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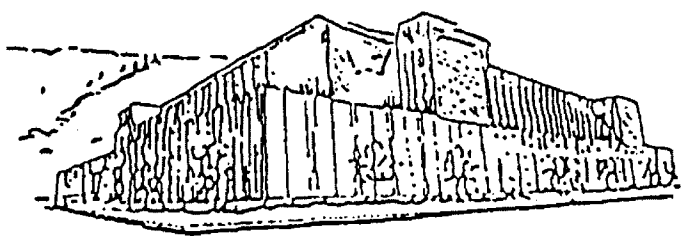
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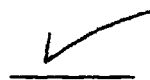
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COMPARISON OF BIRD COMMUNITIES
IN DEVELOPED, UNDEVELOPED, AND GREENBELT
RIPARIAN AREAS

by

Kelley P. Segars

M.S. The University of Montana, 1997

presented in partial fulfillment of the requirements

for the degree of

Master of Science

The University of Montana

1997

Approved by:



Chairperson



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Comparison of Bird Communities in Developed, Greenbelt, and Undeveloped Riparian Areas (40 pp.)

Director: Vicki Watson

VW

Over 90 percent of riparian areas in the western U.S. have been altered or eliminated by human activities. Residential development is increasing in the United States, so further change is expected. Riparian ecosystems are extremely important to wildlife, especially to songbirds. While the effects of residential development on songbirds have been studied for many years, the effects of development in riparian corridors on bird communities have not been adequately examined.

The purpose of this study was to compare bird communities among developed, greenbelt, and undeveloped riparian areas near Missoula, Montana. I was specifically interested in the hypothesis that streamside buffer zones (greenbelts) significantly reduce effects of development and maintain bird communities more similar to undeveloped sites.

The results showed that there were significant differences across the three riparian categories. Developed and greenbelt areas had more generalist species such as American Robin and European Starling. Brown-Headed Cowbirds were found in highest numbers on greenbelt sites. European Starling was absent on undeveloped sites. Winter Wren was found only on undeveloped sites. The House Finch was noted only on developed sites, and was one of the most common species in that bird community. The most abundant species on greenbelt sites was the Yellow Warbler. On undeveloped sites, the Black-capped Chickadee was the most abundant species.

The greenbelts provided some mitigation of effects of development. They shared more species with undeveloped than developed sites. Species abundance was greater on greenbelt sites than either undeveloped or developed for 29% of the species on which data analysis was performed. However, the diversity of developed and greenbelt sites was the same. The greenbelt sites also contained predatory and parasitic species, leading to the question of whether these areas are acting as ecological traps.

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Table of Contents

Abstract.....	ii
Acknowledgements.....	iii
List of Tables.....	v
Chapter	
I. Introduction.....	1
II. Study Area and Methods.....	3
III. Results.....	5
IV. Discussion.....	6
V. Implications for Management.....	11
VI. Appendices	
1. List of all species observed.....	13
2. Significant differences between treatments in species abundance.....	14
3. Description of sites.....	16
4. Literature review.....	19
5. Sampling data.....	24
VII. Literature Cited.....	37

List of Tables

Table 1		
	Mean number of birds per point in 3 types of riparian habitat near Missoula, Montana, 1997	7
Appendix 1		
	List of all species observed	13
Appendix 2		
	Significant differences between treatments in species abundance	14
Appendix 3		
	Description of sites	16
Appendix 5		
	Sampling data	24

INTRODUCTION

Riparian areas in the western U.S. are highly diverse and productive ecosystems. They are also severely threatened (Wright 1983, Knopf 1985). Approximately 95 percent of this habitat has been converted to other uses, or eliminated altogether (Saab and Groves 1992, Ohmart 1994). In western Montana, 59 percent of landbird species use riparian areas for breeding, and 36 percent of those are riparian obligates (Mosconi and Hutto 1982).

Residential development in the West frequently occurs within riparian areas. The most important aspects of residential development for native bird density is that the volume of vegetation, specifically native vegetation, changes (Mills and Carothers 1986, Mills et al 1989). Neotropical migrants have been found to be dependent on the amount of vegetation cover and foliage height diversity (Lancaster and Rees 1979). In addition, Mills et al. (1989) found that native species were negatively correlated with the number of houses and housing area. Under extreme development, urban and suburban bird communities tend to be dominated by a few ground-feeding omnivores, which is unusual in undeveloped areas (Howard 1973, Emlen 1974, Lancaster and Rees 1979, Bessinger and Osborne 1982, DeGraaf 1987).

While studies have documented the effects of residential development on bird communities, especially in the Southwest and the East (e.g. Aldrich and Coffin 1980, Emlen 1974, Howard 1973), these studies have not focused on riparian areas. Two exceptions are Croonquist and Brooks (1993), and

Smith and Schaefer (1992), both of which took place in the East. The differences between eastern and western riparian areas are significant, so there is a clear need for studies of the effect of urbanization on western riparian systems (Krueper 1993). Due to the importance and scarcity of riparian zones in the West, further impacts on this type of habitat should be carefully evaluated.

The purpose of this study was to determine how development alters riparian avian communities in western Montana. I also wished to assess whether leaving a streamside buffer zone, or greenbelt, reduces the effects of development on riparian bird communities.

STUDY AREA AND METHODS

The study was conducted on five creeks within a 40-km radius of Missoula, Montana ($46^{\circ} 50' 45''$ N, $114^{\circ} 3' 50''$ W). The study areas were located in foothill riparian habitat. The creeks were chosen primarily on the basis of their similarity in vegetation composition, stream size, elevation, and variation in degree of residential development. Sites within creeks were classified as either developed, greenbelt, or undeveloped. Developed sites were defined as those containing more than 2.5 houses per 100 m of stream. Greenbelt sites were defined as undeveloped streamside buffer zones (generally less than 700 m long and greater than 50 m wide) that were surrounded by residential development. Undeveloped sites were defined as those located at least 2 km from developed areas (although a few individual houses may have been within that distance).

