HOW DOES HIMALAYAN BLACKBERRY (*RUBUS ARMENICAUS*) IMPACT BREEDING BIRD DIVERSITY? A CASE STUDY OF THE LOWER MAINLAND OF BRITISH COLUMBIA

By

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Abstract

Awareness of the spread of invasive plant species has grown, but quantitative measures of their impacts are lacking. This study analyses the impact of Himalayan blackberry (*Rubus armeniacus*) on breeding bird diversity finding a significant difference in bird diversity between "natural" and *R. armeniacus*-dominated understoreys. More bird species were noted in habitats with greater structural and compositional diversity. Simpson's richness/evenness index was significantly different between habitat types for Stanley Park and Maplewood Flats ($P<0.05$) but not Jericho Park ($P>0.05$), likely due to lower overall bird diversity at Jericho Park and lack of overstorey trees at *R. armeniacus* thickets. When *R. armeniacus* is the dominant understorey shrub in a forested setting it has the greatest negative impact on breeding bird diversity.

Introduction

Non-native species are those that have moved or been transported to, and become established in, areas where they are not normally found (Boersma, Reichard and Buren, 2006). Non-native species can include important economic crop species such as corn and wheat, livestock such as cows, and ornamental flowers, trees and shrubs prized for landscaping and gardening (Boersma et al., 2006). Not all non-native species cause problems within their introduced ecosystem: to be classified as an invasive species, the non-native species must become naturalized in the new habitat and have the ability to further colonize the new environment at the detriment of native species.

Invasive species can be defined in several ways. The most common names for invasive species are “non-native”, “alien”, “exotic” or “introduced”. In short, invasive species are not native in the ecosystem they are invading and are doing harm to that ecosystem (Boersma et al., 2006). Invasive species are not limited to one guild. Mammals, amphibians, insects, plants and any other taxa can all be invasive.

It is a common belief that invasive species are harmful to the environments that they invade. The impact of invasive plants in particular has been quantified using economic indicators (Schwartz, Porter, Randall and Lyons 1996; EC, 2004; Frid, Knowler, Murray, Myers and Scott, 2009). Invasive plants have a tendency to grow rapidly and overtake other native species changing the structural and

compositional diversity of an ecosystem (Boersma et al., 2006; Buddenhagen, 2006). The monocultures that result from this tendency may in turn reduce the availability of suitable foraging, refuge and breeding habitat of wildlife. Although circumstantial evidence suggests such invaders impact local biodiversity, the measurement of such impacts is frequently lacking (Hager & McCoy, 1998).

Birds are a common form of urban wildlife and are easily studied. Their habitat requirements range from generalist species that have adapted to disturbed habitats, such as American robins, to less common species with more stringent habitat requirements, including purple martins. Passerines[1] are easily studied during the breeding season and include many habitat specialists susceptible to changes in the landscape (M□rtberg, 2001). By comparing the diversity of birds in one habitat to another, assumptions can be made regarding the suitability of that habitat to support breeding activities. In this study, the diversity of breeding birds in *R. armeniacus*-dominated habitats was compared to those found in more diverse habitats to determine if the presence of *R. armeniacus* had an impact on available breeding habitat.

The main objective of this study is to provide the information necessary for land managers to manage *R. armeniacus* during appropriate timing windows to have the least impact on breeding birds. Organizations in Coastal British Columbia such as Evergreen and the Langley Environmental Partners Society (LEPS) incorporate *R. armeniacus* removal as part of their stream and terrestrial habitat restoration programs. Listed as a

[1] Songbirds

weed of a concern by California and Oregon, land managers in these regions must manage a species that not only dominates high quality agricultural land, but can also be indirectly responsible for contaminating watercourses through herbicide application (Caplan & Yeakley, 2006). Understanding how birds in urban areas use *R. armeniacus* during a vital period in their life cycles will allow these groups to time their activities during the most appropriate windows, and make decisions regarding management.

Literature Review

Invasive Plant Species

Invasive or alien plant species include species of plants introduced into a foreign ecosystem that have the potential to cause ecological, social, and/or economic damage (Schwartz et al., 1996; Frid et al., 2009). Few disturbed habitats, such as brownfields, urban park trails and managed ditches, are free from invasive plant species, and frequently these species dominate the ecosystems by suppressing the growth of native species (MacDougall & Turkington, 2005).

The issue of invasive plant species is becoming increasingly important as their direct impacts on native plants and ecosystems are fully realized. The Invasive Plant Council of BC T.I.P.S. factsheet (2009) defines an invasive plant as:

> Any invasive alien plant species that has the potential to pose undesirable or detrimental impacts on humans, animals or ecosystems. Invasive plants have the capacity to establish quickly and easily on both disturbed and un-disturbed sites,

> and can cause widespread negative economic, social, and environmental impacts (pg. 1).

Colonization by invasive plants is gaining recognition as a threat to natural and anthropogenic habitats (Hobbs & Humphries, 1994). Invasive plants are characterised by prolific seed production, ability to reproduce asexually, aggressive establishment and ability to exploit disturbed or marginal habitats (FBC, 2003; Boersma et al., 2006). Many invasive plant species share these common traits. For example, Chinese privet (*Ligustrum sinense*) is thought to be able to outcompete native understorey vegetation through prolific seed production and dispersal, asexual reproduction through cloning and superior shade tolerance (Wilcox & Beck, 2007); traits shared by many invasive plant species common to North America and the Pacific Northwest.

The spread of invasive plants generally starts with a small, contained colony of the plant (Hobbs & Humphries, 1995; Buddenhagen, 2006). This population may remain small and stable for a number of years or decades until the plant adapts and begins to spread rapidly (Hobbs & Humphries, 1995).

Impacts

Invasive plants cause disturbance to native ecosystems. They out-compete native plant species, reduce plant biodiversity, increase soil erosion, and may contain substances that are toxic to humans, wildlife, and other plants (GVIPC, 2009). Invasive

species have been identified as the second greatest threat to biodiversity after habitat loss (Burdick, 2005).

With increasing globalization, invasive plant species are continuously spreading throughout the world. They are spread accidentally through animals, wind, and naturalization of agricultural crops, intentionally through human activities (Boersma et al., 2006; Buddenhagen, 2006) and unintentionally through recreation, including ATVs and water craft, or vehicle and foot travel through infested areas (IPC BC, 2009). International trade routes and movement of goods around the world provides many opportunities for an invasive species to be introduced into a new environment and establish (Boersma et al., 2006).

Invasive plant species can have a direct effect on species at risk. Approximately 24 % of the species at risk recognized by The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2002 may be threatened with extinction due to invasive species (EC, 2004). Many of the invasive species at issue are plant species and these same species may alter ecosystems by changing hydrologic and nutrient cycles, altering fire regimes, increasing erosion (EC, 2004), and degrading breeding habitats for wildlife. The British Columbia Weed Control Regulation (BC Laws, 1985) uses the term "weed" to define invasive plant species that cause economic damage or have the potential to cause human or livestock health issues. This act imposes a duty on the landowner to remove or manage weed species on their property. The Act defines a list of "noxious" weeds that must be managed. Noxious weeds, such as

tansy ragwort (*Senecio jacobaea*) and diffuse knapweed (*Centaurea diffusa*) limit available agricultural land and require hours of manual labour to remove, while others, such as giant hogweed (*Heracleum mantegazzianum*) may cause skin blistering and other health issues to humans and livestock (FBC, 2003; EC, 2004).

