APPARENT MOVEMENTS OF BIRDS WITHIN AN URBAN RIPARIAN CORRIDOR DURING THE BREEDING SEASON

by

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A thesis

submitted in partial fulfillment

of the requirements for the degree of

Master of Sciences in Biology

Boise State University

May 2013

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BOISE STATE UNIVERSITY GRADUATE COLLEGE

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of the thesis submitted by

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Thesis Title: The Apparent Movements of Birds Within an Urban Riparian Corridor During the Breeding Season.

Date of Final Oral Examination: 21 March 2013

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DEDICATION

This thesis is dedicated to Dr. Alfred Dufty who served as an amazing mentor and great friend for many years.

ACKNOWLEDGEMENTS

This thesis would not have been possible without the help of many wonderful and dedicated people. First of all I would like to thank Dr. Alfred Dufty Jr. who served as my major adviser for the first few years of this thesis. He gave me the freedom to pursue my own interests while helping to develop them into a successful thesis. His kind demeanor and wise words were unforgettable. Due to tragic circumstances he left this world mid-way through the thesis. I'd like to give a huge thanks to Dr. Jesse Barber and Dr. Chris McClure who helped transform the thesis and see it through to the finish. I'd also like to thank committee members Dr. Julie Heath and Christina Fenske for their scientific contribution. I would also like to acknowledge Dr. Susan Earnst for her significant help in the development of the project design.

There were also several organizations that helped significantly with the thesis. First of all, I'd like to acknowledge the Golden Eagle Audubon Society for helping me recruit some amazing volunteers. I'd like to thank Gary Worthington, R.L. Rowland and Susan Norton for their two-year dedication to the thesis, conducting bird surveys along the Boise River. I would also like to acknowledge the Idaho Foundation for Parks and Lands and the Land Trust of Treasure Valley for their tremendous help in locating study sites and granting permission to enter needed areas along the Boise River.

Finally, I'd like to thank my family and friends, especially my husband, Matt O'Brien, for his continued patience and support. I'd also like to thank my fellow graduate students and the many friends I have made throughout the course of this thesis.

ABSTRACT

Riparian corridors provide diverse vegetation and a water supply that facilitates foraging and provides breeding areas for all sorts of wildlife. Increasing amounts of urbanization has adverse effects on wildlife that utilize riparian areas. Previous studies of habitat use by urban or riparian birds assumed that individuals were unlikely to move from a site once they settled in their breeding areas, however recent studies have shown that site use by birds may not remain static throughout the breeding season and movement may occur. I test the hypothesis that birds move throughout the breeding season leading to changes of habitat use as the breeding season progresses, especially with increasing amounts of human development and activity. I conducted point counts throughout the breeding season along the Boise River, ID. I placed species into 14 functional guilds to increase counts needed for analysis. Using detailed aerial photography, buffers were placed around each of the point count sites in ArcGIS and were hand digitized to assess the landscape composition of the area. At each site, vegetation metrics were taken within the riparian area to assess structure. This information was analyzed to give me models that estimated abundance and possible movement. Movement models outcompeted static models for every guild. Furthermore, I found evidence that birds not only moved throughout the breeding season but that movement is associated with aspects of urbanization and the riparian corridor at differing spatial scales. Within the urban matrix, I found that birds were more likely to move from urban areas into areas with larger amounts of riparian forest. In this study, I showed the

importance of riparian habitat to wildlife, such as breeding birds, and the need to manage riparian areas that are becoming encroached by urbanization and increased land use.

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INTRODUCTION

Riparian corridors are considered among the most diverse and complex habitats on Earth (Naiman et al. 1993). They are important transitional areas that are often considered 'ecological hotspots' because they occur at land-water junctions often acting as a buffer between uplands and streams (Groffman et al. 2003). Diverse vegetation and proximity to water afforded by riparian areas facilitate foraging and breeding behaviors of a wide range of wildlife species. For example, juvenile wood turtles rely on streams to provide appropriate thermal and moisture conditions, and the riparian vegetation provides needed cover for reptiles and small mammals (Naiman and Decamps 1997, Brewster and Brewster 1991). Along the lower Yellowstone River, riparian cover was the major factor influencing density of white-tailed deer (Compton et al. 1988). Another study in British Columbia found that bat activity levels were significantly greater in riparian areas when compared to other upland habitat (Grindal et al. 1999). For avifauna, riparian areas create vegetation corridors that become key stopover sites for migrants (Mehlman et al. 2005) and may provide more nesting sites for birds than any other habitat (Sanders and Edge 1998).

Although the importance of riparian areas to wildlife is widely recognized, they also harbor a complex history with human development because development is highly influenced by the access to water for drinking, irrigation, and transportation (Groffman et al. 2003). Conversion of rural or undeveloped land into large, more populated cities is a common definition of urbanization. Differing levels of urban expansion lead to reduced and fragmented levels of native vegetation, and the native vegetation that remains may be continually altered by the introduction of exotics, increased impervious surfaces, and other human activities (e.g., Melles et al. 2003, Bessinger and Osborne 1982, Germaine et al. 1998). Anthropogenic changes, such as modified plant communities and increased human activity, can affect the bird community's composition and abundance throughout an area (Schlesinger et al. 2008).

Effects of urbanization on a riparian ecosystem can occur at different spatial scales, which may yield differing effects on birds and other wildlife. Studies suggest that birds may first select a habitat based on landscape scale characteristics, followed by local scale characteristics to choose areas to forage and nest (e.g., McClure and Hill 2012, Johnson 1980, Hutto 1985). At a landscape scale, urbanization of the surrounding area has been shown to influence species composition (Fletcher and Hutto 2008). At a local level, disturbances from human activity (Fernandez-Juricic 2000, Miller and Hobbs 2000, Miller et al. 2003) and changes in vegetation structure and composition (McKinney 2002, Miller et al. 2003, Donnelly and Marzluff 2006) can add additional ecological challenges for birds. Simply the presence of humans has been shown to reduce the abundance of birds (Fernandez-Juricic 2000, Mallord et al. 2007).

For local managers, information regarding habitat use by the local bird community is essential for maintaining diversity and protecting threatened species. Previous studies of habitat use by riparian or urban birds implicitly assumed that individuals were unlikely to move from a site once they settled in their breeding territories (e.g., Miller et al. 2003, Blair 1996, Sanders and Edge 1998, Trammell et al.

2011), therefore assuming that habitat use was constant during the breeding season. However, a recent study by McClure and Hill (2012) found that habitat use by birds may not remain static throughout the breeding season and certain types of cover may be associated with local colonization and extinction. Failure to examine or incorporate movement of individuals throughout the breeding season could lead to incomplete or misleading inference from studies of breeding habitat use. To date, no study has examined changes of habitat use during the breeding season within a community of urban or riparian birds.

In this study, I test the hypothesis that birds move throughout the breeding season, thus leading to changes in habitat use as the breeding season progresses, especially with encroaching human development and activity. I further seek to characterize the spatial scale at which habitat, including increased amounts or urban development, influences patterns of movement during the breeding season. I conducted point-counts along a 50 km stretch of the Boise River, Idaho and characterized habitat along the urban-riparian corridor using GIS and vegetation surveys.

The focal bird species seen during the point-counts were placed into 14 functional guilds to increase their counts for analysis. The guilds chosen were migratory (resident and neotropical migrants, Bryce et al. 2002), nesting (understory and cavity, Bryce et al. 2002, Blair 2004), foraging (ground and foliage, Bryce et al. 2002), diet (omnivore, granivore, and insectivore, Bryce et al. 2002), brood (multi or single brooders, Blair 2004), and native or introduced (Bryce et al. 2002, Chiron et al. 2009). Based on previous studies, I developed certain predictions as to how certain guilds would react to increasing urbanization and human activity. I predicted that neotropical migrants would decrease as urbanization and human activity increased and that residents may not show as much of an effect, or possibly a slight increase in numbers in levels of moderate urbanization and human activity, but would decline as these increased (Bryce et al. 2002). I also predicted that both understory and cavity nesters would decline with increased urbanization and human activity because their nesting areas would be restricted to the vegetation within the riparian corridor and increasing human activity could increase levels of predation and other disturbances (Bryce et al. 2002, Blair 2004). Predictions for the dietary and foraging guilds were based on Bryce et al. (2002), which found that for the dietary and foraging guilds, bird abundance within the omnivore, granivore, and ground gleaners increased with urbanization and human activity. Multiple brooders have been shown to do well with increasing urbanization and human activity, while single brooders tend to decline in numbers (Blair 2004). I finally predict that introduced species would do well with high levels of urbanization, or human modified landscapes (Chiron et al. 2009) as species, such as the European Starling, are known to be very adaptive, and I predict that native species will decline with increasing amounts of urbanization (Bryce et al. 2002).