Within each site, I established 2 point count stations that were at least 150 m apart. In developed sites, points were located in the yards of houses between 10 and 50 m from the creek, depending on the loudness of the water. In greenbelt and undeveloped sites, the points were located between 10 and 50 m from the creek, depending on the loudness of the water and the width of the riparian zone. I sampled bird communities in 12 developed sites, (5 on Rattlesnake Creek and 7 on Grant Creek), 5 greenbelt sites (3 on Rattlesnake Creek and 2 on Grant Creek), and 6 undeveloped sites (2 on West Fork Schwartz Creek, 3 on Lolo Creek, and 1 on Howard Creek).

I and my assistant sampled breeding birds from 27 May through 12 June 1997. All points were sampled three times using standard point-count methodology (Ralph et al. 1993). Sampling began at sunrise and was completed within 3 hr on calm, clear mornings. Counts began at different points each day to avoid time-of-day biases. Counts lasted 10 min, during which time all birds seen or heard were noted. Species detected flying over the census area were noted separately. Prior to the study, a training period was used to intercalibrate observations between observers and minimize inter-observer bias.

Before testing for differences among riparian categories, I first averaged observations across the 3 visits for each point. These averages were then used in a Mann-Whitney U-test for each species that was observed more than three times during the study. Quotient of similarity (Sorensen 1948) was used to determine the degree of similarity between the three types of bird communities. This similarity index is based only on presence of species, not abundance.

RESULTS

We detected 57 bird species across all points. Of those, 34 were observed more than three times during the census period (Table 1). Species richness was highest (38) on the developed and greenbelt census points; the richness for undeveloped points was 30. Although the greenbelt avian community was more similar to the developed community in diversity, it was more similar to the undeveloped community in species composition, with a similarity index of 0.71, compared to 0.66.

The most abundant bird species on the developed sites were the American Robin (*Turdus migratorius*), Black-Capped Chickadee (*Parus atricapillus*), and House Finch (*Carpodacus mexicanus*). The most abundant species on greenbelt sites were Yellow Warbler (*Dendroica petechia*), Black-Capped Chickadee, American Redstart (*Setophaga ruticilla*), Song Sparrow (*Melospiza melodia*), American Robin, and Brown-Headed Cowbird (*Molothrus ater*). The most abundant species on undeveloped sites were Black-Capped Chickadee, Warbling Vireo (*Vireo gilvus*), and Yellow Warbler.

DISCUSSION

If vegetation structure determines bird diversity, one would expect that the greenbelt avian diversity and composition would be more similar to undeveloped sites than developed. However, due to the difference in size between greenbelts and undeveloped areas, one might expect greenbelts to be intermediate between undeveloped and developed plots. Greenbelts have the vegetation structure of undeveloped sites (e.g. several layers of vegetation, abundant woody vegetation), but also contain exotic vegetation such as Norway Maple (*Acer platanoides*). I was not surprised to find that the greenbelt avian community was more similar in composition to the undeveloped community. In assessing whether the greenbelt was mitigating the effects of development, I determined species abundance in greenbelt was intermediate between undeveloped and developed for 26% of the species for which data analysis was performed (Table 1). Species abundance was greater on greenbelt sites than either developed or undeveloped sites for 29% of the species. These percentages suggest that greenbelts reduce some of the effects of development, but do not completely mitigate its effect.

Combined with the data showing high similarity between undeveloped and greenbelt bird communities, the equal diversity (38) found on developed and greenbelt sites seems to suggest that the greenbelt communities represent a blending of the 2 communities, with a loss of 3 undeveloped community members and 5 developed community members. For example, European

Table 1

Mean number of birds per point in 3 types of riparian habitat near Missoula, Montana, 1997.

Species	Treatment		
	Undevel	Greenbelt	Devel
Ruffed Grouse (<i>Bonasa umbellus</i>)	0.14 c	*	*
Calliope Hummingbird (<i>Stellula calliope</i>)	* b	—	0.10
Willow Flycatcher (<i>Empidonax traillii</i>)	0.11 a	0.10	*
Hammond's Flycatcher (<i>Empidonax hammondi</i>)	*	*	0.17
Western Wood-Pewee (<i>Contopus sordidulus</i>)	0.44 b	—	0.11
Tree Swallow (<i>Tachycineta bicolor</i>)	—	0.23	0.42
Black-billed Magpie (<i>Pica pica</i>)	—	0.17	0.21
American Crow (<i>Corvus brachyrhynchos</i>)	0.14 c	*	0.10
Common Raven (<i>Corvus corax</i>)	* a	0.10	0.06
Black-capped Chickadee (<i>Parus atricapillus</i>)	0.94 a	0.93	1.30
Red-breasted Nuthatch (<i>Sitta canadensis</i>)	0.08 a	0.10	—
Winter Wren (<i>Troglodytes troglodytes</i>)	0.17	—	—
Ruby-crowned Kinglet (<i>Regulus calendula</i>)	0.36 c	0.13	0.22
Swainson's Thrush (<i>Catharus ustulatus</i>)	0.17 c	*	0.08
American Robin (<i>Turdus migratorius</i>)	0.14 c	0.60	2.14
Gray Catbird (<i>Dumetella carolinensis</i>)	0.20 c	0.13	*
European Starling (<i>Sturnus vulgaris</i>)	—	0.20	0.17
Solitary Vireo (<i>Vireo solitarius</i>)	0.14 a	0.20	—
Red-eyed Vireo (<i>Vireo olivaceus</i>)	—	0.10	0.14
Warbling Vireo (<i>Vireo gilvus</i>)	0.70 c	0.27	0.28
Yellow-rumped Warbler (<i>Dendroica coronata</i>)	0.17 c	0.13	0.04
Yellow Warbler (<i>Dendroica petechia</i>)	0.64 a	1.27	0.58
MacGillivray's Warbler (<i>Oporornis tolmiei</i>)	0.42 c	0.33	0.40
American Redstart (<i>Setophaga ruticilla</i>)	0.42 c	0.93	0.18
Black-headed Grosbeak (<i>Pheucticus melanocephalus</i>)	0.08 a	0.30	0.15