Invasions of plant species cause impacts to biodiversity, ecosystem function and aesthetics, and they can also cause serious economic damage (Schwartz et al., 1996). In the United States, an estimated $97 million is lost in agricultural profits to the impacts of non-native species, and in Canada, an estimated $7.5 billion is lost annually from impact to agricultural crops and forestry (EC, 2004). The Invasive Plant Council of BC has calculated the combined economic damage for six invasive plant species: Eurasian watermilfoil (*Mirioohyllum spicatum*), purple loosestrife (*Lythrum salicaria*), Scotch broom (*Cystius scoparious*), diffuse knapweed (*Centaurea diffusa)*, hawkweed (*Hieraceum* sp.), and cheatgrass (*Bromus tectorum*) (IPCBC, 2009). Based on their studies, these six species alone caused $65 million in damages in 2008, and are forecast to cause upwards of $139 million by 2020 (IPCBC, 2009).

The direct impact of invasive species on wildlife has not been studied extensively in North America. Studies on bird diversity in urban areas are generally performed without considering the presence of invasive plant species. One such study focused on determining bird diversity within urban areas and did consider ecosystems impacted by non-native vegetation, (Melles, Glenn, and Martin, 2003) but no single invasive species monoculture was included in the ecosystem types assessed. It is

possible that rapidly growing aggressive invasive species cause more changes in biodiversity than just urbanization alone.

Bird diversity and vegetation composition

It is a common belief among ecologists that bird diversity is likely higher in habitats with greater diversity of vegetation. Regenerating habitats with varied species of vegetation are often the site of high levels of bird diversity due to the variety and rapid growth of recolonizing vegetation (Fink et al., 2006, Evans, Newson and Gaston, 2008). Fink et al. (2006) cite numerous studies that show that bird species richness increases with vegetation diversity and density (p. 185). This is corroborated by Evans et al. (2008), who found that vegetation diversity, especially trees and shrubs, in an urban setting will possibly enhance bird diversity (pg. 24). They cited studies that showed that many urban species also preferred habitats with mature and structurally diverse vegetation (Fink et al, 2006). They also note that the response of birds will vary, but that maintaining structural diversity promotes greater bird diversity.

Wilcox & Beck (2007) provide concrete examples of the impacts of invasive plants on bird diversity. Their research showed that the density of grassland birds such as the grasshopper sparrow (*Ammodramus savannarum*), savannah sparrow (*Passerculus sandwichensis*) and chestnut-collared longspur (*Calcarius ornatus*) were negatively impacted by invasions of leafy spurge (*Euphorbia esula*) and crested wheatgrass (*Agropyron cristatum*) (Wilcox & Beck, 2007). This research shows that there may be a direct correlation between the introduction of an invasive plant and a

reduction in the density of breeding birds in an ecosystem. This may also be the case with *R. armeniacus* invasions.

Himalayan blackberry (Rubus armeniacus)

In the Pacific Northwest, and in particular British Columbia, invasive plants are becoming established in open spaces at a very rapid rate (Sandiford, Krannitz, and Parken, 2001). *Rubus armeniacus* is an example of a plant that may be causing changes in biodiversity in urban areas. *R. armeniacus* is a thorny shrub native to the Caucasus region of Eurasia which includes Azerbaijan, Armenia, and Georgia and parts of Western Europe (Boersma et al., 2006; Caplan & Yeakley, 2006).

A common invader of disturbed areas (IPCBC, 2008), *R. armeniacus* has spread through the Lower Mainland, Gulf Islands and Queen Charlotte Islands, Vancouver Island, and through into the Interior (IPCBC, 2008). Introduced to the Pacific Northwest (PNW) in 1885 it was actively being grown as an agricultural crop by 1890 and by 1945 it had escaped from agricultural land and was naturalized along the West Coast (Boersma et al., 2006; Bennett, 2007). Although *R. armeniacus* has become invasive in North America, studies on blackberry cultivars in Australia and the United States show that few if any of the cultivated blackberry crops in use today have established outside of farm fields as weeds (McGregor, 1998). Blackberry cultivars used today lack the weediness inherent in *R. armeniacus*, require managed soil to grow successfully, and lack the hardiness displayed by invasive blackberry species (McGregor, 1998).

Since its initial introduction *R. armeniacus* has become established and naturalized throughout the Pacific Northwest, including California, Washington, Oregon and British Columbia (Boersma et al., 2006; Caplan & Yeakley, 2007). In this region *R. armeniacus* can be seen growing in disturbed areas such as abandoned fields and undeveloped lots. In many urban and rural settings, *R. armeniacus* is the dominant vegetation species, outcompeting other shrubs, small trees and herbaceous species (pers. obs., Sandiford et al., 2001). It is an aggressive plant that creates dense thickets through both seed and by clonal reproduction through tiprooting (Caplan & Yeakley, 2006; IPCBC, 2008).

Ecology of Rubus armeniacus

Rubus armeniacus is a colonizer of disturbed sites resulting from anthropogenic activities. Areas cleared of other vegetation may be attractive to this plant, as space, light and soil resources are more available, and no other competing plants have established (Caplan & Yeakley, 2007). It is also commonly found along riparian corridors; dominating the vegetation growing along streambanks and around lakes, wetlands and ponds. By contrast to native riparian plant communities *R. armeniacus* provides little shade for streams, cannot contribute large woody debris to the channel and it has a relatively shallow root system, thus potentially contributing to increased stream bank erosion (Bennett, 2007).

It is an efficient exploiter of available resources and shows little to no water or nutrient stress when fruiting (McDowell & Turner, 2002). This may be important to its success as an invasive plant species, as it may be able to tolerate lower levels of soil water and nutrients that would limit the reproductive success of native plants. The spread of the plant is aided by its methods of reproduction, which as previously noted principally involve seed dispersal and clonal growth.

Rubus armeniacus displays a number of characteristics of the "ideal weed" including rapid growth, copious seed production, over 700 fruits per cane are possible (IPCBC, 2008), and ability to out-compete native plant species for nutrients, sun and water (Schwartz et al., 1996; IPC BC, 2004; Caplan & Yeakley, 2006). It has few known natural controls in North America, as it has heavily armoured stems that prevent browsing by herbivores (Caplan & Yeakley, 2006). It also has the ability to reproduce quickly through rooting stem tips, sprouting from root buds, and via seed dispersal (Caplan & Yeakley, 2006; IPC BC, 2008).

The main pathogen of this species in Eurasia, fungal rust (*Phragmidium violaceum*), has only just been discovered in North America, specifically Oregon; previously, *R. armeniacus* was virtually free of natural enemies in its introduced range in North America (Caplan & Yeakley, 2006; Bennett, 2007). There is no evidence to suggest *P. violaceum* was intentionally introduced, therefore it may have been brought in on cultivated plants or infected clothing or machinery. *P. violaceum* has been shown to effectively control blackberry species (*R. fruticosus*) in Australia, through defoliation

and reduction in tiprooting, but has not been shown to impact cultivated blackberry species (ODA, 2007; Gomez, Evans, Harvey, Baker & Scott, 2008). First noted in Oregon in 2005 (ODA, 2007) if this fungus is able to spread, then it may also become the main pathogen of *R. armeniacus* in North America.

