EFFECTS OF SEASONAL BURNS ON AVIAN FORAGING IN A CENTRAL TEXAS ASHE JUNIPER-LIVE OAK SAVANNA

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Macy Brown, B.S.

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DEDICATION

This thesis is dedicated to three, strong, Texan women: Margaret Ann Phipps, Joyce Scott and Mary Bell Phipps. I miss you all dearly.

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I thank my committee members John Baccus and Clay Green for all their time and feedback. Also Mark Simmons of the Lady Bird Johnson Wildflower Center at the University of Texas at Austin provided insight and encouragement throughout the process. I am especially grateful to Thomas R. Simpson for all his help in getting this project going and sticking with me until the end. Without his support this study would not have been possible.

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And finally, I thank my husband who endured the insanity, took the girls while I worked and joined me for birding in 100 degree August afternoons. I thank you for all your support and encouragement.

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ABSTRACT

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SUPERVISING PROFESSOR: THOMAS R. SIMPSON

North American grassland birds have been declining for the past three decades. Loss of habitat from urbanization, agricultural land use, and encroachment of woody species may account for this decline. Prescribed burning is one method for restoring remnants of grassland habitat, typically performed in wet, cool periods when fire behavior is more benign. Fires historically helped to maintain grasslands by suppressing woody plants and encouraging herbaceous growth; however, the majority of these natural fires occurred in the summer growing season. To determine if this shift in burn season affects avian forage availability, I examined avian species foraging on summer, fall and winter burns plus unburned control plots over a year. I found no difference in forage use by avian species on seasonal burn treatments; however, there was a significant difference in use on pooled burn data versus the unburned control. I did not find many defined trends from Detrended Correspondence Analysis; however foliage insectivores and ground insectivores had an even distribution in fall and winter months. The majority of

grassland birds were omnivores and their distribution was uneven over the year. Managing grasslands with prescribed burns during dormant periods did not negatively affect foraging by grassland birds. Future studies should investigate how changes in vegetation based on different seasonal burns influence avian foraging.

INTRODUCTION

Since European settlement, grassland ecosystems of North America have declined (Samson and Knopf 1994, Noss et al. 1995). In some areas, North American prairies have decreased by 99.9% (Samson and Knopf 1994, Noss et al. 1995). In Texas an estimated 90% of the tallgrass prairie, 30% of the mixed prairie and 80% of the shortgrass prairie have declined from their historic maximum extent (Samson and Knopf 1994). Major reasons for these changes include agricultural land use, urbanization, fragmentation of land, loss of nomadic herbivores and suppression of wildfires (Vogl 1974, Wright 1974, Knopf 1994, Herkert et al. 1996).

Wildfires started by lightning strikes and Native Americans historically maintained the grasslands of North America (Pyne 1982, Anderson 1990). Natural fires were more prevalent during dry summer months when the frequency of thunderstorms was greatest and fine herbaceous fuel had low moisture content (Komarek 1966, Bock and Bock 1978, Whelan 1995). With European colonization, suppression of wildfires and replacement of free-ranging grazers by livestock altered conditions maintaining grasslands and permitted the invasion of shrubs and other woody species into grasslands.

Breeding Bird Survey data indicate many grassland bird populations are declining with the loss of grassland habitat. Over the last 30 years, the loss has been greater in the grassland bird guild than in any other guild of birds (Droege and Sauer1994, Knopf 1994, Peterjohn and Sauer 1999). Notable causes of this reduction in bird populations are habitat loss and degradation (Knopf 1994). Succession in grasslands unchecked by disturbances, such as fire causes a decline in the ecological succession in the community that affects niche number and requirements for breeding and foraging grassland birds (Vogl 1974, Herkert et al. 1996, Kirkpatrick et al. 2002).

In an effort to restore and maintain the remaining grassland ecosystems, prescribed burning has emerged as a powerful management tool. Prescribed burning typically has been implemented in winter with cooler temperatures and low wind speeds (Wright 1974, Wright and Bailey 1982, Whelan 1995). However, prescribed fires differ in the timing, frequency and intensity of natural fires (Reinking 2005). Studies have shown that the season of a burn impacts the vegetation, which in turn, affects grassland use by avian species (Box and White 1969, Bragg 1982).

Many studies in winter or spring have examined the effects of prescribed burns on avian nesting or abundance (Vogl 1973, Pylypec 1991, Reynolds and Krausman 1998, Kirkpatrick et al. 2002, Reinking 2005). Bock and Bock (1978) examined bird abundance in response to summer and winter burns on sacaton (*Sporobolus wrightii*) grasslands. Other studies focused on foraging by birds in association with fire. Hartung (2005) examined foraging activity of insectivorous songbirds in the forest canopy after a burn. Likewise, Winter (1984) looked at the foraging ecology of two species of sparrow following a burn and determined that burns did not affect foraging, but these two species still required unburned areas for escaping predators and nesting.

Because fire creates such a dramatic effect on the environment, the amount of food available after a fire or the accessibility to it may produce new foraging opportunities for birds (Woinarski 1990, Artman et al. 2001). In Brazil, Cavalcanti and Alves (1997) noted a change in foraging by White-banded Tanagers (*Neothraupis* *fasciata*). After a fire they fed exclusively on the ground for several weeks instead of foraging on the ground and in low-shrubs. Burns can cause an increase in trunk and branch foraging, especially by woodpeckers (Murphy and Lehnhausen 1998, Kreisel and Stein 1999). Wirtz (1981) found that granivorous-insectivorous and granivorous species were more common on burned sites than unburned sites the first year following a burn. He also noted insectivorous and frugivorous species and gleaners decreased initially on burned areas versus unburned areas.

In managing remnants of prairie ecosystems, it is important to understand the tools required to benefit species that evolved in those ecosystems (Herkert et al. 1996). Using prescribed burns as a management tool to restore grasslands, may require burning during the growing season however, the intensity associated with this type of fire may cause a decline in available forage for birds (Howe 1995, Owens et al. 2002). The season of a burn can affect arthropod and vegetative diversity (Bock and Bock 1978, Dunwiddie 1991, Vermeire et al. 2004).

Presently, few published studies have used multi-seasonal burns with an experimental design having multiple burn plots and unburned plots as controls. The Lady Bird Johnson Wildflower Center at The University of Texas at Austin (hereafter, LBJWC) has implemented such an experimental design to investigate vegetative response to seasonal prescribed burns in the context of grassland restoration. I collected information on foraging birds within the framework of this experimental design. My objectives were to answer questions about seasonal burning by: 1) Documenting foraging activity of birds on seasonally burned experimental plots, 2) Comparing species richness and diversity of foraging birds on seasonally burned experimental plots, 3) Determining any differences in foraging activity of birds based upon the season of the prescribed burn, and 4) Predicting the season during which a prescribed burn is most beneficial in enhancing available forage for birds.

