Species Richness, Abundance and Reproductive Responses of Riparian Birds to Habitat Restoration in the Okanagan Valley

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Timothy Robert Forrester

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Name: **Timothy Robert Forrester**

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Title: ***Species Richness, Abundance and Reproductive Responses of Riparian Birds to Habitat Restoration in the Okanagan Valley***

Examining Committee: **Chair:** Dr. David Lank
Adjunct Professor

Dr. David J. Green
Senior Supervisor
Professor

Dr. Christine A. Bishop
Co-Supervisor
Research Biologist
Wildlife Research Division
Environment Canada

Dr. Ronald C. Ydenberg
Supervisor
Professor

Dr. Kathy Martin
External Examiner
Professor
Department of Forest and Conservation Sciences
University of British Columbia

Date Defended/Approved: January 26, 2015

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Abstract

In western North America, most riparian habitats have been destroyed or degraded as a result of human settlement and urban development. I examined temporal trends in the abundance, richness and breeding performance of riparian birds in response to restoration of remnant riparian habitat within the south Okanagan Valley, an arid region of Canada. Total abundance and richness increased over the last decade. Restoration increased the abundance of Yellow-breasted Chats (*Icteria virens auricollis*), the target of management activities, but did not have a detectable effect on the abundance of other songbirds. The habitat characteristics and breeding performance of Yellow-breasted Chats in restored habitat are currently similar to those of Yellow-breasted Chats in reference sites. Habitat characteristics on multiple spatial-scales (shrub cover of the territory and foliage height of the nest patch) influenced the breeding performance of Yellow-breasted Chats. These results provide evidence that limiting grazing is beneficial to some shrub-nesting songbirds.

Keywords: Riparian; restoration; songbirds; temporal trends; demography; breeding performance

For my family.

Thank you for believing in me

and letting me follow my passions,

even when it takes me far away from you.

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Chapter 1. General Introduction

Riparian habitat, the wetland interface between land and lakes or rivers, is particularly valuable in western North America because the water and vegetation in this habitat provide resources for animals that otherwise occupy more arid and unproductive habitats (Chaney et al. 1990). Consequently, more vertebrates use riparian habitat at some point in their life cycle than any other habitat type (Sedgwick and Knopf 1987; Douglas et al. 1992; Naiman et al. 1993). Riparian habitat also provides many valuable ecosystem services, such as filtering sediments, reducing erosion and slowing or preventing flooding (Carothers 1977; Chaney et al. 1990). Destruction, fragmentation and degradation of riparian habitat have resulted from human settlement and growth. Human activities are concentrated in riparian areas, so habitat degradation results from river flow management, agriculture, urbanization, recreation, pollution and grazing (Krueper 1993). Historically extensive stands of cottonwood and willow habitat patches have mostly been destroyed, often for agriculture. Beginning in the late nineteenth century, widespread overgrazing by livestock began the extensive deterioration of western riparian habitats (Chaney et al. 1990). Over 90% of riparian habitat has now been destroyed in many areas of western North America (Krueper 1993). Determining demographic and reproductive trends of species in remnant riparian habitat is essential to determine if fragmented and degraded habitat is able to maintain diverse communities.

Destruction, fragmentation and degradation of riparian habitat can negatively affect riparian bird communities. Destruction of riparian habitat decreased the abundance and richness of riparian birds in Louisiana, Pennsylvania and Montana (Burdick et al. 1989; Popotnik and Guiliano 2000; Scott et al. 2003). Livestock grazing can degrade riparian habitat by reducing canopy, shrub and herb cover, increasing cover of bare ground, compacting soil and eroding stream banks (Fleishner 1994; Schulz and Leininger 1990; Kauffman and Krueger 1984). Habitat degradation by livestock can reduce nest success (i.e., the probability of fledgling at least one nestling) of songbirds

(Ammon & Stacey 1997). Habitat loss, combined with increased parasitism by Brown-headed Cowbirds (*Molothrus ater*) as a result of increased livestock grazing, caused a severe decline to the abundance of the endangered Least Bell's Vireo (*Vireo bellii*) in California (U.S. Fish and Wildlife Service 1988). Declines of endangered songbirds, along with decreases in the abundance and diversity of riparian bird communities, have led to the recognition of the importance of riparian habitat in the arid west.

Riparian habitats that have experienced extensive habitat loss or degradation are often recipients of restoration efforts. Restoration efforts range from extensive replanting of native vegetation to simply removing a disturbance such as livestock grazing, therefore allowing vegetation to regrow (Goodwin et al. 1997). Removing livestock and replanting vegetation can improve songbird abundance and diversity (Krueper et al. 2003; Earnst et al. 2005; Argent and Zwier 2007; Gardali and Holmes 2011), although not always to the levels of protected habitats (Gardali et al. 2006). Although many studies have examined the effect of restoration on the abundance of songbirds, few have quantified its effects on breeding performance (e.g., nest success, number of fledglings produced, clutch size and parasitism rate).

Because abundance may be a misleading indicator of habitat quality when populations persist in habitat sinks (Dwernychuck and Boag 1972; Gates and Gystel 1978, Robertson and Hutto 2006), monitoring of the breeding performance of riparian-obligate songbirds is essential for assessing habitat quality and evaluating restoration efforts. Determining if habitat characteristics influence breeding site selection and subsequent breeding performance can also inform restoration efforts. It is often assumed that songbirds select territories that will maximize their breeding performance (Martin 1998), but measured habitat preferences often do not influence breeding performance (Chalfoun and Schmidt 2012). For example, although Brewer's Sparrows occupy breeding sites with greater than average shrub cover and height, these vegetation characteristics did not predict reproductive success (Chalfoun and Martin 2007). Nestling mass and the number of broods was, however, positively correlated with shrub cover. In addition, small-scale habitat preferences such as the density of nest shrubs did influence nest success. Studies that aim to determine the influence of habitat preferences should therefore examine habitat on a variety of spatial scales and measure diverse fitness consequences (Chalfoun and Martin 2007).

The Okanagan Valley of British Colombia, Canada, is an arid region at the northern tip of the Great Basin. Riparian habitat was once common on the valley floor but was lost at a rapid rate following human settlement (Lea 2008). Tourism, real estate development, agriculture, forestry, and construction, all of which can negatively affect riparian habitat, represent the dominant industries in the Okanagan (Okanagan Valley Economic Development Society 2013). As is the case across North America (Martin and Finch 1995; Hayden et al. 2000), the loss, fragmentation and degradation of riparian habitat are presumed to have resulted in declines of riparian dependent songbirds in the Okanagan, including the now endangered Western Yellow-breasted Chat (*Icteria virens auricollis*) population (Environment Canada 2014). The remaining riparian habitat still provides breeding and stopover habitat for a large number of species (Cannings et al. 1987). Despite the high species richness of Okanagan riparian habitat, no studies have examined long-term temporal changes of riparian bird populations. Morgan et al. (2006), however, examined trends in the abundance of the Brown-headed Cowbird and some of its host species between the early 1990s and early 2000s. Ward and Smith (1997) and Morgan et al. (2006) also examined the breeding performance of some riparian-obligate songbirds in 1992-1994 and 2001-2003, respectively. An assessment of the abundance and richness of the riparian bird community and of the breeding performance of individual riparian-obligate species is needed to determine if riparian songbirds are thriving in remnant riparian habitat of the south Okanagan Valley.

The Okanagan Valley represents the north-western limit of the range of the Yellow-breasted Chat, which has been the focus of conservation efforts since it was listed as endangered in British Columbia in 2000 (Environment Canada 2014). Restoration efforts, mainly consisting of excluding or limiting livestock grazing, were initiated with the goal of improving riparian habitat for the Yellow-breasted Chat (Environment Canada 2014). Yellow-breasted Chats in the Okanagan prefer habitat with high shrub cover and low tree, grass-forb and bare ground cover (McKibbin and Bishop 2010), but it is unknown how characteristics of the territory, nest patch or nest site influence breeding performance. This information is necessary to guide continuing restoration efforts that aim to re-establish an abundant and productive population of this endangered songbird in the Okanagan.

In Chapter 2 of this thesis, I build on previous research conducted in the south Okanagan Valley to provide the first long-term study of population trends and breeding performances of riparian birds in this heavily modified area of Canada. I use data collected in 2002-2004 and 2012-2014 to assess temporal changes in the abundance, richness and diversity of the riparian songbird community, as well as to the abundance and breeding performance of five riparian-obligate songbirds. I assess the impact of riparian habitat restoration on these metrics by making a spatial comparison between sites that were historically protected and degraded sites that were the target of restoration activities in the early 2000s. I also use data spanning two decades to examine temporal trends in the breeding performance of riparian-obligate songbirds, as well as the abundance of the Brown-headed Cowbird.

In Chapter 3, I use a 13-year dataset to examine long-term trends in the breeding performance of the recovering population of Yellow-breasted Chats in the south Okanagan Valley. I assess whether or not increased abundance has led to density-dependent decreases to the breeding performance of Yellow-breasted Chats. I also examine the influence of breeding habitat characteristics (measured at three different spatial scales) on the parasitism rate, clutch size, nest success and productivity of successful Yellow-breasted Chat nests. Finally, I assess the impact of habitat restoration on the breeding performance of Yellow-breasted Chats by comparing the breeding performance and nest habitat characteristics between historically protected sites and sites that had experienced restoration activities. I also compare historically occupied and recently settled Yellow-breasted Chat territories to determine if newly restored habitat has similar habitat characteristics and supports similar Yellow-breasted Chat breeding performance as historically occupied territories in ungrazed sites. In Chapter 4, I place my results in the context of a large body of research, discuss the management implications of my results and suggest areas that deserve further research.

Chapter 2. Temporal Variation in the Abundance, Richness and Breeding Performance of Riparian Birds in Response to Habitat Restoration in the South Okanagan Valley, British Columbia, Canada

2.1. Abstract

Riparian habitat supports the highest density and diversity of songbirds in Western North America despite covering less than 1% of the land area. Widespread destruction and degradation of riparian habitat, especially by livestock grazing, has led to habitat restoration efforts. In 2000, management of livestock grazing was initiated in an attempt to restore habitat for the endangered Western Yellow-breasted Chat (*Icteria virens auricollis*) in the south Okanagan Valley of British Columbia, Canada. I examined temporal trends in the abundance and richness of riparian birds, and the breeding performance of five riparian-obligate songbird species, in response to habitat restoration over the past decade. I also examined longer-term trends in the abundance of Brown-headed Cowbirds (*Molothrus ater*), parasitism rates and the nest success of five riparian-obligate songbirds. Abundance and richness of riparian birds increased over the past decade.

Restoration activities increased the abundance of Yellow-breasted Chats but did not have detectable effects on the abundance, richness or breeding performance of other riparian birds. Brown-headed Cowbird abundance decreased by 85% and parastisim rates decreased by 7 to 29% from 1992 to 2014. Songbird nest success increased between the early 1990s and early 2000s. My study provides evidence that the abundance, richness and breeding performance of riparian birds in remnant habitat of the south Okanagan Valley have not decreased despite continued anthropogenic pressure and that limiting livestock grazing is beneficial to some, but not all, shrub-nesting riparian songbirds.

2.2. Introduction

Riparian habitat supports the greatest diversity and highest densities of songbirds in western North America. (Knopf et al. 1988; Skagen et al. 1998; Dobkin et al. 1988). Riparian habitats are utilized by humans for a variety of purposes, especially in arid regions, and are vulnerable to a variety of anthropogenic activities such as development, agriculture, river channelization and grazing (Patten 1998; Miller et al. 2003). Consequently, this valuable habitat has been lost at a high rate in North America (Krueper 1993) and now comprises less than 1% of western land area (Chaney et al. 1990). Destruction and degradation of riparian habitat often reduces the abundance and species richness of riparian bird communities (Tewksbury 2002; Scott et al. 2003; Smith and Wachob 2006) and the breeding performance of birds that are dependent on these areas for breeding (Knopf et al. 1988; Popotnik and Guiliano 2000). Development of the landscape surrounding riparian habitat can also negatively impact riparian bird abundance, richness and breeding performance (Saab 1999; Lichstein et al. 2002; Tewksbury et al. 2006). Recognition of the importance of riparian habitat has led to the protection of many remnant habitats. Protected habitats are nevertheless vulnerable to degradation by urban growth, agriculture, development and livestock grazing. Livestock grazing can degrade riparian habitat in a variety of ways, such as reducing shrub cover and eroding stream banks (Chaney et al. 1990; Fleishner 1994; Brown and McDonald 1995).

Conservation biologists have attempted to restore degraded habitat through cattle exclusion (Nelson et al. 2011), replanting of native vegetation (Kus 1998) and diverting rivers to restore wetlands (Hughes and Rood 2003), among other strategies. Restoration often increases the abundance, richness, and diversity of riparian songbirds (Krueper et al. 2003; Earnst et al. 2005; Gardali et al. 2006). The effects of habitat degradation and restoration activities on the breeding performance of songbirds is less clear. Unlike in the eastern and mid-western USA, habitat fragmentation did not result in decreased nest success or increased parasitism of songbirds in riparian sites of western Montana (Tewksbury et al. 1998). Songbirds in grazed riparian habitats can have similar nest success to those ungrazed habitats (Popotnik and Guiliano 2000; Harrison et al.

2011), and removal of livestock has resulted in increased nest success (Ammon and Stacey 1997). However, songbirds in restored riparian forests can also have lower nest success than protected forests (Larison et al. 2001). Few studies have examined how restoration influences songbird productivity (i.e., number of fledglings produced).

The desert-like Okanagan Valley of interior British Columbia, at the northern tip of the Great Basin, contains a mosaic of ecosystems that provide breeding habitat to over 200 species of birds (Cannings et al. 2010), possibly the most diverse community of breeding birds in the country (Richard Cannings, personal communication). A large number and diversity of these birds, including species-at-risk, utilize riparian habitat at some point in their life cycle (Cannings et al. 1987). Historically, riparian forests composed of black cottonwood floodplains and water birch wetlands, containing dense understories of shrubs (especially *Rosa* sp.) and willows, were widespread on the valley floor. Unforested patches of thick shrubs were also common. These nutrient rich floodplains and swamps followed the length of the winding Okanagan River. However, rapid human settlement and the resulting development led to the loss of 58% of Black Cottonwood habitat and 92% of water birch habitat since the mid 1800s (Lea 2008). The remaining riparian habitat, much of which is on private property, has been severely fragmented by urban and agricultural activities, logging, and road building (Lea 2008). Riparian habitat loss and fragmentation has putatively been a major factor in population declines of some riparian dependent songbird species in the south Okanagan Valley, including the population of endangered Western Yellow-breasted Chats (Environment Canada 2014).

The small number of breeding bird survey routes in the Okanagan Valley (Sauer et al. 2014) are inadequate for describing detailed temporal trends in the abundance and richness of riparian birds in the south Okanagan Valley. However, two studies have quantified the abundance and breeding performance of riparian birds in the Okanagan. In the early 1990s, Ward and Smith (1997) assessed the abundance of Brown-headed Cowbirds and the abundance, parasitism rates, and productivity of their hosts. In the early 2000s, a larger-scale effort was made to assess the abundance of the riparian bird community, as well as the abundance and breeding performance of riparian-obligate songbirds (Morgan et al. 2006; Morgan et al. 2007). I build on this research to provide the first long-term examination of riparian bird population trends in the south Okanagan

Valley.

In this chapter, I examine temporal changes in the abundance and richness of the riparian bird community and the breeding performance of five riparian-obligate songbird species in the south Okanagan Valley. I also compare the abundance, richness and breeding performance of riparian songbirds in protected “Reference” sites to “Restoration” sites, which have experienced restoration regimes through livestock exclusion and/or natural succession in the past decade. Finally, I assess long-term trends in the abundance of the Brown-headed Cowbird, as well as the parasitism rates and nest success of riparian-obligate songbird species in the Okanagan over the past two decades.

2.3. Methods

2.3.1. Study Sites

I studied riparian birds in the same areas of the south Okanagan Valley, British Columbia that Ward and Smith (1997) examined the impacts of brood-parasitism by Brown-headed Cowbirds on riparian songbirds in 1992-1994. I conducted point counts at the eight sites and monitored breeding performance at four of the five sites that Morgan et al. (2006, 2007) monitored in 2001-2004 (Figure 2.1). Sites ranged in size from one to 180 hectares. Riparian habitat at these sites is composed of black cottonwood and water birch forest patches, interspersed with thick patches of wild rose and other shrubs. Due to access issues, not all sites could be monitored every year. I classified the study sites as “Reference” sites, “Restoration” sites or “Currently Grazed” sites (Table 2.1). Reference sites contain dense stands of riparian habitat and have not been historically grazed. These sites gained protection at varying times after the 1950s. As of the late 1990s, Restoration sites had degraded shrub layers from historic livestock grazing. In 2001, Restoration sites were the subjects of restoration activities, either by permanently excluding livestock by using fencing or by seasonally removing livestock from May through August. To assess the impact of habitat restoration measures, I compared the abundance and richness of the riparian bird community and the breeding performance of riparian-obligate songbirds in Reference and Restored sites in 2001-2003 and 2012-

2014. When measuring breeding performance, I combined sites 5 and 7 into one site because of their close proximity and small size. Site 11, the "Currently Grazed" site, had been heavily degraded but had not received any restoration activities, so it could not be classified as either a Reference or Restoration site. This site was only included in analyses of valley-wide long-term temporal trends, which ignored site classification, in the parasitism rate and nest success of riparian-obligate songbirds.

2.3.2. Survey Methods for Assessing Abundance, Richness and Diversity of Riparian Birds

To measure changes in the abundance and richness of the riparian songbird community over time, I utilized the same unlimited-radius point count protocol used in 2001-2003 (Morgan et al. 2006) and recommended by Dobkin et al. (1998). In 2012 and 2013, I completed point counts at the same stations surveyed in 2001-2003. In both years, I surveyed each site once in the early summer and once in the late summer, as close as possible to the dates that the sites were surveyed in the early 2000s. I completed 10-minute point counts at 41 stations within eight of the 11 riparian study sites in the south Okanagan Valley (Table 2.1, Figure 2.1). Fifteen point count stations were located in Reference sites (n=4) and 26 were located in Restoration sites (n=4). The number of point count stations at a site varied in relation to the size of the site. I conducted point counts only in fair weather, with no precipitation and little wind. I initiated point counts at sunrise and concluded within four hours. Point counts were conducted between May 26th and July 3rd. Four sites were sampled in both 2012 and 2013 and four were sampled only in 2012. Any differences between periods due to observer effects were minimized by having one of the observers from 2001-2003 train the observer who conducted all of the surveys in 2012-2013.

2.3.3. Survey Methods for Assessing the Breeding Performance of Riparian Focal Species

I intensively examined the abundance and breeding performance of five riparian-obligate species in the south Okanagan Valley. The focal species included one endangered species, the Yellow-breasted Chat and four common species: Willow

Flycatcher (*Empidonax traillii*), Song Sparrow (*Melospiza melodia*), Yellow Warbler (*Setophaga petechial*) and Gray Catbird (*Dumetella carolinensis*).

The British Columbia population of the Western Yellow-breasted Chat subspecies was designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2000 and placed on the British Columbia red list in 2001 (Environment Canada 2014). The majority of Yellow-breasted Chats in British Columbia breed in the Okanagan and Similkameen Valleys, but a small population breeds in the Pend'Oreille River Valley in the Kootenays. An estimated 170 pairs currently breed in the province (Environment Canada 2014). Small population declines have been documented in Washington (-0.84% per year) and Oregon (-1.79% per year) during the past decade, while Yellow-breasted Chat populations increased in the Great Basin, (+1.29% per year) (Sauer et al. 2014), of which the Okanagan Valley represents the northern tip.