The stretch of the Boise River used in this study passes through Boise, Idaho as well as neighboring suburbs, agricultural, private, public, and preservation land. A unique aspect to this location is that a 70-ft setback was implemented between the construction of urban structures and the river’s high water mark. This mandate has left the river with an intact riparian corridor going through the city centers, leaving a unique composition of riparian habitat that abuts many urban features, both of which are utilized by the birds and may lead to shifts in movement. I therefore hypothesized that habitat use by an urban-riparian bird community is not static during the breeding season. I therefore predicted that models, which estimate movement between rounds of point counts, would outperform models, which assume a closed population throughout the study period. I further predicted that direction of movement would be away from urban environments and into riparian areas.

METHODS

Study Area

The study area was the riparian corridor along both sides of a 50-km stretch of the Boise River corridor, ranging from Lucky Peak Dam to the southeast, and Star, Idaho to the northwest (Figure 1). The central stretch included the cities of Boise, Eagle, and Garden City, Idaho (43°36′49″N 116°14′16″W, T3N R2E). The riparian strip was as narrow as 5 meters (perpendicular to the river) but in some of the more rural/agricultural sites was wider the 20 meters. Areas outside this riparian strip consisted of varying degrees of concrete, buildings, bare ground, and manicured lawns. Intermixed within these features were varying levels of upland shrubs seen all throughout the neighboring hills.

Vegetation seen throughout the study area included various riparian species as well as trees and manicured lawns commonly placed in urban developments. Some of the common species were as follows: common grasses were *Bromus tectorum* (cheatgrass) and *Agrostis* species (lawn or fairway grasses). Common shrubs were from the genera *Prunis* (primarily chokecherry, *P. virginianus*), *Sambucus* (elderberry), *Ribes* (gooseberries and currants), and *Salix* (willow). Common trees were *Salix* species (willow) and *Poplar* species (cottonwood).

Sampling Design

The original 120-point count locations were systematically placed along the centerline of the river with 0.4 km between points (Figure 2). The systematic sampling provided even coverage of the 50-km stretch of river, and the distance between points reduced the chances of overlap of point count radii. Every second survey point was assigned to be surveyed during the first field season (summer 2009) and the remaining points were assigned to the second field season (summer 2010), resulting in 60 points per field season. For sites within a field season, I moved every second point from the river's centerline to the north shoreline, and I moved the remaining sites to the south shoreline. The point count center was placed on the shoreline approximately 9 m from the river's high water mark (Figure 2). Ten survey points per season were not used because I was unable to obtain permission to conduct surveys on the property.

Point Count Surveys

Three point count surveys were conducted by trained observers at each of the 100 sites in 2009 and 2010, following standard point count methods (Ralph et al. 1995). The surveys were conducted from mid-May to early July, which included the majority of the breeding season of most common birds in the study area. These dates were chosen based on a similar study conducted in southeastern Idaho (Saab 1999). Surveys were not conducted in rain or high winds. Each survey was 10 minutes long and was done within four hours after sunrise (range: 0645 – 1045 am). Observers recorded each individual bird detected within 50 m, excluding flyovers. During surveys, observers recorded each biker, walker, or dog crossing though the 50m circles. Background noise during surveys was recorded as 1 = none, 2 = little, 3 = moderate, or 4 = loud.

During each field season, the 50 point count locations were visited three times by at least two (usually three) observers. Approximately 15-25 points were visited per week, with different portions of the river sampled throughout the week. All 50 points were visited once before repeat visits occurred. Repeat visits to a point occurred on different days of the week and at different times of the morning. Surveys were restricted to weekdays because human activity was uncharacteristically low during the weekends (A. Korte pers obs.).

Bird Guilds

I restricted analysis to mostly to *Passeriformes* (passerines), *Columbiformes* (doves), and *Piciformes* (woodpeckers) because the point count method is not an efficient survey method for species usually detected visually, such as raptors, waterfowl, shorebirds, and other water birds (see Table 1 for complete list of species detected and analyzed). I placed focal species in 14 functional guilds. I analyzed guilds that have previously been shown to be affected by urbanization and human activity. The guilds I chose were migratory (resident and neotropical migrants, Bryce et al. 2002), nesting (understory and cavity, Bryce et al. 2002, Blair 2004), foraging (ground and foliage, Bryce et al. 2002), diet (omnivore, granivore, and insectivore, Bryce et al. 2002), brood (multi or single brooders, Blair 2004), and native or introduced (Bryce et al. 2002, Chiron et al. 2009). I realize that Root (1967) defines guilds as a group of species that exploits the same class of environmental resources but for remainder of the paper I label all of the above as guilds.

Riparian Vegetation (Field) Surveys

After all bird surveys were completed in 2010, I surveyed vegetation within the riparian zone of each point count location. Vegetation surveys were completed only for point count circles containing riparian vegetation. Seven sites were excluded from habitat models because property owners or high water made them inaccessible for vegetation surveys. Thus, 93 sites were used in habitat models.

I conducted vegetation sampling on 100 m of vegetation transects within the riparian zone of each 50 m point count circle. For each circle, the width of the riparian zone was categorized as narrow (5-10 m), medium (10-20 m), or wide (> 20 m). For point count circles with narrow riparian strips, I placed 20 5-m transect perpendicular to the river, each separated by 5 m; for medium strips, I used 10 10-m transects separated by 10 m; for wide strips, I used 5 20-m transects separated by 20 m. In each case, the first transect was oriented perpendicular to the river and towards the point count center; additional transects were placed systematically on each side of the first transect.

I estimated percent shrub cover by walking vegetation transects and estimating the length of path intercepted by shrubs. To facilitate accuracy, I made estimates for one 10-m length of transect at a time. I estimated overall shrub cover as well as cover of willow (*Salix*) shrubs. I also recorded the presence or absence of shrubs bearing fruit at the time of vegetation sampling (typically *Prunis*, *Sambucus,* or *Ribes).*

Tree count was the number of all trees with trunks at least half within a 1-m strip on one side of the vegetation transect line. I also specifically recorded the number of conifer (*Coniferae)*, willow (*Salix*), and cottonwood (*Poplar*) trees. Each tree was visually categorized by height (< 2 m, 2-6 m, and > 6m).

Landscape Analysis

I quantified the percentage of the cover types at 50 m, 100 m, and 200 m around each point count center using Arc GIS 9.3, 2007 Orthophotos, and 2009 National Agriculture Imagery Program (NAIP) aerial photographs (insideidaho.org). An orthophoto is an aerial photograph that has been geometrically corrected so that distances can be accurately measured and points can be mapped. The NAIP imagery is of lower resolution than the orthophotos, but it was useful in identifying any major land use changes within point count circles throughout the river corridor. The 2009 NAIP imagery was supplemented with the 2007 orthophotos as the project didn't begin until 2008, a year after the orthophotos were taken. Thus, the 2009 NAIP imagery allowed me to see major land use changes, such as development of new bridges, buildings, and parks that occurred between 2007 and 2009.

For each buffer extent, I visually categorized features on the orthophotos into seven cover types (bare ground, brush land, buildings, concrete, grass, riparian, or water), digitized those features into individual polygons using ArcGIS, and then calculated the area and percent of area comprised by each cover type within each buffer extent (Figure 3). The resolution of the orthophotos (approximately 0.15 meters in urban areas and 0.3 meters in rural areas) allowed precise identification of specific buildings, patches of vegetation, and other landmarks.

In summary, this yielded total area (m^2) and percent of area comprised by the seven cover types (water, riparian, brush land, bare ground, building, grass, and concrete) within the 200 m, 100 m, and 50 m-buffered areas for each of the 100 survey sites.

