

Archives/
Closed
LD
175
-A40K
T.D.
020

**SHORT-TERM EFFECTS OF LOW-INTENSITY WILDFIRE ON BREEDING BIRDS
IN SOUTHERN APPALACHIAN OLD-GROWTH/PRE-SETTLEMENT FORESTS**

A Thesis

by

JASON DALE RIDDLE

Submitted to the Cratis D. Williams Graduate School

Appalachian State University

In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2003

Major Department: Biology

**WILLIAM LEONARD EURY
APPALACHIAN COLLECTION
APPALACHIAN STATE UNIVERSITY
BOONE, NORTH CAROLINA 28608**

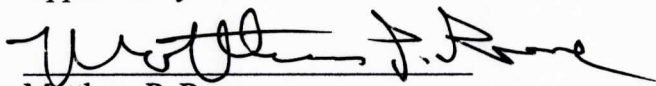
SHORT-TERM EFFECTS OF LOW-INTENSITY WILDFIRE ON BREEDING BIRDS
IN SOUTHERN APPALACHIAN OLD-GROWTH/PRE-SETTLEMENT FORESTS

A Thesis

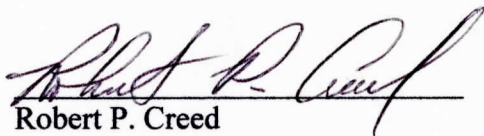
by

JASON DALE RIDDLE

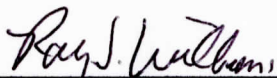
Approved by:



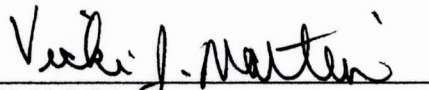
Matthew P. Rowe
Chairperson, Thesis Committee



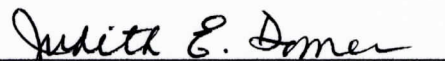
Robert P. Creed
Member, Thesis Committee



Ray S. Williams
Member, Thesis Committee



Vicki J. Martin
Chairperson, Department of Biology



Judith E. Domer
Dean, Graduate Studies and Research

**Copyright by Jason Dale Riddle 2003
All Rights Reserved**

ABSTRACT

SHORT-TERM EFFECTS OF LOW-INTENSITY WILDFIRE ON BREEDING BIRDS IN SOUTHERN APPALACHIAN OLD-GROWTH/PRE-SETTLEMENT FORESTS.

(August 2003)

Jason Dale Riddle, B.S., The College of William and Mary

M.S., Appalachian State University

Thesis Chairperson: Matthew P. Rowe

Avian declines in the southern Appalachians are some of the most severe in North America. These declines may be the result of reductions of both late- and early-successional habitats via industrial logging and fire suppression. Many conservationists recommend restoring these habitats and their associated bird communities by restricting logging in some areas while reintroducing fire and silviculture in others. However, little is known about the relative importance of these habitats or the effects of fire on wildlife in the southern Appalachians. For the present study, breeding bird communities were sampled in burned and unburned stands of old-growth/pre-settlement acidic cove and slope and thermic oak-pine forests. All data were collected by the point count method in Linville Gorge Wilderness during the 2001 breeding season. This was the first breeding season following the Brushy Ridge Wildfire complex. Several main effects of vegetation were discovered. Specifically, bird abundance and species richness were significantly higher in thermic oak-pine for short-distance migrants, early-succession birds, ground-

low nesters, and ground foragers. Total bird abundance, total species richness, and high conservation priority bird abundance and species richness were also higher in thermic oak-pine, but this finding was only marginally significant. No main effects of wildfire on breeding birds were found. Also, there were few interactions between fire and vegetation on breeding birds. Only low conservation priority bird abundance and species richness were significantly higher in unburned acidic cove and slope and burned thermic oak-pine than in burned acidic cove and slope and unburned thermic oak-pine. Overall, these findings suggest that acidic cove and slope and thermic oak-pine forests both provide valuable avian habitat. However, thermic oak-pine, a fire maintained forest, is particularly important for a number of bird guilds. These findings also suggest that the very fires that maintain this forest type have little if any short-term effects on breeding bird communities at the guild level. This is the first study to investigate the effects of fire on bird communities in the southern Appalachians. Further, long-term studies are needed to fully elucidate the impacts of fire on bird communities in various southern Appalachian habitats.

ACKNOWLEDGEMENTS

My tenure in the Biology Department at Appalachian State University has been one of the most formative and transformative periods of my life. This thesis and the physical and social environment in which it took place have functioned as an intellectual cocoon for my world view. I would like to recognize the following individuals and groups for their contributions to the metamorphosis.

First and foremost, I would like to thank our Creator for Linville Gorge. I could not have asked for a more challenging and rewarding research site. Without the provisions and protection of God I would not have survived this project or the Linville Gorge Wilderness.

I would especially like to thank my wife and my family for their seemingly endless support of myself and this project in the way of finances, prayer, and encouragement. Without their help I would have given up long ago. Prayer, challenge, direction, and encouragement were also provided by: The Griffin House, The Wythe House, my committee, ASU staff and faculty, the Biology Graduate students, the Rowe Lab, Tracy and Sherry Gould, and Steve Webster. I would also like to thank Dan Cristol, Ruth Beck, and the rest of the William and Mary Biology faculty for their direction.

I would like to give special recognition to my committee. Matt Rowe has been a mentor in every sense of the word. Indeed, his advice and contributions to my life are as much like that of a friend or family member as they are that of an academic advisor. I

would also like to give special recognition to Robert Creed and Ray Williams. Like Matt, Robert and Ray tolerated and even welcomed lengthy and unscheduled conversations about biology, conservation, statistics, and life in general.

The following individuals helped me immensely in the field and/or the GIS lab: Matt Rowe, Shay Dumas, Jonathan Riddle, Chad Horton, Beth Hudson, Carrie Gass, Robert Pleszewski, Brian and Jessica Ball, Don Sloan, Ken Fortino, Larrisa Knebel, Raleen Wilson, Art Rex, Dr. Xingong Li, and Chris Larson. Betsy Harris, Vicky Isaacs, and Val Somers provided much needed logistical support and encouragement. This project would not have been possible without phone, computer, and van access from the ASU Department of Biology.

Additionally, this project would have been impossible without extensive financial and logistical support from The Cratis D. Williams Graduate School, the Graduate Student Association Senate, the Ecological Society of America (Southeastern Chapter), The Wilderness Society (in agreement with the Dover Foundation), Carolina Bird Club, North Carolina Garden Club, Rhododendron Garden Club, and the USDA Forest Service. I would especially like to thank Dr. Chris Haney (currently with The Nature Conservancy) for his role in providing Wilderness Society funding and statistical advice. Dr. Jill Richie, ASU Mathematical Sciences Department, also provided important statistical advice. Forest Service employees, such as Robin Kastler, Bonnie Amaral, Dan Selig, Holly Selig, and Bill Jackson, provided invaluable logistic support throughout the project.

Drs. Bob Peet, Claire Newell, and Cecil Frost were particularly informative and helpful with the plant and fire ecology of Linville Gorge Wilderness.

This thesis is dedicated to my God, my wife, and my family.

TABLE OF CONTENTS

	<u>Page</u>
List of Tables	x
List of Figures	xi
Introduction	1
Methods	12
Results	15
Discussion	57
Bibliography	63
Appendix A	70
Appendix B	73
Vita	76

LIST OF TABLES

	<u>Page</u>
Table 1a	23
Table 1b	24
Table 2	25

LIST OF FIGURES

	<u>Page</u>
Figure 1	8
Figure 2	9
Figure 3	10
Figure 4	11
Figure 5	26
Figure 6	27
Figure 7	28
Figure 8	29
Figure 9	30
Figure 10	31
Figure 11	32
Figure 12	33
Figure 13	34
Figure 14	35
Figure 15	36
Figure 16	37
Figure 17	38
Figure 18	39

Figure 19	40
Figure 20	41
Figure 21	42
Figure 22	43
Figure 23	44
Figure 24	45
Figure 25	46
Figure 26	47
Figure 27	48
Figure 28	49
Figure 29	50
Figure 30	51
Figure 31	52
Figure 32	53
Figure 33	54
Figure 34	55
Figure 35	56

INTRODUCTION

The conservation status of North American birds has been a dominant theme in avian ecology for the past several decades. Declines in neotropical migratory birds, especially those that breed and/or winter in forests, have received the most attention (e.g., Robbins 1980, Wilcove 1985, Robbins et al. 1989, Terborgh 1989, Askins et al. 1990, Askins 1993, Simons et al. 1999). Neotropical migrants breed throughout much of the North American continent but migrate to the New World tropics for the winter. Declines in forest-dependent neotropical migrants are generally believed to be the result of habitat destruction via deforestation and fragmentation of their breeding and/or wintering grounds (e.g., Brittingham and Temple 1983, Wilcove 1985, Blake and Karr 1987, Robbins et al. 1989, Askins et al. 1990, Askins 1993). While declines in neotropical migrants, especially forest-dependents, have received much attention, it should be noted that the geographic and temporal extent of these declines are still debated (James and McCulloch 1995, James et al. 1996, Maurer and Villard 1996).

Short-distance migrants (birds that breed and winter in different locations within North America) and permanent residents may be experiencing more severe declines than neotropical migrants (Sauer et al. 1994). Most short-distant migrants and permanent residents are early-succession birds (Askins 1993). These birds depend on naturally occurring, disturbance-mediated habitats such as grasslands, shrublands, early-successional forests, and savannas (Brawn et al. 2001). Not surprisingly, declines in

early-succession birds have been attributed to the loss of disturbance-mediated habitat. These losses are usually associated with direct habitat destruction via agriculture and development or indirect habitat destruction via the alteration and/or removal of natural disturbances such as flooding and fire (Askins 1993, Brawn et al. 2001, Hunter et al. 2001). Little debate exists regarding the intense and widespread decline of early-succession birds (e.g., Askins 1993, Brawn et al. 2001, Hunter et al. 2001).

The southern Appalachians support an extremely rich avian fauna (Simons et al. 1999). This is especially true with regard to neotropical migrants, 75 species of which can be found breeding in the southern Appalachians, accounting for up to 80% of the breeding bird community (MacArthur 1959, Simons et al. 1999). Many of these species have their largest breeding populations in the Appalachian Mountains (James et al. 1996). However, avian populations in the southern Appalachians, especially the Blue Ridge Mountains, exhibit some of the most severe declines recorded in North America. For example, James et al. (1996) studied population trends in 26 species of neotropical migrants in eastern and central North America. They estimated that 75% of the study species which occurred in the Blue Ridge Mountains were in decline. Other studies have also demonstrated similar population trends in the southern Appalachians (e.g., Alsop and Laughlin 1991, Sauer and Droege 1992, Holt 2000). These negative population trends are not limited to neotropical migrants. Populations of many short-distance migrants and permanent residents are decreasing in the southern Appalachians as well (Hunter et al. 1999).

Declines in birds that utilize different wintering grounds but share the same breeding grounds suggest that breeding habitats are being degraded. However, many

populations of both forest-dependent and early-succession species are in simultaneous decline in the southern Appalachians (Hunter et al. 1999). Simultaneous declines in forest-dependent and early-succession birds seem somewhat counterintuitive. One would expect an increase in early-successional habitat (and therefore early succession birds) at the expense of forested habitat (and therefore forest-dependent birds) and vice versa. One possible explanation of this apparent paradox is diminished landscape heterogeneity. Namely, the replacement of old-growth forests, oak woodlands, thermic oak-pine stands, thermic yellow pine stands, and grasslands (e.g. meadows and grassy balds) with closed canopy mid-successional hardwoods (see Delcourt and Delcourt 1997, Buckner and Turrill 1999, Hunter et al. 1999, South and Buckner 2003).

The most likely causes of diminished landscape heterogeneity in the southern Appalachians are industrial logging, logging-induced conflagrations, and subsequent fire exclusion (Fig. 1, page 8; Buckner and Turrill 1999, see also Delcourt and Delcourt 1997). The southern Appalachians were extensively logged during the late 1800's and early 1900's (e.g., Korstian 1937, Pyne 1982, SAMAB 1996, Bratton and Meier 1998). This resulted in massive losses of forests with old-growth characteristics (see Newell and Peet 1998). Industrial logging practices of the late 1800's and early 1900's left unprecedented amounts of dead woody debris on the ground (Korstian 1937, Buckner and Turrill 1999). The cured slash from logging was easily ignited by locomotives, whiskey stills, smoking, arsonists, etc. As a consequence, conflagrations became common in the southern Appalachians (Korstian 1937, Pyne 1982, Bratton and Meier 1998). These conflagrations probably did much to sway public opinion in opposition to forest fires. Fire "protection" increased dramatically during the 1940's and still continues

today (Skeen et al. 1992). In the absence of fire, regenerating forests were quickly dominated by hardwoods. Presently, the southern Appalachians are heavily forested with closed canopy mid-successional hardwood stands which lack both the structural complexity of old-growth forests and the open successional characteristics of woodlands and grasslands (SAMAB 1996, Buckner and Turrill 1999, Hunter et al. 1999).

Prior to the late 1800's, fire was probably one of the most important ecological forces for creating and maintaining a diverse array of various forest types and early-successional habitats in the southern Appalachians (Fig. 2, page 9; SAMAB 1996, Buckner and Turrill 1999). North- and east-facing lower-slopes, moist coves, and moist ravines provide natural fire shelters and therefore rarely experienced fire (Harmon 1982, Delcourt and Delcourt 1997, Bratton and Meier 1998). As such, mixed mesophytic, cove hardwood, and some riparian plant communities rarely burned (but see Delcourt and Delcourt 1998). In the absence of industrial logging, these sites would have probably had old-growth forests. On the other hand, dryer mid- to upper-slope positions with south to southwest aspects probably burned every 5-25 yrs from human and lightning set fires (Frost 1998, Buckner and Turrill 1999). These sites would have supported oak, yellow pine, and oak-pine forests. Many of these forests had open understories (Bratton and Meier 1998, Buckner and Turrill 1999) with a vegetation composed of grasses and bracken fern (Delcourt and Delcourt 1997, C. Frost *personal communication*). Fire also may have been an important factor in promoting grassy balds (Pitillo et al. 1998, Buckner and Turrill 1999, Van Lear and Waldrop 1999). The role that fire once played in shaping southern Appalachian plant and animal communities is further supported by the current or historical presence of fire-associated species such as Table mountain pine (*Pinus*

pungens) and pitch pine (*Pinus rigida*) (see Williams and Johnson 1992); mountain golden heather (*Hudsonia Montana*) (Van Lear and Waldrop 1999); and the red-cockaded woodpecker (*Picoides borealis*) (Harrod et al. 1998).

Some avian ecologists are recommending extensive restoration efforts to reestablish landscape heterogeneity in the southern Appalachians (Hunter et al. 1999). Old-growth forests will only be restored by restricting logging and burning in some areas (Delcourt and Delcourt 1997, Hunter et al. 1999). It may take hundreds of years for these forests to reach old-growth status. In the meantime, silvicultural techniques could be utilized to make the structural attributes of mid-successional hardwood stands more similar to that of old-growth forests (Hunter et al. 1999). Woodlands and grasslands would best be restored by combinations of fire, silviculture, and grazing (Delcourt and Delcourt 1997, Buckner and Turrill 1999, Hunter et al. 1999). Nevertheless, the importance of these habitat types and their respective disturbance regimes deserves extensive investigation (e.g., Donovan et al. 2002). Exactly what kind of avian communities existed in these habitats prior to industrial logging and fire suppression? What was the relative importance of old-growth vs. disturbance-mediated successional habitats such as thermic oak-pine forests? How did disturbances such as fire affect bird communities in these habitats?

These questions can only be asked in a few places within the southern Appalachians. One such place is Linville Gorge Wilderness. This 4,950 ha wilderness is located on the eastern edge of the Blue Ridge Mountains in Burke County, North Carolina. The wilderness area includes Linville Gorge, as well as the immediately surrounding area. Linville Gorge is one of the deepest river gorges in the eastern United

States, with elevations ranging from approximately 390-1260 m. The extremely rugged topography of the Linville Gorge area made timber access difficult during the late 1800's and early 1900's. As such, most of Linville Gorge Wilderness contains old-growth/pre-settlement vegetation. In a detailed vegetation study, Newell and Peet (1998) determined that approximately 95% of Linville Gorge Wilderness is composed of old-growth/pre-settlement forests. These forests are classified as acidic cove and slope, thermic oak-pine, montane oak, rich cove and slope, and alluvial. Acidic cove and slope (ACS) forests and thermic oak-pine (TOP) forests make up 47% and 42% of the total land cover in Linville Gorge Wilderness, respectively (Fig. 3, page 10).

Acidic cove and slope forests are generally found on cool, sheltered, mid-lower slope positions within this landscape. These forests are typically dominated by eastern hemlock (*Tsuga canadensis*), white pine (*Pinus strobus*), and chestnut oak (*Quercus montana*) with a dense evergreen understory of rhododendron (*Rhododendron maximum*, Newell and Peet 1998). The topographic position and vegetative composition of ACS strongly suggest that this forest type has been naturally sheltered from fire.

Thermic oak-pine forests are generally found on dry, mid-upper slope positions and ridgelines within this landscape. These forests are typically dominated by Table Mountain pine (*Pinus pungens*), Virginia pine (*P. virginiana*), pitch pine (*P. rigida*), white oak (*Quercus alba*), red oak (*Q. rubra*), and Carolina hemlock (*Tsuga caroliniana*) with an evergreen understory of mountain laurel (*Kalmia latifolia*) and sparse rhododendron of various species (Newell and Peet 1998). The topographic position and vegetative composition of TOP suggest a relatively frequent fire interval in this forest type. Indeed, the historic fire regime for these forests in Linville Gorge was one of low-

intensity ground fires approximately every 5-7 yrs. and stand replacement fires approximately every 75 yrs. (Frost 1998, C. Frost *personal communication*). Until recently, most stands of TOP within Linville Gorge Wilderness had been fire suppressed for approximately 50 yrs. (C. Frost *personal communication*).

During early November of 2000, a complex of low-intensity surface fires (officially named the Brushy Ridge Wildfire by the USDA Forest Service) swept through approximately 2,935ha of Linville Gorge Wilderness (Fig. 4, page 11). Approximately 50% and 68% of all ACS and TOP forests burned, respectively (Riddle and Gass 2002). These fires cleared the forest floor of accumulating leaf litter and caused considerable defoliation of the evergreen understory. They rarely burned or even scorched the midstory and canopy layers of either ACS or TOP forests (Riddle 2001). Annual leaf fall was still in progress at the time of the fires. Therefore, there was a mild replenishing of the leaf litter layer immediately following the wildfires (Riddle, *personal observation*).

Thus, Linville Gorge Wilderness is an ideal landscape for determining the relative importance of old-growth (in this case ACS) and disturbance mediated (in this case TOP) habitats for bird communities. Moreover, recent wildfires provide a unique opportunity to examine the effects of fire on birds in these habitats. I sampled breeding bird communities in recently burned and unburned ACS and TOP forests within Linville Gorge Wilderness to determine the effects of fire on birds in habitats that are as similar as possible to those predating industrial logging and fire suppression.