The Willow Flycatcher is listed as a watch-list species in North America (Partners in Flight 2007) and as secure in Canada (Wild Species 2005). Small population declines have been documented in British Columbia (-2.21% per year), Washington (-1.21% per year), Oregon (-3.91% per year) and the Great Basin (-0.96% per year) over the past decade (Sauer et al. 2014). However, there is still a large population of Willow Flycatchers breeding in British Columbia (Partners in Flight 2007).

Song Sparrow, Yellow Warbler and Gray Catbird all have large populations in British Columbia and these species do not present immediate conservation challenges (Partners in Flight 2007). Over the past decade, these species showed varying population trends in the Pacific Northwest and the Great Basin. Annual population declines of Song Sparrows have occurred in British Columbia (-2.02% per year), Washington (-1.36% per year), Oregon (-1.34% per year) and the Great Basin (-1.47% per year). Yellow Warblers declined in British Columbia (-1.56% per year) and Oregon (-2.43% per year) and had stable trends in Washington (+0.12% per year) and the Great Basin (+0.22% per year). Gray Catbirds had yearly increases in British Columbia (+5.11% per year), Washington (+2.94% per year), Oregon (+15.33% per year), and the Great Basin (Sauer et al. 2014, +5.24 per year).

In May through mid-August of 2012 through 2014, I measured breeding performance of the riparian focal species at five of the six study sites monitored by Morgan et al. (2007); access to the remaining site was not granted. Nest were usually checked at least once every three days to determine the date that incubation started, observed clutch size, occurrences of brood-parasitism by Brown-headed Cowbirds, number of fledglings, and nest success (defined as fledging at least one non-Cowbird fledgling). I aged nestlings based on feather development. I considered nests to have failed if the nest was obviously destroyed or if eggs/nestlings were missing before the anticipated fledging date or if there was no evidence of fledglings or parental behaviour near the nest immediately after fledging. I considered nests as successful if they were found empty within one day of the anticipated fledge date and if fledglings were observed or if parental behaviour indicated the presence of fledglings in the area.

2.3.4. Data Analysis

I analyzed data collected in 2001-2003 and 2012-2013 to determine trends in abundance, richness, diversity and breeding performance. First I utilized linear mixed effects models using *lme4* (Bates et al. 2012) to evaluate whether total abundance of all riparian birds, total richness of all riparian birds or the abundance of the five focal species (per point count station) varied with time period (2001-2003 or 2012-2013) and the study site category (Reference or Restoration). I included site category, time period and whether the survey was completed in early or late summer (survey time) as fixed effects. I also included interactions between study period and site category as well as between survey time and time period. The point count station and year were specified as random effects. I excluded Ring-billed Gull (*Larus delawarensis*) from the analysis because they were a flyover species that did not utilize riparian habitat, as well as large flocks (over 20 individuals) of European Starlings (*Sturnus vulgaris*), House Sparrows (*Passer domesticus*), and Rock Doves (*Columbia livia*). Differences across time periods or between Reference and Restoration sites were not driven by data collected at the largest site (Site 9); results excluding Site 9 do not differ from those presented. When comparing the results from 10-minute point counts completed by this study and Morgan et al. (2006) to 5-minute point counts completed by Ward and Smith (1997), I truncated raw point count data by only including birds detected in the first five minutes of point counts.

As different numbers of point counts were completed (and therefore different total number of birds detected) in 2001-2003 and 2012-2013, I produced rarefaction curves to compare the richness of study sites between these time periods. I also analyzed species diversity using the Shannon-Wiener and Simpson's Diversity Indices. I calculated Simpson's Index by both calculating an overall ("Overall") index of all point counts and by calculating the Simpson's index for each point count survey and then averaging all of those values (Table 2.2, "Avg Per PC").

Next I utilized linear mixed effects models to evaluate whether productivity (of all nests and of only successful nests), apparent nest success, clutch size and parasitism rate of the five focal species varied with time period or with study site category. When evaluating productivity, nest success and clutch size, I included site category, time period, incubation start date, parasitism status and an interaction between study period and site category as fixed effects. When evaluating parasitism rate, I included site category, time period, incubation start date and an interaction between study period and site category as fixed effects. In these analyses, I included study site and year as random effects.

I calculated daily nest survival using the Logistic-Exposure method (Shaffer 2004). I used generalized linear models implemented in *mass* (Venables and Ripley 2002) to evaluate whether daily nest survival varied between time period and study site category. I included site category, time period, parasitism status, year and an interaction between study period and site category as fixed effects. I also used the Mayfield Method (Mayfield 1975) to analyze daily nest survival to enable a temporal comparison with data from 1992-1994 (Ward and Smith 1997). In this analysis, we assumed Yellow-breasted Chats had a nesting period of 22 days, Willow Flycatchers had a nesting period of 26 days, Song Sparrows had a nesting period of 22 days, Yellow Warblers had a nesting period of 21 days and Gray Catbirds had a nesting period of 23 days (Ehrlich et al. 1988).

For all analyses, visual inspection of residual plots did not reveal any obvious deviations from homoscedasticity or normality. I obtained chi-squared (χ^2) and p-values by starting with a full model and sequentially dropped non-significant ($p>0.05$) terms until only significant terms remained. Significance was assessed by comparing models with and without the term of interest using likelihood ratio tests. All analyses were conducted in Program R (R Core Team 2014).

2.4. Results

2.4.1. Temporal Trends of the Abundance, Richness and Diversity of the Riparian Bird Community

I detected increases in the total abundance and species richness (per point count station) of the riparian bird community between 2001-2003 and 2012-2013 but restoration did not have a detectable effect on abundance and richness that was independent of the temporal changes that occurred at both Reference and Restoration sites (Figures 2.2 and 2.3; Table 2.2). Over the last decade, the total abundance of riparian birds detected during 10-minute point counts increased by 21% or 5.2 birds ($\chi^2(1)=4.77$, $p=0.03$). This pattern was observed at both Reference and Restoration sites (Time Period x Site Category Interaction: $\chi^2(1)=0.57$, $p=0.44$). Total abundance was higher at Restoration sites than at Reference sites ($\chi^2(1)=7.26$, $p<0.01$). The average species richness also increased at both Reference and Restoration sites but was lower in Reference sites than in Restoration sites (Time Period: $\chi^2(1)=5.98$, $p=0.01$; Site Category: $\chi^2(1)=5.14$, $p=0.02$; Interaction: $\chi^2(1)=0.7$, $p=0.4$). Diversity was high at both Reference and Restoration sites in both time periods, but there was no temporal change in diversity (Table 2.2). There were also no temporal changes to the rarefied species richness in all study sites. There were 90.0 ± 3.0 species (95% CI) detected in 2001-2003 and 87.0 ± 0.0 in 2012-2013 (Table 2.2). However, overall species richness and rarefied richness decreased at Reference sites, while overall rarefied richness was lower and stable at Restoration sites (Figure 2.4; Table 2.2). The average abundances of all species detected during point counts are listed in Appendix A.

2.4.2. Temporal Trends of the Abundance of the Five Riparian Focal Species and the Brown-headed Cowbird.

I found strong evidence that restoration increased the abundance of Yellow-breasted Chats over the past decade (Time Period x Site Category Interaction: $\chi^2(1)$=3.80, p=0.05). Yellow-breasted Chats increased from 0.15 ± 0.16 (95% CI) to 1.12 ± 0.44 detections per point count station in Restoration sites (Figure 2.5). Only one Yellow-breasted Chat was detected at Reference sites because the point count stations were not located near any of their territories. Restoration did not have a detectable effect on the abundance of the other riparian songbirds that was independent of temporal changes at both Reference and Restoration sites (Figure 2.5; Time Period x Site Category Interaction for WIFL: $\chi^2(1)$=0.93, p=0.34; SOSP: $\chi^2(1)$<0.01, p=0.95; YEWA: $\chi^2(1)$=0.07, p=0.79; GRCA: $\chi^2(1)$=2.45, p=0.12) . Song Sparrows were more abundant in Reference sites than in Restoration sites but their abundance did not change over time (Time Period: $\chi^2(1)$=0.91, p=0.34; Site Category: $\chi^2(1)$=3.89, p=0.05). There was an increase of Yellow Warbler abundance in both Reference and Restoration sites but their abundance did not differ between these site categories (Time Period: $\chi^2(1)$=8.30, p<0.01; Site Category: $\chi^2(1)$=2.34, p=0.13). There were no temporal changes to the abundance of Gray Catbirds or Willow Flycatchers (GRCA: $\chi^2(1)$=0.23, p=0.63; WIFL: $\chi^2(1)$=1.95, p=0.16). Gray Catbird and Willow Flycatcher abundance also did not differ in Reference and Restoration sites (GRCA: $\chi^2(1)$=1.02, p=0.31; WIFL: $\chi^2(1)$=1.95, p=0.16). Brown-headed Cowbird abundance was lower in Reference sites than Reference sites and decreased in both site categories, although declines were greater in Reference sites (Figure 2.5; Time Period x Site Category Interaction: $\chi^2(1)$=3.84 p=0.05).

2.4.3. Temporal Trends of Songbird Productivity

I detected no consistent temporal trends in the productivity of the five riparian focal species over the past decade (Table 2.3; Figure 2.6). Restoration did not have a detectable effect on productivity that was independent of temporal changes at both Reference and Restoration sites (Time Period x Site Category Interaction for YBCH: $\chi^2(1)$=1.18, p=0.28; WIFL: $\chi^2(1)$=0.02, p=0.88; SOSP: $\chi^2(1)$=0.51, p=0.48; YEWA: $\chi^2(1)$=0.15, p=0.7). Gray Catbird productivity increased in Reference sites and decreased in Restoration sites (Time Period x Site Category Interaction: $\chi^2(1)$=9.19, p<0.01). Productivity of Yellow-breasted Chats increased in both Reference and Restoration sites but did not differ between these sites (Time Period: $\chi^2(1)$=3.70, p=0.05; Site Category: $\chi^2(1)$=0.03, p=0.86). Productivity of Song Sparrows did not change in either Reference or Restoration sites but was higher in Reference sites (Time Period: $\chi^2(1)$=2.53, p=0.11; Site Category: $\chi^2(1)$=4.38, p=0.04). There were no temporal changes in the productivity of Willow Flycatchers or Yellow Warblers in both Reference and Restoration sites (WIFL: $\chi^2(1)$=0.04, p=0.85; YEWA: $\chi^2(1)$=0.41, p=0.52). Productivity of Willow Flycatchers and Yellow Warblers also did not differ between these sites (WIFL: $\chi^2(1)$=0.11, p=0.874; YEWA: $\chi^2(1)$=0.04, p=0.85). The incubation initiation date did not affect the productivity of any of the focal species (YBCH: $\chi^2(1)$=0.03, p=0.87; WIFL: $\chi^2(1)$=0.46, p=0.5; SOSP: $\chi^2(1)$<0.01, p=0.98; YEWA: $\chi^2(1)$=0.01, p=0.92; GRCA: $\chi^2(1)$=0.16, p=0.69).

When I examined the productivity of only nests that were successful (i.e., fledged at least one non-Cowbird nestling), I also found that restoration did not have a detectable effect on productivity that was independent of temporal changes (Table 2.3; Time Period x Site Category interaction for YBCH: $\chi^2(1)$=0.07, p=0.79; WIFL: $\chi^2(1)$=2.57, p=0.11; SOSP: $\chi^2(1)$=0.18, p=0.67; YEWA: $\chi^2(1)$=0.78, p=0.38; GRCA: $\chi^2(1)$=0.59, p=0.44). I did find, however, some evidence that productivity of successful Willow Flycatchers nests increased over the last decade ($\chi^2(1)$=3.42, p=0.06). Productivity (of successful nests) of Yellow-breasted Chats, Song Sparrows, Yellow Warblers and Gray Catbirds did not change over time (YBCH: $\chi^2(1)$=0.51, p=0.47; SOSP: $\chi^2(1)$=0.02, p=0.9; YEWA: $\chi^2(1)$=0.16, p=0.69, GRCA: $\chi^2(1)$=0.06, p=0.81). Gray Catbird nests were more productive earlier in the breeding season but incubation initiation date had no effect on the productivity of the other focal species (GRCA: $\chi^2(1)$=5.69, p=0.02; YBCH: $\chi^2(1)$=2.58, p=0.11; WIFL: $\chi^2(1)$=0.13, p=0.72; SOSP: $\chi^2(1)$=0.03, p=0.85; YEWA: $\chi^2(1)$=0.53, p=0.47). Productivity of successful Yellow-breasted Chat, Willow Flycatcher and Gray Catbird nests did not differ between Reference and Restoration sites (YBCH: $\chi^2(1)$=0.66, p=0.42; WIFL: $\chi^2(1)$=0.20, p=0.6, GRCA: $\chi^2(1)$=0.62, p=0.43). However, productivity of Song Sparrows and Yellow Warblers was higher in Reference sites than in Restoration sites (SOSP: $\chi^2(1)$=4.40, p=0.04; YEWA: $\chi^2(1)$=4.70, p=0.03).

2.4.4. Temporal Trends of Songbird Nest Success

I found no detectable effect of restoration on the apparent nest success (i.e., the chance of fledgling at least one non-Cowbird nestling) of the five riparian focal species that was independent of temporal changes (Table 2.3; Time Period x Site Category interaction for YBCH: $\chi^2(1)$=0.04, p=0.85; WIFL: $\chi^2(1)$=1.82, p=0.18; SOSP: $\chi^2(1)$=0.01, p=0.94; YEWA: $\chi^2(1)$=0.02, p=0.9). However, I detected a decrease of Gray Catbird nest success in Restoration sites and an increase in Restoration sites (Time Period x Site Category Interaction: $\chi^2(1)$=7.88, p<0.01), analogous to temporal trends of Gray Catbird productivity. Nest success of Yellow-breasted Chats, Song Sparrows, Willow Flycatchers and Yellow Warblers did not change over time (YBCH: $\chi^2(1)$=1.69, p=0.19; SOSP: $\chi^2(1)$=1.54, p=0.21; WIFL: $\chi^2(1)$=0.97, p=0.32; YEWA: $\chi^2(1)$=0.71, p=0.40). Nest success of Yellow-breasted Chats, Song Sparrows, Willow Flycatchers and Yellow Warblers also did not differ between Reference and Restoration sites (YBCH: $\chi^2(1)$=0.12, p=0.89; SOSP: $\chi^2(1)$=2.10, p=0.15; WIFL: $\chi^2(1)$=0.14, p=0.71; YEWA: $\chi^2(1)$=0.56, p=0.45). Incubation initiation date did not affect the nest success of any of the focal species (YBCH: $\chi^2(1)$=0.19, p=0.66; WIFL: $\chi^2(1)$=0.06, p=0.81; SOSP: $\chi^2(1)$=0.06, p=0.8; YEWA: $\chi^2(1)$=0.47, p=0.49; GRCA: $\chi^2(1)$=0.79, p=0.37)

2.4.5. Temporal Trends of Songbird Daily Nest Survival

I also found no detectable effect of restoration on the daily nest survival of the five riparian songbirds that was independent of temporal changes (Table 2.3; Time Period x Site Category Interaction for YBCH: $\chi^2(1)$=0.63, p=0.43; WIFL: $\chi^2(1)$=0.02, p=0.88; SOSP: $\chi^2(1)$=0.06, p=0.81; YEWA: $\chi^2(1)$=0.33, p=0.57). Similar to their productivity and nest success, the daily nest survival of Gray Catbirds increased in Reference sites and decreased in Restoration sites (Time Period x Site Category Interaction: $\chi^2(1)$=13.27, p<0.01). Daily nest survival of Yellow-breasted Chats, Song Sparrows, Willow Flycatchers and Yellow Warblers did not change over the last decade (YBCH: $\chi^2(1)$=0.65, p=0.42; SOSP: $\chi^2(1)$=0.81, p=0.37; WIFL: $\chi^2(1)$=1.33, p=0.25; YEWA: $\chi^2(1)$=2.06, p=0.15). Daily nest survival of Yellow-breasted Chats, Willow Flycatchers and Yellow Warblers did not differ between Reference and Restoration sites but the daily nest survival of Song Sparrows was higher in Reference sites than in Restoration sites

(YBCH: $\chi^2(1)$=0.11, p=0.74; WIFL: $\chi^2(1)$=1.78, p=0.18; YEWA: $\chi^2(1)$=0.63, p=0.43; SOSP: $\chi^2(1)$=3.96, p=0.05). Daily nest survival of all five focal species did not vary by year (YBCH: $\chi^2(1)$=1.08, p=0.3; WIFL: $\chi^2(1)$=1.57, p=0.21; SOSP: $\chi^2(1)$=0.56, p=0.46; YEWA: $\chi^2(1)$=1.55, p=0.21; GRCA: $\chi^2(1)$=0.62, p=0.43).

2.4.6. Temporal Trends of Songbird Clutch size

I also found no detectable effect of restoration on the clutch sizes of the five riparian-obligates that was independent of temporal change (Table 2.3; Time Period x Site Category interaction for YBCH: $\chi^2(1)$=1.66, p=0.2; WIFL: $\chi^2(1)$=2.47, p=0.12; SOSP: $\chi^2(1)$=0.48, p=0.49; YEWA: $\chi^2(1)$=0.01, p=0.9; GRCA: $\chi^2(1)$=0, p=1). Clutch sizes of all five songbirds did not change over time (YBCH: $\chi^2(1)$=0.37, p=0.54; SOSP: $\chi^2(1)$=0.08, p=0.78; YEWA: $\chi^2(1)$=2.73, p=0.1; WIFL: $\chi^2(1)$=1.80, p=0.18; GRCA: $\chi^2(1)$=0.51, p=0.47). The clutch size of Yellow-breasted Chats was higher in Reference sites than in Restoration sites ($\chi^2(1)$=4.03, p=0.04). I also found some evidence that Song Sparrow clutch size was higher in Reference sites than in Restoration sites ($\chi^2(1)$=2.98, p=0.08). However, clutch sizes of Willow Flycatchers, Yellow Warblers and Gray Catbirds did not differ between Reference and Restoration sites (WIFL: $\chi^2(1)$=0.25, p=0.62; YEWA: $\chi^2(1)$=1.68, p=0.20; GRCA: $\chi^2(1)$=1.28, p=0.26). Yellow-breasted Chat and Willow Flycatcher nests initiated earlier in the year had higher clutch sizes than those initiated later and we found some evidence of the same trend for Song Sparrow clutch sizes (YBCH: $\chi^2(1)$=4.38, p=0.04; WIFL: $\chi^2(1)$=12.09, p<0.01; SOSP: $\chi^2(1)$=2.87 p=0.09). Incubation initiation date had no effect on the clutch size of Yellow Warblers and Gray Catbirds (YEWA: $\chi^2(1)$=0.07, p=0.79; GRCA: $\chi^2(1)$=0.01, p=0.92).

