramatically throughout the season;
- Within Section 2 & Section 10 – Water course runs through survey area and perpendicular to hedgerow;
- Within Section 3 & Section 8 - Entrances to fields in east and west;
- Actively managed farm fields to the south, west and east – using pesticides;
- Outside survey area - <50 m from Fraser River (North of survey site);
- Outside survey area - Perpendicular walking path to survey area - location of which marks end point of survey area (Section10).

Figure 5: Facing northward into Section 1 of Reference 2 survey area from beside barn (not seen).

2.3 DFWT1

2.3.1 Primary Transect

The DFWT1 hedgerow is located on Westham Island and is surrounded by agricultural fields (Figure 7). This hedgerow is one of the oldest hedgerows planted and managed by DF&WT (Sibbald, 2016). It is a single, linear hedgerow bordering an actively used farmers field, growing potatoes in 2017. The field, eastward of the hedgerow, remained as bare soil for most of the survey period (Figure 8). Mary Taitt noted during a training session that the hedge had been significantly trimmed back from the previous year (Mary Taitt, DF&WT, *pers. comm*. 2017). Birds physically engaged with the hedgerow vegetation were considered 'associated with hedgerow', birds observed in the field or flying over were not.

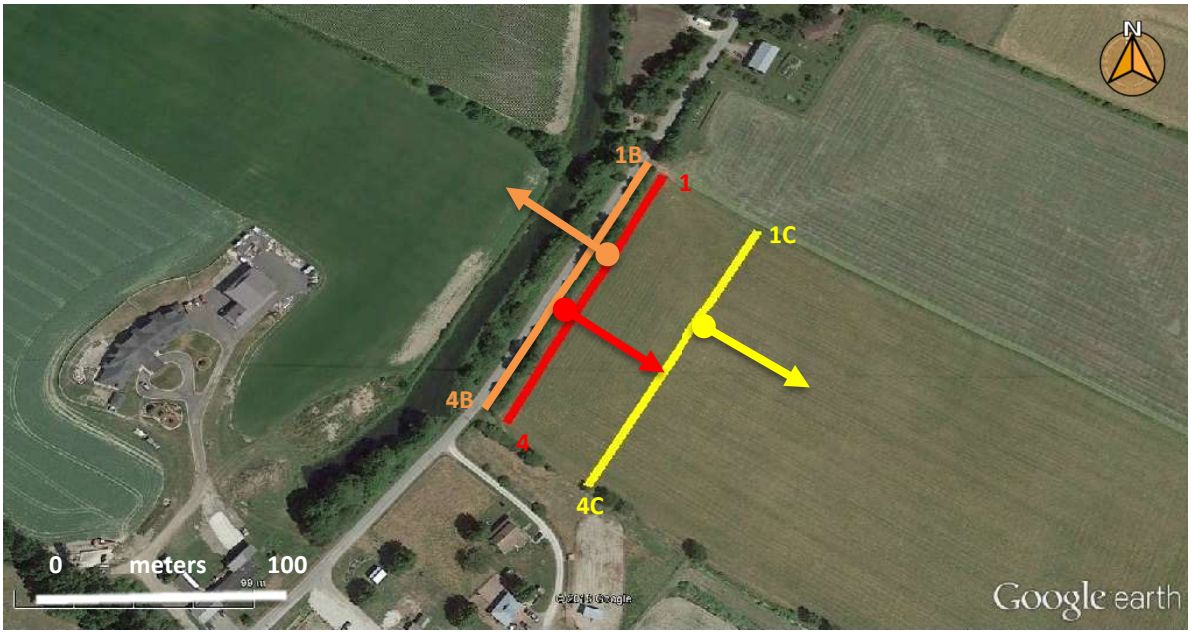

Figure 6: Location along the DFWT1 hedgerow of the transects used for Landbird and vegetation surveys (shown in red), control transect (shown in yellow), Secondary (shown in orange) conducted in May through July of 2017 in Delta, BC. Arrows indicate approximate 50m range limits of survey distance into farmers field. Number code indicates flag number.

Additional landscape features that may affect bird communities in the DFWT1 hedgerow included:

- Outside survey area (southwest) – 2.5m fence runs along southern end of hedgerow as entrance to field;
- Outside survey area (northeast) – hedgerow continues past northern entrance to field;
- Outside survey area – <50 m to buildings;

- Outside survey area – decorative treed line (pseudo-hedge) runs perpendicular to hedge at south end of survey site dividing property lines;
- Active farmers field.

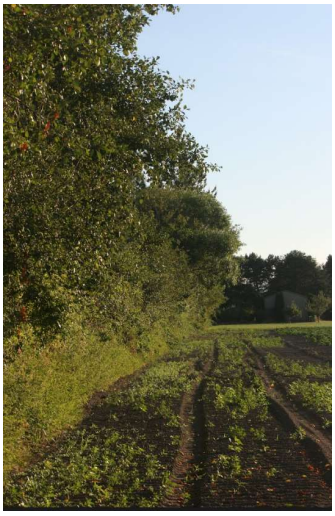

Figure 7: Facing northward along the DFWT1 survey site.

2.3.2 Control Transect

The DFWT1 hedgerow is one of three hedgerows with an additional control transect for Landbird surveys (Figure 4). The control transect was offset 50m from the hedgerow transect, ran an equal length, and occurred within the adjacent tall grass field (Sibbald, 2016). As noted, the field was bare soil for most of the study in 2017.

2.3.3 Secondary Transect

The DFWT1 hedgerow is also one of four hedgerows with a secondary survey. Surveyor walked along roadway to detect birds in hedge and 50m westward; inclusive of roadway and neighbouring property.

Additional landscape features (other than those mentioned in the Primary Site) that may affect bird communities in the DFWT1 Secondary included:

- 5m wide light traffic road running parallel and west of hedgerow with a 1.5m grassy buffer
- Remnant hedgerow (intermingled with blackberry) runs parallel to surveyed hedge on west side of road
- 20m wide slough with riparian vegetation parallel to hedge is located on west side of remnant hedgerow
- Powerlines (4-lines) on west side of road parallel with hedgerow

2.4 DFWT2

2.4.1 Primary Transect

The DFWT2 hedgerow is located in East Delta, east of Highway 99 (Figure 9). The site consists of one continuous hedgerow that wraps around the perimeter of the DFWT2 property. The DFWT2 hedgerow is unique among hedgerows considered in this study in that it was established alongside their Field Margin Ditch Program (Sibbald, 2016). The combination of a hedgerow, grass-margin, and riparian area increases the diversity of niches and habitat quality for Landbirds, while improving drainage for irrigation purposes (Sibbald, 2016).

Figure 8: Location along the DFWT2 hedgerow of the transect used for Landbird (shown in red) conducted in May through July of 2017 in Delta, BC. Riparian area created through the Field Margin Ditch Program is marked with a star. Arrows indicate approximate 50m range limits of survey distance into farmers field. Number code indicates flag number.

Birds physically engaged with the hedgerow vegetation were considered 'associated with hedgerow', birds observed on in the fence, in the path or flying over were not (Figure 10).

Additional landscape features possibly affecting bird communities in the DFWT2 hedgerow include:

- Manicured grassy 3m wide margin separated hedge from parallel wire fence line
- Within Section 5 & Section 9 - Fence line branches perpendicular to hedge

- Outside survey area - light-traffic road and powerlines running parallel to west hedgerow
- Outside survey area - ditch running parallel to west and east hedgerow sections
- Outside survey area - Agricultural fields surrounding north, east, and south hedgerow sections
- Outside survey area - buildings and horse stables <50 m.

Figure 9: Facing south in Section 9 of DFWT2 hedgerow; note manicured path and wire fence line separating hedge from field.

2.5 DFWT3

2.5.1 Primary Transect

The DFWT3 hedgerow is located in East Delta along the border of Highway 99 (Figure 11). This location makes it unique among the DF&WT hedgerows because it is the only one near a major highway. The close proximity to Highway 99 results in significant noise that likely reduces Landbird diversity and abundance (Sibbald, 2016), as well as surveyor's capacity to detect signs of birds. Birds physically engaged with the hedgerow vegetation were considered 'associated with hedgerow'.

Noted for the assistance of future surveyors is the location of the entrance to the hedgerow (Figure 11).

Figure 10: Location along the DFWT3 hedgerow of the transect used for Landbird and vegetation surveys (shown in red) conducted in May through July of 2017 in Delta, BC. Arrows indicate approximate 50m range limits of survey distance into farmers field. Car icon notes entrance to field. Number code indicates flag number.

Additional landscape features that may affect bird communities in the DFWT3 hedgerow included:

- Outside survey area – behind the hedgerow was Hwy 99;
- Within Section 2 – section is predominantly a grassy gap window to Hwy 99;
- Within Section 6 & 7 - 1.5 m tall shrub hedge runs perpendicular to surveyed hedgerow;

- Outside survey area – Section 13 butts against Industrial site (Figure 12);
- Outside survey area – powerlines to northwest of hedgerow;
- Active farmers field;
- Frequent propeller plane overhead;
- Outside survey area – <50 to buildings and industrial site;
- Blueberry cannons frequently going off;
- DFWT3 hedgerow has relatively less connectivity to other hedgerows, and is surrounded by an expanse of agricultural fields.

Figure 11: Facing northwest along DFWT3 hedgerow. Note Industrial site which butts against the end of the hedgerow marked by arrow, next to Section13.

2.6 DFWT4

The DFWT4 hedgerow is located in Delta south of Ladner (Figure 13). DF&WT initially planted the hedgerow in partnership with the farmers who owned the land. Since that time the land has been sold to a Railway Company, which has thus far left the hedgerow intact. (Sibbald, 2016).

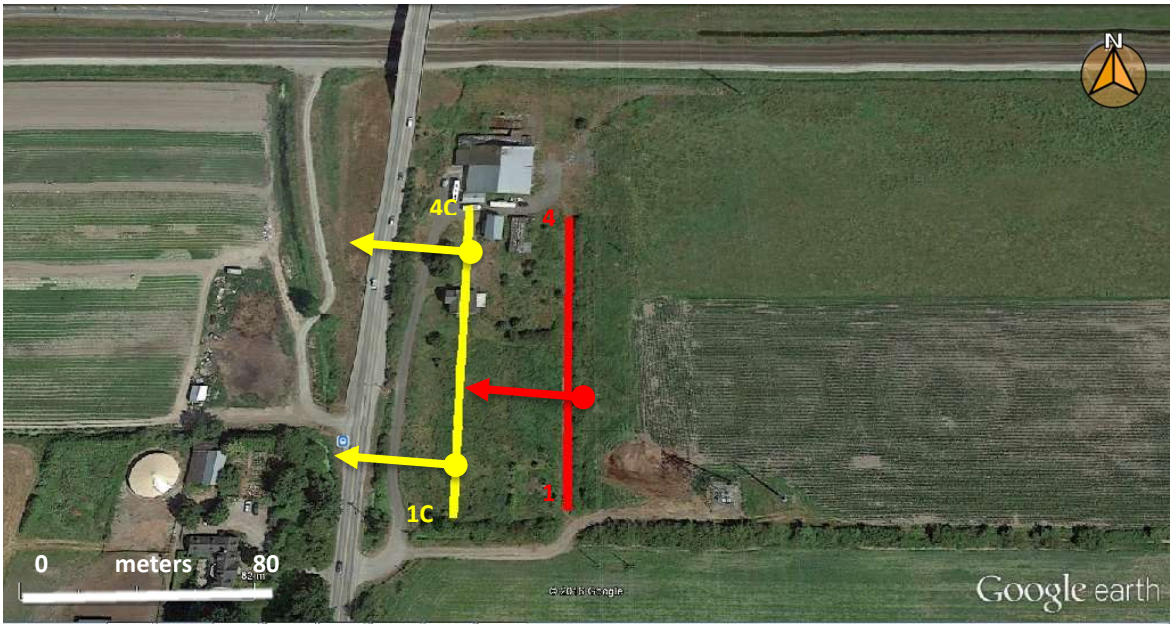

Figure 12: Location along the DFWT4 hedgerow of the transects used for Landbird and vegetation surveys (shown in red) conducted in May through July of 2017 in Delta, BC. The control transect used for Landbird surveys is shown in yellow. Number code indicates flag number.

2.6.1 Primary Transect

The DFWT4 hedgerow is unique in the diversity of habitats and structures that are included in the survey area, west of the hedgerow. Birds physically engaged with the hedgerow vegetation were considered 'associated with hedgerow', birds observed on in the road or buildings, flying over etc. were not.

