Impacts of Livestock Grazing of Grassland Set-asides on Wildlife

Prepared for:

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EXECUTIVE SUMMARY

This study assessed the effects of livestock grazing of agricultural fields on small mammal and raptor abundance in Delta, BC during May to July 2020. Delta Farmland and Wildlife Trust (DF&WT) works with local farmers to protect productive agricultural land while also enhancing wildlife habitat. One of DF&WT’s stewardship initiatives is the grassland set-aside (GLSA) program, which entails removing a field from crop rotation and instead planting it with grasses to improve soil as well as wildlife habitat values. To encourage participation in the GLSA program, DF&WT is exploring whether livestock grazing of GLSAs alters wildlife habitat. To assess effects of grazing, I conducted surveys of vegetation structure and composition, small mammal abundance, and raptor abundance and behaviour on two un-grazed and two grazed GLSAs. Vegetation surveys were conducted twice on each GLSA, once in June 2020 and once in July 2020. Four small mammal trapping sessions were conducted on each GLSA during June to July 2020. Nine raptor surveys were conducted on each GLSA during May to July 2020.

Vegetation structure and composition were relatively similar in grazed and un-grazed GLSAs, except for grass height which was 43.5% lower in grazed GLSAs. I caught a total of 1120 small mammals, of which 1077 were Townsend’s Voles (Microtus townsendii). Townsend’s Vole abundance was higher on un-grazed versus grazed GLSAs. The abundance of Northern Harriers (Circus hudsonius) was greater on grazed GLSAs, but harriers spent more time hunting on un-grazed GLSAs. The results of this study suggest that wildlife habitat values differ between un-grazed and grazed GLSAs. I suggest that future research assess how the seasonal timing, intensity, and long-term duration of grazing affect wildlife habitat on GLSAs.
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1.0 INTRODUCTION

I studied the effects of livestock grazing on small mammal and raptor populations in agricultural fields in Delta, British Columbia (BC). The Fraser Delta is an essential ecosystem for migrating and wintering birds, aquatic animals, and other wildlife, and the area supports the largest density of over-wintering birds in Canada (Murray 2016). Many of the raptors that feed on land primarily feed on grassland rodents, such as Townsend’s Vole (Microtus townsendii).

Historically, the alluvial soils of the Fraser River Delta supported extensive grasslands and marshes, but much of this landscape has been altered by development, especially agricultural land development (Cannings and Cannings 2015). Delta Farmland and Wildlife Trust (DF&WT) promotes the annual enhancement of >3,500 acres of wildlife habitat on farmland through co-operative management with local farmers. The goal of DF&WT stewardship programs is to conserve productive agricultural land while also promoting wildlife habitat. DF&WT provides financial incentive for farmers to establish wildlife habitat and promote soil fertility on their farms.

1.1 DF&WT Grassland Set-Aside Program

One of DF&WT’s initiatives is the Grassland Set-Aside (GLSA) program, which entails removal of a field from crop rotation for up to four years and planting it with a grass/legume mix. As incentive, DF&WT shares in the costs with participating farmers.

GLSAs benefit agricultural production by increasing organic matter in the soil, improving soil fertility, and attracting pollinating insects. Additionally, the GLSA program can help farmers transition to organic production. In addition to benefiting farmers, GLSAs provide important benefits for birds and small mammals. For instance, GLSAs support large numbers of Townsend’s Voles, a native mammal that is a valuable food source for predatory birds such as Northern Harriers (Circus hudsonius) and Red-tailed Hawks (Buteo jamaicensis) (Lee and Rudd 2003).
1.2 Livestock Grazing and Small Mammals

Historically, cattle grazing has not been permitted on GLSAs. However, the amount of agricultural land in the Fraser River Delta is declining which makes it difficult for farmers to incorporate GLSAs into their rotation. To promote increased participation in the GLSA program, DF&WT is exploring alternative management options, such as allowing livestock grazing. Beginning in spring 2019, light livestock grazing was permitted on two GLSAs.

Livestock grazing can change vegetation structure and composition of a field, which can in turn affect small mammals and their predators. Voles are associated with herbaceous ground cover, moisture, and the organic layer at the surface of the soil (Ream 1981). In general, vole abundance declines with increased grazing (Lagendijk et al. 2019). However, the underlying cause for the decline in vole abundance may vary. Grazing can lead to decreased food availability for voles and thereby increasing competition (Bakker 2009). Alternatively, livestock grazing reduces vegetation density and height thereby reducing security cover and increasing risk of predation (Taitt et al. 1981).

In addition to effecting small mammals, livestock grazing can impact the hunting success of Northern Harriers. Harriers use vegetation and terrain to ambush prey, and thus require fields with moderate-heavy cover (Slate and Rock 2005). Agricultural fields that have been abandoned or taken out of rotation with vegetative cover tend to be more used by Northern Harriers than fields that are heavily grazed or used for farming (Smith et al. 2020).

1.3 Objectives

The purpose of this study was to identify whether livestock grazing of GLSAs affects the abundance of small mammals and thus raptor feeding opportunities. Study results will help assess whether livestock grazing of GLSAs is a viable management option, which should expand participation in the GLSA program.
The three objectives of this study were to compare un-grazed and grazed GLSAs in terms of:

1. Vegetation structure and composition, as well as evidence of grazing;
2. Small mammal abundance; and
3. Raptor abundance and hunting behaviour.

To achieve these objectives, I conducted surveys of vegetation, small mammal abundance, and raptor abundance and behaviour on un-grazed and grazed GLSAs.