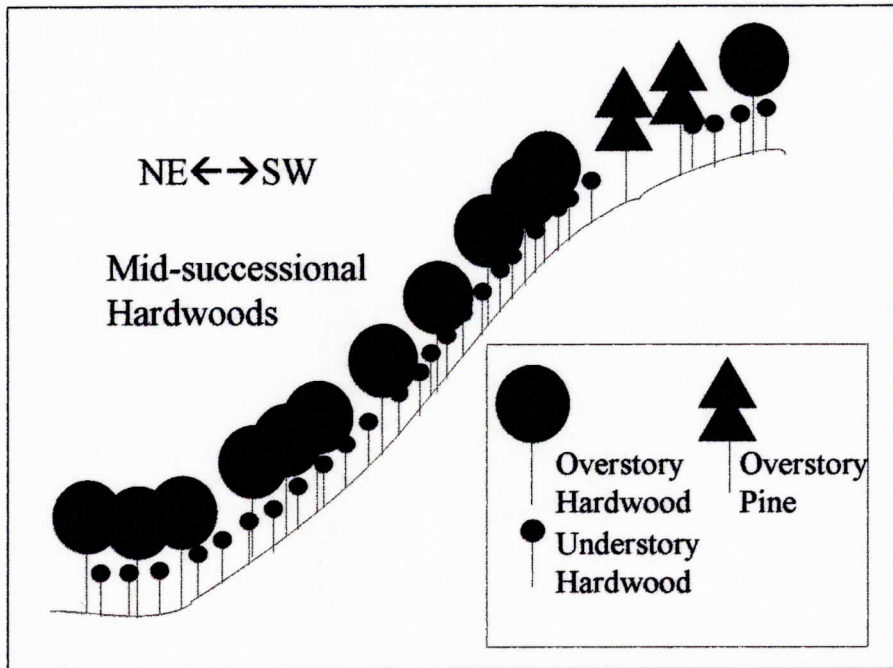


Figure 1. Generalized southern Appalachian landscape (adapted from Buckner and Turrill 1999).

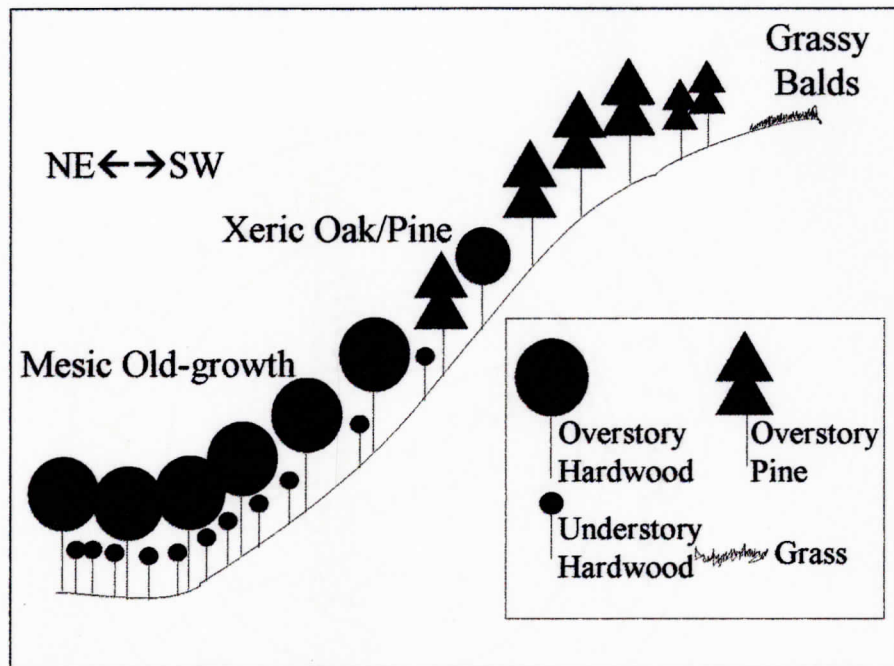


Figure 2. Historical southern Appalachian landscape (adapted from Buckner and Turrill 1999).

Linville Gorge Wilderness Area

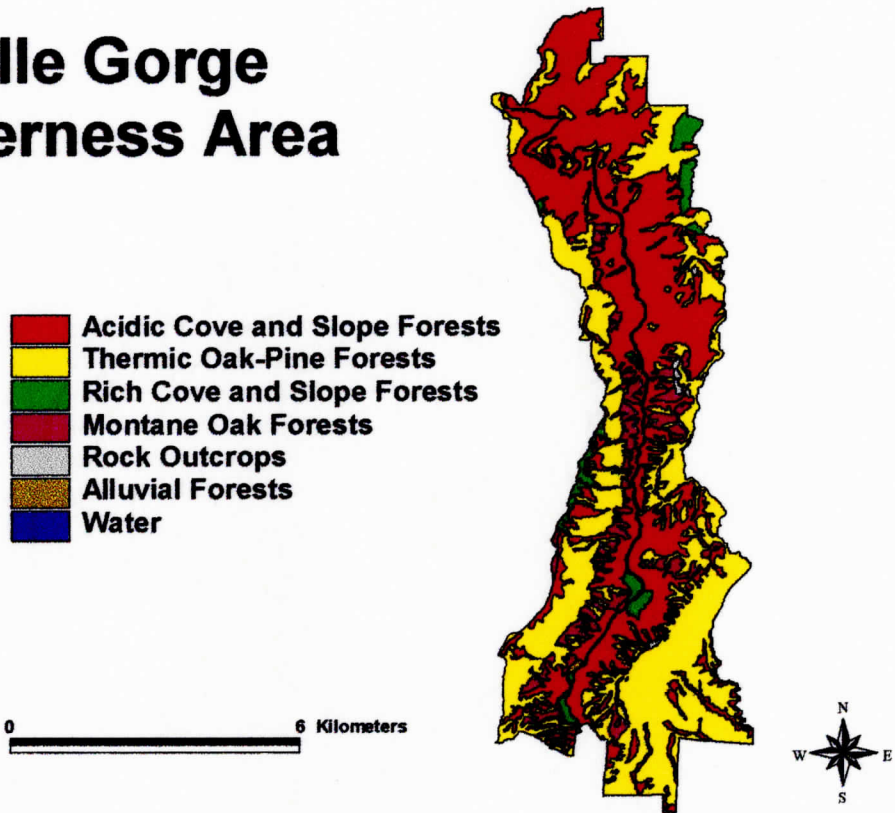
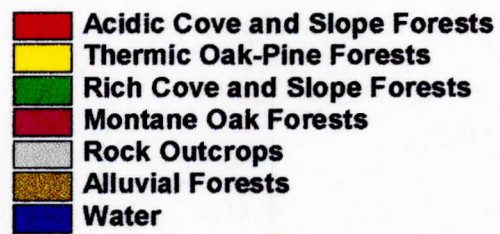


Figure 3. Land cover classification of Linville Gorge Wilderness (adapted from Newell and Peet 1998).

Linville Gorge Wilderness Area



0 6 Kilometers

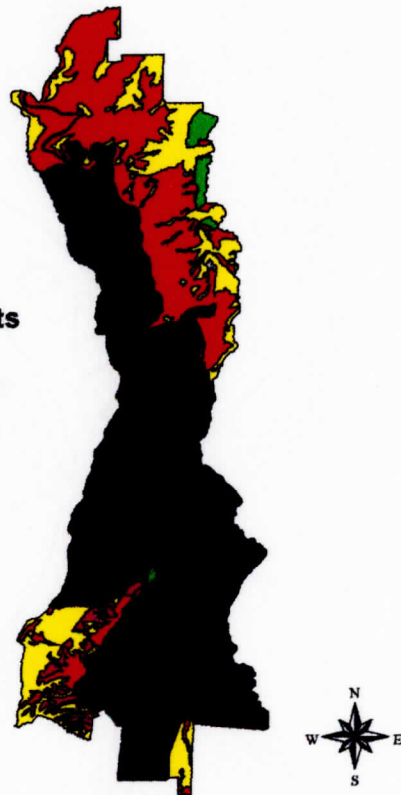


Figure 4. The extent of the Brushy Ridge Wildfire (shown in black) within Linville Gorge Wilderness.

METHODS

Avian Sampling

Breeding bird communities were sampled using 125 m fixed-radius point counts of 10 min duration according to the protocols set forth by Ralph et al. (1995). A two-by-two factorial treatment structure was used with fire and forest type as main effects. Specifically, 98 point counts were stratified across the following four treatments: burned ACS (n = 24), unburned ACS (n = 20), burned TOP (n = 36), unburned TOP (n = 18). All plots were sampled once between 6:30 and 10:30am from May 15-June 30, 2001 (see Ralph et al. 1995). This was the first breeding bird season following the Brushy Ridge Wildfire.

Statistical Techniques

Total bird abundance (number of individuals) and total species richness (number of species) were calculated for each point count. Bird abundance and species richness for groups of birds that shared ecological attributes (i.e. guilds such as migratory habit, breeding habitat, nest location, nest type, foraging strata, and conservation status) were also calculated. Migratory, breeding habitat, nest location, nest type, and foraging strata guild classifications were based on Sauer et al. (2001) and Ehrlich et al. (1988). Migratory guilds included permanent residents, short-distance migrants, and neotropical migrants. Breeding habitat guilds included woodland breeders and early-succession breeders. Early-succession breeders included birds that prefer urban, successional, or scrub habitats. Nest location guilds included ground-low nesters and midstory-canopy

nesters. Nest type guilds included cup nesters and cavity nesters. Foraging guilds included ground foragers and foliage foragers.

Conservation guilds included "high priority birds" and "low priority birds". High priority birds were those listed by Partners in Flight (Hunter et al. 1999) and/or determined to be significantly or nonsignificantly declining in the Blue Ridge Mountains from 1966-2000 according to the Breeding Bird Survey (Sauer et al. 2001). Low priority birds were those not listed by Partners in Flight (Hunter et al. 1999) and/or determined to be significantly or nonsignificantly increasing in the Blue Ridge Mountains from 1966-2000 according to the Breeding Bird Survey (Sauer et al. 2001). See Appendix A for a list of observed species and respective guild designations. See Appendix B for a complete list of species observations in each treatment.

A two-way ANOVA (PROC GLM, SAS institute) was used to assess the main effects of fire, vegetation, and the interaction thereof on total bird abundance and total species richness. A two-way MANOVA (PROC GLM, SAS institute) was used to assess overall main effects of fire, vegetation, and the interaction thereof on bird abundance and species richness in a suite of guilds (e.g., migratory habit or nest location). Guild member abundance and species richness were considered multiple dependent variables in these analyses. For example, a two-way MANOVA on bird abundance for the migratory guilds would assess the overall main effects of fire, vegetation, and the interaction thereof on permanent resident, short-distance migrant, and neotropical migrant abundance simultaneously. Two-way ANOVA was then used to assess main effects of fire, vegetation, and the interactions thereof on bird abundance and species richness in each

guild separately. In this way, ANOVA results pertaining to individual guild responses could aid in the interpretation of MANOVA results pertaining to overall guild responses.

I considered p values ≤ 0.01 to be highly significant; p values ≤ 0.05 but > 0.01 were significant; p values ≤ 0.10 but > 0.05 were marginally significant. The Holm procedure was used to control for strong familywise error rates (Oehlert 2000). A family of tests was considered to be the group of ANOVAs that considered all guild members within a guild suite. When necessary, data were transformed to meet the assumptions of normality and homogeneity of variance using the following formula:

$$\text{Log}(x + 1)$$

where “ x ” is bird abundance or species richness of the response variable of interest.

Some data could not be normalized with this or any other transformation. However, this was not considered to be a major problem as ANOVA and MANOVA are robust to deviations from normality (Zar 1999, Tabachnick and Fidell 2001). More importantly, the raw and/or transformed data generally seemed to meet the more important assumption of homogenous variances (see Oehlert 2000).

RESULTS

Total Bird Abundance and Species Richness

Bird abundance

There was no main effect of fire or interaction of fire and vegetation on total bird abundance (Table 1a, page 23). There was a marginally significant main effect of vegetation ($F_{1,94} = 3.78$, $P = 0.0549$; Table 1a). Specifically, total bird abundance was slightly higher in TOP than ACS forests (7.43 ± 2.48 vs. 6.25 ± 2.85 respectively, mean \pm 1 standard deviation; Fig. 5, page 26).

Species richness

There was no significant main effect of fire or interaction of fire and vegetation on total species richness (Table 1b, page 24). There was a marginally significant main effect of vegetation ($F_{1,94} = 3.68$, $P = 0.0581$; Table 1b). Specifically, total species richness was slightly higher in TOP than ACS forests (6.11 ± 1.99 vs. 5.20 ± 2.24 ; Fig. 6, page 27).

Migratory Guilds

Bird abundance

There was a significant overall vegetation effect on bird abundance in the migratory guilds ($F_{3,92} = 3.15$, $P = 0.0287$; Table 2, page 25, Fig. 7, page 28). This appeared to be caused by a highly significant vegetation effect on short-distance migrant bird abundance ($F_{1,94} = 9.59$, $P = 0.0026$; Table 1a). Specifically, short-distance migrant

bird abundance was higher in TOP than ACS forests (1.59 ± 1.24 vs. 0.86 ± 0.98 , Fig. 8, page 29). There was no main effect of vegetation on permanent resident or neotropical migrant bird abundance (Table 1a). There was no overall main effect of fire or overall interaction of fire and vegetation on bird abundance in the migratory guilds (Table 2). Similarly, there was no main effect of fire or interaction of fire and vegetation on short-distance and neotropical migrant bird abundance (Table 1a). However, there was a marginally significant main effect of fire on permanent resident bird abundance ($F_{1,94} = 3.31$, $df = 1$, $P = 0.0718$, Table 1a). Permanent resident bird abundance was slightly higher in burned forests than unburned (1.48 ± 1.57 vs. 0.97 ± 0.91 , Fig. 9, page 30).

Species richness

There was a marginally significant overall vegetation effect on species richness in the migratory guilds ($F_{3,92} = 2.66$, $P = 0.0528$; Table 2, Fig. 10, page 31). This seemed to be caused by a highly significant vegetation effect on short-distance migrant species richness ($F_{1,94} = 8.09$, $P = 0.0055$; Table 1b). Specifically, short-distance migrant species richness was higher in TOP than ACS forests (1.31 ± 1.01 vs. 0.77 ± 0.83 , Fig. 11, page 32). There was no main effect of vegetation on permanent resident or neotropical migrant species richness (Table 1b). There was no overall main effect of fire or overall interaction of fire and vegetation on species richness in the migratory guilds (Table 2). Similarly, there was no main effect of fire or interaction of fire and vegetation on permanent resident, short-distance migrant, or neotropical migrant species richness (Table 1b).

Breeding Habitat Guilds

Bird abundance

There was a highly significant overall vegetation effect on bird abundance in the breeding habitat guilds ($F_{2,93} = 11.27$, $P < 0.0001$; Table 2, Fig. 12, page 33). This was caused by a highly significant vegetation effect on early-succession bird abundance ($F_{1,94} = 21.93$, $P < 0.0001$; Table 1a). Specifically, early-succession bird abundance was higher in TOP than ACS forests (1.74 ± 1.40 vs. $0.57 \pm .90$, Fig. 13, page 34). There was no significant main effect of vegetation on woodland bird abundance (Table 1a). There was no overall main effect of fire or overall interaction of fire and vegetation on bird abundance in the breeding habitat guild (Table 2). Similarly, there was no main effect of fire or interaction of fire and vegetation on early-succession or woodland bird abundance (Table 1a).

Species richness

There was a highly significant overall vegetation effect for species richness in the breeding habitat guilds ($F_{2,93} = 9.16$, $P = 0.0002$; Table 2, Fig. 14, page 35). This was caused by a highly significant vegetation effect on early-succession species richness ($F_{1,94} = 18.08$, $P < 0.0001$; Table 1b). Specifically, early-succession species richness was higher in TOP than ACS forests (1.44 ± 1.21 vs. 0.55 ± 0.82 , Fig. 15, page 36). There was no main effect of vegetation on woodland species richness (Table 1b). There was no overall main effect of fire or interaction of fire and vegetation on species richness in the breeding habitat guilds (Table 2). Similarly, there was no main effect of fire or interaction of fire and vegetation on early-succession or woodland species richness (Table 1b).

Nest Location Guilds

Bird abundance

There was a highly significant overall vegetation effect on bird abundance in the nest location guilds ($F_{2,93} = 11.80$, $P < 0.0001$; Table 2, Fig. 16, page 37). This was the result of a highly significant vegetation effect on ground-low nesting bird abundance ($F_{1,94} = 22.52$, $P < 0.0001$; Table 1a). Specifically, ground-low nesting bird abundance was higher in TOP than ACS forests (2.87 ± 1.47 vs. 1.61 ± 1.69 , Fig. 17, page 38). There was no significant main effect of vegetation on midstory-canopy nesting bird abundance (Table 1a). There was no overall main effect of fire on bird abundance in the nest location guilds (Table 2). Similarly, there was no main effect of fire on ground-low or midstory-canopy nesting bird abundance (Table 1a). There was a marginally significant overall interaction of fire and vegetation on bird abundance in the nest location guilds ($F_{2,93} = 2.74$, $P = 0.0696$; Table 2, Fig. 18, page 39). This was caused by a marginally significant interaction of fire and vegetation on midstory-canopy nesting bird abundance ($F_{1,94} = 3.09$, $P = 0.0822$; Table 1a). Specifically, midstory-canopy nesting bird abundance was higher in unburned ACS (4.90 ± 2.25) and burned TOP (4.83 ± 2.05) than in burned ACS (4.42 ± 2.12) and unburned TOP (3.67 ± 1.78 , Fig. 19, page 40). There was no interaction of fire and vegetation on ground-low nesting bird abundance (Table 1a).

Species richness

There was a highly significant overall vegetation effect on species richness in the nest location guilds ($F_{2,93} = 8.36$, $P = 0.0005$; Table 2, Fig. 20, page 41). This was the result of a highly significant vegetation effect on ground-low nesting species richness

($F_{1,94} = 16.20$, $P = 0.0001$; Table 1b). Specifically, ground-low nesting species richness was higher in TOP than ACS forests (2.30 ± 1.28 vs. 1.41 ± 1.40 , Fig. 21, page 42). There was no main effect of vegetation on midstory-canopy nesting species richness (Table 1b). There was no overall effect of fire on species richness in the nest location guilds (Table 2). Similarly, there was no main effect of fire on ground-low or midstory-canopy nesting species richness (Table 1b). There was a marginally significant overall interaction of fire and vegetation on species richness in the nest location guilds ($F_{2,93} = 2.82$, $P = 0.0646$; Table 2, Fig. 22, page 43). This was caused by a marginally significant interaction of fire and vegetation on midstory-canopy nesting species richness ($F_{1,94} = 3.06$, $P = 0.0835$; Table 1b). Specifically, midstory-canopy nesting species richness was higher in unburned ACS (4.00 ± 1.62) and burned TOP (4.03 ± 1.68) than in burned ACS (3.63 ± 1.58) and unburned TOP (3.11 ± 1.49 , Fig. 23, page 44). There was no interaction of fire and vegetation on ground-low nesting species richness (Table 1b).