Lazuli Bunting (<i>Passerina amoena</i>)	0.08 a	0.10	—
Song Sparrow (<i>Melospiza melodia</i>)	0.31 a	0.80	0.39
Rufous-sided Towhee (<i>Pipilo erythrophthalmus</i>)	0.11 a	*	—
Chipping Sparrow (<i>Spizella passerina</i>)	* a	*	0.24
Dark-eyed Junco (<i>Junco hyemalis</i>)	0.36 c	0.10	0.09
Yellow-headed Blackbird (<i>Xanthocephalus xanthocephalus</i>)	—	—	0.06
Brown-headed Cowbird (<i>Molothrus ater</i>)	0.08 c	0.50	0.42
Common Grackle (<i>Quiscalus quiscula</i>)	—	—	0.14
House Finch (<i>Carpodacus mexicanus</i>)	—	—	0.70

— species was not observed

* species observed fewer than four times

a mean differs significantly from developed at $\alpha = 0.05$ (Mann-Whitney U-test)

b mean differs significantly from greenbelt at $\alpha = 0.05$

c mean differs significantly from both developed treatments at $\alpha = 0.05$

Starling (*Sturnus vulgaris*) was found only on developed and greenbelt sites, and was more abundant on greenbelt points. Black-billed Magpie (*Pica pica*) was found in significant numbers only on developed and greenbelt sites. Winter Wren (*Troglodytes troglodytes*) was found only on undeveloped sites. Rufous-sided Towhee (*Pipilo erythrophthalmus*) and Ruffed Grouse (*Bonasa umbellus*) were species observed in significant numbers only on undeveloped sites, and rarely on greenbelt sites.

Brown-Headed Cowbirds were observed most frequently on greenbelt points. Brown-headed cowbirds are obligate brood parasites, meaning they lay their eggs in the nests of other species. The host species usually incubates the cowbird egg(s) and then feeds the nestling(s), often at the expense of the host's young. Species such as Yellow Warbler, Warbling Vireo, and American Redstart were also found in high numbers in greenbelt areas. These species are frequent cowbird hosts.

Of the species found in higher numbers on greenbelt sites than undeveloped sites, many are tree-nesting foliage-gleaners such as American Robin, American Redstart, and Black-headed Grosbeak. Many of those noted in higher numbers on undeveloped sites are shrub-nesters such as MacGillivray's Warbler, Swainson's Thrush, and Ruffed Grouse. Two species, Dark-eyed Junco and Rufous-sided Towhee, are also ground-gleaners. This could be a result of the high level of disturbance in greenbelts from human-related activity (hiking, biking, pets) compared to undeveloped areas. All of the

greenbelt points on Rattlesnake Creek were located along paths used for hiking or biking.

The higher diversity of the developed and greenbelt sites compared to undeveloped sites may be at least partly an artifact of site selection. For this study, I examined aerial photographs and drove up many streams trying to locate suitable undeveloped sites. It is difficult to access streams near Missoula that possess wide riparian zones with dense native vegetation and are not developed. The greenbelts I used contained wider riparian zones than most of the undeveloped sites. This could be because the streams with wide riparian areas were more attractive to developers. The ones surrounded by steep hillsides would not be as easily developed. It may be that there are wide riparian areas with dense vegetation on streams that are not accessible. My search was restricted to a 40-km radius of Missoula, which also helps to explain the difficulty in finding suitable undeveloped streams. It may be that we have lost the ability to study the issue of development in riparian areas because there are no adequate control areas left undeveloped.

IMPLICATIONS FOR MANAGEMENT

Are greenbelts the answer to maintaining wildlife in urban and suburban areas? Stauffer and Best (1980) report that the minimum mean width of plots necessary to support breeding populations of Warbling Vireos is 90 m, while American Redstart and Rufous-sided Towhee (*Pipilo erythrophthalmus*) require 200 m. Spackman and Hughes (1995) state that a 150-175-m wide streamside buffer is needed to maintain 90-95% of bird species. The greenbelts I investigated were 50-150 m wide.

Geis (1986) states that: "The single most important environmental factor causing desirable urban bird populations was the amount of woody vegetation present." Older neighborhoods with small lots and an abundance of mature shrubs had high densities of birds. Adams (1994) proposes cluster zoning as a way to mitigate impact on wildlife. He states: "Large-lot, residential zoning on the order of 2 to 3 acres (0.8 to 1.2 ha) is particularly destructive" because it "sprawls structures over the landscape."

Protecting riparian zones as greenbelts means more habitat is available for songbirds than in areas where the riparian zone is cleared for lawns. However, the proximity to developed areas means that the greenbelts also have high numbers of Brown-Headed Cowbirds, along with generalist species like European Starling and American Robin. The European Starling is an introduced species which competes with other species for cavity nests. These factors lead to the question of nest success within these areas. Although this

study makes it appear that the greenbelts hold rich bird communities, further study needs to assess the nest success rates, focusing on parasitism and predation. The types of predators should also be studied to determine if they are coming in from developed areas (e.g. cats). The greenbelts could be serving as an ecological trap, meaning that the healthy riparian vegetation makes the area appear to be ideal breeding grounds, but the presence of cowbirds and predators and the proximity of humans results in high rates of nest and adult mortality.

This study found that buffer zones and greenbelts between 50- and 150-m can maintain avian communities about 70% similar to undeveloped areas in composition. However, predators, brood parasites, and other destructive elements still have access to these areas from the residential development. If greenbelts are serving as ecological traps because of nest parasites and predators, then we need to resolve whether greenbelts are actually doing more harm than good to wildlife populations. There are other important reasons for having streamside buffer zones, including maintaining water quality and aquatic habitat. Until further study is done to examine the ecological trap hypothesis in riparian greenbelts, I would recommend avoiding locating new developments in riparian areas. There is simply not enough of this habitat left intact in the western U.S.