MATERIALS AND METHODS

Study area. My research was conducted at the LBJWC located in southwestern Travis County, Texas at the southeastern edge of the Edwards Plateau (30° 11'N, 97° 52'W, elevation 247 m). Historically, this area was an Ashe juniper (*Juniperus ashei*)-live oak (*Quercus fusiformis*) savanna. With historic changes in fire frequency and grazing regimes, Ashe juniper densities increased despite being manually cleared in the early 1950s. Prior to 1985 this 113-ha site was a cattle, goat and sheep ranch (O'Connor 2003). Along with Ashe juniper and live oak, other woody species include sugarberry (*Celtis laevigata*), cedar elm (*Ulmus crassifolia*), Texas persimmon (*Diospyros texana*), gum bumelia (*Sideroxylon lanuginosum*) and cacti (*Opuntia* spp.). Warm-season grasses such as, silver beardgrass (*Bothriochloa laguroides*), curly-mesquite (*Hilaria belangeri*), King Ranch bluestem (*Bothriochloa ischaemum*) and cool-season grasses such as, Texas wintergrass (*Nassella leucotricha*), Japanese brome (*Bromus japonicus*), Ozarkgrass (*Limnodea arkansana*) and over 200 annual and perennial forbs including Indian blanket (*Gaillardia pulchella*), western ragweed (*Ambrosia psilostachya*), and black-eyed Susan (*Rudbeckia hirta*) compose the understory. The underlying soils are well-drained Speck stony clay loam with 1% to 5% slopes (U.S.D.A. 1974). The mean annual precipitation is 796 mm (NOAA 2008). A prescribed burn regime began on experimental plots at LBJWC in the winter of 2001. There are 54 experimental plots of approximately 0.6 ha each, consisting of summer, winter and fall burn treatments, unburned control plots and mowed plots to simulate grazing (Fig. 1). Prescribed burns were conducted at 2-year intervals until severe regional drought conditions in the winter of 2005 through 2006 forced a change to 3-year intervals. A summary of the burn history is shown in Table 1.

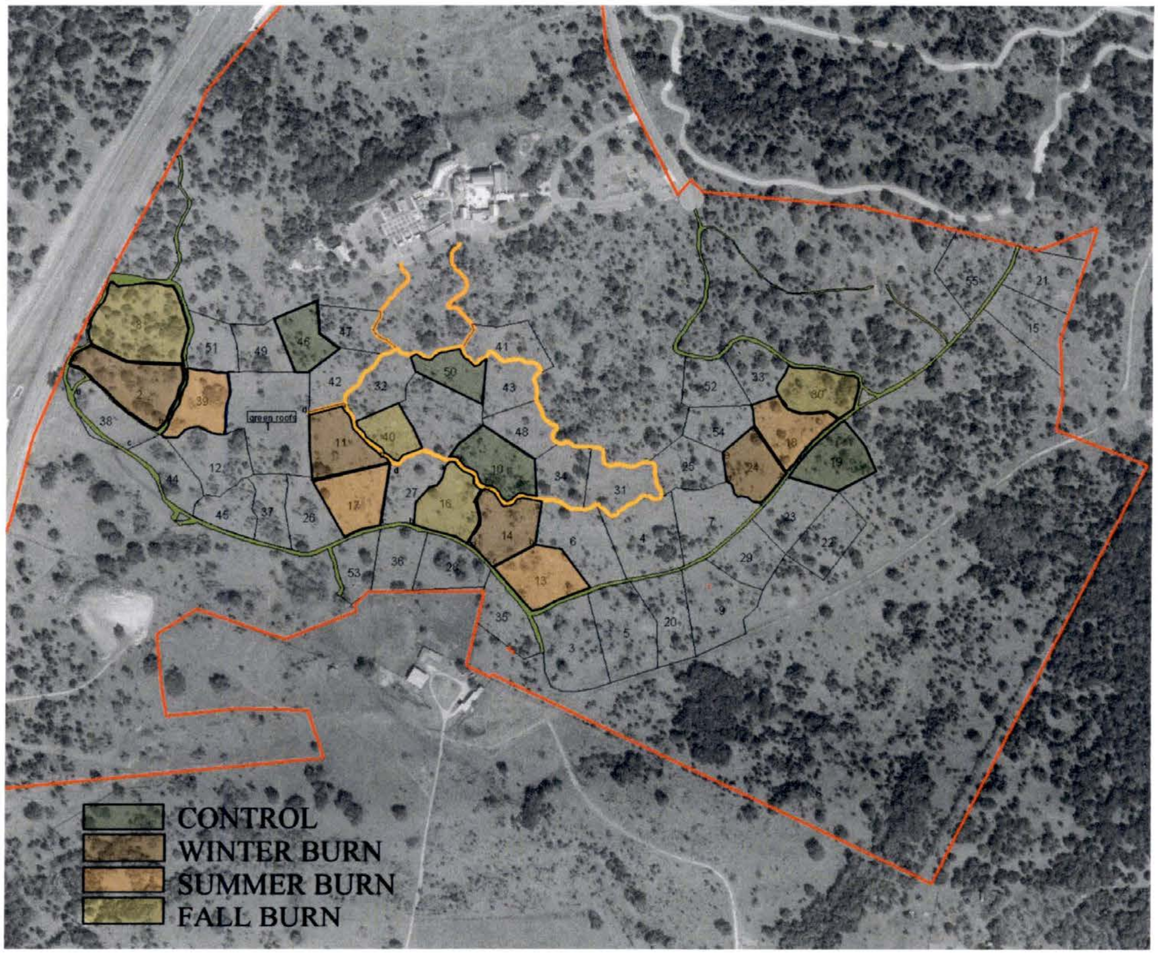

Figure 1. Aerial map of Lady Bird Johnson Wildflower Center, southwest Travis County, Texas. Shaded areas represent burn treatments included in study.

Table 1. Burn history of research plots on the Lady Bird Johnson Wildflower Center, Travis Co., Austin, Texas, 2001-2005. Average temperature (°C), relative humidity (%) and wind speed (km/hr) are reported.

Year of burn	Treatment	Temperature (°C)	Relative Humidity (%)	Wind Speed (km/hr)
2001	Winter	18-25	36-65	2 - 10
2001	Summer	29-35	35-65	2 - 8
2001	Fall	15-25	25-60	2 - 12
2002	Winter	11-16	20-54	3 - 8
2002	Summer	32-36	35-51	1 - 8
2002	Fall	18-24	23-52	4 - 7
2004	Winter	15-21	32-60	2 - 10
2004	Summer	26-35	45-70	4 - 8
2004	Fall	21-28	25-50	5 - 12

Field methods. Four study units were chosen. Each contained an experimental plot for each treatment type and a control. Treatments followed the design implemented by the LBJWC and were summer, fall and winter burns. Walking observation transects 75 m in length were marked in each treatment and control plot. Each week from February 2006 to February 2007, I recorded every bird seen foraging or exhibiting foraging behavior within 20 m of transects. When possible the items foraged were also recorded. The observational sequence of treatment plots was randomized. Observations were made within 3 ½ h after sunrise and 3 ½ h before sunset. Observations were not made during inclement weather (e.g. periods of heavy winds or rain). Because plot sizes were small (0.6 ha), I focused on foraging behavior on localized food sources rather than larger scale behaviors such as homerange or territoriality.

Data Analysis. Data were analyzed using a linear-mixed effects ANOVA that addressed both individual and species of birds. I also used the linear-mixed effects ANOVA to analyze individuals of grassland species (Vickery et al. 1999). Treatment, month, and treatment X month interaction and treatment, season, and treatment X season interaction were analyzed for significant differences at $\alpha = 0.05$. Further, individuals were pooled as burned versus unburned plots and analyzed for differences using a single factor ANOVA. I used Program R (2007) to conduct the linear mixed effect models and subsequent analysis of variance analyses.

I classified bird species by foraging guild as aerial insectivore (AI), bark insectivore (BI), carnivore (CA), foliage insectivore (FI), ground insectivore (GI), nectarivore (NE), or omnivore (OM) (Saab and Powell 2005). Detrended Correspondence Analysis (DCA) was used to detect patterns in bird distribution either by guild or by burn treatment by season with PC-ORD (Hill and Gauch 1980, McCune and Mefford 1999). Additionally, I examined guilds by warm (spring-summer) and cool (fall-winter) periods. Simpson's Index of Diversity (1 – D) was used to determine species diversity on the entire research area (Krebs 2000).