Additional landscape features possibly affecting bird communities in the DFWT4 hedgerow include:

- Outside survey area – Agricultural fields surrounding all sides;
- Within Section 1 - Ephemeral wetland -10m diameter pond;
- Within Section 2 – 5m tall perpendicular hedge to surveyed hedgerow, abandoned house and decorative shrubbery;
- Within Section 3 – abandoned garden with immature conifers and abandoned greenhouse and additional house;

- Outside survey area – <50 m to powerline transformer supporting an active Bald Eagle - '*Haliaeetus leucocephalus*' nest;
- Outside survey - area to north are barns and vehicle storage area, power cables connect to abandoned house in survey area.

2.6.2 Control Transect

DFWT4 is another of the three sites to have an additional control transect. The control transect was offset 50m from the primary hedgerow transect, ran an equal length, and occurred within the adjacent tall grass field (Sibbald, 2016). This control transect survey area faces west, and includes an embankment, ranging from 15m to 0m tall and impeded the ability to survey 50m.

Additional landscape features possibly affecting bird communities in the DFWT4 control include:

- 4m wide driveway runs parallel with survey transect;
- Embankment (ranging from 15m to 0m tall) runs parallel with survey transect supports moderate-traffic road and severs surveyors' ability to detect birds 50m from transect;
- Power and telephone lines (10 cables total) – run parallel to transect;
- Within Section 6 C - Culvert with open water runs beside the major road behind embankment;
- Outside survey area - south of survey area runs 2m tall hedge.

2.7 DFWT5

The DFWT5 hedgerow is located roughly 2 km from the DFWT4 hedgerow south of the town of Ladner (Figure 14). Site features and surveys area were similar to the DFWT1 site on Westham island. However, the DFWT5 site had a consistent clover crop growing in the field; which was harvested near to the end of study. Birds physically engaged with the hedgerow vegetation were considered 'associated with hedgerow', birds observed on in the road or in the fields etc. were not.

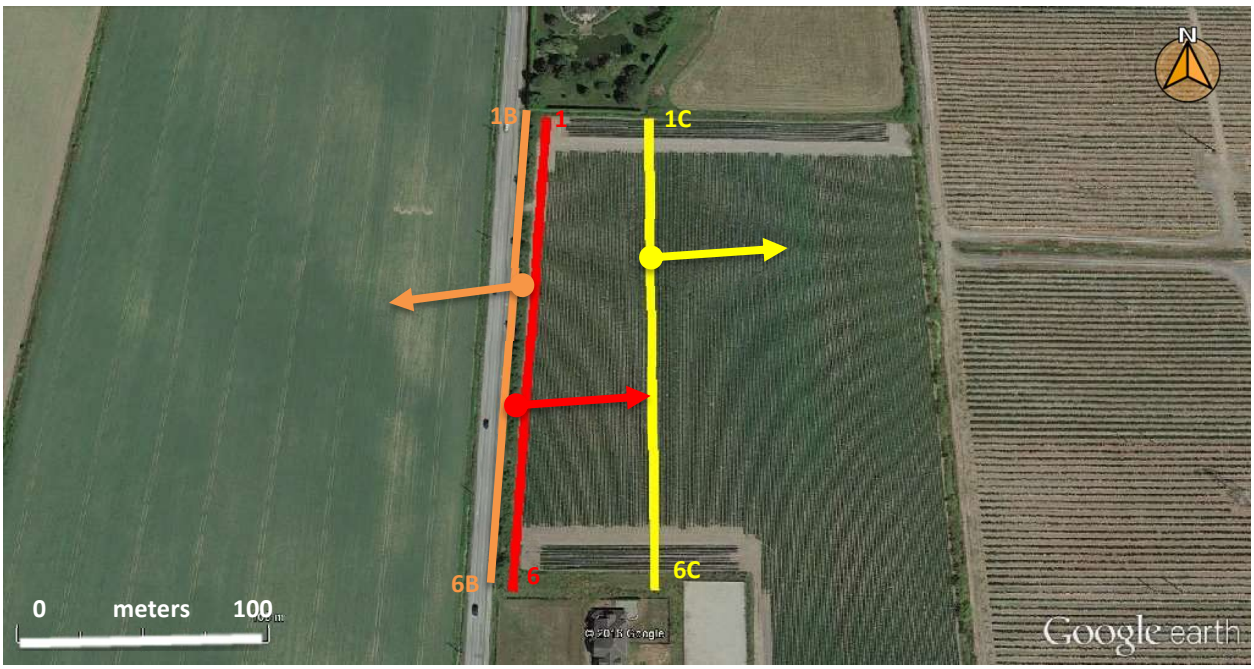

Figure 13: Location along the DFWT5 hedgerow of the transects used for Landbird and vegetation surveys (shown in red) conducted in May through July of 2016 in Delta, BC. The control transect used for Landbird surveys is shown in yellow. Number code indicates flag number.

2.7.1 Primary Transect

Additional landscape features possibly affecting bird communities in the DFWT5 hedgerow include:

- Within Section 2 – includes gap in hedgerow for entrance into field;
- Outside survey area - Agricultural fields surrounding all sides;
- Outside survey area – to north is 4m tall cedar hedge separating property lines;
- Within Section 5 and outside survey area - grass margin heavily overgrown with reed-canary grass;
- Outside survey area – to south and north of survey area <50 m to buildings;
- Outside survey area – to west <50 m to moderate-traffic road and powerlines.

2.7.2 Control Transect

This hedgerow was another of the three to have an additional control transect. The control transect was offset 50 m from the hedgerow transect into the field, ran an equal length, and used primary sites flags as section markers.

- Outside survey area – to east is short hedge and drainage ditch separating property lines.

2.7.3 Secondary Transect

This hedgerow was another of the four sites to have an additional secondary transect (Figure 15). Surveying took place from the roadside directed 50m across 52nd Street into neighbouring farmers field.

Additional landscape features possibly affecting bird communities in the DFWT5 secondary transect, other than those listed in the primary transect, include:

- Running parallel to hedgerow is 3m grassy buffer separating hedgerow from medium-traffic road – repaved in May first 3 weeks of May, interrupting training period;
- Powerlines (with 6 cables) running parallel and west of road;
- Under powerlines runs a drainage ditch with sedges;
- Ditch butts against an active farmers field;
- Outside survey area – to south and north of survey area <50 m to buildings.

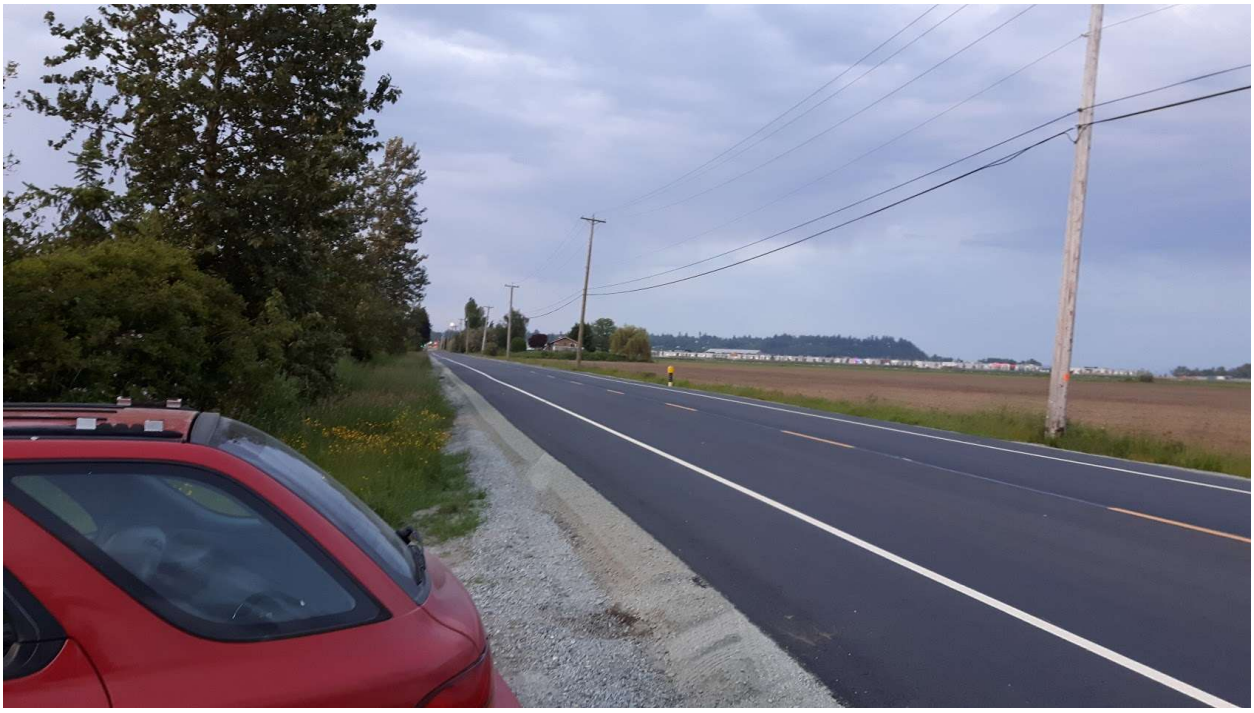

Figure 14: Facing southward along the DFWT5 Secondary survey site. Arrow points to drainage ditch.

2.8 DFWT6

2.8.1 Primary Transect

The DFWT6 hedgerow is located in East Delta, east of Highway 99 (Figure 16). This hedgerow is less than 1 km from the DFWT2 hedgerow. The hedgerow is separated into two sections: one L-shaped section to the west, and one linear section to the east. Birds physically engaged with the hedgerow vegetation were considered 'associated with hedgerow', birds observed on in the path, fence, structures or in the fields etc. were not.

Figure 15: Location along the DFWT1 hedgerow of the transects used for Landbird and vegetation surveys (shown in red) conducted in May through July of 2017 in Delta, BC. Number code indicates flag number.

Additional landscape features possibly affecting bird communities in the DFWT6 hedgerow include:

- Heavily overgrown grass margins run parallel to hedgerow (Sections 4 – 7) (Figure 17);
- Outside survey area – Mature conifer hedge to the east, south, and west;
- Horse trails to north, east and west of hedgerow;
- Within Section 2 - Horses in paddock;
- Outside survey area – <50 m to light-traffic road with powerlines;
- Outside survey area – <50 m to buildings;
- Within Section 2, 4 & 5 - Bird boxes;
- Double 3-beam fence line separating path from horse fields;

- Tall blackberry bramble associated with fence.

Figure 16: Facing eastward through 'linear component' survey areas of Section 4 - 6 of DFWT6 hedgerow. Note overgrowth of path and double fence to the north.

2.9 DFWT7

The DFWT7 hedgerow is the youngest of all the hedgerows. This hedgerow entails one linear section located on the border of Cropthorne Organic Farm on Westham Island (Figure 18). A drainage ditch / slough lies roughly parallel to the east of the hedgerow, it is included within the northern portion of the secondary survey area. Birds physically engaged with the hedgerow vegetation were considered 'associated with hedgerow'.

Figure 17: Local context of DFWT7 hedgerow and linear transect for songbird surveys conducted in May through July of 2016 in Delta, BC. Number code indicates flag number.

2.9.1 Primary Transect

Additional landscape features possibly affecting bird communities in the DFWT5 hedgerow include:

- Outside survey area - Ditch with riparian vegetation running perpendicular to north hedgerow;
- Agricultural fields surrounding all sides (Figure 19)
- Outside survey area - Dyke located at South end of farmers field - with established 2 - 3m tall vegetation.

Figure 18: Facing Southward along DFWT7 hedgerow into primary site survey area

2.9.2 Secondary Transect

The additional landscape features possibly affecting bird communities in the secondary transect of the DFWT5 site include those listed for the primary transect as well as:

- Outside survey area - Old radar station south-east of survey area;
- 9m wide grassy buffer runs parallel hedgerow separating active farmers field;
- Drainage ditch / slough lies roughly parallel to hedgerow and included in survey area 1B and 2B.

3.0 Methods

3.1 Landbird Surveys along Hedgerows

Methods for transect surveys of Landbird abundance and diversity were based on survey techniques used in 2015 and 2016. In 2017, an additional bird survey transect was established along the opposite side of four DF&WT hedgerows (Reference 1, DFWT1, DFWT5 and DFWT7). These four sites were selected because the opposing side of the hedgerow could be safely accessed. The original survey transects established in 2015/2016 are referred to as primary transects, and the transects established on the opposing side of these four hedgerows are referred to as secondary transects, however they are labelled as 'backside' in the accompanying excel documents.

All transect surveys of Landbirds were conducted from 15 mins before sunrise to 4 hrs after sunrise (roughly 05:00 to 09:00 hrs) on Mondays and Tuesdays from 20 May to 12 June 2016 and then 23 May to 18 July 2017 in Delta, BC. Each hedgerow was surveyed on eight days in 2016 and on five days in 2017. The order in which hedgerows were surveyed was rotated for each survey day to avoid bias related to time of day.