My hypothesis was that small mammal abundance and therefore raptor hunting would be lower in GLSAs with livestock grazing. In general, vole abundance declines with increased grazing, but the mechanism behind this pattern varies (Bakker 2009; Lagendijk et al. 2019).

2.0 STUDY SITE

This study was conducted in Delta, BC. The climate in the region is temperate and warm with high levels of precipitation in winter. Mean monthly temperatures range from 0.6 °C in January to 22.2 °C in July (PCIC 2013). The mean annual monthly precipitation in the study area ranges from 0.74 mm/day in July to 5.61 mm/day in November (PCIC 2013).

The study was conducted on four GLSAs in Delta, including two on Westham Island and two in south Delta (Figure 1). Two of the GLSAs had a history of grazing and two GLSAs had no previous grazing. The grazed sites were the only GLSAs with a history of grazing at the time of this study. The un-grazed GLSAs were selected because they had similar vegetation composition and age class to the grazed GLSAs (Table 1; Table 2). To minimize bias associated with GLSA age, I selected GLSAs with similar planting dates: for both grazed and un-grazed GLSAs, one GLSA was planted in 2017 and one GLSA was planted in 2018 (Table 2).
Figure 1. Locations of the two un-grazed and two grazed GLSAs in Delta, BC on which vegetation, small mammal, and raptor surveys were conducted during May to July 2020.

Table 1. Vegetation composition of two un-grazed and two grazed GLSAs on which small mammal, raptor, and vegetation surveys were conducted during May to July 2020.

<table>
<thead>
<tr>
<th>Field ID</th>
<th>Seed mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLSA 1802 (un-grazed)</td>
<td>Tall fescue; Orchardgrass; Red top grass; Double cut red clover; Annual Ryegrass</td>
</tr>
<tr>
<td>GLSA 1701 (un-grazed)</td>
<td>Fescue sp.; Red clover; Annual Rye nurse crop</td>
</tr>
<tr>
<td>GLSA 1806 (grazed)</td>
<td>Fescue sp.; Orchardgrass; Timothy</td>
</tr>
<tr>
<td>GLSA 1705 (grazed)</td>
<td>Fescue sp.; Timothy; Creeping Red Fescue</td>
</tr>
</tbody>
</table>
Table 2. Age class and size of two un-grazed and two grazed GLSAs on which vegetation, small mammal, and raptor surveys were conducted during May to July 2020.

<table>
<thead>
<tr>
<th>Field ID</th>
<th>Year planted</th>
<th>Grazed/un-grazed</th>
<th>Size (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLSA 1802</td>
<td>2018</td>
<td>Un-grazed</td>
<td>12</td>
</tr>
<tr>
<td>GLSA 1701</td>
<td>2017</td>
<td>Un-grazed</td>
<td>15</td>
</tr>
<tr>
<td>GLSA 1806</td>
<td>2018</td>
<td>Grazed</td>
<td>16</td>
</tr>
<tr>
<td>GLSA 1705</td>
<td>2017</td>
<td>Grazed</td>
<td>17</td>
</tr>
</tbody>
</table>

GLSA 1802 (un-grazed) is located on 40 Street in Delta, BC. The GLSA is bordered by roads on the east and west side of the GLSA. The north edge is bordered by a water-filled ditch and the south edge is bordered by residential developments and fields. On the property south of the GLSA, there are several, large deciduous trees.

GLSA 1701 (un-grazed) is located on 34b Avenue in Delta, BC. The GLSA is bordered by orchards on two sides, a grassy field on the east side, and a road on the north edge with residential properties. This GLSA is within 350 m of Deltaport Way and a train track.

GLSAs 1806 and 1705 (grazed) are located on the edge of Westham Island in Delta, BC. The GLSAs are adjacent to one another but are separated by a water-filled ditch except for a 6 m grassy path connecting them. The other edges are bordered by agricultural fields. Because the GLSAs are located on the edge of Westham Island, there are few residential developments in the surrounding areas. The GLSAs are bordered by a dyke and wetland on the southern edge (Appendix I).

2.1 Grazing History

Livestock grazing was permitted on GLSA 1806 and 1705 beginning in the spring of 2019. For approximately one year, light livestock gazing occurred on both GLSAs. Grazing did not occur in the GLSAs during April and May 2020 but resumed in June and July 2020. Light grazing is defined as the whole herd grazing for a few days, or a few individuals grazing for longer. Because the two GLSAs are connected at one edge, cattle were able to move freely between GLSAs. The total number of cattle in the herd during the study was approximately 60 individuals, including 25 cows, 23 calves, 11 yearling steers, and 1 bull (Jack Zellweger
pers. comm. 2020). A detailed record of grazing intensity and duration was not recorded before this study began.

3.0 METHODS

I conducted vegetation structure and composition surveys, small mammal trapping, and raptor counts and behavioural surveys on two grazed and two un-grazed GLSAs in Delta, BC. For these surveys, each GLSA was divided into four approximately equal quadrants (Appendix II).