Appendix 1

List of all species observed

Family Ardeidae	Ruby-crowned Kinglet
Great Blue Heron	Western Bluebird
Family Anatidae	Veery
Common Merganser	Swainson's Thrush
Family Accipitridae	American Robin
Red-tailed Hawk	Family Lanidae
Family Phasianidae	Northern Shrike
Ruffed Grouse	Family Mimidae
Family Trochilidae	Gray Catbird
Calliope Hummingbird	Family Sturnidae
Family Alcendinidae	European Starling
Belted Kingfisher	Family Vireonidae
Family Picidae	Solitary Vireo
Northern Flicker	Red-eyed Vireo
Red-naped Sapsucker	Warbling Vireo
Downy Woodpecker	Family Emberizidae
Hairy Woodpecker	Orange-crowned Warbler
Pileated Woodpecker	Yellow-rumped Warbler
Family Tyrannidae	Townsend's Warbler
Western Wood-Pewee	Yellow Warbler
Dusky Flycatcher	MacGillivray's Warbler
Hammond's Flycatcher	American Redstart
Family Hirundinidae	Black-headed Grosbeak
Tree Swallow	Lazuli Bunting
Family Corvidae	Rufous-sided Towhee
Steller's Jay	Song Sparrow
Clark's Nutcracker	Chipping Sparrow
Black-billed Magpie	Dark-eyed Junco
American Crow	Yellow-headed Blackbird
Common Raven	Brown-headed Cowbird
Family Paridae	Common Grackle
Black-capped Chickadee	Northern Oriole
Family Sittidae	Western Tanager
Red-breasted Nuthatch	Family Fringillidae
Family Troglodytidae	American Goldfinch
House Wren	Pine Grosbeak
Winter Wren	House Finch
Family Muscicapidae	

Appendix 2 Significant differences between treatments in species abundance

SPECIES	DEVEL VS	GREEN VS	UNDEV VS
	UNDEV	DEVEL	GREEN
Ruffed Grouse	** undev	** green	** undev
Calliope Hummingbird	* devel	absent on green	absent on green
Willow Flycatcher	-	** green	** green
Hammond's Flycatcher	** undev	-	** undev
Western Wood-pewee	** undev	absent on green	absent on green
Tree Swallow	absent on undev	** devel	absent on undev
Black-billed Magpie	absent on undev	-	absent on undev
American Crow	* devel	-	** green
Common Raven	-	** green	** green
Black-capped Chickadee	-	-	** undev
Red-breasted Nuthatch	absent on devel	absent on devel	** green
Ruby-crowned Kinglet	** undev	-	** undev
Swainson's Thrush	** undev	** devel	** undev
American Robin	** devel	-	** green
Gray Catbird	** undev	** green	** undev
Solitary Vireo	absent on devel	absent on devel	** green

Red-eyed Vireo	absent on undev	** green	absent on undev
Warbling Vireo	** undev	-	** undev
Yellow-rumped Warbler	** undev	** green	** undev
Yellow Warbler	-	** green	** green
MacGillivray's Warbler	* undev	* green	** undev
American Redstart	* undev	** green	** green
Black-headed Grosbeak	-	** green	** green
Lazuli Bunting	absent on devel	absent on devel	** green
Song Sparrow	-	** green	** green
Chipping Sparrow	-	-	** undev
Dark-eyed Junco	** undev	-	** undev
Brown-headed Cowbird	* devel	** green	** green
European Starling	absent on undev	* green	absent on undev
Rufous-sided Towhee	absent on devel	absent on devel	** undev
Northern Flicker	absent on undev	** green	absent on undev

* difference is significant @ 5% confidence level

** difference is significant @ 1% confidence level

- no significant difference

Appendix 3 Description of sites

Developed**Rattlesnake**

- Point 1* City Drive, on the street 25 m. from the footbridge
mostly lawn, sparse ornamental trees and shrubs, no streamside buffer
- Point 2* Charis Court, in the middle of the circle near Apartments 5 and 6
narrow streamside buffer (less than 5-m wide) of small shrubs and
mature trees, mature ponderosa pines
- Point 3* 2209 Missoula St., mostly lawn, no streamside buffer
- Point 4* 2321 Wylie St., mostly lawn, sparse trees and shrubs, a few shrubs
along stream edge
- Point 5* 2502 Sycamore, mostly lawn, narrow streamside buffer (less than 10-
m), horse pasture approximately 100 m away, adjacent to empty lot with
weeds
- Point 6* 2614 Scyamore, mostly lawn with sparse trees and shrubs, cat seen
nearby, adjacent to a garden, medium streamside buffer (10-m wide)
- Point 7* 3019 Old Pond Rd., mostly lawn in front, backyard very small, a few
streamside ornamental shrubs. A bridge crosses a branch of the creek
and leads to a park-like area, some mature cottonwoods
- Point 8* 3313 Old Pond Rd., mostly lawn right up to the creek
- Point 9* 4125 Fox Farm Rd., small yard, mostly lawn, narrow shrub border on
stream
- Point 10* 4501 Fox Farm Rd., mostly lawn, very narrow streamside buffer,
adjacent to park area

Grant

- Point 1* 5428 Prospect Dr., large yard, mostly lawn, wide streamside buffer
(approximately 30-m)
- Point 2* 5446 Prospect Dr., medium yard, mostly lawn, hummingbird feeder
and bird feeder, wide streamside buffer (50-m)
- Point 3* 2519 Comstock Ct., large yard, mostly lawn, two hummingbird
feeders, 25-m wide streamside buffer
- Point 4* 2502 Klondike Ct., large yard, mostly lawn, 50-m streamside buffer,
grazed field 75-m away
- Point 5* 7165 Old Grant Creek Rd., small yard, half lawn and half low shrubs
(snowberry), 25-m streamside buffer
- Point 6* 7405 Old Grant Creek Rd., medium-sized yard, mostly lawn, no
streamside buffer on house side, wide buffer zone on other side of creek
- Point 7* 1195 Rankin Rd., 15-m streamside buffer, large yard, mostly lawn,
garden plot, purple martin house with 12 compartments, several bird

houses and bird feeders

Point 8 9015 Pickering Ln., large yard, mostly lawn, 10-15-m streamside buffer, garden plot