Nest Type Guilds

Bird abundance

There were no significant overall main effects or interaction of fire and vegetation on bird abundance in the nest type guild (Table 2). There was a marginally significant main effect of fire on cavity nesting bird abundance ($F_{1,94} = 3.06$, $P = 0.0836$, Table 1a). Specifically, cavity nesting bird abundance was higher in burned forests than in unburned (1.50 ± 1.24 vs. 0.97 ± 0.94 , Fig. 24, page 45). There was no main effect of vegetation or interaction of fire and vegetation on cavity nesting bird abundance (Table 1a). There was

no main effect of vegetation, fire, or interaction thereof on cup nesting bird abundance (Table 1a).

Species richness

There were no significant overall main effects or interaction of fire and vegetation on species richness in the nest type guild (Table 2). There was a marginally significant main effect of fire on cavity nesting species richness ($F_{1,94} = 3.13$, $P = 0.0799$, Table 1b). Specifically, cavity nesting species richness was higher in burned forests than in unburned (1.28 ± 1.03 vs. 0.89 ± 0.86 , Fig. 25, page 46). There was no main effect of vegetation or interaction of fire and vegetation on cavity nesting species richness (Table 1b). There was no main effect of vegetation, fire, or interaction thereof on cup nesting species richness (Table 1b).

Foraging Guilds

Bird abundance

There was a highly significant overall vegetation effect on bird abundance in the foraging guilds ($F_{2,93} = 14.36$, $P < 0.0001$; Table 2, Fig. 26, page 47). This appeared to be the result of a highly significant vegetation effect on ground foraging bird abundance ($F_{1,94} = 28.88$, $P < 0.0001$, Table 1a). Specifically, ground foraging bird abundance was higher in TOP than ACS (2.78 ± 1.46 vs. 1.36 ± 1.18 , Fig. 27, page 48). There was no main effect of vegetation on foliage foraging bird abundance. There was no overall main effect of fire or interaction of fire and vegetation on bird abundance in the foraging guilds (Table 2). Similarly, there was no significant main effect of fire or interaction of fire and vegetation on either ground or foliage foraging bird abundance (Table 1a).

Species richness

There was a highly significant overall vegetation effect on species richness in foraging guilds ($F_{2,93} = 8.90$, $P = 0.0003$, Table 2, Fig. 28, page 49). This appeared to be the result of a highly significant vegetation effect on ground foraging species richness ($F_{1,94} = 17.94$, $P < 0.0001$, Table 1b). Specifically, ground foraging species richness was higher in TOP than ACS (2.20 ± 1.25 vs. 1.25 ± 1.06 , Fig. 29, page 50). There was no main effect of vegetation on foliage foraging species richness. There was no overall main effect of fire or interaction of fire and vegetation on species richness in the foraging guilds (Table 2). Similarly, there was no significant main effect of fire or interaction of fire and vegetation on either ground or foliage foraging species richness (Table 1b).

Conservation Guilds

Bird abundance

There was a marginally significant overall interaction of fire and vegetation on bird abundance in the conservation guilds ($F_{2,93} = 2.61$, $P = 0.0792$, Table 2, Fig. 30, page 51). This was likely the result of a significant interaction of fire and vegetation on low priority bird abundance ($F_{1,94} = 5.07$, $P = 0.0266$; Table 1a). Specifically, low priority bird abundance was higher in unburned ACS (1.45 ± 0.94) and burned TOP (1.53 ± 1.34) than burned ACS (0.83 ± 0.76) and unburned TOP (1.11 ± 1.08 , Fig. 31, page 52). There was no interaction of fire and vegetation on high priority bird abundance. There was no significant overall main effect of fire or vegetation on bird abundance in the conservation guild (Table 2). Similarly, I found no main effect of fire or vegetation on low priority bird abundance. However, there was a marginally significant main effect of vegetation on high priority bird abundance ($F_{1,94} = 3.26$, $P = 0.0742$, Table 1a). Specifically, high

priority bird abundance was slightly higher in TOP than ACS (1.39 ± 1.27 vs. 1.11 ± 0.89 , Fig. 32, page 53). There was no main effect of fire on high priority bird abundance.

Species richness

There was a marginally significant overall interaction of fire and vegetation on species richness in the conservation guilds ($F_{2,93} = 3.04$, $P = 0.0527$, Table 2, Fig. 33, page 54). This was likely the result of a significant interaction of fire and vegetation on low priority species richness ($F_{1,94} = 5.67$, $P = 0.0193$; Table 1b). Specifically, low priority species richness was higher in unburned ACS (3.95 ± 1.73) and burned TOP (4.92 ± 1.86) than burned ACS (4.46 ± 2.25) and unburned TOP (5.00 ± 1.81 , Fig. 34, page 55). There was no interaction of fire and vegetation on high priority species richness. There was no significant overall main effect of fire or vegetation on species richness in the conservation guilds (Table 2). Similarly, I found no main effect of fire or vegetation on low priority species richness. However, there was a marginally significant main effect of vegetation on high priority species richness ($F_{1,94} = 3.49$, $P = 0.0647$, Table 1b). Specifically, high priority species richness was slightly higher in TOP than ACS (1.17 ± 1.06 vs. 0.98 ± 0.76 , Fig. 35, page 56). There was no main effect of fire on high priority species richness.

Table 1a. Means, standard deviations, and F values of bird abundance in each guild. F and p values are from ANOVA. * = $P \leq 0.10$, ** = $P \leq 0.05$, *** = $P \leq 0.01$.

	Mean Bird Abundance (with one Standard Deviation)				F Values (Bird Abundance)		
	ACS	ACS	TOP	TOP	Vegetation	Fire	Interaction
	Burned	Unburned	Burned	Unburned			
Total Bird Abundance	6.17 (3.03)	6.35 (2.70)	7.58 (2.39)	7.11 (2.70)	3.78*	0.07	0.34
Migratory Guilds							
<i>Neotropical Migrants</i>	4.04 (2.12)	4.60 (2.19)	4.47 (2.05)	4.22 (2.10)	0.02	0.11	0.99
<i>Short-Distance Migrants</i>	0.92 (1.10)	0.80 (0.83)	1.44 (1.03)	1.89 (1.57)	9.59***	0.14	0.27
<i>Permanent Residents</i>	1.21 (0.93)	0.95 (0.89)	1.67 (1.26)	1.00 (0.97)	0.58	3.31*	0.47
Breeding Habitat Guilds							
<i>Woodland</i>	5.58 (3.02)	5.80 (2.67)	5.86 (2.11)	5.33 (2.50)	0.08	0.09	0.76
<i>Early-Succession</i>	0.58 (1.02)	0.55 (0.76)	1.72 (1.43)	1.78 (1.40)	21.93***	0.03	0.00
Nest Location Guilds							
<i>Ground-low</i>	1.75 (1.78)	1.45 (1.61)	2.61 (1.34)	3.39 (1.61)	22.52***	0.12	2.16
<i>Midstory-canopy</i>	4.42 (2.12)	4.90 (2.25)	4.83 (2.05)	3.67 (1.78)	0.82	0.50	3.09*
Nest Type Guilds							
<i>Cup Nesters</i>	4.46 (2.41)	4.40 (1.96)	4.67 (2.01)	4.61 (2.43)	0.21	0.00	0.12
<i>Cavity Nesters</i>	1.21 (1.02)	1.00 (0.97)	1.69 (1.35)	0.94 (0.94)	0.47	3.06*	0.74
Foraging Guilds							
<i>Ground</i>	1.29 (1.12)	1.45 (1.28)	2.69 (1.56)	2.94 (1.26)	28.88***	0.87	0.07
<i>Foliage</i>	2.71 (1.65)	2.95 (1.73)	3.17 (1.80)	2.44 (1.58)	0.01	0.46	1.45
Conservation Guilds							
<i>High Priority</i>	5.33 (2.68)	4.90 (2.29)	6.06 (2.45)	6.00 (2.06)	3.26*	0.23	0.14
<i>Low Priority</i>	0.83 (0.76)	1.45 (0.94)	1.53 (1.34)	1.11 (1.08)	0.60	0.19	5.07**

Table 1b. Means, standard deviations, and F values for species richness in each guild. F and p values are from ANOVA. * = $P \leq 0.10$, ** = $P \leq 0.05$, *** = $P \leq 0.01$.

	Mean Species Richness (with one Standard Deviation)				F Values (Species Richness)		
	ACS Burned	ACS Unburned	TOP Burned	TOP Unburned	Vegetation	Fire	Interaction
Total Species Richness	5.21 (2.45)	5.20 (2.02)	6.22 (1.88)	5.89 (2.22)	3.68*	0.15	0.13
Migratory Guilds							
<i>Neotropical Migrants</i>	3.33 (1.74)	3.55 (1.47)	3.67 (1.45)	3.44 (1.82)	0.10	0.00	1.00
<i>Short-Distance Migrants</i>	0.79 (0.88)	0.75 (0.79)	1.19 (0.89)	1.56 (1.20)	8.09***	0.29	0.30
<i>Permanent Residents</i>	1.08 (0.88)	0.90 (0.79)	1.36 (1.02)	0.89 (0.90)	0.21	2.41	0.47
Breeding Habitat Guilds							
<i>Woodland</i>	4.67 (2.37)	4.65 (1.93)	4.81 (1.47)	4.39 (2.20)	0.04	0.41	0.68
<i>Early-Succession</i>	0.54 (0.88)	0.55 (0.76)	1.42 (1.25)	1.50 (1.15)	18.08***	0.10	0.00
Nest Location Guilds							
<i>Ground-low</i>	1.58 (1.47)	1.20 (1.24)	2.08 (1.13)	2.72 (1.49)	16.20***	0.02	2.57
<i>Midstory-canopy</i>	3.63 (1.58)	4.00 (1.62)	4.03 (1.68)	3.11 (1.49)	0.61	0.52	3.06*
Nest Type Guilds							
<i>Cup Nesters</i>	3.67 (1.88)	3.45 (1.39)	3.92 (1.56)	4.00 (1.94)	1.29	0.04	0.18
<i>Cavity Nesters</i>	1.08 (0.97)	0.95 (0.89)	1.42 (1.05)	0.83 (0.86)	0.29	3.13*	1.24
Foraging Guilds							
<i>Ground</i>	1.21 (1.02)	1.30 (1.13)	2.14 (1.27)	2.33 (1.24)	17.94***	0.43	0.03
<i>Foliage</i>	2.13 (1.19)	2.35 (1.18)	2.61 (1.42)	2.00 (1.19)	0.01	0.36	1.91
Conservation Guilds							
<i>High Priority</i>	4.46 (2.25)	3.95 (1.73)	4.92 (1.86)	5.00 (1.81)	3.49*	0.28	0.54
<i>Low Priority</i>	0.75 (0.68)	1.25 (0.79)	1.31 (1.14)	0.89 (0.83)	0.25	0.05	5.67**

Table 2. MANOVA F values for bird abundance and species richness. All F values are for Pillai's Trace statistic. * = $P \leq 0.10$, ** = $P \leq 0.05$, *** = $P \leq 0.01$.

	F Values (Bird Abundance)			F Values (Species Richness)		
	Vegetation	Fire	Interaction	Vegetation	Fire	Interaction
Migratory Guilds	3.15**	1.24	0.68	2.66*	1.10	0.77
Breeding Habitat Guilds	11.27***	0.05	0.38	9.16***	0.23	0.34
Nest Location Guilds	11.80***	0.32	2.74*	8.36***	0.27	2.82*
Nest Type Guilds	0.30	1.53	0.40	0.73	1.55	0.47
Foraging Guilds	14.36***	0.69	0.77	8.90***	0.42	0.99
Conservation Guilds	1.87	0.22	2.61*	1.87	0.16	3.04*

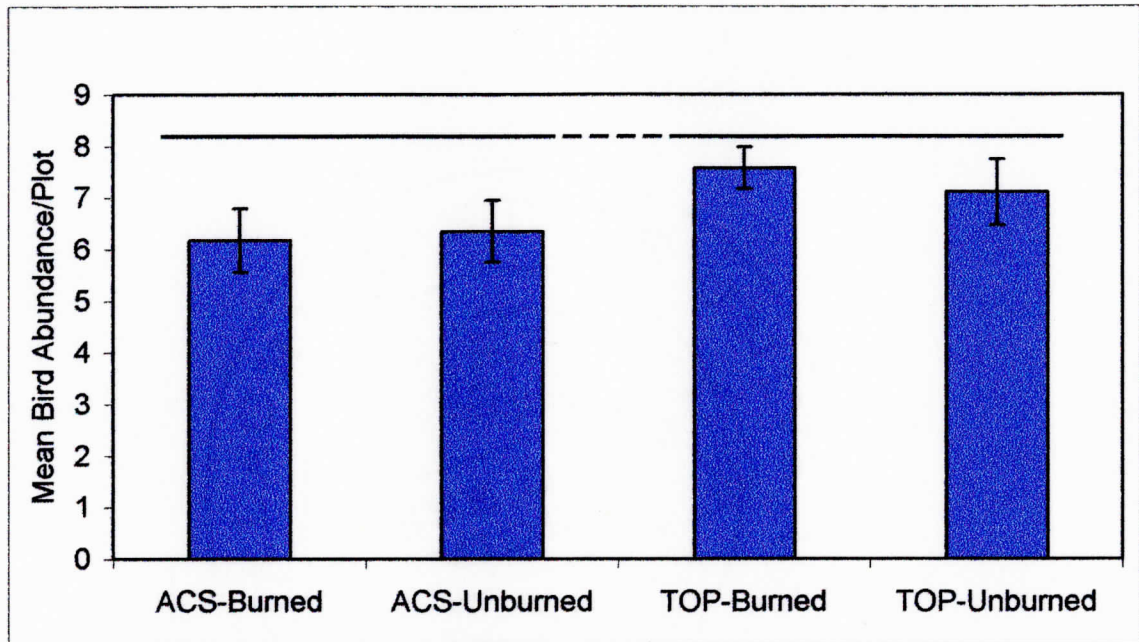


Figure 5. Mean total bird abundance (note that for this and all following figures: error bars represent 1 standard error, histograms overscored by the same solid bar are not statistically different, histograms connected by broken lines are marginally different, and histograms that are not connected by lines are significantly different).

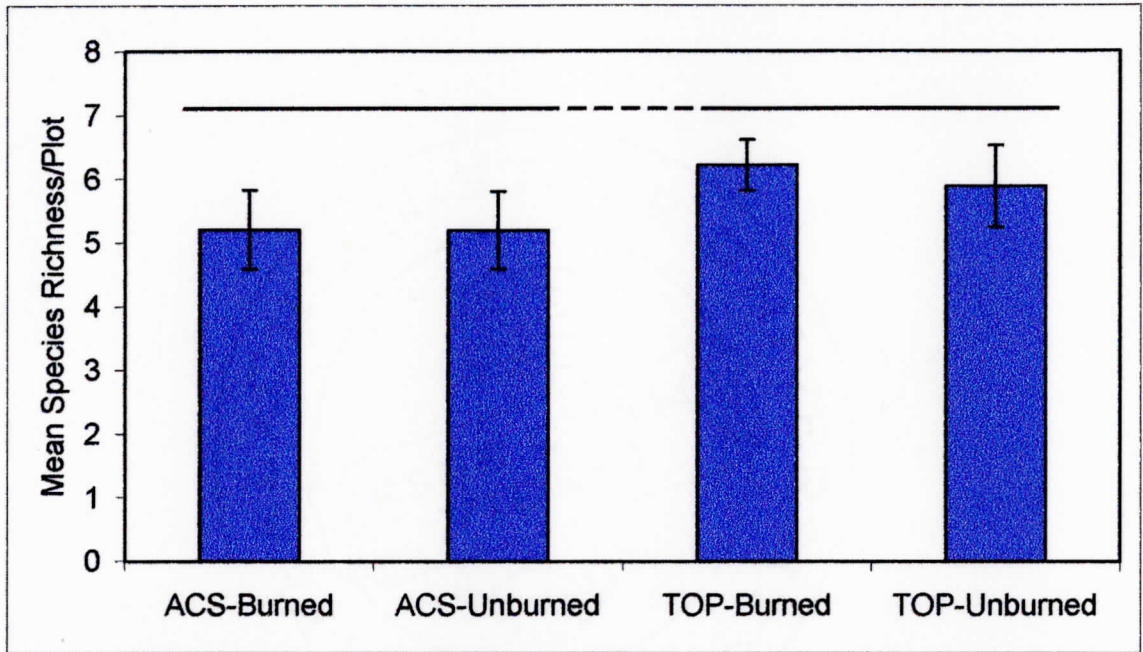


Figure 6. Mean total species richness.

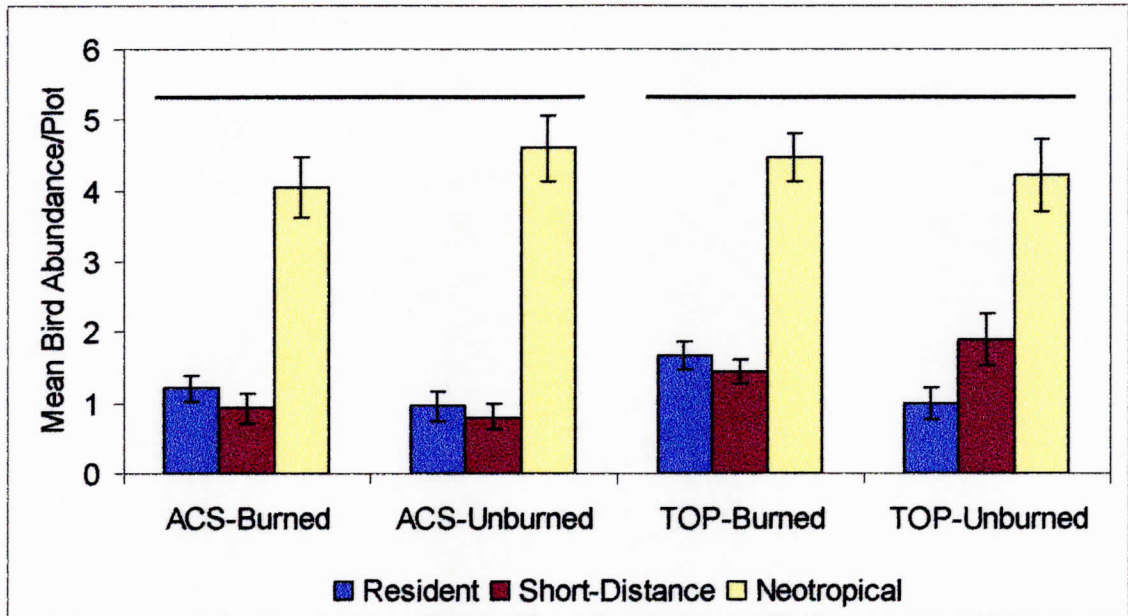


Figure 7. Mean bird abundance of all migratory guilds.