3.1 Vegetation Surveys

I surveyed vegetation structure and composition relative to grazing at each GLSA twice, once at the beginning of the field season (2 to 8 June 2020) and once at the end (6 to 14 July 2020). For each GLSA, I randomly selected a starting point along the edge of the GLSA and randomly selected a bearing to create a transect running from one edge of the GLSA to the other edge. Then, I established parallel transects every 30 m. The number of transects per GLSA depended on the width of the field (GLSA 1802: 5 transects; GLSA 1701: 7; GLSA 1806: 8; GLSA 1705: 9). For each transect, I randomly selected the distance from the edge (0-30 m) for the first plot, and then systematically established subsequent plots every 60 m (GLSA 1802: 22 plots; GLSA 1701: 32; GLSA 1806: 37; GLSA 1705: 36). At each point, I established a 0.5 m × 0.5 m plot and randomly selected a single plot orientation that was used for all surveys. For each plot, I estimated and recorded:

- Grass height
- Thatch height
- Cover class of grass, thatch, bare ground, and grazed stems (Table 3)
- Dominant vegetation species
- Number of cow dung piles
- Number of cow tracks
- Evidence of flooding
I used a metre stick to measure grass and thatch height and rounded values to the nearest decimetre. Percent cover was determined using the Vegetation Resources Inventory protocol and recorded as a cover class (Table 3; Appendix III) (MFLNRO 2016).

Table 3. Grass, thatch, bare ground, and grazed stem cover were recorded using cover classes in vegetation surveys on two un-grazed and two grazed GLSAs between June to July 2020 in Delta, BC.

<table>
<thead>
<tr>
<th>Cover class</th>
<th>Percent cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>1</td>
<td>1 – 5%</td>
</tr>
<tr>
<td>2</td>
<td>5 – 10%</td>
</tr>
<tr>
<td>3</td>
<td>10 – 25%</td>
</tr>
<tr>
<td>4</td>
<td>25 – 50%</td>
</tr>
<tr>
<td>6</td>
<td>75 – 100%</td>
</tr>
</tbody>
</table>

For data summary and analysis, I compared each variable in June and July 2020 on each GLSA. If there was minimal change between the two surveys, or similar change occurring across all four GLSAs, I averaged the values from the June and July surveys for each GLSA. I did not average June and July values for variables that changed significantly from June to July, and instead I reported both the June and July values in the results. All means are reported ± standard deviation.

3.2 Small Mammal Trapping

Two trapping grids were established in each GLSA (Figure 2). In the un-grazed GLSAs, I established one trapping grid in each of two quadrants because the GLSAs had relatively homogenous vegetation structure. The first quadrant was randomly selected, and then to achieve good coverage of the GLSA, the second quadrant was located diagonally from the first. I randomly selected the locations of grids within each quadrant using ArcMap. If the randomly selected grid was in a flooded area, I randomly selected a different location.
Because the grazed GLSAs had relatively heterogeneous vegetation structure, the grids were strategically placed in areas that had similar vegetation composition and structure to the un-grazed sites, except in terms of evidence of previous grazing and/or vegetation likely to be grazed (Appendix IV). Thus, areas with winter flooding and duck grazing were avoided. As well, grids were placed in areas of the GLSA likely to be grazed by cattle, such as areas with grass >0.15 m without significant bare ground (Jack Zellweger pers. comm. 2020). All trapping grids were established >20 m from the edge.

I established each grid in a 5 × 5 pattern in the GLSA using a Garmin GPS for reference, with 5 m between each station (i.e., total grid size was 20 m × 20 m). At each station, I placed one Longworth “Little Critter” trap for a total of 25 traps per station. If the 25 traps within a single grid were saturated with ≥ 16 animals (approximately 65%) during the first check of any trapping session and most of these animals had no ear tags, then a second trap was added to each station for subsequent trapping sessions. This ensured that there was equal capturability of animals across all GLSAs. I added double traps to GLSA 1802 (un-grazed) and GLSA 1701 (un-grazed) for trapping sessions 2, 3, and 4, and to GLSA 1806 (grazed) for trapping sessions 3 and 4. When possible, I placed traps in a vole runway with the doorside on a downward slope to help keep the door shut upon capture. I baited the traps with oats for food, carrot for moisture, and cotton for warmth. As well, a wooden cover board was placed on top of every trap to provide shade.

In total, I conducted four trapping sessions on each GLSA during 3 June to 16 July 2020. Each GLSA was sampled every two weeks with one week of pre-baiting. During pre-baiting, the traps were locked open with oats, cotton, carrots, and a cover board to familiarize the animals with the trap locations. Following pre-baiting and trapping, the traps and cover boards were removed from the GLSAs for one week to allow for livestock grazing on the grazed GLSAs. Traps and cover boards were also removed from the un-grazed GLSAs to avoid bias. For each session, I rotated which GLSA and grid was set first to minimize bias.

During each trapping session, I set the traps in the evening the day before trapping between 1800 and 2030 hrs and then checked the traps the next morning starting at 0600 hrs in the
same order they were set. On 2 June 2020, I started setting the traps at 2040 hrs, however I adjusted to start setting at 1800 hrs for all subsequent trapping days. After the first check, I re-set the traps and conducted a second check about 3 hours later. I checked the traps twice to increase the detection rate of individuals. All traps were disabled by about 1100 hrs to minimize mortality due to heat stress. Additionally, I monitored the temperature and was prepared to close traps early if the temperature increased to 24 °C or higher.

For each captured animal, I recorded the grid number, station number, species, tag number (if present), body mass (g), and reproductive status (males = testes abdominal or scrotal) (females = perforate or not perforate; nipples small, medium, or large; pelvic girdle closed, slightly open, or open). Additionally, I recorded pregnancies and trap litters. If no tag was present, I tagged the right ear, or the left ear if the right ear was torn, with National Band and Tag Co. metal ear tags. I used a Pesola scale to measure body mass and a field guide to determine species (Eder and Pattie 2001). All animals were handled for the minimum time possible according to RISC standards (British Columbia Ministry of Environment 1998).