Rubus armeniacus is very recognizable as it forms dense, evergreen shrubs, and rapidly becomes a dominant species in most ecosystems that it colonizes (Boersma et al., 2006). *Rubus armeniacus* grows from sea level to approximately 1500 feet elevation and grows in a wide range of soil types, generally preferring disturbed sites, with well-drained soils (Boersma et al., 2006). In British Columbia, Himalayan blackberries are evergreen, with leaves persisting throughout the winter (Boersma et al., 2006). *Rubus armeniacus* bushes form thick, impenetrable thickets, with dead canes overgrown with the following year's growth. These stems can reach densities of as high as 525 canes/m^2 but are generally in the range of 1.5 – 21.5 canes/m^2 (Bennett, 2002). Leaves are palmately compound, with new growth having five leaflets, and older canes having three (Boersma et al., 2006; IPCBC, 2008). Flowers are white to pinkish-white with five petals and clustered on the branches. Canes arch as they grow, and new growth runners can root from their tips. Canes are protected by large, formidable downward curving thorns, up to 2 cm in length (pers. obs.).

Berries generally form and ripen in late summer. Fruit is large, black and sweet. Second year canes produce fruit and then die. The plant is able to allocate resources to either growth or reproduction, and can therefore put a lot of energy purely into

reproduction under some conditions (McDowell & Turner, 2002) resulting in large fruit crops and seed banks up to 13,000 seeds per square meter (Caplan & Yeakley, 2006; Boersma et al., 2006; Bennett, 2007). Seeds are dispersed by birds, mammals and humans, and provide forage especially for other invasive or nuisance animals, including several species of invasive birds and mammals. Reproduction is achieved asexually through "tiprooting" canes producing daughter plants, and through seed production (Boersma et al., 2006).

In addition to invading disturbed areas, *R. armeniacus* can invade relatively undisturbed areas, including parks and urban greenspaces, which have sufficient light and space requirements for germination (Caplan & Yeakley, 2006). Such environments may represent small isolated areas of high quality habitat in an urban setting that may be suitable for a wide variety of birds. In particular, forest edges, such as those found in all three of the study areas, attract a wide variety of bird species including both forest and shrubland species of birds (Fink, Thompson, and Tudor, 2006). However, edge habitats may also result in increased nest parasitism and predation and can also impact nest fidelity and habitat use (Fink et al., 2006). If high quality urban habitat is degraded through the invasion of *R. armeniacus*, it may not be available to the same variety of birds, and the overall biodiversity of the area may be negatively impacted.

Although there is a paucity of information available on the impact of invasive plant species on biodiversity, specifically avian biodiversity, based on what is known about the biology and growing habits of *R. armeniacus* it is very likely that this particular species has a large impact on habitat availability and diversity for birds

(Sandiford et al., 2001). The combination of unique structural and ecological traits, including its growth habit and highly competitive nature (Sandiford et al., 2001) gives *R. armeniacus* the potential for a significant negative impact on bird diversity.

Research Methodology

Study design

Breeding bird surveys followed the Resource Inventory Standard Committee (RISC) standard for forest and grassland bird surveys (MWLAP, 1999). Three locations were selected based on ease of access; Jericho Park and Stanley Park, located in Vancouver, and Maplewood Flats in North Vancouver.

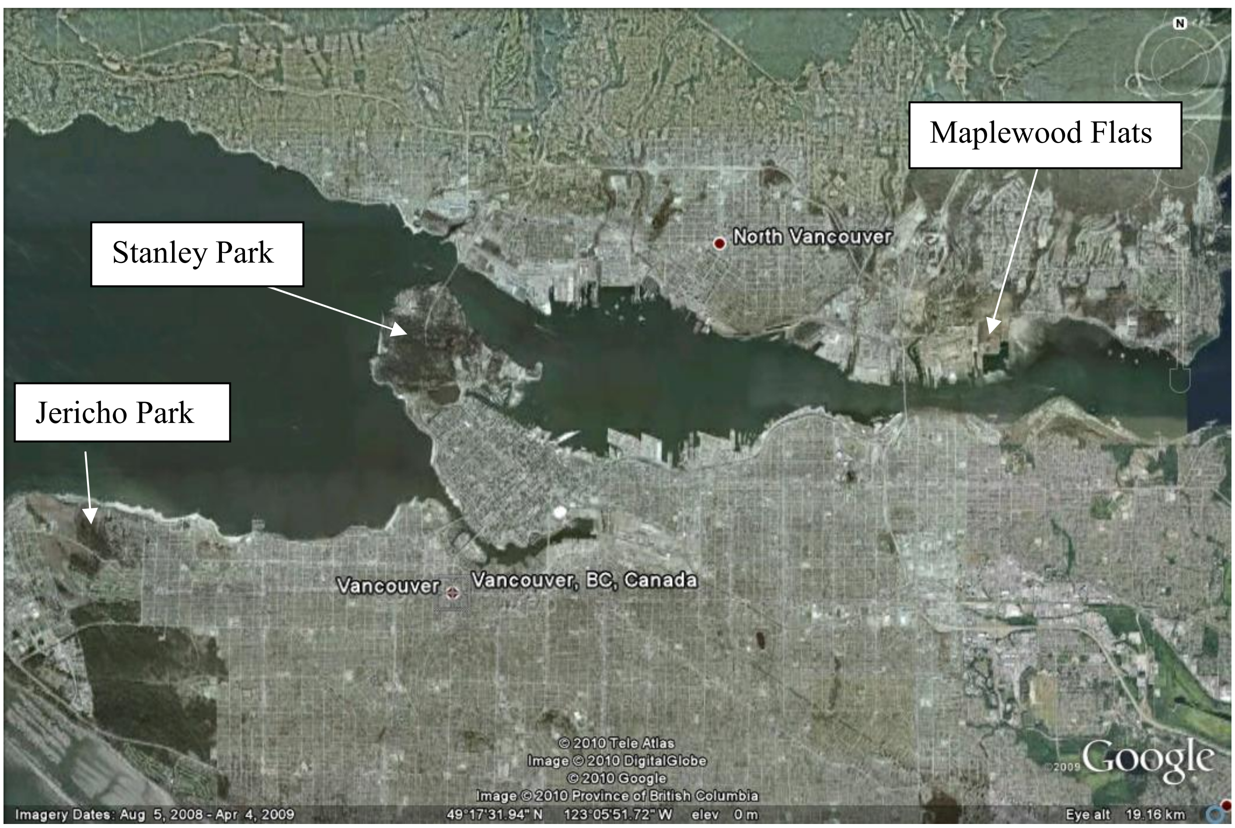


Figure 1. Locations of study sites (Google Inc., 2009)

Description of Study Area

The three locations were chosen for this study based on a variety of criteria. Consideration was given to ease of access (especially important as bird surveys took place at dawn) amount of *R. armeniacus* infestation and availability of suitable comparison control plots.

In total, 26 point count stations, or plots, were established spread over the three locations; thirteen in *R. armeniacus* thickets or *R. armeniacus*-dominated stands, and thirteen in control habitats with more diverse overstoreys and understoreys. Jericho Park and Maplewood Flats had five "blackberry" and five control plots each, while the small size of the Stanley Park location allowed for only three blackberry and three control plots.