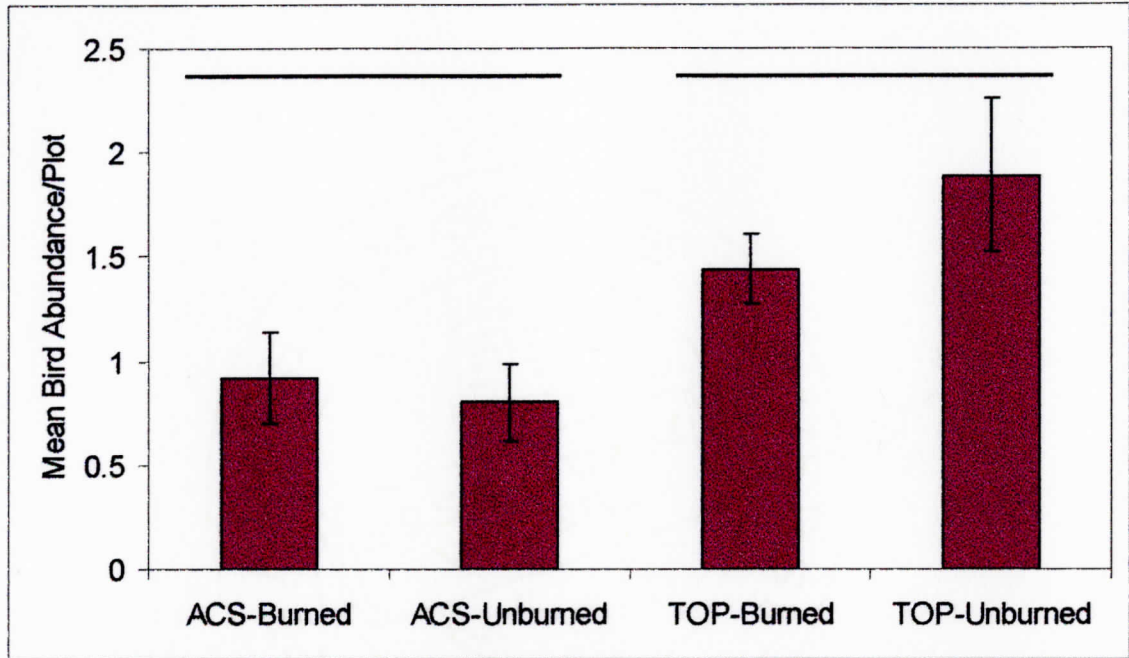


Figure 8. Mean short-distant migrant bird abundance.

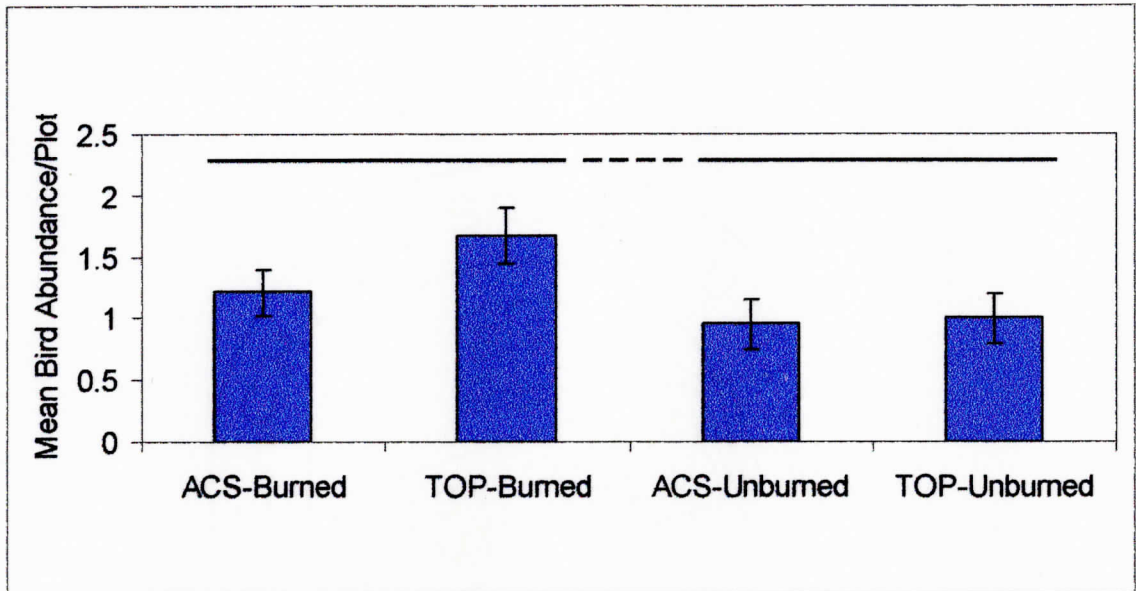


Figure 9. Mean permanent resident bird abundance.

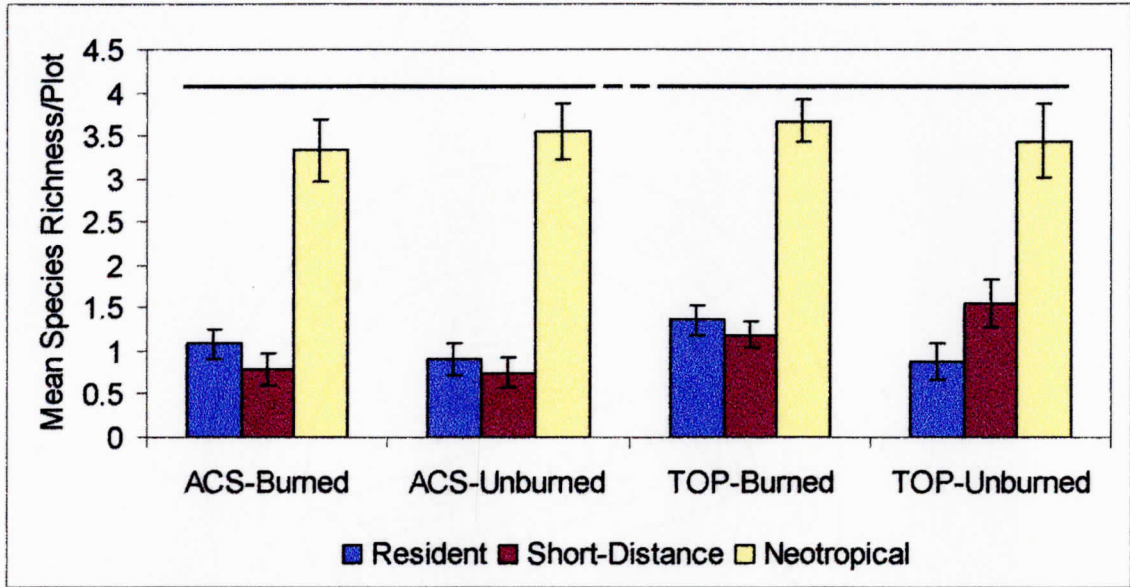


Figure 10. Mean species richness of all migratory guilds.

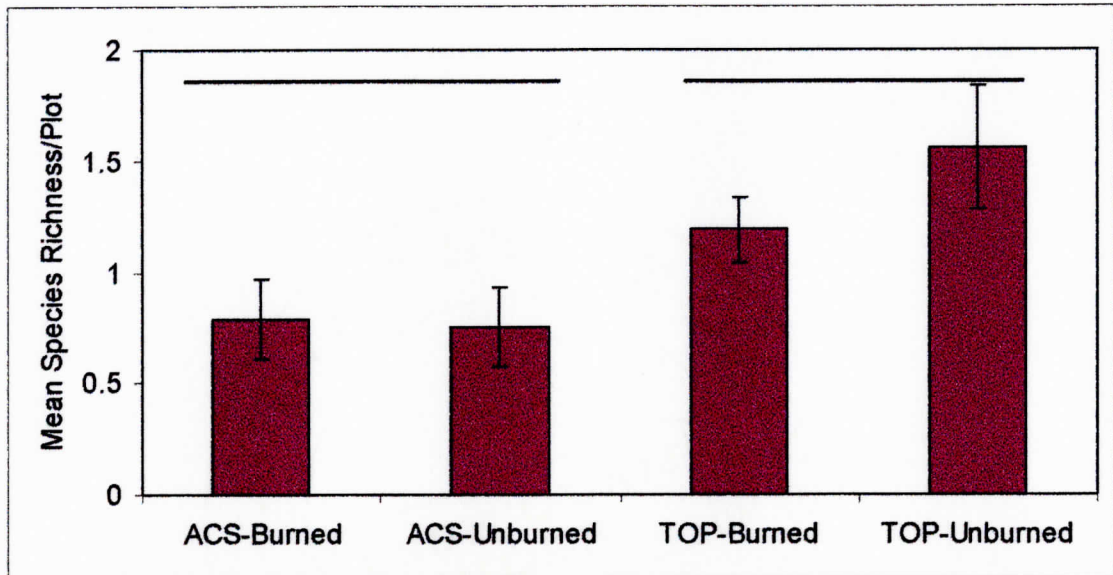


Figure 11. Mean species richness of short-distance migrant birds.

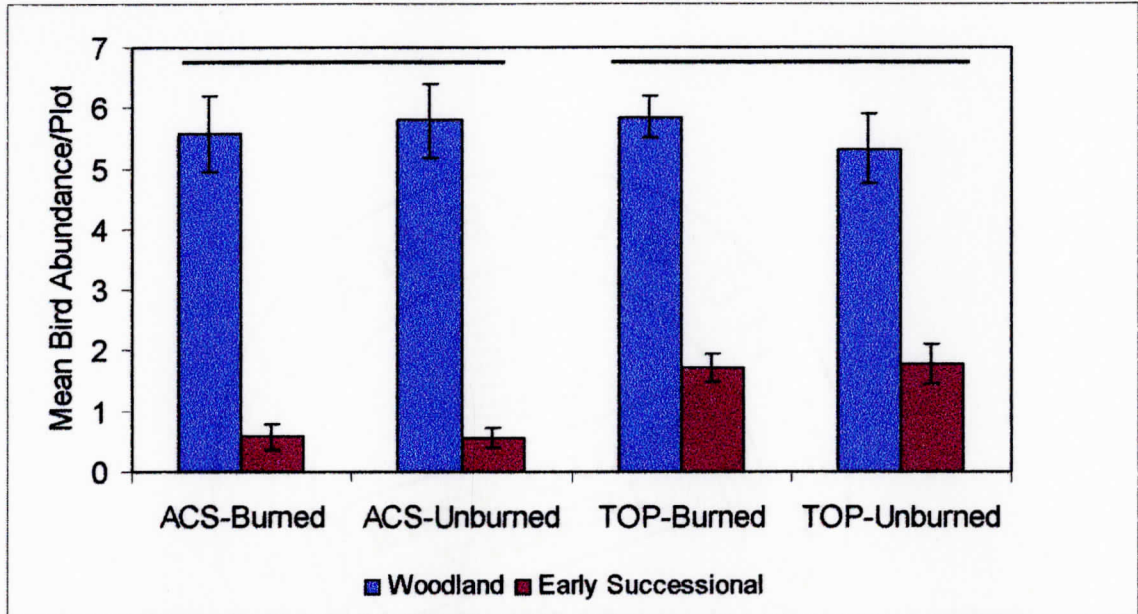


Figure 12. Mean bird abundance of both breeding habitat guilds.

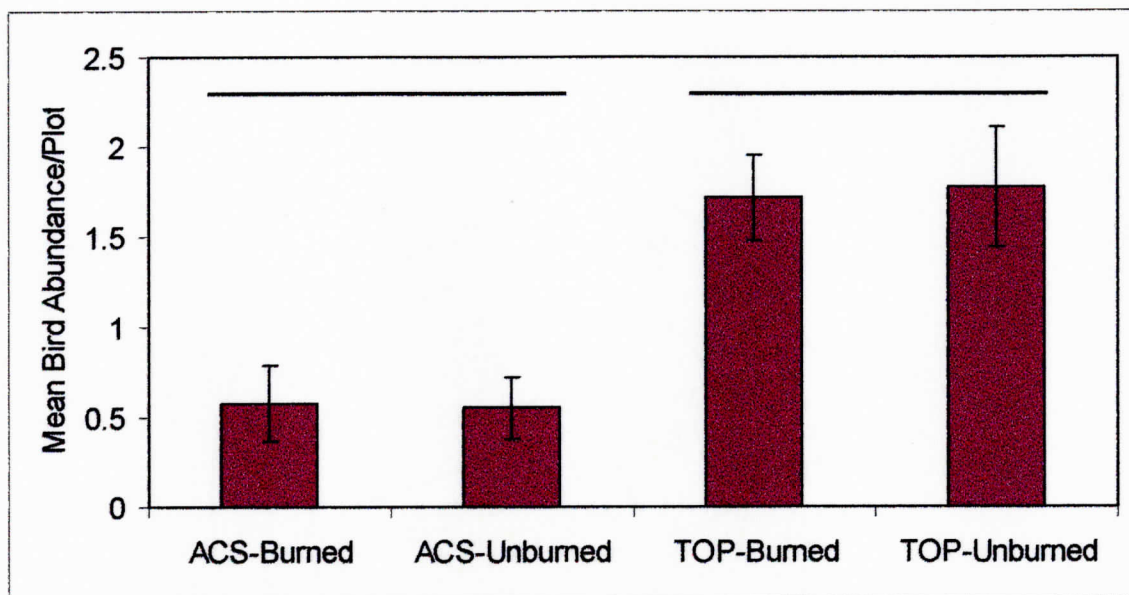


Figure 13. Mean early succession bird abundance.

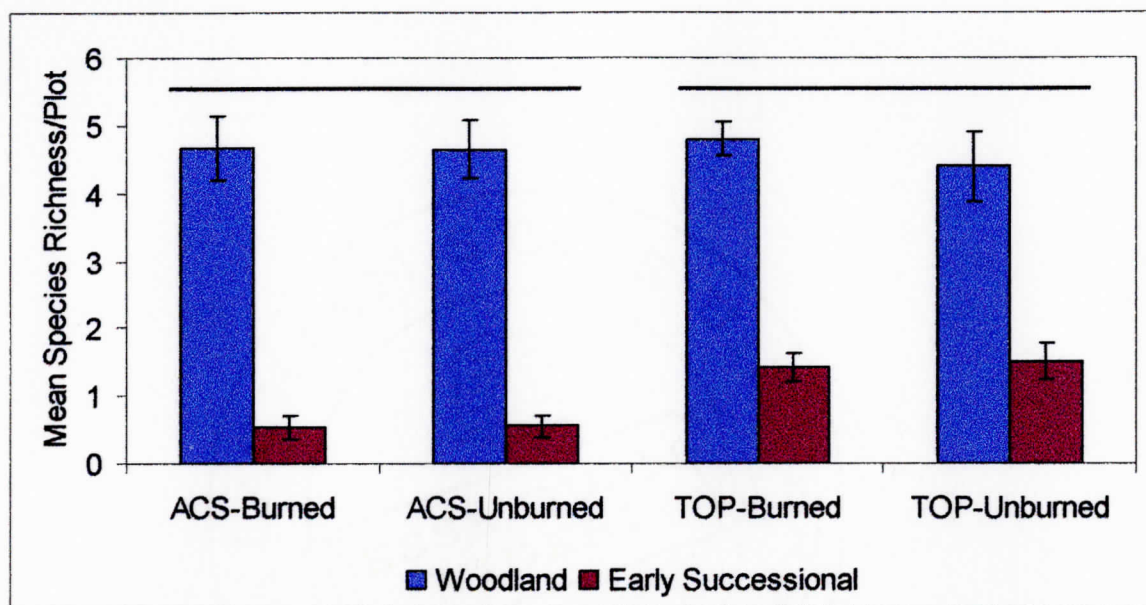


Figure 14. Mean species richness of both breeding habitat guilds.

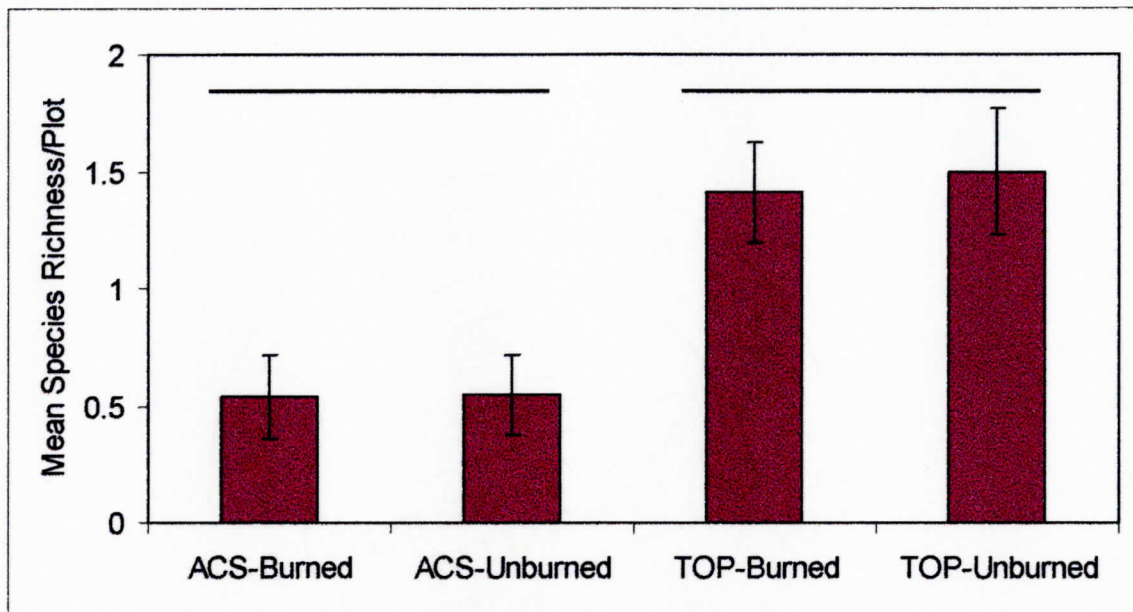


Figure 15. Mean species richness of early-succession birds.