Point 9 9275 Springfield, large yard, mostly lawn, no streamside buffer along most of backyard, adjacent to empty lots with mostly shrubs and mature trees, five bird houses and several bird feeders

Point 10 9620 Nevada Trail, large yard, mostly lawn, 20-25-m streamside buffer, sparse mature shrubs in yard

Point 11 Snowbowl Rd., on northeast side of bridge, large yard, mostly lawn, 10-m streamside buffer

Point 12 10005 Grant Creek Rd., large yard, mostly lawn, no streamside buffer, adjacent to areas with thick riparian vegetation, bird feeder and bird house

Point 13 10295 Grant Creek Rd., large yard, mostly lawn, no streamside buffer

Point 14 10405 Grant Creek Rd., large yard, mostly lawn in front, half lawn and half low and medium shrubs in back, 5-m streamside buffer for half of yard

Greenbelt

Rattlesnake

Points 1 and 2 Greenough Park, thick riparian vegetation, large cottonwood and aspen, wide streamside buffer (more than 50-m)

Points 3 and 4 Tom Green Park, large cottonwood and aspen, thick riparian vegetation

Points 5 and 6 Rattlesnake Recreation Area, just south of the dam, cow pasture 100-m away, extremely dense riparian vegetation, mature cottonwoods and aspen

Grant

Points 1 through 4 Wild Bird Sanctuary, dense riparian vegetation, mature cottonwoods and aspen

Undeveloped

West Fork Schwartz Creek

Points 1 through 4 narrow riparian zone, mature cottonwoods and aspen, undergrowth not very dense, steep hillsides surround stream zone

Mormom Creek

Points 5 and 6 narrow riparian zone, mature ponderosa pines and some

large aspen, thick medium-sized and small shrubs

Lolo Creek

Points 7 and 8 Fort Fizzle, riparian zone mixed with conifer, large cottonwood and aspen, thick riparian vegetation, adjacent to parking lot and large picnic area

Points 9 and 10 Lewis and Clark Campground, wide riparian zone, thick vegetation, no large aspen or cottonwoods, large conifers, adjacent to small picnic area, campground on other side of creek approximately 100-m away

Points 11 and 12 Mormon Creek Rd., narrow riparian zone, large cottonwoods and aspen, thick vegetation

Appendix 4

Literature Review

Characteristics of urban and suburban areas that affect wildlife, particularly birds, include: lawns, isolated trees, bird feeders, design of buildings (e.g. type of vents and eaves), exotic vegetation (both landscaping and weeds), domestic predators, human disturbance, presence of water (e.g. watering of lawns and gardens), and traffic (Leedy and Adams 1986). The most important aspects of residential development in regard to bird density is the volume of vegetation, specifically native vegetation (Mills and Carothers 1986, Mills et al 1989). The most important vegetation attributes for bird abundance are: tree species and diversity, vegetation height diversity and foliage volume (Stauffer and Best 1980). The presence of both coniferous and deciduous trees, and the density of trees have also been cited as positive factors for birds in urban area (Adams 1994). Robbins et al (1993) stress the importance of having "a high diversity of microhabitats with green vegetation at all heights." Mills et al (1989) cautions:

Although it may be possible to maintain natural densities of territorial native birds by using native plants in landscaping, one cannot merely duplicate the original volume without considering the predevelopment distribution of volume among layers and plant species. Both the amount (volume) and types of plants used are important.

Changes in vegetation are not the only factors influencing bird communities in urban habitats. Factors such as predators, traffic, and other human activities can have significant negative effects on birds (Emlen 1974). In 1990, there were an estimated 54.5 million pet dogs and 63.2 million pet cats, in addition

to feral animals, in the United States. The estimated total of pet and feral cats in the U.S. is 100 million (Coleman et al 1997). An individual free-ranging cat can kill as many as 1000 wild animals each year (Bradt 1949). A study in England estimated that 70 million birds and small mammals are killed by cats each year. In Wisconsin, the mortality rate is estimated at 39 million birds per year (Coleman and Temple 1996). In California, cats caused 24 percent of the known mortality of mourning doves (Adams 1994). Even when fed regularly, a cat will continue to hunt (Adamec 1976).

Predators are not the only cause of avian mortality in urban and suburban areas. Tens of millions of birds in the U.S. die each year due to collisions with windows or plate glass (Klem, Jr. 1987).

Bird feeders also have a significant effect on bird communities in residential areas (Lancaster and Rees 1979, Mills et al 1989). Each year in the U.S., 82 million people feed birds more than one billion pounds of seed (Adams 1994). Lancaster and Rees (1979) caution that feeders are not necessarily beneficial:

This subsidy, however, is largely restricted to seeds, grains, bread, food processing wastes, and table scraps made available at point sources or on ground level surfaces. Thus, the quality of such urban food enhances only a few species, or species that defend nest sites only.

Urban and suburban bird communities tend to be dominated by a few ground-feeding omnivores (Howard 1973, Emlen 1974, Lancaster and Rees 1979, Bessinger and Osborne 1982, DeGraaf 1987). Due to high densities of these

species, avian biomass and numbers of individuals increase in developed areas (Emlen 1974, Bessinger and Osborne 1982, Duncan et al 1986, Mills et al 1989, Adams 1994). The density of exotic species is strongly correlated with exotic vegetation volume and the area of lawn (Mills et al 1989). House sparrow and European starling are two of the most abundant species in urban/suburban areas (Howard 1973, Lancaster and Rees 1979). These species are exotic cavity-nesters which displace native cavity-nesters. They are most abundant in residential areas dominated by lawns (Lancaster and Rees 1979, Aldrich and Coffin 1980). In fact, house sparrow numbers are negatively correlated with amount of vegetative cover (Lancaster and Rees 1979). Ground-gleaning insectivores can increase with development because of the availability of lawns to forage in (Emlen 1974).