Blackberry plots were those where *R. armeniacus* represented >80% total shrub cover. Plots were marked on a Global Positioning System (GPS) device to eliminate the need for visual marking. The variable radius point count method was utilized to take into account the variety of sizes of blackberry plots and control habitats. The variable radius point count is effective as it allows the habitat to dictate the size of the survey plot (MWLAP, 1999). For example, a large monoculture of *R. armeniacus*, such as Jericho Park, may require a 30 m radius plot, whereas a long narrow riparian corridor, as in Stanley Park, may dictate a longer but narrower plot. This approach provides flexibility by accommodating a wide variety of bird species, and also allowing for comparison between habitats (MWLAP, 1999). Using a variable radius point count

system also allows for variations in plot radii such as riparian strips and urban habitats (MWLAP, 1999). Survey locations were situated within urbanized areas, therefore point count plots were a maximum of 30m wide. Each plot was visited a minimum of six times during the study and surveys occurred a minimum of one week apart.

As per provincial standards (MWLAP, 1999), surveys took place from sunrise and lasted for approximately three hours. All surveys were performed between April 23 and July 4, 2009, corresponding with the recommended survey season of May 1 to the first week of July. Weather conditions during surveys were generally sunny to overcast, and surveys did not take place if there was steady rain or winds of greater than 16 km/hr (Beaufort scale 2). Temperatures ranged from 10 to 25°C. A minimum of two surveyors participated in each count. At each point count station, there was an initial rest period of one minute to allow the birds to acclimate to the surveyors' presence. During that time, information on weather conditions and habitat was collected. After the rest period, a five-minute count was performed. Birds were recorded on a bullseye chart during the five-minute listening period, Figure 2.

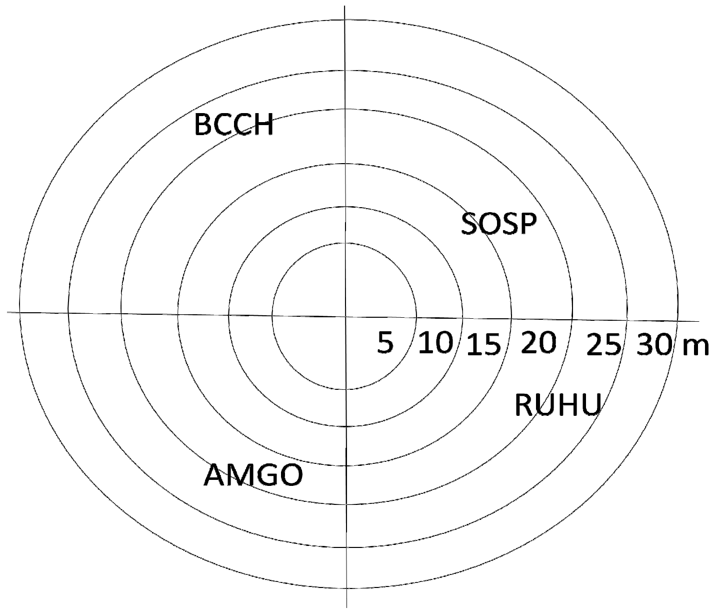


Figure 2. Example point count station data collection chart (Adapted from MWLAP, 1999)

Within the five-minute period, data were recorded, including species, observed vs. heard, sex (if observed) and direction of travel, if applicable. Birds inside and outside of the plot radius were recorded as were birds flying through the plot; however, only those birds singing from a stationary location within the plot were considered in the data analysis. Other notes were also recorded, such as nest defence behaviour, presence of potential predators, and habitat disturbance.

Study Locations

Maplewood Flats is a 75 acre park and wildlife habitat conservation area managed by the Wild Bird Trust of BC. It is located in North Vancouver on Dollarton Highway, just east of Highway 1. Figure 3 shows an aerial overview of the park.

Figure 3. Location of Maplewood Flats (Google Inc., 2009)

A total of 237 species of birds have been identified within the park (WBT, undated). The park lies within the Coastal Western Hemlock dry maritime (CWHdm) biogeoclimatic zone. The CWHdm occurs from sea level to approximately 650 m throughout the Lower mainland and adjacent Gulf Islands This zone has warm, dry summers and moist, mild winters providing a long growing season with little snowfall. Dominant vegetation species include western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesii* spp. *menziesii*), western redcedar (*Thuja plicata*), salal (*Gaultheria shallon*) and sword fern (*Polystichum munitum*) (Green & Klinka, 1994).

Rubus armeniacus plots were characterised by >80% shrub cover, dominated by blackberry bushes (Figure 4). A variety of plots were sampled, and were represented by shrubby habitats with scattered trees, forested habitats with a dense *R. armeniacus* understorey, and shrub habitats dominated by *R. armeniacus* with native and ornamental shrubs interspersed. Terrestrial Ecosystem Mapping (TEM) ecosystem survey methods were used to characterise the vegetation cover at each plot, and dominant species composition was recorded on a standard Ground Inspection Form (GIF). Appendix A contains a summary of the TEM information gathered at each plot for all three study locations.

The two plot types, control and blackberry, were designed to best characterise vegetation differences between structurally diverse plots (control) and *R.* armeniacus-dominated plots (blackberry). Control plots were selected to represent a range of available habitats. This included shrubby habitats with grassy openings, young mixed forest with a mix of shrubs in the understorey (Figure 5), pole/sapling alder forest with an open understorey, and mature mixed forest with a variety of shrubs and saplings in the understorey. This in turn created a number of canopy layers, from dominant trees above the canopy to mid-level young trees and tall shrubs, to low shrubs and ground covers. Blackberry plots, by comparison, were usually comprised of only one understorey level of shrubs with an overstorey of trees. In some cases, *R. armeniacus* comprised the dominant vegetation cover with sporadic trees providing little to no canopy.

Figure 4. Example of Rubus armeniacus-dominated understorey (PCS MW004)

Figure 5. Example of young forest with mixed shrub understorey (PCS MW008)

The Stanley Park plots were also located within the CWHdm. These plots were more disturbed by human activity, and were also more narrow and disjointed. The plots were located within 50 m of a stream, and exhibited characteristics of riparian vegetation. Figure 6 shows vegetation cover in the vicinity of the point count stations.

Figure 6. Location of Stanley Park study area (Google Inc., 2009)

The control plots in Stanley Park were selected adjacent to the blackberry thickets. These locations were characterised by mature coniferous trees with an understorey of native shrubs.

Figures 7 and 8 show examples of habitat types at the Stanley Park point count stations. Blackberry locations were surrounded by trees and native shrubs. Control plots had less than 20% *R. armeniacus* cover in the understorey

Figure 7. Example of *Rubus armeniacus*-dominated point count station (PCS SP003)

Figure 8. Example of control point count station vegetation, (PCS SP004)

Jericho Beach Park is located in Vancouver in the Coastal Western Hemlock very dry (CWHxm1) biogeoclimatic zone. This zone is very similar to the CWHdm but extends from the south side of the Fraser River and into the Fraser Valley and along the Sunshine Coast, from sea level to 700 m. This biogeoclimatic subzone also has warm, dry summers and mild, moist winters with little snowfall. Dominant vegetation includes Douglas-fir, with some western hemlock and western redcedar, with salal, dull Oregon-grape (*Mahonia nervosa*), and red huckleberry (*Vaccinium parvifolium*) (Green and Klinka, 1994). Figure 9 provides an overview of Jericho Park.