Statistical Analysis

To analyze the population dynamics of birds along the Boise River, I compared the Royle's n-mixture model (Royle 2004) to the more generalized version known as the 'Dail-Madsen' model (Dail and Madsen 2010). The Dail-Madsen model allows for movement between sampling occasions by estimating apparent survival, or the probability of birds remaining at a site between sampling occasions, and recruitment, the number of birds moving into a site —i.e., it allows for an 'open population.' Whereas the Royle n-mixture model assumes no movement between sampling occasions or assumes a 'closed population.' Both models account for imperfect detection, or the probability of a bird going undetected. All statistical analysis were run with software from the R Development Core Team (2009).

The open and closed models allow for the use of Poisson, negative binomial, or zero-inflated Poisson distributions. For each guild, I chose the appropriate distribution by comparing the null models under each of the distributions using Akaike's Information Criterion (AIC; Akaike 1974), and used the best for all subsequent models. After preliminary analysis, I determined that negative binomial was the best-fit distribution for all guilds. To confirm my decision to use a negative binomial distribution, I compared the final models, including additional covariates, under all distributions using AIC. Negative binomial remained the best-fit option. I also found that over-dispersion was significant for all guilds further justifying my use of the negative-binomial distributions.

I tested several hypotheses regarding the associations of birds with habitat (because species abundance, apparent survival, and recruitment may vary with habitat) using combinations of covariates chosen a priori based on previous studies (Table 2). Covariates within each model were not highly correlated ($r < 0.5$).

To assess abundance, apparent survival, and recruitment of each guild, I tested the landscape models at the 50 m, 100 m and 200 m scales as well as the vegetation models, a null model, and the noise and activity models. I also tested several detection models, which included time of day, date, noise, observer, and human activity level. I performed analysis in a forward step-wise fashion—assessing a different parameter in each step—because running all possible combinations of models for all parameters would result in thousands of models. For each step, covariates within the top model were used for the rest of the analysis. This forward step-wise analysis process was based on Akaike's Information Criterion (AIC) as a way to find the best-supported hypothesis from Table 2 for each parameter. At every step of the analysis, all covariates within models $\Delta AIC<2$ and with 95% confidence intervals that excluded zero were considered to be useful for inference. I also used the model weights at each step to assess the support of models from each scale.

Royle 'Closed Model'

For the closed models, I first tested models that included only detection covariates (time of day, date, noise, human activity level) while holding abundance constant at the intercept. Next, I incorporated the best detection model into models of across-season abundance representing the hypotheses in Table 2. Models including vegetation characteristics only were tested at the 50 m scale, whereas landscape models were tested at the 50, 100, and 200 m scale. The model with the lowest AIC score from step two represented the best closed model of each guild.

Dail-Madsen ‘Open Models’

Whereas the close models estimate abundance across all survey occasions, the open models estimate abundance during the first survey then derive abundance during the second and third surveys based on estimates of recruitment and apparent survival. I stress that I am estimating “apparent” survival because my surveys were of unmarked individuals and I do not know whether the loss of an individual at a site is caused by mortality or permanent emigration (Chandler and King 2011). When developing open models, I followed a protocol similar to that used for the closed models. I first modeled detection while holding all other parameters constant at the intercept, then incorporated the best detection model into all models of initial abundance representing the hypotheses in Table 2. I then modeled apparent survival and recruitment following the protocol examining the hypotheses in Table 2 while retaining the best model for parameters examined in previous steps. I assessed the scale at which each group of birds selects habitat by comparing the summed Akaike weights of models across each scale (vegetation and 50-m, 100-m, and 200-m buffers) for abundance, apparent survival, and recruitment and considered one scale to be substantially more influential than the others if the summed Akaike weight was > 0.95. I finally assessed the hypothesis that site use by birds is not static across the breeding season by comparing the AIC score of the final closed model to that of the final open model.

RESULTS

Effects of Detection

I detected a total of 58 species, placed into 14 different functional guilds, which were included in the analysis (Table 1). I found that detection of all groups of birds varied with measured covariates and present those results as $\beta \pm$ SE (Table 3). Cavity nesters and ground foragers were less detectable by one of the observers. The detectability of understory nesters was negatively associated with human activity. Time of day was associated with the detectability of the following guilds: canopy nesters, migrants, introduced, natives, grainivores, insectivores, single-brooders, and multi-brooders (Table 3). Lastly, the detectability of cavity nesters and foliage gleaners is positively associated with julian date (Table 3).

Open vs. Closed Model Results

The Dail-Madsen model for open populations outperformed the Royle n-mixture model for closed populations for every guild analyzed (Table 4). My analysis therefore revealed patterns of movement for all guilds during the breeding season. I found that for each of the guilds, riparian and brush land features tended to be more positively associated with abundance, apparent survival and recruitment, while features linked with urbanization appeared to be negatively associated with site use.

Influence of Landscape and Vegetation Characteristics

Each of the following guilds were positively associated with the proportion of riparian forest within 50, 100, or 200 m buffers: natives (apparent survival), ground foragers (recruitment), cavity nesters (apparent survival), understory nesters (recruitment), introduced (recruitment), residents (apparent survival), migrants (apparent survival), foliage gleaners (abundance and apparent survival), insectivores (recruitment), single (survival and recruitment) and multi-brooders (recruitment), and total species (apparent survival) (Table 5). Apparent survival of ground foragers and introduced species was negatively associated with riparian forest at the 50 m scale, yet both guilds were positively associated with riparian at the 100 m scale for recruitment (Table 5). Canopy nesters and grainivores were the only guilds not associated with riparian forest at any scale for any of the three parameters tested.

I also tested several models representing hypotheses related to the effects of the structure of riparian vegetation on the distributions of breeding birds. Only four guilds were associated with vegetation covariates. Native species (abundance), understory nesters (abundance), migrants (recruitment), and total species (recruitment) (Table 5).

The following guilds were positively associated with brush land at either the 50, 100 or 200 m scale: natives (recruitment), migrants (abundance), foliage gleaners (apparent survival), insectivores (recruitment), single-brooders (recruitment), and total species (abundance) (Table 5). The initial abundance of cavity nesters and survival of residents were the only parameters negatively associated brush land.

In contrast to native vegetation types such as brush land and riparian forest, urban and concrete landscape scale covariates were the major urbanization features that came out as significantly associated with the guilds of interest. Urban landscape feature is a combination of the building and concrete features. The following guilds were negatively associated with the urban landscape feature at either the 50, 100, or 200 m scale: natives (apparent survival), ground foragers (abundance and apparent survival), introduced (apparent survival), residents (abundance), migrants (apparent survival), foliage gleaners (abundance), insectivores (abundance), single (apparent survival) and multi-brooders (abundance), and total species (abundance) (Table 5). The cavity nesting guild was the only guild to show a positive association with urban (Table 5).

In addition to the combined urban covariate, birds were also affected by concrete and buildings, by themselves. Concrete was negatively associated with abundance of the following guilds: natives, ground foragers, residents, foliage gleaners, insectivores, multi-brooders, and total species, as well as the recruitment of cavity nesters (Table 5). A few guilds were associated with buildings, which are also included in the grouped urban covariate. Introduced species and canopy nesters were positively associated with recruitment for buildings, while cavity nesters were positively associated with apparent survival for buildings (Table 5). Human activity was negatively associated with the abundance of migrants and multi-brooders and apparent survival of canopy nesters (Table 5).

Eight of the guilds were influenced by the proportion of grass surrounding a site. Natives (apparent survival), ground foragers (recruitment), understory nesters (recruitment), introduced (abundance), residents (recruitment), and multi-brooders (recruitment) were positively associated with grass (Table 5). Apparent Survival of cavity nesters, ground foragers, understory nesters, introduced species, and multi-brooders was negatively associated with grass (Table 5). Lastly the following guilds were positively associated for apparent survival with the bare-ground covariate, at either the 50, 100, or 200 m scale: understory nesters, residents, insectivores, and multi-brooders (Table 5). The bare-ground covariate was negatively associated for abundance with single-brooders.

Influence of Scale

Survival and/or recruitment of several groups of birds were associated with one particular scale (Table 6). Interestingly, of the nine instances where a parameter was heavily influenced by one scale (summed Akaike weight > 0.95), only one was most influenced by the vegetation scale. Further, landscape level characteristics at the 50, 100, or 200 m scale are associated with abundance, recruitment, or apparent survival for every guild except grainivores. All models that contained covariates for recruitment of granivores failed to converge. Further, the confidence intervals for all covariates within models of abundance and recruitment of grainivores overlapped zero.