Many avian guilds are negatively correlated with residential development, including ground nesters, cavity nesters, warblers, and insectivores (Aldrich and Coffin 1980, DeGraaf and Wentworth 1986, DeGraaf 1987, Franklin 1986). DeGraaf reports that insectivores are associated with tree cover and woodlots, rather than development. He states that:

Planted trees, no matter how mature or abundant, apparently do not replace natural forest stands as breeding habitat for insectivorous birds. Edge species will probably continue to thrive in suburbs, but for insectivorous migratory species, which have been used as measures of avifaunal quality, natural woodland must be retained wherever possible.

Neotropical migrants have been found to be dependent on the amount of

vegetation cover and foliage height diversity (Lancaster and Rees 1979). Mills et al (1989) found that native species were negatively correlated with the number of houses and housing area. Johnson and Van Druff (1987) discovered that native species were negatively correlated with building volume, the number of humans and automobiles, and the age of structures. Species not usually found in suburban areas include: pileated woodpecker, least flycatcher, tree swallow, winter wren, solitary vireo, warbling vireo, and Swainson's thrush (DeGraaf 1987).

Although DeGraaf assumes that edge species "will probably continue to thrive in suburbs," there is some evidence to the contrary. Howard (1973) found that American robins in residential areas were not producing enough young to replace the population. Howard states that there was low productivity of young "despite multiple nesting attempts by almost every pair." The low nest success rate was due to human disturbance, predation, and low food supply. The "carefully tended gardens and lawns" meant that there was little leaf litter for the robins to forage in. The local abundance of robins was the result of individuals coming in from other areas.

Studies of residential development's effects on bird communities have taken place in the Southwest and the East (e.g. Aldrich and Coffin 1980, Emlen 1974, Howard 1973). With the amount of development taking place in the Northwest, especially western Montana, these areas should be examined. Riparian areas have seemingly been neglected in urbanization studies. Smith and Schaefer

(1992) looked at urban riparian zones in Florida; however, the differences between eastern and western riparian areas are significant (Krueper 1993). Due to the importance and scarcity of riparian zones in the West, further impacts on this type of habitat should be carefully evaluated. Residential development may seem to have less impact than other types of conversion, but activities such as rip-rap and channelization often accompany neighborhoods. Also, while activities like grazing can be excluded from the riparian zone at any time, once a subdivision is built, there is little chance of restoring the area.

Appendix 5		Sampling data	* indicates overflight
<u>Treatment</u>	<u>Site-Point</u>	<u>Species</u>	<u>Average count over 3 visits</u>
dev	Ra 1-1	robin	4.7
		chickadee	2.0
		magpie	0.3
		y. warbler	1.3
		merganser	0.3 *
		s. sparrow	1.3
		cowbird	0.3
		blackbird	1.7
		h. finch	0.7
		raven	0.3 *
		t. swallow	1.0 *
		flicker	0.3 *
dev	Ra 1-2	robin	4.3
		crow	0.3
		magpie	1.3
		s. sparrow	0.7
		goldfinch	0.3 *
		grackle	0.7
		starling	0.3
		h. wren	0.3
		w. flycatcher	0.3
		m. warbler	0.3
		cowbird	0.3
		dev	Ra 2-1
		chickadee	1.3
		d. woodpecker	0.3
		merganser	0.3 *
		cowbird	0.7
		b. grosbeak	0.7
		h. finch	1.0
		starling	0.3
		magpie	0.3
		y. warbler	0.3
		s. sparrow	0.7
dev	Ra 2-2	robin	3.7
		chickadee	1.3
		h. finch	1.3
		y. warbler	1.7

		goldfinch	0.3
		redstart	0.3
		b. grosbeak	0.3
		starling	0.3
		s. sparrow	0.7
		junco	0.3
		r. kinglet	0.3
		cowbird	0.3
dev	Ra 3-1	robin	1.3
		chickadee	0.3
		h. finch	0.7
		raven	0.3
		magpie	0.7
		grackle	0.7
		t. swallow	1.0 *
		s. sparrow	0.3
		c. sparrow	0.3
		cowbird	0.7
		y. warbler	0.3
dev	Ra 3-2	robin	2.3
		chickadee	2.0
		h. finch	1.7
		starling	0.7
		raven	0.7 *
		magpie	0.7
		redstart	0.3
		cowbird	1.3
		c. sparrow	0.7
		s. sparrow	0.3
		d. flycatcher	0.3
dev	Ra 4-1	robin	2.3
		chickadee	2.3
		cowbird	0.7
		s. sparrow	0.7
		c. sparrow	0.7
		t. swallow	2.0 *
		y. warbler	0.3
		merganser	0.3 *
		cowbird	0.3

dev	Ra 4-2	robin	1.7	
		magpie	0.3	
		cowbird	1.0	
		grackle	0.3	
		starling	0.3	
		s. sparrow	0.3	
		redstart	0.3	
		flicker	0.3	
dev	Ra 5-1	chickadee	2.0	
		starling	0.3	
		cowbird	0.7	
		t. swallow	0.7 *	
		s. sparrow	0.3	
		robin	1.7	
		c. sparrow	0.3	
		wood-pewee	0.3	
		redstart	0.3	
		h. finch	0.3	
		y. warbler	0.3	
		m. warbler	0.3	
		dev	Ra 5-2	robin
chickadee	1.0			
y-r. warbler	0.7			
s. sparrow	1.0			
c. hummingbird	0.7			
redstart	0.7			
h. finch	1.0			
y. warbler	0.3			
m. warbler	0.3			
r. kinglet	0.3			
dev	Gr 1-1			robin
		h. finch	1.0	
		y. warbler	1.3	
		r. kinglet	0.3	
		starling	0.3 *	
		crow	0.3	
		w. vireo	1.0	
		redstart	0.3	
		w. bluebird	0.3	
		cowbird	0.3	