Figure 9. Location of Jericho Park study area (Google, 2009)

There is a large, contiguous *R. armeniacus* patch located just west of the tennis courts in the park. The patch is 114 m wide by 130 m long and has several trails running through it. A number of introduced domestic rabbits have established a colony in the *R. armeniacus*. Blackberry point count stations were located around and within the large patch. Each station was located at least 30 m away from the previous plot to prevent double counting of birds. Several small deciduous trees were scattered throughout the blackberries.

Control plots were located within the forested portion of the park to the south. The plots were selected to represent a broad range of habitats found within the park. These included young alder forest with a mixed shrub understorey, shrubby habitats

with grassy openings, and maturing mixed forest with a developing shrubby understorey.

Results

A total of 957 birds were observed during the three month survey period, representing 44 different species (Table 1).

Table 1. Total numbers for the bird species observed at each of the three Vancouver study sites, comparing *R. armeniacus* monoculture and natural areas within each site[2]

Species	Jericho Blackberry	Natural	Stanley Park Blackberry	Natural	Maplewood Flats Blackberry	Natural
AMGO	36	23	2	3	14	14
AMRO	29	58	8	10	32	40
ANHU	4	0	0	0	0	0
BCCH	3	54	11	10	29	28
BHGR	0	0	0	0	1	2
BCHO	1	0	0	0	0	0
BEWA	0	0	0	1	0	0
BUSH	0	4	0	0	0	0
BHGR	0	0	0	1	0	0
CEWA	0	1	0	0	0	11
CHSP	0	1	0	0	0	0
DEJU	10	11	4	6	0	8
DOWO	0	0	0	0	0	2
EUST	2	0	0	0	0	0
GBHE	0	0	0	8	0	0
GCKI	0	16	0	3	5	18
GCSP	0	2	0	0	0	0
GRCA	0	0	0	0	0	1
HETH	0	0	0	0	1	0
HOFI	2	0	1	2	1	1
HOSP	1	0	0	0	0	0
NOFL	0	1	0	2	0	0
MCWA	0	0	0	0	1	1
PISI	0	3	0	1	1	1

[2] See Appendix B for a list of the full names of the bird species detected in this study

Species	Jericho Blackberry	Natural	Stanley Park Blackberry	Natural	Maplewood Flats Blackberry	Natural
PIWO	0	0	0	0	1	0
PSFL	0	3	0	1	0	5
PUMA	0	0	0	0	0	1
RCKI	0	0	1	1	0	0
REVI	0	1	0	0	1	16
RUHU	19	6	1	1	1	5
SASP	0	0	0	0	1	1
SOSP	37	47	7	13	34	23
SPTO	7	20	10	5	16	26
SSHA	0	0	0	0	0	1
SWTH	0	1	1	7	0	6
TRSW	0	1	0	0	0	0
UNFL	0	0	0	0	0	1
UNWA	0	1	0	1	0	0
VGSW	0	0	0	1	0	1
WAVI	0	0	0	0	1	6
WCSP	14	0	0	1	0	0
WIFL	0	1	0	3	0	7
WIWR	0	24	2	6	0	1
YEWA	0	2	0	3	1	3
YRWA	0	0	0	1	0	1
Total individuals	165	281	48	91	141	231
Total species	13	22	11	24	17	28

Five species of birds were observed either displaying nest defending behaviours, or displaying (singing) from a location that may have been close to a nest site. The following birds were likely using the *R. armeniacus* bushes as potential nest habitat: rufous humming bird (nest defence), Anna's hummingbird (nest defence), American robin (flushed off a partially completed nest during a previous survey, pers. obs.), song sparrow (consistently singing from locations around *R. armeniacus* bushes) and spotted towhee (potentially flushed from nest). The spotted towhee flushed from the *R. armeniacus* bushes was silent until startled, and was flushed from a location deep in the bushes. This suggests that the bird was likely on the nest. Birds tend to vocalize only

when displaying or foraging, and are generally silent when in proximity to their nests. The other birds observed within the plots were using tall canes or other trees and shrubs growing above the thickets as display and singing posts. The species of birds observed in *R. armeniacus* bushes are shrub nesting species.

Species Richness and Evenness

Simpson's reciprocal index of diversity and Simpson's evenness index were calculated for each survey plot location (Table 2).

Table 2. Simpson's Indices

	Blackberry	Control
Richness		
Jericho	6.6291	7.7319
Maplewood	5.861	11.7596
Stanley Park	7.1847	15.1107
Evenness		
Jericho	0.8492	0.8707
Maplewood	0.8294	0.915
Stanley Park	0.8608	0.9338

Using the Simpson values, it is clear that species richness and evenness was greater in plots that had greater structural and compositional diversity as seen in the control plots by comparison to the blackberry plots.

A two-tailed t-test was also performed to determine statistical significance for each location. Simpson's richness and evenness at Maplewood Flats ($P<0.05$) and Stanley Park ($P<0.05$) showed significant difference between plots. Simpson's richness and evenness at Jericho Park showed the least difference between blackberry and control

plots (P>0.05). Although the two-tailed t-test did not show a significant difference in the Jericho Park results, the Simpson's richness and evenness values were higher for the control plots than the blackberry plots, where 22 different species of bird were detected compared to just 13 in the blackberry plots. A difference of similar magnitude was observed in Maplewood Flats and Stanley Park, where almost twice as many bird species were detected in the control plots. There are at least three potential reasons why bird diversity at Jericho Park was not statistically significant. First, the park is heavily used and is in close proximity to a busy road; traffic noise could be heard in the majority of the plots. This may reduce overall diversity at the site, thereby masking differences. Secondly, overall bird diversity is lower in the park due to disturbance, masking any impacts of *R. armeniacus*. Third, and likely most importantly, this is the only study site where the *R. armeniacus* bushes stand alone on the landscape. The large *R. armeniacus* patch in the park has no overstorey, and is surrounded by mown and managed grasses. This may mean that birds in this area will frequent the *R. armeniacus* patch more often as there are few suitable singing and display locations.

In comparison, the *R. armeniacus* thickets in Maplewood Flats and Stanley Park dominate the understorey of young and maturing forest cover. Native trees in the canopy and more diverse habitats adjacent to the infested locations provide alternate habitats and draw birds into these areas. This is shown by the more significant results of the biodiversity indices.

Discussion

Habitat characteristics

Avian richness, particularly during the breeding season is a good indicator of habitat suitability. *R. armeniacus*-dominated sites were easily found within potential breeding bird habitats in the study areas covered in this study and included both stand-alone thickets and forest settings where it was the dominant understorey shrub species. Based on the results of this study, it appears that *R. armeniacus* has the greatest negative impact in forested ecosystems. When located in the open, surrounded by grass or other shrubs, species richness and evenness is not significantly impacted. However, when introduced into a forested ecosystem, usually a young forest where sunlight can reach the understorey, both species richness and evenness are significantly higher in understoreys with a diversity of young trees and shrubs.