DISCUSSION

Movement in Response to Riparian and Urban Landscapes

I found evidence of not only movement throughout the breeding season but that the movement is associated with certain aspects of urbanization and the natural riparian corridor at differing spatial scales. Birds were more likely to move into and remain in riparian forests as 12 of the 14 guilds had movement parameters (recruitment and apparent survival) positively associated with riparian forest. In contrast to the positive association with the riparian forest, every association of survival with urban features were negative except for apparent survival or cavity nesters. So within the urban matrix, birds are more likely to move out of higher levels of the urban gradient and move into and remain in areas with riparian forest. I found that birds move throughout the breeding season and that local as well as landscape scale habitat features within the urban gradient are associated with the movement as the breeding season progresses.

Following what previous studies have shown, this study reinforces the importance of riparian habitat to the local bird population (Mehlman et al. 2005, Sanders and Edge 1998, Naiman et al. 1993, etc.). I found that initial abundance, apparent survival (the probability of birds remaining at a site between sampling occasions), and/or recruitment (the number of birds moving into a site) for every guild except the canopy nesting and granivore guild were positively associated with riparian habitat. This shows the importance of riparian habitat to all aspects of the birds' breeding season.

My results parallel those of past studies demonstrating that human settlement has a profound impact on riparian bird communities (e.g., Trammell et al. 2011, Miller et al. 2003, Fletcher and Hutto 2008). The majority of the guilds studied had a negative association with aspects of the urban environment, including the amount of concrete, buildings, or a combination of both. However, some guilds were positively associated with aspects of urbanization. For example, cavity nesters and introduced species show positive associations with buildings (Table 5). Certain species within these guilds, such as the House Sparrow, European Starling, and the Rock Pigeon are considered to be generalists and thrive in the urban environment (Marzluff et al. 2001). Blair (1996) found that the Rock Dove and the House Sparrow had maximal densities within the business district of downtown Palo Alto, CA, both species have been introduced by humans. A study in Vancouver, BC, found that available habitat and food in highly urbanized environments favor cavity-nesting species (Lancaster and Rees 1979).

Contradictions

Some of my results are contrary to those of past studies. For instance, disturbances from human activity present many challenges for the local bird community, including increased predation (Miller and Hobbs 2000), habitat loss (Miller et al. 2003), and increasing competition (Fernandez-Juricic 2000). Surprisingly, only 3 guilds were negatively associated with human activity (which includes walkers, dogs, and bikers) (Table 5). It is unknown if this lack of response to human activity is due to the birds adapting to repeated human activity disturbances (habituation) or due to the overriding importance of the habitat. My results are also somewhat contrary to those of Blair (2004) who showed that the proportion of single-brooding species declined with increasing urbanization while the proportion of multiple-brooding species increased with urbanization. My results demonstrate that initial abundance of single-brooded species within my study site is not particularly associated with urbanization. However, the single-brooded birds that initially settle in urbanized areas are less likely remain there as the season progresses. Differences between my results and those of Blair (2004) may be due to the spatial extent of Blair's habitat measurements (only within 50 m) or my ability to account for movement during the breeding season.

Importance of Scale

My results support the hypothesis that birds select sites using landscape scale characteristics, followed by characteristics of vegetation at the local scale (e.g., McClure and Hill 2012, Johnson 1980, Hutto 1985). The landscape scale was important regarding apparent survival and recruitment of birds with 12 of the 14 guilds associated with landscape characteristics at the 50 m, 100 m, or 200 m levels. However, only 2 guilds showed an association with local or vegetation characteristics suggesting that characteristics of vegetation may not be as important as the presence of riparian forest itself. The importance of landscape scale characteristics and lack of associations at the local or vegetation scale suggests that the habitat surrounding the local environment drives decisions regarding movements during the breeding season. Therefore, habitat managers and city-planners should focus efforts on increasing the amount of riparian forest within urban landscapes as opposed to maintaining certain aspects of vegetation structure within those forests.

Issues with Migrants

Many breeding bird surveys have standards set as to when in the season to start the surveys (e.g., Ralph et al. 1995, Sauer et al. 2011). Surveys need to start late enough in the spring so that counts do not include migrating birds. One of the guilds examined in this study was migratory species, so it is possible that my samples include birds passing through the area on their migratory route. I stress that this problem of counting migrating birds along with birds on breeding territories is a potential problem with any survey conducted early in the breeding season. However, the benefit of my analysis is that I can treat each sampling occasion separately and therefore avoid contamination of my entire dataset by migrating birds. My first round of surveys began on May 19^{th}, which is early in the breeding season. It is likely that my study may have inadvertently counted some proportion of migrants early during the early breeding season. However, because I visited sites three times throughout the season and assessed habitat associations during each round of counts, even if there were some migratory birds counted during the first visit, the birds would have moved on or settled in by the second or third surveys. Therefore, although my estimates of initial abundance of migrants may be contaminated by some migrating individuals, estimates of the habitats associated with recruitment and apparent survival are likely based only on breeding birds.

Movement and Habitat Use

My study supports previous findings by McClure and Hill (2012) showing that birds use different habitats as the breeding season progresses. Other works showed that black-throated blue warblers change occupancy throughout the breeding season (Betts et al. 2008). Hoover (2003) found that prothonotary warblers abandon unsuccessful nest sites and nest in other areas. Evidence is mounting that habitat associations of birds are not static during the breeding season and that apparent re-settlement within the breeding season does occur. I found movement within this urban/riparian habitat. Betts et al. (2008) found indirect evidence for time lags in breeding site selection, suggesting that a site that a bird first settles on might not be of best quality, and therefore might explain a bird moving to a different site. In this study, I found evidence that many birds appear to shift away from urban areas and into riparian forest, therefore supporting the notion that increasing amounts of urbanization is not ideal for the breeding bird community.

Management Implications

Learning more about habitat associations and what drives an animal to leave or stay at a site is important for making management and land use decisions. My study provides a gateway into understanding the pressures that urban environments place when encroaching onto a more natural environment. One conclusion that can be drawn from this study is that within an urbanized environment maintaining a riparian corridor along riverbanks is extremely important to the local native bird population. Further, managers should take note of the effects of the habitat surrounding the corridor at larger extents.

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Table 1 **Bird species observed (ordered alphabetically), scientific name, number of individuals counted across all survey and all sites, and pertinent guild assignments (migrant status, nesting guild, foraging guild, diet, brood, and residency) along the Boise River, Boise Idaho.**

Species	Scientific Name	Abundance	Migrant Status	Nesting Guild	Foraging Guild	Diet	Brood	Residency
American Crow	*Corvus brachyrhynchos*	28	Resident	Canopy	Ground	Omnivore	Single	Native
American Goldfinch	*Carduelis tristis*	22	Resident	Understory	Foliage	Granivore	Multi	Native
American Robin	*Turdus migratorius*	266	Resident	Canopy	Foliage	Insectivore	Multi	Native
Bank Swallow	*Riparia riparia*	62	Neotropical			Insectivore	Single	Native
Barn Swallow	*Hirundo rustica*	96	Neotropical			Insectivore	Multi	Native
Belted Kingfisher	*Ceryle alcyon*	23	Resident			Other	Single	Native
Black-billed Magpie	*Pica hudsonia*	70	Resident	Canopy	Ground	Omnivore	Single	Native
Black-capped Chickadee	*Poecile atricapilla*	57	Resident	Cavity	Foliage	Insectivore	Single	Native
Black-chinned Hummingbird	*Archilochus alexandri*	14	Neotropical	Understory		Other	Multi	Native
Black-headed Grosbeak	*Pheucticus melanocephalus*	39	Neotropical	Understory	Foliage	Insectivore	Single	Native
Brewer's Blackbird	*Euphagus cyanocephalus*	48	Resident	Understory	Ground	Insectivore	Multi	Native
Brown-headed Cowbird	*Molothrus ater*	157	Resident		Ground	Insectivore		Native
Bullock's Oriole	*Icterus bullockii*	73	Neotropical	Canopy	Foliage	Insectivore	Single	Native
California Quail	*Callipepla californica*	109	Resident		Ground	Granivore	Multi	Introduced
Canyon Wren	*Catherpes mexicanus*	1	Resident		Ground	Insectivore	Multi	Native
Cassin's Finch	*Carpodacus cassinii*	5	Resident	Canopy	Ground	Granivore	Multi	Native
Cedar Waxwing	*Bombycilla cedrorum*	18	Resident	Canopy	Foliage	Frugivore	Multi	Native