Data for birds were recorded within 50 m sections along each transect. Hedgerows varied in length, and thus each had a different number of 50 m sections. The last section of each hedgerow ranged from 1 to 50 m. Hedgerow length and 50 m sections were measured using an Eslon tape, and 50 m sections were marked with flagging tape (Sibbald, 2016).

The surveyor walked in a straight line along the hedgerow, roughly 5 m from the edge of the hedgerow (Figure 20). The total width of each transect was about 50 m extending from the far edge of the hedgerow into the adjacent field, and varied slightly as a result of hedgerow width. This is because the 50m width extended from the edge of the hedgerow nearest the surveyor into the adjacent field, yet birds observed on the far side of the hedgerow were also recorded (Sibbald, 2016).

Birds physically engaged with the hedgerow vegetation were considered 'associated with hedgerow' (versus birds observed flying over hedgerows, or in association with adjacent roads or buildings).

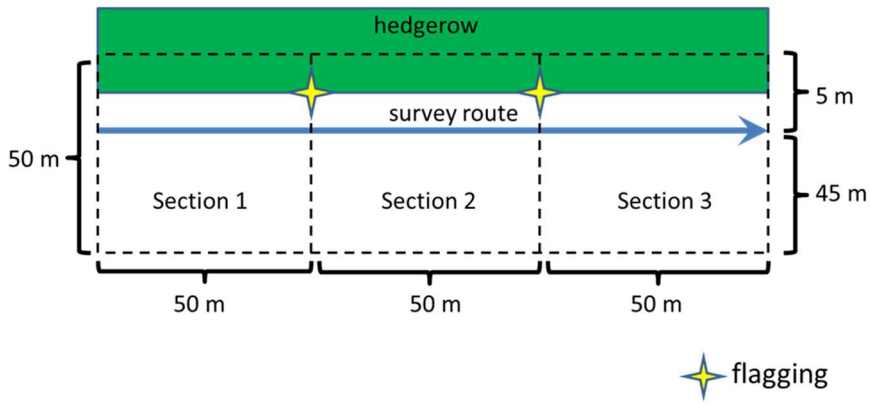

Figure 19: Schematic of transect survey for Landbirds along hedgerows in Delta, BC during May through July of 2017. Total transect width was about 50 m, with the survey route located 5 m from the edge of the hedgerow. Birds were recorded separately within 50 m sections (image obtained from Kujawiak 2015 & Sibbald, 2016).

Landbird surveys were conducted only in mornings during peak bird activity, between 05:00 – 09:00 hrs. Each hedgerow was surveyed for birds once per week. For future reference: GPS coordinates are saved in the associated spreadsheets and locked into DF&WT Garmin GPS unit.

For each bird survey, the observer slowly and quietly approached the hedge. Surveys were conducted while maintaining a steady pace of about 3 min per 50 m section, with pauses used to confirm species identification, count the number of individuals per species, and to record data. In 2017, birds that were observed in 50 m sections were tallied and recorded in the section in which they were first observed. Birds were only recorded when walking in one direction along each transect. However, this may not have been the case in the 2016 Reference sites. Hence, values may differentiate slightly from those reported for 2016 in "Effects of Hedgerow Age, Structure, and Plant Species Composition on Landbird Abundance and Diversity in Delta, BC" (2016, Sibbald).

All data gathered by year included the following:

2017 Data:

- Date and hedgerow location
- Number of individuals by species
- 50 m section in which bird was observed
- Aural or visual detection (A or V)
- Whether the individual was observed (e.g. perching, singing) in hedgerow (Y or N)
- Weather category (i.e. clear, cloudy, overcast, light rain, moderate rain, and heavy rain)
- Start and end time of transect

2016 Data (in addition to data gathered in 2017):

- Behaviour Code (Appendix B)
- Breeding Code (see link)
  Breeding codes: http://www.birdatlas.bc.ca/bcdata/codes.jsp?lang=en

Survey methods used for primary and secondary transects were identical. Secondary transects were used to help assess influences of site features on bird species in the survey area. Because surveys were performed from the primary site to the secondary site, the time of day, weather and light should be negligible for the two surveys; in the same manner as the control sites (Sibbald, 2016). As such, except for possible disturbance by the surveyor, the only modified factor affecting hedgerow associated bird communities should be the difference in neighbouring landscape features. For sites that had both primary and secondary transects, the order in which these transects were surveyed were switched each week. This reduced bias and ensured that birds were not consistently 'flushed' during one transect survey before the other. Some surveyor bias may be in play in considering the species associated with the hedgerow; such that, if a bird was witnessed external to the hedge; but, jumped into the hedge for cover (with or without the surveyor's awareness) the individual would have been considered hedge associated and counted as such. Other factors relative data bias includes surveyor capabilities, and height/density to the hedgerow; shorter and thinner hedgerows enabled the surveyor to directly observe birds within the hedgerow.

3.2 Data Summaries

Comparisons of total species detected for the study include all surveys performed between mid May – mid July, including training sessions, for both 2016 and 2017 (Section 4.1). This data is understandably non-comparable, as surveyor skill sets and availability of 'singing' birds varied significantly between the years, specifically from the beginning of May to the end of the study period. However, the inclusive data will give a better general sense of total seasonal presence of Landbird species in Delta hedgerows.

Four complete surveys were deemed to be sufficient to estimate bird diversity and abundance (Section 4.2 and 4.3) in each hedgerow (E. M. Anderson, Ecological Restoration Program, BCIT, *pers. comm*.). Surveys from mid June to mid July 2017 were compared to the same period in 2016 to avoid a seasonal bias in comparing the two years. For each survey date, relative abundance, species richness, and Simpson's diversity of Landbirds were summarized separately for each 50 m section. Values for 50 m sections within each hedgerow were then averaged for each survey date. These mean values were then averaged across the four survey days to obtain one value of bird abundance, species

richness, and Simpson's diversity for each hedgerow. All measures were reported per 100 m hedgerow section because some sections were <50 m (Sibbald, 2016).

Exotic European Starlings – '*Sturnus vulgaris*' were removed from abundance and diversity data summaries in the 2016 due to their highly skewed value, but were not removed from 2017 data in this report because they appeared less abundant in 2017 versus 2016.

A special note on Reference 1. A confusion occurred between the two years with data collection and number of sections. There are six sections in Reference 1; with the last section listed as 9m for 2016 and 18m in 2017. Large abundances were found in the shorter 9m section in 2016 spreadsheet; however, for most weeks, data was only entered for five sections total. It is probable that the last section was miscalculated in 2016 as four 50m sections with one 9m section in the spreadsheets, but should have been five 50m sections with one shorter 9m section. This report has adjusted data for 2016 in the analysis to reflect six sections, summarizing the last section as 59m in the accompanying Excel document LSchleck2017_SummerHedgerow2_BirdDataSummaries.xls.

4.0 Results and Discussion

4.1 Study Totals (May – July)

The total number of individual birds and species identified are numbers inclusive of training sessions and include a different number of surveys for each year, 2016 (n ~ 11 surveys) and 2017 (n ~ 8 surveys); therefore, can not be accurately compared. Surveyor starting date, experience and error will have made a difference in these results; particularly as my skills improved, converse to songbirds' identifier songs seasonally diminishing. However, baring these differences and for the interest of the DF&WT, in May – July 2016 (*n* ~ 11 surveys) a total of 55 species and 4510 individual birds were observed across the nine DF&WT hedgerows. In May – July 2017 (*n* ~ 8 surveys) a total of 61 species and 2968 individual birds were observed in primary, secondary and control transects combined. See Appendix A Hedgerow Table – Species by Hedgerow 2016 and Appendix B Hedgerow Table – Species by Hedgerow 2017.

2016 had a marked increase in European Starlings; a total of 865 birds compared to only 272 in 2017. In 2016 only 58 individual birds were listed as unknown whereas 378 individual birds were considered unidentifiable in 2017. Still, it remains possible that the 2016/2017 record breaking winter cold snap (McElroy & Horemans, 2017), or some other unknown factor may also have attributed to the large difference in individual numbers.

In both 2016 and 2017 Reference 1 and Reference 2 had the highest number of bird species observed from May – July (Figure 21). In 2016, the lowest total number of species observed were found to be in DFWT3, DFWT5, and DFWT7 sites. Consistent with the previous year, in 2017, the lowest total number of species observed as DFWT5 and DFWT7, with only DFWT3 proving inconstant. In fact, in comparing the data from the two years, there were more species identified for DFWT7, DFWT3, DFWT6 and DFWT5. Increases in diversity for DFWT7 and DFWT5, and minorly for DFWT1 in 2017, is likely due in part to the addition of the secondary data to these two sites diversity counts; this was not a consistent trend for the Reference 1, which also had a secondary transect.

The top ten birds identified in both years were similar. Both years included American Goldfinch – '*Spinus tristis*', American Robin – '*Turdus migratorius*', Barn Swallow – '*Hirundo rustica*', Black-capped Chickadee – '*Poecile atricapillus*', European Starling – '*Sturnus vulgaris*', Savannah Sparrow – '*Passerculus sandwichensis*' and Tree Swallow – '*Tachycineta bicolor*'. 2016's top ten list also included Common Yellowthroat – '*Geothlypis trichas*', House Finch – '*Haemorhous mexicanus*' and Song Sparrow – '*Melospiza melodia*'; whereas 2017's list included; Brown-headed Cowbird – '*Molothrus ater*', Cedar Waxwing – '*Bombycilla cedrorum*' and Spotted Towhee – '*Pipilo maculatus*'. All species listed were within the top twenty for both years.

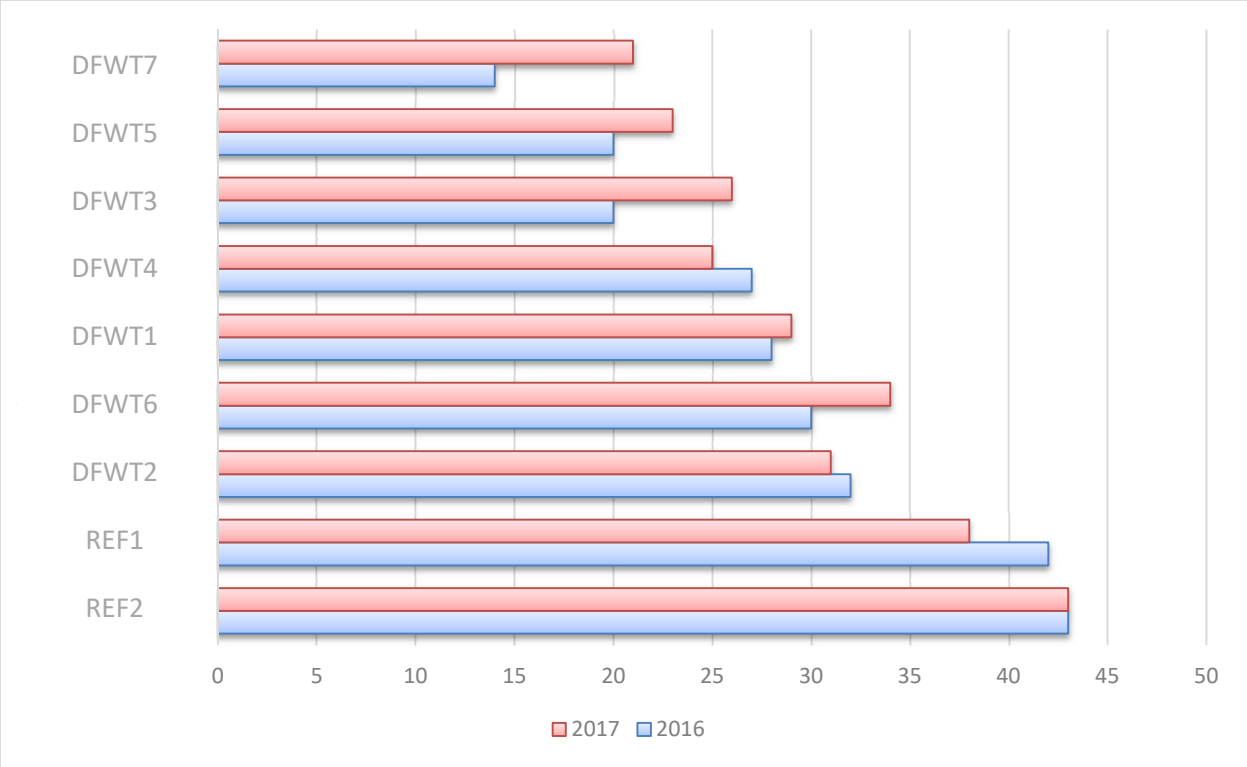

Figure 20: Total number of bird species observed (May – July) across all surveys by hedgerow during 2016 (*n* ~ 11 surveys) and 2017 (*n* ~ 8 surveys) in Delta, BC. Data by site is combined observations for primary, secondary and controls.