For data summary and analysis, I recorded the number of individual voles caught on each trapping grid during each trapping session (one trapping session = one trap night). I determined the mean number of voles/trap night for each GLSA by averaging the number of voles/trap night on the two grids. Then, I averaged the mean voles/trap night across all four trapping sessions for each GLSA. Finally, I determined the mean voles/trap night for the un-grazed and grazed GLSAs. All means are reported ± standard deviation.

3.3 Cattle Grazing

Between each trapping session, about 60 cows grazed GLSA 1806 and 1705 for one week. Because the GLSAs are connected, the cows roamed freely between the two GLSAs resulting in selective grazing within the GLSAs, and uneven grazing between the two GLSAs (Appendix IV).
Figure 2. Locations of the two small mammal trapping grids on each of two un-grazed and two grazed GLSAs between 3 June and 16 July 2020 in Delta, BC.
3.4 Raptor Surveys

Raptor surveys were conducted at each GLSA from an access point with good visibility of the entire GLSA. I used binoculars (8×42) to observe animals. Northern Harriers were the target species for this study, but all raptor species were recorded except Bald Eagles (*Haliaeetus leucocephalus*).

I surveyed raptors within three daily time periods: before 1000 hrs, 1000 to 1400 hrs, and after 1400 hrs to account for the diurnal behaviour of Northern Harriers (Smith et al. 2020). Each GLSA was surveyed nine times (i.e., on nine separate days) throughout the field season (three times in each daily time period). Each raptor survey consisted of behaviour surveys, abundance surveys, and dive counts. For each survey, I recorded the date, weather, location, start time, and end time.

*Behaviour surveys*

Each behaviour survey lasted for two hours. During each survey, I conducted observations of individuals for a maximum of 15 minutes, or until I could no longer see the individual raptor for more than 20 seconds. During each observation, I recorded the species and which quadrant it was in (Appendix II). Every 10 seconds, I recorded the behaviour (flying <5 m above ground, flying 5-10 m, flying >10 m, perching on ground, perching on shrub/tree, diving, other), and whether the behaviour occurred within or outside of the GLSA. If there were multiple individuals, I randomly selected one individual to observe for a maximum of 15 minutes, or until it left the study site. I waited at least five minutes between each observation to ensure the independence of samples, unless I was certain it was a different individual (e.g., multiple individuals observed simultaneously, or clear colour change from male-female Northern Harrier). For each individual, I determined the percent frequency of each behaviour inside the GLSA. To do this I divided the number of times the individual was observed in that behaviour by the total number of times the individual was observed, times 100%. All means are reported ± standard deviation.
**Dive counts**

During the two-hour behaviour survey, I recorded separately for all raptors present the number of each of the following behaviours per species and which quadrant they occurred in:

- Dive: no touchdown
- Dive: touchdown – successful and prey category (bird, small mammal, other, unknown)
- Dive: touchdown – unsuccessful
- Dive: touchdown – success unknown

**Abundance surveys**

Before, half-way through, and following each two-hour behaviour survey, I conducted a five-minute abundance count. I recorded all individual raptors in the GLSA and in areas immediately adjacent to the GLSA along with its species, behaviour, and quadrant. Abundance surveys conducted on 25 and 26 May 2020 were 10 minutes long. Due to a low raptor abundance, I adjusted the time to five minutes for all subsequent surveys.
4.0 RESULTS

4.1 Vegetation Surveys

Mean grass height was higher in the un-grazed versus grazed GLSAs in both June and July 2020 surveys (Figure 3). Mean grass height in the un-grazed GLSAs did not change significantly in June and July surveys, but mean grass height in the grazed GLSAs decreased by 43.5% from June to July (Figure 3). Mean thatch height, thatch cover, and bare ground cover were slightly higher in the un-grazed versus grazed GLSAs while mean grass cover was similar in all GLSAs (Figure 4). Fescue (Fescuta) sp. was the most dominant vegetation in most plots in both un-grazed and grazed GLSAs (Appendix V). There were slightly more plots with flood evidence, on average, in un-grazed versus grazed GLSAs (Appendix V). There was no evidence of grazing in the un-grazed GLSAs (Figure 5). In the grazed GLSAs, there was minimal evidence of grazing during the June surveys and significantly more evidence of grazing during the July surveys (Figure 5).