2.4.7. Temporal Trends of Brown-headed Cowbird Nest Parasitism Rates and Effects on Reproductive Success

I did not detect any consistent temporal changes to the parasitism rates of the riparian focal species over the last decade and found no evidence that restoration had a detectable effect on parasitism that was independent of temporal change (Table 2.3; Time Period x Site Category interaction for YBCH: $\chi^2(1)$=0.54, p=0.46; WIFL: $\chi^2(1)$=0.01, p=0.93; SOSP: $\chi^2(1)$=3.79, p=0.05; YEWA: $\chi^2(1)$=1.57, p=0.21). I found no evidence that

Gray Catbird nests were parasitized in either 2002-2004 or 2012-2014. Parasitism rate of Yellow-breasted Chat nests did not change significantly over time, although parasitism increased by 20% in Reference sites and by 5% in Restoration sites ($\chi^2(1)$=2.09, p=0.15). Parasitism rates of Willow Flycatcher and Yellow Warbler nests did not change over time (WIFL: $\chi^2(1)$=0.64, p=0.42; YEWA: $\chi^2(1)$=<0.01, p=0.98). There were no differences in the parasitism rates of Yellow-breasted Chat and Willow Flycatchers nests in Reference and Restoration sites, but parasitism rates of Yellow Warbler nests were higher in Restoration sites than in Reference sites (YBCH: $\chi^2(1)$=0.24, p=0.62; WIFL: $\chi^2(1)$=0.01, p=0.94; YEWA: $\chi^2(1)$=4.49, p=0.03). Parasitism rates of Song Sparrow nests showed a significant temporal trend, decreasing by 20% in Reference sites and increasing by 25% in Restoration sites (Time Period x Site Category Interaction: $\chi^2(1)$=3.79, p=0.05). Song Sparrow nests initiated earlier in the breeding season were parasitized less than those initiated later ($\chi^2(1)$=11.11, p<0.01). Incubation initiation date did not affect the parasitism rates of Yellow-breasted Chats, Willow Flycatchers or Yellow Warblers (YBCH: $\chi^2(1)$=0.56, p=0.45; WIFL: $\chi^2(1)$=0.13, p=0.72; YEWA: $\chi^2(1)$=0.03, p=0.85).

I found that the effects of parasitism on the productivity, nest success, daily nest survival and clutch size of riparian songbirds differed between species with Song Sparrow and Willow Flycatcher being the most negatively affected (Table 2.4). Parasitism reduced average productivity per nest of Song Sparrows and Willow Flycatchers (SOSP: $\chi^2(1)$=4.32, p=0.04; WIFL: $\chi^2(1)$=33.90, p<0.01). Parasitism also reduced the average productivity of successful Yellow-breasted Chat nests ($\chi^2(1)$=4.68, p=0.03). It also reduced the apparent nest success of Song Sparrows and Willow Flycatchers (SOSP: $\chi^2(1)$=7.57, p<0.01; WIFL: $\chi^2(1)$=42.13, p<0.01). No parasitized Willow Flycatcher nests were successful. Furthermore, parasitism reduced the daily nest survival of Willow Flycatcher nests ($\chi^2(1)$=9.83, p<0.01). Parasitism also reduced the clutch size of the four parasitized species (YBCH: $\chi^2(1)$=26.11, p<0.01; SOSP: $\chi^2(1)$=9.54, p<0.01; YEWA: $\chi^2(1)$=11.84, p<0.01; WIFL: $\chi^2(1)$=10.33, p<0.01). Finally, there was a lower parasitism rate of Song Sparrows nests that were laid earlier in the season ($\chi^2(1)$=13.17, p<0.01) but incubation initiation date did not affect the parasitism status of the other focal species (YBCH: $\chi^2(1)$=0.56, p=0.45; WIFL: $\chi^2(1)$=0.13, p=0.72; YEWA: $\chi^2(1)$=0.03, p=0.85).

2.4.8. Riparian Songbird Demography over a 22-year period

I detected longer-term changes in the abundance of Brown-headed Cowbirds and the breeding performance of riparian-obligate songbirds when I compared data from 1992-1994 (Ward and Smith 1997) to data from 2001-2004 and 2012-2014. There was an 85% decrease in the abundance of Brown-headed Cowbirds, with most of the decrease occurring between 1992-1994 and 2001-2003 (Figure 2.7). I found that the overall parasitism rate of riparian focal species and individual parasitism rates for three of the four focal species decreased as Brown-headed Cowbird abundance decreased. Gray Catbird nests were parasitized at a low level in 1992-1994 but not after that (Table 2.5).

Nest success (estimated using the Mayfield method) of all four species with data available increased between 1992-1994 and 2002-2004 (Table 2.5). Because I found that parasitism reduces Song Sparrow nest success, I can attribute their increase in nest success at least partially to decreased cowbird abundance and parasitism rate. I also found that parasitism also reduces Willow Flycatcher nest success. However, Willow Flycatchers did not experience reduced nest success between 1992-1994 and 2002-2004, despite an increased parasitism rate. Yellow Warbler and Gray Catbird nest success also increased between 1994 and 2002-2004.

2.5. Discussion

Continued pressure on remnant riparian habitat due to urbanization, agriculture and development has led to concern about populations of riparian birds in the south Okanagan Valley. In this study, 108 bird species were detected. In 2001-2003 I detected 93 species and in 2012-2013 others detected 87 species, though more point counts were completed in 2001-2003 and rarefied richness did not differ between these time periods. I found that riparian bird richness in the Okanagan is similar to or higher than the richness of other western riparian habitats, all with larger study areas. A three-year study in Colorado detected 95 species (Miller 2003), a six-year study in California detected 87 species (Nelson et al. 2011) and a four-year study in Arizona detected 60 species (Brand et al. 2008). Only studies that surveyed far larger areas than my study area found higher richness, such as a four-year study with 173 point count stations that detected 124 species in California (Heath and Gates 2002). Despite continued pressure from the surrounding landscape matrix I found a substantial increase in the abundance (+21% per point count) and species richness (+18% per point count) of riparian birds in the Okanagan over the last decade. Significant increases in the abundances of riparian-obligates such as Yellow-breasted Chat, Yellow Warbler and Sora, and habitat generalists such as American Goldfinch, Cedar Waxwing, and Lazuli Bunting contributed to the increased abundance at my sites. Despite persisting in only 8% of the historic area of riparian habitat, the riparian bird community of the south Okanagan Valley has maintained high abundance and species richness over the past decade.

Restoration efforts (i.e., removing or limiting livestock grazing) in the south Okanagan Valley were initiated with the goal of creating new habitat and improving degraded habitat for the endangered Yellow-breasted Chat (Environment Canada 2014). I expected that Yellow-breasted Chats would function as an umbrella species and that management for Yellow-breasted Chats would also benefit other riparian-obligate songbirds, particularly shrub-nesting songbirds that are more adversely affected by grazing than species that nest at greater heights (Saab et al. 1995). However, restoration increased the abundance of Yellow-breasted Chats, but I did not detect that it affected other riparian bird abundance and species richness. I suggest that this may be because, although livestock degraded my Restoration sites, they still contained large patches of riparian forest and shrubs as of the early 2000s. Studies that found increased abundance of songbirds in response to restoration often started out with sites that were in far worse condition (e.g., having almost no riparian vegetation) than my sites (Krueper et al. 2003; Earnst et al. 2005; Farley 1994; Dobkin et al. 1998; Gardali et al. 2006). Complete removal of grazing has resulted in increased abundance of Yellow Warblers, Song Sparrows and Willow Flycatchers in the Great Basin (Taylor and Littlefield 1986; Earnst et al. 2012). In contrast, seasonal removal of livestock did not increase the abundance of these riparian-obligate songbirds (Knopft et al. 1988) but did result in increased overall abundance of riparian bird communities (Nelson et al. 2011). Seasonal removal of livestock in my sites may not have been sufficient to allow for increased abundance of other riparian songbirds. However, Yellow-breasted Chat and Common Yellowthroat, both low, open-cup nesting species, were previously suggested to be good indicators of grazing pressure (Sedgwick and Knopft 1987), and restoration increases to the abundance of both of these species, providing some evidence that restoration increased the abundance of some other riparian-obligate species.

I expected that the breeding performance of riparian-obligate songbirds in the Okanagan would suffer as a result of increased pressure on remnant riparian habitat and/or improve as a consequence of restoration efforts. Although I did not detect a significant interaction between time period and site category, productivity of Yellow-breasted Chats was low at degraded sites prior to restoration (1.1 fledglings per nest) and improved to levels similar to Reference sites after restoration (Table 2.3; 2.2 fledglings per nest in Restoration sites compared to 2.1 in Reference sites). Productivity of Yellow-breasted Chats was not lower in fragmented habitats as compared to large habitat patches in the south Okanagan Valley (Morgan et al. 2007), so my results provide some evidence that Yellow-breasted Chat productivity is reduced by a degraded shrub layer but not by habitat fragmentation. However, Yellow-breasted Chats can only persist in fragmented habitats if they are still able to occupy territories that meet their habitat preferences. The breeding performance of my other riparian focal songbirds did not increase after seasonal livestock removal. However, grazing does not always negatively affect riparian-obligate songbirds, especially species such as Yellow Warbler which are not entirely dependent on the shrub-layer for nesting (Rich 2002). However, the productivity of Yellow Warbler, Willow Flycatcher and Gray Catbird were similar in my Reference and Restoration sites ten years ago, suggesting that the degraded shrub layer was not the primary influence on their productivity. Similar to Dybala et al. (2014), I found that restoration activities did not decrease the parasitism rates of riparian-obligate songbird nests. Persistent parasitism in both my Reference and Restoration sites was probably more influential than the quality of the shrub layer on the productivity of Willow Flycatchers and Song Sparrows, which are particularly vulnerable to parasitism (Rogers et al. 1997; Whitfield and Sogge 1999; Lorenzana and Sealy 1999). Regardless, the nest success, clutch size and productivity (of successful nests) of all five of my riparian-obligate species did not decrease in the last decade, providing evidence that the dominant riparian songbirds in the south Okanagan Valley have stable reproductive success.

Research on brood parasitism by Brown-headed Cowbirds and nest success of riparian songbirds in the south Okanagan Valley in the early 1990s (Ward and Smith 1997) allowed us to assess longer-term changes in the breeding performance of riparian-obligate songbirds. I found that over the past 20 years, there has been a large reduction (-85%, -4.25% per year) in the abundance of Brown-headed Cowbirds. This decrease is more pronounced than those observed in the Great Basin (-0.94%), British Columbia (-3.50% per year), Washington (-1.09% per year) and Oregon (Sauer et al. 2014; -1.90% per year). Decreasing cattle production in British Columbia between 1991 and 2011 may have contributed to the decreased abundance of Brown-headed Cowbirds (Statistics Canada 2012). I also found a general decrease in parasitism rates between 1992-1994. Declines were strongest in Yellow Warblers and Song Sparrows, which had the highest parasitism rates. Gray Catbirds, a species that rejects cowbird parasitism (Lorenzana and Sealy 2000), was parasitized at a low rate in 1992-1994 but not after that. Decreases to the parasitism rate of Willow Flycatchers, a species that is particularly vulnerable to parasitism (This study, Remsen 1978), were not detected. Reduced parasitism rates may have been partially responsible for increased nest success of Yellow Warblers and Song Sparrows, species that are also sensitive to parasitism (This study; Clark and Robertson 1981; Rogers et al. 1997).

My study has provided the first long-term and detailed examination of riparian songbird population changes in the south Okanagan Valley, a heavily modified region of Canada. Although only a tiny fraction of historic riparian habitat remains (Lea 2008), the riparian bird community in this remnant habitat has not experienced decreased abundance, richness or breeding performance over the last decade. In addition, removing and limiting livestock grazing has successfully increased the abundance of the target species Yellow-breasted Chat, of which only about 20 pairs were breeding in the Okanagan a decade ago (Environment Canada 2014). Other riparian-obligate songbirds have also not experienced declines in abundance or breeding performance. Over two decades, I observed decreased abundance of Brown-headed Cowbirds, along with decreased parasitism and increased nest success of some riparian-obligate songbird nests. Remnant riparian habitat of the south Okanagan Valley continues to provide critical habitat to birds that breed in or migrate through the interior of British Columbia. Ongoing efforts to protect and restore riparian habitat will help this abundant and rich riparian bird community to persist despite heavy human settlement and development of this unique area of Canada.

2.6. Tables and Figures

Table 2.1 Description of study sites including site category (Reference / Restoration), size, number of point count (PC) stations, the years that point counts were completed, whether or not breeding performance was measured and years that breeding performance was measured.

Site	Category	Size (Ha)	# PC Stations	Years PCs Completed	Breeding Performance Measured?	Years Breeding Performance Measured
1	Restoration	22	4	2002, 2012-2013	Yes	2002-2004, 2012-2014
2	Reference	40	9	2001-2003, 2012-2013	No	-
3	Reference	25	2	2001-2003, 2012-2013	Yes	2003-2004, 2012-2013
4	Reference	30	3	2001, 2003, 2012-2013	No	-
5	Reference	5	1	2001-2003, 2012	Yes	2002-2004, 2012-2014
6	Restoration	1	1	2001-2003, 2012	No	-
7	Reference	15	0	-	Yes	2002-2004, 2012-2014
8	Reference	25	0	-	Yes	2002-2004
9	Restoration	180	15	2001-2003, 2012	Yes	2002-2004, 2012-2014
10	Restoration	55	6	2003, 2012	No	-
11	Currently Grazed	13	0	-	Yes	2012-2013

Table 2.2 Number of point count (PC) stations, number of point counts completed, average abundance per point count, number of individual birds detected, species richness (number of species detected), rarefied richness, average richness per point count and diversity indices of the riparian songbird community in 2001-2003 and 2012-2013 in all sites as well as in Reference and Restoration sites.

Time Period	**2001-2003**			**2012-2013**		
Site Category	**All**	**Reference**	**Restoration**	**All**	**Reference**	**Restoration**
Point Count Stations	41	15	26	41	15	26
Point Counts Completed	187	75	112	118	58	60
Abundance Per PC (95% CI)	21.2 ± 3.0	18.8 ± 3.1	22.9 ± 4.1	25.6 ± 2.6	24.7 ± 3.9	26.6 ± 3.5
Individuals Detected	3976	1407	2569	3025	1431	1594
Species Richness	93	76	78	87	69	69
Rarefied Richness (95% CI)	90.0 ± 3.0	76.0 ± 0.0	69.2 ± 4.5	87.0 ± 0.0	68.9 ± 0.7	67.6 ± 2.2
Richness Per PC (95% CI)	12.1 ± 0.5	11.2 ± 0.7	12.7 ± 0.7	14.3 ± 0.5	14.0 ± 0.8	14.5 ± 0.7
Shannon Wiener Index	3.71	3.62	3.57	3.65	3.52	3.53
Simpson's Index (Overall)	0.97	0.96	0.96	0.96	0.95	0.96
Simpson's Index (Avg Per PC)	0.87	0.87	0.87	0.89	0.89	0.9

Table 2.3 **Breeding Performance of Yellow-breasted Chats (YBCH), Willow Flycatchers (WIFL), Song Sparrows (SOSP), Yellow Warblers (YEWA) and Gray Catbirds (GRCA) in Reference and Restoration study sites of the south Okanagan Valley. Clutch size (# of eggs), Parasitism Rate (%), Productivity (# of fledglings), Apparent Nest Success (%) and Daily Nest Survival (Decimal %) are listed. Time Period 1 is 2002-2004 and Time Period 2 is 2012-2014. Daily Nest Survival is calculated using the Logistic-Exposure method. Sample size (n) is the number of nests.**

	YBCH				WIFL				SOSP				YEWA				GRCA			
Site Category	Restoration		Reference		Restoration		Reference		Restoration		Reference		Restoration		Reference		Restoration		Reference	
Time Period	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Clutch Size	3.1	3.3	3.6	3.4	3.5	3.0	3.4	3.3	3.2	3.3	3.7	3.8	2.8	3.3	3.3	3.9	3.9	4.0	4.1	4.4
N	15	36	73	27	25	24	5	12	15	22	14	28	11	29	13	13	30	31	25	18
Parasitism Rate	37.5	42.9	32.9	52.9	40.0	30.8	38.5	31.3	46.7	71.4	41.2	20.8	52.9	63.9	43.8	26.7	0.0	0.0	0.0	0.0
N	16	35	70	31	25	26	13	16	15	21	17	24	17	36	16	15	37	35	25	21
Productivity (all nests)	1.1	2.2	1.7	2.1	1.1	1.3	1.2	1.5	0.3	1.0	1.0	2.1	1.0	1.1	0.8	1.2	2.8	1.9	1.7	3.1
N	16	35	79	16	23	25	14	17	19	27	19	28	13	33	17	14	29	34	24	20
Productivity (successful nests)	2.8	3.0	3.1	2.5	3.7	2.5	2.8	2.8	2.5	2.2	3.0	3.1	2.6	2.5	2.7	3.5	3.6	3.3	3.4	3.8
N	6	25	43	22	8	13	6	9	2	12	6	19	5	16	5	4	23	20	12	16
Nest Success (Apparent)	52.9	64.9	57.6	72.2	28.0	52.0	37.5	52.9	29.2	40.7	36.8	63.0	33.3	43.2	26.1	33.3	70.6	57.1	42.3	80.0
N	17	37	87	31	25	25	16	17	24	27	19	27	15	37	23	18	34	35	26	20
Daily Nest Survival	0.945	0.946	0.952	0.965	0.942	0.964	0.971	0.982	0.912	0.936	0.956	0.968	0.936	0.957	0.925	0.949	0.990	0.968	0.948	0.987
Exposure Days	185	449	921	177	290	309	123	264	100	224	132	246	175	362	170	167	517	505	252	315
N	20	37	77	14	22	24	9	13	11	26	9	26	14	31	16	14	31	34	25	20

Table 2.4 Breeding Performance of parasitized and unparasitized nests of the five riparian focal species in the South Okanagan. Data is combined from 2002-2004 and 2012-2014. Daily Nest Survival rates are calculated using the Logistic-Exposure method. ** Indicates significance of p<0.05 for differences between unparasitized and parasitized nests

	GRCA		SOSP		YBCH		YEWA		WIFL	
Parasitized?	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
Clutch Size	4.1	N/A	3.8	3.04**	3.8	2.86**	3.7	2.94**	3.4	2.78**
n	99	0	32	27	80	61	33	33	48	18
Productivity (all nests)	2.3	N/A	1.6	0.58**	1.9	1.7	1.3	0.9	2.0	0.0**
n	107	0	40	33	83	62	40	38	50	27
Productivity (successful nests)	3.5	N/A	3.1	2.4	3.2	2.59**	2.9	2.5	2.9	N/A
n	71	0	20	8	51	41	17	14	34	0
Nest Success (Apparent)	61.7	N/A	51.3	18.75**	61.9	62.9	43.9	34.1	68.0	0.0**
n	115	0	39	32	84	62	41	41	50	26
Daily Nest Survival	0.976	N/A	0.947	0.949	0.963	0.971	0.950	0.940	0.974	0.919**
Exposure Days	1589	0	390	312	1149	784	487	387	776	210
n	109	0	38	23	84	61	39	35	50	17

Table 2.5 Combined nest parasitism rates for all five focal species and individual parasitism rates and nest success (calculated using the Mayfield method) of Yellow-breasted Chats (YBCH), Willow Flycatchers (WIFL), Song Sparrows (SOSP), Yellow Warblers (YEWA) and Gray Catbirds (GRCA) in 1992-1994, 2002-2004 and 2012-2014 in the south Okanagan Valley. Numbers in parentheses are sample sizes (number of nests).