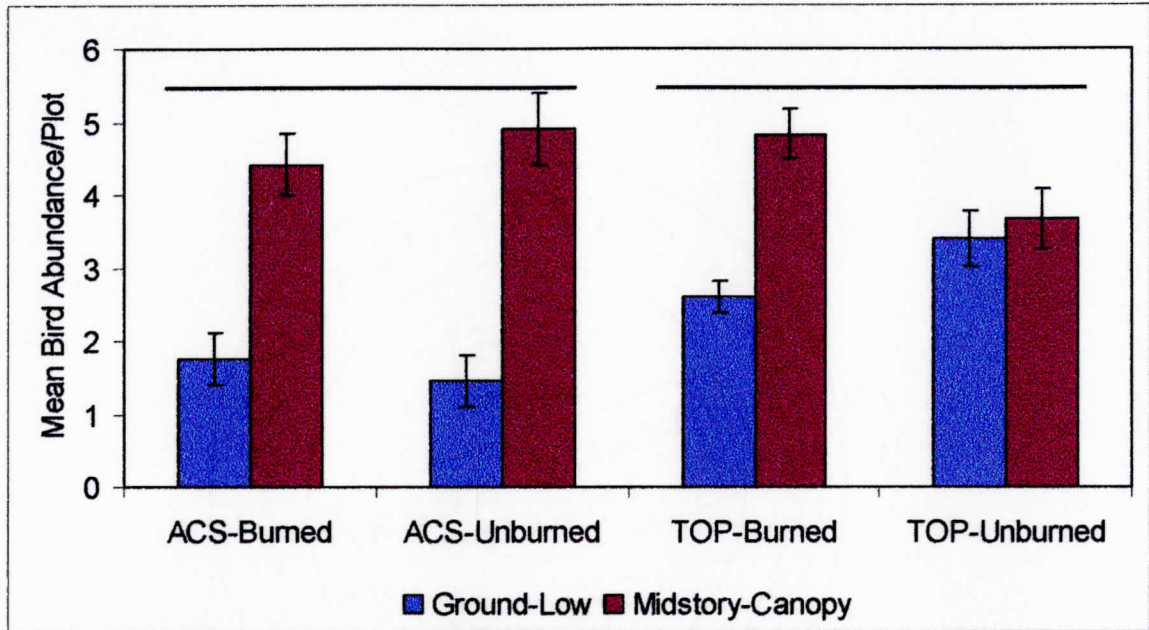


Figure 16. Mean bird abundance of both nest location guilds.

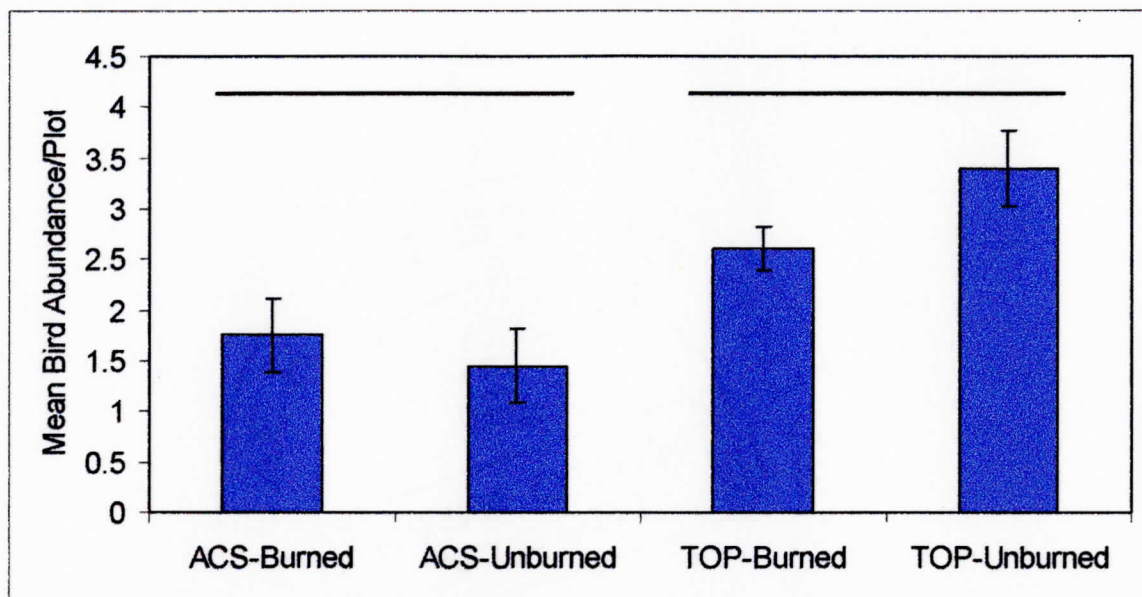


Figure 17. Mean ground-low nesting bird abundance.

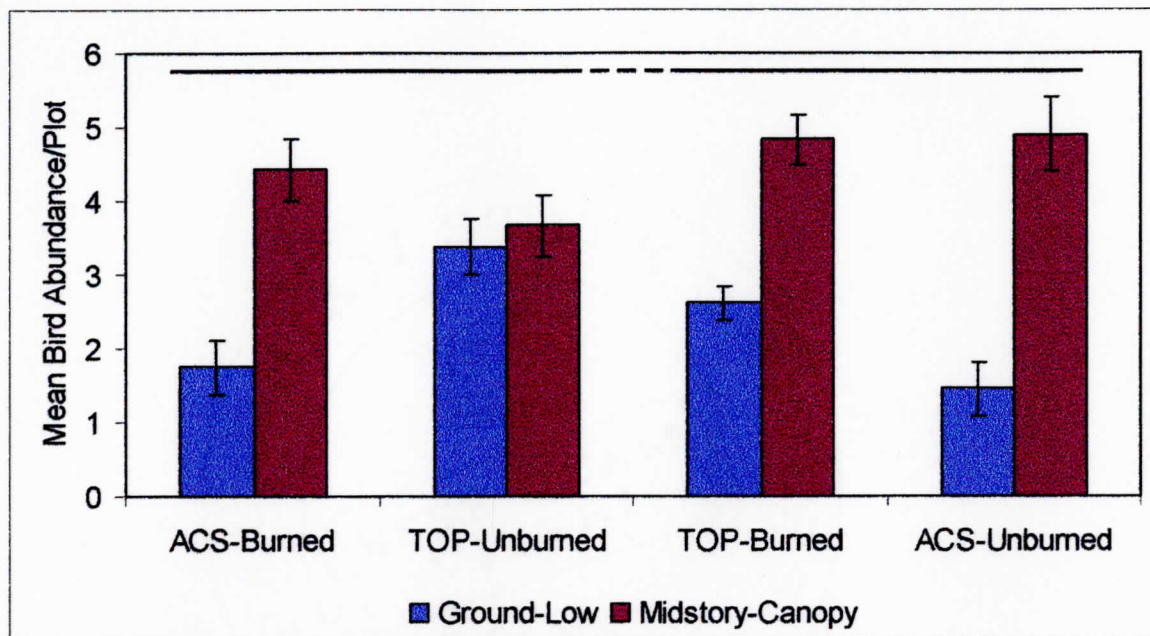


Figure 18. Mean bird abundance of both nest location guilds.

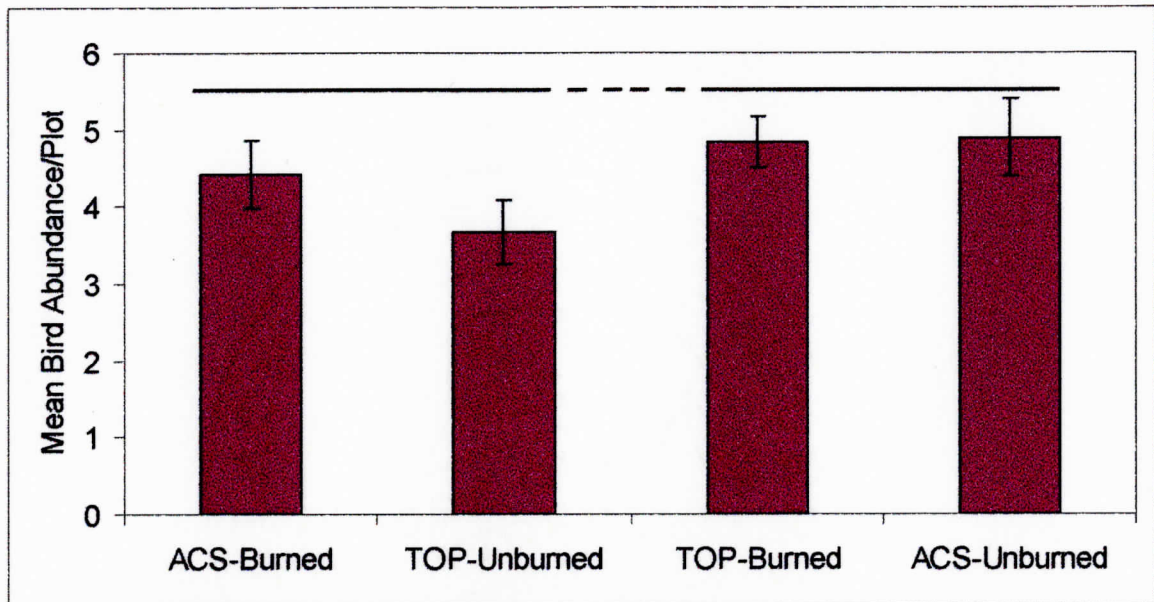


Figure 19. Mean midstory-canopy nester bird abundance.

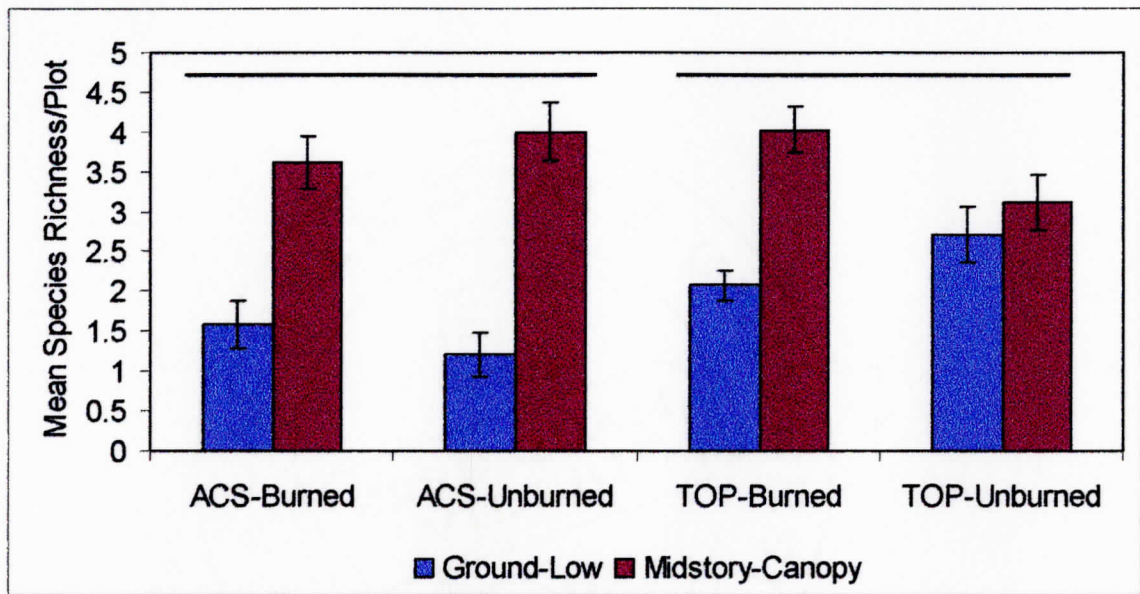


Figure 20. Mean species richness of both nest location guilds.

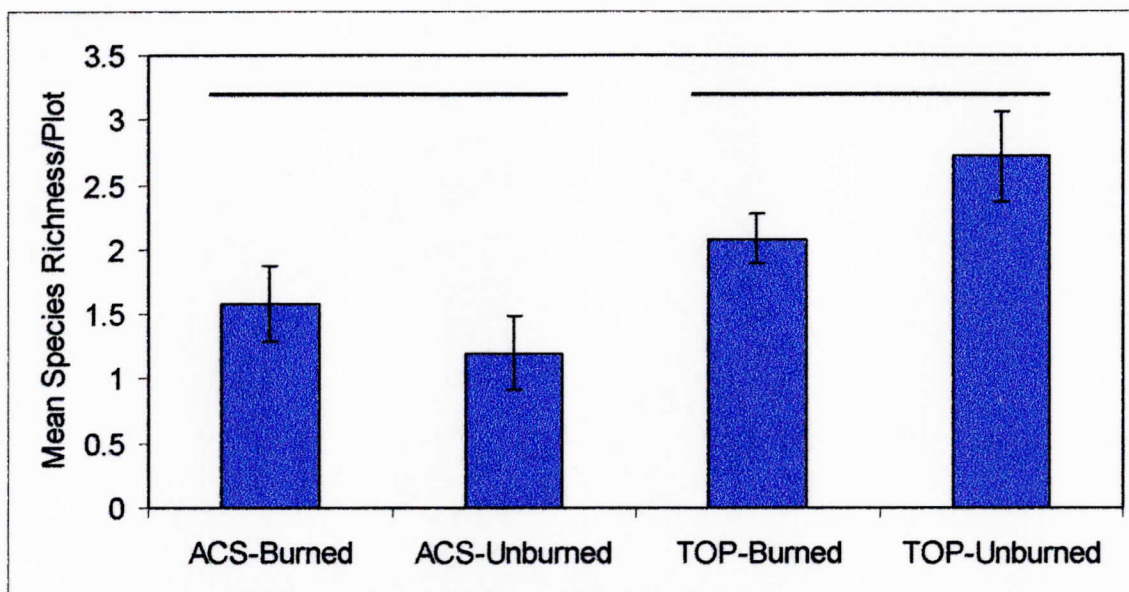


Figure 21. Mean species richness of ground-low nesting birds.

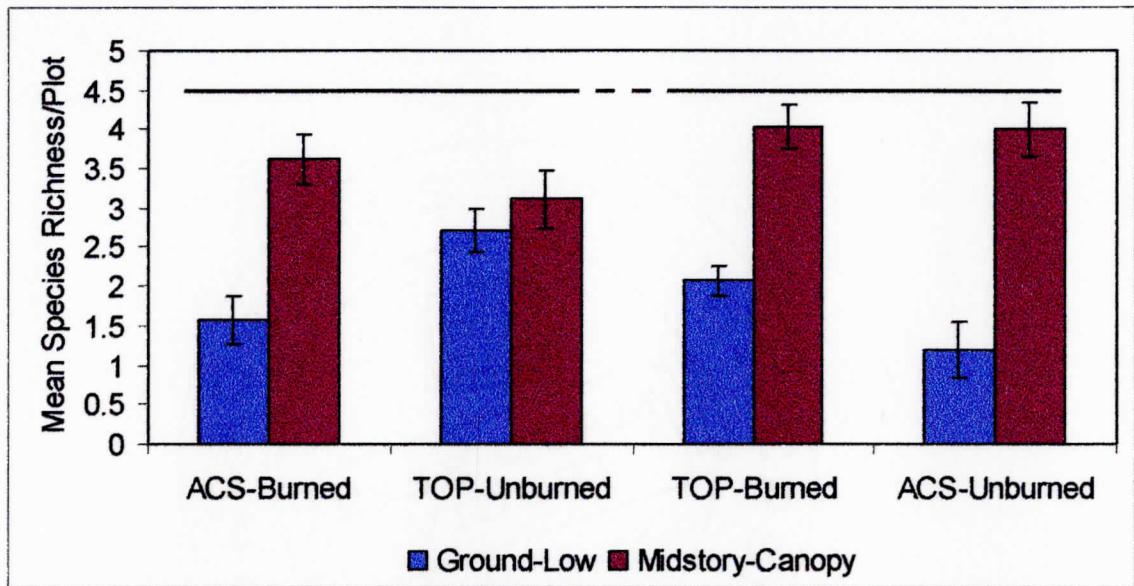


Figure 22. Mean species richness of both nest location guilds.

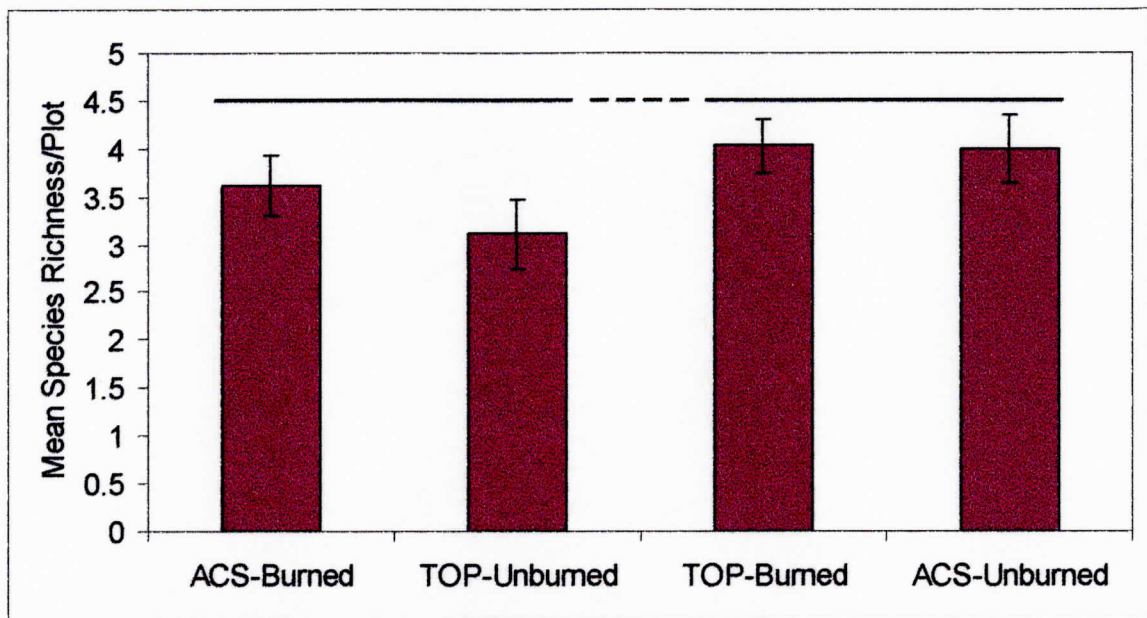


Figure 23. Mean species richness of midstory-canopy nesting birds.