Figure 3. Boxplots showing grass height in two un-grazed and two grazed GLSAs during June and July 2020 vegetation surveys in Delta, BC. The bold black lines represent the median grass height for each field, the boxes represent the middle 50% of grass heights, the bars represent grass heights outside of the middle 50%, and the dots represent outliers. The green line is the mean grass height on un-grazed GLSAs (June: 0.66 ± SD = 0.46 m; July: 0.67 ± 0.44 m) and the red line is the mean grass height on grazed GLSAs (June: 0.46 ± 0.19 m; July: 0.26 ± 0.16 m).
Figure 4. Boxplots for four variables commonly affected by cattle grazing (thatch height, grass, thatch, and bare ground cover) on two un-grazed and two grazed GLSAs during June and July 2020 surveys in Delta, BC. The bold black lines represent the median for each GLSA, the boxes represent the middle 50%, the bars represent values outside of the middle 50%, and the dots represent outliers. The green lines are the means on un-grazed GLSAs (thatch height: 0.12 ± SD = 0.07 m; grass: 3.2 ± 1.4; ground: 1.7 ± 2.1; thatch cover: 2.6 ± 1.7) and the red lines are the means on grazed GLSAs (thatch height: 0.11 ± 0.08 m; grass: 3.2 ± 1.4; ground: 1.7 ± 1.9; thatch cover: 2.1 ± 1.5). Cover class 0 = 0%; 1 = 1 – 5%; 2 = 5 – 10%; 3 = 10 – 25%; 4 = 25 – 50%; 6 = 75 – 100%.
Figure 5. Boxplots for three variables that are metrics of grazing (grazed stem cover, cattle dung, cattle tracks) in two un-grazed and two grazed GLSAs during June and July 2020 in Delta, BC. The bold black lines represent the median grass height for each field, the boxes represent the middle 50% of the values, the bars represent values outside of the middle 50%, and the dots represent outliers. The green line is the mean grass height on un-grazed GLSAs (stem – June: 0.0; July: 0.0; dung – June: 0.0; July: 0.0; tracks – June: 0.0; July: 0.0) and the red line is the mean grass height on grazed GLSAs (stem – June: 0.0; July: 1.8 ± SD = 2.3; dung – June: 0.1 ± 0.2; July 0.2 ± 0.6; tracks – June: 0.1 ± 0.4; July: 0.1 ± 0.4). Cover class 0 = 0%; 1 = 1 – 5%; 2 = 5 – 10%; 3 = 10 – 25%; 4 = 25 – 50%; 6 = 75 – 100%.
4.2 Small Mammal Trapping

Small Mammal Density

I captured a total of 1120 small mammals over four trapping sessions in all GLSAs, including animals recaptured in subsequent weeks. In total, 599 unique individuals and three species were caught over all trapping sessions. Townsend’s Voles were the most abundant species captured with 562 total individuals caught (Table 4). Other species captured included 26 shrews (Sorex sp.) and 11 Deer Mice (Peromyscus maniculatus). For this study, I considered shrews and Deer Mice as incidental captures and thus these species were not included in analyses.

Townsend’s Vole mean abundance was higher in un-grazed versus grazed GLSAs (Figure 7). All GLSAs had the highest number of mean voles/trap night during trapping session 2 (17 to 18 June 2020), except GLSA 1806 which had the highest mean voles/trap night during trapping session 3 (30 June to 2 July 2020) (Figure 6).

Table 4. Total number of Townsend’s Voles, Deer Mice, and shrew sp. captured on two un-grazed and two grazed GLSAs during four trapping sessions from 3 June to 16 July 2020 in Delta, BC.

<table>
<thead>
<tr>
<th>GLSA</th>
<th>Total Townsend’s Voles</th>
<th>Total Deer Mice</th>
<th>Total shrew sp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1802 (un-grazed)</td>
<td>194</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>1701 (un-grazed)</td>
<td>143</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>1806 (grazed)</td>
<td>143</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>1705 (grazed)</td>
<td>82</td>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>
Figure 6. Bar graph showing the mean Townsend’s Vole catch per unit effort (±SD) during four trapping sessions on two un-grazed and two grazed GLSAs between 3 June to 16 July 2020 in Delta, BC.

Figure 7. Boxplots showing Townsend’s Vole catch per unit effort on two un-grazed and two grazed GLSAs in Delta, BC. Trapping occurred every two weeks on two grids within each GLSA from 3 June to 16 July 2020 for a total of four trapping sessions on each GLSA. The bold black lines represent the median vole abundance for each field, the boxes represent the middle 50% of values, the bars represent the values outside of the middle 50%, and the dots represent outliers. The green line is the mean vole abundance on un-grazed GLSAs (36.7 ± SD = 9.3 voles/trap night) and the red line is the mean vole abundance on grazed GLSAs (21.6 ± 9.3 voles/trap night).
**Small Mammal Demographics**

Voles were heavier on average in the grazed versus un-grazed GLSAs (Figure 8). There was a slightly higher proportion of females to males caught during each trapping session in grazed versus un-grazed GLSAs (Figure 9). However, there were more total reproductive females in the un-grazed GLSAs (Table 5).

![Boxplot showing Townsend's Vole body mass on four GLSAs between 3 June to 16 July 2020 in Delta, BC. The bold black lines represent the median body mass for each GLSA, the boxes represent the middle 50% of values, the bars represent the values outside of the middle 50%, and the dots represent outliers. The green line is the mean body mass on un-grazed GLSAs (46.6 ± SD = 17.5 g) and the red line is the mean body mass on grazed GLSAs (52.4 ± 17.2 g).]
**Figure 9.** Boxplot showing mean percentage of female Townsend’s Voles across trapping sessions on two un-grazed and two grazed GLSAs between 3 June to 16 July 2020 in Delta, BC. The bold black lines represent the median percentage of females for each GLSA, the boxes represent the middle 50% of values, the bars represent the values outside of the middle 50%, and the dots represent outliers. The green line is the mean percentage of females on un-grazed GLSAs (52.0 ± SD = 6.9%) and the red line is the mean percentage of females on grazed GLSAs (55.6 ± 10.9%).

**Table 5.** Distribution of Townsend’s Voles by sex and age class (adult vs. juvenile) in each of two grazed and two un-grazed GLSAs surveyed during 3 June to 16 July 2020 in Delta, BC.