Variable	Species	1992-1994	2002-2004	2012-2014
Percent Parasitism	Focal Species	51 (121)	29 (251)	36 (261)
	YBCH	N/A	34 (86)	53 (66)
	WIFL	25 (16)	39 (38)	31 (42)
	SOSP	66 (44)	44 (32)	43 (46)
	YEWA	77 (35)	48 (33)	53 (51)
	GRCA	7 (26)	0 (62)	0 (56)
Nest Success	YBCH	N/A	47 (97)	60 (53)
	WIFL	32 (16)	34 (31)	51 (37)
	SOSP	8 (44)	38 (20)	33 (52)
	YEWA	12 (35)	27 (30)	37 (45)
	GRCA	36 (26)	60 (56)	58 (54)

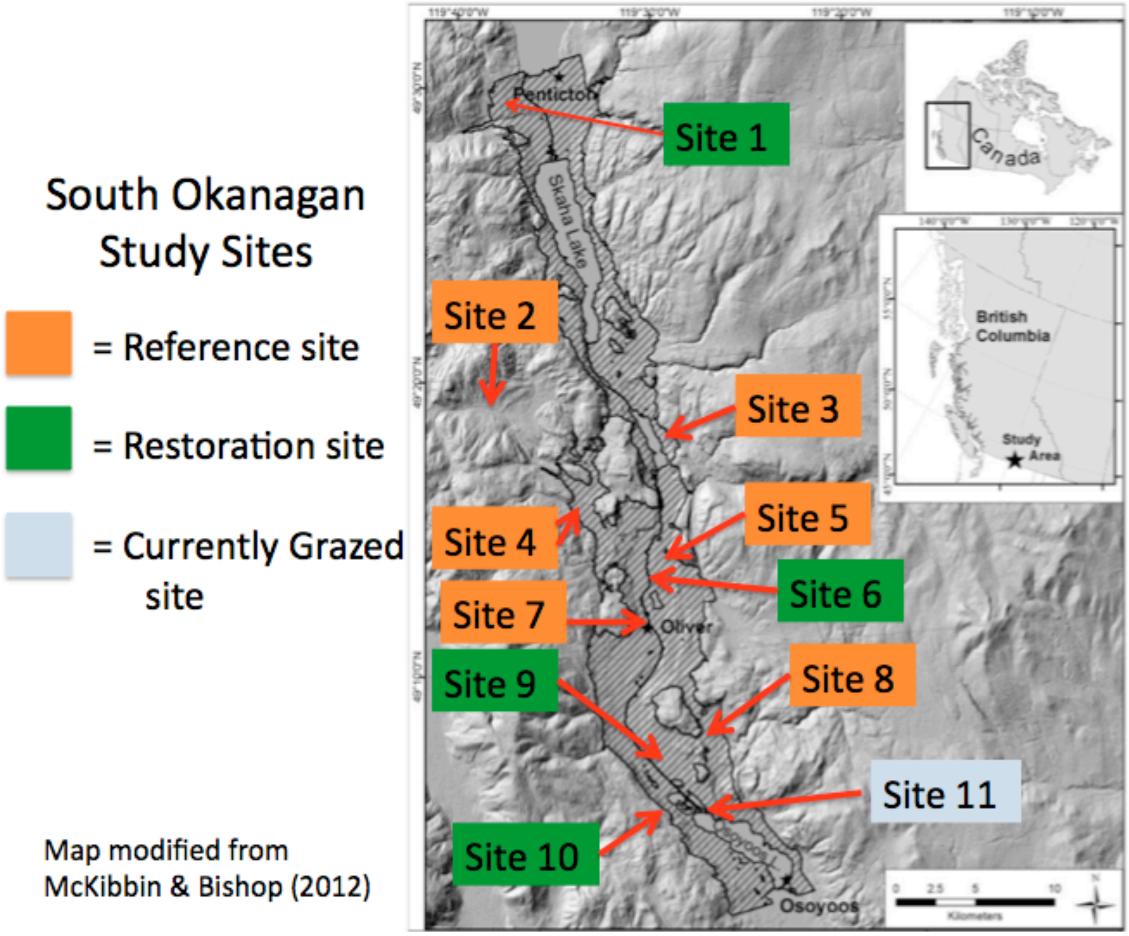

Figure 2.1 **Riparian study sites (classified as either Reference, Restoration, or Currently Grazed) for measuring abundance, richness and diversity of riparian birds in the south Okanagan Valley. Study sites 1, 3, 5, 7, 8, 9 and 11 were also used for monitoring breeding performance of riparian-obligate songbird species. Sites 5 and 7 were combined in analyses of breeding performance.**

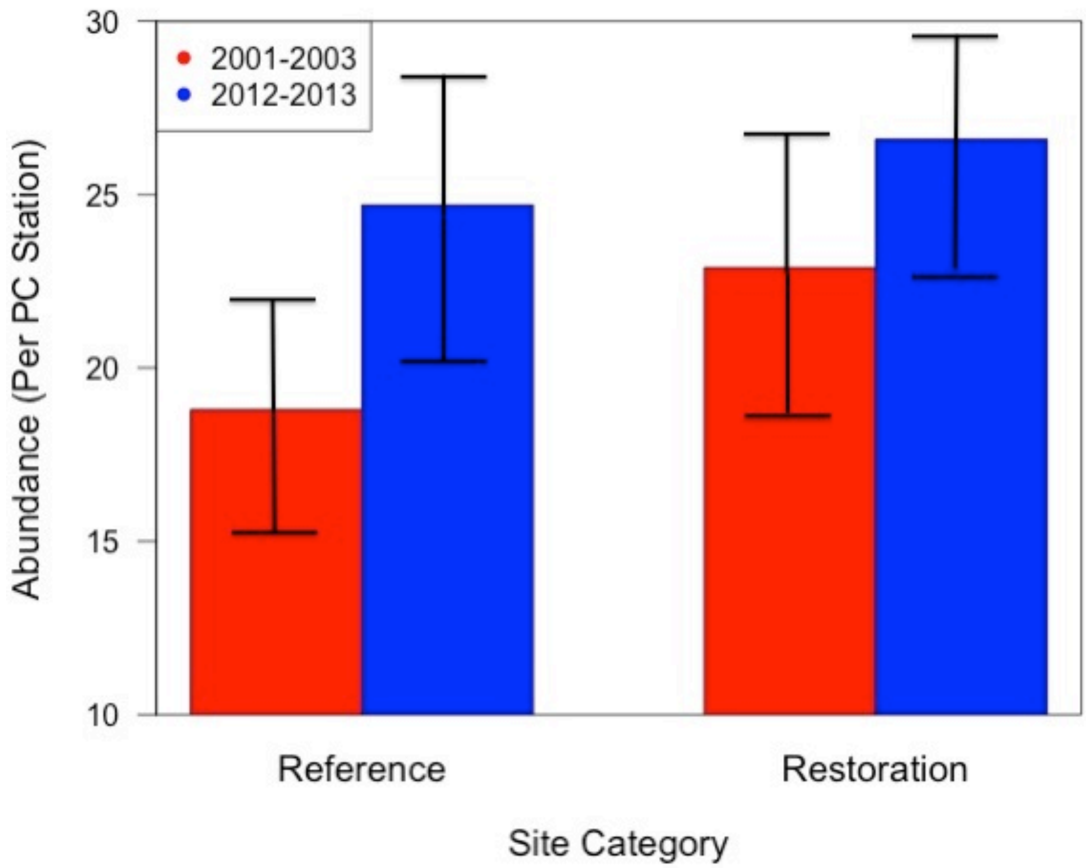

Figure 2.2 Total abundance (with bars showing 95% confidence intervals) per point count station of all riparian birds at Reference and Restoration sites in 2001-2003 and 2012-2013 in the south Okanagan Valley.

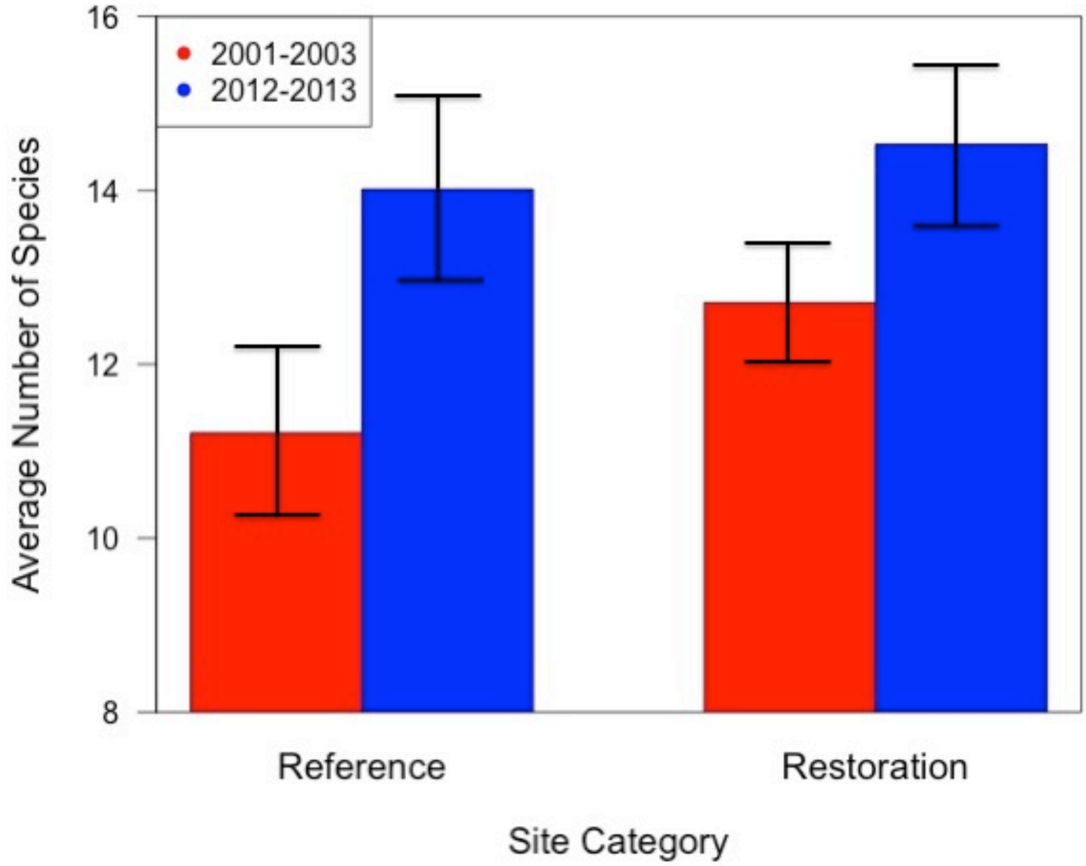

Figure 2.3 **Average species richness (with bars showing 95% confidence intervals) of riparian birds per point count station at Reference and Restoration sites in 2001-2003 and 2012-2013 in the south Okanagan Valley.**

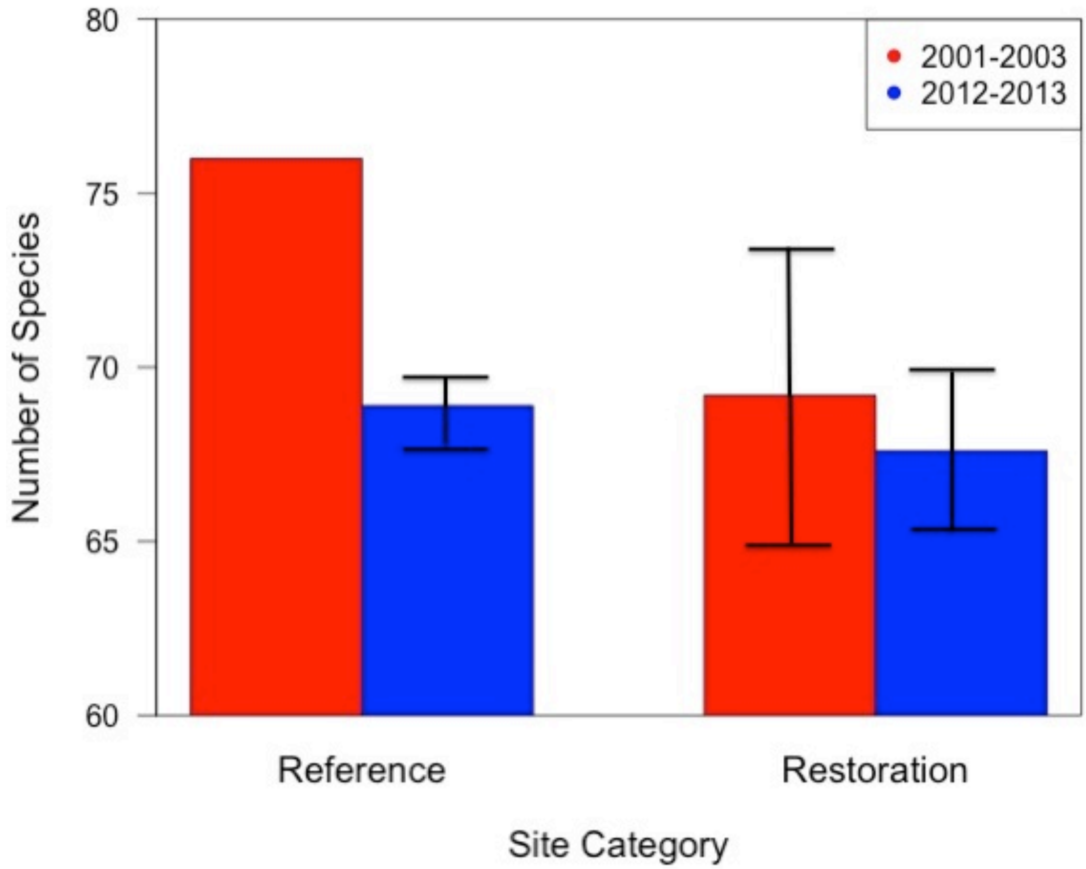

Figure 2.4 **Overall rarefied richness (with bars showing 95% confidence intervals) of all riparian birds at Reference and Restoration sites in 2001-2003 and 2012-2013 in the south Okanagan Valley. See Table 2.2 for the number of individual birds detected in each category.**

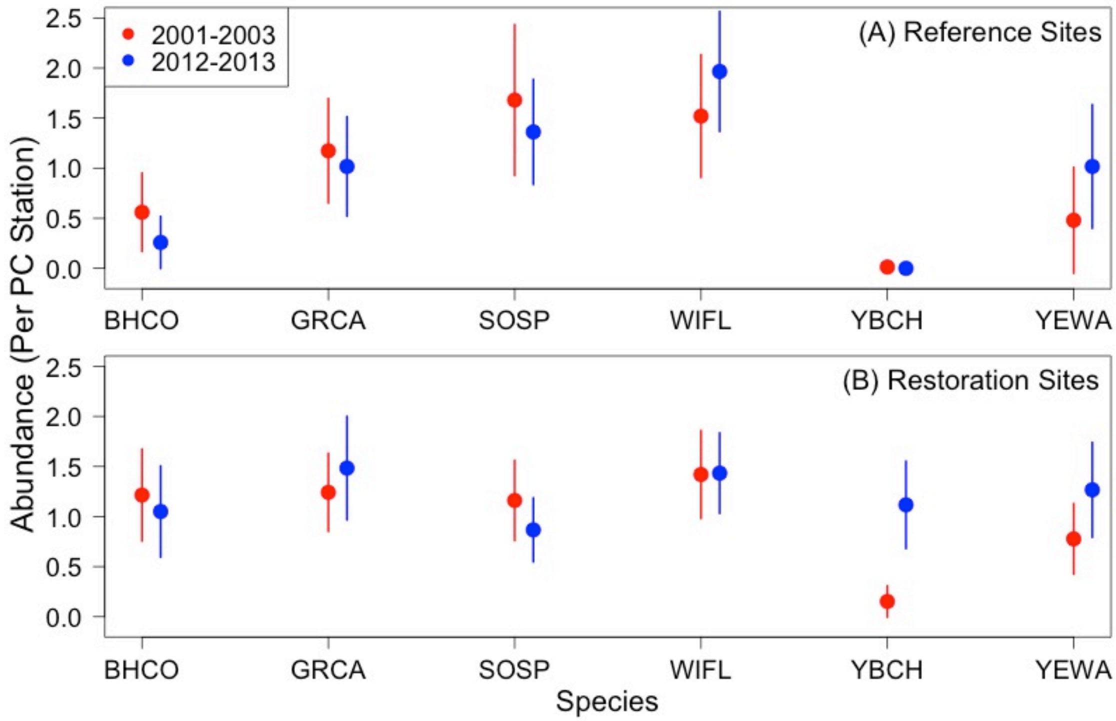

Figure 2.5 **Average abundances (with bars showing 95% confidence intervals) per point count station of Yellow-breasted Chats (YBCH), Willow Flycatchers (WIFL), Song Sparrows (SOSP), Yellow Warblers (YEWA), Gray Catbirds (GRCA) and Brown-headed Cowbirds (BHCO) in (A) Reference and (B) Restoration sites of the south Okanagan Valley in 2001-2003 and 2012-2013.**

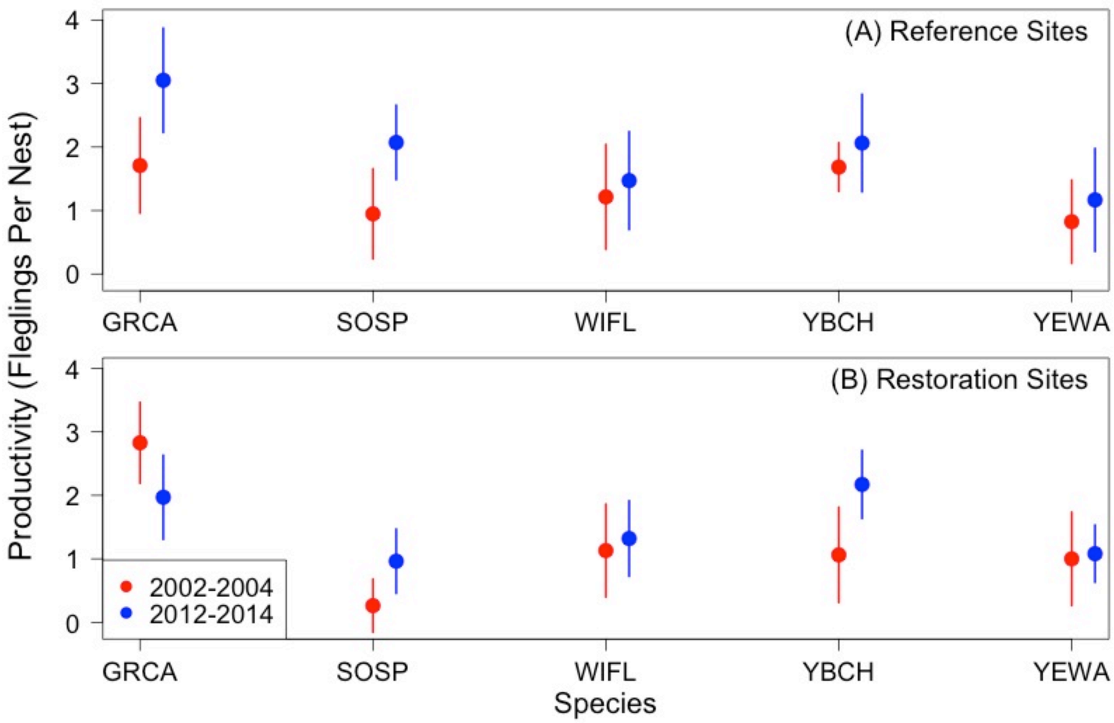

Figure 2.6 Average productivity (with bars showing 95% confidence intervals) of Yellow-breasted Chats (YBCH), Willow Flycatchers (WIFL), Song Sparrows (SOSP), Yellow Warblers (YEWA) and Gray Catbirds (GRCA) in (A) Reference and (B) Restoration sites of the south Okanagan Valley in 2002-2004 and 2012-2014.