Species	**Scientific Name**	**Abundance**	**Migrant Status**	**Nesting Guild**	**Foraging Guild**	**Diet**	**Brood**	**Residency**
Chipping Sparrow	***Spizella passerina***	**3**	Neotropical		Ground	Insectivore	Multi	Native
Common Yellowthroat	***Geothlypis trichas***	**1**	Neotropical	Understory	Foliage	Insectivore	Multi	Native
Downy Woodpecker	***Picoides pubescens***	23	Resident	Cavity		Insectivore	Single	Native
Dusky Flycatcher	***Empidonax oberholseri***	**4**	Neotropical	Understory		Insectivore	Single	Native
Eurasian Collared-Dove	***Streptopelia decaocto***	**1**	Resident	Understory	Ground	Granivore	Multi	Introduced
European Starling	***Sturnus vulgaris***	**430**	Resident	Cavity	Ground	Insectivore	Multi	Introduced
Gray Catbird	***Dumetella carolinensis***	**4**	Neotropical	Understory	Ground	Insectivore	Multi	Native
House Finch	***Carpodacus mexicanus***	**93**	Resident	Canopy	Ground	Granivore	Multi	Native
House Sparrow	***Passer domesticus***	**89**	Resident	Cavity	Ground	Granivore	Multi	Introduced
House Wren	***Troglodytes aedon***	**29**	Neotropical	Cavity	Ground	Insectivore	Multi	Native
Lark Sparrow	***Chondestes grammacus***	**2**	Neotropical		Ground	Granivore	Single	Native
Lazuli Bunting	***Passerina amoena***	**1**	Neotropical	Understory	Ground	Insectivore	Multi	Native
Lewis's Woodpecker	***Melanerpes lewis***	**4**	Resident	Cavity		Insectivore	Single	Native
MacGillivary's Warbler	***Oporornis tolmiei***	**1**	Neotropical	Understory	Foliage	Insectivore	Single	Native
Mourning Dove	***Zenaida macroura***	**177**	Resident	Understory	Ground	Granivore	Multi	Native
Nashville Warbler	***Oreothlypis ruficapilla***	**3**	Neotropical	Understory	Foliage	Insectivore	Single	Native
Northern Flicker	***Colaptes auratus***	**101**	Resident	Cavity	Ground	Insectivore	Single	Native
Northern Rough-winged Swallow	***Stelgidopteryx serripennis***	**42**	Neotropical			Insectivore	Single	Native
Orange-crowned Warbler	***Vermivora celata***	**1**	Neotropical	Understory	Foliage	Insectivore	Single	Native

Species	Scientific Name	Abundance	Migrant Status	Nesting Guild	Foraging Guild	Diet	Brood	Residency
Pine Siskin	***Spinus pinus***	**3**	Resident	Canopy	Foliage	Granivore	Multi	Native
Red-breasted Nuthatch	***Sitta canadensis***	3	Resident	Cavity		Insectivore	Single	Native
Red-winged Blackbird	***Agelaius phoeniceus***	**500**	Resident	Understory	Ground	Insectivore	Multi	Native
Rock Pigeon	***Columba livia***	**71**	Resident		Ground	Granivore	Multi	Introduced
Rock Wren	***Salpinctes obsoletus***	**5**	Resident		Ground	Insectivore	Multi	Native
Ruby-crowned Kinglet	***Regulus calendula***	**2**	Resident	Canopy	Foliage	Insectivore	Single	Native
Song Sparrow	***Melospiza melodia***	**313**	Resident	Understory	Ground	Insectivore	Multi	Native
Tree Swallow	***Tachycienta bicolor***	**1**	Resident	Cavity		Insectivore	Single	Native
Violet-green Swallow	***Tachycienta thalassina***	**75**	Neotropical	Cavity		Insectivore	Single	Native
Warbling Vireo	***Viero gilvus***	**7**	Neotropical	Canopy	Foliage	Insectivore	Multi	Native
Western Kingbird	***Tyrannus verticalis***	**10**	Neotropical	Canopy		Insectivore	Multi	Native
Western Meadowlark	***Sturnella neglecta***	**1**	Resident		Ground	Insectivore	Multi	Native
Western Tanager	***Piranga ludovicana***	**70**	Neotropical	Canopy	Foliage	Insectivore	Single	Native
Western Wood-Pewee	***Contopus sordidulus***	**35**	Neotropical	Canopy		Insectivore	Single	Native
Willow Flycatcher	***Empidonax traillii***	**12**	Neotropical	Understory		Insectivore	Single	Native
Wilson's Warbler	***Wilsonia pusilla***	**1**	Neotropical	Understory	Foliage	Insectivore	Single	Native
Yellow Warbler	***Setophaga petechia***	**273**	Neotropical	Understory	Foliage	Insectivore	Multi	Native
Yellow-breasted Chat	***Icteria virens***	**8**	Neotropical	Understory	Foliage	Insectivore	Multi	Native
Yellow-headed Blackbird	***Xanthocephalus xanthocephalus***	**7**	Neotropical	Understory	Ground	Insectivore	Multi	Native
Yellow-rumped Warbler	***Setophaga coronata***	**20**	Resident	Canopy	Foliage	Insectivore	Multi	Native

Table 2 List of hypotheses, and their sources, tested regarding the association of birds with the habitat. Each hypothesis was tested against each of the bird guilds for effects on abundance, recruitment and apparent survival.

	Model	Source of hypothesis
Landscape	Urban	Beissinger and Osborne (1982), Donnelly and Marzluff (2006), Oneal and Rottenberry (2009)
	Brush land	Saab (1999), Oneal and Rottenberry (2009)
	Impervious Surface	Germaine et al. (1998), Hennings and Edge (2003)
	Brush land + Riparian forest	Hennings and Edge (2003), Sandström et al. (2006)
	Riparian forest	Smith and Schaeffer (1993), Miller et al. (2003), Pennington and Blair (2011)
	Buildings	Miller et al. (2003), Pennington and Blair (2011)
	Grass	Miller et al. (2003), Pennington and Blair (2011)
	Urban + Riparian forest	Germaine et al. (1998), Hennings and Edge (2003), Oneal and Rottenberry (2009)
	Buildings + Grass	Miller et al. (2003), Pennington and Blair (2011)
	Urban + Riparian forest + Grass	Miller et al. (2003), Pennington and Blair (2011)
Vegetation	Willow shrubs	Oneal and Rottenberry (2009)
	Shrubs + Short trees + Mid trees + Tall trees	MacArthur and MacArthur (1961), Smith and Schaeffer (1993), Hennings and Edge (2003)
	Trees	Miller et al. (2003), Donnelly and Marzluff (2006), Pennington and Blair (2011)
	Cottonwoods	Saab (1999)
	Willows	Saab (1999)
	Shrubs	Saab (1999), Miller et al. (2003)
	Fruit bearing shrubs	Melles et al. 2003
	Conifers	Melles et al. 2003
	Medium trees	Miller et al. (2003)
	Shrubs + Short trees	Pennington and Blair (2011)
Disturbance	Noise	Slabbekoorn and Ripmeester (2007), Barber et al. (2010)
	Human activity	Miller et al. (2003)

Table 3 Parameter estimates and standard error of variables that represent the AIC best-ranked model for variables that effected detection of the studied bird guilds.

Detection		Time	$Time^2$	Date	$Date^2$	Activity	Observer 1
Cavity Nesters	β			0.82			-0.41
	SE			0.27			0.12
Understory Nesters	β					-0.05	
	SE					0.02	
Canopy Nesters	β	1.39					
	SE	0.53					
Migrants	β	-17.44	-1.57				
	SE	7.34	0.10				
Residents	β						
	SE						
Introduced	β	27.2	-15.9				
	SE	9.18	5.33				
Native	β	-16.7	10.7				
	SE	4.7	2.71				
Foliage Gleaners	β			8.75	-8.53		
	SE			2.29	2.21		
Ground Foragers	β						-0.25
	SE						0.7
Grainivores	β	2.75					
	SE	0.59					
Insectivores	β	-21.05	13.1				
	SE	5.12	2.95				
Single Brooded	β	-26.07	16.91				
	SE	8.05	4.63				
Multi Brooded	β	0.73					
	SE	0.30					
Total	β						
	SE						

Table 4 Akaike's Information Criterion value, the difference in AIC between the model with the lowest AIC and a given model (ΔAIC), and the Akaike weights (wi) for models either assuming an 'open population' during the breeding season and models that estimate a 'closed population' during the breeding season. Models were tested for 14 bird guilds consisting of species seen along the Boise River, Idaho. Species that make up the guilds are presented in Table 1.