Rubus armeniacus produces copious attractive fruit ingested by a number of wildlife species. This may seem to be a benefit to wildlife, as an easily obtained and abundant food source. However, the fruit is produced at a time of year when other native food sources are available (late July to early August); native fruit-producing shrubs produce fruit from early spring to late fall. Berries are dehiscent and remain on the canes over the winter, and these may provide some additional forage for birds during winter months (pers. obs). The thickets and fruit can also attract additional nest predators. Eastern grey squirrels (*Sciurus carolinensis*) and raccoons (*Procyon lotor*), as well as rats (*Rattus* sp.), house cats (*Felis cattus*), and garter snakes (*Thamnophis* sp.) may have easier access to low-level nests increasing the potential for nest predation,

especially in urban environments (Burhans & Thompson, 2006). Raccoons and squirrels were regularly observed using the blackberry bushes in Stanley Park for cover during this study (pers. obs.), Figure 10.

Figure 10. Raccoons using blackberry bushes as cover in Stanley Park

There are some potential beneficial impacts of *R. armeniacus*-dominated habitats on bird habitat and ecosystem function in general. For example, in 2003 honey bees produced 3.25 million pounds of honey produced from blackberry flowers in Washington State (Boersma et al., 2006). Numerous birds, including American robin, pine grosbeak, band-tailed pigeon, and spotted towhee, as well as certain mammal species (Tirmenstein, 1989), consume *R. armeniacus* fruits, which may persist through winter providing a source of forage (Sandiford et al., 2001).

The tendency of *R. armeniacus* to form dense thickets also provides secure cover and potential nesting habitat. However, careful analysis of the ecological impacts that *R. armeniacus* has on native vegetation communities and bird diversity indicates that detrimental effects outweigh any potential benefits. It is clear from this study that diversity of birds is negatively impacted by the presence of a monoculture of *R. armeniacus*, especially in a forested ecosystem, as found in Maplewood Flats and Stanley Park. The greater diversity found in control plots than blackberry plots in the current study provides a strong indication of the lack of suitability of *R. armeniacus* habitat for a wide range of bird species. Birds are pushed out of potential breeding habitats by *R. armeniacus* monocultures, and may be forced into lesser habitats, have reduced nest success, or be excluded from an area entirely. Although this may not be an issue for habitat generalists species such as the American robin, small or isolated populations of rare or endangered species, or species with stringent breeding habitat requirements may be extirpated following the introduction of *R. armeniacus*.

One of the potential reported benefits of *R. armeniacus* is its ability to create copious fruits. Birds that actively forage on the fruits may be exploiting an easily attainable food source; however, this foraging also compounds the problem of the spread of the plant. There is an obvious benefit for the birds from a copious and nutritional food source, and the plant benefits by having a source for seed dispersal (Gosper, Stansbury & Vivian-Smith, 2005). Invasive fruit-producing plants may also alter the availability patterns of native fruit-producing plants. Some fruiting plants produce their fruit at a time of year when native plants not longer have fruit, or have not

begun to produce fruit. A readily available food source may attract frugivores and other wildlife that prefer this food source. By being the only fruit source available, the non-native plant ensures that its seed bank is the only one available and therefore is spread easily (Gosper et al., 2005). As birds adopt the invasive fruit as a food source, the invasive plant is spread further across the landscape which may in turn cause habitat loss and reduction in native fruit availability (Gosper et al., 2005). Although the plentiful fruits of the invasive plant may be an attractive food source for birds, they may only be present in abundance for a small part of the year, usually midsummer through autumn in the Pacific Northwest (Soll, 2004). By reducing diversity of native fruit-producing plants, the availability of fruit throughout the year, and therefore resources required at other times of the birds' life cycle, may be negatively impacted. This can also have a cascading effect throughout a food web; with decreasing songbird populations due to loss of suitable breeding habitat, raptors and other wildlife species that prey on birds may also decline. Other wildlife species requiring a diverse understorey may also be negatively impacted by *R. armeniacus* infestation as forage and refuge habitats may be significantly degraded.

Observed bird use of Rubus armeniacus habitats

Rubus armeniacus provides some measure of protective cover for nesting birds and other non-reproductive behaviours. During the bird surveys, a male American goldfinch and a female Anna's hummingbird were observed preening within the *R. armeniacus* canes, and four white-crowned sparrows, several American robins and

spotted towhees were seen on a number of occasions foraging beneath the bushes. When startled, they retreated into the thickets for cover.

The breeding bird surveys conducted in this study suggested that at least some bird species were actively nesting in the thickets. Bell (undated) provides some guidance to shrub-nesting bird species in the Vancouver area with data compiled from various sources, Table 3. Three of the species on the list were regularly encountered during this study: American robin, song sparrow and spotted towhee.

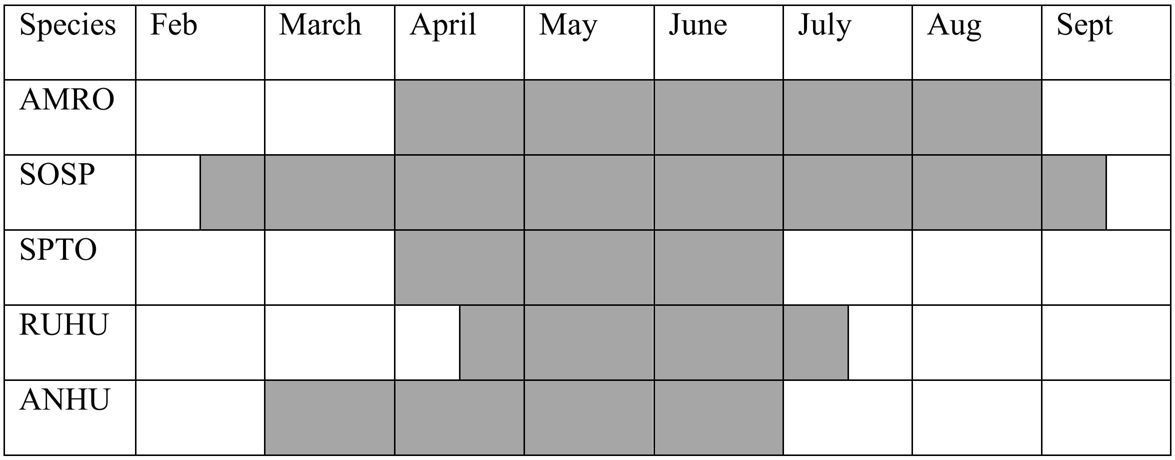
Table 3. Preferred nesting habitats of three of the birds encountered in *R. armeniacus* during this study

Species	Nest Habitat	Nest Height (above ground)
AMRO	Deciduous trees and shrubs	0-24 m, most 2-4 m
SOSP	Low, attached to plant stems	0-10 m, most 0.1-0.6 m
SPTO	On the ground, low shrubs, and *R. armeniacus*	0-10 m, most 0-1.8 m

Two hummingbird species, Anna`s hummingbird and rufous hummingbird, were also observed displaying nest defence behaviour in the *R. armeniacus* thicket in Jericho Park, and are commonly found nesting in low shrubs (Calder, 2006; Russell, 2010).

The five species noted above are likely using *R. armeniacus* as nesting habitat. Table 4 displays the most likely breeding windows for these species.