RESULTS

From 1 February 2006 to 31 January 2007, I observed 60 species of birds with 896 individual bird detections in the study plots on during 53 d of observations (Fig. 2 - 9). The most frequently encountered species were the Northern Cardinal (*Cardinalis cardinalis*) (20.8%), Northern Mockingbird (*Mimus polyglottus*) (14.8%) and Ruby-crowned Kinglet (*Regulus calendula*) (7.36%). Of the total species, 16.7% were observed only once on treatment plots. Forty-three species were observed on summer burns, 41 on fall burns and 40 species on both winter burns and control plots (Appendix A). Fifteen species (25%) observed were obligate or facultative grassland birds (Vickery et al. 1999).

Mean abundance for birds foraging on summer treatments per observation was 4.925 (SE = 4.052), while the mean for species foraging on summer treatments per observation was 2.868 (SE =1.861). Mean abundance for birds foraging on fall treatments per observation was 4.377 (SE = 4.386), while the mean for species foraging on fall treatments per observation was 2.736 (SE = 1.799). For winter treatments the mean abundance of foraging birds per observation was 4.509 (SE = 3.796), with the mean abundance of species foraging per observation was 2.66 (SE = 1.72). On control plots, the mean abundance of foraging birds per observation was 4.698 (SE = 2.952); the mean abundance of species foraging on control plots per observation was 2.943 (SE = 1.726).

Simpson's and Brillouin's diversity indices showed higher avian diversity on all burned plots compared to control plots (Table 2).

Table 2. Diversity indexes for foraging birds on each burn treatment at the Lady Bird Johnson Wildflower Center, Travis County, Austin, Texas.

	Summer	Fall	Winter	Control	Total
Simpson's Diversity (1-D)	0.921	0.934	0.923	0.887	0.92
Brillouin's Diversity (H)	4.041	4.123	4.035	3.689	4.445

Graphing species and individuals per month by treatment (Fig. 2-5) showed no distinct patterns. Fall burn treatments in August 2006 had an unusually high number of individuals foraging (Appendix B). Fall migrants including groups of orioles (*Icterus* sp.) may have accounted for the high number of foraging birds for this season. Low numbers of foraging birds were observed across all treatments and control plots in February 2006. Peaks in the number of species foraging existed for summer burn treatments in March 2006 and fall burn treatments in August 2006. Lows in number of species foraging occurred across all treatments and control plots in February 2006 as well as September 2006 on fall burn treatments and November 2006 on winter burn treatments.

There was a difference in avian foraging activity in burned plots versus unburned plots ($F_{1,104} = 65.55695$, $P \leq 0.001$). However, a linear mixed effects ANOVA showed no difference in the number of individual birds ($F_{3,12} = 0.10061$, $P = 0.9581$) or bird species ($F_{3,12} = 0.18802$, $P = 0.9025$) among burn treatments by month. There was a difference among months for both individual detections ($F_{11,768} = 1.99281$, $P = 0.0265$) and species ($F_{11,768} = 3.02478$, $P = 0.0006$). However, there was no difference in the interaction of month and treatment for individuals ($F_{33,768} = 1.13512$, $P = 0.2776$) or species ($F_{33,768} = 1.15713$, $P = 0.2516$). With the linear mixed effects ANOVA, I also found no differences among birds ($F_{3,12} = 0.09921$, $P = 0.9589$) or species ($F_{3,12} =$

0.18464, $P = 0.9048$) among burn treatments by season. Differences could be seen in individual birds by season ($F_{3,800} = 3.64780$, $P = 0.0124$) and species by season ($F_{3,800} = 5.74773$, $P = 0.0007$) but not in the interaction of season and treatment for individuals ($F_{9,800} = 0.54719$, $P = 0.8403$) or in the interaction of season and treatment for species ($F_{9,800} = 1.29892$, $P = 0.2334$).

I also found no differences in foraging grassland birds among treatments ($F_{12,768} = .33070$, $P = 0.8033$) or with the treatment and month interaction ($F_{33,768} = 0.81717$, $P = 0.7581$), but again there were differences by month ($F_{11,768} = 1.60307$, $P = 0.0930$).

Results of the single factor ANOVA performed on pooled treatment data showed a significant difference ($F_{1,104} = 65.55695$, $P \leq 0.001$) in foraging activity by birds on burned versus unburned plots.

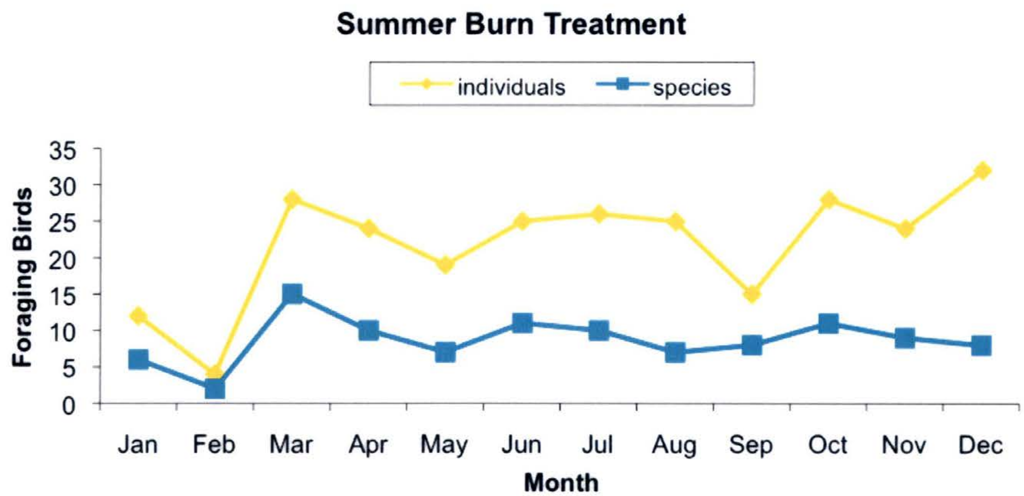

Figure 2. The number of foraging birds and bird species on summer burn treatments at the Lady Bird Johnson Wildflower Center from 1 February 2006 to 31 January 2007.

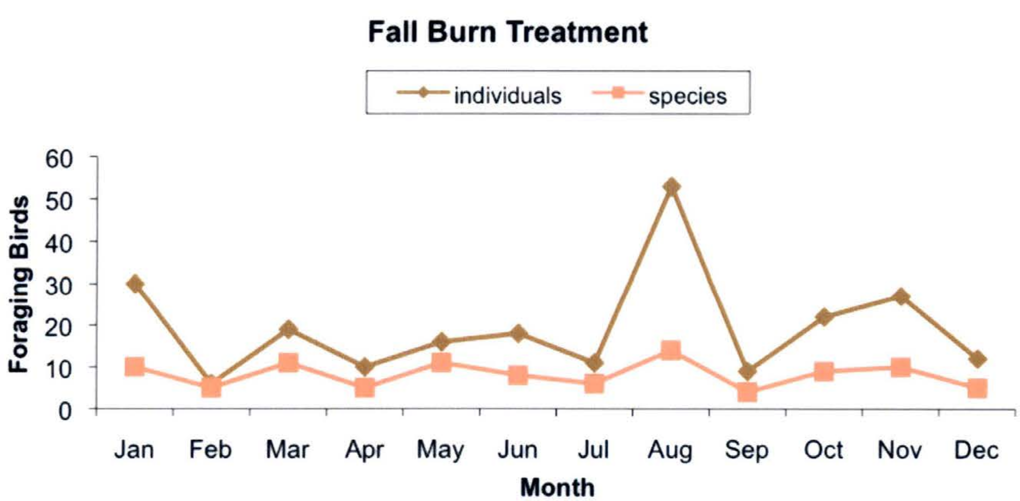

Figure 3. The number of foraging birds and bird species on fall burn treatments at the Lady Bird Johnson Wildflower Center from 1 February 2006 to 31 January 2007.