4.2 Bird Abundance (June – July)

In June – July 2016, the highest abundance of birds occurred in the DFWT1 hedgerow, followed by, Reference 1, DFWT4 and DFWT6 (Figure 23). These same four sites had an appreciable difference in abundance between the all species and hedgerow associated species; likely due to the unique diversity of habitat features and niches available. The high abundance, in 2016, at these sites was also due in part to the presence of the three species of swallow (i.e. Barn Swallow – '*Hirundo rustica*', Tree Swallow – '*Tachycineta bicolor*', and Violet-green Swallow – '*Tachycineta thalassina*') which tend to flock in large numbers (2016, Sibbald).

Mean bird abundance was greater in 2016 versus 2017 for the following sites: Reference 1 (all species and hedgerow associated), DFWT1 (All Sp. & Control), and DFWT7 (All Sp.) in comparison to the 2017 data (Figure 22 & 23). A contributing factor to this discrepancy may lie in the fact that species common to large flocks; Swallow species, European Starlings – '*Sturnus vulgaris*' or Brown-headed Cowbirds – '*Molothrus ater*' were rarely observed as large flocks in 2017.

The DFWT1 site in 2016 was left fallow or grew grasses for the survey season. In 2017 this site was tilled and remained as barren soil for the majority of the study. This difference may have resulted in the much higher abundance of species in the DFWT1 control in 2016, compared to a significantly lower value in 2017; as the birds in the survey area would have little to no cover or viable food sources to support them in 2017. Field usage associated effects on species abundance and richness, is partially supported by the observed increase in abundance at the DFWT5 control Site in 2017 compared to 2016. Although both years saw higher abundance in the control site compared to the hedgerow associated species, the associated field to the site was left fallow for the season in 2017; growing only clover, until it was harvested in the last week of June. This may have enabled greater nesting and foraging habitat in the control site for Landbirds in 2017 compared to 2016. However, this also somewhat discredits the notion that hedgerows improve habitat quality for bird communities in agricultural landscapes.

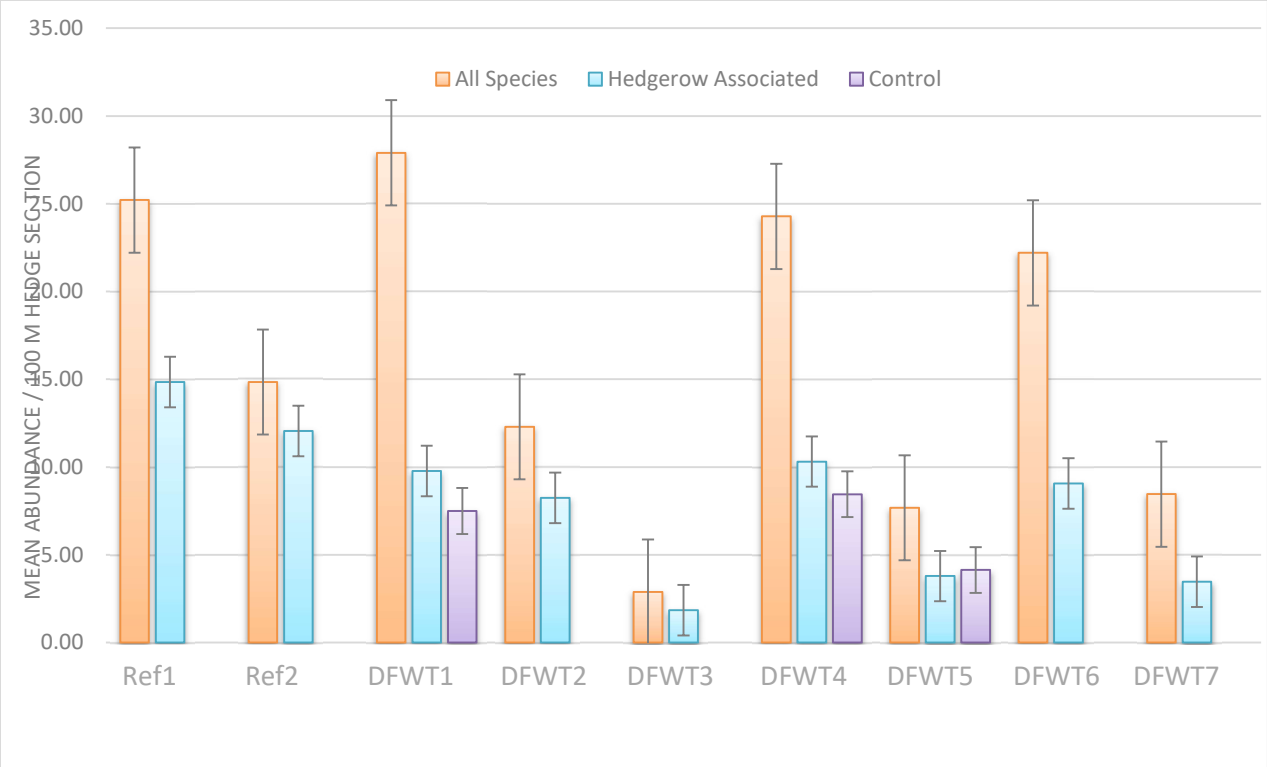

Figure 21: Mean (with 95% CI) bird abundance for all DF&WT hedgerows surveyed during June through July of 2016 in Delta, BC. 'All Species' are the species observed within the approximately 50 m wide transect area, while 'Hedgerow Associated Species' are those observed in direct association with the hedgerow. Paired 'Control' transects were surveyed for three sites, and indicate bird abundance in non-hedgerow habitats.

In the summer months June – July 2017, DFWT6 had the highest mean number of individual birds observed, followed by DFWT4, Reference 2, and Reference 1 (Figure 23). DFWT1, which had the highest level of abundance in 2016 was fourth and followed very

closely by DFWT5 in 2017 for mean total abundance. Both reference sites likely benefit bird abundance through their connectivity to each other, the Reifel Bird Sanctuary and the Fraser River.

Both DFWT6 and DFWT4 were unique sites in that they have extremely diverse features to their sites including, overgrown herb vegetation, buildings and human made structures, increasing 'niches' relative to other stand-alone hedgerows. In 2017, these two sites, along with DFWT5, had significantly higher mean bird abundance per 100 m for all species compared to the hedgerow associated species. Although these sites (DFWT6 and DFWT4) were relatively undisturbed during the hours of surveying, they were also sites with regular human activities other than agricultural practice. In fact, DFWT4 control was the only site which saw a significant increase in bird abundance in 2017 compared to 2016.

Bird abundance was lowest for the DFWT3 and DFWT7 hedgerows in both 2016 and 2017; likely due in part to proximity to high-traffic roads for DFWT3, relatively high habitat fragmentation, and immature vegetation in the case of DFWT7.

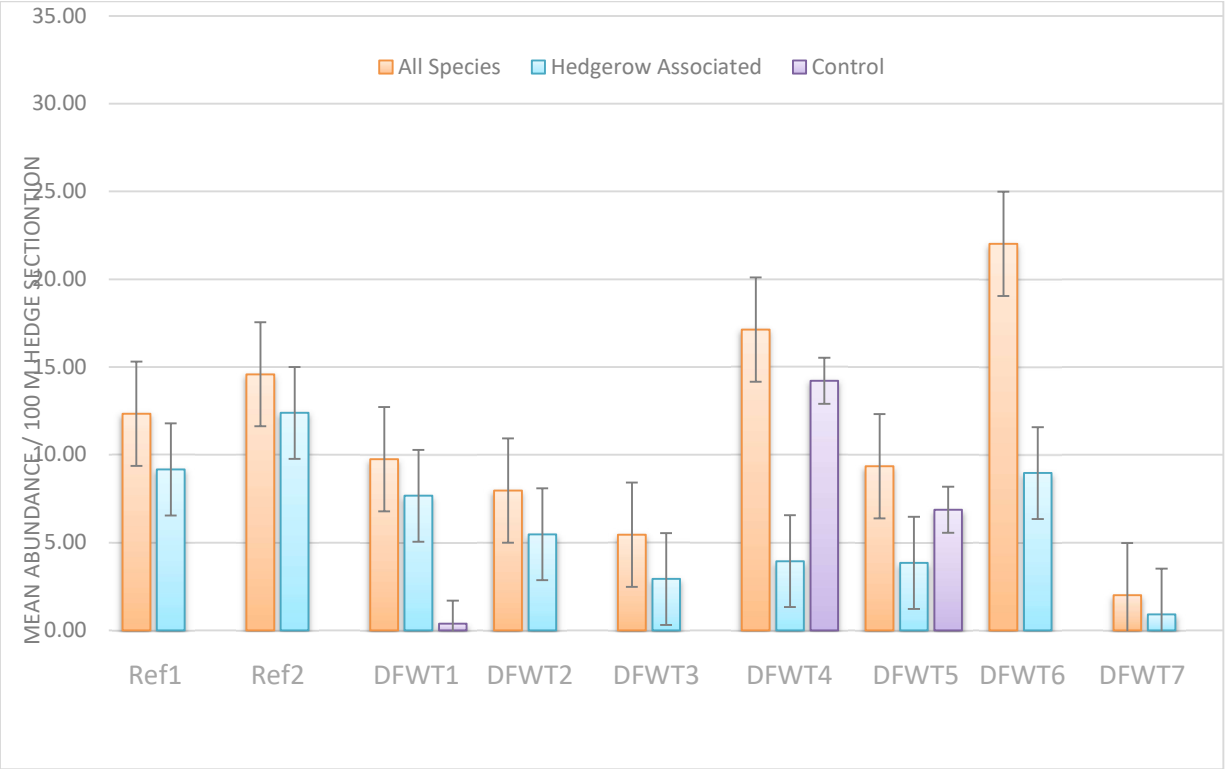

Figure 22: Mean (with 95% CI) bird abundance for all DF&WT hedgerows surveyed during June through July of 2017 in Delta, BC. 'All species' are the species observed within the approximately 50 m wide transect area, while 'Hedgerow Associated Species' are those observed in direct association with the hedgerow. Paired 'Control' transects were surveyed for three sites, and indicate bird abundance in non-hedgerow habitats.

With the exception of DFWT1 (all species), abundance was similar in all paired comparisons of primary and secondary transects (Figure 24). At DFWT1, DFWT5 and DFWT7, a slough or watercourse in the secondary survey were unique features not associated with the primary side. However, this feature did not appear to be associated with a noteworthy increase the bird abundance for either DFWT7 or DFWT5.

Mean bird abundance for all species compared to their hedgerow associated species was much higher in DFWT1 secondary, DFWT5 primary, and DFWT5 secondary. In the instance of DFWT5, it can be assumed this is a relative reflection of the niche worth of the hedgerow, by comparison to its surrounding area, and that the differences in apparent landscape features have negligible effect on the abundance of bird species in the hedgerow itself.

Reference 1 secondary was an open field, compared to the 'double hedgerow' feature (including road and telephone lines) of the primary site. An expanded visual field for the surveyor may be one reason for the slight, increase in abundance of birds observed on the secondary of Reference 1 compared to it's primary site.