Table 4. Breeding period of common bird species thought to be using *R. armeniacus* thickets in Vancouver during this study (BNA, 2009)



Based on these observations, removal of *R. armeniacus* should be avoided during the breeding period of these five species where possible. If this is unavoidable, a thorough nest survey must be performed by a suitable qualified individual and removal completed immediately. Table 3 outlines the most critical breeding period for the five species of birds thought to utilize *R. armeniacus* for breeding.

To avoid disturbing breeding birds within the *R. armeniacus* bushes, removal should be avoided during the most critical breeding window: early April to late July. During this time period, all five of the most common birds have the potential to be present and breeding within the *R. armeniacus* bushes. If removal or management of *R. armeniacus* is unavoidable, then a professional biologist or other highly experienced individual should be retained to perform detailed nest surveys to eliminate the potential

for disturbing the nest. Any nests located during the survey should be positively identified to species, a protective buffer applied that is appropriate to the size of the thicket, and should be revisited throughout the breeding season until the nest is vacant. If no nests are located, then clearing can proceed. If retaining a biologist is not feasible given the size of the project or limited budget, then clearing of *R. armeniacus* should be limited to small areas around the edges of the thicket proceeding with caution and supervision by experienced field staff.

Management

Rubus armeniacus is not listed in the BC Weed Act, partly because economic or health impacts are not great or at least not quantified. In fact, blackberries are actively cultivated throughout the region as an attractive cash crop and “wild” blackberry picking is an acceptable and enjoyable pastime for many people (pers. obs.). This makes management of this species especially difficult. It is clear through this study that *R. armeniacus* has an impact on breeding bird diversity but complete eradication is not a feasible management option. *R. armeniacus* has become well-established within the Pacific Northwest, and thickets are often large, ranging from a few square metres to several hectares in size (pers. obs.) and well-established. Re-growth, even after extensive removal efforts, is a serious concern requiring a significant amount of time, effort and money to manage. Therefore, management of existing thickets, and prevention of colonization into new areas should be the focus of invasive species removal strategies.

Removal and replanting

Removal of *R. armeniacus* is best accomplished using mechanical removal methods. Given the predilection of *R. armeniacus* to colonize riparian corridors, the use of pesticides should be limited to upland areas only and in municipalities where their use is permitted by law. Removal should take place in four steps, as described in Bennett (2007, pg. 4):

1. Removal of above-ground plant parts to allow access for the remaining steps
2. Removal and destruction of root crowns and roots to prevent further regrowth into the site
3. Replanting with native vegetation
4. Monitoring and maintenance of the site to prevent spread, remove regrowth and monitor health of replanted vegetation

Prompt replacement of the *R. armeniacus* with suitable native species is necessary to ensure that wildlife habitat is maintained. A potentially successful replanting approach is to establish a coniferous or deciduous canopy of trees to prevent some spread of *R. armeniacus* (Bennett, 2007) but create a more diverse ecosystem.

Suitable replacement food species should be flowering and fruiting species. By replacing *R. armeniacus* with a variety of shrubs, fruit availability throughout the year

should be addressed. Recommended species for replanting based on dominant species in the CWHdm and CWHxm1 (Green and Klinka, 1994) are:

- Snowberry (*Symphocarpus alba*)
- Salmonberry (*Rubus spectabilis*)
- Thimbleberry (*Rubus parvifolum*)
- Pacific crabapple (*Malus fusca*)
- Vine maple (*Acer macrophyllum*)
- Black twinberry (*Lonicera involucrata*)
- Red elderberry (*Sambucus racemosa*)

These species will provide structural diversity, while also providing berries and fruits into the winter months, such as snowberry berries that persist throughout the winter (Pojar and MacKinnon, 2004).

Removal of *R. armeniacus* bushes may leave exposed soil increasing the potential for erosion while also providing an ideal growing surface for other invasive plants (McGregor, 1998). By replanting with native species as soon as the *R. armeniacus* is removed, colonization by other species and regrowth of *R. armeniacus* may be avoided. The goal of replanting should be to mimic the vegetation composition of a "natural" habitat, and to ensure that the species chosen represent the ecosystem. An important goal is also to provide fruit and shelter for birds and other wildlife throughout the year, not only through the breeding season.

A dense planting plan of 1-2 plants per square metre will not only create a thick understorey, but will also help to prevent regrowth of *R. armeniacus* shoots. Using a combination of the above plants will ensure that fruit is available to birds throughout the year.

Removal vs. management

Complete eradication of *R. armeniacus* in many areas of the Pacific region of North America is not a feasible option. Therefore pruning of bushes into manageable sized plots is a potential option. Given that *R. armeniacus* produces copious fruits that are readily dispersed by birds, one option is to create artificial perch structures, such as planted snags or constructed perches, to act as "seed sinks" (Gosper et al., 2005). Retaining *R. armeniacus* bushes around these structures or around trees that grow above the *R. armeniacus* thickets will concentrate seed deposition and also provide dense vegetation patches for birds that actively take refuge in the canes and for other wildlife (Gosper et al., 2005).

Although the fungal rust *P. violaceum* may be an effective biological control of *R. armeniacus*, not enough is known about its impacts to Canadian cultivars to suggest its introduction into the Pacific Northwest. If shown to be effective in controlling invasive blackberry species, this pathogen may be included into an integrated blackberry management plan.

Conclusion

Invasive plant species have become naturalized throughout the world due to increasing globalization, human movements and degradation of natural habitats. For species that are widespread and well established, eradication may not be a feasible option for control. Studying the impacts of invasive plants on native biodiversity may provide the information required to focus management activities and resources. *R. armeniacus* is a particularly difficult plant to manage as it provides some forage and habitat for wildlife. This study has shown that when it occurs in the understorey of a forested ecosystem, it has a negative impact on bird diversity. If management of *R. armeniacus* is not performed, there is potential for it to exclude a number of bird species, reducing reproductive success and possibly creating local extirpations.

Removal and replanting with a variety of native species will increase structural composition and diversity, providing a better selection of forage species and several canopy layers for nesting and refuge. Further study is needed to determine more about the extent of the impact of *R. armeniacus* on bird diversity and specific bird species, and if other invasive plant species also have the same effect. It is evident that this species has a detrimental impact to bird species in an urban setting, and should be appropriately managed to improve bird diversity and nest habitat quality.

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Appendix A. Terrestrial Ecosystem Mapping data

Plot	Date	Aspect	Slope %	Struct stage	Crown closure	Tree species	% cover	Total shrub cover %	Shrub species	% cover	Total herb cover %	Herb species	% cover
JP001	07-Aug-09	E	7	3b	0	0	0	100	Rubu arm	100	5	Canada thistle	3
												Grasses	2
JP002	07-Aug-09	NE	5	3b	0	0	0	100	Rubu arm	96	10	Canada thistle	5
									Salix sp.	2		Common tansy	3
									Ornamental	2		Grasses	2
JP003	07-Aug-09	0	0	3b	0	0	0	100	Rubu arm	93	10	Common tansy	8
									Salix sp.	93		Grasses	2
									Act	1			
									Samb rac	3			
JP004	07-Aug-09	0	0	3b	0	0	0	100	Rubu arm	90	10	Grasses	10
									Ornamental	1		Agave	1
									Dr	2		Canada thistle	0.1
									Act	1			
									Salix sp.	1			
									Hawthorn	1			
JP005	07-Aug-09	0	0	3b	0	0	0	100	Rubu arm	93	2	Canada thistle	2
									Act	3			
									Acer sp.	2			
									Hawthorn	2			
JP006	07-Aug-09	W	5	5	50	Dr	47	40	Rubu spe	10	10	Japanese	10