Guild	Model	AIC	ΔAIC	Wi
Cavity Nesters	Open	1383.6	0.00	1.00
	Closed	1419.59	35.99	0.00
Migrants	Open	1444.44	0.00	1.00
	Closed	1470.44	26.00	0.00
Introduced	Open	1382.08	0.00	1.00
	Closed	1430.50	48.42	0.00
Native	Open	1993.40	0.00	1.00
	Closed	2076.74	83.34	0.00
Canopy Nesters	Open	1177.79	0.00	1.00
	Closed	1206.02	28.23	0.00
Foliage Gleaners	Open	1231.62	0.00	1.00
	Closed	1263.55	31.93	0.00
Grainivores	Open	1207.73	0.00	1.00
	Closed	1231.87	24.14	0.00
Understory Nesters	Open	1488.44	0.00	1.00
	Closed	1523.60	35.16	0.00
Residents	Open	2082.2	0.00	1.00
	Closed	2141.13	58.93	0.00
Ground Foragers	Open	1997.86	0.00	1.00
	Closed	2084.10	86.24	0.00
Total	Open	2309.00	0.00	1.00
	Closed	2401.79	92.79	0.00
Insectivores	Open	1886.70	0.00	1.00
	Closed	1968.30	81.60	0.00
Single Brooded	Open	1303.88	0.00	1.00
	Closed	1322.12	18.24	0.00
Multi Brooded	Open	2110.98	0.00	1.00
	Closed	2183.30	72.32	0.00

Table 5 Parameter estimates and standard errors and scale-of-measurement for the variables within models ΔAIC<2 for abundance, apparent survival and recruitment of the listed guilds.

Initial Abundance		Shrubs	Short Trees	Tall Trees	All Trees	Activity	Bare-Ground	Brush Land	Buildings	Concrete	Riparian	Urban	Grass
Cavity Nesters	β							-1.5					2.07
	SE							0.47					0.79
	Scale							200					50
Understory Nesters	β	1.15		-1.13									
	SE	0.30		0.40									
	Scale	veg		veg									
Canopy Nesters	β												
	SE												
	Scale												
Migrants	β					-0.03		0.83					
	SE					0.01		0.40					
	Scale							50					
Residents	β												
	SE												
	Scale												
Introduced	β												2.2
	SE												0.9
	Scale												50
Native	β	0.78		-0.10						-2.44			
	SE	0.19		0.27						0.60			
	Scale	veg		veg						100			
Foliage Gleaners	β									-3.31	1.36	-1.84	
	SE									1.16	0.40	0.90	
	Scale									50	50	50	
Ground Foragers	β									-2.07		-1.71	
	SE									0.74		0.56	

	Scale									100		100	
Grainivores	β												
	SE												
	Scale												
Insectivores	β									-2.81		-1.92	
	SE									0.60		0.46	
	Scale									100		100	
Single Brooded	β						-2.67						
	SE						1.30						
	Scale						200						
Multi Brooded	β					-0.03				-2.09		-1.4	
	SE					0.01				0.69		0.48	
	Scale									100		100	
Total	β							0.62		-1.3		-1.22	
	SE							0.25		0.47		0.41	
	Scale							200		200		100	

Survival		Shrubs	Short Trees	Tall Trees	All Trees	Activity	Bare Ground	Brush Land	Buildings	Concrete	Riparian	Urban	Grass
Cavity Nesters	β								45.2		19.76	32.89	-12.4
	SE								16.5		4.99	7.99	4.09
	Scale								200		200	200	200
Understory Nesters	β						45.31						-4.47
	SE						13.96						1.57
	Scale						50						50
Canopy Nesters	β					-0.18							
	SE					0.06							
	Scale												
Migrants	β										18.46	-9.25	
	SE										5.21	2.38	
	Scale										200	200	

Residents	β								
	SE								
	Scale								
Introduced	β						-27.4	-42.3	-36.9
	SE						7.88	12.55	11.47
	Scale						50	50	50
Native	β						16.78	-5.31	6.13
	SE						3.86	1.69	2.49
	Scale						200	200	200
Foliage Gleaners	β		6.35				12.11		
	SE		2.80				5.09		
	Scale		200				200		
Ground Foragers	β						-29	-44.9	-40
	SE						9.07	14.48	13
	Scale						50	50	50
Grainivores	β								
	SE								
	Scale								
Insectivores	β	39.20							-3.46
	SE	10.00							1.27
	Scale	100							100
Single Brooded	β						18.07	-5.46	
	SE						4.78	2.55	
	Scale						200	200	
Multi Brooded	β	18.13							-1.69
	SE	4.34							0.71
	Scale	100							50
Total	β						5.46		
	SE						1.59		
	Scale						200		

Recruitment		Shrubs	Short Trees	Tall Trees	All Trees	Activity	Bare Ground	Brush Land	Buildings	Concrete	Riparian	Urban	Grass
Cavity Nesters	β									-70.5			
	SE									28.53			
	Scale									200			
Understory Nesters	β										2.15		2.07
	SE										0.65		0.91
	Scale										200		200
Canopy Nesters	β								6.68				
	SE								1.75				
	Scale								50				
Migrants	β		-2.97		-1.06								
	SE		1.48		0.48								
	Scale		veg		veg								
Residents	β												
	SE												
	Scale												
Introduced	β								22.8		7.04		
	SE								6.12		2.1		
	Scale								100		100		
Native	β							3.74					
	SE							0.6					
	Scale							50					
Foliage Gleaners	β												
	SE												
	Scale												
Ground Foragers	β										3.30		8.89
	SE										1.35		1.30
	Scale										100		100
Grainivores	β												

	SE					
	Scale					
Insectivores	β			2.33	2.3	
	SE			0.42	0.37	
	Scale			100	100	
Single Brooded	β			7.23	6.26	
	SE			3.01	3.03	
	Scale			100	100	
Multi Brooded	β				1.67	4.87
	SE				0.33	0.69
	Scale				200	100
Total	β	0.57	-0.88			
	SE	0.10	0.15			
	Scale	veg	veg			

Table 6 Summed Akaike weights of models of abundance, survival, and recruitment at each scale at which habitat variables were measured. No models of recruitment of grainivores reached convergence.

Guild		Vegetation	50m	100m	200m
Cavity Nesters	Abundance	0.02	0.23	0.24	0.72
	Survival	0.16	0.25	0.16	0.44
	Recruitment	0.02	0.01	0.01	**0.94**
Understory Nesters	Abundance	0.73	0.00	0.09	0.00
	Survival	0.02	0.94	0.04	0.01
	Recruitment	0.00	0.01	0.05	0.93
Canopy Nesters	Abundance	0.33	0.16	0.16	0.26
	Survival	0.00	0.02	0.05	0.29
	Recruitment	0.02	0.94	0.03	0.01
Migrants	Abundance	0.20	0.20	0.21	0.27
	Survival	0.00	0.00	0.02	**0.96**
	Recruitment	0.48	0.42	0.06	0.02
Residents	Abundance	0.10	0.056	0.59	0.21
	Survival	0.03	0.05	0.47	0.45
	Recruitment	0.01	0.02	**0.95**	0.03
Introduced	Abundance	0.11	0.51	0.19	0.13
	Survival	0.02	**0.96**	0.00	0.02
	Recruitment	0.00	0.05	0.95	0.00
Native	Abundance	0.48	0.01	0.23	0.24
	Survival	0.00	0.02	0.01	**0.97**
	Recruitment	0.00	**1.00**	0.00	0.00
Foliage Gleaners	Abundance	0.04	0.67	0.17	0.11
	Survival	0.00	0.07	0.01	0.87
	Recruitment	0.16	0.27	0.42	0.12
Ground Foragers	Abundance	0.08	0.07	0.54	0.24
	Survival	0.06	0.87	0.00	0.07
	Recruitment	0.00	0.15	0.86	0.00
Grainivores	Abundance	0.35	0.23	0.25	0.11
	Survival	**0.10**	0.00	0.00	0.00
	Recruitment	NA	NA	NA	NA
Insectivores	Abundance	0.00	0.01	0.59	0.38
	Survival	0.00	0.00	**0.10**	0.00
	Recruitment	0.00	0.00	**0.99**	0.00
Single Brooded	Abundance	0.23	0.24	0.21	0.23
	Survival	0.02	0.03	0.22	0.66
	Recruitment	0.15	0.40	0.35	0.06
Multi Brooded	Abundance	0.15	0.06	0.40	0.29
	Survival	0.16	0.249	0.594	0.002
	Recruitment	0.00	0.00	0.33	0.67
Total	Abundance	0.12	0.05	0.41	0.39
	Survival	0.00	0.00	0.02	**0.98**