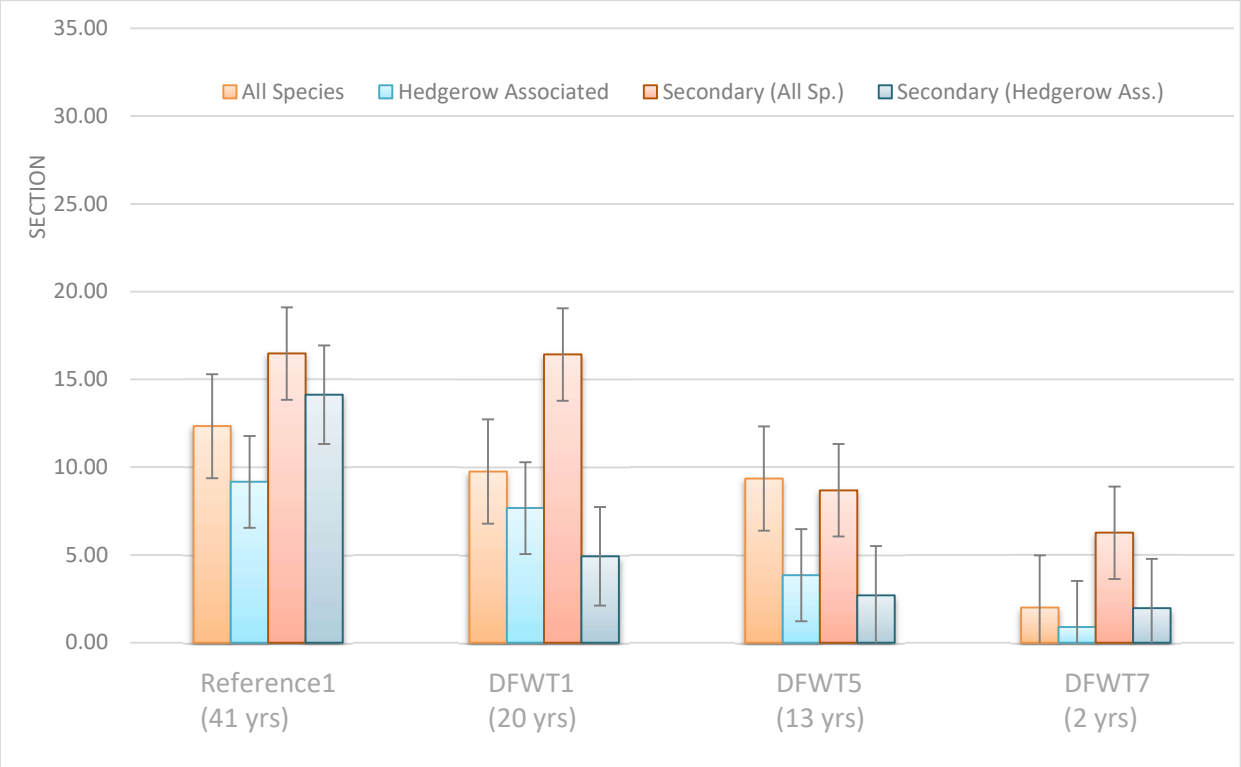

Figure 23: Mean (with 95% CI) bird abundance for DF&WT hedgerows surveyed during June through July of 2017 in Delta, BC. 'all species' are the species observed within the approximately 50 m wide transect area, while 'Secondary (All Sp.)' are the equivalent on the reverse side of the hedgerow. 'Hedgerow Associated Species' are those observed in direct association with the hedgerow primary side whereas, 'Secondary (Hedgerow Ass.) are those on the reverse side of the hedgerow.

4.3 Bird Species Richness (June – July)

In June – July 2016, patterns among hedgerows in species richness were similar to those seen in bird abundance. The DFWT1 site had the highest mean richness in 2016, followed by, DFWT4, Reference 1, DFWT6, and Reference 2 sites (Figure 25). In 2017, the DFWT4 Site, followed closely by DFWT6 had the highest all species, whereas the Reference 2 and Reference 1 sites had the highest mean hedge associated species richness. (Figure 26).

DFWT1, DFWT4, Reference 1, and DFWT6 had a substantial difference in richness between the all species and hedgerow associated species in 2016. Whereas only DFWT4 and DFWT6 maintained that degree of difference in 2017. In 2016 mean bird richness per 100 m were significantly higher for Reference 1 (All Sp. & Hedge Ass.) and DFWT1 (All Sp.) compared to the 2017 data.

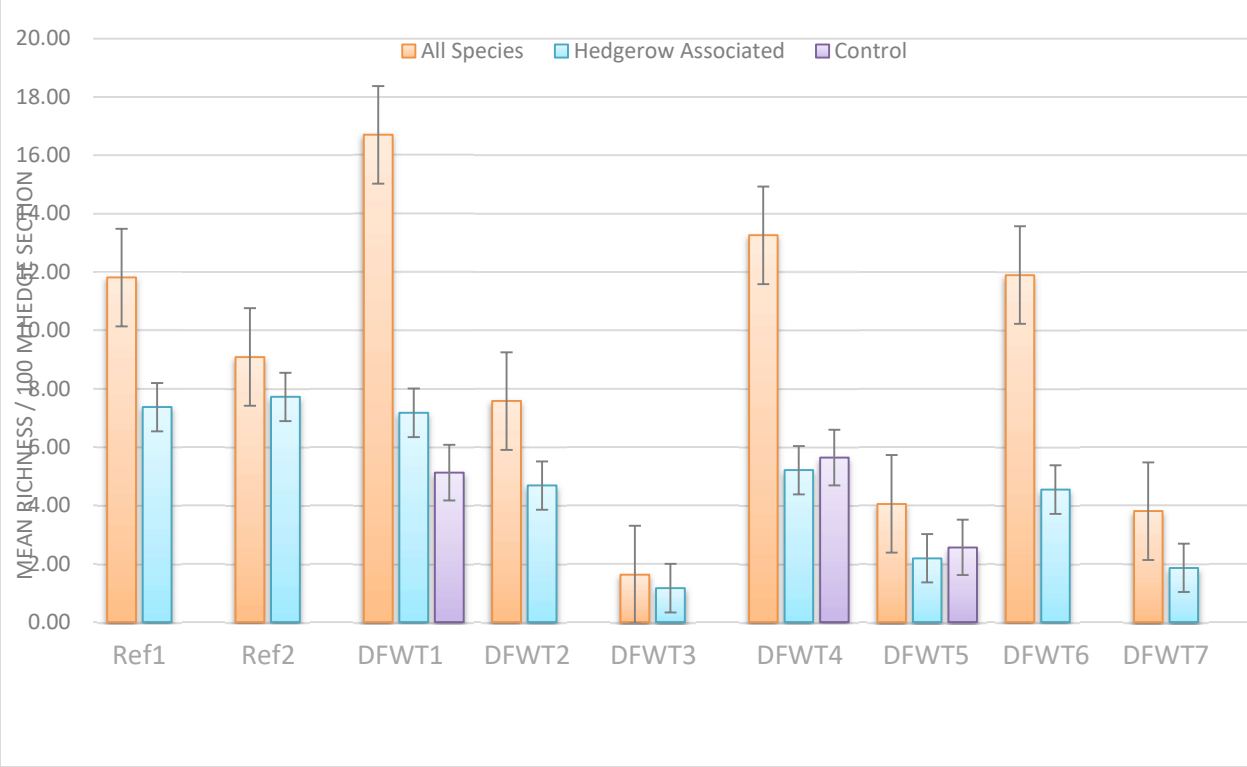

Figure 24: Mean (with 95% CI) bird species richness for all DF&WT hedgerows surveyed during June through July of 2016 in Delta, BC. 'All Species' are the species observed within the approximately 50 m wide transect area, while 'Hedgerow Associated Species' are those observed in direct association with the hedgerow. Paired 'Control' transects were surveyed for three sites, and indicate bird species richness in non-hedgerow habitats.

Reference 1, Reference 2 and DFWT1 are part of a mosaic of hedgerows (remnant and planted), ditches, and agricultural fields on Westham Island, thus having high habitat diversity and connectivity (2016, Sibbald). Hence it is no surprize that these sites had

similar richness with hedge associated species due to this connectivity in 2016 and slightly less consistent in 2017. In 2017 the two Reference sites were expectedly comparable in richness for all species compared to hedgerow associated species; whereas, they were not in 2016; likely due to greater presence of flocking species.

In 2017, mean bird species richness was highest for the DFWT4, DFWT6, Reference 2, Reference 1, and the DFWT1, sites (Figure 26). Richness appeared to have dropped for the Reference 1 and DFWT1 Sites since 2016, in comparison to the other sites.

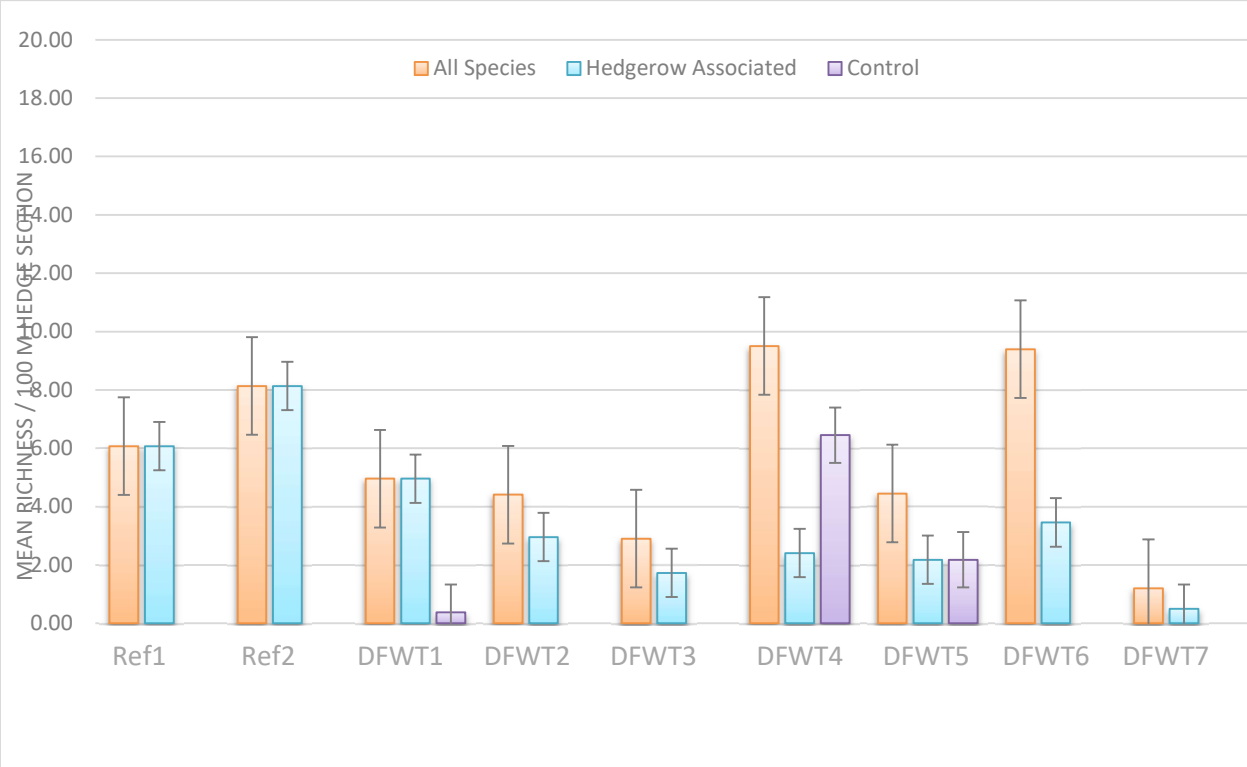

Figure 25: Mean (with 95% CI) bird species richness for all DF&WT hedgerows surveyed during June through July of 2017 in Delta, BC. 'All Species' are the species observed within the approx. 50 m wide transect area, while 'Hedgerow Associated Species' are those observed in direct association with the hedgerow. Paired 'Control' transects were surveyed for three sites, and indicate bird species richness in non-hedgerow habitats.

In 2016 and 2017 the DFWT3 and DFWT7 hedgerows had the lowest bird species richness of all sites surveyed; with DFWT5 equaling hedge-associated richness with DFWT7 in 2017 only. At the DFWT3 site, high noise levels from Highway 99 may inhibit the ability of Landbirds to communicate songs or calls effectively, or be heard by the observer. The highway a may also acting as an effective barrier to movement for some birds, which could also be an influencing factor on birds at the DFWT5 site. The DFWT7 site compared to all other sites is extremely immature in structure, and surrounded by water courses and alternate hedgerow habitat would serve as a better habitat to the exposure the DFWT7

hedgerow currently offers. Interestingly, both DFWT7 and DFWT5 are favored by Savannah Sparrows – '*Passerculus sandwichensis*' despite their difference and age and structures.

As with abundance, species richness only differed between primary and secondary transects for all species in the DFWT1 site. This difference at the DFWT1 site may in part be due to greater bird abundance associated with telephone lines and blackberry that were more prevalent along the secondary transect.