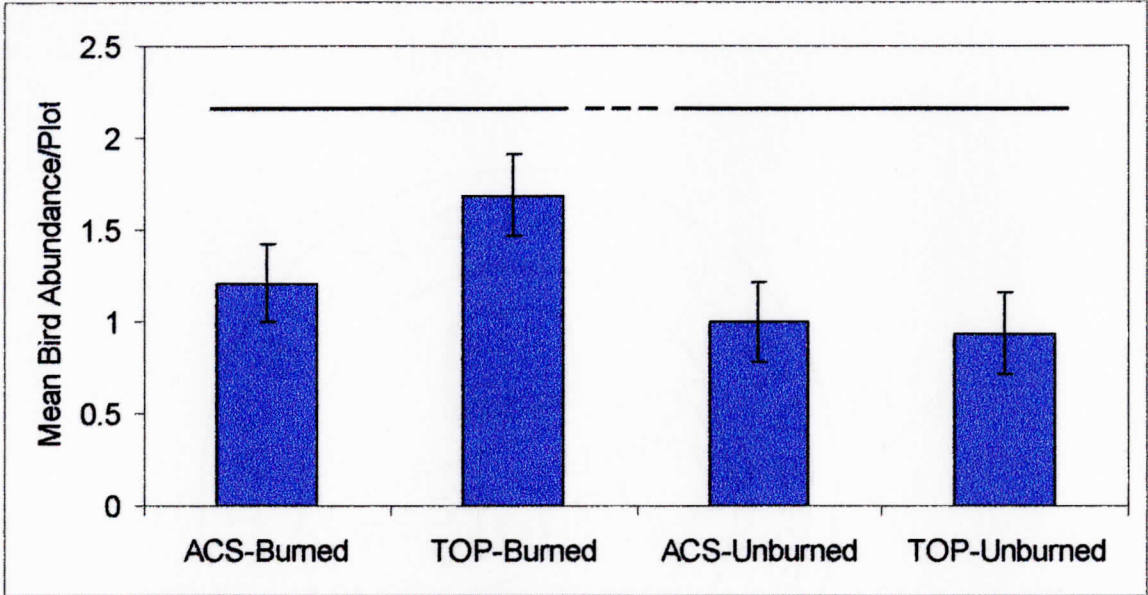


Figure 24. Mean cavity nesting bird abundance.

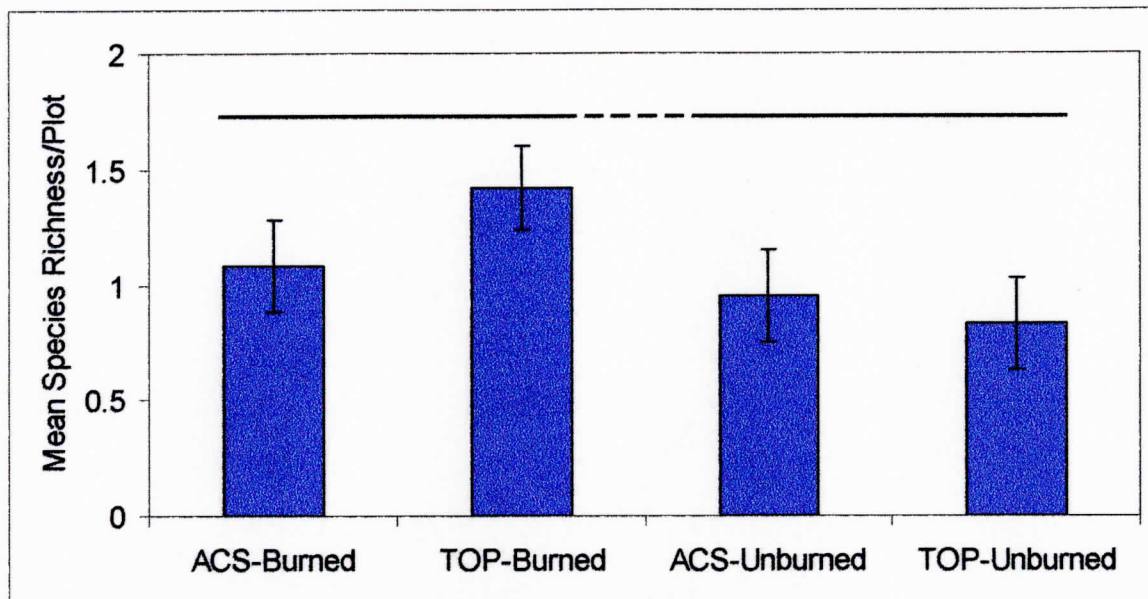


Figure 25. Mean species richness of cavity nesting birds.

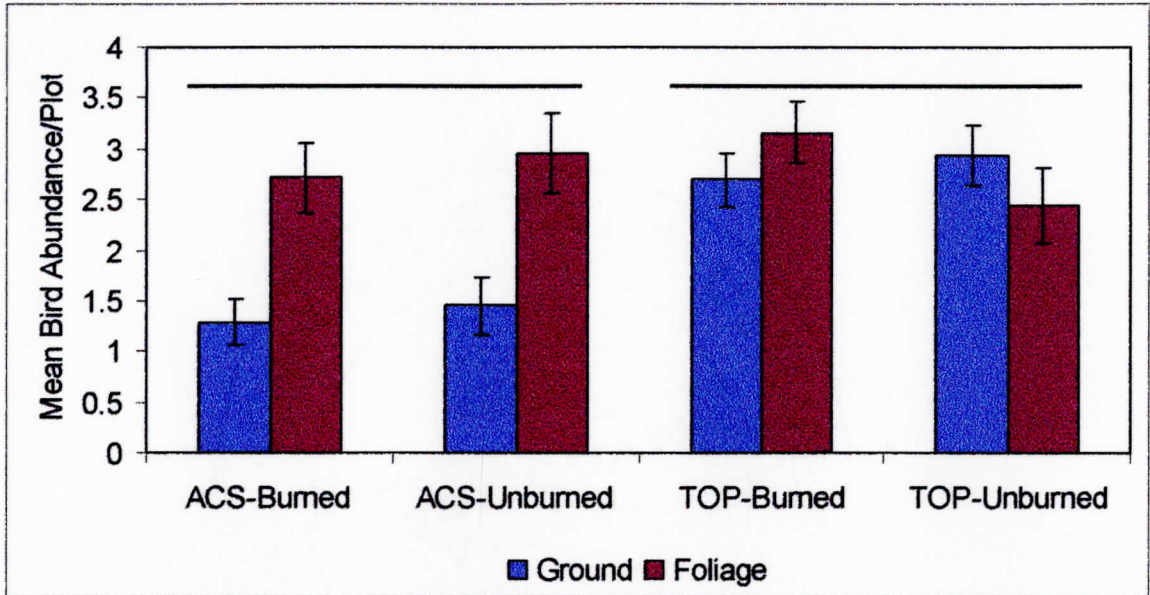


Figure 26. Mean bird abundance of both foraging guilds.

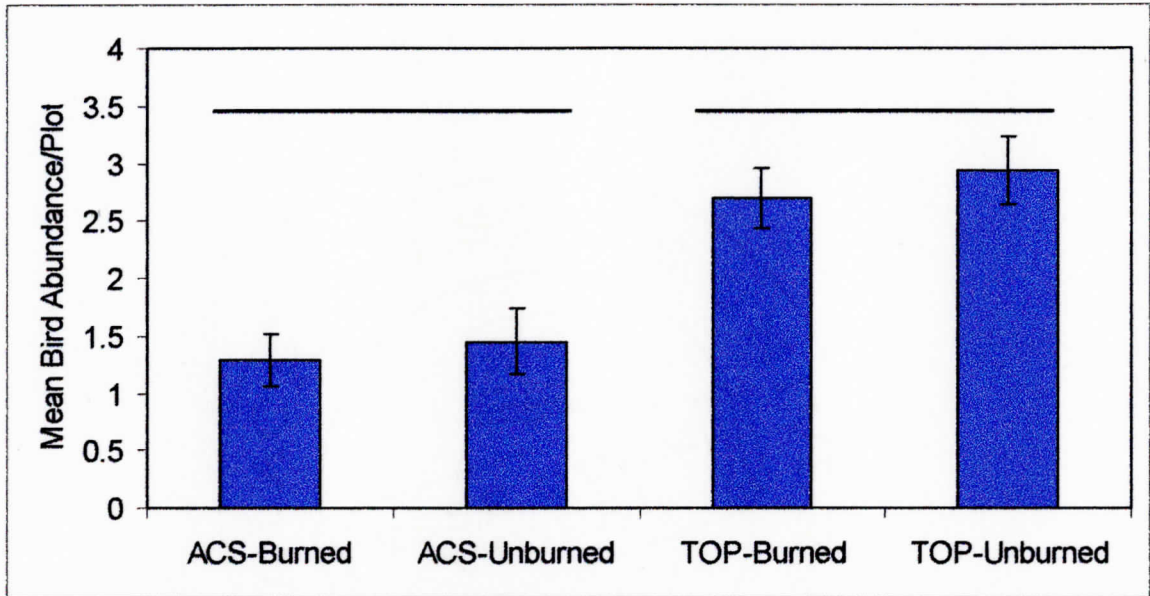


Figure 27. Mean ground foraging bird abundance.

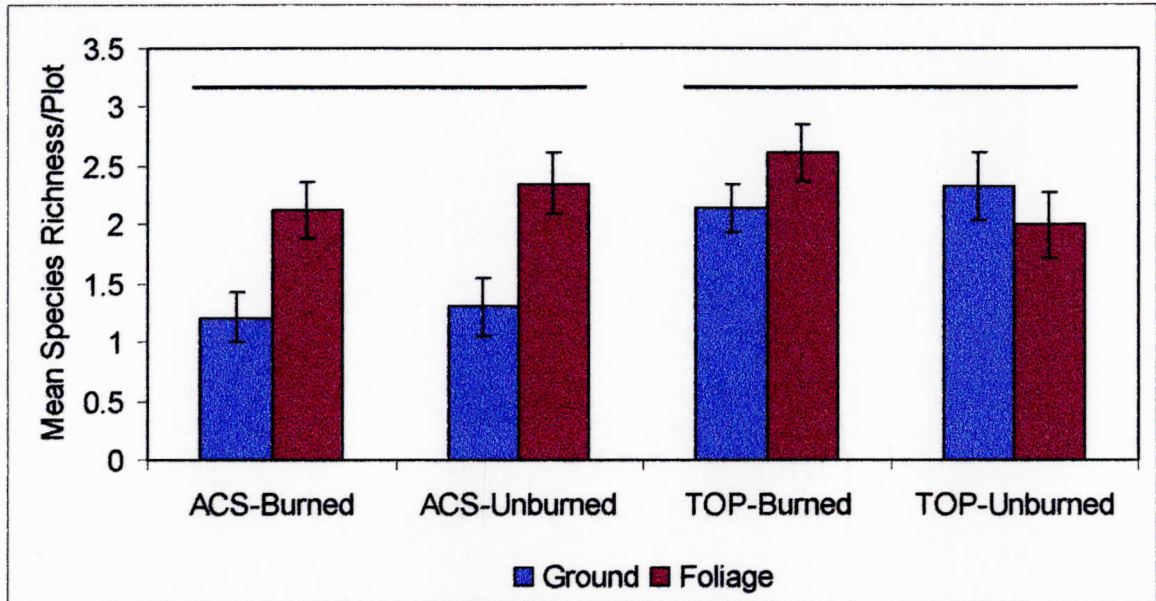


Figure 28. Mean species richness of both foraging guilds.

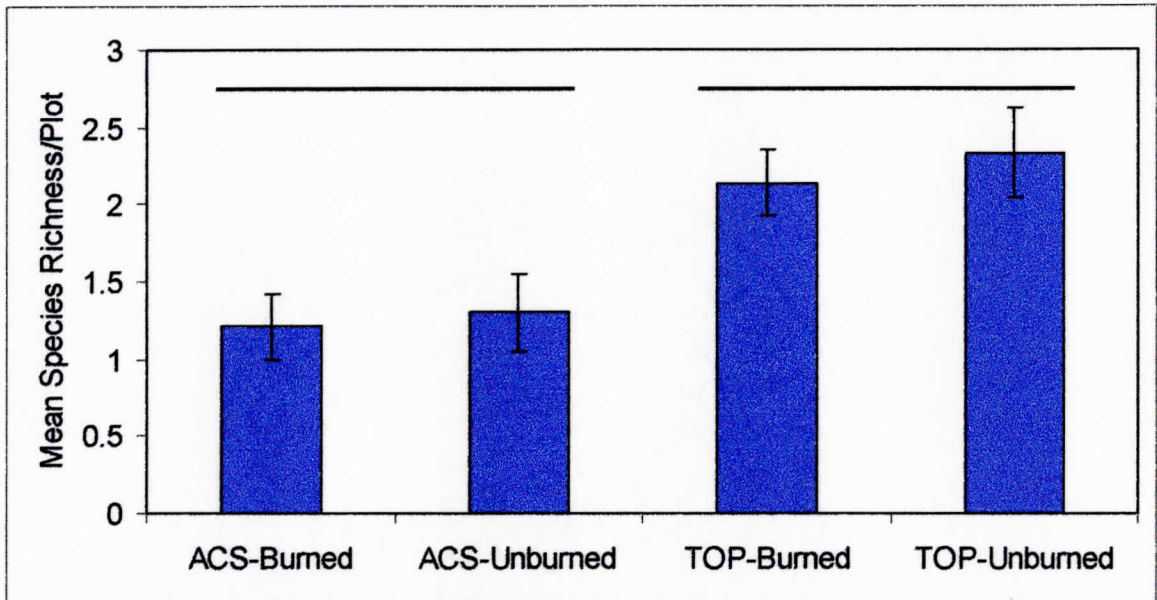


Figure 29. Mean species richness of ground foraging birds.

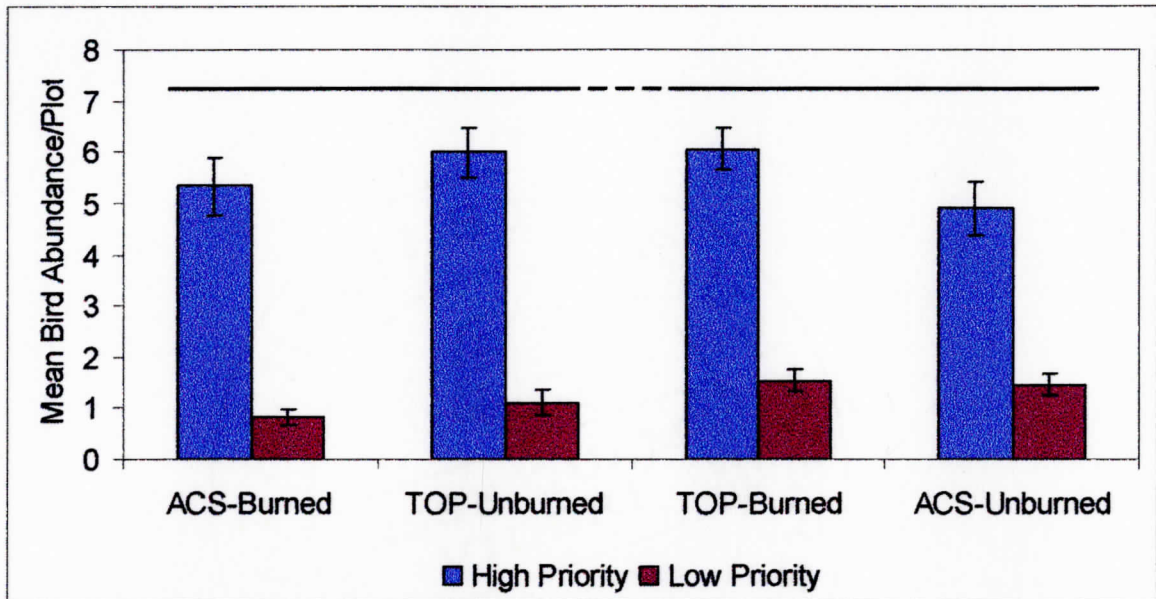


Figure 30. Mean bird abundance of both conservation guilds.

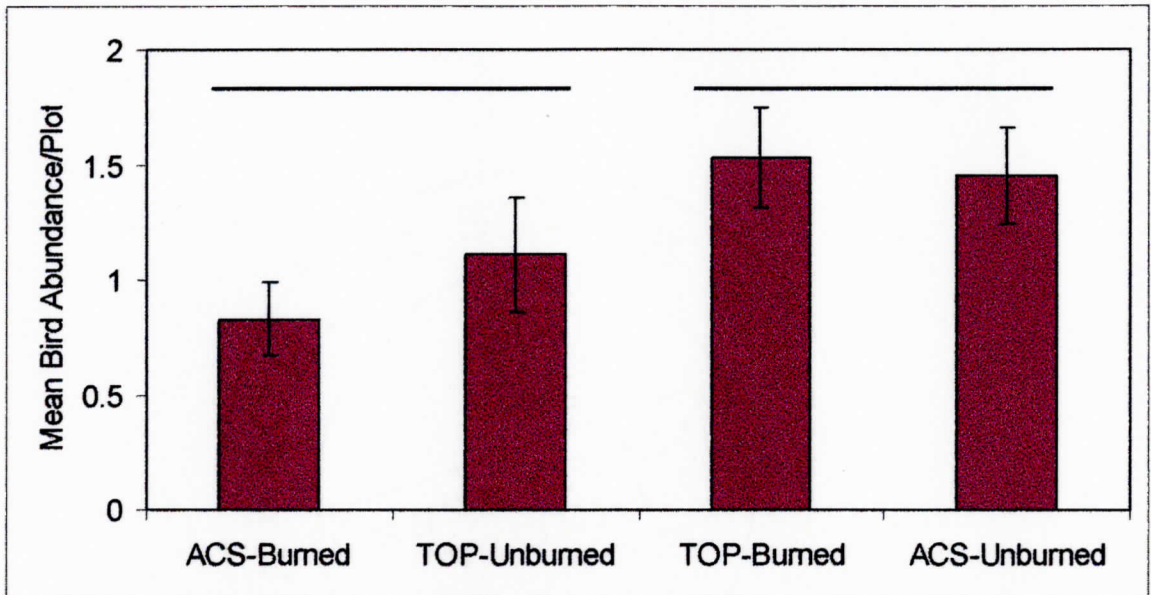


Figure 31. Mean low priority bird abundance.

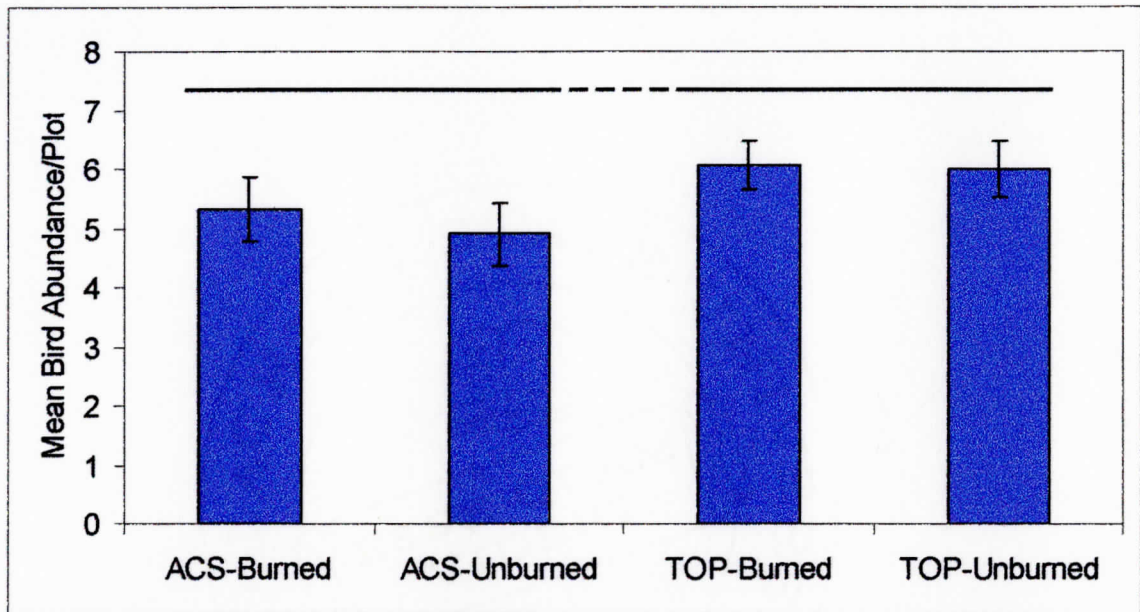


Figure 32. Mean high priority bird abundance.