<table>
<thead>
<tr>
<th>GLSA</th>
<th>1802 (un-grazed)</th>
<th>1701 (un-grazed)</th>
<th>1806 (grazed)</th>
<th>1705 (grazed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total reproductive females</td>
<td>62</td>
<td>56</td>
<td>54</td>
<td>26</td>
</tr>
<tr>
<td>Total reproductive males</td>
<td>57</td>
<td>47</td>
<td>46</td>
<td>27</td>
</tr>
<tr>
<td>Total juvenile females</td>
<td>31</td>
<td>13</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>Total juvenile males</td>
<td>47</td>
<td>28</td>
<td>22</td>
<td>18</td>
</tr>
</tbody>
</table>
4.3 Raptor Surveys

*Behaviour Surveys*

I observed three raptor species on the GLSAs: Northern Harrier, Red-tailed Hawk, and American Kestrel (*Falco sparverius*). However, only Northern Harriers were observed hunting within the GLSAs. Flying <5 m above the ground and diving were considered to entail hunting behaviour (Slater and Rock 2005; Smith et al. 2020). Red-tailed Hawks were only observed in un-grazed GLSAs (five times in GLSA 1802 and four times in GLSA 1701) and were only observed flying >10 m above the ground. American Kestrels were observed in GLSA 1701 (un-grazed) once flying >10 m and once perched in a tree. Red-tailed Hawks and American Kestrels were not considered in further analysis.

I observed more Northern Harriers in grazed versus un-grazed GLSAs. Northern Harriers were observed once in GLSA 1802 (un-grazed), five times in GLSA 1701 (un-grazed), 12 times in GLSA 1806 (grazed), and 16 times in GLSA 1705 (grazed). Of these observations, hunting behaviour was observed once in GLSA 1802 (un-grazed), five times in GLSA 1701 (un-grazed), nine time in GLSA 1806 (grazed), and 14 times in GLSA 1705 (grazed).

Northern Harriers spent slightly more time hunting (flying <5 m above the ground or diving) in un-grazed versus grazed GLSAs (Figure 10). Additionally, harriers spent more time flying 5-10 m and flying >10 m in the un-grazed GLSAs and perching in grazed GLSAs.

In the grazed GLSAs (1806, 1705), most harriers were observed in quadrants 3 and 4 (Table 6). All harriers in GLSA 1701 (un-grazed) used quadrant 2, and the single harrier observed in GLSA 1802 (un-grazed) used all four quadrants (Table 6).
Figure 10. Boxplots of the fraction of time that Northern Harriers allocated to six behaviours on two un-grazed and two grazed GLSAs during surveys from 25 May to 13 July 2020 in Delta, BC. The bold black lines represent median values, the boxes represent the middle 50% of values, the bars represent the values outside of the middle 50%, and the dots represent outliers. Green lines are means for un-grazed GLSAs (Dive: 6.4 ± SD = 11.5%; Flying <5: 44.5 ± 25.3%; Flying 5-10: 9.6 ± 10.9%; Flying >10: 17.8 ± 24.1%; Perch ground: 0.0%; Perch shrub: 0.0%) and red lines are means for grazed GLSAs (Dive: 0.4 ± 2.4%; Flying <5: 35.9 ± 36.7%; Flying 5-10: 3.6 ± 6.1%; Flying >10: 8.3 ± 18.0%; Perch ground: 3.6 ± 17.4%; Perch shrub: 25.4 ± 41.2%).
Table 6. Percentage of Northern Harrier observations in each quadrant on two un-grazed and two grazed GLSAs from behavioural surveys conducted from 25 May to 13 July 2020 in Delta, BC.

<table>
<thead>
<tr>
<th>Quadrant</th>
<th>GLSA 1802 (un-grazed)</th>
<th>GLSA 1701 (un-grazed)</th>
<th>GLSA 1806 (grazed)</th>
<th>GLSA 1705 (grazed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quadrant 1</td>
<td>100%</td>
<td>20%</td>
<td>25%</td>
<td>12.5%</td>
</tr>
<tr>
<td>Quadrant 2</td>
<td>100%</td>
<td>100%</td>
<td>41.7%</td>
<td>0%</td>
</tr>
<tr>
<td>Quadrant 3</td>
<td>100%</td>
<td>40%</td>
<td>58.3%</td>
<td>93.8%</td>
</tr>
<tr>
<td>Quadrant 4</td>
<td>100%</td>
<td>20%</td>
<td>58.3%</td>
<td>31.3%</td>
</tr>
</tbody>
</table>

Abundance Surveys

Northern Harrier abundance was relatively low across surveys, with no difference in abundance between grazed and un-grazed GLSAs. No detections were recorded during 26 of 27 total surveys for GLSA 1701 (un-grazed), GLSA 1802 (un-grazed), and GLSA 1806 (grazed). No detections were recorded during 18 of 27 total surveys for GLSA 1705 (grazed). For abundance surveys with detections of Northern Harriers, a single harrier was observed on all occasions, except during one survey where two harriers were observed in GLSA 1705 (grazed).