		junco	0.3	
		y. warbler	1.3	
		s. sparrow	0.3	
		chickadee	1.3	
		m. warbler	0.3	
		o. warbler	0.3	
		catbird	0.3	
dev	Gr 1-2	robin	4.3	
		crow	1.0 *	
		magpie	0.3 *	
		s. thrush	0.7	
		y. warbler	1.3	
		b. grosbeak	0.3	
		t. swallow	1.0 *	
		cowbird	0.7	
		chickadee	0.7	
		s. sparrow	0.3	
		h. finch	1.3	
		m. warbler	0.7	
		c. hummingbird		0.7
dev	Gr 2-1	robin	1.3	
		h. finch	2.7	
		h. wren	0.3	
		cowbird	0.3	
		s. thrush	0.7	
		chickadee	0.7	
		s. sparrow	0.7	
		m. warbler	0.7	
		flicker	0.3	
dev	Gr 2-2	robin	2.7	
		h. finch	0.3	
		r. kinglet	0.7	
		starling	1.3	
		h. woodpecker	0.3	
		cowbird	0.3	
		s. sparrow	0.3	
		grackle	0.7	
		chickadee	0.7	
		s. sparrow	0.7	
		m. warbler	0.7	

		flicker	0.3	
dev	Gr 3-1	y. warbler	1.0	
		c. nutcracker	0.3 *	
		h. flycatcher	1.0	
		redstart	0.7	
		t. swallow	0.3 *	
		c. sparrow	0.3	
		robin	1.0	
		chickadee	0.3	
		h. finch	0.3	
		r. kinglet	0.3	
dev	Gr 3-2	robin	1.3	
		chickadee	0.3	
		r. kinglet	0.3	
		w. vireo	0.7	
		h. flycatcher	1.3	
		wood-pewee	0.3	
		magpie	0.3	
		grackle	0.7	
		t. swallow	2.3 *	
		y. warbler	0.3	
		c. hummingbird		0.3
		cowbird	0.3	
dev	Gr 4-1	robin	4.3	
		chickadee	1.3	
		h. finch	2.3	
		starling	0.7	
		b. grosbeak	0.3	
		c. sparrow	1.7	
		h. woodpecker	1.0	
		r. kinglet	0.3	
		w. vireo	0.3	
		raven	0.3 *	
		t. swallow	1.0 *	
		s. sparrow	0.3	
dev	Gr 4-2	robin	1.7	
		chickadee	1.3	
		h. finch	1.0	
		r. kinglet	0.7	
		w. vireo	0.7	

		d. flycatcher	1.0	
		cowbird	1.0	
		t. swallow	2.7 *	
		c. sparrow	0.7	
		s. sparrow	0.3	
		y. warbler	0.3	
dev	Gr 5-1	chickadee	2.3	
		h. finch	0.3	
		w. vireo	0.7	
		y. warbler	0.3	
		b. grosbeak	0.7	
		h. flycatcher	0.3	
		robin	0.3	
		s. sparrow	0.7	
dev	Gr 5-2	m. warbler	0.7	
		chickadee	1.7	
		r. kinglet	0.3	
		raven	0.3 *	
		y. warbler	1.0	
		b. grosbeak	0.7	
		c. hummingbird		1.0
		cowbird	0.7	
		m. warbler	2.0	
		robin	0.7	
		s. sparrow	0.7	
		d. flycatcher	0.7	
dev	Gr 6-1	w. vireo	0.7	
		robin	1.0	
		chickadee	1.3	
		r. kinglet	0.3	
		s. thrush	0.3	
		b. grosbeak	0.3	
		redstart	0.3	
		m. warbler	0.7	
		h. flycatcher	0.7	
		veery	0.3	
		n. shrike	0.3 *	
		r. vireo	0.3	
		r. grouse	0.3	
dev	Gr 6-2	robin	0.7	

		chickadee	1.7	
		w. vireo	1.7	
		y. warbler	0.7	
		c. sparrow	0.3	
		redstart	0.7	
		d. flycatcher	0.3	
		r. kinglet	0.3	
		m. warbler	1.3	
		s. sparrow	0.7	
		c. hummingbird		0.3
dev	Gr 7-1	robin	2.0	
		chickadee	1.7	
		r. kinglet	1.0	
		y. warbler	1.7	
		b. grosbeak	1.3	
		h. flycatcher	0.7	
		redstart	0.3	
dev	Gr 7-2	robin	1.3	
		chickadee	2.0	
		w. vireo	1.3	
		y. warbler	1.7	
		cowbird	0.7	
		m. warbler	0.3	
		s. sparrow	0.3	
		r. kinglet	0.3	
green	Ra 1-1	robin	2.0	
		crow	0.7 *	
		y. warbler	2.7	
		redstart	2.7	
		p. grosbeak	0.3	
		g. catbird	1.0	
		n. oriole	0.3	
		s. sparrow	1.0	
		chickadee	0.7	
		d. woodpecker	0.3	
		magpie	0.3	
		b. grosbeak	1.3	
		cowbird	0.7	
		starling	0.3 *	
		r. vireo	0.3	

green	Ra 1-2	robin	2.0	
		chickadee	1.7	
		magpie	1.3	
		y-r. warbler	0.7	
		s. sparrow	0.3	
		cowbird	0.7	
		redstart	1.3	
		r. nuthatch	0.3	
		y. warbler	1.0	
		w. vireo	0.3	
		b. grosbeak	0.3	
		m. warbler	0.3	
		s. vireo	0.3	
		green	Ra 2-1	robin
starling	1.3			
t. swallow	0.7			
p. woodpecker	0.7			
chickadee	1.3			
y. warbler	1.0			
h. flycatcher	0.3			
s. sparrow	0.3			
flicker	0.3			
catbird	1.0			
green	Ra 2-2	robin	0.7	
		chickadee	2.0	
		c. sparrow	0.3	
		s. sparrow	2.3	
		raven	0.3 *	
		y. warbler	0.3	
		green	Ra 3-1	chickadee
r. kinglet	0.3			
r. nuthatch	0.3			
w. vireo	1.7			
y. warbler	1.7			
m. warbler	1.0			
redstart	1.3			
s. sparrow	0.7			
p. grosbeak	0.3			
cowbird	0.7			
		c. hummingbird	0.3	