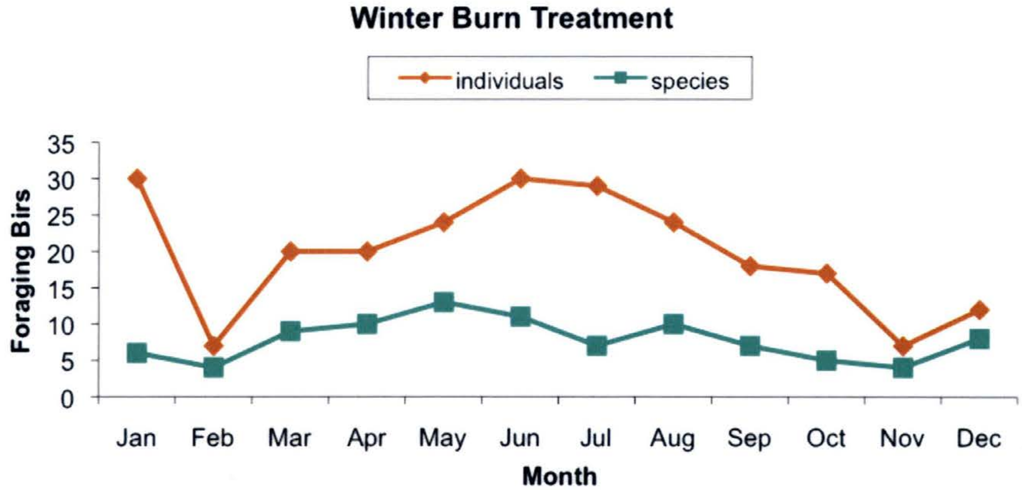

Figure 4. The number of foraging birds and bird species on winter burn treatments at the Lady Bird Johnson Wildflower Center from 1 February 2006 to 31 January 2007.

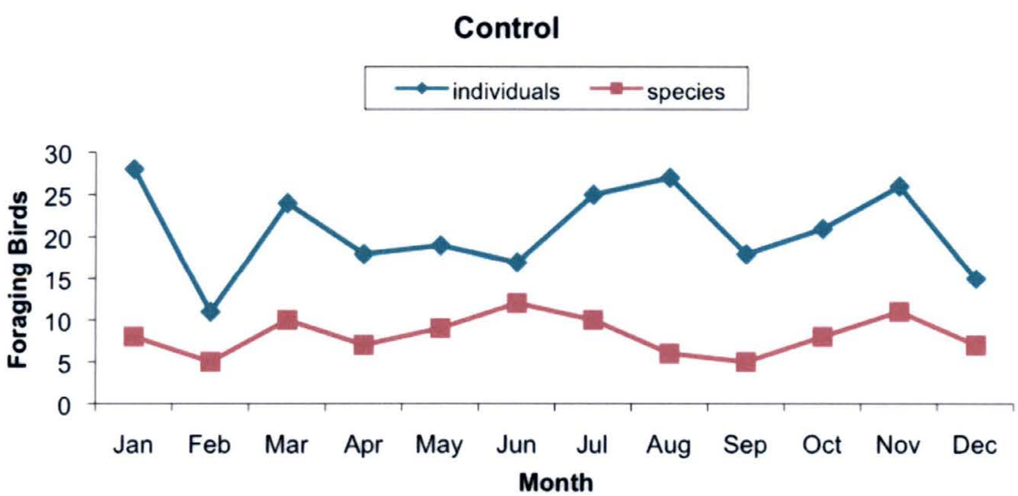

Figure 5. The number of foraging birds and bird species on control plots at the Lady Bird Johnson Wildflower Center from 1 February 2006 to 31 January 2007.

There were very few trends seen in the DCA (Fig. 6-9), and eigenvalues (Table 3) showed no strong relationships (Hall and Gauch 1980). Fifty-seven percent of the grassland birds I observed were omnivores, which can be seen unevenly distributed on the DCA plots. When the omnivores were removed, there was an even distribution of the foliage insectivores and the ground insectivores especially during the fall and winter months (Fig. 9).

Table 3. Eigenvalues from Detrended Correspondence Analysis of season of observation of foraging birds on burned and control treatment plots at the Lady Bird Johnson Wildflower Center.

	Eigenvalues		
	Axis 1	Axis 2	Axis 3
All Seasons	0.3271485	0.2217195	0.1628019
Spring	0.5423976	0.3789793	0.3052191
Summer	0.4879300	0.3054883	0.1747113
Fall	0.6909355	0.4294486	0.2597834
Winter	0.7016568	.03517003	0.2108404
Spring/Summer	0.3745329	0.2530295	0.1853299
Spring/Summer without omnivores	0.4207477	0.3273511	0.2208929
Fall/Winter	0.4743624	0.3334386	0.1640211
Fall/Winter without omnivores	0.5930516	0.2074489	0.1299174

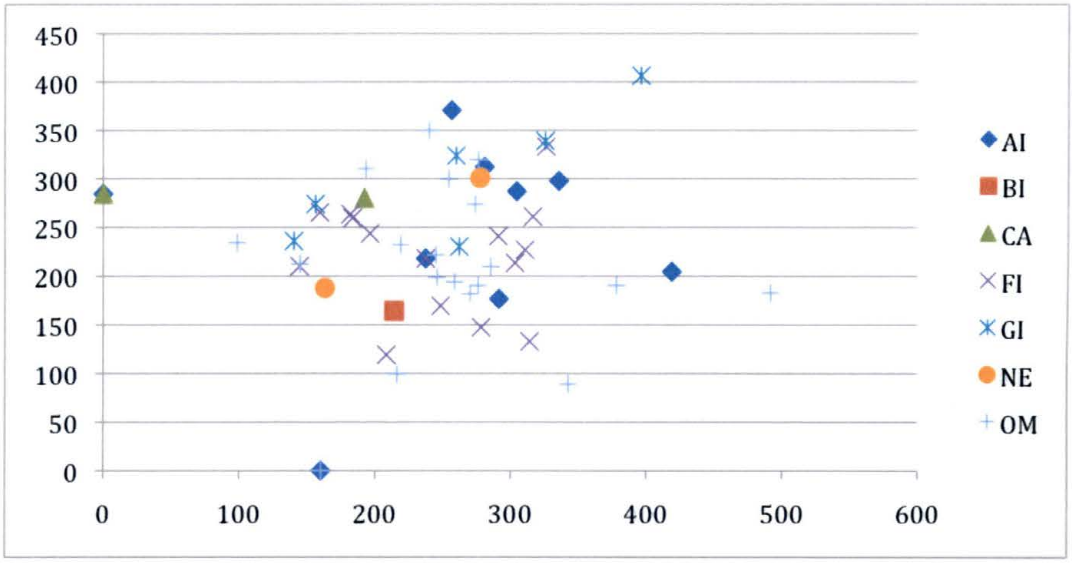

Figure 6. Detrended Correspondence Analysis of foraging guilds observed in spring and summer on treatment plots at the Lady Bird Johnson Wildflower Center. AI = aerial insectivore, BI = bark insectivore, CA = carnivore, FI = foliage insectivore, GI = ground insectivore, NE = nectarivore, OM = omnivore.