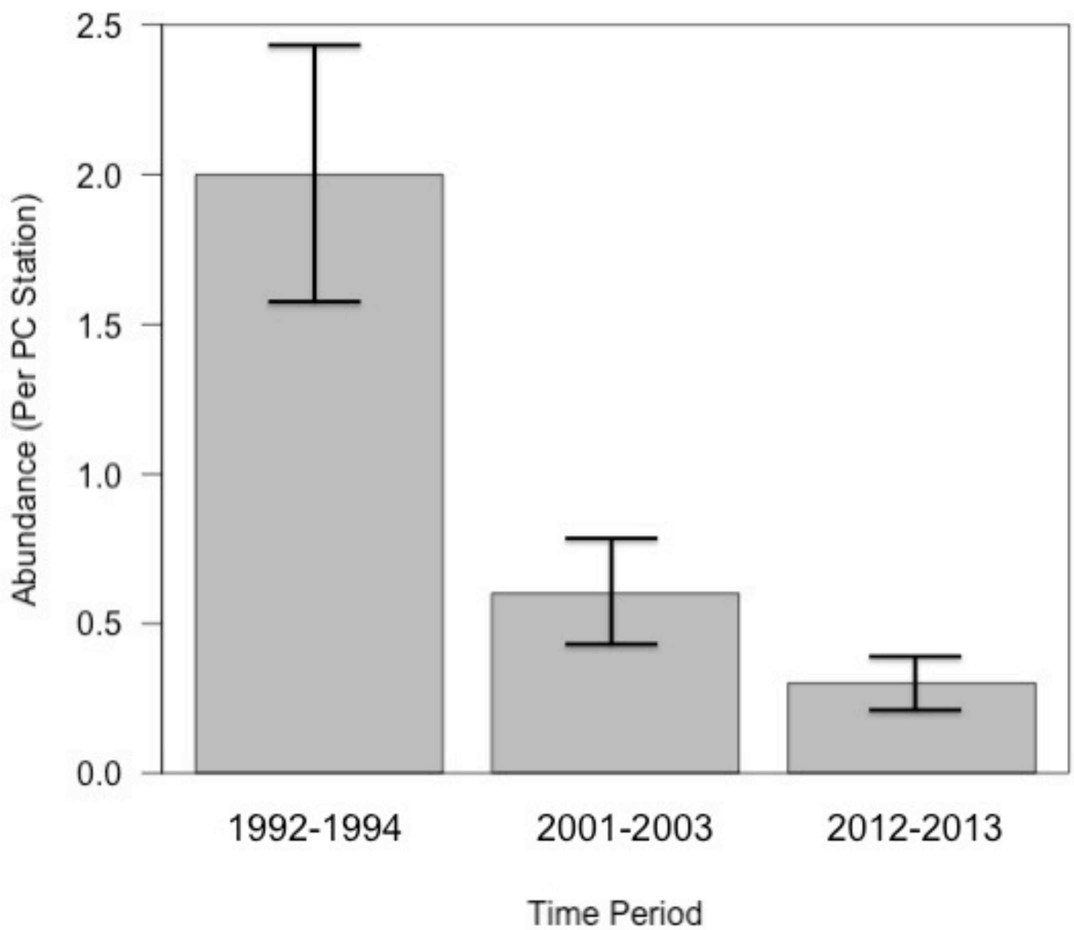

Figure 2.7 Mean abundance (with bars showing standard error) of Brown-headed Cowbirds (5-minute point counts) in riparian habitat of the south Okanagan Valley in 1992-1994, 2001-2003 and 2012-2013. Data from 1992-1994 is from Ward and Smith (1997). Data from 2001-2003 and 2012-2013 is pooled from both Reference and Restoration sites.

Chapter 3. Long-term Breeding Performance of Yellow-breasted Chats in Restored Riparian Habitat of the South Okanagan Valley, British Columbia, Canada

3.1. Abstract

Long-term monitoring of the breeding performance of endangered songbirds is essential for assessing habitat suitability and evaluating recovery efforts. Quantification of breeding habitat, on multiple spatial-scales, can guide management of degraded habitats by identifying habitat characteristics that influence breeding performance. At the north-western limit of their breeding range, endangered Western Yellow-breasted Chats (*Icteria virens auricollis*) in the south Okanagan Valley of British Columbia, Canada, have increased in abundance as a result of habitat restoration. I used a 13-year dataset to examine temporal trends in the breeding performance of this recovering songbird. I also examined the influence of habitat on breeding performance and evaluated the influence of restoration on Yellow-breasted Chat breeding habitat. Breeding performance of Yellow-breasted Chats was stable between 2002 and 2014. Habitat characteristics at the territory (% shrub cover within 50m of nests) and nest patch scale (average foliage height within 10m and distance from nest to edge of patch) were positively associated with productivity. Restoration sites now have similar habitat characteristics as historically protected habitats. Recently settled Yellow-breasted Chat territories also had similar habitat characteristics to historically occupied territories. Yellow-breasted Chats consequently have similar breeding performances in Reference and Restored sites and in Historic and Recent territories. Restoration efforts therefore appear to have created more suitable breeding habitat for Yellow-breasted Chats, leading to an increase in abundance and a stable breeding performance of this endangered songbird.

3.2. Introduction

Long-term monitoring of the abundance and breeding performance of endangered populations is essential for effective conservation planning and evaluation of recovery efforts. Abundance may be a misleading metric of population recovery if animals occupy low quality habitat that functions as a population sink. Low-quality sink habitats may result in low breeding performance, so populations will rely on frequent emigration from the source habitat to persist. (Dwernychuck and Boag 1972; Gates and Gystel 1978; Robertson and Hutto 2006). Studies that determine habitat preferences and link habitat features to reproductive success can aid in the conservation of endangered species. For example, long-term monitoring of the reproductive success of Golden-cheeked Warblers (*Setophaga chrysoparia*) has led to identification of habitat variables that have strong influence on their productivity, informing management decisions for this species (Peak and Thompson 2014). However, habitat features that influence settlement may not always predict reproductive success, particularly in habitats disturbed by anthropogenic activities. In a review of 70 studies, Chalfoun and Schmidt (2012) found that less than half of the 85 species examined showed congruence between habitat preferences and nest success.

Restoration efforts that create new habitat or improve existing habitat, if successful, will increase the density and/or abundance of songbirds. Increased population density may improve overall productivity (i.e., number of fledglings) but may also reduce the productivity of individuals. The Individual Adjustment Hypothesis proposes that population density is more influential than habitat and that increased competition at higher densities will reduce reproductive success of all individuals (Ferrer and Donazar 1996; Krueger et al. 2012). Productivity of Black-throated Blue Warblers (*Dendroica caerulescens*) in New Hampshire was reduced in this manner (Sillet et al. 2004). Conversely, the Habitat Heterogeneity Hypothesis proposes that habitat is influential regardless of density and states that since higher quality habitat is assumed to be occupied first, settlement of lower quality habitat by new individuals will lower mean reproductive success of the population (Ferrer and Donazar 1996; Rodenhouse et al. 1997; Krueger et al. 2012). Productivity of a population of Eastern Yellow-breasted Chats (*Icteria virens virens*) in Indiana was reduced in accordance with this hypothesis

(Thompson 1977). Regardless of the mechanism, increased density can slow the growth rate of recovering populations by reducing productivity.

The Western Yellow-breasted Chat is an endangered species that has been the focus of conservation efforts within remnant riparian habitat of the south Okanagan Valley of British Columbia (Environment Canada 2014). Their population has increased following restoration efforts aimed at improving habitat quality by removing or restricting livestock grazing (Chapter 2), but is still thought to be far smaller than historical levels (Taverner 1922 in Cannings et al. 1987). Yellow-breasted Chats in the Okanagan occupy territories that have higher shrub cover and lower tree cover than randomly selected plots. They also select nest patches with high wild rose cover and low grass-forb and bare ground cover (McKibbin and Bishop 2010). However, the influence of territory, nest patch and nest site vegetation on the breeding performance of Western Yellow-breasted Chats is currently unknown. The breeding performance of Eastern Yellow-breasted Chats in the USA was correlated with habitat characteristics at multiple spatial scales. Yellow-breasted Chats in Indiana had increased nest success in large and continuous nest patches (Burhans and Thompson 1999). In Kentucky, nest success was negatively related to shrub cover and positively related to nest height (Ricketts and Ritchison 2000). Parasitism rates increased with patch size and the number of large stems near nests in Indiana (Burhans and Thompson 1999).

In this chapter, I use a 13-year database to evaluate if there have been temporal changes to the breeding performance (i.e., parasitism rate, clutch size, nest success, and productivity of successful nests) of Yellow-breasted Chats. I also examine if territory, nest patch and nest site vegetation variables influence the breeding performance of Yellow-breasted Chats. Since restoration activities have resulted in breeding territories in previously unoccupied areas, I also investigate if there are A) temporal trends in the breeding performance of Yellow-breasted Chats at historic territories that have been monitored for at least 11 years and B) differences in the territory, nest patch and nest site characteristics, as well as reproductive success of Yellow-breasted Chats in historically occupied and recently settled territories. Identification of habitat and density-dependent fitness consequences for Yellow-breasted Chats is important to evaluate and inform recovery efforts for this endangered songbird as well as to provide general knowledge on how reduced populations of riparian-obligate songbirds can be managed in complex and heavily modified arid landscapes.

3.3. Methods

3.3.1. Study Species

The Western Yellow-breasted Chat is a large (22-27g) wood warbler that breeds across the western USA and in southern Canada. The south Okanagan Valley is the northwest limit of its breeding range (Eckerle and Thompson 2001). The British Columbia population of the Yellow-breasted Chat subspecies was designated as endangered by COSEWIC in 2000 and placed on the British Columbia provincial red list in 2001 (Environment Canada 2014). The majority of Yellow-breasted Chats in British Columbia breed in the Okanagan and Similkameen Valleys, but a small population breeds in the Pend'Oreille River Valley in the Kootenays (Environment Canada 2014). The number of breeding Yellow-breasted Chats in the south Okanagan Valley increased from about 20 to 170 breeding pairs (Environment Canada 2014) between 2002 and 2014, particularly in formerly degraded sites that had been the subject of restoration efforts (Chapter 2). This subspecies has a large range and is still common in parts of the USA but is listed as a species of concern in California (California Department of Fish and Game 2008) and a focal species for riparian areas by Partners in Flight (Ricketts and Kuss 2000) due to loss of riparian habitat in areas with intensive agriculture and urban development. Yearly population declines have occurred in Washington (-0.84% per year) and Oregon (-1.79% per year) during the past decade, while Yellow-breasted Chat populations increased in the Great Basin, (Sauer et al. 2014; +1.29% per year), of which the Okanagan Valley represents the northern tip.

3.3.2. Study Sites

I measured the breeding performance of Yellow-breasted Chats at six sites located on the valley floor of the south Okanagan Valley between Penticton and Osoyoos, British Columbia (Figure 3.1). Sites ranged in size from one to 180 hectares. Riparian habitat at these sites is composed of black cottonwood and water birch forest patches, interspersed with thick patches of wild rose and other shrubs (Cannings et al. 1987). I did not monitor Yellow-breasted Chats at all sites in all years because I were unable to obtain permission to access every site each year.

I classified the six study sites as “Reference” (n=3), “Restoration” (n=2) or “Currently Grazed” (n=1) (Figure 3.1). Reference sites gained legal protection at varying times after 1950. Urbanization, development, or livestock grazing had not degraded riparian habitat within theses sites. Restoration sites were fragmented by urbanization, development, agriculture, and river channelization and degraded by livestock grazing. Starting in 2000, livestock were excluded year round or during the songbird breeding season in an attempt to restore the riparian habitat by allowing the understory to regrow. Fencing was also installed at these sites between 2001 and 2006 to completely exclude livestock from certain riparian areas. The one “Currently Grazed” could not be classified as either Reference or Restoration because it was heavily degraded by grazing and had never received any restoration activities, so it was excluded from analyses comparing these site categories.

3.3.3. Monitoring of Yellow-breasted Chat Territory Occupancy and Breeding Performance

From 2002 through 2014, study sites were surveyed where access had been granted to determine the number of breeding pairs of Yellow-breasted Chats. I defined a Yellow-breasted Chat territory as the area defended by a breeding pair. Territory occupancy by breeding pairs and territory boundaries were determined using the same methods as McKibbin and Bishop (2010). I classified Yellow-breasted Chat territories into one of two age categories: “Historic” or “Recent”. Historic territories were occupied by breeding Yellow-breasted Chats during at least one year between 2002 and 2004. Recent territories were occupied during at least one year from 2005 onwards but not in 2002 through 2004.

From 2002 through 2014 (except for in 2011), Yellow-breasted Chat breeding pairs were observed and breeding attempts were monitored from May through mid-August using the same methods as Morgan et al. (2007). Nest were usually checked at least one every three days to determine incubation start date, observed clutch size, occurrences of brood-parasitism by Brown-headed Cowbirds, number of fledglings and nest success (defined as fledging at least one Yellow-breasted Chat). Yellow-breasted Chat nestlings typically fledge on day nine or ten (Ehrlich et al. 1988). I assumed nests fledged all nestlings observed at nests on day eight or later if there were no signs of predation and if nestlings were detected after fledge date. As part of a separate study examining the effect of removing cowbird eggs/nestlings from Yellow-breasted Chat nests on their breeding performance, Brown-headed Cowbird eggs or nestlings were removed, or the eggs were shaken and then returned to the nest, from some parasitized nests from 2007 through 2010.

3.3.4. Habitat Characteristics of Territory, Nest Patch and Nest Site

I measured habitat characteristics of the territory (50m radius around the nest), the nest patch (continuous patch of shrubs that the nest was located in) and the nest site (the shrub the nest was placed in) of Yellow-breasted Chats using established methods (Martin et al. 1997; Morgan et al. 2006; McKibbin and Bishop 2010). The nine habitat characteristics included variables associated with habitat selection and/or breeding performance of Yellow-breasted Chat and other riparian songbirds (Powell and Steidl 2000; Peak et al. 2004; McKibbin and Bishop 2010; Quinlan and Green 2012). At the territory scale, I used tape measures or range finders to determine a 50m radius around the nest and divided the territory into four quadrants. I then estimated the percentage cover of shrubs and trees within each quadrant and then averaged the percentages from the four quadrants to get overall cover estimates. At the nest patch scale, I laid tape measures out at a distance of 5m in the four cardinal directions from the nest, dividing the nest patch into four quadrants. I then estimated the percentage of wild rose (*Rosa sp.*) and the number of tree stems within each quadrant and averaged the percentages from the four quadrants to get overall cover estimates. I also determined the area of the nest patch by measuring its length and width. To determine the average height of foliage around the nest, I then chose two random directions to lay the tape measure out and measured the height of the vegetation at 2, 4, 6, 8 and 10m away from the nest. Dead branches were not considered as foliage. Heights were placed into five height classes: <0.5m (1), 0.5-1m (2), 1-2m (3), 2-4m (4) and >4m (5). The ten height measurements were then averaged. I also measured the distance from the center of the nest to the nearest edge of the nest patch. At the nest shrub scale, I measured the height of the shrub that the nest was placed in. I determined nest concealment by estimating the percentage of the nest covered by vegetation from 1m away at nest height from each of the four cardinal directions.

3.3.5. Data Analysis

I first examined temporal trends in four aspects of the breeding performance of all Yellow-breasted Chats monitored between 2002 and 2014; parasitism by brown-headed cowbirds (yes/no), observed clutch size (number of eggs), daily nest survival, and the productivity of successful nests (number of Yellow-breasted Chats nestlings fledged). I used linear mixed effects models implemented in *lme4* (Bates et al. 2014) to evaluate if parasitism rate, clutch size and productivity of successful nests showed temporal trends. I included year and incubation start date as fixed effects when evaluating parasitism rate. I included year, parasitism status, incubation start date and an interaction between year and parasitism status as fixed effects when evaluating clutch size. I included year, parasitism status, an interaction between year and parasitism status, incubation start date and whether or not cowbird eggs or nestlings were removed from the nest or shaken as fixed effects when evaluating productivity of successful nests. In all of these analyses the territory, study site and year were specified as random effects. I calculated daily nest survival using the Logistic-Exposure method (Shaffer 2004). I used generalized linear models implemented in *mass* (Venables and Ripley 2002) to evaluate whether daily nest survival showed temporal trends. I included year, study site, parasitism status, an interaction between year and parasitism status and whether or not cowbird eggs or nestlings were removed from the nest or shaken as fixed effects. We calculated nest success using our estimate of daily nest survival assuming a nesting period of 22 days (Ehrlich et al. 1988). I included nests that had cowbird eggs or nestlings removed or shaken because I wanted to represent the actual temporal trends in breeding performance of Yellow-breasted Chats, even if they were altered by human involvement.

I next determined the fitness consequences of variation in territory, nest patch and nest site habitat characteristics by utilizing linear mixed effects models to evaluate if each of the habitat characteristics had an effect on the parasitism rate, clutch size, apparent nest success (success/failure) and productivity of successful nests. I Log_{10} transformed habitat characteristic data when necessary to meet the assumption of normality. This analysis was conducted using the entire data set of Yellow-breasted Chat nests with habitat measurements. Because territory vegetation was measured less often than nest patch and nest shrub vegetation, I first completed univariate tests of all vegetation variables with the full data set. When evaluating parasitism rate, I included the vegetation variable in question as a fixed effect. When evaluating clutch size, I included the vegetation variable and parasitism status as fixed effects. When evaluating nest success, I included the vegetation variable and whether or not cowbird eggs or nestlings were removed or shaken as fixed effects. When evaluating productivity of successful nests, I included the vegetation variable, parasitism status and whether or not cowbird eggs or nestlings were removed or shaken as fixed effects. The territory, study site and year were specified as random effects in all analyses. I then used multivariate linear mixed effects models to determine the relationship between vegetation characteristics that were significant in the univariate models and parasitism rate, clutch size, nest success and the productivity of successful nests. In these models, I included the significant vegetation variables and the same other fixed effects and random effects as I included in the univariate models. I concluded that vegetation characteristics had a significant effect on breeding performance if p-values were less than 0.05. If p-values were between 0.1 and 0.05, I considered this to be some evidence of an effect on breeding performance.

I then determined temporal trends in the breeding performance of Yellow-breasted Chats in Historic territories (those that were occupied during at least one year between 2002 and 2004). I did this using the same methods used to determine temporal trends in the breeding performance of all Yellow-breasted Chats.

Finally, I utilized linear mixed effects models to evaluate whether the nine habitat variables and Yellow-breasted Chat parasitism status, clutch size and productivity of successful nests differed according to territory age (Historic / Recent) and site category (Reference / Restoration). When evaluating each of the nine habitat variables and parasitism rate, I included territory age, site category and an interaction between territory age and site category as fixed effects. When evaluating clutch size and productivity of successful nests, I included those same fixed effects and also parasitism status. I again included territory, study site and year as random effects. I used generalized linear models to evaluate whether daily nest survival differed between site categories and territory ages. I calculated daily nest survival using the Logistic-Exposure method (Shaffer 2004). I included territory age, site category, an interaction between territory age and site category, study site and year as fixed effects. For analyses examining differences in each of the breeding performance metric between sites and territories, I excluded nests that had cowbird eggs or nestlings removed or shaken if I found that this significantly affected the breeding performance metric in question.

For all analyses, visual inspection of residual plots did not reveal any obvious deviations from homoscedasticity or normality. I obtained chi-squared and p-values by starting with a full model and sequentially dropped non-significant ($p>0.05$) terms until only significant terms remained. Significance was assessed by comparing models with and without the term of interest using likelihood ratio tests. All analyses were conducted in Program R (R Core Team 2014).

3.4. Results

3.4.1. Temporal Variation in Yellow-breasted Chat Breeding Performance in the South Okanagan

I found a total of 508 Yellow-breasted Chat nests between 2002 and 2014, monitoring, on average, 48 nests per year (minimum: 19, maximum: 74). I detected no significant temporal changes to the breeding performance of Yellow-breasted Chats in the south Okanagan Valley between 2002 and 2014 (Figure 3.2). However, I found some evidence that parasitism rate increased between 2002 and 2014 ($\chi^2(1)=3.68$, $p=0.06$). The average parasitism rate was 49.6% over this period. Incubation initiation date did not affect parasitism status ($\chi^2(1)=1.33$, $p=0.25$).