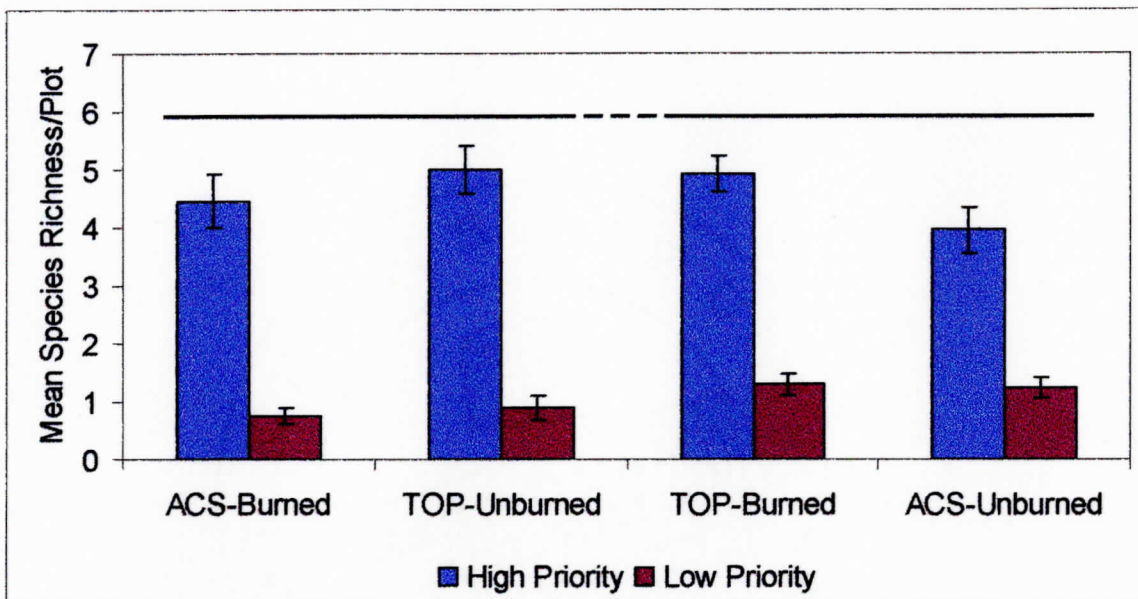


Figure 33. Mean species richness of both conservation guilds.

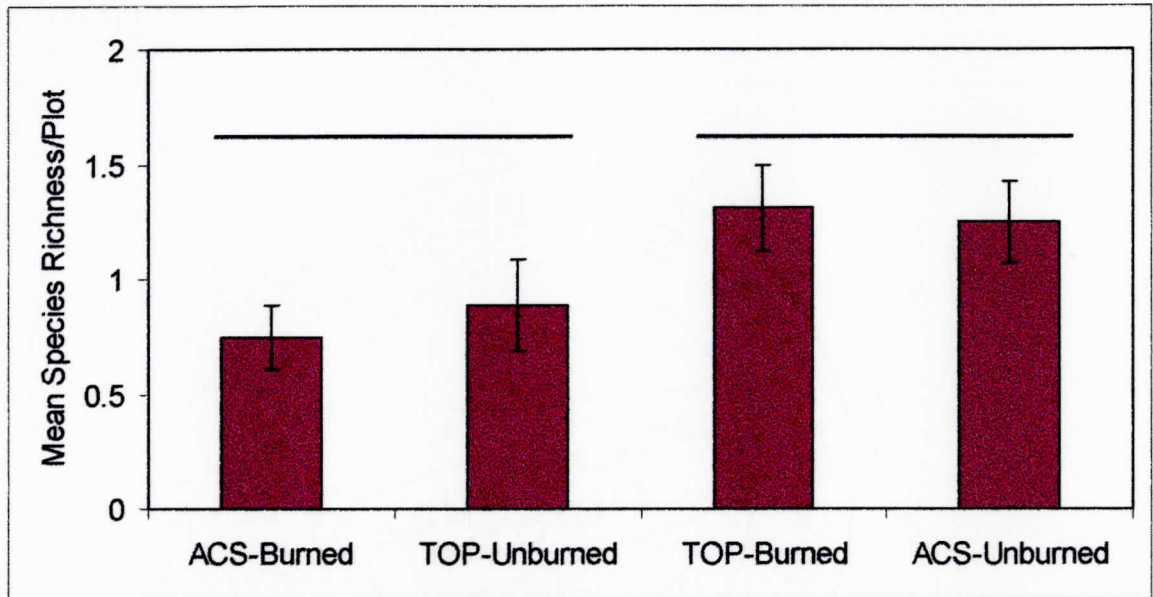


Figure 34. Mean species richness of low priority birds.

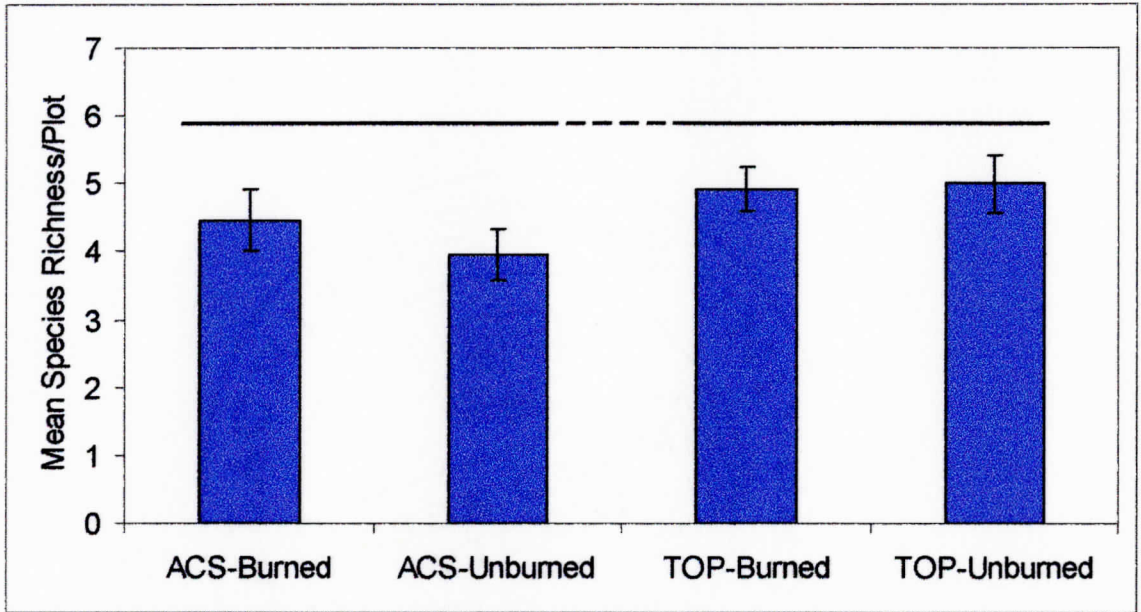


Figure 35. Mean species richness of high priority birds.

DISCUSSION

Acidic cove and slope and TOP are dramatically different forest types in terms of plant community composition (Newell and Peet 1998) and physical structure (*personal observation*). Plant community composition and especially physical structure have been shown to be primary factors affecting avian community composition (e.g., MacArthur and MacArthur 1961, MacArthur et al. 1962, James 1971, Karr and Roth 1971, Wilson 1974, Rotenberry and Wiens 1980, Robinson and Holmes 1984). Therefore, one would expect to find different avian communities in ACS and TOP forests (i.e., vegetation effects). The wildfires which swept through these forests altered the species composition (S. Dumas, *personal communication*) and physical structure of the herbaceous and shrub layers (Riddle 2001). As such, one would also expect the rapid and dramatic habitat changes brought on by fire to have a substantial short-term impact on bird communities (i.e., fire effects). However, one would also expect the effects of fire to vary by forest type (i.e., interactions) because of the historical absence of fire disturbance in ACS and the historical presence of fire in TOP. It was anticipated that the profound impact of a wildfire in two extremely different vegetative communities would result in interactions that were more dramatic than either of the main effects by themselves.

The preponderance of vegetation effects was the most surprising finding of this study. In general, ACS and TOP forests both appear to provide relatively abundant habitat for neotropical migrants (see Fig. 7, page 28), woodland breeders (see Fig. 12,

page 33), midstory-canopy nesters (see Fig. 16, page 37), foliage foragers (see Fig. 26, page 47), and birds of high conservation priority (see Fig. 30, page 51). However, TOP supported significantly more early-succession, short-distance migrant, ground-low nester, and ground foraging bird abundance and species richness than ACS. Additionally, TOP supported slightly higher total bird abundance, total species richness, high conservation priority bird abundance, and high conservation priority species richness than ACS. Remarkably, birds from all other guilds did not show decreases in TOP. For example, TOP forests supported more early-succession birds and species than ACS forests, while at the same time supporting a statistically similar abundance and richness of woodland birds. TOP supported more short-distance migrants than ACS, but still supported a statistically similar abundance and richness of neotropical migrants and permanent residents. Similarly, TOP supported more ground-low nesters and ground foragers than ACS, but without corresponding losses of midstory-canopy nester and foliage forager abundance and richness.

Fire did not have statistically significant effects on *any* response variable. Permanent resident abundance and cavity-nester abundance and richness showed slight increases in burned forests, but these findings were only marginally significant. However, these increases made biological sense because fire can promote snags which are common nesting and foraging substrates for cavity nesters, many of which are permanent residents (e.g., Blackford 1955, Hutto 1995, Murphy and Lehnhausen 1998, Imbeau et al. 1999, Kreisel and Stein 1999, White et al. 1999).

There were very few interactions between fire and vegetation type. Low conservation priority bird abundance and species richness were lower in burned ACS and

unburned TOP. Midstory-canopy nester bird abundance and species richness decreased slightly in burned ACS and unburned TOP, but these findings were only marginally significant. The decreases exhibited in low conservation priority birds and midstory-canopy nesters made biological sense because burned ACS and unburned TOP (which has been fire suppressed for approximately 50 yrs.) represent unnatural disturbance regimes for these forests.

The paucity of fire effects and interactions may have been due to the intensity and timing of the Brushy Ridge Wildfire. If the fire had been more intense and/or occurred closer to or during the breeding season, the effects on breeding bird communities may have been dramatic.

Biologists have recommended using varying degrees of silviculture and burning to restore the landscape heterogeneity that existed in the southern Appalachians prior to industrial logging and fire suppression (Delcourt and Delcourt 1997, Buckner and Turrill 1999, Hunter et al. 1999). Avian ecologists (e.g., Hunter et al. 1999) suggest that more heterogeneous landscapes would benefit both woodland and early-succession birds as well as other birds of high conservation priority. The studies presented in this thesis have demonstrated that ACS (an old-growth forest) and TOP (a fire-maintained successional forest) appear to provide quality habitat for a number of birds, most notably neotropical migrants, woodland breeders, and other birds of high conservation priority. Additionally, TOP provides relatively more habitat for short-distance migrants, early-succession breeders, ground-low nesters, ground foragers, and birds of high conservation priority than ACS. Therefore, the findings presented here are consistent with predictions by Hunter et al. (1999) in that they suggest simultaneous maintenance and promotion of late-

and early-successional forests should provide habitat for a variety of birds of management concern. This is especially true with regards to TOP forests, as this habitat seems to provide both woodland and early-successional habitat to bird species.

This is the only study to my knowledge to examine the impact of fire on bird communities in old-growth and successional forests in the southern Appalachians. A somewhat similar study was conducted by Hines (1999) in southeastern Kentucky on the western edge of the Cumberland Plateau. She studied the effects of fire and hardwood thinning on birds in pine-oak stands. Comparisons of her results with those presented here are tentative as our study sites had many dissimilarities. For example, her mixed pine and oak sites occurred at a much lower elevation than mine, approximately 270-390m vs. 800-1260m (M. Hines, *personal communication*). Her sites were also different than mine in terms of plant species composition (e.g., total absence of *P. pungens* and scarcity of *P. rigida*) and physical structure (e.g., approximately half of her sites had very little midstory due to mechanical removal of hardwoods and repeated prescribed burning every 3-5 yrs.). Nevertheless, she also found relatively large numbers of ground foragers and ground-low nesters, especially in sites which had been thinned and burned.

The affinity of ground foragers and ground-low nesters to fire-associated plant communities, especially those which have recently burned, is a consistent theme in southeastern ecosystems (e.g. this study, Engstrom et al. 1984, Breininger and Smith 1992, Wilson et al. 1995, Hines 1999, Plentovich et al. 1999, White et. al. 1999). Historically, the southeast was subject to frequent low to mid-intensity ground fires (see Frost 1998). This fire regime often results in the removal of young hardwoods from the understory. Fire and/or hardwood removal can promote a rich herbaceous layer of

grasses, legumes, and forbs (e.g., Dickson 1981, Mobley and Balmer 1981, Provencher et al. 2001). This rich herbaceous layer provides critical food and cover for birds that feed or nest on or near the ground (Mobley and Balmer 1981, Provencher et al. 2002).

Ground-low foragers, as well as birds that depend on tree trunks for nesting and/or foraging sites (especially woodpeckers), also benefit from fire in the coniferous forests of northern and western North America (e.g., Blackford 1955, Bock and Lynch 1970, Taylor and Barmore 1980, Apfelbaum and Haney 1981, Raphael et al. 1987, Hutto 1995, Murphy and Lehnhausen 1998, Imbeau et al. 1999, Kreisel and Stien 1999). However, fires in these ecosystems tend to be higher intensity stand replacement fires (hence the increased abundance of snags and woodpeckers). As a result, it is difficult to compare the effect of fire on birds in northern and western ecosystems to that of southeastern ecosystems.

Future research and management recommendation

Again, the findings presented in this thesis give support to arguments which favor managing for both late- and early-successional habitats within the southern Appalachians. In particular, land managers should give special consideration to habitats such as TOP forests which benefit both woodland and early-succession birds. The most natural and effective management prescription for this forest will undoubtedly depend heavily on fire. Ironically, the very fires that maintain this forest type appear to have little if any direct short-term effects on breeding bird communities. Indeed, they appear to benefit birds in the long-term in that they maintain an extremely unique and valuable avian habitat on the landscape. However, additional research is needed to corroborate these findings.

Future research should focus on the mechanisms by which fire maintains TOP forests and its unique avian communities. Specifically, the relationship between fire and arthropod abundance, seed production, and nest site availability deserves investigation. The effects of fire on these resources will likely affect avian productivity and nest site selection in or near burned areas. Arthropod abundance, seed production, and nest site selection may vary with different fire regimes (i.e., different fire frequencies and intensities). Therefore, future research should also focus on the effects of various fire regimes on bird communities in TOP and a variety of other fire adapted habitats (e.g., balds and oak woodlands).

BIBLIOGRAPHY

- Alsop III, F.J., and T.F. Laughlin. 1991. Changes in the spruce-fir avifauna of Mt. Guyot, Tennessee, 1967-1985. *Journal of the Tennessee Academy of Science* **66**:207-209.
- Apfelbaum, S., and A. Haney. 1981. Bird populations before and after wildfire in a Great Lakes pine forest. *The Condor* **83**:347-354.
- Askins, R.A. 1993. Population trends in grassland, shrubland, and forest birds in eastern North America. *Current Ornithology* **11**:1-34.
- Askins, R.A., J.F. Lynch, and R. Greenberg. 1990. Population declines in migratory birds in eastern North America. *Current Ornithology* **7**:1-57.
- Blackford, J.L. 1955. Woodpecker concentration in burned forest. *The Condor* **57**:28-30.
- Blake, J.G., and J.R. Karr. 1987. Breeding birds of isolated woodlots: area and habitat relationships. *Ecology* **68**:1724-1734.
- Bock, C.E., and J.F. Lynch. 1970. Breeding bird populations of burned and unburned conifer forest in the Sierra Nevada. *The Condor* **72**:182-189.
- Bratton, S.P., and A.J. Meier. 1998. The recent vegetation disturbance history of the Chattooga River watershed. *Castanea* **63**:372-381.
- Brawn, J.D., S.K. Robinson, and F.R. Thompson III. 2001. The role of disturbance in the ecology and conservation of birds. *Annual Review of Ecology and Systematics* **32**:251-276.
- Breining, D.R., and R.B. Smith. 1992. Relationships between fire and bird density in coastal scrub and slash pine flatwoods in Florida. *American Midland Naturalist* **127**:233-244.
- Brittingham, M.C., and S. A. Temple. 1983. Have cowbirds caused forest songbirds to decline? *Bioscience* **33**:31-35.

- Buckner, E.R., and N.L. Turrill. 1999. Fire Management. Pages 329-347 in J.D. Peine, editor. Ecosystem management for sustainability: principles and practices illustrated by a regional biosphere reserve cooperative. Lewis Publishers, Boca Raton, Florida, USA.
- Delcourt, H. R., and P. A. Delcourt. 1997. Pre-Columbian Native American use of fire on Southern Appalachian landscapes. *Conservation Biology* 11:1010-1014.
- Delcourt, P. A., and H. R. Delcourt. 1998. The influence of prehistoric human-set fires on oak-chestnut forests in the Southern Appalachians. *Castanea* 63:337-345.
- Dickson, J.G. 1981. Effects of forest burning on songbirds. Pages 67-72 in G.W. Wood editor. Prescribed fire and wildlife in southern forests: proceedings of a symposium. April 6-8, Myrtle Beach, South Carolina, USA.
- Donovan, T.M., C.J. Beardmore, D.N. Bonter, J.D. Brawn, R.J. Cooper, J.A. Fitzgerald, R. Ford, S.A. Gauthreaux, T.L. George, W.C. Hunter, T.E. Martin, J. Price, K.V. Rosenberg, P.D. Vickery, and T.B. Wigly. 2002. Priority research needs for the conservation of Neotropical migrant landbirds. *Journal of Field Ornithology* 73:329-339.
- Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. *The Birder's Handbook: A Field Guide to the Natural History of North American Birds*. Simon and Shuster, Inc. New York, New York.
- Engstrom, R.T., R.L. Crawford, and W.W. Baker. 1984. Breeding bird populations in relation to changing forest structure following fire exclusion: a 15-year study. *The Wilson Bulletin* 96:437-450.
- Frost, C.C. 1998. Presettlement fire frequency regimes of the United States: a first approximation. Pages 70-81 in Pruden, T.L. and L.A. Brennen, editors. Fire in ecosystem management; shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings Number 20. Tall Timbers Research Station, Tallahassee, Florida, USA.
- Harmon, M.E. 1982. Fire history of the westernmost portion of Great Smoky Mountains National Park. *Bulletin of the Torrey Botanical Club*. 109:74-79.
- Harrod, J., P. S. White, and M. E. Harmon. 1998. Changes in xeric forests in western Great Smoky Mountains National Park, 1936-1995. *Castanea* 63:346-360.
- Hines, M. 1999. Managing red-cockaded woodpeckers (*Picoides borealis*) affects breeding-bird communities of pine-oak forests in southeastern Kentucky. *Journal of the Kentucky Academy of Science* 60:78-86.