Recruitment	0.32	0.27	0.41	0.00

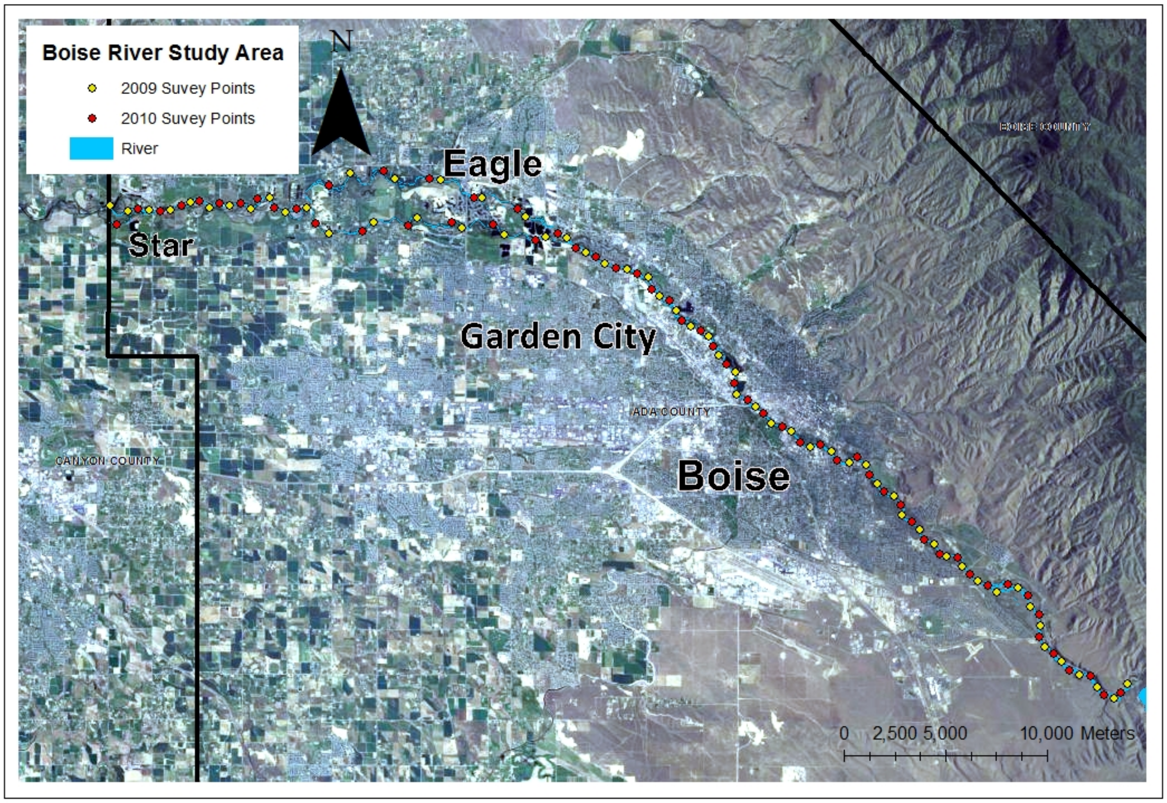

Figure 1 **Boise River study area stretching from Lucky Peak Reservoir to the southeast and Star Idaho to the northwest. Study sites placed along the river are identified by colored dots. Yellow indicating sites studied during the 2009 season, red indicating sites studied in the 2010 season. Cities and town in which the river intersected are labeled.**

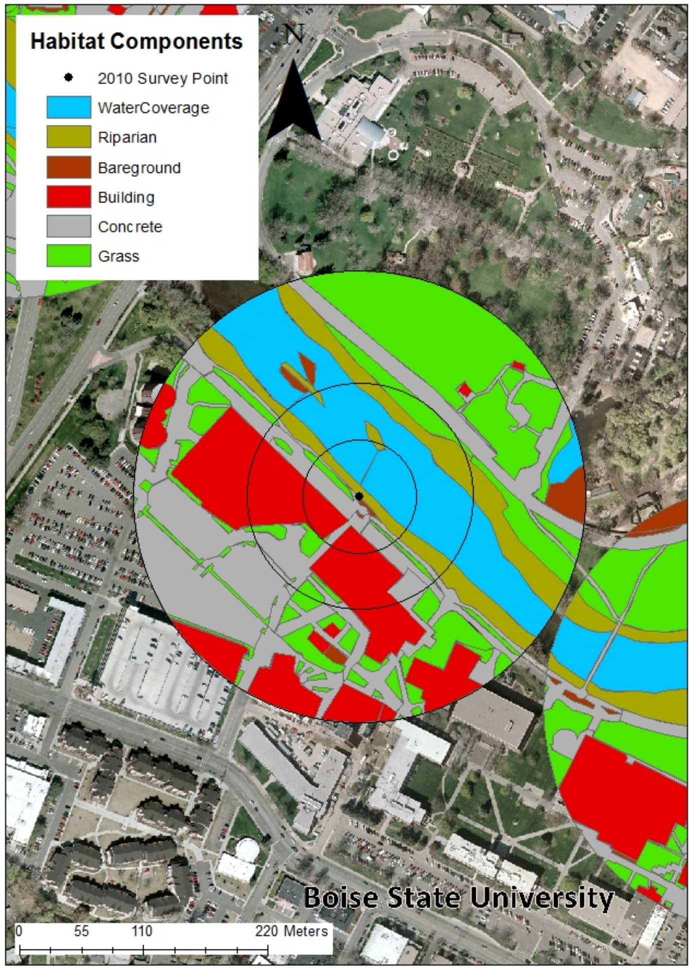

Figure 2 **Example of a site to which a 50m, 100m, and 200m buffer were placed around the center of the survey point. Using 2007 orthophotos the area was divided into 7 habitat or landscape components (site above has no brushland represented in the digitized area). From this the total area and percent composition was calculated for the components at the 3 different spatial scales.**