I found no evidence that clutch size changed over the course of the study but clutch size declined as the season progressed (Figure 3.2; Year: $\chi^2(1)=0.77$, $p=0.38$; Incubation Date: $\chi^2(1)=12.44$, $p<0.01$). Parasitism reduced observed clutch sizes (unparasitized = 3.6 ± 0.7 SD eggs, parasitized = 2.9 ± 0.9 eggs, $\chi^2(1)$=75.41, p<0.01), presumably because cowbirds often remove eggs when laying their own (Robinson et al. 1995). The effects of parasitism on clutch did not vary by year (Year x Parasitism interaction: $\chi^2(1)$=1.61, p=0.20).

Daily nest survival varied, being highest from 2005 through 2007 and in 2014, but there was no temporal trend in daily nest survival between 2002 and 2014 ($\chi^2(1)$=0.09, p=0.76). I also found some evidence that nest success varied between study sites ($\chi^2(1)$=10.61, p=0.06). On average, we estimated that 54.3% of nests would successfully fledge young. Parasitism by Brown-headed Cowbirds did not reduce daily nest survival ($\chi^2(1)$=0.76, p=0.38) and the effects of parasitism on daily nest survival did not vary by year (Year x Parasitism interaction: $\chi^2(1)$=0.72, p=0.40). However, removing or shaking cowbird eggs increased daily nest survival ($\chi^2(1)$=8.12, p<0.01).

I found no evidence of a temporal trend in productivity of successful nests over the study period (Figure 3.2; $\chi^2(1)$=0.74, p=0.3) or during the breeding season ($\chi^2(1)$=1.26, p=0.26). Parasitism reduced the number of Yellow-breasted Chat fledged from successful nests (unparasitized = 3.1 ± 1.0 [SD] fledglings, parasitized = 2.3 ± 0.9 fledglings, $\chi^2(1)$=41.69, p<0.001) but the effects of parasitism did not vary by year (Year x Parasitism interaction: x^2=0.16, p=0.69). Removing or shaking cowbird eggs ($\chi^2(1)$=0.51, p=0.47) did not affect productivity.

3.4.2. Influence of Territory, Nest Patch and Nest Site Vegetation on Yellow-breasted Chat Breeding Performance

I measured vegetation at a total of 414 Yellow-breasted Chat nests from 2002 through 2014. Territory, nest patch and nest site vegetation was measured at 155 of these nests, only territory vegetation was measured at 30 of these nests and only nest patch and nest site vegetation was measured at 229 of these nests. Vegetation influenced some aspects of Yellow-breasted Chat breeding performance (Table 3.1).

I found some evidence that the chance of parasitism by Brown-headed Cowbirds was negatively associated with the percentage of shrubs within 50m of nests and the average foliage height within 10m of nests (Table 3.1). In addition, after controlling for differences due to parasitism, I found some evidence that clutch size was positively associated with foliage height within 10m of nests (Table 3.1). I also found some evidence that nest success was positively related to foliage height within 10m of nests (Table 3.1) after controlling for the removal or shaking of cowbird eggs.

After controlling for parasitism, I detected a significant positive relationship between the productivity of successful Yellow-breasted Chats nests and three territory and nest patch habitat characteristics: the percentage of shrubs within a 50m radius, the average foliage height within a 10m radius (Table 3.1, Figure 3.3) and the distance from the nest to the edge of the nest patch (Table 3.1). When I tested a multi-variate model that included these three variables, the percentage of shrubs remained significant but foliage height and distance to the edge of the nest patch did not (Shrubs: $\chi^2(1)=4.77$, $p=0.03$; foliage height: $\chi^2(1)=2.05$, $p=0.15$; distance to edge: $\chi^2(1)=2.59$, $p=0.11$). This is evidence that the percentage of shrubs within 50m of the nest is the most influential habitat characteristic on productivity.

I also assessed the role of foliage height and distance to the edge of patch in a separate analysis that did not include the percentage of shrubs because territory vegetation was assessed at fewer successful nests than nest patch and nest site vegetation (Table 3.1). After controlling for the other variable, foliage height had a significant positive effect ($\chi^2(1)=4.92$, $p=0.03$) on productivity of successful nests but the distance to the edge of patch did not ($\chi^2(1)=1.72$, $p=0.19$). These analyses suggest that the percentage of shrubs within 50m of the nest has the most influence on the productivity of successful nests, followed by foliage height within 10m of the nest, while distance from the nest to the edge of patch has some influence but not as much as the other two significant habitat characteristics.

3.4.3. Temporal Variation in the Breeding Performance of Yellow-breasted Chat in Historic Territories Monitored for at Least 11 Years.

Nests were monitored within 65 territories that were occupied by Yellow-breasted Chats at least one year from 2002 through 2004. Subsequently, an average of 25 (range 4-43) nests per year were monitored in these Historic territories. In this sample of nests, I found no evidence of temporal variation in parasitism rate ($\chi^2(1)$=1.44, p=0.23), observed clutch size ($\chi^2(1)$=0.89, p=0.35), nest success ($\chi^2(1)$=0.47, p=0.49) or productivity of successful nests (Figure 3.4; $\chi^2(1)$=2.05, p=0.15). For all of the other fixed effects that we evaluated, we found the same results as in Section 3.4.1, except for nest success in historically occupied territories did not vary between study sites ($\chi^2(1)$=7.33, p=0.12).

3.4.4. Breeding Performance and Nest Vegetation of Yellow-breasted Chats at Historically Occupied and Recently Settled Territories

From 2002 through 2004, Yellow-breasted Chats in the south Okanagan Valley occupied 65 territories, which I called Historic territories. From 2008 through 2014, vegetation was measured at 39 nests found in 21 Historically occupied territories and at 85 nests found in 51 Recently settled territories. The classification of a site influenced differences in the vegetation characteristics surrounding nests at Historic and Recent territories. In Reference sites, nests in Recent territories had a lower percentage of shrubs in a 50m radius and a higher average height of foliage in a 10m radius than nests in Historic territories (Table 3.2). In Restoration sites, nests in Recent territories had a higher percentage of shrubs in a 50m radius and a lower average height of foliage in a 10m radius than nests in Historic territories (Table 3.2). All other vegetation variables that were measured did not differ between Historic and Recent territories or between Reference and Restoration sites (Table 3.2).

From 2008 through 2014, I monitored the breeding performance of Yellow-breasted Chats at 27 of these Historic territories and at 59 Recent territories. I found 74 nests in Historic territories and 126 nests in Recent territories. Yellow-breasted Chat parasitism rate, observed clutch size, nest success and productivity of successful nests did not differ between Historic and Recent territories or between Reference and Restoration sites (Table 3.2). Parasitism rate did not differ between Historic and Recent territories or between Reference and Restoration sites (Table 3.2). After controlling for parasitism, clutch size and productivity of successful nests also did not differ between Historic and Recent territories or between Reference and Restoration sites (Table 3.2).

After controlling for study site and year, nest success also did not differ between Historic and Recent territories or between Reference and Restoration sites (Table 3.2).

3.5. Discussion

The Yellow-breasted Chat population in the south Okanagan Valley, British Columbia, at the north-western tip of their breeding range, has been the subject of conservation actions over the last decade that have resulted in detectable increases in abundance (Chapter 2). In this study, I demonstrate that the breeding performance of this endangered population has remained stable over this period. This population had higher nest success and similar productivity compared to more southern populations despite high rates of parasitism by Brown-headed Cowbirds. Apparent nest success was higher in the Okanagan (61%) than in Indiana (22%, Thompson and Nolan 1973). When calculated using the Logistic-Exposure or the Mayfield method, nest success in the Okanagan (54%) was also higher than nest success in Missouri (45%, Morris et al. 2013) and Kentucky (41%, Ricketts and Ritchison 2000). Successful Yellow-breasted Chat nests in the Okanagan produced 3.1 fledglings per unparasitized nest and 2.3 fledglings per parasitized nest. This was similar to 2.9 fledglings produced per unparasitized nest and 2.3 fledglings per parasitized nest in more intact habitats of South Carolina (Whitehead et al. 2000). This study confirms that Yellow-breasted Chats can breed successfully in fragmented landscapes if suitable habitat is available (Morgan et al. 2007).

Yellow-breasted Chats in the Okanagan occupy territories with high shrub cover and low tree cover and nest patches with high wild rose cover (McKibbin and Bishop 2010). I found that shrub cover within 50m of nests was positively related to productivity of successful nests but tree cover within 50m and rose cover within 5m had no effect on breeding performance. Breeding habitat characteristics and their influence on the breeding performance of Western Yellow-breasted Chats in the south Okanagan Valley were different than those that were reported for Eastern Yellow-breasted Chats. In Indiana, nest patch size was positively associated with nest success but nest patch size and the number of large stems near nests were negatively associated with parasitism rate (Burhans and Thompson 1999). In Kentucky, forb cover was positively associated with nest success, while shrub and canopy cover were negatively associated with nest success (Ricketts and Ritchison 2000). However, the positive relationship of shrub cover and productivity of Yellow-breasted Chats in the Okanagan was also reported for other riparian songbirds in the west, such as Yellow Warblers in the interior British Columbia (Quinlan and Green 2012).

Restoration efforts aimed to improve Yellow-breasted Chat breeding habitat by removing livestock during the songbird breeding season and erecting fences to permanently exclude livestock from certain riparian corridors. In the south Okanagan Valley, previously degraded riparian habitat that was the target of restoration efforts now does not differ from as historically protected habitat. I found that Yellow-breasted Chats settling in Restoration sites after 2004 (in Recent territories) occupied territories with higher shrub cover than territories occupied in 2002 through 2004 (Historic territories), suggesting that limiting grazing increased shrub cover in areas that were previously unsuitable for Yellow-breasted Chats. Other studies in western riparian habitats have found that the removal of grazing resulted in increased shrub cover (Schulz and Leininger 1990; Earnst et al. 2012). Before the initiation of restoration, livestock grazing likely reduced vegetation height in Restoration sites. In Nevada, grazing reduced riparian vegetation height to less than 50cm (Ammon and Stacey 1997), far lower than the average height of Yellow-breasted Chat nest shrubs in the Okanagan (178cm; McKibbin and Bishop 2010). I found that Recent Yellow-breasted Chat territories in Restoration sites had higher foliage height in 10m around nests than did Historic territories in Reference sites, suggesting that limiting grazing increased foliage height. Removal of grazing has resulted increased foliage height in other arid western riparian habitats (Ammon and Stacey 1997). My results suggest that restoration activities in the Okanagan led to increased shrub cover and foliage height in formerly degraded riparian habitats, resulting in increased abundance of the endangered Yellow-breasted Chat.

The increased abundance of Yellow-breasted Chats following restoration efforts may have led to reduced breeding performance as a result of density dependent effects, as many experimental and observation studies have found (Sinclair 1989; Dhont et al. 1992; Both et al. 1998). For example, experimentally reduced density increased the productivity of Black-throated Blue Warblers (Sillett et al. 2004), while Song Sparrows on a British Columbia island were observed to have decreased nest success and clutch size at higher densities (Arcese et al. 1992). However, other studies of Song Sparrows (Chase et al. 2005) and flycatchers (Both 2000) did not detect any density dependent effects on breeding performance. I found no evidence for density dependent decreases to breeding performance as the abundance of Yellow-breasted Chats in the Okanagan increased over the last decade. This contrasts with research conducted in Indiana that found that newly arriving Yellow-breasted Chats had lower productivity because established males excluded them from high quality territories (Thompson 1977). I may not have observed decreased breeding performance because newly arriving Yellow-breasted Chats were settling in vacant, recently created habitat (Recent territories) and not in the historically occupied habitat (Historic territories), suggesting that although abundance has increased, density has not.

Yellow-breasted Chats in British Columbia were listed as endangered because their population was very small and their breeding habitat was fragmented and degraded. My earlier work found that, over the past decade, Yellow-breasted Chat abundance increased in response to restoration efforts in the south Okanagan Valley. This study suggests that limiting livestock grazing has resulted in increased shrub cover and foliage height in formerly degraded riparian habitats. This has led to increased settlement of Restoration sites by the target species Yellow-breasted Chat. I show that the breeding performance of Yellow-breasted Chats in the south Okanagan Valley has not declined despite their drastic population increase. I also determined that territory and nest patch habitat characteristics affect the breeding performance of Yellow-breasted Chats. Finally, I showed that the breeding performance of Yellow-breasted Chats in restored habitats is similar to that of Yellow-breasted Chats in historically protected habitats. The high nest success and productivity of this population, in addition to higher than average return rates of males (44%) and nestlings (10%), as well as high site fidelity (McKibbin and Bishop 2012), provide more evidence that this is an established and productive population on the fringe of the specie's range. Restoration efforts aimed at re-establishing an abundant and productive Yellow-breasted Chat population in the south Okanagan Valley can therefore be considered a success.

3.6. Tables and Figures

Table 3.1 Summary of the effects of territory, nest patch and nest site vegetation on the parasitism rate, clutch size, nest success and productivity (of successful nests) of Yellow-breasted Chat nests in the south Okanagan Valley from 2002-2014. Chi-squared and p-values are from univariate models. Sample size (n) is the number of nests. ** indicates significance of p<0.05, * indicates significance of p<0.10.

	Parasitism Rate			Clutch Size			Nest Success			Productivity (Successful Nests)		
Habitat Variables	**χ^2**	**p-value**	**n**	**χ^2**	**p-value**	**n**	**χ^2**	**p-value**	**n**	**χ^2**	**p-value**	**n**
Territory Vegetation												
% Shrubs (50m)	3.45*	0.06*	164	0.18	0.67	148	0.07	0.79	184	4.44**	0.04**	104
% Trees (50m)	0.25	0.62	164	0.29	0.59	148	0.19	0.66	184	2.01	0.16	104
Nest Patch Vegetation												
Nest patch area (m^2)	0.87	0.35	339	0.29	0.59	305	0.01	0.92	359	1.93	0.16	214
Foliage height (10m)	2.96*	0.09*	339	3.27*	0.07*	305	2.7*	0.1*	359	5.24**	0.02**	214
% Rose (5m)	0.3	0.59	339	2.59	0.11	305	1.75	0.19	359	0.27	0.6	214
# Tree stems (5m)	1.46	0.22	339	1.01	0.31	305	0.48	0.49	359	0.67	0.41	214
Distance to edge (cm)	0.09	0.76	339	0.11	0.74	305	0.27	0.6	359	4.08**	0.04**	214
Nest Site Vegetation												
Nest shrub height (cm)	0.49	0.49	339	<0.01	0.98	305	1.95	0.16	359	<0.01	0.97	214
Nest concealment (%)	0.81	0.37	339	0.08	0.78	305	2.63	0.11	359	0.56	0.46	214

Table 3.2 **Territory, nest patch and nest site vegetation, as well as the breeding performance of Yellow-breasted Chats in historically occupied and recently settled territories in Reference and Restoration sites of the south Okanagan Valley from 2008 through 2014. Standard deviation (SD), sample size (number of nests), and number of territories (terr.) are listed. A summary of the effects of territory age category (Historic / Recent), site category (Reference / Restoration), and their interaction on nest vegetation and the breeding performance of Yellow-breasted Chats is also given. ** indicates significance of p<0.05.**

	Reference Sites								Restoration Sites										
	Historic Territories				Recent Territories				Historic Territories				Recent Territories				p-values		
	Value	SD	nests	terr.	Value	SD	nests	terr.	Value	SD	nests	terr.	Value	SD	nests	terr.	Hist-Rec	Ref-Rest	Inter-action
Territory Vegetation																			
% Shrubs (50m)	38.9	20.0	7	3	31.8	9.7	22	14	37.9	14.1	12	10	47.6	16.3	43	27	N/A	N/A	0.02**
% Trees (50m)	30.7	27.5	7	3	32.6	13.3	22	14	24.8	17.2	12	10	23	14.2	43	27	0.43	0.09	0.41
Nest Patch Vegetation																			
Nest patch area (m^2)	248	309	10	6	823	1077	23	15	925	1286	28	15	1656	2679	62	36	0.23	0.64	0.73
Foliage height (10m)	2.8	0.5	10	6	3.5	0.6	23	15	3.6	0.6	29	15	3.2	0.6	62	36	N/A	N/A	<0.01**
% Rose (5m)	45.7	31.6	10	6	60.1	22.9	23	15	66	21.5	29	15	69.3	24.3	62	36	0.15	0.08*	0.27
# Tree stems (5m)	0.1	0.3	10	6	0.5	1.3	23	15	1.6	2.2	29	15	0.7	1.6	62	36	0.31	0.41	0.13
Distance to edge (cm)	129	86	10	6	230	156	23	15	263	188	28	15	675	2119	62	36	0.24	0.23	0.62
Nest Site Vegetation																			
Nest shrub height (cm)	168	34	10	6	176	42	23	14	191	33	29	15	180	43	62	36	0.49	0.31	0.36
Nest concealment (%)	61.9	20.2	10	6	67.2	26.0	22	14	70.9	18.3	29	15	73.4	18.5	62	36	0.75	0.17	0.96
Breeding Performance																			
Parasitism Rate (%)	68	-	22	9	65	-	43	21	48	-	48	16	60	-	83	37	0.29	0.19	0.39
Clutch Size (# Eggs)	3.3	0.8	22	9	3	0.7	32	17	3	0.8	44	16	3.1	0.9	75	34	0.69	0.26	0.18
Nest Success (%)	47	-	13	5	44.5	-	22	16	42.6	-	44	18	40	-	60	35	0.78	0.69	0.6
Prod. (# Fledge)	2.8	1.2	16	8	2.4	1.0	28	17	2.4	0.9	25	14	2.7	1.0	43	28	0.68	0.87	0.35

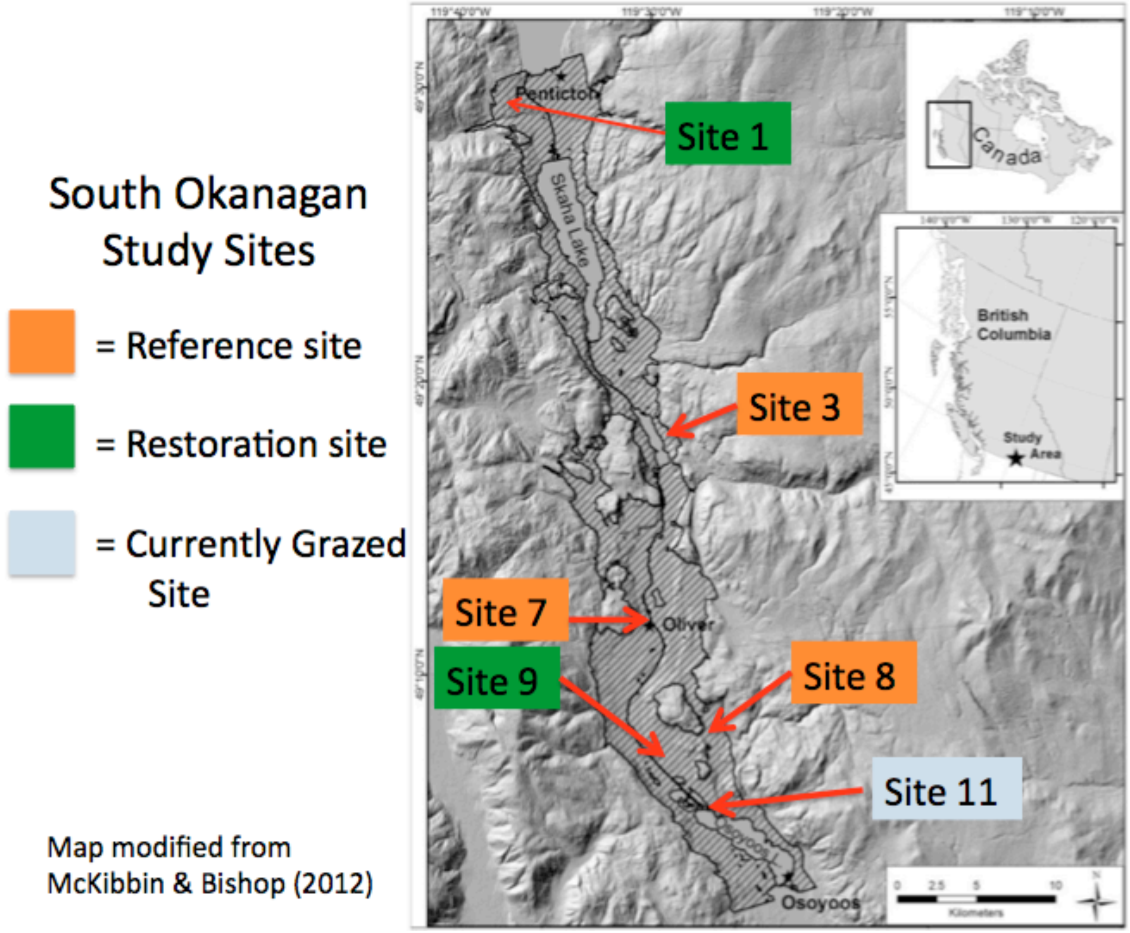

Figure 3.1 **Riparian study sites (classified as either Reference, Restoration, or Currently Grazed) for measuring the breeding performance of riparian-obligate songbirds in the south Okanagan Valley.**