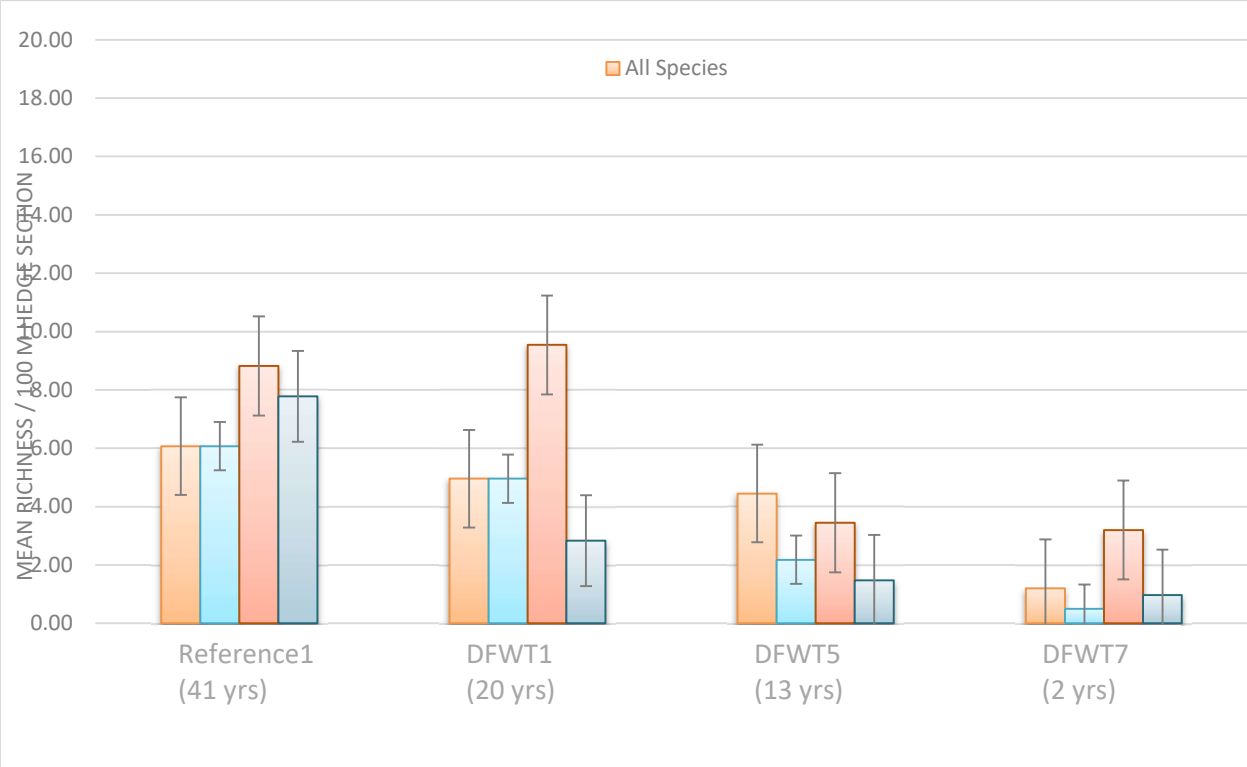

Figure 26: Mean (with 95% CI) bird species richness for DF&WT hedgerows surveyed during June through July of 2017 in Delta, BC. 'all species' are the species observed within the approximately 50 m wide transect area, while 'Secondary (All Sp.)' are the equivalent on the reverse side of the hedgerow. 'Hedgerow associated species' are those observed in direct association with the hedgerow primary side; whereas, 'secondary (Hedgerow Ass.) are those on the reverse side of the hedgerow.

4.4 Simpson's Diversity of Birds

In summer 2016 (June – July), patterns in Simpson's Diversity were similar to those seen in bird abundance and species richness (Figures 28). As with bird abundance and species richness in 2016, DFWT1, DFWT4 and DFWT6 had the highest Simpson's Diversity (Figure 28). Similarly, the DFWT3, DFWT5 and DFWT7 hedgerows all had a relatively lower Simpson's diversity.

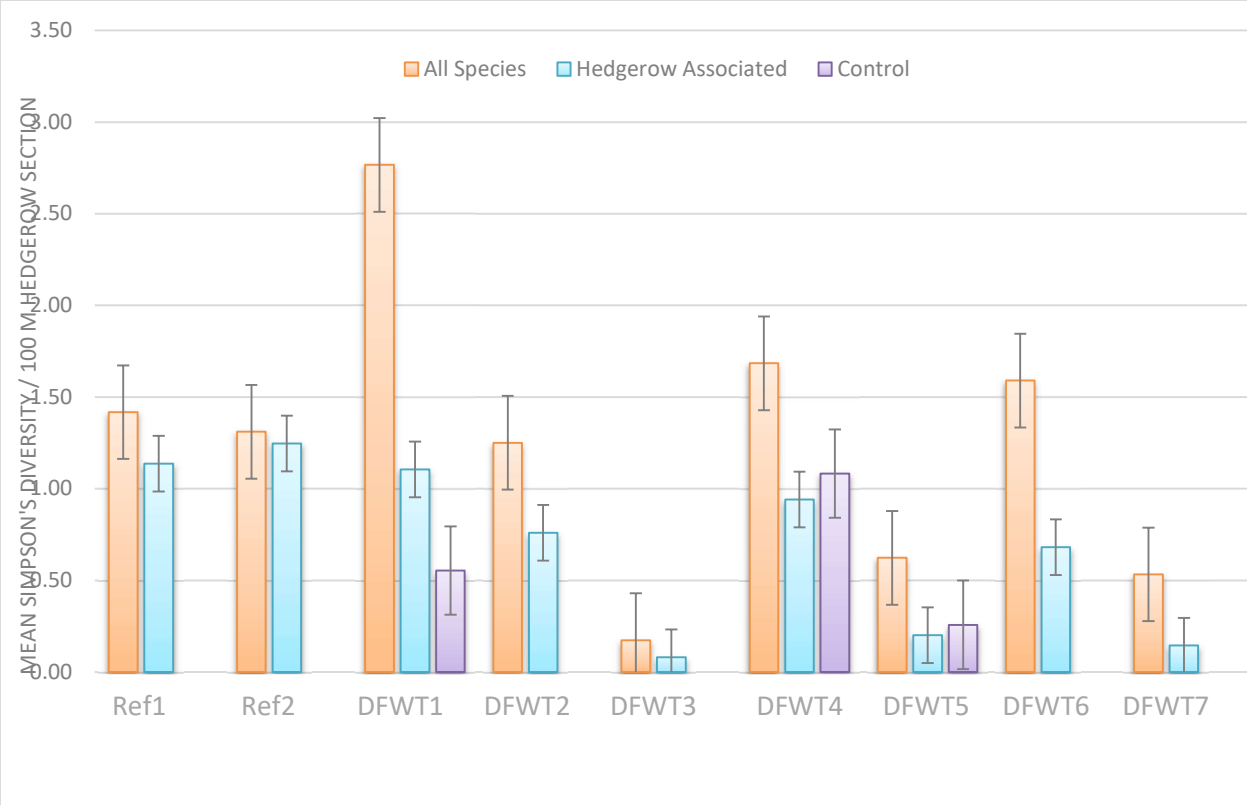

Figure 27: Mean (with 95% CI) Simpson's diversity for all DF&WT hedgerows surveyed June through July of 2016 in Delta, BC. 'all species' are the species observed within the approximately 50 m wide transect area, while 'hedgerow associated species' are those observed in direct association with the hedgerow. Paired-control transects were surveyed for three sites, and indicate Simpson's diversity in non-hedgerow habitats.

In summer 2017 (June – July), patterns in Simpson's diversity were also similar to those seen in bird abundance and species richness; although similar, they did not necessary compare to the year prior, specifically for the DFWT1 Site which was almost more than 1/3 less in Simpson's Diversity from 2016 to 2017. In 2017 the highest Simpson's diversity was seen in, DFWT4, DFWT6 and Reference 2 (Figures 29). Similarly, the DFWT7 and DFWT3 hedgerows all had a relatively lower Simpson's diversity by comparison.

DFWT1, DFWT4 and DFWT6 had a large difference in Simpson's Diversity between the all species and hedgerow associated species in 2016. Whereas only DFWT4 and DFWT6 maintained that degree of difference in 2017. In 2016 mean bird richness per 100 m were higher for Reference 1 (All Sp. & Hedge Ass.) and DFWT1 (All Sp. & Control) and DFWT4 (Hedge Ass.) compared to the 2017 data.

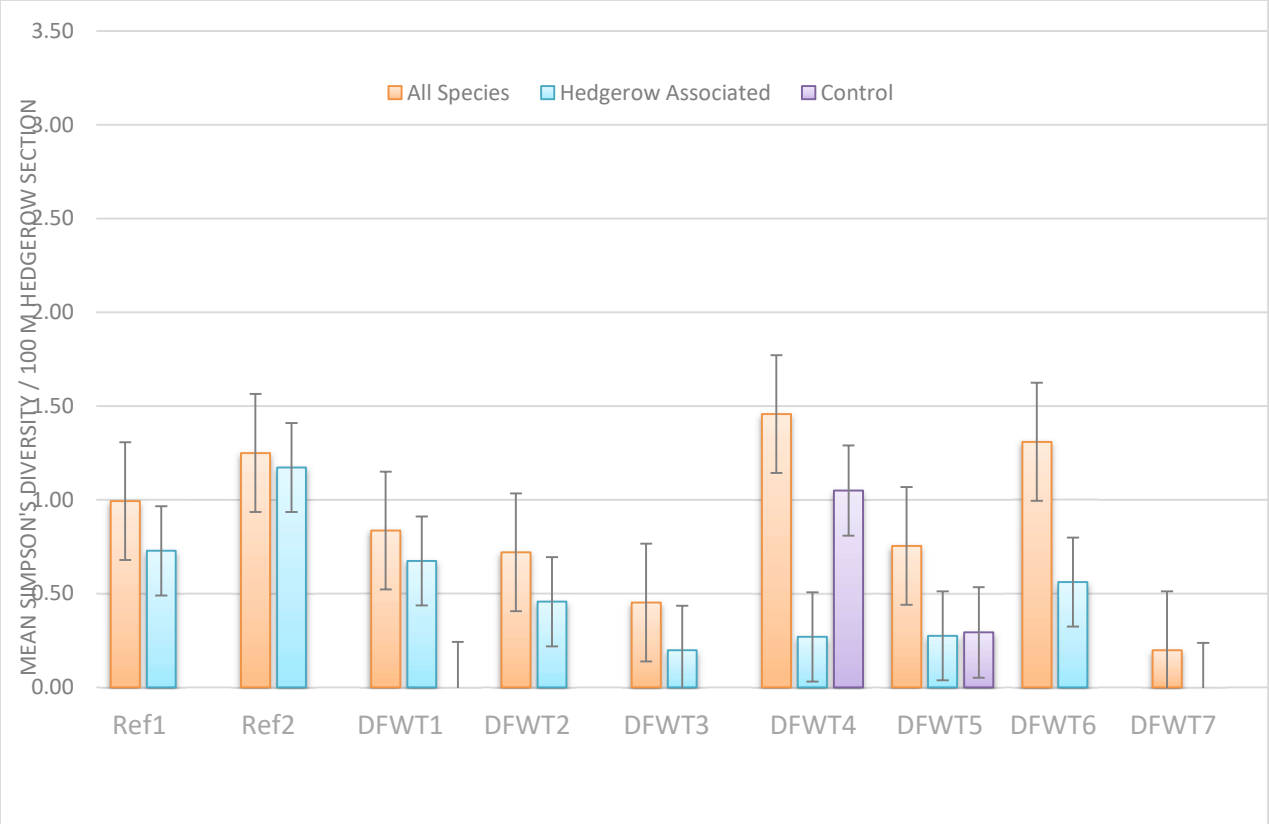

Figure 28: Mean (with 95% CI) Simpson's diversity for all DF&WT hedgerows surveyed June through July of 2017 in Delta, BC. 'all species' are the species observed within the approximately 50 m wide transect area, while 'hedgerow associated species' are those observed in direct association with the hedgerow. Paired-control transects were surveyed for three sites, and indicate Simpson's diversity in non-hedgerow habitats.

With the exception of Reference 1 (hedgerow associated species), there was no substantial difference in Simpson's Diversity for all species or hedgerow associated species when comparing the primary to secondary sites (Figure 30). This indicates that site features on opposing sides of the hedgerow may not affect the combined abundance and diversity contributed by the Simpson's Diversity product.