- Holt, J.P. 2000. Changes in bird populations on the Highlands Plateau, North Carolina (USA), 1946-1995, with emphasis on neotropical migrants. *Natural Areas Journal* **20**:119-125.
- Hunter, W.C., K. Robert, D.N. Pashley, and R. P. Ford. 1999. Partners in Flight Southern Blue Ridge Bird Conservation Plan (Physiographic Area 23). Version 1.0.
- Hunter, W.C., D.A. Buehler, R.A. Canterbury, J.L. Confer, and P.B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. *Wildlife Society Bulletin* **29**:440-455.
- Hutto, R.L. 1995. Composition of bird communities following stand-replacement fires in northern Rocky Mountains (U.S.A.) conifer forests. *Conservation Biology* **9**:1041-1058.
- Imbeau, L., J-P. L. Savard, and R. Gagnon. 1999. Comparing bird assemblages in successional black spruce stands originating from fire and logging. *Canadian Journal of Zoology* **77**: 1850-1860.
- James, F.C. 1971. Ordinations of habitat relationships among breeding birds. *The Wilson Bulletin* **83**:215-236.
- James, F.C., and C.E. McCulloch. 1995. The strength of inferences about causes of trends in bird populations. Pages 40-51 in T.E. Martin and D.M. Finch, editors. *Ecology and management of Neotropical migratory birds: a synthesis and review of critical issues*. Oxford University Press, New York, USA.
- James, F.C., C.E. McCulloch, and D.A. Wiedenfeld. 1996. New approaches to the analysis of population trends in land birds. *Ecology* **77**:13-27.
- Karr, J.R., and R.R. Roth. 1971. Vegetation structure and avian diversity in several new world areas. *The American Naturalist* **105**:423-435.
- Korstian, C.F. 1937. Perpetuation of spruce on cut-over and burned lands in the higher Southern Appalachian Mountains. *Ecological Monographs* **7**:125-167.
- Kreisel, J.K., and S.J. Stein. 1999. Bird use of burned and unburned coniferous forests during winter. *The Wilson Bulletin* **111**:243-250.
- MacArthur, R.H. 1959. On the breeding distribution pattern of North American migrant birds. *The Auk* **76**:318-325.
- MacArthur, R.H., and J.W. MacArthur. 1961. On bird species diversity. *Ecology* **42**:594-598.

- MacArthur, R.H., J.W. MacArthur, and J. Preer. 1962. On bird species diversity II. Prediction of bird census from habitat measurements. *The American Naturalist* **96**:167-174.
- Maurer, B.A., and M.-A. Villard. 1996. Special feature: continental scale ecology and neotropical migratory birds: how to detect declines amid the noise. *Ecology* **77**: 1-2.
- Mobley, H.E., and W.E. Balmer. 1981. Current purposes, extent, and environmental effects of prescribed fire in the South. Pages 15-21 *in* G.W. Wood editor. Prescribed fire and wildlife in southern forests: proceedings of a symposium. April 6-8, Myrtle Beach, South Carolina, USA.
- Murphy, E.C., and W.A. Lehnhausen. 1998. Density and foraging ecology of woodpeckers following a stand replacement fire. *Journal of Wildlife Management* **62**:1359-1372.
- Newell C.L., and R.K. Peet. 1998. Vegetation of Linville Gorge Wilderness, North Carolina. *Castanea* **63**:275-322.
- Oehlert, G.W. 2000. *A First Course in Design and Analysis of Experiments*. W.H. Freeman and Company. New York, USA.
- Pitillo, J. D., R. D. Hatcher Jr., and S. W. Buol. 1998. Introduction to the environment and vegetation of the Southern Blue Ridge Province. *Castanea* **63**:202-216.
- Plentovich, S., N.R. Holler, and G.E. Hill. 1999. Habitat requirements of Henslow's sparrows wintering in silvicultural lands of the Gulf Coastal Plain. *The Auk* **116**:109-115.
- Provencher, L., B.J. Herring, D.R. Gordon, H.L. Rodgers, K.E.M. Galley, G.W. Tanner, J.L. Hardesty, and L.A. Brennan. 2001. Effects of hardwood reduction techniques on longleaf pine sandhill vegetation in northwest Florida. *Restoration Ecology* **9**:13-27.
- Provencher, L., N.M. Gobris, and L.A. Brennan. 2002. Effects of hardwood reduction on winter birds in northwest Florida longleaf pine sandhill forests. *The Auk*. **119**:71-87.
- Pyne, S.J. 1982. *Fire in America*. Princeton University Press. Princeton, New Jersey. USA.

- Ralph C.J., J.R. Sauer, and S. Droege. 1995. Monitoring bird populations by point counts. USDA Forest Service. Pacific Southwest Research Station. Albany, California. **PSW-GTR-149**.
- Raphael, M.G., M.L. Morrison, and M.P. Yoder-Williams. 1987. Breeding bird populations during twenty-five years of postfire succession in the Sierra Nevada. *The Condor* **89**:614-626.
- Riddle, J.D. 2001. Classification and analysis of wildfires in Linville Gorge Wilderness. Report to the USDA Forest Service, Southern Office, Ashville NC.
- Riddle, J.D., and C.B. Gass. 2002. Linville Gorge fire project. Report to the USDA Forest Service, Southern Office, Ashville NC.
- Robbins, C.S. 1980. Effect of forest fragmentation on breeding bird populations in the piedmont of the Mid-Atlantic region. *Atlantic Naturalist* **33**:31-36.
- Robbins C.S., J.R. Sauer, R.S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the neotropics. *Proceedings of the National Academy of Sciences (USA)* **86**:7658-7662.
- Robinson, S.K., and R.T. Holmes. 1984. Effects of plant species and foliage structure on the foraging behavior of forest birds. *The Auk* **101**:672-684.
- Rotenberry, J.T., and J.A. Wiens. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. *Ecology* **61**:1228-1250.
- SAMAB (Southern Appalachian Man and the Biosphere). 1996. The Southern Appalachian Assessment (SAA) Terrestrial Technical Report. Report 5 of 5. USDA Forest Service, Southern Region, Atlanta, GA.
- SAS Institute. 2001. The SAS system for Windows. Version 8.2. SAS Institute Inc., Cary, North Carolina, USA.
- Sauer, J.R., and S. Droege. 1992. Geographic patterns in population trends of Neotropical migrants in North America. Pages 26-42 *in* J.M. Hagan III and D.W. Johnston, editors. *Ecology and conservation of Neotropical migrant landbirds*. Smithsonian Institution Press, Washington D.C., USA.
- Sauer, J.R., B.G. Peterjohn, and W.A. Link. 1994. Observer differences in the North American Breeding Bird Survey. *The Auk* **111**:50-62.

- Sauer, J. R., J. E. Hines, and J. Fallon. 2001. The North American Breeding Bird Survey, Results and Analysis 1966 - 2000. Version 2001.2, USGS Patuxent Wildlife Research Center, Laurel, MD.
- Skeen, J. N., P. D. Doerr, and D. H. Van Lear. 1992. Oak-hickory-pine forests. Pages 1-33 in W. H. Martin, S. G. Boyce, and A. C. Echternacht editors. Biodiversity of the southeastern United States: upland terrestrial communities. John Wiley & Sons, INC. New York, New York. USA.
- Simons, T.R., K.N. Rabenold, D.A. Buehler, J.A. Collazo, and K.E. Franzreb. 1999. The role of indicator species: neotropical migratory song birds. Pages 187-208 in J.D. Peine, editor. Ecosystem management for sustainability: principles and practices illustrated by a regional biosphere reserve cooperative. Lewis Publishers, Boca Raton, Florida, USA.
- South, D.B., and E.R. Buckner. 2003. The decline of southern yellow pine timberland. *Journal of Forestry* **101**:30-35.
- Tabachnick, B.G., and L. S. Fidell. 2001. Using Multivariate Statistics. 4th edition. Allyn and Bacon. Boston, Massachusetts. USA.
- Taylor, D.L., and W.J. Barmore, Jr. 1980. Post-fire succession of avifauna in coniferous forests of Yellowstone and Grand Teton National Park, Wyoming. Pages 130-145 in Management of western forests and grasslands for nongame birds. USDA Forest Service. Intermountain Forest and Range Experiment Station. Ogden, Utah. **GTR-INT-86**.
- Terborgh, J.W. 1989. Where have all the birds gone? Essays on the biology and conservation of birds that migrate to the American tropics. Princeton University Press, Princeton, New Jersey, USA.
- Van Lear, D. H., and T. A. Waldrop. 1999. History, uses, and effects of fire in the Appalachians. USDA Forest Service. Southeastern Forest Experiment Station, Asheville, North Carolina, USA. **GTR SE-54**.
- White, D.H, B.R. Chapman, J.H. Brunjes, IV, R.V. Raftovich, Jr., and J.T. Seginak. 1999. Abundance and reproduction of songbirds in burned and unburned pine forests of the Georgia piedmont. *Journal of Field Ornithology* **70**:414-424.
- Wilcove, D.S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. *Ecology* **66**:1211-1214.
- Williams, C.E., and W.C. Johnson. 1992. Factors affecting recruitment of *Pinus pungens* in the southern Appalachian Mountains. *Canadian Journal of Forest Research* **22**:878-887.

Wilson, M.F. 1974. Avian community organization and habitat structure. *Ecology* **55**:1017-1029.

Wilson, C.W., R.F. Masters, and G.A. Bukenhofer. 1995. Breeding bird response to pine-grassland community restoration for red-cockaded woodpeckers. *Journal of Wildlife Management* **59**:56-67.

Zar, J.H. 1999. *Biostatistical Analysis*. 4th edition. Prentice Hall. Upper Saddle River, New Jersey, USA.

APPENDIX A
List of observed species with guild designations

Species	Migratory ^a	Breeding ^b	Nest Location ^c	Nest Type	Foraging	Conservation Priority
acadian flycatcher	NM	WL	M-C	Cup	*	High
American crow	SD	ES	M-C	Cup	Ground	Low
American robin	SD	ES	M-C	Cup	Ground	High
black-and-white warbler	NM	WL	G-L	Cup	*	High
black-throated blue warbler	NM	WL	M-C	Cup	*	High
black-throated green warbler	NM	WL	M-C	Cup	Foliage	High
blue jay	SD	ES	M-C	Cup	Ground	High
Canada warbler	NM	WL	G-L	Cup	*	High
Carolina chickadee	PR	WL	M-C	Cavity	Foliage	High
Carolina wren	PR	ES	G-L	Cavity	Ground	High
cedar waxwing	SD	WL	M-C	Cup	Foliage	High
chimney swift	NM	ES	M-C	*	*	High
common raven	PR	ES	*	Cup	Ground	High
downy woodpecker	PR	WL	M-C	Cavity	*	High
eastern phoebe	SD	ES	M-C	Cup	*	High
eastern towhee	SD	ES	G-L	Cup	Ground	High
eastern tufted titmouse	PR	WL	M-C	Cavity	Foliage	High
eastern wood peewee	NM	WL	M-C	Cup	*	High
golden-crowned kinglet	NM	WL	M-C	*	Foliage	High
great-crested flycatcher	NM	WL	M-C	Cavity	*	High
hairy woodpecker	PR	WL	M-C	Cavity	*	Low
hooded warbler	NM	WL	G-L	Cup	Foliage	High
house wren	NM	ES	M-C	Cavity	Ground	Low
indigo bunting	NM	ES	G-L	Cup	Foliage	High
Louisiana waterthrush	NM	WL	G-L	Cup	Ground	High
mourning dove	SD	ES	M-C	*	Ground	Low
northern cardinal	PR	ES	G-L	Cup	Ground	High
northern parula	NM	WL	M-C	*	Foliage	High
ovenbird	NM	WL	G-L	*	Ground	High
pileated woodpecker	PR	WL	M-C	Cavity	*	Low
pine warbler	SD	WL	M-C	Cup	*	Low
red-breasted nuthatch	PR	WL	M-C	Cavity	*	High
red-eyed vireo	NM	WL	M-C	Cup	*	High
rose-breasted grosbeak	NM	WL	M-C	Cup	Foliage	High
ruby-throated hummingbird	NM	WL	M-C	Cup	*	High
ruffed grouse	PR	WL	G-L	*	*	High
scarlet tanager	NM	WL	M-C	*	*	High
slate colored junco	SD	WL	G-L	Cup	Ground	Low
solitary vireo	NM	WL	M-C	Cup	Foliage	Low
song sparrow	SD	ES	G-L	Cup	Ground	Low
Swainson's warbler	NM	WL	G-L	Cup	Ground	High
veery	NM	WL	G-L	Cup	Ground	High

(continued on next page)

(continued)

Species	Migratory	Breeding	Nest Location	Nest Type	Foraging	Conservation Priority
white-breasted nuthatch	PR	WL	M-C	Cavity	*	Low
winter wren	SD	WL	M-C	Cavity	Ground	*
wood thrush	NM	WL	M-C	Cup	Ground	High
worm-eating warbler	NM	WL	G-L	Cup	Foliage	High
yellow-billed cuckoo	NM	WL	G-L	*	Foliage	High
yellow-shafted flicker	SD	ES	M-C	Cavity	Ground	High
yellow-throated warbler	NM	WL	M-C	Cup	*	High

a. PR = permanent resident, SD = short-distance migrant, NM = neotropical migrant

b. ES = early successional, WL = woodland

c. G-L = Ground-low, M-C = midstory-canopy

* this species could not be assigned to either guild within the respective guild suite.

APPENDIX B
Species observations for each treatment

Species	Burned ACS (n = 24)	Unburned ACS (n = 20)	Burned TOP (n = 36)	Unburned TOP (n = 18)	Total observations per species
acadian flycatcher	2	1	0	0	3
American crow	3	3	10	7	23
American robin	0	0	1	0	1
black-and-white warbler	13	2	3	5	23
black-throated blue warbler	8	10	4	4	26
black-throated green warbler	31	20	34	16	101
blue jay	1	4	6	6	17
Canada warbler	1	0	0	0	1
Carolina chickadee	9	2	18	8	37
Carolina wren	1	0	1	0	2
cedar waxwing	3	0	0	0	3
chimney swift	1	1	1	0	3
common raven	0	0	5	1	6
downy woodpecker	0	0	0	1	1
eastern phoebe	0	0	1	1	2
eastern towhee	1	2	23	13	39
eastern tufted titmouse	12	7	14	2	35
eastern wood peewee	0	0	1	0	1
golden-crowned kinglet	0	6	0	0	6
great-crested flycatcher	0	0	4	0	4
hairy woodpecker	1	0	1	0	2
hooded warbler	2	0	7	8	17
house wren	0	0	1	0	1
indigo bunting	0	0	11	3	14
Louisiana waterthrush	2	2	0	0	4
mourning dove	0	0	1	1	2
northern cardinal	3	1	0	0	4
northern parula	3	2	0	0	5
ovenbird	6	6	32	21	65
pileated woodpecker	2	7	10	3	22
pine warbler	0	0	2	0	2
red-breasted nuthatch	0	1	8	2	11
red-eyed vireo	17	13	15	8	53
rose-breasted grosbeak	0	0	1	0	1
ruby-throated hummingbird	3	0	0	0	3
ruffed grouse	1	0	0	0	1
scarlet tanager	1	3	7	3	14
slate colored junco	9	5	7	6	27
solitary vireo	4	13	20	2	39
song sparrow	1	0	0	0	1
Swainson's warbler	1	2	0	0	3

(continued on next page)

(continued)

Species	Burned ACS (n = 24)	Unburned ACS (n = 20)	Burned TOP (n = 36)	Unburned TOP (n = 18)	Total observations per species
veery	0	0	1	0	1
white-breasted nuthatch	0	1	3	1	5
winter wren	1	2	0	0	3
wood thrush	0	2	10	1	13
worm-eating warbler	1	8	6	2	17
yellow-billed cuckoo	0	1	3	3	7
yellow-shafted flicker	3	0	1	0	4
yellow-throated warbler	1	0	0	0	1
Total observations/treatment	148	127	273	128	676

VITA

Jason Dale Riddle was born at Halifax Regional Hospital in Halifax, VA on August 20, 1977. His immediate family members include Tommy Dale Riddle (father), Margaret Joye Riddle (mother), and Jonathan Dale Riddle (younger brother). Jason attended Bluestone Senior High School in Skipwith, VA where he graduated with honors in 1995. While at Bluestone, he focused his studies on the life sciences and art. Jason received a B.S. in Biology with a minor in Anthropology from The College of William and Mary in Virginia in May of 1999. During the summer of 1998, he worked with Ruth Beck (professor of Biology, William and Mary) on a couple of avian research projects that focused on shorebird communities on threatened island and beach habitats with an emphasis on piping plovers, least terns, black-necked stilts, and American avocets. That same summer he also worked as a field assistant for Chris Gordon (Biology graduate student, William and Mary) on a project involving bird marking and data collection on the food limitations of black skimmers. Together, these positions opened the door for a year long independent research project with Dan Cristol (professor of Biology, William and Mary) on the clam dropping behavior of herring gulls. During his senior year of college, Jason proposed to Jenny Ann Nehme (his high school sweetheart). She said "yes". They were married on May 20, 2000.

Jason began graduate studies in the Department of Biology at Appalachian State University in Boone, NC in the Fall of 1999. His mentor, Matthew Rowe, helped him to obtain funding for a field project designed to examine the bird diversity of Linville Gorge Wilderness. This project was "slightly" altered when a large wildfire swept through the Gorge during the middle of Jason's data collection. The unknown relationship between birds and fire in the southern Appalachians had been discussed for years, but never studied. Matt and Jason seized this once-in-a-lifetime opportunity of which this project is a result. Jason sought out many funding opportunities/jobs in an attempt to fund this project and avoid bankruptcy. This included internships at the Daniel Boone Native Gardens, contracts with the Wilderness Society and USDA Forest Service, a field technician/wilderness ranger position with the USDA Forest Service, and an internship with Rolling Hills Land and Timber. The relationships he forged through these work-related opportunities have been as formative to his academic development as the thesis itself.

Jason received his M.S. in Biology in August 2003. Currently, he is working as a forestry/wildlife consultant and as a wildland firefighter. He will be a Hoffman Fellow in the doctoral program in Forestry at North Carolina State University beginning in August 2003. He can be reached at the following address or by contacting the Appalachian State University Department of Biology in case of an address change:

2144 Ravenglass Place Apartment H
Raleigh, NC 27612