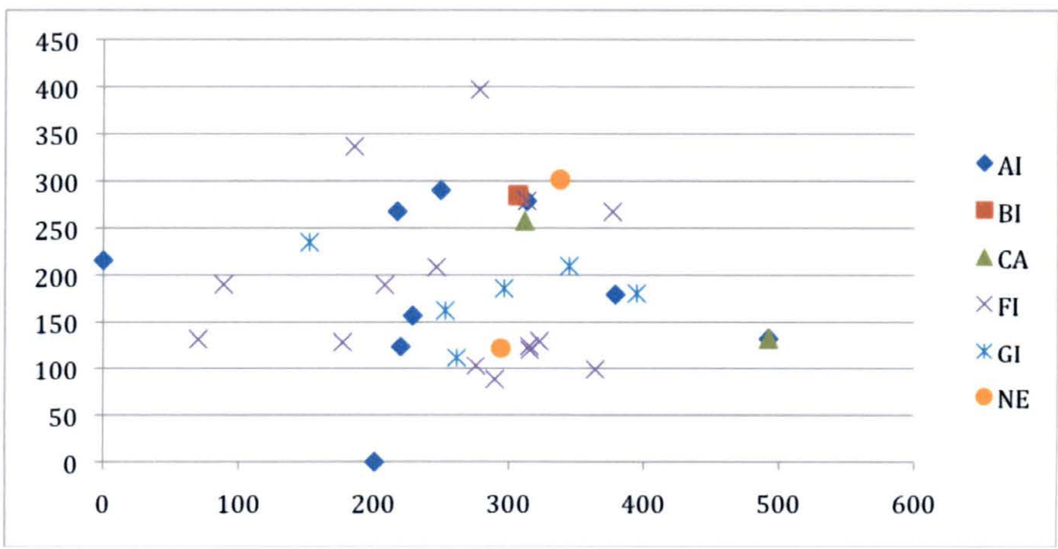

Figure 7. DCA of foraging guilds observed during spring and summer on treatment plots at the Lady Bird Johnson Wildflower Center with omnivores omitted. AI = aerial insectivore, BI = bark insectivore, CA = carnivore, FI = foliage insectivore, GI = ground insectivore, NE = nectarivore, OM = omnivore.

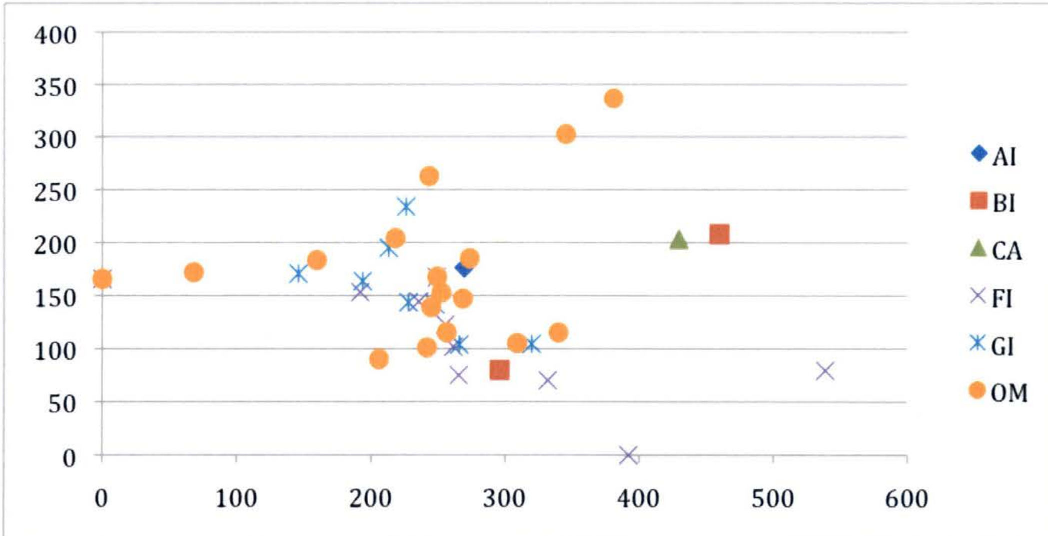

Figure 8. DCA of foraging guilds observed during fall and winter on treatment plots at the Lady Bird Johnson Wildflower Center. AI = aerial insectivore, BI = bark insectivore, CA = carnivore, FI = foliage insectivore, GI = ground insectivore, NE = nectarivore, OM = omnivore.

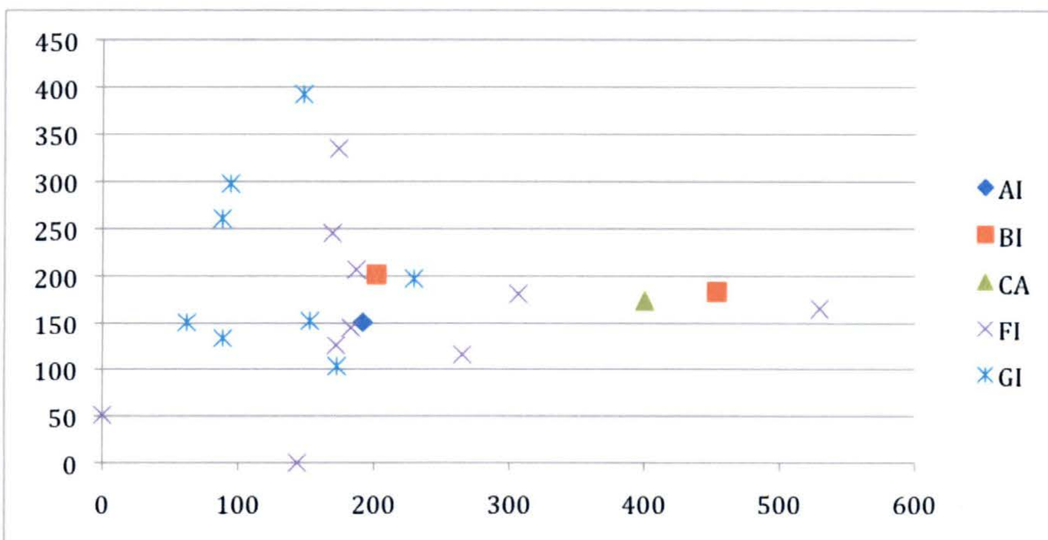

Figure 9. DCA of foraging guilds observed during fall and winter on treatment plots at the Lady Bird Johnson Wildflower Center with omnivores omitted. AI = aerial insectivore, BI = bark insectivore, CA = carnivore, FI = foliage insectivore, GI = ground insectivore, NE = nectarivore, OM = omnivore.

DISCUSSION

Avian foraging activity on a central Texas grassland is not significantly influenced by the seasonality of burn treatments even among those species classified as grassland species. However, there is a significant difference in foraging activity on burned, in any season, versus unburned plots.

While few studies have examined avian foraging following burns, my research coincides with studies that have reported a difference in use among burn and unburned plots (Lawrence 1966, Huber and Steuter 1984). Ellis et al. (1969) studied the response by Northern Bobwhites (*Colinus virginianus*) to fire in Illinois and also concluded that bobwhites responded positively because their primary forage items responded well to fire. Bock and Bock (1983) observed nesting birds after a fire and found the incidence of nesting increased the first year post-fire and decreased the second year. They postulated this effect was due to the temporary change in quantity and quality of the forage after the fire. Also, Apfelbaum and Haney (1981) found that fire increased opportunities for ground-brush foragers even though they had decreased individuals from observations before the fire, the number of species they observed doubled.