Dive Counts

Observations of dives for Northern Harriers were relatively low across surveys, with no difference in dive frequency between un-grazed and grazed GLSAs. Dive frequency was slightly greater on GLSA 1701 (un-grazed) and GLSA 1705 (grazed) (0.3 ± SD = 0.5 dives/hour observed on both GLSAs) compared to GLSA 1802 (un-grazed) (0.1 ± 0.3 dives/hour) and an average observed on GLSA 1806 (grazed) (0.2 ± 0.4 dives/hour).
5.0 DISCUSSION

5.1 Vegetation Surveys
Mean grass height was higher in the un-grazed GLSAs than the grazed GLSAs. This result was expected because a typical effect of grazing is a reduction in vegetation height. On the un-grazed GLSAs grass height was similar in June and July 2020, but on grazed GLSAs grass height declined during this period by 43.5%. While mean thatch height was slightly higher on un-grazed GLSAs, there was no significant change in thatch height between June and July surveys on all GLSAs.

There was no sign of grazing (i.e., cow dung, tracks grazed stems) on GLSAs 1701 and 1802 during June and July 2020 surveys, confirming that the designation of these GLSAs as un-grazed was accurate. There was minimal sign of grazing on the grazed GLSAs during the June survey which likely resulted from there being no livestock present on the GLSAs for two months preceding the study. July surveys of grazed GLSAs detected increased evidence of grazing compared to June surveys, reflecting the presence of livestock on these GLSAs during the study.

5.2 Small Mammal Trapping
Supporting my hypothesis, Townsend’s Vole mean abundance was 41% higher in un-grazed versus grazed GLSAs during trapping sessions from 3 June to 16 July 2020. The greater abundance of Townsend’s Voles on un-grazed GLSAs was likely related in part to the greater grass height in these sites. Conversely, the similarities in thatch height and cover, grass cover, and bare ground cover between the un-grazed and grazed GLSAs suggests that vole abundance is less influenced by these environmental factors. Lower grass height could result in less cover, but it is difficult to conclude a causal relationship without further research. Additionally, the presence of livestock could potentially impact vole abundance by trampling burrows and soil compaction.
Due to the limited number of GLSAs assessed in this study and the fact that the grazed GLSAs were adjacent to one another, the difference in vole abundance between un-grazed and grazed GLSAs should be viewed with caution. Additionally, it is important to note that although un-grazed GLSAs had higher mean vole abundance, GLSA 1701 (un-grazed) and GLSA 1806 (grazed) had relatively similar vole abundance. Greater replication and studies of vole habitat needs are required to clarify the relationship between livestock grazing and vole abundance.

The mean fraction of female Townsend’s Voles was 4.6% greater in grazed versus un-grazed GLSAs. However, the difference in sex ratio between un-grazed and grazed GLSAs is minimal and does not indicate a significant difference.

On average, Townsend’s Voles were 15.9% heavier on grazed GLSAs compared to un-grazed GLSAs. Possible reasons for this difference may include greater abundance or quality of food in grazed GLSAs, or reduced competition for food in grazed GLSAs (due to lower vole abundance). Further studies are needed to determine the reason for this difference.

5.3 Raptor Surveys

The detection of Northern Harriers was relatively low during this study. One possible explanation for this is that during the breeding season (about March to August) the average home range for harriers decreases dramatically because they tend to stay close to roosting areas (Lee and Rudd 2003; Slater and Rock 2005; Mary Taitt pers. comm. 2020). For example, Northern Harriers’ year-round home range can be up to 15,000 ha, while during breeding season the average home range is about 260 ha (Lee and Rudd 2003). The low abundance of harriers could have resulted from breeding sites being relatively distant from the GLSA survey sites.

While raptor detection was low overall, more raptors were observed in the grazed GLSAs. One possible explanation for the greater abundance of harriers on the grazed GLSAs is that the reduction in vegetation cover improved hunting success (Taitt et al. 1981; Lagendijk et al. 2019). Harriers spent more time hunting on un-grazed GLSAs, which supports the theory.
that reduced vegetation cover improves hunting success because it suggests that harriers on the un-grazed GLSAs needed to spend more time to achieve the same rate of food intake. However, due to the low sample size in this study, further research is necessary to study the relationship between livestock grazing and raptor hunting on GLSAs.

Another explanation for the difference in raptor abundance on un-grazed and grazed GLSAs is the difference in surrounding areas between GLSAs. The grazed GLSAs are located on the edge of Westham Island, which has reduced human impacts compared to the locations of the un-grazed GLSAs. Additionally, the grazed GLSAs are adjacent to a wetland habitat (Appendix I). Both un-grazed GLSAs are located in relatively urban areas adjacent to residential developments and busy roads. Most of the harriers I observed in GLSA 1705 and GLSA 1806 used quadrants three and four which are adjacent to the wetland area (Table 6). Thus, the difference in observations between the grazed and un-grazed GLSAs may be reflective of the high quality adjacent habitat, not the GLSA itself.

5.4 Limitations
The main limitation of this study was that there were few potential grazed GLSAs available. GLSA 1806 and GLSA 1705 were the only two available set-asides with a history of grazing to conduct this study. Because of this, the site selection for this study was inherently biased and the results from this study can not be extrapolated to apply to grazed and un-grazed GLSAs in general.

During the small mammal trapping session on 18 June 2020 for GLSA 1802 and 1701 (un-grazed), the second check of the traps was shortened due to high temperatures. On all other trapping days, the second check was conducted in the same order as the first check to allow approximately three hours between checks. However, on 18 June, I conducted the second check in reverse order to shut down the traps as quickly as possible and eliminate travel time between sites. The result was that the traps on GLSA 1701 grid 2 were only set for approximately one-hour before conducting the second check and resulted in reduced captures. Additionally, I could not check 12 traps in GLSA 1802 grid 2 and released those
animals without recording any information because the temperature was too high to continue trapping. GLSA 1701 grid 1 and GLSA 1802 grid 1 were not noticeably affected.