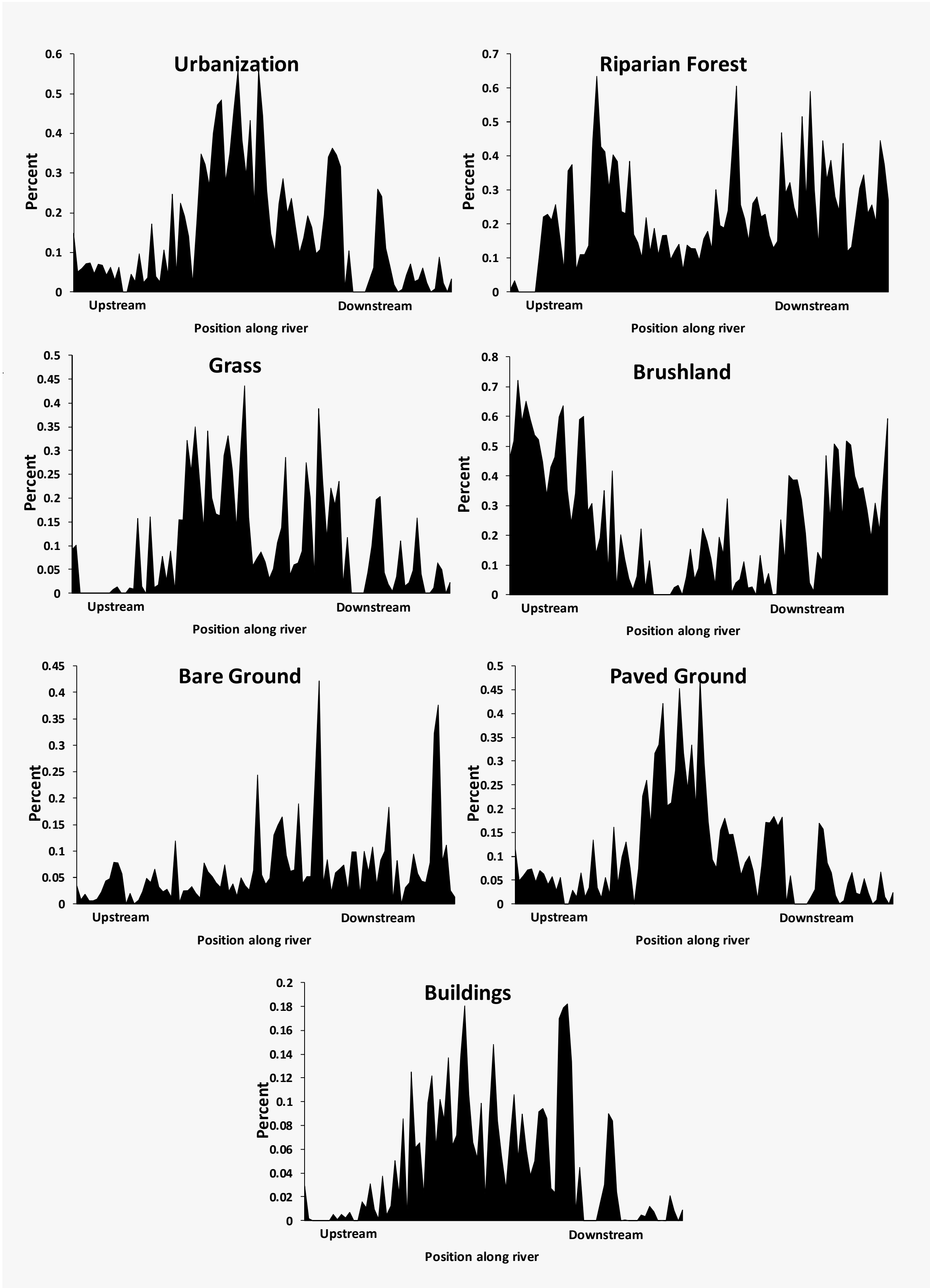
Urbanization
0.6
0.5
0.4
0.3
0.2
0.1
0
Percent
Upstream
Downstream
Position along river
Riparian Forest
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Percent
Upstream
Downstream
Position along river
Grass
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Percent
Upstream
Downstream
Position along river
Brushland
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Percent
Upstream
Downstream
Position along river
Bare Ground
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Percent
Upstream
Downstream
Position along river
Paved Ground
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Percent
Upstream
Downstream
Position along river
Buildings
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Percent
Upstream
Downstream
Position along river

Figure 3 Percent composition of the following landscape characteristics: urbanization (concrete + buildings), riparian Forest, grass, bare-ground, paved ground and buildings along the Boise River urban/riparian gradient. The largest peak on the urbanization chart represents the downtown Boise area.

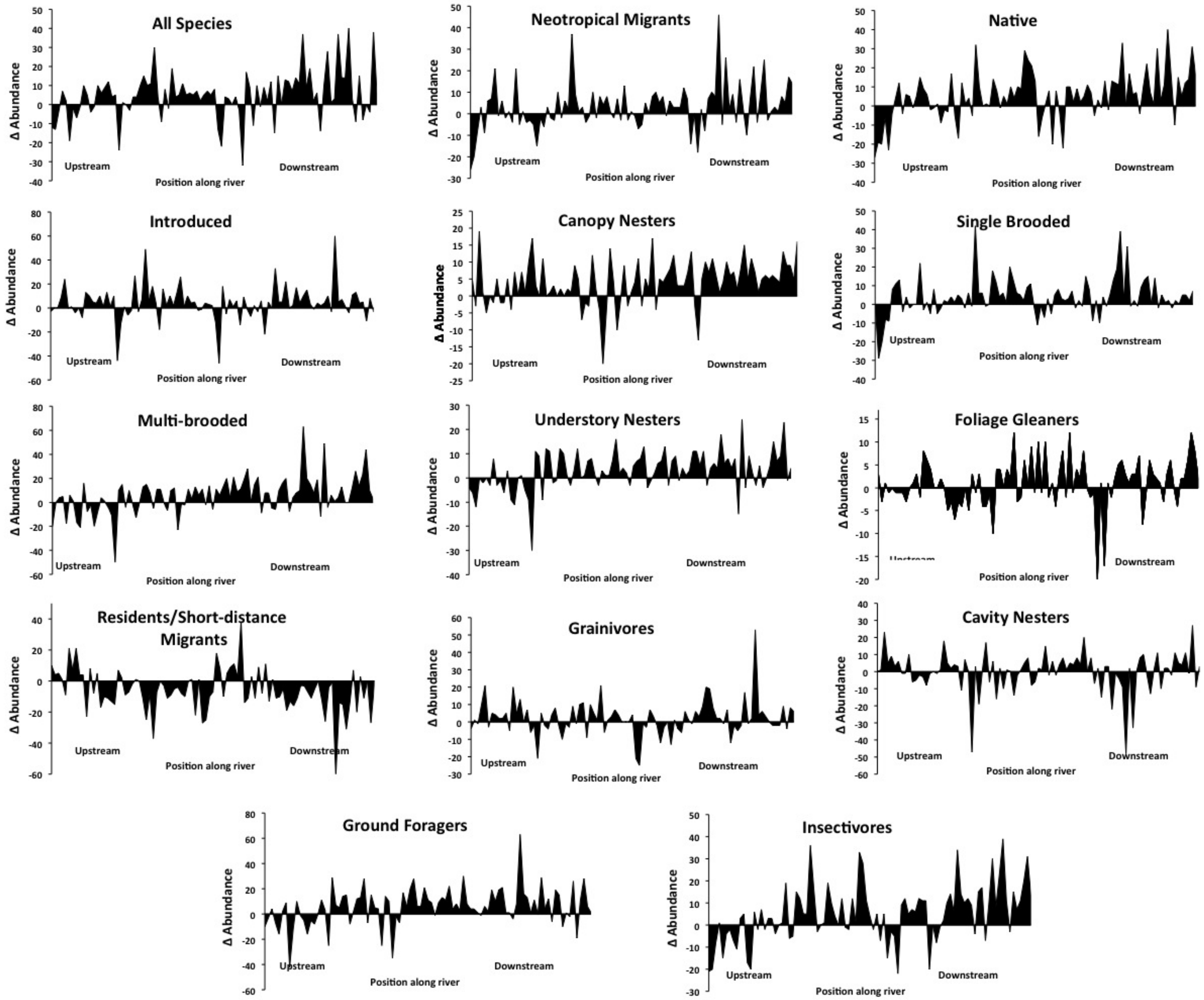
All Species
Δ Abundance
Upstream
Downstream
Position along river
Neotropical Migrants
Δ Abundance
Upstream
Downstream
Position along river
Native
Δ Abundance
Upstream
Downstream
Position along river
Introduced
Δ Abundance
Upstream
Downstream
Position along river
Canopy Nesters
Δ Abundance
Upstream
Downstream
Position along river
Single Brooded
Δ Abundance
Upstream
Downstream
Position along river
Multi-brooded
Δ Abundance
Upstream
Downstream
Position along river
Understory Nesters
Δ Abundance
Upstream
Downstream
Position along river
Foliage Gleaners
Δ Abundance
Downstream
Position along river
Residents/Short-distance Migrants
Δ Abundance
Upstream
Downstream
Position along river
Grainivores
Δ Abundance
Upstream
Downstream
Position along river
Cavity Nesters
Δ Abundance
Upstream
Downstream
Position along river
Ground Foragers
Δ Abundance
Upstream
Downstream
Position along river
Insectivores
Δ Abundance
Upstream
Downstream
Position along river

Figure 4 **Estimated change in abundance throughout the breeding season along the Boise River urban/riparian gradient for each of the following guilds: all species, neotropical migrants, natives, introduced, canopy nesters, single-brood, multi-brood, understory nesters, foliage gleaners, residents/short-distance migrants, granivores, cavity nesters, ground foragers, and insectivores. Change in abundance was calculated by using the highest ranked model of recruitment for each guild to estimate change in abundance between the first and last survey occasions.**