														knotweed	
								Mb	3		Acer cir	5		Cala sp.	0.1
											Rubu arm	10			
											Cw	10			
											Ilex	0.01			
											Mb	2			
											Hw	3			
JP007	07-Aug-09		0	0		4	30	Dr	28	96	Mb	10	13	Japanese knotweed	8
								Act	2		Rubu arm	80		Grasses	3
											Hawthorn	1		Burweed	0.1
											Acer cir	3		Wall lettuce	2
											Dr	2			
JP008	07-Aug-09	N		15	3b		15	Spruce	5	40	Malu fus	10	100	Canada thistle	10
								Fd	5		Rosa nut	15		Grasses	60
								Dr	5		Cw	5		Vetch	35
											Hawthorn	5		Common tansy	5
											Pl	0.1			
											Holo dis	0.1			
											Quercus	0.1			
JP009	07-Aug-09		0	0		4	40	Mb	10	86	Acer cir	1	16	Burdock	5
								Act	25		Rubu arm	80		Galium sp.	0.1
								Dr	2		Dr	5		Plantago	0.01
								Fd	3					Grasses	10
														Mullein	0.01
														Cala sp.	1
JP010	07-Aug-09	N		15		4	30	Lombardi poplar	1	60	Dr	2	20	Cala sp.	20
								Dr	25		Rubu arm	50			
								Hw	0.1		Holo dis	3			
								Act	5		Mb	0.1			

										Act	3			
										Hawthorn	2			
										Sorb sit	1			
SP001*	13-Sep-09		0	0	3b	30	Fd	10	60	Rubu arm	50			
							Dr	20		Rubu spe	10			
SP003	13-Sep-09	S		10	3b	10	Cw	8	90	Rubu arm	80			
							Dr	2		Rham pur	5			
										Sorb sit	5			
SP004	13-Sep-09	S		10	3b	10	Cw	5	80	Acer cir	5	10	Conv arv	10
							Fd	5		Rubu arm	70			
										Samb rac	3			
										Prunus sp.	2			
MW001	14-Sep-09	W		5	3b	0	0	0	90	Rubu arm	90			
MW002	14-Sep-09	W		10	3b	30	Dr	30	90	Rubu arm	80	10	Grasses	10
										Quercus	2			
										Malu fus	3			
										Spir dou	5			
MW003	14-Sep-09		0	0	3b	10	Act	5	90	Rubu arm	80	10	Equi arv	5
							Dr	5		Spir dou	1		Grasses	5
										Salix sp.	2			
										Sorb sit	2			
										Oeml cer	5			
MW004	14-Sep-09		0	0	5	30	Dr	30	95	Rubu arm	80	20	Ranunc sp.	15
							Quercus	1		Dr	2		Grasses	5
										Sorb sit	3		Poly mun	0.1
										Rham pur	5			
										Holo dis	5			
MW005	14-Sep-09		0	0	4	40	Dr	40	90	Rubu arm	85			
										Sorb sit	3			
										Mb	1			
										Dr	2			
MW006	14-Sep-09		0	0	4	40	Dr	30	80	Rubu spe	30	20	Grasses	20
							Act	10		Rubu arm	30			

										Loni inv	10			
										Rham pur	10			
										Spir dou	2			
MW007	14-Sep-09	0	0	3b	0		0	0	50	Salix sp.	30	50	Juncus sp.	30
										Spir dou	10		Carex sp.	15
										Malu fus	5		Equi arv	3
										Dr	2		Grasses	3
										Act	3			
MW008	14-Sep-09	0	0	3b	20	Dr		20	50	Rubu arm	30	50	Yarrow	10
										Symp alb	5		Grasses	40
										Fd	5			
										Sorb sit	10			
MW009	14-Sep-09	0	0	4	30	Act		10	80	Rubu arm	40			
						Dr		20		Sorb sit	10			
										Oeml cer	30			
										Rubu spe	10			
MW010	14-Sep-09	0	0	5	60	Dr		50	80	Rubu spe	30	20	Poly mun	15
						Act		10		Oeml cer	30		Gera rob	5
										Loni inv	1			
										Rubu urs	1			
										Sorb sit	10			
										Mb	10			

* TEM plot cards for SP002, SP004 and SP006 were lost during field work

Appendix B. Bird species names

Code	Latin name	Common name
AMGO	*Spinus tristis*	American Goldfinch
AMRO	*Turdus migratorius*	American Robin
ANHU	*Calypte anna*	Anna's Hummingbird
BCCH	*Poecile atricapillus*	Black-capped Chickadee
BHCO	*Molothrus ater*	Brown-headed Cowbird
BHGR	*Pheucticus melanocephalus*	Black-headed Grosbeak
BEWA	*Thryomanes bewickii*	Bewick's Wren
BUSH	*Psaltriparus minimus*	Bushtit
CEWA	*Bombycilla cedrorum*	Cedar Waxwing
CHSP	*Spizella passerina*	Chipping Sparrow
DEJU	*Junco hyemalis*	Dark-eyed Junco
DOWO	*Picoides pubescens*	Downy Woodpecker
EUST	*Sturnus vulgaris*	European Starling
GBHE	*Ardea herodias*	Great Blue Heron
GCKI	*Regulus satrapa*	Golden-crowned Kinglet
GCSP	*Zonotrichia atricapilla*	Golden-crowned Sparrow
GRCA	*Dumetella carolinensis*	Grey Catbird
HETH	*Catharus guttatus*	Hermit Thrush
HOFI	*Carpodacus mexicanus*	House Finch
HOSP	*Passer domesticus*	House Sparrow
NOFL	*Colaptes auratus*	Northern Flicker
MCWA	*Oporornis tolmiei*	McGillivray's Warbler
PISI	*Carduelis pinus*	Pine Siskin
PIWO	*Dryocopus pileatus*	Pileated Woodpecker
PSFL	*Empidonax difficilis*	Pacific-slope Flycatcher
PUMA	*Progne subis*	Purple Martin
RCKI	*Regulus calendula*	Ruby-crowned Kinglet
REVI	*Vireo olivaceus*	Red-eyed Vireo
RUHU	*Selasphorus rufus*	Rufous Hummingbird
SASP	*Passerculus sandwichensis*	Savannah Sparrow
SOSP	*Melospiza melodia*	Song Sparrow
SPTO	*Pipilo maculatus*	Spotted Towhee
SSHA	*Accipiter striatus*	Sharp-shinned Hawk
SWTH	*Catharus ustulatus*	Swainson's Thrush
TRSW	*Tachycineta bicolor*	Tree Swallow
UNFL	--	Unknown Flycatcher
UNWA	--	Unknown Warbler
VGSW	*Tachycineta thalassina*	Violet-green Swallow
WAVI	*Vireo gilvus*	Warbling Vireo
WCSP	*Zonotrichia leucophrys*	White-crowned Sparrow
WIFL	*Empidonax traillii*	Willow Flycatcher
WIWR	*Troglodytes troglodytes*	Winter Wren

YEWA	*Dendroica petechia*	Yellow Warbler
YRWA	*Dendroica coronata*	Yellow-rumped Warbler