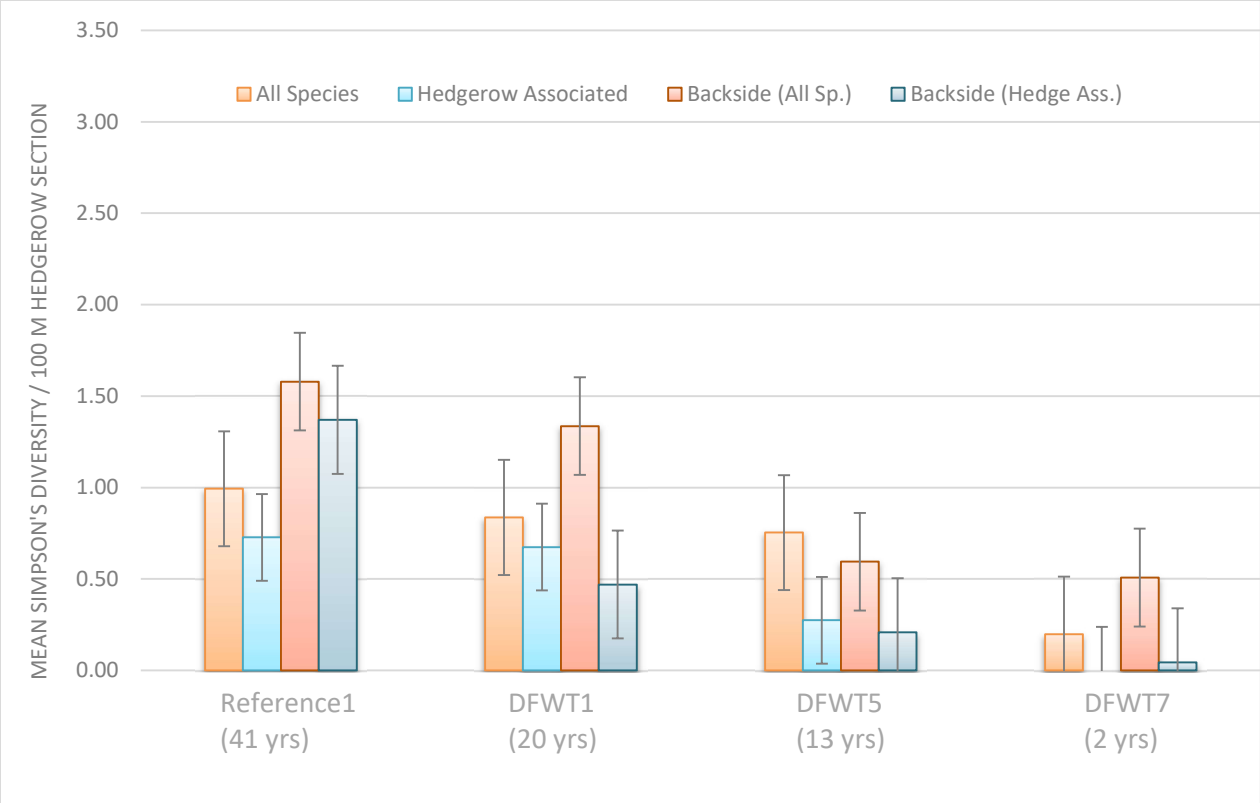

Figure 29: Mean (with 95% CI) bird Simpson's diversity for DF&WT hedgerows surveyed during June through July of 2017 in Delta, BC. 'all species' are the species observed within the approximately 50 m wide transect area, while 'Secondary (All Sp.)' are the equivalent on the reverse side of the hedgerow. 'hedgerow associated species' are those observed in direct association with the hedgerow primary side; whereas, 'Secondary (Hedgerow Ass.) are those on the reverse side of the hedgerow.

5.0 Conclusion and Recommendations

In this study, Landbird abundance, species richness, and Simpson's diversity of nine DF&WT hedgerows were compared between two survey years (2016 and 2017). In addition to investigating abundance and diversity among hedgerows, a comparison study between the primary and secondary sites were investigated. Specifically, this aspect of the study was used to assess whether site features that differed between opposing sides of a hedgerow contributed to differences in bird abundance and diversity.

Data comparisons of Landbirds in DF&WT hedgerows for 2016 and 2017 had differences; abundance and both measures of diversity generally lower in 2017 versus 2016, and this could be due to observer bias or annual differences (e.g., due to a colder/wetter spring in 2017). With rare exceptions, abundance and diversity were similar for primary and secondary transects. Therefore, it is probable that surveying one side of a transect is sufficient to describe its bird community. However, as secondary sites were not surveyed in early spring when the Landbirds were at their most vocal, it is advisable to continue with the secondary transects in future studies.

Analysed data was taken from the June 13, 2016 – July 12, 2016 and June 12, 2017 – July 18, 2017 with exclusion to data sets in 2017 which may have been compromised due to weather or site noise. This gave five sets of data in 2016 to compare to four sets of data in 2017. The selection of these data sets lead to different outcomes presented in the total seasonal data reported in the 2016 Report "Effects of Hedgerow Age, Structure, and Plant Species Composition on Landbird abundance and Diversity in Delta, BC" by J. Sibbald. Also, in consideration of the novice skill sets of the 2017 surveyor and rapidly changing seasonal availability of singing birds used in identification of species, a **'Study Totals'** section has been included in the Results and Discussion section of this report for the interest of the DF&WT members. **This section should be regarded with some caution; as the data contained is for all survey data collected, inclusive of training sessions.**

I suggest that this study should continue for an additional season to monitor Landbird abundance and diversity changes over time in DF&WT hedgerows. Connections to annual weather patterns should be taken into consideration in future studies. As well as feature usage and alterations by farmers e.g. cutbacks and trimming of the hedge recorded between the years and within the seasons themselves.

With the continuance of employing a student from the Ecological Restoration Program at BCIT for the internship, further recommendations from the author include:

- Set-up all survey sites at the earliest possible convenience. If possible set up the sites early/mid April – without the aid of the student, to enable surveyor training at the beginning of breeding season.
- A surveyor with birding experience is convenient but not necessary for the position. However, it should be emphasized to the inexperienced birder the severity of learning curve for the position.
- Data from the 2015 study should be included in future comparisons of diversity and abundance. It is advisable that future reporting should include a section on the evolving comparisons of Landbird diversity and abundance inclusive of all years the study has occurred.
- Mapping software is necessary for more accurate and detailed site descriptions. Future interns should seek assistance from the Rivers Institute for access to BCIT's software.
- Spreadsheets have been built over multiple years; attempts have been made to break links to external documents. However, it is advisable not to 'update' links if prompted by the MS Excel or Word programming.
- GPS coordinates have been programmed into the DF&WT's Garmin GPS unit. Use these coordinates to mark flags separating sections at all sites.
- Several attempts to use a rangefinder for the 2017 site surveys. It was believed the deciduous leaf foliage was impeding accurate measurements, so data was not included in this report. Future interns should seek pre-emptive training on all equipment usage prior to entering the field. All equipment can be borrowed from the BCIT Rivers Institute.

6.0 References

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7.0 Appendices

A Hedgerow Table – Species by Hedgerow 2016 - Lists of all species observed in each hedgerow transect during surveys conducted in May through July of 2016 in Delta, BC

Table 1: Species by hedgerow observed during surveys conducted in May through July of 2016 in Delta, BC.

2016			
Reference 1			
American Goldfinch	Common Yellowthroat	Northwestern Crow	Violet-green Swallow
American Robin	Eurasian Collared-dove	Pine Siskin	Warbling Vireo
Anna's Hummingbird	European Starling	Red-tailed Hawk	White-crowned Sparrow
Bald Eagle	Glaucous-winged Gull	Ruby-crowned Kinglet	Wilson's Warbler
Barn Swallow	Golden-crowned Kinglet	Rufous Hummingbird	Yellow Warbler
Berwick's Wren	Golden-crowned Sparrow	Sandhill Crane	Yellow-rumped Warbler
Black-capped Chickadee	Great Blue Heron	Savannah Sparrow	
Black-headed Grosbeak	House Finch	Song Sparrow	
Brown-headed Cowbird	Killdeer	Spotted Towhee	
Bullock's Oriole	Mallard	Swainson's Thrush	
Bushtit	Marsh Wren	Tree Swallow	
Cedar Waxwing	Northern Harrier	unknown sp.	
		TOTAL	**42**
Reference 2			
American Goldfinch	Bushtit	Marsh Wren	Tree Swallow
American Robin	Cedar Waxwing	Northern Flicker	unknown sp.
Anna's Hummingbird	Common Yellowthroat	Northwestern Crow	Violet-green Swallow
Bald Eagle	Dark-eyed Junco	Orange-crowned Warbler	White-crowned Sparrow
Barn Swallow	Downy Woodpecker	Pacific-slope Flycatcher	Wilson's Warbler
Barred Owl	Eurasian Collared-dove	Red-tailed Hawk	Yellow Warbler
Berwick's Wren	European Starling	Rufous Hummingbird	Yellow-rumped Warbler
Black-capped Chickadee	Golden-crowned Kinglet	Savannah Sparrow	
Black-headed Grosbeak	Great Blue Heron	Song Sparrow	
Brown Creeper	House Finch	Spotted Towhee	
Brown-headed Cowbird	Killdeer	Swainson's Thrush	
Bullock's Oriole	Mallard	DFWT4's Warbler	
		TOTAL	**43**
DFWT1			
American Goldfinch	Brown-headed Cowbird	House Sparrow	Song Sparrow
American Robin	Canada Goose	Mallard	Spotted Towhee
Anna's Hummingbird	Cedar Waxwing	Orange-crowned Warbler	Tree Swallow
Bald Eagle	Common Yellowthroat	Red-tailed Hawk	unknown sp.
Barn Swallow	Eurasian Collared-dove	Ruby-crowned Kinglet	White-crowned Sparrow
Berwick's Wren	European Starling	Rufous Hummingbird	Wilson's Warbler
Black-capped Chickadee	House Finch	Savannah Sparrow	Yellow Warbler
		TOTAL	**28**

DFWT2			
American Goldfinch	Cedar Waxwing	Killdeer	Spotted Towhee
American Robin	Common Yellowthroat	Northern Flicker	Tree Swallow
Anna's Hummingbird	Downy Woodpecker	Northern Harrier	unknown sp.
Bald Eagle	European Starling	Northwestern Crow	Violet-green Swallow
Barn Swallow	Glaucous-winged Gull	Rock Pigeon	White-crowned Sparrow
Berwick's Wren	Golden-crowned Sparrow	Rufous Hummingbird	Wilson's Warbler
Black-capped Chickadee	House Finch	Savannah Sparrow	Yellow Warbler
Brown-headed Cowbird	House Sparrow	Song Sparrow	Yellow-rumped Warbler
		TOTAL	**32**
DFWT3			
American Goldfinch	Brown-headed Cowbird	House Finch	Song Sparrow
American Robin	Cedar Waxwing	Killdeer	Tree Swallow
Bald Eagle	Common Yellowthroat	Savannah Sparrow	unknown sp.
Barn Swallow	Eurasian Collared-dove	Savannah Sparrow	Violet-green Swallow
Black-capped Chickadee	European Starling	Sharp-shinned Hawk	White-crowned Sparrow
		TOTAL	**20**
DFWT4			
American Goldfinch	Cedar Waxwing	Mallard	Spotted Towhee
American Robin	Common Yellowthroat	Marsh Wren	Tree Swallow
Anna's Hummingbird	Eurasian Collared-dove	Northwestern Crow	unknown sp.
Bald Eagle	European Starling	Rock Pigeon	Violet-green Swallow
Barn Swallow	House Finch	Rufous Hummingbird	White-crowned Sparrow
Black-capped Chickadee	House Sparrow	Savannah Sparrow	Wilson's Warbler
Brown-headed Cowbird	Killdeer	Song Sparrow	
		TOTAL	**27**
DFWT5			
American Goldfinch	Brown-headed Cowbird	European Starling	Rufous Hummingbird
American Robin	Canada Goose	House Finch	Savannah Sparrow
Anna's Hummingbird	Cedar Waxwing	Mallard	Tree Swallow
Barn Swallow	Common Yellowthroat	Northern Harrier	unknown sp.
Black-capped Chickadee	Eurasian Collared-dove	Rock Pigeon	White-crowned Sparrow
		TOTAL	**20**
DFWT6			
American Goldfinch	Cedar Waxwing	Northern Flicker	Tree Swallow
American Robin	Common Yellowthroat	Northwestern Crow	unknown sp.
Anna's Hummingbird	Downy Woodpecker	Red-tailed Hawk	Violet-green Swallow
Bald Eagle	Eurasian Collared-dove	Rock Pigeon	White-crowned Sparrow
Barn Swallow	European Starling	Rufous Hummingbird	Willow Flycatcher
Berwick's Wren	Glaucous-winged Gull	Savannah Sparrow	Yellow-rumped Warbler
Black-capped Chickadee	House Finch	Savannah Sparrow	
Brown-headed Cowbird	House Sparrow	Song Sparrow	
		TOTAL	**30**
DFWT7			

American Robin	Common Yellowthroat	Mallard	Tree Swallow
Barn Swallow	European Starling	Marsh Wren	unknown sp.
Brewer's Blackbird	House Finch	Northwestern Crow	
Brown-headed Cowbird	Killdeer	Savannah Sparrow	
		TOTAL	**14**
TOTAL SPECIES OBSERVED	**SPRING/SUMMER 2016**		**55**

B Hedgerow Table – Species by Hedgerow 2017 - Lists of all species observed in each hedgerow transect during surveys conducted in May through July of 2017 in Delta, BC

Table 2: Species by hedgerow observed during surveys conducted in May through July of 2016 in Delta, BC.