5.5 Implications and Recommendations for Future Research

The results of this study suggest there are differences between un-grazed and grazed GLSAs, but further research is needed to better understand the implications of these results. Because of these findings, I suggest that DF&WT continue to work with farmers to limit livestock grazing on GLSAs. However, to increase participation in the GLSA program, it may be necessary to allow grazing on some GLSAs. When allowing livestock grazing on GLSAs, I would suggest limiting to light grazing, however further studies are needed to understand the difference between light and heavy grazing, and to determine the long-term effects of grazing on GLSAs.

I recommend that this study be continued in future years to further understand the difference between un-grazed and grazed GLSAs. When replicating this study, I suggest the following changes be made:

1. I suggest starting with two small mammal traps per station on all GLSAs when conducting trapping overnight during the breeding season. This will prevent having to double the traps mid-way through the study.

2. In addition to conducting vegetation surveys on the entire GLSA, I suggest measuring grazing on each small mammal trapping grid in order to more accurately relate voles/trap night to grazing intensity.

3. Because of the relatively low raptor abundance observed during this study, I suggest conducting raptor counts and behavioural surveys used in this study outside of breeding season. Additionally, if conducting this study during breeding season, I suggest keeping a log of all incidental Northern Harrier observations in the GLSAs outside of formal raptor surveys would expand the range of inference given the low abundance.
4. I recommend conducting small mammal trapping on these GLSAs during the winter to study whether grazing impacts small mammal abundance during the season when flooding occurs. However, when comparing results of winter surveys to the results of this study, it will be necessary to recognize that abundance is generally higher during breeding season (March to August).

5. I recommend that for every GLSA with livestock grazing, a log be kept with the duration and number of animals grazing on each GLSA. This information will be useful for making comparisons across studies, as well as for assessing how grazing intensity affects vegetation, small mammals, and raptors. Additionally, I suggest testing different grazing intensities. For example, testing the difference between GLSAs with no, light, and heavy grazing.

6. I suggest selecting fields that are not side-by-side to minimize bias. Because the grazed GLSAs were side-by-side during this study, similarities between them could be due to environmental factors other than livestock grazing.
6.0 REFERENCES CITED


APPENDIX I

GLSA 1806 and 1705 (grazed) are adjacent to a wetland area.
APPENDIX II

GLSAs were split into four approximately equal quadrants for vegetation, small mammal, and raptor surveys between May to July 2020 in Delta, BC.
APPENDIX III

Vegetation percent cover was determined using Vegetation Resources Inventory protocol during vegetation surveys during June and July 2020 in Delta, BC (MFLNRO 2016).

APPENDIX IV

Photos of two trapping grids on each of two un-grazed and two grazed GLSAs during 14 to 16 July 2020 in Delta, BC. All photos were taken from station A1 pointing towards E5.

**Un-grazed GLSAs:**

<table>
<thead>
<tr>
<th>Un-grazed GLSA 1802 grid 1</th>
<th>Un-grazed GLSA 1802 grid 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Un-grazed GLSA 1802 grid 1" /></td>
<td><img src="image2" alt="Un-grazed GLSA 1802 grid 2" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Un-grazed GLSA 1701 grid 1</th>
<th>Un-grazed GLSA 1701 grid 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Un-grazed GLSA 1701 grid 1" /></td>
<td><img src="image4" alt="Un-grazed GLSA 1701 grid 2" /></td>
</tr>
</tbody>
</table>
Grazed GLSAs:

GLSA 1806 grid 1

GLSA 1806 grid 2

GLSA 1705 grid 1

GLSA 1705 grid 2
**APPENDIX V**

Mean vegetation structure and grazing evidence on survey GLSAs from vegetation surveys between June – July 2020 in Delta, BC.

<table>
<thead>
<tr>
<th>GLSA 1802 (un-grazed)</th>
<th>GLSA 1701 (un-grazed)</th>
<th>GLSA 1806 (grazed)</th>
<th>GLSA 1705 (grazed)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>June</strong></td>
<td><strong>July</strong></td>
<td><strong>June</strong></td>
<td><strong>July</strong></td>
</tr>
<tr>
<td>Mean grass height (m)</td>
<td>0.89 ±0.45</td>
<td>0.95 ±0.36</td>
<td>0.51 ±0.41</td>
</tr>
<tr>
<td>Mean thatch height (m)</td>
<td>0.10 ±0.05</td>
<td>0.11 ±0.04</td>
<td>0.14 ±0.07</td>
</tr>
<tr>
<td>Mean grass cover class</td>
<td>3.3 ±1.2</td>
<td>4.0 ±1.2</td>
<td>2.9 ±1.4</td>
</tr>
<tr>
<td>Mean thatch cover class</td>
<td>2.1 ±1.5</td>
<td>2.6 ±1.3</td>
<td>2.9 ±1.9</td>
</tr>
<tr>
<td>Mean bare ground cover class</td>
<td>2.0 ±2.0</td>
<td>1.0 ±1.1</td>
<td>2.2 ±2.3</td>
</tr>
<tr>
<td>Plots with flood evidence (%)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.39</td>
</tr>
<tr>
<td>Plots dominated by <em>Fescuta</em> sp. (%)</td>
<td>0.55</td>
<td>0.77</td>
<td>0.71</td>
</tr>
<tr>
<td>Mean grazed stem cover class</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Mean number of dung piles per plot</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Mean number of tracks per plot</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>