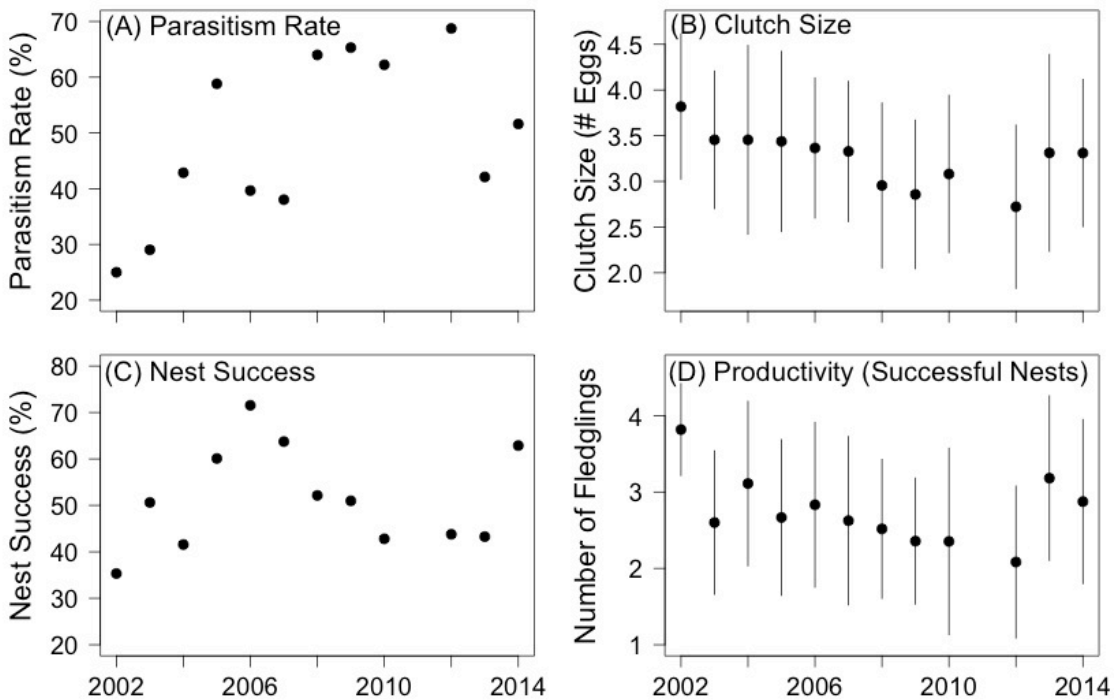

Figure 3.2 **Temporal variation in the (A) rate of nest parasitism by Brown-headed Cowbirds, (B) clutch size, (C) nest success and (D) productivity (of successful nests) of all Yellow-breasted Chat nests found in the south Okanagan Valley between 2002 and 2014. Nest success is calculated using the Logistic-Exposure method. Bars show standard deviation.**

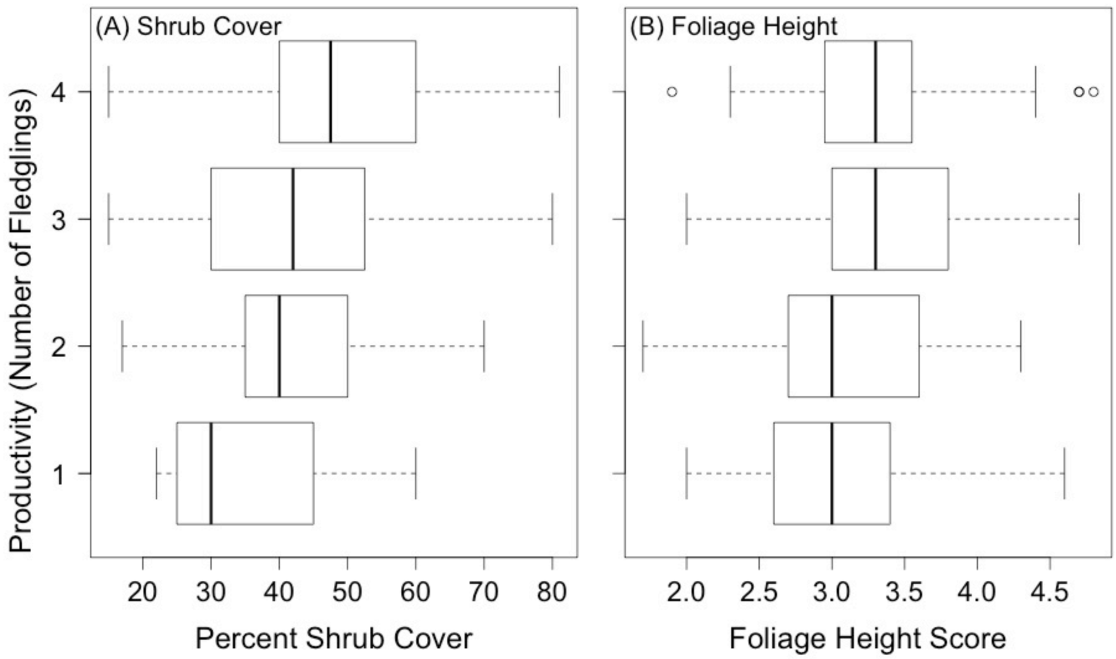

Figure 3.3 **(A) Percent shrubs in a 50m radius and (B) average foliage height in a 10m radius around Yellow-breasted Chat nests compared to productivity of successful Yellow-breasted Chat nests (including both unparasitized and parasitized nests) in the south Okanagan Valley from 2002-2014.**

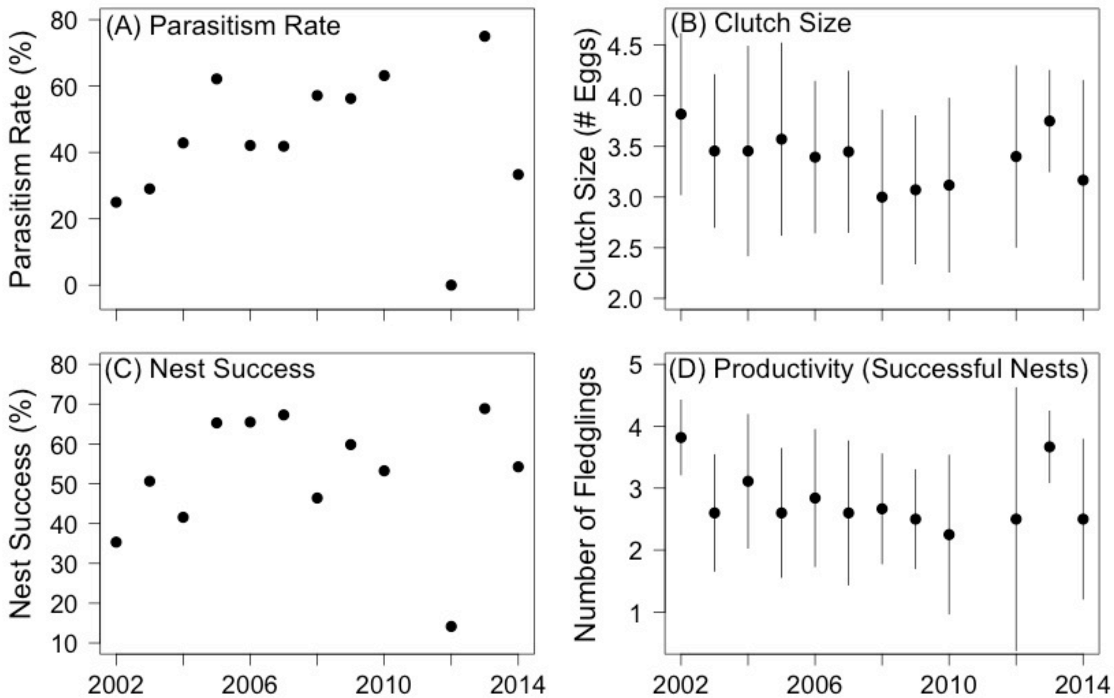

Figure 3.4 **Temporal variation in the (A) rate of nest parasitism by Brown-headed Cowbirds, (B) clutch size, (C) nest success, and (D) productivity (of successful nests) of Yellow-breasted Chat nests in Historic territories (i.e., territories that were occupied at least once between 2002 and 2004). Nest success is calculated using the Logistic-Exposure method. Bars show standard deviation.**

Chapter 4. General Conclusions

Following the length of the Okanagan River, riparian habitat in the south Okanagan Valley was once extensive. Like most areas in the west, extensive human settlement and the urbanization, industrialization, agriculture and grazing that followed resulted in the destruction of most of the riparian habitat in the Okanagan Valley by the 1960s (Lea 2008). Loss, fragmentation and degradation of riparian habitat across western North America reduced the abundance and richness of riparian bird communities and the reproductive success of some riparian-obligate species (Tewksbury et al. 2002; Krueper et al. 2003). In this thesis, I evaluated if the riparian bird community in the south Okanagan Valley showed temporal trends in abundance, richness and breeding performance in response to restoration (i.e., limiting of livestock grazing) of degraded riparian habitat. I also examined the relationship between the breeding habitat and the breeding performance of an endangered but recovering songbird, as well as the effects of restoration on its habitat and breeding performance.

I expected restoration to positively benefit overall abundance and richness of riparian birds in the Okanagan, as other studies have found (Krueper et al. 2003; Earnst et al. 2005; Gardali et al. 2006). As presented in Chapter 2, I did find that abundance and richness increased over the past decade, but I found no evidence that these changes were a result of restoration. Average total abundance and richness per point count station increased in both Reference and Restoration sites. Restoration may not have improved the abundance and richness of riparian birds in the Okanagan because, although my Restoration sites were degraded by livestock grazing as of the early 2000s, they still had large amounts of shrub and tree cover that enabled an abundant and rich songbird community, especially composed of songbirds that are not as sensitive to disturbance by grazing (Knopft et al. 1988). Studies that found increased abundance and richness in response to restoration usually took place at sites that were far more degraded than my Restoration sites, often requiring complete replanting of native vegetation (Kus 1998).

Previous management of degraded western riparian habitats has been successful in attracting settlement by endangered riparian-obligate songbirds such as the Least Bell's Vireo (Kus 1998). Although restoration efforts in the south Okanagan Valley could not explain the overall increase in abundance and richness of birds within riparian habitat, it did lead to increased abundance of the endangered Yellow-breasted Chat, which was the target of restoration activities. The increased Yellow-breasted Chat abundance I detected was much more pronounced than the 1.29% yearly increase in the Great Basin and in contrast to declines in Washington (-0.84% per year) and Oregon (-1.79% per year) during the last decade (Sauer et al. 2014). The population of Yellow-breasted Chats in the Okanagan was very small as of the early 2000s (Environment Canada 2014). Limiting of livestock grazing likely had a strong effect on Yellow-breasted Chat abundance because they are dependent on shrubs for nesting and grazing degrades the shrub layer (Sedgwick and Knopf 1987; Saab et al. 1995). Natural improvements to the shrub layer after the limiting of grazing, which also occurred in other studies (Schulz and Leininger 1990; Earnst et al. 2012), created more suitable nesting habitat and enabled increased abundance in Restoration sites. I expected restoration to also increase the abundance of other riparian-obligate songbirds but I found no evidence that it did. I suggest that this is because some of these songbird species are not entirely dependent on the shrub layer for nesting (Rich 2002) so a degraded shrub layer would not have been as detrimental to them. In addition, abundances of these riparian songbirds were much higher than Yellow-breasted Chats in Restoration sites as of the early 2000, providing more evidence that the degraded state of Restoration sites was not negatively affecting them, so removal of livestock would likely not increase their abundances.

Similar to other studies (Popotnik and Guiliano 2000; Larison et al. 2001, Harrison et al. 2011), I also found no strong evidence that restoration increased the breeding performance of riparian-obligate songbirds. However, the breeding performance of my riparian-obligate focal species did not decline over the last decade. A decade ago, the productivity of three of my riparian focal species was similarly low in both Reference and Restoration sites, providing additional evidence that a degraded shrub layer does not always reduce breeding performance (Popotnik and Guiliano 2000; Harrison et al. 2011). However, I did detect general improvements to the breeding performance of some of these species between the early 1990s and 2000s. Brown-headed Cowbird populations have been declining across North America (Sauer et al. 2014), possibly as a result of decreased cattle production (Cox et al. 2012). I found that the abundance of Brown-headed Cowbirds in the Okanagan decreased drastically between the early 1990s and 2000s. I also observed a general decrease to the parasitism rates and a general increase in the nest success of riparian-obligate songbirds during this time. Although parasitism in the Okanagan still poses a serious threat to vulnerable species such as Song Sparrow and Willow Flycatcher (Rogers et al. 1997; Whitfield and Sogge 1999; Lorenzana and Sealy 1999), decreased Brown-headed Cowbird abundance and parasitism rates likely contributed to the increased nest success of some riparian-obligate songbirds after the early 1900s.

The increased abundance of Yellow-breasted Chats, which resulted from restoration efforts in the south Okanagan Valley, could have led to a decrease in the mean breeding performance of their population because of increased competition or because newly arriving males could have been excluded from high quality territories by established males (Ferrer and Donazar 1996; Rodenhouse et al. 1997; Krueger et al. 2012). In Chapter 3, I utilized a 13-year dataset to show that the breeding performance (i.e., parasitism rate, clutch size, nest success and productivity) of Yellow-breasted Chats in the Okanagan remained stable despite increases in abundance. Increasing abundance may not have reduced the breeding performance of Yellow-breasted Chats because newly arriving males settled in new, suitable habitat created by restoration activities, and were not competing for existing territories. Removal of cattle has previously been shown to be effective in increasing shrub and forb cover (Schulz and Leininger 1990; Earnst et al. 2012). I found that in Restoration sites, historically occupied and recently settled territories had similar habitat characteristics. Yellow-breasted Chats breeding in these Historic and Recent territories also had similar breeding performances. My results suggest that limiting livestock grazing has allowed many areas of Restoration sites to re-grow and establish similar habitat characteristics to historically ungrazed Reference sites, resulting in increased abundance and stable breeding performance of the target species Yellow-breasted Chat. Although Yellow-breasted Chats can persist in fragmented habitats (Morgan et al. 2007), they still require territories with specific vegetation characteristics (e.g., high shrub cover), so it is not safe to assume that habitat degradation will not negatively affect them.

Determining how nesting habitat characteristics influence the breeding performance of songbirds is important for effective management of degraded habitats. Previous work has demonstrated that Yellow-breasted Chats in the south Okanagan Valley select territories with high shrub cover and low tree cover, as well as nest patches with high wild rose (*Rosa sp.*) cover and low grass-forb cover (McKibbin and Bishop 2010). In Chapter 3, I showed that the percentage of shrub cover in territories and the foliage height of nest patches positively influence the productivity of Yellow-breasted Chat nests. Similar habitat characteristics influence the breeding performance of other riparian songbirds in the west (Quinlan and Green 2012) but different characteristics influence the breeding performance of Eastern Yellow-breasted Chats (Burhans and Thompson 1999; Ricketts and Ritchison 2000). Restoration efforts that increase shrub cover and foliage height could therefore increase the productivity of Western Yellow-breasted Chats and other riparian songbirds in riparian habitats of the arid west.

Overall, the results of this thesis are in partial agreement with many other restoration studies that have detected increased abundance of open-cup shrub-nesting species in response to removal of livestock grazing (Taylor and Littlefield 1986; Krueper et al. 2003; Nelson et al. 2011; Earnst et al. 2012). My results differ from some of these studies (Farley 1994; Dobkin et al. 1998) in that I did not detect improvements to abundance and richness of the riparian bird community. This is most likely explained by the higher quality and more intact starting condition of my Restoration sites. The stable breeding performance of Yellow-breasted Chats as their population increased is a positive finding that indicates restored riparian habitat of the south Okanagan Valley is able to support an abundant and productive population of this endangered riparian-obligate songbird that was almost locally extinct a decade ago.

4.1. Management Implications

This thesis provides evidence that exclusion of livestock allows riparian vegetation to regrow and creates suitable breeding territories for Yellow-breasted Chats.

I found that the shrub cover of territories, the foliage height of nest patches and the distance from the nest to the edge of the nest patch positively influence the productivity of successful Yellow-breasted Chat nests. I also found some evidence that increased shrub cover and foliage height result in decreased parasitism. Additionally, I found some evidence that increased foliage height leads to increased clutch size and nest success. Future Yellow-breasted Chat habitat restoration efforts should attempt to increase shrub cover and foliage height by permanently or seasonally excluding livestock from riparian habitats. Yellow-breasted Chat conservation and recovery efforts should give priority to protecting and restoring areas that already contain high shrub cover, though replanting of wild rose and other native shrub species may be effective in creating new breeding habitat. In British Columbia, Yellow-breasted Chats have now been found nesting as far north as Vernon, over 100km north of my study area (pers. obs.). Conservation and restoration of riparian habitats north of Penticton should also be encouraged to create more suitable breeding habitat for this recovering endangered species.

Despite their seasonal removal, livestock likely still have a negative influence on riparian birds in the Okanagan. Livestock were not always removed from Restoration sites by the required date of May 1st (pers. obs.), so strict enforcement of removal dates is essential as grazing during the summer has many negative effects on riparian habitat and songbirds (Knopf et al. 1988b). Continued use of riparian habitats by livestock outside of the breeding bird season has likely contributed to high parasitism rates of Yellow-breasted Chats, despite the drastic decrease in Brown-headed Cowbird abundance in the Okanagan between the early 1990s and early 2000s. I found that parasitism by Brown-headed Cowbirds reduces the productivity of successful Yellow-breasted Chat nests. Brown-headed Cowbirds may also occasionally predate Yellow-breasted Chat nests (Arcese et al. 1996; Granfors et al. 2001). However, Brown-headed Cowbirds are not nearly as detrimental to Yellow-breasted Chats as they are for some other riparian-obligate songbirds, so habitat restoration efforts should take priority over Brown-headed Cowbird control measures when planning future conservation efforts for this species. However, Brown-headed Cowbird control measures may be beneficial to vulnerable songbird species such as Song Sparrow and Willow Flycatcher (Rogers et al. 1997; Whitfield and Sogge 1999; Lorenzana and Sealy 1999), which I found to experience reduced productivity, nest success and clutch size as a result of parasitism.