Further investigation with DCA showed no strong patterns on foraging distribution by guild or by burn treatment (Table 3). When separated by season of observation, there were no patterns of separation of foraging guild in spring and summer (Fig 6). However, there was guild separation of both the foliage insectivores and the ground insectivores during fall and winter (Fig 9). This could be expected, as these guilds are using different vegetative structures, which may differ among treatments and control plots. There was, however, a wide dispersion of omnivores across all treatments, which seems appropriate given they forage under a variety of conditions. This is important because the majority of foraging grassland birds I observed were omnivorous.

Differences in foraging by months and seasons were likely due to seasonal changes. Further studies may explore the connection between the vegetation present and avian foraging on the vegetation. Studying vegetation affected by seasonal burns, such as broomweed (*Amphiachyris dracunculoides*), Hall's panicgrass (*Panium hallii*) or Buffalograss (*Bouteloua dactyloides*) and linking these plants to avian foraging activity may give more information on selectivity of foraging (Box et al. 1967, Wright 1974).

The LBJWC plots are in a process of grassland restoration; the land had previously been overgrazed and invaded by woody species including an abundance of Ashe Juniper. This may be why the majority of the birds observed were generalist such as the Northern Cardinal and Northern Mockingbird. The restoration process may not be at a point suitable to sustain a variety of grassland birds. Another factor possibly affecting my research was the size (0.6 ha) of the experimental plots. The experimental design implemented by the LBJWC was to evaluate the response of vegetation to seasonal burning. Consequently the plot size may be too small to evaluate even a localized activity such as foraging by birds. Finally, the change in gross vegetation composition, with the exception of gradual removal of woody species is slow even with a landscape restoration tool as effective as prescribed burns. Effective changes in habitat may take years especially in a degraded system where seed may be limited and the system may be in a dramatically altered state (Westoby et al. 1989, Turnbull et al. 2000).

The results of my research were particularly important, since it followed repeated seasonal burns and addressed community issues and diversity measures. Because grassland birds are declining rapidly, managing remnants of grasslands in an efficient manner is important. If the impact of seasonal prescribed burns on avian foraging is equal for all treatments, land managers need not be concerned that the timing of prescribed burns will have a major impact in terms of forage. It is clear that prescribed burns, regardless of season, do benefit omnivorous species, many of which are grassland species. For land managers looking to restore grasslands previously overgrazed or invaded by woody species with prescribed burns, my study indicated seasonal prescribed burns could be implemented when it is most convenient. Instead of foraging, attention may be placed on requirements such as nesting, where studies have shown that the seasonality of burns may help or harm nesting avian species (Ellis et al. 1969, Huber and Steuter 1984, Pylypec 1991, Reynolds and Krausman 1998). The importance in restoring grasslands may depend more on the vegetative structure that supports nesting and less on the way fire affects the available forage.

APPENDIX A

Number of bird species seen foraging on seasonal burn plots or control and their foraging guild at the Lady Bird Johnson Wildflower Center from 1 February 2006 to 1 February 2007.

			TREATMENT			
Common Name	Scientific Name	Guild	Summer	Fall	Winter	Control
January						
Downy Woodpecker	*Picoides pubescens*	BI	-	1	-	-
Ladder-backed Woodpecker	*Picoides scalaris*	BI	1	-	-	-
Loggerhead Shrike*	*Lanius ludovicianus*	CA	1	-	-	-
Western Scrub-Jay	*Aphelocoma californica*	OM	-	2	-	-
Black-crested Titmouse	*Baeolophus atricistatus*	FI	-	2	2	-
Carolina Wren	*Thryothorus ludovicianus*	GI	1	-	-	-
House Wren	*Troglodytes aedon*	GI	-	1	1	-
Wren sp.		-	-	1	-	-
Golden-crowned Kinglet	*Regulus satrapa*	FI	-	-	10	1
Ruby-crowned Kinglet	*Regulus calendula*	FI	4	6	10	8
Hermit Thrush	*Catharus guttatus*	GI	-	1	1	-
Northern Mockingbird	*Mimus polyglottos*	GI	4	3	-	6
Orange-crowned Warbler	*Vermivora celata*	FI	-	1	-	1
Yellow-rumped Warbler	*Dendoica coronata*	FI	-	-	-	3
Northern Cardinal	*Cardinalis cardinalis*	OM	-	10	-	6
Spotted Towhee	*Pipilo maculates*	OM	1	1	-	1
Song Sparrow	*Melospiza melodia*	GI	-	-	-	1
Lincoln's Sparrow	*Melospiza lincolnii*	OM	-	-	3	-
Sparrow sp		-	-	-	1	1
unidentified		-	-	1	2	-
February						
Mourning Dove*	*Zenaida macroura*	OM	1	-	-	-
Carolina Chickadee	*Poecile carolinensis*	FI	-	1	-	2

Wren sp		-	-	1	-	-
Ruby-crowned Kinglet	*Regulus calendula*	FI	-	-	1	-
Northern Mockingbird	*Mimus polyglottos*	GI	-	-	-	2
Orange-crowned Warbler	*Vermivora celata*	FI	-	-	-	1
Yellow-rumped Warbler	*Dendoica coronata*	FI	-	-	1	-
Northern Cardinal	*Cardinalis cardinalis*	OM	-	1	3	4
Spotted Towhee	*Pipilo maculates*	OM	-	1	-	-
Lincoln's Sparrow	*Melospiza lincolnii*	OM	-	1	-	-
Sparrow sp		-	3	1	2	2
March						
Ladder-backed Woodpecker	*Picoides scalaris*	BI	1	-	-	-
Eastern Phoebe	*Sayornis phoebe*	AI	1	-	-	1
White-eyed Vireo	*Vireo griseus*	FI	-	1	-	-
Carolina Chickadee	*Poecile carolinensis*	FI	3	-	2	1
Carolina Wren	*Thryothorus ludovicianus*	GI	1	-	-	-
Ruby-crowned Kinglet	*Regulus calendula*	FI	2	1	2	5
Blue-gray Gnatcatcher	*Polioptila caerulea*	FI	1	-	3	-
Northern Mockingbird	*Mimus polyglottos*	GI	-	1	1	3
Orange-crowned Warbler	*Vermivora celata*	FI	1	-	-	2
Black-throated Green Warbler	*Dendroica virens*	FI	1	-	-	-
Yellow-rumped Warbler	*Dendoica coronata*	FI	1	1	-	1
Northern Cardinal	*Cardinalis cardinalis*	OM	1	-	5	-
Spotted Towhee	*Pipilo maculates*	OM	-	1	-	-
Field Sparrow	*Spizella pusilla*	OM	1	-	-	-
Grasshopper Sparrow*	*Ammodramus savannarum*	OM	-	3	1	1
LeConte's Sparrow*	*Ammodramus leconteii*	OM	3	-	-	-
Savannah Sparrow*	*Passerculus sandwichensis*	OM	2	1	2	1
Song Sparrow	*Melospiza melodia*	GI	-	1	-	-
Lincoln's Sparrow	*Melospiza lincolnii*	OM	3	2	1	1
White-crowned Sparrow	*Zonotrichia leucophrys*	OM	1	-	2	-
Sparrow sp.		-	-	2	-	-
Brown-headed Cowbird*	*Molothrus ater*	OM	-	-	-	1
American Goldfinch	*Carduelis tristis*	OM	-	1	-	-
Lesser Goldfinch	*Carduelis psaltria*	OM	-	1	-	-
unidentified		-	5	3	1	7
April						