green	Ra 3-2	w. flycatcher	0.3		
		robin	0.7		
		chickadee	0.7		
		w. vireo	1.3		
		y. warbler	1.7		
		redstart	1.0		
		m. warbler	1.0		
		cowbird	1.0		
		s. sparrow	0.7		
		t. swallow	1.0 *		
		r. hawk	0.3		
		r. towhee	0.3		
		o. warbler	0.3		
		r. kinglet	0.3		
		w. flycatcher	0.3		
		raven	0.3 *		
		b. grosbeak	0.3		
		w. tanager	0.3		
		l. bunting	0.3		
green	Gr 1-1	w. vireo	0.3		
		b. grosbeak	0.7		
		g. heron	0.3		
		l. bunting	1.0		
		s. sparrow	1.0		
		redstart	0.3		
		t. swallow	0.7 *		
		cowbird	0.7		
		chickadee	0.3		
		s. thrush	0.3		
		s. vireo	0.7		
		y. warbler	0.7		
		w. flycatcher	0.3		
		junco	0.3		
		robin	0.3		
		y-r. warbler	0.3		
		green	Gr 1-2	r. vireo	0.7
				s. sparrow	0.7
				redstart	0.7
s. vireo	0.7				
cowbird	1.0				

		s. thrush	0.3	
		y. warbler	0.7	
		b. grosbeak	0.3	
		r. grouse	0.3	
green	Gr 2-1	chickadee	0.3	
		r. kinglet	0.3	
		w. vireo	0.3	
		y. warbler	1.7	
		s. sparrow	0.3	
		redstart	1.0	
		cowbird	0.3	
		junco	0.3	
		s. thrush	0.3	
		w. flycatcher	0.3	
		chickadee	0.3	
		s. vireo	0.3	
		b. grosbeak	0.3	
		m. warbler	0.3	
		l. bunting	0.3	
green	Gr 2-2	g. heron	0.3 *	
		chickadee	1.7	
		w. vireo	0.7	
		y. warbler	1.0	
		b. grosbeak	1.0	
		r. nuthatch	0.3	
		junco	0.3	
		r. kinglet	0.3	
		r. grouse	0.3	
		cowbird	0.3	
		l. bunting	0.3	
		redstart	0.3	
		y-r. warbler	0.3	
undev	Sch 1-1	chickadee	1.3	
		junco	0.3	
		w. vireo	1.0	
		h. flycatcher	1.0	
		c. hummingbird	0.3	
		robin	0.7	
		l. bunting	0.7	
		r. grouse	0.3	

		s. thrush	0.7
		redstart	0.3
undev	Sch 1-2	chickadee	1.0
		junco	1.0
		w. wren	1.0
		r. grouse	0.3
		r. kinglet	0.7
		h. flycatcher	0.3
		c. sparrow	0.3
undev	Sch 2-1	chickadee	1.3
		y. warbler	0.3
		h. flycatcher	0.3
		r. kinglet	0.3
		w. wren	0.3
undev	Sch 2-2	chickadee	1.7
		r. kinglet	0.3
		w. wren	0.7
		robin	0.3
		junco	0.7
		w. vireo	0.7
		h. flycatcher	0.7
		s. thrush	0.3
		redstart	0.3
undev	Ho 1-1	chickadee	1.3
		r. kinglet	1.7
		w. vireo	0.3
		h. flycatcher	1.3
		t. warbler	0.3
		s. sparrow	1.0
		junco	0.7
		r. nuthatch	0.7
		s. thrush	0.7
		y. warbler	0.7
		redstart	0.3
		wood-pewee	0.3
undev	Ho 1-2	chickadee	0.7
		junco	0.7
		r. kinglet	0.7
		y-r. warbler	0.3
		y. warbler	0.7

		h. flycatcher	1.0	
		m. warbler	0.3	
		redstart	1.0	
		wood-pewee	0.3	
undev	Lolo 1-1	chickadee	1.0	
		r. kinglet	0.3	
		w. vireo	1.0	
		y. warbler	1.0	
		h. flycatcher	1.0	
		m. warbler	0.7	
		s. sparrow	0.7	
		redstart	1.0	
		r. nuthatch	0.3	
		crow	1.0	
		b. kingfisher	0.3	
		junco	0.3	
		y-r. warbler	0.3	
		r. grouse	0.3	
undev	Lolo 1-2	r. kinglet	0.7	
		w. vireo	1.7	
		y. warbler	1.0	
		r. towhee	0.7	
		l. bunting	0.3	
		h. flycatcher	0.3	
		c. hummingbird	0.3	0.3
		robin	0.3	
		chickadee	1.0	
		b. grosbeak	0.3	
		redstart	0.7	
undev	Lolo 2-1	chickadee	1.0	
		y. warbler	1.0	
		b. grosbeak	0.3	
		g. catbird	1.0	
		m. warbler	1.3	
		crow	1.0 *	
		r. grouse	1.0	
		robin	0.3	
		y-r. warbler	0.3	
		cowbird	0.3	
		r. towhee	0.3	

		w. flycatcher	0.7
		s. jay	0.3
		s. sparrow	0.3
undev	Lolo 2-2	chickadee	2.0
		y. warbler	0.7
		redstart	0.7
		w. flycatcher	0.7
		s. sparrow	1.0
		t. warbler	0.3
		r. towhee	0.3
		crow	0.3
		w. vireo	0.7
		g. catbird	0.7
		cowbird	0.3
		m. warbler	0.7
		r. sapsucker	0.3
		junco	0.3
		y-r. warbler	0.3
undev	Lolo 3-1	chickadee	0.3
		r. kinglet	0.3
		w. vireo	0.3
		g. catbird	0.3
		y. warbler	0.3
		wood-pewee	0.3
undev	Lolo 3-2	g. catbird	0.3
		y. warbler	0.7
		m. warbler	0.3
		w. vireo	0.3

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