2017			
Reference 1			
American Goldfinch	Dark-eyed Junco	Pine Siskin	Yellow Warbler
American Robin	Eurasian Collared-dove	Rock Pigeon	Yellow-rumped Warbler
Anna's Hummingbird	European Starling	Rufous Hummingbird	
Bald Eagle	Glaucous-winged Gull	Savannah Sparrow	
Barn Swallow	Hairy Woodpecker	Song Sparrow	
Bewick's Wren	House Finch	Spotted Towhee	
Black-capped Chickadee	Hummingbird (unknown)	Tree Swallow	
Brown-headed Cowbird	Killdeer	Violet-green Swallow	
Bushtit	Mallard	Western Tanager	
Canada Goose	Northern Flicker	White-crowned Sparrow	
Cedar Waxwing	Orange-crowned Warbler	Wilson's Warbler	
Common Yellowthroat	Pacific-slope Flycatcher	Woodpecker (unknown)	
		TOTAL	**38**
Reference 2			
American Goldfinch	Common Yellowthroat	Pacific-slope Flycatcher	Western Tanager
American Robin	Dark-eyed Junco	Raptor (unknown)	Willow Flycatcher
Bald Eagle	Downy Woodpecker	Red-breasted Nuthatch	Wilson's Warbler
Barn Swallow	European Starling	Rufous Hummingbird	Wood Duck
Black-capped Chickadee	Great Blue Heron	Red-winged Blackbird	Woodpecker (unknown)
Bewick's Wren	House Sparrow	Savannah Sparrow	Yellow Warbler
Brown-headed Cowbird	Hummingbird (unknown)	Song Sparrow	Yellow-rumped Warbler
Black-headed Grosbeak	Hutton's Vireo	Spotted Towhee	
Brewer's Blackbird	Mallard	Swainson's Thrush	
Bushtit	Northwestern Crow	Tree Swallow	
Canada Goose	Orange-crowned Warbler	Violet-green Swallow	
Cedar Waxwing	Pileated Woodpecker	White-crowned Sparrow	
		TOTAL	**43**
DFWT1			

American Goldfinch	Cedar Waxwing	Mallard	Swallow (unknown)
American Robin	Common Yellowthroat	Orange-crowned Warbler	Tree Swallow
Bald Eagle	Dark-eyed Junco	Raptor (unknown)	White-crowned Sparrow
Barn Swallow	Eurasian Collared-dove	Red-breasted Nuthatch	Wilson's Warbler
Black-capped Chickadee	European Starling	Red-winged Blackbird	Yellow Warbler
Brewer's Blackbird	Great Blue Heron	Savannah Sparrow	
Brown-headed Cowbird	Gull (unknown)	Song Sparrow	
Bushtit	House Sparrow	Spotted Towhee	
		TOTAL	**29**
DFWT2			
American Goldfinch	Cedar Waxwing	Killdeer	Savannah Sparrow
American Robin	Common Yellowthroat	MacGillivray's Warbler	Song Sparrow
Anna's Hummingbird	Eurasian Collared-dove	Northern Harrier	Tree Swallow
Bald Eagle	European Starling	Northwestern Crow	White-crowned Sparrow
Barn Swallow	Glaucous-winged Gull	Orange-crowned Warbler	Wilson's Warbler
Black-capped Chickadee	House Finch	Pacific Wren	Yellow Warbler
Bewick's Wren	House Sparrow	Purple Finch	Yellow-rumped Warbler
Brewer's Blackbird	Hummingbird (unknown)	Rufous Hummingbird	
		TOTAL	**31**
DFWT3			
American Goldfinch	Common Yellowthroat	Northwestern Crow	White-crowned Sparrow
American Robin	European Starling	Ruby-crowned Kinglet	Western Tanager
Bald Eagle	Great Blue Heron	Red-tailed Hawk	Western Wood-Pewee
Barn Swallow	Glaucous-winged Gull	Savannah Sparrow	Yellow Warbler
Black-capped Chickadee	House Finch	Song Sparrow	Yellow-rumped Warbler
Brown-headed Cowbird	House Sparrow	Tree Swallow	
Cedar Waxwing	Killdeer	Violet-green Swallow	
		TOTAL	**26**
DFWT4			
American Goldfinch	Cedar Waxwing	House Sparrow	Song Sparrow
American Robin	Common Yellowthroat	Killdeer	Spotted Towhee
Bald Eagle	Eurasian Collared-dove	Mallard	Tree Swallow
Barn Swallow	European Starling	Northwestern Crow	Violet-green Swallow
Black-capped Chickadee	Glaucous-winged Gull	Raptor (unknown)	
Brewer's Blackbird	Great Blue Heron	Red-winged Blackbird	
Brown-headed Cowbird	House Finch	Savannah Sparrow	
		TOTAL	**25**
DFWT5			
American Goldfinch	Cedar Waxwing	House Sparrow	Raptor (unknown)
American Robin	Common Yellowthroat	Killdeer	Savannah Sparrow
Barn Swallow	Eurasian Collared-dove	Mallard	Song Sparrow
Black-capped Chickadee	European Starling	Marsh Wren	White-crowned Sparrow
Brewer's Blackbird	Glaucous-winged Gull	Northwestern Crow	Willow Flycatcher
Brown-headed Cowbird	House Finch	Purple Finch	
		TOTAL	**23**
DFWT6			
American Goldfinch	Chesnut-backed Chickadee	Killdeer	Tree Swallow
American Robin	Cedar Waxwing	Mallard	Violet-green Swallow

Anna's Hummingbird	Common Yellowthroat	Northwestern Crow	White-crowned Sparrow
Bald Eagle	Eurasian Collared-dove	Pacific-slope Flycatcher	Western Tanager
Barn Swallow	European Starling	Ring-necked Pheasant	Western Wood-Pewee
Black-capped Chickadee	Glaucous-winged Gull	Red-winged Blackbird	Willow Flycatcher
Belted Kingfisher	House Finch	Savannah Sparrow	Wilson's Warbler
Bewick's Wren	House Sparrow	Song Sparrow	
Brown-headed Cowbird	Hummingbird (unknown)	Spotted Towhee	
		TOTAL	**34**
DFWT7			
American Goldfinch	Brewer's Blackbird	Gull (unknown)	Red-winged Blackbird
American Robin	Brown-headed Cowbird	Killdeer	Savannah Sparrow
Barn Swallow	Common Yellowthroat	Mallard	Tree Swallow
Barred Owl	Duck (unknown)	Marsh Wren	
Bewick's Wren	European Starling	Pacific Wren	
Black-capped Chickadee	Great Blue Heron	Raptor (unknown)	
		TOTAL	**21**
TOTAL SPECIES OBSERVED	**SPRING/SUMMER 2017**		**61**

C Individual Birds Observed by Species - Lists of all individuals observed in each all Sites of the DF&WT transects during surveys conducted in May through July of 2016 and 2017 in Delta, BC

Table 3: Number of individuals observed during surveys conducted in May through July of 2016 and 2017 in Delta, BC.

Total observations of bird species in hedgerows
NOTE: Species detected (2017) are for all surveys (including trainings) of Sites. Number of surveys, dates and times will vary for every survey.

2016	**4510**	**2017**	**2968**
Species	**# individuals**	**Species**	**# individuals**
EUST	865	Species (unknown)	378
SAVS	528	SAVS	274
AMRO	409	EUST	272
BCCH	292	CEWA	268
TRES	273	BCCH	230
HOFI	231	AMRO	220
AMGO	197	BHCO	118
BARS	185	TRES	113
COYE	165	BARS	104
SOSP	160	AMGO	87
WCSP	142	SPTO	77
BHCO	131	COYE	76
CEWA	116	HOSP	73
SPTO	97	SOSP	64
HOSP	61	WCSP	60
UNKN	58	BEWR	41

BEWR	50	BUSH	40
MAWR	42	HOFI	38
ANHU	40	GWGU	35
RUHU	39	CANG	28
ROPI	32	NOCR	24
VGSW	29	YEWA	24
Hummingbird sp.	28	EUCD	23
NWCR	28	KILL	23
ECDO	27	VGSW	23
BAEA	25	BAEA	20
MALL	23	BRBL	20
YEWA	19	YRWA	18
BHGR	17	MALL	14
WIWA	16	BHGR	13
KILL	13	Hummingbird (unknown)	13
EUCO	12	ANHU	12
juvenile sparrow sp.	12	WIWA	12
PISI	12	OCWA	10
BUSH	10	PSFL	10
GWGU	10	Woodpecker (unknown)	10
CANG	9	SWTH	9
gull sp.	9	MAWR	8
NOCR	8	RUHU	8
RTHA	7	RWBL	7
YRWA	7	WETA	7
DOWO	6	DEJU	6
PSFL	6	Raptor (unknown)	6
OCWA	5	DOWO	5
BRBL	4	GBHE	5
BRCR	4	RBNU	4
GCKI	4	WIFL	4
NOHA	4	PUFI	3
RCKI	4	RCKI	3
SWTH	4	CBCH	2
BUOR	3	Gull (unknown)	2
NOFL	3	HAWO	2
Sparrow sp.	3	HUVI	2
Warbler sp.	3	NOHA	2
WIFL	3	PAWR	2
BAOW	2	PISI	2
BDOW	2	ROPI	2
DEJU	2	WEWP	2
GBHE	2	BADO	1
GCSP	2	BEKI	1
Hawk sp.	2	Duck (unknown)	1
SACR	2	MGWA	1
flycatcher sp.	1	NOFL	1
raptor sp.	1	PIWO	1
SSHA	1	RTHA	1
TOWA	1	RNEP	1
WAVI	1	Swallow (unknown)	1
woodpecker sp.	1	WODU	1

Total	**4510**	**Total**	**2968**

D List of all bird species

Table 4: Lists of all species observed during surveys conducted in May through July of 2016 in Delta, BC.

All Species Observed in 2016 Hedgerow Study		
American Goldfinch	Eurasian Collared-dove	Red-tailed Hawk
American Robin	European Starling	Rufous Hummingbird
Anna's Hummingbird	Great Blue Heron	Sandhill Crane
Bald Eagle	Golden-crowned Kinglet	Savannah Sparrow
Barn Swallow	Golden-crowned Sparrow	Song Sparrow
Black-capped Chickadee	Glaucous-winged Gull	Spotted Towhee
Barred Owl	House Finch	Sharp-shinned Hawk
Bewick's Wren	House Sparrow	Swainson's Thrush
Brown-headed Cowbird	Killdeer	DFWT4's Warbler
Black-headed Grosbeak	Mallard	Tree Swallow
Brewer's Blackbird	Marsh Wren	Violet-green Swallow
Brown Creeper	Northwestern Crow	Warbling Vireo
Bullock's Oriole	Northern Flicker	White-crowned Sparrow
Bushtit	Northern Harrier	Willow Flycatcher
Canada Goose	Orange-crowned Warbler	Wilson's Warbler
Cedar Waxwing	Pine Siskin	Yellow Warbler
Common Yellowthroat	Pacific-slope Flycatcher	Yellow-rumped Warbler
Dark-eyed Junco	Ruby-crowned Kinglet	
Downy Woodpecker	Rock Pigeon	
Total		**55 Species**

Table 5: Lists of all species observed during surveys conducted in May through July of 2017 in Delta, BC.

All Species Observed in 2017 Hedgerow Study		
American Goldfinch	Glaucous-winged Gull	Red-winged Blackbird
American Robin	Great Blue Heron	Ring-necked Pheasant
Anna's Hummingbird	Hairy Woodpecker	Rock Pigeon
Bald Eagle	House Finch	Ruby-crowned Kinglet
Barn Swallow	House Sparrow	Rufous Hummingbird
Barred Owl	Hutton's Vireo	Savannah Sparrow
Belted Kingfisher	Killdeer	Song Sparrow
Bewick's Wren	MacGillivray's Warbler	Spotted Towhee
Black-capped Chickadee	Mallard	Swainson's Thrush
Black-headed Grosbeak	Marsh Wren	Tree Swallow
Brewer's Blackbird	Northern Flicker	Violet-green Swallow
Brown-headed Cowbird	Northern Harrier	Western Tanager
Bushtit	Northwestern Crow	Western Wood-Pewee
Canada Goose	Orange-crowned Warbler	White-crowned Sparrow
Cedar Waxwing	Pacific Wren	Wilson's Warbler
Chesnut-backed Chickadee	Pacific-slope Flycatcher	Wood Duck
Common Yellowthroat	Pine Siskin	Yellow Warbler
Dark-eyed Junco	Purple Finch	Yellow-rumped Warbler
Downy Woodpecker	Red-breasted Nuthatch	Willow Flycatcher
Eurasian Collared-dove	Pileated Woodpecker	
European Starling	Red-tailed Hawk	
Total		**61 Species**