White-winged Dove	*Zenaida asiatica*	OM	-	-	-	2
Archilochus sp.		NE	-	-	-	2
Ruby-throated Hummingbird	*Archilochus colubris*	NE	-	-	1	1
White-eyed Vireo	*Vireo griseus*	FI	-	-	-	2
Carolina Chickadee	*Poecile carolinensis*	FI	-	-	2	-
Sedge Wren*	*Cistothorus platensis*	GI	-	-	1	-
Bewick's Wren	*Thryomanes bewickii*	GI	-	-	2	-
House Wren	*Troglodytes aedon*	GI	-	1	2	-
Ruby-crowned Kinglet	*Regulus calendula*	FI	1	-	-	-
Blue-gray Gnatcatcher	*Polioptila caerulea*	FI	-	-	1	-
Northern Mockingbird	*Mimus polyglottos*	GI	4	-	1	-
Tennessee Warbler	*Vermivora peregrina*	FI	-	1	1	-
Nashville Warbler	*Vermivora ruficapilla*	FI	-	-	-	1
Black-throated Green Warbler	*Dendroica virens*	FI	-	-	-	1
Yellow-breasted Chat	*Icteria virens*	FI	1	-	-	-
Northern Cardinal	*Cardinalis cardinalis*	OM	4	4	6	5
Painted Bunting	*Passerina ciris*	OM	1	1	-	
Spotted Towhee	*Pipilo maculates*	OM	1	-	-	-
Grasshopper Sparrow	*Ammodramus savannarum*	OM	2	-	-	-
Lincoln's Sparrow	*Melospiza lincolnii*	OM	6	2	1	-
White-crowned Sparrow	*Zonotrichia leucophrys*	OM	2	-	-	-
Sparrow sp		-	1	-	-	3
unidentified		-	-	1	2	3
May						
Northern Bobwhite*	*Colinus virginianus*	OM	-	-	2	2
Common Ground-Dove*	*Columbina passerina*	OM	-	-	1	-
Yellow-billed Cuckoo	*Coccyzus americanus*	FI	-	-	2	-
Archilochus sp.		NE	1	-	-	2
Ruby-throated Hummingbird	*Archilochus colubris*	NE	-	-	-	1
Ladder-backed Woodpecker	*Picoides scalaris*	BI	-	-	1	-
Least Flycatcher	*Empidonax minimus*	AI	1	1	4	2
Ash-throated Flycatcher*	*Myiarchus cinerascens*	AI	1	-	-	-
Western Kingbird*	*Tyrannus verticalis*	AI	-	1	1	-
Barn Swallow	*Hirundo rustica*	AI	-	1	1	2
Cliff Swallow	*Petrochelido pyrrhonota*	AI	-	1	-	-
Carolina Chickadee	*Poecile carolinensis*	FI	-	2	-	-

Carolina Wren	*Thryothorus ludovicianus*	GI	2	1	-	3
Bewick's Wren	*Thryomanes bewickii*	GI	1	-	-	1
Northern Mockingbird	*Mimus polyglottos*	GI	-	3	3	-
Yellow Warbler	*Dendroica petechia*	FI	-	1	-	1
Common Yellowthroat*	*Geothlypis trichas*	FI	-	-	1	-
Warbler sp		-	1	1	-	-
Northern Cardinal	*Cardinalis cardinalis*	OM	10	-	5	3
Painted Bunting	*Passerina ciris*	OM	-	1	-	1
Common Grackle	*Quiscalus quiscula*	OM	-	1	-	-
Lesser Goldfinch	*Carduelis psaltria*	OM	-	-	1	1
House Finch	*Carpodacus mexicanus*	OM	-	2	1	-
unidentified		-	2	-	-	1
June						
Northern Bobwhite	*Colinus virginianus*	OM	2	-	2	2
White-winged Dove	*Zenaida asiatica*	OM	3	-	-	-
Mourning Dove	*Zenaida macroura*	OM	-	-	1	3
Yellow-billed Cuckoo	*Coccyzus americanus*	FI	-	1	-	-
Archilochus sp		NE	-	-	1	-
Ruby-throated Hummingbird	*Archilochus colubris*	NE	-	-	1	-
Ladder-backed Woodpecker	*Picoides scalaris*	BI	2	-	-	1
Western Kingbird	*Tyrannus verticalis*	AI	-	-	1	1
White-eyed Vireo	*Vireo griseus*	FI	1	-	-	-
Barn Swallow	*Hirundo rustica*	AI	1	5	1	1
Cliff Swallow	*Petrochelidon pyrrhonota*	AI	-	-	1	1
Carolina Chickadee	*Poecile carolinensis*	FI	-	-	-	1
Carolina Wren	*Thryothorus ludovicianus*	GI	1	2	-	-
Bewick's Wren	*Thryomanes bewickii*	GI	-	-	1	1
Northern Mockingbird	*Mimus polyglottos*	GI	1	3	2	1
Yellow-breasted Chat	*Icteria virens*	FI	-	-	-	1
Northern Cardinal	*Cardinalis cardinalis*	OM	9	2	14	3
Painted Bunting	*Passerina ciris*	OM	2	1	4	-
Brown-headed Cowbird	*Molothrus ater*	OM	-	1	-	-
Lesser Goldfinch	*Carduelis psaltria*	OM	1	3	-	1
House Finch	*Carpodacus mexicanus*	OM	2	-	1	-
July						
White-winged Dove	*Zenaida asiatica*	OM	-	1	-	-

Chimney Swift	*Chaetura pelagica*	AI	6	-	-	-
Archilochus sp		NE	2	-	-	1
Ruby-throated Hummingbird	*Archilochus colubris*	NE	1	-	-	-
Ladder-backed Woodpecker	*Picoides scalaris*	BI	1	2	1	1
Western Kingbird	*Tyrannus verticalis*	AI	4	1	1	2
Barn Swallow	*Hirundo rustica*	AI	2	-	3	2
Cliff Swallow	*Petrochelidon pyrrhonota*	AI	2	-	5	3
Carolina Chickadee	*Poecile carolinensis*	FI	-	-	-	1
Carolina Wren	*Thryothorus ludovicianus*	GI	2	-	-	1
Northern Mockingbird	*Mimus polyglottos*	GI	3	2	8	7
Northern Cardinal	*Cardinalis cardinalis*	OM	2	4	6	6
Painted Bunting	*Passerina ciris*	OM	1	1	-	-
House Finch	*Carpodacus mexicanus*	OM	-	-	5	1
August						
Merlin*	*Falco columbarius*	CA	-	1	-	-
Northern Bobwhite	*Colinus virginianus*	OM	2	1	1	-
White-winged Dove	*Zenaida asiatica*	OM	1	-	1	-
Archilochus sp.		NE	-	-	1	-
Great Crested Flycatcher	*Myiarchus crinitus*	AI	-	4	-	-
Western Kingbird	*Tyrannus verticalis*	AI	-	2	-	-
Flycatcher sp		AI	-	1	-	-
Loggerhead Shrike	*Lanius ludovicianus*	CA	-	-	2	-
Barn Swallow	*Hirundo rustica*	AI	1	4	7	-
Cliff Swallow	*Petrochelidon pyrrhonota*	AI	-	4	-	-
Purple Martin	*Progne subis*	AI	1	-	-	-
Carolina Chickadee	*Poecile carolinensis*	FI	-	2	-	4
Carolina Wren	*Thryothorus ludovicianus*	GI	-	5	-	1
Northern Mockingbird	*Mimus polyglottos*	GI	14	3	2	10
Warbler sp		-	-	-	-	1
Northern Cardinal	*Cardinalis cardinalis*	OM	5	6	4	7
Baltimore Oriole	*Icterus galbula*	OM	-	7	-	4
Orchard Oriole	*Icterus spurious*	FI	-	2	3	-
Lesser Goldfinch	*Carduelis psaltria*	OM	1	4	-	-
House Finch	*Carpodacus mexicanus*	OM	-	7	2	1
September						
White-winged Dove	*Zenaida asiatica*	OM	2	2	1	-