Conservation efforts initiated in the early 2000s have successfully increased the abundance of Yellow-breasted Chats in remnant riparian habitat of the south Okanagan Valley. However, the 8% of remaining riparian habitat (Lea 2008) is still under pressure from the surrounding landscape matrix, which is being continually developed. Conservation of large riparian habitat patches, such as the South Okanagan Wildlife Management Area in Osoyoos, is critical to ensure the availability of suitable breeding and stopover habitat for Yellow-breasted Chats and other riparian songbirds. Programs such as the Habitat Stewardship Program Riparian Fencing Project (which is funded by a variety of federal, provincial and local conservation groups) should continue to arrange agreements with private landowners to protect and restore riparian habitat patches. Compared to purchasing habitat, partnerships with landowners are a cost effective way to increase the amount of suitable riparian habitat available for riparian birds. As new restoration projects are initiated, detailed baseline data of habitat characteristics and of the riparian bird community should be collected to enable temporal comparisons and evaluations of different restoration techniques. The overall riparian bird community in the south Okanagan Valley has not decreased in abundance or richness over the past decade, so conservation of remnant riparian habitat will likely be sufficient to retain this diverse riparian community. However, continued development of the landscape surrounding remnant habitat of the Okanagan could potentially further degrade riparian habitats (Gergel et al. 2002) and reduce riparian bird abundance, richness and breeding performance (Saab 1999; Lichstein et al. 2002; Tewksbury et al. 2006). Future studies should examine large, landscape-scale effects on these measures of riparian bird success in the south Okanagan Valley.

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Appendix A.

Abundance of all species detected in the south Okanagan Valley in 2001-2003 and 2012-2013.

		2001-2003									2012-2013								
		All			Reference			Restoration			All			Reference			Restoration		
Species	Code	Avg.	SD	#	Avg.	SD	#	Avg.	SD	#	Avg.	SD	#	Avg.	SD	#	Avg.	SD	#
American Coot	AMCO	0.01	0.07	1	0.00	0.00	0	0.01	0.09	1	0.02	0.13	2	0.03	0.18	2	0.00	0.00	0
American Crow	AMCR	0.34	0.86	64	0.45	1.09	34	0.27	0.66	30	0.57	0.84	67	0.22	0.53	13	0.90	0.95	54
American Goldfinch	AMGO	1.18	1.17	221	0.81	1.00	61	1.43	1.21	160	1.68	1.89	198	1.24	1.80	72	2.10	1.90	126
American Kestrel	AMKE	0.01	0.10	2	0.01	0.12	1	0.01	0.09	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
American Robin	AMRO	0.35	0.64	65	0.32	0.62	24	0.37	0.66	41	0.50	0.83	59	0.41	0.62	24	0.58	1.00	35
American Wigeon	AMWI	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.02	0.18	2	0.00	0.00	0	0.03	0.26	2
Bald Eagle	BAEA	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.02	0.13	1
Bank Swallow	BANS	0.11	0.91	21	0.03	0.23	2	0.17	1.16	19	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Barn Swallow	BARS	0.28	1.65	52	0.16	0.64	12	0.36	2.06	40	0.12	0.44	14	0.14	0.44	8	0.10	0.44	6
Black-billed Magpie	BBMA	0.08	0.34	15	0.01	0.12	1	0.13	0.43	14	0.28	1.00	33	0.43	1.34	25	0.13	0.47	8
Black-capped Chickadee	BCCH	0.41	0.91	76	0.40	0.85	30	0.41	0.95	46	0.59	1.13	70	0.48	0.98	28	0.70	1.27	42
Black-chinned Hummingbird	BCHU	0.01	0.10	2	0.03	0.16	2	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.02	0.13	1
Belted Kingfisher	BEKI	0.02	0.13	3	0.00	0.00	0	0.03	0.16	3	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Brown-headed Cowbird	BHCO	0.95	1.09	178	0.56	0.78	42	1.21	1.20	136	0.66	1.00	78	0.26	0.52	15	1.05	1.19	63
Black-headed Grosbeak	BHGR	0.40	0.69	74	0.23	0.51	17	0.51	0.77	57	0.32	0.67	38	0.29	0.53	17	0.35	0.78	21
Bobolink	BOBO	0.06	0.35	12	0.00	0.00	0	0.11	0.45	12	0.10	0.56	12	0.00	0.00	0	0.20	0.78	12
Brewer's Blackbird	BRBL	0.34	1.68	63	0.65	2.53	49	0.13	0.59	14	0.05	0.41	6	0.00	0.00	0	0.10	0.57	6

		2001-2003									2012-2013								
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Bullock's Oriole	BUOR	0.54	0.90	101	0.43	0.87	32	0.62	0.91	69	0.45	0.65	53	0.59	0.70	34	0.32	0.57	19
Blue-winged Teal	BWTE	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.02	0.13	1
Cassin's Finch	CAFI	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.05	0.29	6	0.10	0.41	6	0.00	0.00	0
California Gull	CAGU	0.01	0.07	1	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Calliope Hummingbird	CAHU	0.16	0.45	29	0.39	0.66	29	0.00	0.00	0	0.10	0.36	12	0.17	0.46	10	0.03	0.18	2
Canada Goose	CANG	0.03	0.44	6	0.00	0.00	0	0.05	0.57	6	0.06	0.30	7	0.09	0.39	5	0.03	0.18	2
California Quail	CAQU	0.30	0.72	56	0.31	0.75	23	0.29	0.71	33	0.30	0.63	35	0.36	0.69	21	0.23	0.56	14
Cassin's Vireo	CAVI	0.01	0.10	2	0.01	0.12	1	0.01	0.09	1	0.01	0.09	1	0.02	0.13	1	0.00	0.00	0
Clay-colored Sparrow	CCSP	0.01	0.10	2	0.01	0.12	1	0.01	0.09	1	0.07	0.48	8	0.14	0.69	8	0.00	0.00	0
Cedar Waxwing	CEDW	0.88	1.47	165	1.08	1.28	81	0.75	1.58	84	2.67	3.37	315	3.34	3.51	194	2.02	3.12	121
Chipping Sparrow	CHSP	0.13	0.55	24	0.32	0.84	24	0.00	0.00	0	0.12	0.42	14	0.22	0.56	13	0.02	0.13	1
Cliff Swallow	CLSW	0.21	1.24	40	0.01	0.12	1	0.35	1.59	39	0.02	0.13	2	0.00	0.00	0	0.03	0.18	2
Cooper's Hawk	COHA	0.01	0.07	1	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Common Loon	COLO	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.02	0.13	2	0.00	0.00	0	0.03	0.18	2
Common Merganser	COME	0.01	0.07	1	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Common Nighthawk	CONI	0.01	0.10	2	0.03	0.16	2	0.00	0.00	0	0.05	0.55	6	0.00	0.00	0	0.10	0.77	6
Common Raven	CORA	0.05	0.38	9	0.01	0.12	1	0.07	0.48	8	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Common Yellowthroat	COYE	0.37	0.73	69	0.24	0.52	18	0.46	0.84	51	0.63	0.92	74	0.40	0.77	23	0.85	1.01	51
Dark-eyed Junco	DEJU	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	0.09	1	0.02	0.13	1	0.00	0.00	0
Downy Woodpecker	DOWO	0.06	0.26	11	0.01	0.12	1	0.09	0.32	10	0.03	0.16	3	0.00	0.00	0	0.05	0.22	3
Dusky Flycatcher	DUFL	0.02	0.13	3	0.03	0.16	2	0.01	0.09	1	0.02	0.13	2	0.02	0.13	1	0.02	0.13	1
Eastern Kingbird	EAKI	0.55	0.76	103	0.56	0.87	42	0.54	0.68	61	0.39	0.69	46	0.57	0.82	33	0.22	0.49	13

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Eurasian Collared-Dove	EUCD	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.02	0.13	1
European Starling	EUST	1.23	3.61	230	0.55	1.58	41	1.69	4.44	189	0.55	1.98	65	0.10	0.41	6	0.98	2.68	59
Gadwall	GADW	0.01	0.07	1	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Great Blue Heron	GBHE	0.01	0.07	1	0.01	0.12	1	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.02	0.13	1
Gray Catbird	GRCA	1.21	1.02	227	1.17	1.03	88	1.24	1.02	139	1.25	1.20	148	1.02	0.98	59	1.48	1.35	89
Grasshopper Sparrow	GRSP	0.01	0.07	1	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
House Finch	HOFI	0.13	0.48	25	0.05	0.28	4	0.19	0.58	21	0.16	0.52	19	0.17	0.53	10	0.15	0.52	9
House Sparrow	HOSP	0.40	5.34	75	0.00	0.00	0	0.67	6.90	75	0.03	0.37	4	0.00	0.00	0	0.07	0.52	4
House Wren	HOWR	0.69	1.01	129	0.52	0.83	39	0.80	1.10	90	0.55	0.87	65	0.36	0.64	21	0.73	1.02	44
Killdeer	KILL	0.05	0.24	9	0.04	0.26	3	0.05	0.23	6	0.06	0.33	7	0.02	0.13	1	0.10	0.44	6
Lark Sparrow	LASP	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Lazuli Bunting	LAZB	0.16	0.43	30	0.31	0.59	23	0.06	0.24	7	0.92	1.20	108	1.17	1.42	68	0.67	0.88	40
Long-billed Curlew	LBCU	0.01	0.07	1	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Least Flycatcher	LEFL	0.07	0.34	14	0.00	0.00	0	0.13	0.43	14	0.04	0.20	5	0.05	0.22	3	0.03	0.18	2
Long-eared Owl	LEOW	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.03	0.21	3	0.05	0.29	3	0.00	0.00	0
Mallard	MALL	0.06	0.48	12	0.01	0.12	1	0.10	0.61	11	0.10	0.42	12	0.03	0.18	2	0.17	0.56	10
Marsh Wren	MAWR	0.13	0.50	25	0.00	0.00	0	0.22	0.63	25	0.08	0.38	10	0.03	0.18	2	0.13	0.50	8
MacGillivray's Warbler	MGWA	0.03	0.16	5	0.03	0.16	2	0.03	0.16	3	0.05	0.22	6	0.09	0.28	5	0.02	0.13	1
Mountain Bluebird	MOBL	0.03	0.19	5	0.07	0.30	5	0.00	0.00	0	0.04	0.38	5	0.09	0.54	5	0.00	0.00	0
Mourning Dove	MODO	0.32	0.66	60	0.08	0.27	6	0.48	0.78	54	0.26	0.56	31	0.21	0.41	12	0.32	0.68	19
Nashville Warbler	NAWA	0.07	0.32	14	0.17	0.48	13	0.01	0.09	1	0.02	0.13	2	0.03	0.18	2	0.00	0.00	0
Northern Flicker	NOFL	0.47	0.69	87	0.25	0.50	19	0.61	0.76	68	0.52	0.84	61	0.33	0.57	19	0.70	1.01	42

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Northern Harrier	NOHA	0.01	0.07	1	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Northern Shoveler	NOSH	0.01	0.15	2	0.00	0.00	0	0.02	0.19	2	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Northern Waterthrush	NOWA	0.02	0.15	4	0.03	0.16	2	0.02	0.13	2	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Northern Rough-winged Swallow	NRWS	0.16	1.03	30	0.15	0.51	11	0.17	1.27	19	0.29	0.93	34	0.33	0.98	19	0.25	0.88	15
Orange-crowned Warbler	OCWA	0.03	0.19	5	0.07	0.30	5	0.00	0.00	0	0.03	0.16	3	0.05	0.22	3	0.00	0.00	0
Osprey	OSPR	0.09	0.36	16	0.01	0.12	1	0.13	0.46	15	0.18	0.50	21	0.07	0.32	4	0.28	0.61	17
Pied-billed Grebe	PBGR	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.02	0.18	2	0.03	0.26	2	0.00	0.00	0
Pine Siskin	PISI	0.04	0.31	8	0.08	0.43	6	0.02	0.19	2	0.18	0.97	21	0.36	1.36	21	0.00	0.00	0
Pileated Woodpecker	PIWO	0.01	0.10	2	0.03	0.16	2	0.00	0.00	0	0.02	0.13	2	0.03	0.18	2	0.00	0.00	0
Pacific-slope Flycatcher	PSFL	0.01	0.10	2	0.03	0.16	2	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Redhead	REDH	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.02	0.18	2	0.00	0.00	0	0.03	0.26	2
Ring-billed Gull	RBGU	0.03	0.19	5	0.00	0.00	0	0.04	0.25	5	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Red-breasted Nuthatch	RBNU	0.05	0.25	10	0.13	0.38	10	0.00	0.00	0	0.03	0.18	4	0.07	0.26	4	0.00	0.00	0
Red-eyed Vireo	REVI	0.07	0.39	14	0.09	0.37	7	0.06	0.41	7	0.04	0.24	5	0.03	0.26	2	0.05	0.22	3
Ring-necked Pheasant	RGPH	0.15	0.37	28	0.16	0.40	12	0.14	0.35	16	0.19	0.44	23	0.03	0.18	2	0.35	0.55	21
Red-naped Sapsucker	RNSA	0.08	0.33	15	0.19	0.48	14	0.01	0.09	1	0.07	0.25	8	0.14	0.35	8	0.00	0.00	0
Rock Dove	RODO	0.63	3.38	118	0.03	0.23	2	1.04	4.33	116	0.13	1.38	15	0.00	0.00	0	0.25	1.94	15
Red-tailed Hawk	RTHA	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.03	0.18	4	0.02	0.13	1	0.05	0.22	3
Ruffed Grouse	RUGR	0.01	0.10	2	0.03	0.16	2	0.00	0.00	0	0.02	0.13	2	0.03	0.18	2	0.00	0.00	0
Rufous Hummingbird	RUHU	0.02	0.18	4	0.05	0.28	4	0.00	0.00	0	0.04	0.24	5	0.09	0.34	5	0.00	0.00	0
Red-winged Blackbird	RWBL	1.45	2.50	272	0.76	2.17	57	1.92	2.60	215	1.47	2.19	174	0.93	2.21	54	2.00	2.06	120
Say's Phoebe	SAPH	0.02	0.13	3	0.01	0.12	1	0.02	0.13	2	0.03	0.18	4	0.03	0.18	2	0.03	0.18	2

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Savannah Sparrow	SAVS	0.31	1.08	58	0.00	0.00	0	0.52	1.36	58	0.13	0.40	15	0.02	0.13	1	0.23	0.53	14
Sora	SORA	0.05	0.21	9	0.01	0.12	1	0.07	0.26	8	0.14	0.38	17	0.12	0.33	7	0.17	0.42	10
Song Sparrow	SOSP	1.37	1.26	256	1.68	1.49	126	1.16	1.04	130	1.11	0.97	131	1.36	1.04	79	0.87	0.83	52
Spotted Sandpiper	SPSA	0.02	0.13	3	0.03	0.16	2	0.01	0.09	1	0.02	0.18	2	0.00	0.00	0	0.03	0.26	2
Spotted Towhee	SPTO	0.21	0.58	39	0.51	0.83	38	0.01	0.09	1	0.47	0.75	55	0.66	0.83	38	0.28	0.61	17
Sharp-shinned Hawk	SSHA	0.01	0.07	1	0.01	0.12	1	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Tree Swallow	TRSW	0.50	1.07	94	0.15	0.39	11	0.74	1.29	83	0.52	1.19	61	0.29	1.08	17	0.73	1.26	44
Unknown bird	UNBI	0.09	0.33	16	0.08	0.27	6	0.09	0.37	10	0.48	1.39	57	0.41	0.80	24	0.55	1.79	33
Unknown blackbird	UNBL	0.03	0.25	6	0.07	0.38	5	0.01	0.09	1	0.32	0.90	38	0.17	0.82	10	0.47	0.96	28
Unknown chickadee	UNCH	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.03	0.16	3	0.05	0.22	3	0.00	0.00	0
Unknown duck	UNDU	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.13	0.63	15	0.09	0.39	5	0.17	0.81	10
Unknown Empidonax flycatcher	UNEM	0.01	0.07	1	0.01	0.12	1	0.00	0.00	0	0.01	0.09	1	0.02	0.13	1	0.00	0.00	0
Unknown gull	UNGU	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.02	0.13	1
Unknown hummingbird	UNHU	0.05	0.24	9	0.11	0.35	8	0.01	0.09	1	0.09	0.29	11	0.12	0.33	7	0.07	0.25	4
Unknown sparrow	UNSP	0.01	0.10	2	0.01	0.12	1	0.01	0.09	1	0.07	0.25	8	0.10	0.31	6	0.03	0.18	2
Unknown swallow	UNSW	0.14	0.73	26	0.04	0.20	3	0.21	0.92	23	0.09	0.43	11	0.03	0.18	2	0.15	0.58	9
Unknown warbler	UNWA	0.01	0.10	2	0.03	0.16	2	0.00	0.00	0	0.01	0.09	1	0.00	0.00	0	0.02	0.13	1
Unknown woodpecker	UNWO	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.05	0.22	6	0.09	0.28	5	0.02	0.13	1
Veery	VEER	0.42	0.80	79	0.69	1.03	52	0.24	0.54	27	0.65	0.90	77	1.02	1.05	59	0.30	0.53	18
Vesper Sparrow	VESP	0.10	0.38	18	0.24	0.57	18	0.00	0.00	0	0.21	0.50	25	0.43	0.65	25	0.00	0.00	0
Violet-green Swallow	VGSW	0.10	0.90	18	0.01	0.12	1	0.15	1.16	17	0.03	0.21	3	0.03	0.26	2	0.02	0.13	1
Virginia Rail	VIRA	0.03	0.22	5	0.01	0.12	1	0.04	0.27	4	0.08	0.30	9	0.14	0.40	8	0.02	0.13	1

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Warbling Vireo	WAVI	0.10	0.36	18	0.19	0.51	14	0.04	0.19	4	0.37	0.60	44	0.53	0.71	31	0.22	0.42	13
Western Kingbird	WEKI	0.06	0.35	11	0.12	0.52	9	0.02	0.13	2	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Western Meadowlark	WEME	0.14	0.56	27	0.29	0.83	22	0.04	0.21	5	0.32	0.68	38	0.53	0.82	31	0.12	0.42	7
Western Tanager	WETA	0.02	0.15	4	0.05	0.23	4	0.00	0.00	0	0.05	0.22	6	0.09	0.28	5	0.02	0.13	1
Western Wood-Pewee	WEWP	0.30	0.60	56	0.28	0.53	21	0.31	0.64	35	0.42	0.72	50	0.71	0.84	41	0.15	0.44	9
Willow Flycatcher	WIFL	1.46	1.17	273	1.52	1.21	114	1.42	1.14	159	1.69	1.14	200	1.97	1.18	114	1.43	1.05	86
Wilson's Snipe	WISN	0.13	0.40	25	0.13	0.41	10	0.13	0.39	15	0.08	0.36	10	0.17	0.50	10	0.00	0.00	0
Wilson's Warbler	WIWA	0.06	0.30	12	0.11	0.42	8	0.04	0.19	4	0.03	0.22	4	0.00	0.00	0	0.07	0.31	4
Wood Duck	WODU	0.02	0.16	3	0.00	0.00	0	0.03	0.21	3	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Yellow-breasted Chat	YBCH	0.10	0.33	18	0.01	0.12	1	0.15	0.41	17	0.57	0.98	67	0.00	0.00	0	1.12	1.14	67
Yellow Warbler	YEWA	0.66	0.98	123	0.48	1.04	36	0.78	0.92	87	1.14	1.23	135	1.02	1.22	59	1.27	1.23	76
Yellow-headed Blackbird	YHBL	0.04	0.27	8	0.01	0.12	1	0.06	0.34	7	0.21	0.81	25	0.02	0.13	1	0.40	1.11	24

Average abundance per point count (Avg.), standard deviation (SD) and the number of individuals detected for all species detected during 10-minute point counts (with no fixed radius) in riparian habitat of the south Okanagan Valley during 2001-2003 and 2012-2013 in all sites, only Reference sites and only Restoration sites. The number of point count stations and number of point counts completed are listed in Table 2.2.