Western Scrub-Jay	*Aphelocoma californica*	OM	-	-	-	1
Barn Swallow	*Hirundo rustica*	AI	-	-	1	-
Carolina Chickadee	*Poecile carolinensis*	FI	-	-	1	-
House Wren	*Troglodytes aedon*	GI	1	-	-	-
Carolina Wren	*Thryothorus ludovicianus*	GI	-	2	-	1
Blue-gray Gnatcatcher	*Polioptila caerulea*	FI	1	-	-	-
Northern Mockingbird	*Mimus polyglottos*	GI	5	3	2	10
Yellow Warbler	*Dendroica petechia*	FI	1	-	1	-
Warbler sp		-	-	-	-	1
Northern Cardinal	*Cardinalis cardinalis*	OM	1	2	1	5
Baltimore Oriole	*Icterus galbula*	OM	-	-	11	-
Icterus sp.		-	2	-	-	-
House Finch	*Carpodacus mexicanus*	OM	1	-	-	-
unidentified		-	1	-	-	-
October						
White-winged Dove	*Zenaida asiatica*	OM	-	1	-	-
Loggerhead Shrike	*Lanius ludovicianus*	CA	2	-	-	-
White-eyed Vireo	*Vireo griseus*	FI	-	1	-	-
Carolina Chickadee	*Poecile carolinensis*	FI	-	1	-	-
Black-crested Titmouse	*Baeolophus atricistatus*	FI	-	-	-	2
House Wren	*Troglodytes aedon*	GI	1	2	2	1
Wren sp.		-	1	-	3	-
Ruby-crowned Kinglet	*Regulus calendula*	FI	1	9	-	3
Blue-gray Gnatcatcher	*Polioptila caerulea*	FI	1	-	-	1
Northern Mockingbird	*Mimus polyglottos*	GI	2	2	1	6
Yellow-rumped Warbler	*Dendoica coronata*	FI	1	2	-	-
Northern Cardinal	*Cardinalis cardinalis*	OM	1	1	4	6
Lincoln's Sparrow	*Melospiza lincolnii*	OM	1	1	-	-
White-crowned Sparrow	*Zonotrichia leucophrys*	OM	-	-	4	-
Sparrow sp.		-	2	2	2	1
Western Meadowlark*	*Sturnella neglecta*	GI	1	-	1	-
Lesser Goldfinch	*Carduelis psaltria*	OM	10	-	-	-
House Finch	*Carpodacus mexicanus*	OM	4	-	-	1
November						
Eastern Phoebe	*Sayornis phoebe*	AI	1	1	2	-
Western Scrub-Jay	*Aphelocoma californica*	OM	-	1	-	3

Carolina Chickadee	*Poecile carolinensis*	FI	-	3	-	2
Black-crested Titmouse	*Baeolophus atricistatus*	FI	-	-	-	4
House Wren	*Troglodytes aedon*	GI	-	1	-	-
Carolina Wren	*Thryothorus ludovicianus*	GI	-	3	1	-
Bewick's Wren	*Thryomanes bewickii*	GI	-	-	-	1
Wren sp		-	1	-	-	1
Golden-crowned Kinglet	*Regulus satrapa*	FI	2	-	-	3
Ruby-crowned Kinglet	*Regulus calendula*	FI	-	-	2	4
Northern Mockingbird	*Mimus polyglottos*	GI	4	2	2	1
Northern Cardinal	*Cardinalis cardinalis*	OM	7	5	-	3
Spotted Towhee	*Pipilo maculates*	OM	-	-	-	1
Field Sparrow	*Spizella pusilla*	OM	2	5	-	-
Vesper Sparrow*	*Pooecetes gramineus*	OM	2	3	-	-
Lincoln's Sparrow	*Melospiza lincolnii*	OM	-	-	-	1
White-crowned Sparrow	*Zonotrichia leucophrys*	OM	-	2	-	-
Lesser Goldfinch	*Carduelis psaltria*	OM	3	-	-	-
House Finch	*Carpodacus mexicanus*	OM	1	-	-	2
unidentified		-	1	1	-	-
December						
Loggerhead Shrike	*Lanius ludovicianus*	CA	-	-	1	-
Western Scrub-Jay	*Aphelocoma californica*	OM	-	-	-	3
House Wren	*Troglodytes aedon*	GI	1	1	-	-
Carolina Wren	*Thryothorus ludovicianus*	GI	-	2	1	-
Bewick's Wren	*Thryomanes bewickii*	GI	-	-	1	-
Ruby-crowned Kinglet	*Regulus calendula*	FI	3	2	1	1
Northern Mockingbird	*Mimus polyglottos*	GI	1	1	2	2
Cedar Waxwing	*Bombycilla cedrorum*	FI	11	-	-	-
Northern Cardinal	*Cardinalis cardinalis*	OM	6	5	-	4
Spotted Towhee	*Pipilo maculates*	OM	1	-	-	1
Field Sparrow	*Spizella pusilla*	OM	6	-	3	1
Vesper Sparrow	*Pooecetes gramineus*	OM	-	-	-	2
Lincoln's Sparrow	*Melospiza lincolnii*	OM	2	-	1	-
House Finch	*Carpodacus mexicanus*	OM	-	-	1	-
unidentified		-	1	1	1	1

* Grassland species

APPENDIX B

Summary of species and (individual) birds observed foraging on burn treatments and control plots at the Lady Bird Johnson Wildflower Center.

	Summer Burns	Fall Burns	Winter Burns	Control
Jan	6 (12)	10 (30)	6 (30)	8 (28)
Feb	2 (4)	5 (6)	4 (7)	5 (11)
Mar	15 (28)	11 (19)	9 (20)	10 (24)
Apr	10 (24)	5 (10)	10 (20)	7 (18)
May	7 (19)	11 (16)	13 (24)	9 (19)
Jun	11 (25)	8 (18)	11 (30)	12 (17)
Jul	10 (26)	6 (11)	7 (29)	10 (25)
Aug	7 (25)	14 (53)	10 (24)	6 (27)
Sep	8 (15)	4 (9)	7 (18)	5 (18)
Oct	11 (28)	9 (22)	5 (17)	8 (21)
Nov	9 (24)	10 (27)	4 (7)	11 (26)
Dec	8 (32)	5 (12)	8 (12)	7 (15)

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VITA

Macy Brown was born November 26, 1974 in San Antonio, TX to Margaret Ann Phipps. She graduated from Clark High School and in 1998 she received a Bachelor of Science degree in Biology from the University of Texas at San Antonio. After graduation she moved to Galveston, TX and worked for the University of Texas Medical Branch as an assistant laboratory animal technician and then as a research assistant in the NeuroAIDS lab of Dr. Benjamin Gelman. In 2001 she married Kyle Brown and they moved to Austin, TX where she worked for two years as a research assistant for the Waggoner Center for Alcohol and Addiction Research at the University of Texas.

After the birth of her first daughter, Kyra, she entered Texas State University-San Marcos in August 2004. In April 2008 her second daughter Emery was born. She is currently an intern in the Public Drinking Water Section of Texas Commission on Environmental Quality.

Permanent Address: 2705 Winslow Drive

Leander, Texas 78641

This thesis was typed by Macy Brown.